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基于海绵城市建设反思的
广州天河湿地公园设计研究

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Research on the Design of Guangzhou Tianhe Wetland Park Based on the Reflection of Sponge City Construction

A Dissertation Submitted for the Degree of Master

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摘要

改革开放以来，中国的城市经历了片面追求经济增长的粗放发展阶段，产生了许多生态问题，其中水安全和水质量成为困扰城市发展的突出问题之一。为应对水问题，许多发达国家依据自身特点和需求提出了不同的解决策略，2014 年建设部公布《海绵城市建设指南》，标志着海绵城市规划与建设全面启动。而城市湿地公园作为城市之肺，拥有大面积水体和绿地，成为了海绵城市理念的最佳实践场地；同时，它作为公园也是城市公共空间系统的重要组成部分之一，与人们日常生活休戚相关，若能把湿地公园的水处理、湿地生态保护和公共空间设计有机结合将能带来更大的社会和经济效益。

广州市由于地形气候、城市化的原因，也同样面临严峻的水问题，在这方面也有相关的实践。广州市政府曾在 2013 年以海绵城市为指导思想，委托北京土人设计团队设计了广州天河湿地公园。该湿地公园建成至今已运行了 8 年，成为市民休闲娱乐的重要场所，但其在水处理及生态方面效果受到公众质疑。本文希望通过多方面资料搜集和详细现场调研了解其运行状况，基于对现实状况的反思与评价，对未来城市湿地公园如何达到生态性和公共性两者“1+1 大于 2”的效果提出基于城市设计的策略指引。

本文对海绵城市的理论和实践进行研究，综合各类水管理的策略方法，结合湿地公园生态设计方法和满足市民休闲娱乐需求的城市公共空间设计方法，提出广州城市湿地公园设计方法工具箱，并尝试在广州天河湿地公园的优化设计方案中加以运用。首先，梳理国内外水管理相关理念的发展历程，以及其在城市湿地公园设计中的探索过程。其次，分析新加坡、美国、澳大利亚、中国等国家在城市湿地公园的具体设计案例，以水处理、湿地生态保护、公共空间优化等层面总结设计方法。再次，依据广州的地理气候特点和现有海绵城市建设状况，从以上三方面提出适合广州的海绵型城市湿地公园的设计方法。此外，对天河湿地公园的现状作调研分析，总结其在运行过程中存在的问题。最后，基于分析结果，从解决问题角度出发，在上述设计方法中提取适用部分，从湿地公园与周边街区的关系以及公园内部情况两方面提出广州天河湿地公园优化设计方案。

关键词：海绵城市；城市湿地公园；天河湿地公园；公共空间设计

Abstract

Since the reform and opening up, China's cities have experienced a rough development stage of unilaterally pursuing economic growth, which has produced many ecological problems, among which water safety and water quality have become one of the prominent problems plaguing urban development. In order to cope with water problems, many developed countries have put forward different solution strategies based on their own characteristics and needs. In 2014, the Ministry of Construction announced the Guidelines for Sponge City Construction, marking the comprehensive start of sponge city planning and construction. As the lungs of the city, urban wetland parks have large water bodies and green spaces, which become the best practice sites for the concept of sponge city; at the same time, as a park, it is also one of the important components of the urban public space system, which is closely related to people's daily life, and the organic combination of wetland parks, wetland ecological protection, and public space design will bring greater social and economic benefits.

Due to its topography, climate and urbanization, Guangzhou is also facing serious water problems and has relevant practices in this regard. In 2013, the Guangzhou Municipal Government commissioned the Beijing Turenscape to design the Guangzhou Tianhe Wetland Park with the guiding principle of sponge city. The wetland park has been in operation for 8 years since its completion, and has become an important place for public recreation, but its effectiveness in water treatment and ecology has been questioned by the public. In this paper, we hope to understand its operation situation through various data collection and detailed on-site research, and based on the reflection and evaluation of the real situation, we propose a strategic guideline based on urban design on how to achieve the effect of "1+1 is greater than 2" for the future urban wetland parks in terms of both ecology and publicity.

This paper researches the theory and practice of sponge city, synthesizes various water management strategies and methods, combines the ecological design method of wetland parks and the design method of urban public space to meet the needs of citizens for leisure and recreation, and proposes a toolbox of design methods for urban wetland parks in Guangzhou, which will be used in the optimized design scheme of Tianhe Wetland Park in Guangzhou.

Firstly, the development history of water management related concepts at home and abroad and their exploration process in urban wetland park design are sorted out. Secondly, we analyze the specific design cases of urban wetland parks in Singapore, the United States, Australia, China and other countries, and summarize the design methods in terms of water treatment, wetland ecological protection and public space optimization. Once again, based on the geographic and climatic characteristics of Guangzhou and the existing sponge city construction status, the design method of sponge urban wetland park suitable for Guangzhou is proposed from the above three aspects. In addition, the current situation of Tianhe Wetland Park is investigated and analyzed to summarize the problems that exist in the process of its operation. Finally, based on the results of the analysis, from the perspective of problem solving, we extract the applicable parts of the above design methods, and propose the optimized design scheme of Tianhe Wetland Park in Guangzhou from the relationship between the wetland park and the surrounding neighborhoods as well as the internal situation of the park.

Key words: sponge city; urban wetland park; Tianhe Wetland Park; public space design

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Chapter 1 Introduction

1.1 Backgrounds

1.1.1 High level of urbanization brings urban water problems

Water is one of the basic elements of the origin of the city, food, transportation, and even everything in life is inseparable from water, and a good water environment drives the development of the city. But at the same time, water is also a part of nature, it is not under human control. If a city fails to handle the relationship with water well, floods, rainstorms and other disasters will bring huge economic losses and human casualties. Therefore, how to get along with water is an important issue in urban design.

Guangzhou, as one of the most typical cities in China's highly urbanized process. After 40 years of development, from a typical mulberry-based fish pond agricultural area, through the transformation of rural industrialization and urban industrialization, it has gradually built into an innovative urban development model, and its urban built-up area has reached or exceeded the ancient ratio of urbanized land in advanced countries and regions in the world. And high urbanization has profoundly changed the structure, process and function of watershed hydrological system, dramatically degraded the regional water cycle, and exacerbated the problems of urban rainfall and flooding, water resources, water security and water pollution[1].

1.1.2 Wetland parks using the sponge city concept plays an important role in dealing with urban water problems

In order to solve the urban water problem, China has proposed the concept of sponge city design and applied it to almost all kinds of designs from macroscopic regional planning and urban planning to microscopic park green areas, settlements, roads and so on. Park green space is the area of the city that imitates nature and is closest to nature, and is an important public space in the city. Urban green space parks are an important part of the sponge city system because of their large land area and extensive vegetation coverage. And urban wetland parks, on the basis of parks, have large water areas and a large number of aquatic plants, which can be

used to store rainwater and purify water bodies, and are one of the cores of urban natural ecosystems, and more important pillars of urban stormwater management capacity[2]. However, there is still a lack of research on urban wetland parks, resulting in the lack of practical application of urban wetland parks, which could play a great role in urban stormwater management as "big sponges"[3].

1.1.3 Sponge city construction practices encounter questions

Sponge city is China's unique modern rainwater management concept, is still in the construction side of the exploration stage, its technical measures, design standards are not yet perfect. Therefore, in the process of construction, need to take into account ecological, economic and social factors, from the macroscopic scale, mesoscopic scale and microscopic scale of top-down planning and design, to avoid "sponge heat" of unreasonable construction and cause waste [4]. At the same time, China's vast territory, the north-south regional span is large, each city topography, terrain, hydrology, climate, rainfall, etc. are more obvious differences, so the path of sponge city construction methods, such as also have differences, need to take different technical means according to local conditions[5].

However, since the promotion of sponge city pilot city construction in 2015, more than half of the sponge city pilot cities have still experienced widespread flood emergencies and urban flooding, which has subjected the theory of "sponge city" and its practical feasibility to widespread public opinion pressure, as well as questions and criticisms from industry experts[6] . The opinions of various parties focus on the scientific city of the sponge city concept, the small scope of application of specific sponge city measures, the unsatisfactory implementation effect, the high construction cost and the high maintenance cost. However, the main idea that urban stormwater management in China needs to develop like ecological management and not just rely on gray infrastructure is still accepted.

In this case, a review of the operational status of completed sponge city projects, a comparison of the envisioned and actual results, and a proposal for optimization strategies based on the actual situation will provide an important reference basis for future sponge city construction.

1.2 Related concepts

1.2.1 Concepts related to Sponge City

(i)Sponge city

The sponge city is both a vivid description of urban form and a philosophical, theoretical and methodological system of rain, water and stormwater management and governance[4] . In their 2003 book "The Road to Urban Landscape: Talking with Mayors", Chinese scholars Yu Kongjian and Li Dihua used the term "sponge" to describe the natural wetlands on both sides of a river as sponges with the ability to regulate flooding [5] .

After General Secretary Xi Jinping pointed out at the Central Urbanization Work Conference in 2013 that "sponge cities should be built with natural storage, natural infiltration and natural purification", the Ministry of Housing and Construction issued the "Technical Guide for Sponge City Construction" in 2014. The guide clearly defines: sponge city refers to the city in response to natural disasters and other aspects of the problem, like a sponge can play its "elastic" function. It can absorb, store, infiltrate and purify rainwater, and release it when necessary [9] .

According to the theory of Professor Yu Kongjian, sponge city has three scales: macro, meso and micro, which correspond to the overall urban planning, urban control plan and detailed urban planning respectively [7] . It follows the six-word policy of "infiltration, retention, storage, purification, use and drainage", and closely integrates infiltration, retention, storage, purification, recycling and drainage of rainwater, taking into account multiple objectives such as waterlogging prevention, runoff pollution control, rainwater resource utilization and water ecology restoration. The objectives are (i) to protect the original water ecosystem; (ii) to restore the damaged ecology; (iii) to promote low-impact development; and (iv) to effectively reduce surface water runoff through various low-impact measures and their system combinations to mitigate the impact of heavy rainfall on urban operations[10].

(ii) Stormwater management

Precipitation reaching the ground is divided into four parts: interception, infiltration, depression storage, and surface runoff. Surface runoff, river flooding, and pipe network

convergence of rainwater runoff is stormwater, also known as rain flood[11].

Stormwater Management (Stromwater Management) is a concept put forward by foreign countries in the process of studying urban stormwater problems, which means the effort to reduce runoff of rainwater or melted snow into streets, lawns and other sites and the improvement of water quality, including several major aspects such as urban flood control and drainage, stormwater runoff pollution and peak control, stormwater resource utilization, and restoration and improvement of natural water ecosystems in rivers and lakes[12]. Its connotation can be understood as a systematic management approach to reduce or eliminate potential urban flooding, downstream flooding, river channel encroachment candles, stormwater pollution and other problems in the urban rainfall process through planning, design, engineering and management under the guarantee or constraints of laws, policies, economic and other conditions, as well as collecting and utilizing rainwater under specific conditions[13].

(iii) Water treatment

Water treatment in the usual sense has drinking water treatment, wastewater treatment, industrial water treatment, irrigation water treatment, landscape water treatment and other categories. Since sponge cities focus on rainwater management, wetland systems focus on ecologically related natural and artificial waters, and the demand for water in parks focuses on landscape and ecology, the water treatment in this paper refers specifically to rainwater treatment and landscape water treatment based on stormwater management.

1.2.2 Concepts related to Wetland Park

(i) Wetland

Today there are dozens of international definitions of wetlands, and no consensus has been reached, and different countries, or different periods of time in different countries, have different focuses on the definition of wetlands [14] . One of the most widely used is the definition described in the Convention on Wetlands signed in Ramsar, Iran, in 1971, namely: wetland means "a marshy, peaty or watery area, whether natural or artificial, permanent or temporary, with standing or flowing fresh, brackish or salt water bodies, including waters not exceeding 6 m in depth at low tide ".

Also in Article 2.1 it is stated that wetlands may include riparian and coastal areas adjacent to wetlands, as well as islands or bodies of marine water located within wetlands with a depth of more than 6 meters at low tide, especially islands or bodies of water in areas of waterfowl habitat significance." The full title of the Convention, "Convention on Wetlands of International Importance especially as Waterfowl Habitat", shows that the definition of the Convention is also for the purpose of protecting waterfowl[15] .

For ease of understanding, the definition of wetlands in this paper is also chosen to use the definition in the Convention.

(ii)Park

In China's Park Design Code, it is stipulated that a park is "a green space open to the public, with recreation as its main function, with better facilities, and with ecological and beautification functions" [16] . At the same time, the definition of park and related descriptions are also given in the Standard of Basic Urban Planning Terms and the Standard of Basic Garden Terms. It includes the following common characteristics: 1. delineating a certain land area; 2. having public and openness, satisfying people's various related activities; 3. having a good ecological environment[15] .

Parks can be divided into natural parks and urban parks, among which, natural parks refer to large-scale forest parks and national parks (nature reserves). With the development of urban green space and the changing needs of people, many types of urban park green space have emerged, and many countries have determined their own park classification systems according to their national conditions[17]. In China, according to the Standard for Classification of Urban Green Space (CJJ/T85-2002), urban green space is divided into five major categories, including park green space, production green space, protective green space, subsidiary green space and other green space. Among them, park green space is divided into five categories, including comprehensive parks, community parks, special category parks, strip parks and street green space. However, no classification is made for wetland parks [18]. Therefore, the parks discussed in this paper refer to urban park green spaces.

(iii)Urban wetland park

Urban wetland is a wetland based on the concept of wetland above, where the main water

body range is located within the urban planning boundary. It is an excessive ecological space of water and land within the urban ecosystem naturally or by man-made transformation and construction. And the essential difference between wetland parks and other types of parks is that wetland parks are wetland landscape oriented, taking into account certain science and recreation functions, and wetland ecological protection is the key to it[19] .

China's Urban Green Space Classification Standard (CJJ/T85-2017), promulgated in 2017, adjusts the categories of urban green space into park green space, protective green space, square land, subsidiary green space and regional green space. Among them, the wetland park is subordinate to the regional green space under the scenic recreation green space, and is on the same level with the scenic spots, forest parks, country parks and other scenic especially green space [20]. However, since this specification was not introduced at the time of the construction of Tianhe Wetland Park, the urban wetland park referred to in this paper is the urban wetland park of the Ministry of Housing and Urban-Rural Development of China.

The Urban Wetland Park Planning and Design Guidelines issued by the Ministry of Housing and Construction defines an urban wetland park as: an urban wetland park is a park green space within the urban planning area for the purpose of protecting urban wetland resources, with the functions of science education, scientific research, leisure and sightseeing. The definition of wetlands in the guidelines follows the definition of the Convention, while defining urban wetland parks are different from other water parks, the need to emphasize the ecological characteristics of wetland ecosystems and the protection and display of basic functions; also different from wetland nature reserves, the need to emphasize the use of wetlands to carry out ecological protection and popular science activities of educational functions, as well as the full use of wetland landscape value and cultural attributes to enrich the residents of leisure and recreational The social function of making full use of the landscape value and cultural attributes of wetlands to enrich the recreational activities of residents.

The functional zoning of wetlands includes key conservation areas, transition areas and development areas, and the more functional zoning of urban wetland parks at least includes areas such as key conservation areas, wetland display areas, tour activity areas and management service areas, as shown in the diagram below. It can be seen that the functional zoning structure

of urban wetland parks is in line with the three functional zoning approach of nature reserves.

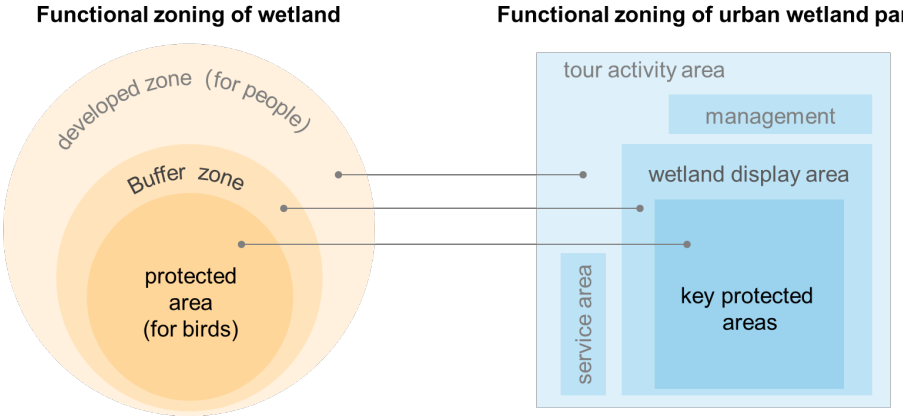


Figure 1- 1 Schematic diagram of functional zoning of wetlands and urban wetland parks (self-drawn)

At the same time, because urban wetland parks have a larger area of water and green space than other parks, they have the functions of water storage, water purification, runoff regulation, groundwater supply, water storage and flood control, regional microclimate regulation and other rainwater storage functions, and play an important role in improving urban and regional ecological environment and biodiversity.

(iv) wetland ecological protection

1.2.3 Concepts related to Urban Public Space

The term "public space" first appeared as a specific term in Western sociology and political philosophy in the 1950's. The concept of "public space" entered the urban planning and design disciplines in the early 1960's in the academic works of Louis Mumford and Jacobs[21]. Louis Mumford and Jacobs [22]. Kevin Lynch, in his description of public space, defines urban public space as a space where people can freely conduct activities[23] .

The Chinese book Principles of Urban Planning suggests that urban public space refers to the open space mention that exists at the time of the building entity, with a narrow and broad definition. The narrow definition is to provide people in the city with outdoor common use space, such as city square, city street, park green space. The broad definition is to cover the infrastructure with public service nature in the city, such as urban green space, commercial area, etc.[23]. The study of urban public space in this paper focuses on the relationship between parks

and green spaces in urban environments and urban streets, squares, and commercial districts.

1.3 Object, purpose and significance of the study

1.3.1 Research object

The object of this study is the Tianhe Wetland Park in Guangzhou, one of the 19 completed wetland parks in Guangzhou, which is a district-level wetland park and also a demonstration site of Guangzhou Sponge City. It is located in the east of the core area of Guangzhou Tianhe Wisdom City, bordering Huangpu District, and is the eastern gate of Tianhe Wisdom City, covering an area of about 46.8 hm^2. The earliest project was named "Tianhe Wisdom City Wisdom Water System (Eastern Water System) Connecting Phase I Project", which was later changed to "Da Guan Wetland Park" in 2019. The earliest project was called "Tianhe Smart City Smart Water System (Eastern Water System) Connectivity Phase I Project", which was later changed to "Grandview Wetland Park". The name was finally changed to "Tianhe Wetland Park" in 2019. It is a model for the construction of wetland parks in Guangzhou and the combination of rainwater treatment facilities and park facilities.

1.3.2 Purpose of the study

The purpose of this study is twofold:

(1) Through literature review and collation, the research experience in the field of rainwater management is integrated, and the research and analysis evaluation methods and specific improvement measures for urban wetland parks are summarized. Through relevant case studies at home and abroad, the spatial design strategy of wetland parks based on rainwater storage is summarized.

(2) In-depth study of the development background and current situation of Guangzhou Tianhe Wetland Park, full investigation of the current physical geography and public space use of the site, and a summary of the existing water treatment problems, wetland environmental problems and space use problems. Using urban design analysis methods, the objectives and problems of wetland park renovation are clarified, and feasible renovation strategies are given.

A feasible design plan is proposed in terms of urban water treatment, wetland public space system and public service facility optimization.

1.3.3 Significance of the study

Urban wetland park is a kind of urban park and green space, which has an important role in dealing with the relationship between the city and the green space and water system. The main point of urban design is how to deal with the relationship between various elements in the city, such as buildings, roads, green spaces, water bodies, etc. The ultimate goal is to improve the quality of public space. By combining water treatment methods and wetland ecological protection principles with park space design, we can create a comfortable and characteristic urban public space for people while dealing with urban stormwater problems and wetland ecological problems.

China's sponge city concept for water problems has been developed for nearly a decade, during which time many attempts and practices have been carried out in the country. And China is less than vast, climate and geography vary greatly, urban construction must be carried out according to local conditions. The Tianhe Wetland Park in Guangzhou is the first artificial wetland park in Guangzhou with the guiding idea of sponge city, which has an important contribution to the city in terms of ecology, education and public services, and its construction experience has played a role of demonstration and leadership. In terms of the rainwater flooding problem in Guangzhou and the current situation of the implementation of sponge city in wetland parks, this study has certain theoretical and practical significance:

(1) Theoretical significance

It compares research and methods in related fields, and proposes strategic guidelines on how to take into account water ecology and public space creation in urban wetland park construction under the guidance of the sponge city concept, providing some theoretical support and methodological reference for the spatial design of urban wetland parks in Guangzhou combined with rainwater treatment methods.

(2) Practical significance

Based on the combing of related literature and research in the early stage, we summarize

the design process and existing problems of Tianhe Wetland Park, and give some reference and practice guidance on the difficulties and challenges that may be encountered in the design process of urban wetland parks in Guangzhou in the future, so that the planning and design of urban wetland parks with the concept of sponge city can be more perfect and objective,.

1.4 Research methodology and Structure

1.4.1 Research methods

（一）Literature Research

Read and study the relevant literature, sort out the knowledge about rainwater storage in sponge cities and urban wetland park construction, clarify the planning and spatial creation methods of wetland parks based on the sponge city concept, and understand the historical evolution, resources and development status of Tianhe Wetland Park.

（二）Case Study

The excellent cases of domestic and foreign wetland parks based on rainwater storage are selected for study, and the experience and methods of the cases in the planning, design and management of park public space and wetland water system are refined to guide the design framework and renovation strategies.

（三）Field research

A study was conducted on Guangzhou Tianhe Wetland Park to investigate the spatial planning and design, vertical design, and the current situation of crowd use in the scenic area to understand the current rainfall and flood storage capacity, ecological status and public space use. This study investigates the physical condition of the wetland park through on-site observation records.

（四）Practical analysis

This study uses the Tianhe Wetland Park in Guangzhou as the project base site, and renovates and designs the park to address existing problems. The feasibility of combining research with actual projects to achieve the coexistence of ecological and public aspects of wetland parks is achieved.

1.4.2 Research framework

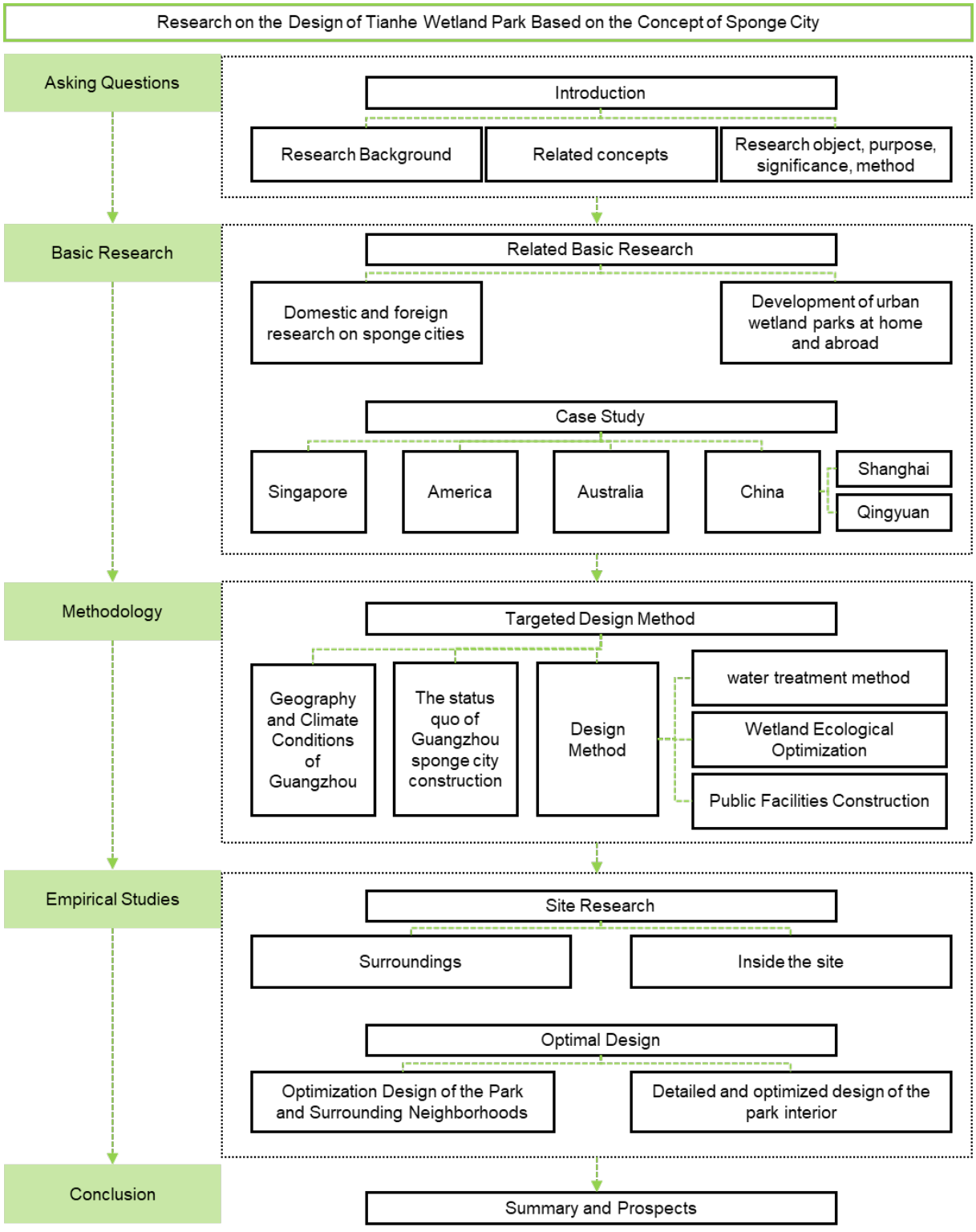


Figure 1- 2 Research framework (self-drawn)

Chapter 2 Basic Research

2.1 Status of foreign sponge city-related theoretical research

Sponge city can be understood as our unique water management system proposed according to the current situation of urban construction and natural climate in China, which is a Chinese description of water management [24] . And accordingly, other countries in the world have also explored water management to suit their own situation. And understanding international trends and dynamics, grasp the connotation and relationship of different concepts and systems, it will not be stuck to the name, but also to avoid misunderstanding and misinterpretation, better and locally appropriate to promote modern water management system, and lay the foundation for the construction of sponge cities.

Overseas research and practice in areas related to sponge city construction began in the 1960s. Representative theories and practices include Best Management Practices (BMPs), Green Infrastructure (GI) and Low Impact Development (LID) in the US, Sustainable Drainage Systems (SUDS) in the UK, Water Sensitive Urban Design (WSUD) in Australia, Natural Open Drainage Systems (NDS) in Germany) and the European Union's Water Framework Directive (EUWFD), among others.

2.1.1 USA: Best Management Practices, Low Impact Development, Green Infrastructure

Due to its vast size and numerous geographical features, the United States has almost every type of climate in the world. The southeast and the Gulf Coast have a "subtropical forest climate," which is influenced by the warm Gulf Stream and is warm and humid, with an annual rainfall of more than 2,000 mm. The U.S. was an early adopter of this theoretical system, from "best management practices" in the 1970s to "low-impact development" in the 1990s to "green infrastructure" today. "Each stage has set a different management goal. From solving water pollution problems caused by urban development, to stormwater management in small and medium-sized neighborhoods and residential areas, to more specific guidance on action strategies, layout, and design standards for infrastructure in urban green spaces. From macro

planning to the design of specific facilities, each step is closely related to the overall urban development. Due to the introduction and implementation of the above theoretical systems, regulations, rules and technologies related to the rapid economic development of cities, cities are more concerned about the health of the city and the improvement of the living environment of citizens [25] .

①Stormwater Best Management Practices (BMPs)

Stormwater Best Management Practices (BMPs) were introduced in Section 319 of the 1987 Clean Water Act Amendments for nonpoint source pollution management. BMPs began with the primary goal of controlling nonpoint source pollution and included both engineered and nonengineered measures[27]. BMPs mainly relied on end-of-pipe measures such as rainwater ponds, stormwater wetlands, and infiltration ponds, which played an important role in controlling runoff pollution and are still used today. However, relying solely on this relatively centralized end-of-pipe treatment approach does not effectively address all stormwater system issues, and has problems such as high investment, low efficiency, and implementation difficulties. However, BMPs have been borrowed and cited by many countries, and their meaning is no longer limited to the original end-of-pipe control of nonpoint source pollution, but can now be broadly used to refer to engineering and non-engineering measures for runoff water quality and quantity control [27] .

②Low Impact Development (LID)

Low-impact development was developed from BMPs measures based on micro-scale landscape control and was first proposed in 1990 by the Maryland Environmental Resources Agency, George Province, USA, in response to the shortcomings of traditional gray drainage facilities and end-of-pipe centralized treatment facilities[26] . It aims to avoid the negative impact of urbanization or site development on the water environment from the source, emphasizing the use of small-scale, decentralized ecological and technical measures to maintain or restore the hydrological cycle before site development, and to solve the comprehensive problems of stormwater systems more economically, efficiently and stably, and to build bioretention and other facilities for engineering demonstration in several residential areas and parking lots, with good results. Low impact development as a new stormwater management technology system

that differs from the traditional use of gray facilities such as stormwater pipes and storage ponds, effectively complements the BMPs system and to some extent makes up for the deficiencies of the BMPs system. It emphasizes the use of small, decentralized green facilities, highlights the source control of stormwater runoff, and reduces the adverse effects of urban development and construction on natural hydrological processes from the source [30]. However, the decentralized small-scale low-impact development facilities still suffer from insufficient capacity for responding to large watersheds and mega-storm events, and covering measures that are not comprehensive enough.

③Green Infrastructure (GI)

GI originated in the United States in the 1990s, mainly emphasizing the reasonable protection and utilization of green space and corridors in urban planning, bringing more ecological benefits to cities. In 2012, the U.S. EPA released a definition of green infrastructure terminology, stating that for urban stormwater In 2012, the US EPA issued a definition of the term green infrastructure, stating that for urban stormwater management, green infrastructure mainly refers to engineering measures that use soil and vegetation in natural ecosystems to control stormwater runoff, such as green roofs, rain gardens, rainwater wetlands, etc., also known as green stormwater infrastructure (GSI), which covers both traditional best management practices (BMPs) and typical low impact development technology measures (LIDs). Low Impact Development (LID) measures. In addition, from a broader perspective, green infrastructure can be seen as an integrated network of natural areas and ecosystems within cities, including green open spaces and greenway systems, which can bring multiple ecological benefits such as regional air purification, heat island effect mitigation, increased biological habitat, and improved biodiversity [28].

2.1.2 UK: Sustainable Urban Drainage System (SUDs)

The UK is located in the mid-latitude, controlled by the westerly wind belt all year round, with the North Atlantic warm current flowing through the north, and a temperate maritime climate with mild and rainy weather throughout the year. Sustainable Urban Drainage systems (SUDs) in the UK were formed and refined based on BMPs from the US[29] . The underground

drainage network in the UK was constructed before the 20th century, but due to the expansion of urban scale, the original network can no longer meet the increasing drainage demand. Relevant authorities such as the National Rivers Authority and the Environmental Protection Agency in the UK also recognize the importance of water quantity control, water quality control and water ecology control. The Construction Industry Research and Information association (CIRIA) has produced a manual on sustainable drainage systems, and SUDs are included in the UK government's Plan Policy Guidance25 (PPG25) on flood risk avoidance in all phases of urban development. Guidance25 (PPG25) [27].

SUDs were initially used only on parcels where drainage systems were freely available, such as business parks, schools, and highway service areas. In order to promote more effective and systematic use, urban developers were later required to consider the use of SUDs before all parcels were planned and built, mainly for urban drainage systems, using a hierarchical drainage stormwater management chain approach to control stormwater runoff, thereby reducing runoff pollution and improving the comfort of the urban environment. SUDs reflect sustainability in how to better deal with drainage problems, and guarantee the implementation of three non-engineering measures through rainwater control in the planning process, regulation of rainwater discharge permits and post-construction maintenance mechanisms, which are of great significance for the improvement of the post-construction maintenance management system of sponge cities in China.

2.1.3 Australia: Water Sensitive Urban Design (WSUD)

Australia has an average altitude of 300 meters above sea level throughout its territory, with a humid climate in parts of the eastern coast, but very dry in the central and western parts, with little total water resources. Due to the small population size of approximately 25.69 million (2021 statistics), the per capita water resources holdings are high, however the distribution of water resources is highly uneven. Due to the demand of economic growth and the local area of water resources transition open flow of water quality deterioration, agricultural irrigation area sub-salinization, groundwater irrational exploitation and water allocation problems century 60s outbreak. 1990s, some rivers cyanobacteria outbreak, resulting in a nationwide water quality

crisis. As a result, the government began to reassess the carrying capacity of water resources and formulate water reforms. In the case of urban storm drainage system is basically perfect, the city of Melbourne as the representative of the 1990s advocated the proposed Water Sensitive Urban Design (WSUD) to seek a more economical, less environmental impact of the integrated way to manage urban water supply, sewage and stormwater. Because urban sewage and drinking water systems have been developed relatively mature, and with urban planning, landscape, architecture, roads and other disciplines of relatively weak intersection, so the relevant text and discussion in the WSUD does not elaborate too much sewage, drinking water systems, but the core of the rainwater system. The key principles are: (1) protect natural systems - protect and enhance natural water systems (streams, rivers, wetlands) while urban development; (2) protect water quality - improve the water quality of the water environment after urban development; (3) integrate stormwater management and landscape design --③ Integrating stormwater management and landscape design - using multi-objective stormwater management tools in landscape design to achieve multiple benefits; ④ Reducing runoff and peak flows - reducing total runoff and peak flows from urban development through site detention and regulation measures, while minimizing impervious areas, etc.[27] .

WSUD realizes the comprehensive use of rainwater in the city by re-integrating the spatial design of the city from the perspective of urban planning and design, and by integrating the rainwater management, water supply and sewage of the city.

2.1.4 Germany: Natural Open Drainage System (NDS)

Germany is located in the middle of Europe and has a temperate maritime climate with cool and humid winters and summers in most areas and an average annual rainfall of 700 ml. Because of the low topography in the north and high topography in the south, Germany has many rivers and is prone to river flooding after heavy rainfall, so its rainwater management system has been developed early and has achieved excellent results in engineering practice, and has been the international leader in rainwater management practice.

In the 1980s, Germany gradually established and improved industry standards and regulations for stormwater utilization, and in 1989, Germany introduced the Standard for

Stormwater Utilization Facilities, marking the initial maturity of stormwater utilization technology. Natural Drainage System (NDS), as a design strategy, aims to address the problems of urban water ecology, reduce the volume of stormwater runoff, link stormwater facility corridors, and reduce the pollutant content of initial stormwater [25] . In 2011, stormwater experts from some EU countries, led by Germany, specifically implemented a In 2011, some EU stormwater experts, led by Germany, conducted a SWITCH project and summarized typical stormwater management planning or design cases at different scales in the US, Germany, Australia, the Netherlands, Poland and other countries, and pointed out that the future direction of sustainable urban stormwater management is "water-sensitive urban design", which agrees with the science and rationality of WSUD. The research results are compiled into a book "Water Sensitive Urban Design", which emphasizes that WSUD is a multidisciplinary combination of urban water management, urban design and landscape planning, encompassing all parts of the urban water cycle, and integrating ecological, economic, social and cultural sustainability in urban design principles with water management functions[27] .

2.1.5 Singapore: Active, Beautiful, Clean Water Programme (ABC)

As an island city, Singapore faces severe water shortages due to high urbanization and lack of natural resources, despite its tropical location and average rainfall of up to 2353 mm[30]. In its early years, drainage facilities in Singapore were built mainly to cope with flooding and the associated sanitation problems, but it was gradually recognized that water bodies should go beyond the functional level to become an environmental resource for all citizens to enjoy, gradually converting concrete drains into soft rivers. The Waterbodies Design Panel (WDP) was also established in 1989 as an internal government advisory body to advise on the design and beautification of major waterways. However, the lack of a unified regulatory framework for water resources management under several different agencies at the time prevented the WDP's plans from being effectively translated into long-term plans, and the WDP was disbanded in May 2000.

Following the restructuring of the regulatory functions of the jurisdictions in 2001, Singapore launched a long-term initiative in 2006, the "ABC Programme", an Active Beautiful

and Clean Water (ABC) programme. Unlike the previous WDP waterways beautification campaign, which was only implemented in a few pilot areas at the micro level, the ABC Water Program provides new recreational spaces for the public by transforming local water bodies to purify, discharge, and supply water so that clean water is continuously supplied to streams, rivers, and lakes. By 2017, Singapore has completed 36 ABC Water projects, one of which is the Bishan Ang Mo Kio Park and the Kallang River Restoration Project Singapore [31]. The ABC Water Programme responds positively to the Blue and Green Plan implemented by the Singaporean authorities and means that Singapore is not only a world-renowned garden city but also a waterfront garden city. Waterfront Garden City.

2.1.6 Japan: "G-cans" underground drainage project

Japan, which is located in the same East Asian region as China, also faces the challenge of rainfall and flooding year-round due to its specific climatic and topographical conditions. Japan is located at the eastern edge of the Asian monsoon climate zone, and the main climatic characteristics are high annual precipitation intensity and concentrated rainfall time. The annual rainfall period is basically concentrated between June and August, when the rainy season and typhoon season alternate, and heavy rainfall occurs in summer, which is the season with the highest risk of rainfall and flooding throughout the year. In addition, Japan is a mountainous country, with mountains and hills accounting for more than 80% of the country's land area, and the steepness of the mountains means that rainfall runoff is fast and the catchment time is short, requiring high immediate drainage capacity in urban areas. Therefore, Japan has explored many ways to solve the rainfall and flood problems since its modernization, from the stage of river management dominated by structural engineering after the Meiji Restoration, to the stage of river management during World War II when large-scale flood control projects and water resources development were emphasized, to the stage of integrated rainfall and flood management since the 1960s with comprehensive measures and watershed coordination. storage and infiltration plan" and "rainwater storage" concept, and in 1992 started the "G-cans" underground drainage project to ensure the safety of urban rainwater flooding in Tokyo Bay area. Construction of the project began in 1992 at a cost of $2 billion and was completed in

2006. The "G-cans" underground drainage project is the world's most advanced and largest underground drainage system, located 50 meters underground, connecting 15,700 kilometers of urban sewers in Tokyo, and is a huge 6.3-kilometer-long, 10.6-meter-diameter vertical pit series drainage and storage system with a capacity of 40 It has a capacity of 400,000 meters3 and is designed to collect excessive flood water in a short period of time during heavy rainfall and discharge it into Tokyo Bay via the Edo River to ensure the urban safety of the Tokyo metropolitan area[32].

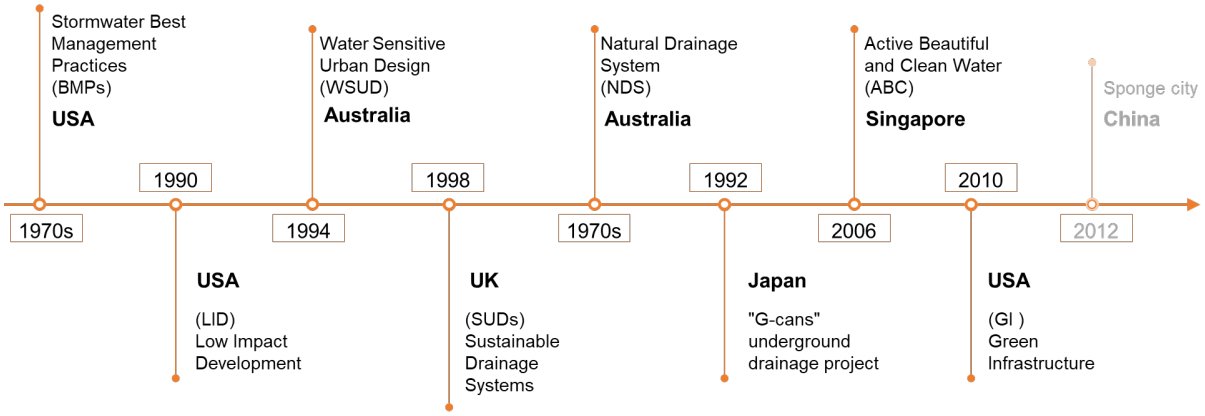


Figure2- 1 Exploration of water treatment methods in various countries (self-drawing)

2.2 Domestic sponge city theory-related research

(I) Concept introduction and development

As an ancient civilization, China has many classical engineering cases with typical modern stormwater management features in its history. For example, the "Fushou Ditch" storage and drainage system in Ganzhou and the "Hani Terraces" in Yunnan and so on. They combine "green" and "gray" measures to control and utilize rain and floods by taking advantage of natural or artificially created conditions of storage, seepage and drainage. This fully demonstrates the wisdom of ancient Chinese people and folk in the control and utilization of rain and flood, water management and water use [33].

The origin of modern urban stormwater management theory and practice technology can be traced back to the 1980s, and initially it was mainly water conservancy engineering and water supply and drainage majors who conducted research on rainwater resource utilization and stormwater model construction. The concept of "sponge city" is proposed in the context of the

increasingly prominent rainfall disaster in China, combining the excellent foreign experience and the existing technical basis of rainfall management in China.

The sponge city is a metaphor for a certain function of the city, first used by the Australian Budge to describe the adsorption effect of the city on the rural population[34]. The Chinese scholar Yu Kongjian used the term "sponge" to describe the natural wetlands on both sides of a river as a sponge with the ability to regulate flooding in his 2003 book "The Road to Urban Landscape: Talking with Mayors" [8]. Subsequently, the term "sponge" was gradually mentioned, and the term "sponge city" was formally introduced at the 2012 Science and Technology Forum on Low Carbon Cities and Regional Development[26] .

After General Secretary Xi Jinping pointed out in 2013 at the Central Urbanization Work Conference that "sponge cities should be built with natural storage, natural infiltration and natural purification", the Ministry of Housing and Construction, together with the Ministry of Water Resources and other departments, issued the "Technical Guide for Sponge City Construction" in 2014. city construction pilot work was fully rolled out, and the first batch of 16 pilot cities were produced in 2015. In 2016, the second batch of sponge city construction pilot city list was born, and a total of 14 cities were selected.

In 2015, authoritative experts and scholars successively interpreted the definition of the concept of "sponge city". From the subtitle of the Guide to the definition of the concept given by Vice Minister Qiu Baoxing, it can be seen that the concept of "sponge city" was closely related to "low-impact development" when it was proposed, and was to some extent influenced by the American theory of low-impact development (LID). The concept is aimed at "maintaining or restoring the pre-development hydrological cycle of a site through small-scale ecological and technical measures at the source and in a decentralized manner"[27] . Professor Che Wu of Beijing University of Architecture, an expert in water supply and drainage engineering, believes that the construction of a "sponge city" is a matter of clarifying the interface between urban gray infrastructure and the city[27]. Professor Yu Kongjian believes that "sponge city" is an ecological approach and the core lies in the construction of water ecological infrastructure across urban and rural scales[7].

It can be seen that the concept of "sponge city" is in a process of continuous development.

The object of the definition has gradually expanded from the initial river flooding to rainwater and sewage, becoming a more integrated and comprehensive water management problem. The scope of research has also shifted from natural to urban areas, eventually including urban and rural areas. The technology has also changed from green infrastructure to a combination of gray and green facilities. In the process of continuous practice of "sponge city", its connotation and definition are still in continuous development and improvement.

(II) Technical means

There are 17 common technical means listed and introduced in the Construction Guide, including permeable pavement, green roofs, sunken green space, bioretention facilities, infiltration ponds, infiltration wells, wet ponds, rainwater wetlands, cisterns, rainwater tanks, regulating ponds, regulating ponds, grass trenches, infiltration pipes/channels, vegetated buffer strips, initial stormwater disposal facilities, and artificial soil infiltration[36] . According to the classification of Professor Qu Jun in his book "Landscape Approach to Sponge City Construction", it can be divided into source retention link, midway transportation link and end storage link. Among them, the source retention link infiltrates, retains, purifies, stores and reuses rainwater through various rainwater management measures such as permeable pavement, green roofs, rainwater receiving containers, sunken green areas and rain gardens, so that rainwater does not need to be discharged into the urban drainage system under normal circumstances. The mid-way transport link uses bioretention facilities, vegetation filter belts, landscape planting ditches and other ways to allow rainwater paths to be transported and transformed above the ground, which has a landscape role while completing ecological functions. The end storage link includes various types of regulating ponds, rainwater parks, and stormwater wetlands, etc., which are suitable for rainfall occurring when rainwater will be sent to the final management area for storage, infiltration and reuse after passing through the above two pathways, usually combined with public space.

(III) Current status of research

According to the data of China Knowledge Network, the term "sponge city" started to appear in the paper database in 2014. The number of papers grew explosively from 2014 to 2017, and most of the hot topics discussed were the concept and definition of sponge cities. The

subsequent period of 2017-2019 is a stable stage of development, and the papers tend to focus on the concept, hydrological simulation model, index system and facilities. 2020 to the present, the research on sponge cities is a little bit less hot, as sponge cities have appeared and operated for a period of time, the research has emerged in the direction of systematic solutions, testing and evaluation, and tends to be more localized research. Therefore, this paper is also a study on how sponge cities can be better utilized in the case of wetland parks in Guangzhou.

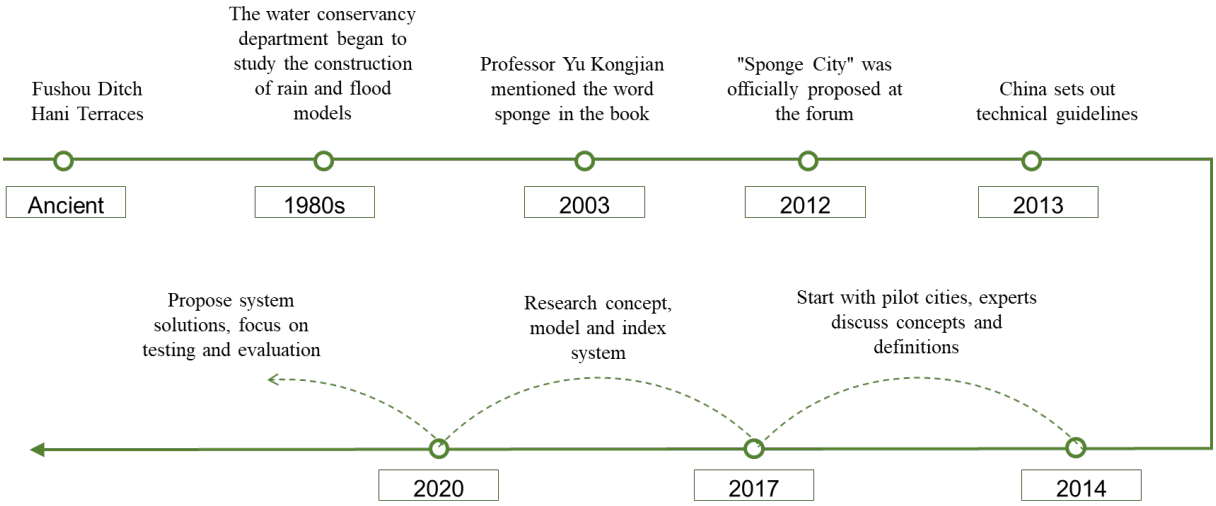


Figure 2- 2 Development of Sponge City Theory in China (self-drawn)

2.3 Foreign research related to urban wetland parks

Since the end of the 19th century, with the rapid development of the world economy and the rapid growth of urban population, the problem of urban ecological environment has become increasingly serious, and the international community has gradually realized the significance of urban ecological environment, especially urban wetlands, to human survival. The Ramsar Convention was a global convention for nature conservation of a specific ecosystem to protect important wetland ecosystems and achieve sustainable development worldwide. Unlike in China, the concept of urban wetland parks basically rarely exists explicitly in foreign countries, but mainly for wetlands and research on wetland conservation, wetland restoration, artificial treatment of wetlands, etc. [15] , and widely used in various types of urban construction sites, combined with the function of the site and the nature of the site rational use.

Foreign research on wetland parks has focused on the following areas:

(I) Restoration of wetland ecosystems

Foreign urban wetland park research originated from the study of urban wetland theory, which attaches great importance to the protection and restoration of urban wetland environment, and believes that urban wetland parks should build complete natural ecosystems that can adapt to external influences and changes, and can self-regulate and sustain development. Nutrient cycling, migration, water level, flow state and dynamic changes of sediment flushing and sedimentation can be carried out entirely within the scope of natural changes, and the naturalness and diversity of plants and animals can be unified in the same area. In 1988, the Ames Lake Wetland Park in St. Paul, USA, was reconstructed to connect the Phalen Lake area to the Mississippi River as a biological corridor for wildlife restoration. The designers removed buildings, created basins, introduced live water, modified soil structure, and separated residential areas from wetland areas with trees and lawns, creating a destination for local residents to enjoy nature without hiking while maintaining a virtuous ecological cycle[37].

(II) The combination of natural and social attributes of urban wetlands

Urban wetland parks have both natural and social attributes, which are interrelated and interfere with each other, so how to make the organic combination of natural and social attributes of urban wetland parks has become a difficult problem for designers to study. The London Wetland Park is planned to be an organic treatment of natural ecological water bodies and human flows. The park is divided into six areas with different water environments according to species habitat characteristics and hydrological features, forming a variety of natural wetland landscapes in the park and providing a variety of habitats for wetland organisms; the park is divided into dynamic and static areas according to the intensity of human activities, and through the dynamic and static zoning and the main building clever layout, it is possible to gather human traffic without disturbing biological rest and recuperation, and also to observe wild The park is divided into quiet and dynamic areas according to the intensity of human activities, and the main building is cleverly laid out in such a way as to gather human traffic without disturbing the resting places of living creatures, and to allow close observation of wildlife[38] .

Foreign urban wetland park research focuses on the protection and restoration of

ecosystems. Wetland park research is not limited to the protection and restoration of natural ecosystems, but considers the wetland park itself and the surrounding rivers, lakes, green spaces, wetlands, plants and animals, people, etc. as a whole ecosystem, with comprehensive and integrated planning, restoring the overall connectedness of the park and the surrounding ecosystem, strengthening the park and human activities, play the role of rainwater collection, water purification, flood control and other ecological functions of wetland parks, and achieve the harmonious unity of wetland landscape, function and human tourism and leisure.

2.4 Chinese urban wetland park construction development

2.4.1 Research and development of Chinese urban wetland parks

Chinese research on urban wetlands and urban wetland parks started late, and the research boom appeared in the middle and late 20th century. Relevant research by Chinese scholars and the community is mainly in the concept and function of urban wetlands, artificial wetland sewage treatment, artificial wetland landscape design, wetland system evaluation, as well as urban wetland monitoring system and prediction models, etc. There is less relevant literature in the theory and technical means of urban wetland restoration and reconstruction, as well as wetland protection policies[39]. China started to build urban wetland parks in 2004, and put forward the concept of wetland conservation in the boom of ecological and environmental protection, and explored the model of urban wetland parks to solve urban environmental problems mainly water environment problems.

Urban wetlands and urban wetland parks play an important role in solving urban flooding, urban water purification and urban water resources utilization, and are an integral part of ecological city construction, and their transformed wetland landscapes are also an indispensable and important part of urban landscape. With the official introduction of the Design Guidelines for Urban Wetland Parks, the protection and rational development and utilization of urban wetlands has entered a critical period. As of June 2023, China has a total wetland area of 56.35 million hectares, a total of 82 internationally important wetlands, 602 wetland nature reserves, and 1,699 wetland parks, including 901 national wetland parks[40] . According to the relevant

forestry data of Guangdong Province, until February 2023, Guangdong Province has built 27 national wetland parks, 5 provincial-level and 181 city-county district-level wetland parks.

2.4.2 Exploration of urban wetland park construction under the concept of domestic sponge city

Yu Kongjian's team, TURENSCAPE, carried out some early practice cases in Beijing, Tianjin and Harbin before the sponge city concept was formally proposed, including: in 2000, artificial wetlands were used to collect rainwater and green space system to purify the medium water in Beijing Zhongguancun Life Science Park; in 2007, in Tianjin Qiaoyuan wetland system, through simple filling and excavation, bubble-shaped ecological sponge was formed to collect rainwater and solve In 2011, in Harbin Qunli National Wetland Park, the mulberry-based fish pond technology was used in the Chinese agricultural tradition to create a green sponge in the center of the city by simply filling and dredging the low-lying areas, which solved urban flooding and gave the nearby residents a natural and ecological recreational green space.

After the sponge city concept was put forward, TURENSCAPE continued to carry out wetland park projects such as Jinhua Yanweizhou Park, Haikou Meishe River Fengxiang Park and Sanya Mangrove Ecological Park, which were quite influential. After the sponge city concept was known, many domestic companies applied the sponge city concept to wetland park design, such as Yijing International's Xi'an Fenghe Wetland Ecological Park, Chongqing Garden Expo Park Jiangnan Wetland Park by Aofan Garden, and Shenzhen Bao'an Dinggang Lake Wetland Park by China Electric Construction Group. These designs have made important explorations in dealing with the harmonious symbiosis of water, ecology and humanistic environment.

2.5 Summary of this chapter

This chapter introduces the theory of urban stormwater management and its practice of urban wetland parks in various countries, with the aim of learning from the experience of stormwater management summarized by various countries, combining the actual situation and existing experience of stormwater management in China, and clarifying the future direction of

sponge city development. The development and construction of foreign urban wetland parks are analyzed, and the research of foreign urban wetland park design focusing on the restoration of wetland ecosystems and the combination of natural and social attributes of urban wetlands is understood. In addition, the development history of domestic sponge city theory is sorted out, and the core ideas and main technical methods of sponge city are clarified. Finally, the development history of domestic wetland parks and the exploration process of urban wetland parks with sponge city as the leading idea are reviewed to provide the basis and support for the subsequent design.

Chapter 3 Case Study

3.1 Singapore Bishan Ang Mo Kio Park

3.1.1 Project background

During the 1960s and 1970s, Singapore underwent rapid modernization and urbanization, and during this period there was extensive construction of concrete drainage and canal systems in the city to prevent widespread flooding. Several key locations in the Kallang River waterway were constructed as concrete ditches to allow for rapid drainage during the rainy season.

Bishan Ang Mo Kio Park is one of the most popular central area parks in Singapore. Built in 1988, the park was originally intended to form a green buffer zone between the new residential area of Bishan and the Ang Mo Kio area and to provide some space for recreation. However, the drainage pipes acted as a thick line that clearly divided the park.

The renovation was carried out by Ramboll Studio Dreiseitl (now merged into Henning Larsen) in 2009 and the official opening took place in 2012. The project covered 52 hectares before the renovation and 62 hectares afterwards. Today the project not only addresses the dual needs of water supply and flood management, but also creates space for people and nature in the city.

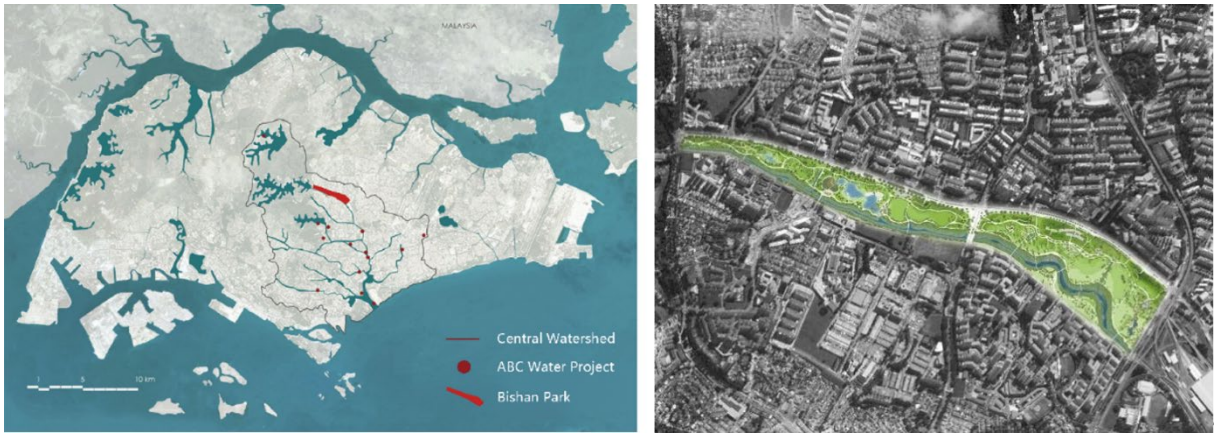


Figure3- 1 Park location, surrounding environment and plan

(Source: gooood)

3.1.2 Water treatment method

①Riverbank restoration:

Soil bioengineering techniques were used to ecologically restore the riverbanks, combining natural materials such as vegetation and rock with engineering techniques to stabilize the riverbanks and prevent erosion, transforming the hard concrete canals into natural rivers with landscaped banks through aesthetic and ecological considerations. The redesigned river cross section widens the maximum width of the river through flood waters from 17-24m to almost 100m, increasing the transport capacity of the river by almost 40%.

Figure3- 2 Restoring natural curves while preventing soil erosion

(Source: gooood)

②Water purification:

The cleansing biotope is located in 15 planting areas at 4 different elevation differences in the upper part of the park, where water is pumped into the biotope, cleaned and purified, and then returned to the river. The plants in the ecological purification communities also serve to further beautify and enhance the biodiversity of the park.

Figure3- 3 Purification of river water using ecological purification communities

(Source: gooood)

③Use of green roofs and vegetated swales:

Other sustainable technological tools for the project include green roofs on park structures and vegetated depressions arranged using former concrete drainage ditch sites to infiltrate, detain and clean stormwater runoff before it reaches the river.

3.1.3 Connection to the city

In the 1991 Green and Blue Plan, Singapore proposed the construction of Park Connectors Network (PCN) to connect the waterfront, parks and the city to form an island-wide recreational pathway system and to help enhance ecological connectivity between natural habitats, creating a beautiful city where nature, water bodies and urban development are seamlessly intertwined[31].The first completed parkway was completed in 1992. The first completed park link was opened on August 14, 1992 along the Kallang River, connecting Bishan Ang Mo Kio Park to Kallang Riverfront Park. Until 2015, more than 300 kilometers of park links have been completed.

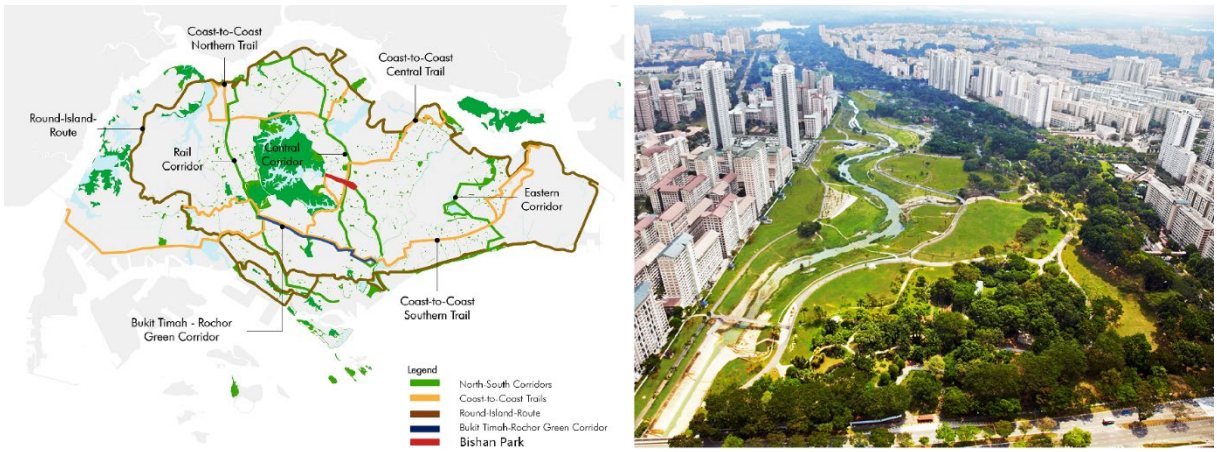


Figure3- 4 Park connection system and the relationship between Park and the city

(Source: https://pcn.nparks.gov.sg/)

PCN breaks the typical land use planning approach, where the restrictions previously planned for different land functions such as green space, housing and water systems are liberated, and the integration of land is planned as a whole to encourage the integration of various types of land and infrastructure with green and water spaces, maximizing the value of the drainage canal and the land along its route.Three playgrounds, restaurants, a new viewing point built using recycled walls from the old concrete canal, and extensive open green spaces complement the natural wonders of the ecologically restored river in the heart of the city. This is a place to kick off your shoes and get close to the water and nature.

3.2 Xuhui Runway Park

3.2.1 Project Background

Xuhui Runway Park, located in Shanghai, China, is an innovative urban revitalization project that breathes new life into Shanghai's unique history. The more than 14-hectare site is located in the former industrial area of Xuhui Waterfront, formerly the runway of Longhua Airport, the only civilian airport in Shanghai before liberation, which operated for more than 80 years. The concrete runway, built in 1948, was 1,830 meters long and 80 meters wide. It was not until 2011 when the airport was closed that its mission of carrying aircraft was officially ended. It was subsequently transformed into a rainwater park by the sasaki office from 2012 and finished in 2020.

Figure3- 5 Scheme diagram

(Source: sasaki)

3.2.2 Water treatment

The stormwater runoff from the park and Yunjin Road is managed in the latest way, with its northern half being directed into a 5,760 square meter street rain garden and its southern half into an 8,107 square meter artificial wetland for treatment. The rain garden in this project is the first rain garden system built along a road in Shanghai. After treatment by the rain garden and front pond, it helps to reduce suspended particulates and pollutants in road runoff to meet the water quality requirements for landscape water under China's surface water quality standards. A portion of the treated runoff is stored in a 39.4 cubic meter underground storage tank and used for park operations and maintenance when necessary. The volume of water is sufficient to irrigate 19,700 square meters of green space and fully meet the water supply requirements for the runway fountain. The stormwater runoff from the entire site is eventually discharged into the Huangpu River via the Airport River.

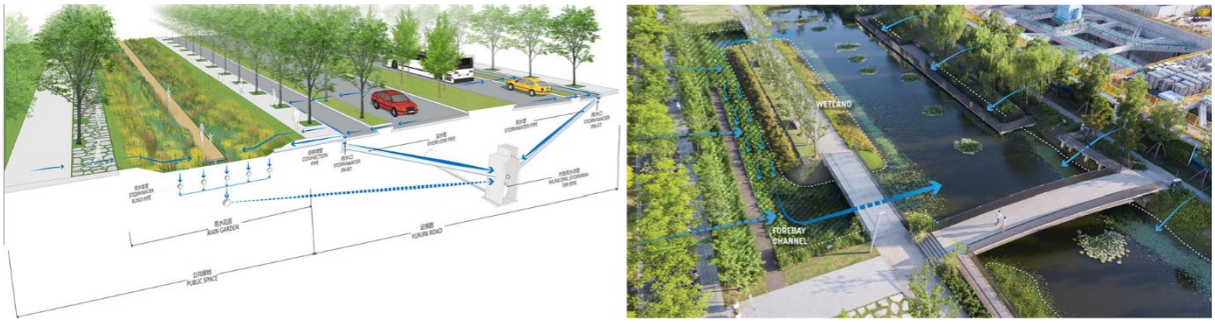


Figure3- 6 Purification of road stormwater through artificial wetlands

(Source: sasaki)

3.2.3 Ecological Protection

LED light sources were used throughout the site, reducing electricity consumption by 167,000 kilowatts per year compared to metal halide light sources. New concrete was placed in individual areas where the existing concrete had been severely damaged to meet the park's current use. The demolished concrete blocks were re-paved in a patchwork fashion along the main park, creating a unique space for recreation and relaxation. The preservation and reuse of the existing concrete not only saved construction costs, but also reduced the greenhouse gases that would have been generated during the production of new concrete.

Most of the construction materials for the project were sourced locally and are environmentally friendly. This reduces carbon emissions during transportation, avoids damage to the rainforest, and supports the region's economy. For example, in designing the park's benches, wooden walkways and riverside viewpoints, the design team did not use common tropical hardwoods, but bamboo instead. Bamboo is a fast-growing, strong, and long-lasting material for outdoor environments, making it an ideal sustainable material.

Figure3- 7 Using bamboo as raw material

(Source: sasaki)

3.2.4 Public space

In the master plan, the former airport runway was transformed into a juxtaposition of public streets and linear parks, making it a runway for modern living, providing recreational space for the nearby community as well as creating valuable green space in the middle of the surrounding high-density redevelopment projects.

Reflecting the historic context of the site, the park design emulates the dynamic qualities of an airport runway by creating diverse linear spaces for motor vehicles, bicycles and pedestrians, organizing the street and park into a unified runway system. Although the spaces are linear, a rich spatial experience is created through the application of different materials, proportions, topography, and their activity programs. The design of many spaces within the park creates experiences for pedestrians and bicyclists to ascend, descend and look down to the ground as they travel, evoking the feeling one gets when flying in an airplane, showing visitors not only the history of the base as an airport runway, but also providing multiple perspectives on how to feel about the site. The silhouette of the outdoor furniture also evokes the partial shape of an airplane, echoing the history of the airport.

Figure3- 8 Materials, fixtures and forms have original memories

(Source: sasaki)

3.3 Adelaide Botanic Gardens Wetland

3.3.1 Project Background

The Adelaide Botanic Gardens Wetland is located in Adelaide, South Australia, a circular parkland area with various parks such as the Adelaide Zoo and Botanic Gardens. Cullity Lethlean (TCL), an Australian landscape design team, designed the project. Adelaide has been a significant contributor to water sensitive urban design (WSUD) dating back to the innovative Salisbury Wetlands in the 1970s. While many WSUD projects have met hydrological, ecological, social and educational objectives, they have often lacked highly skilled execution in terms of spatial design, materials, detailing and finishes. Therefore, the first creek wetland was built to mitigate flooding, capture and purify rainwater, provide habitat for native wildlife and replenish the local aquifer to meet the full water needs of the Adelaide Botanic Gardens within seven years. It also creates an interesting and educational space where city residents can learn first-hand about the way water flows through urban areas.

3.3.2 Water treatment

Adelaide has five seasonal creeks that flow from the Adelaide Hills in the southeast and cross its central metropolitan plain in the wet winter months. The creeks flow into the Torrens River, then to Henley Beach and finally to the sea. The composition of the wetlands can be divided into intake, sediment traps, settling ponds, filtration ponds and impoundments.

Water for the wetland is provided by the first creek, and the wetland inlet has a cage to release larger debris straight into the wetland. The angle of the cage also deflects the stream and flushes away larger debris that may clog the cage. Before the water enters the wetland, it passes through a gross pollutant trap to deposit smaller debris at the bottom before filtering the water and sending it to a settling basin to avoid clogging the wetland with debris. The water then passes through a relatively stationary sedimentation basin to settle sediment before flowing into a slow-flowing filtration basin. The settling basin is divided into three sections by rocks and uses large areas of vegetation to absorb nutrients and pollutants from the water. Finally water is pumped out of the end of the filtration basin and stored in the ground. When the water needs to be reused, different pumps pump the water from underground into the storage tank and pump it into the garden.

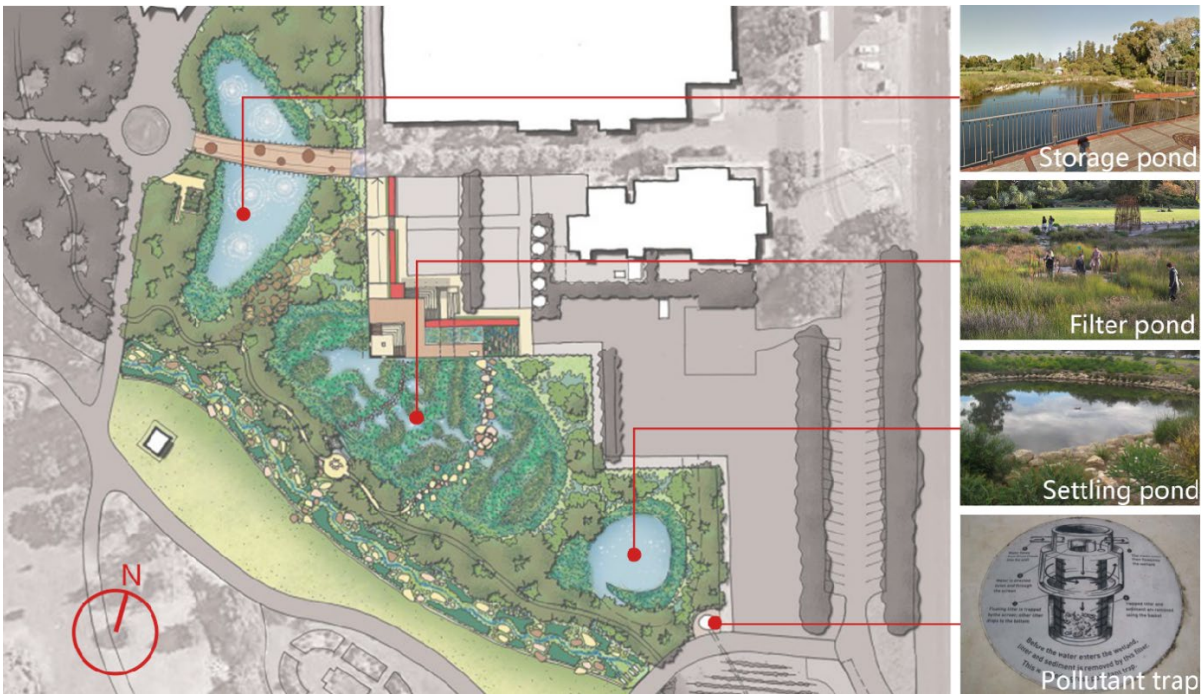


Figure3- 9 Floor plan and water treatment method

(Source: redrawn from TCL)

3.3.3 Ecological Protection

The park is equipped with various types of science carving boards and colorful patterned science columns, along with teachers' explanations to educate children about wetland operations. The park is equipped with a sunken theater, the walls of which use inlaid glass to

allow people to see the wetlands underwater. Combined with the building's observation deck, three levels of vertical experience can be achieved: underwater, horizontal and three meters above the water surface.

The wetland serves as an educational facility serving local primary, secondary and tertiary schools and meets the South Australian curriculum teaching standards. The main amphitheater in the wetland can accommodate approximately 80 people, while the other 10 smaller venues cater to schools and clubs experiencing different aspects of water conservation and biological systems, while it is also available for individual and public event hire.

Figure3- 10 Three levels of observation experience

(Source: redrawn from TCL)

3.4 Feilai Gorge Sponge Park

3.4.1 Project Background

Located in Qingyuan City, Guangdong Province, China, the Feilai Gorge Sponge Park is a 2.1hectare renovation project of a central lake area within the Guangdong Provincial Water Resources Pilot Base. It is close to the Feilai Gorge Reservoir and is geographically located in an area with weak urban infrastructure and no surrounding wastewater treatment plants. As a result, the domestic sewage of the base's researchers and managers could only be treated with a simple secondary septic tank and discharged directly into the central lake, leading to the deterioration of the central lake's water quality year by year. In 2018, Greenview Landscape International Design Group (GVL) used sponge technology to renovate it and completed it in the same year.

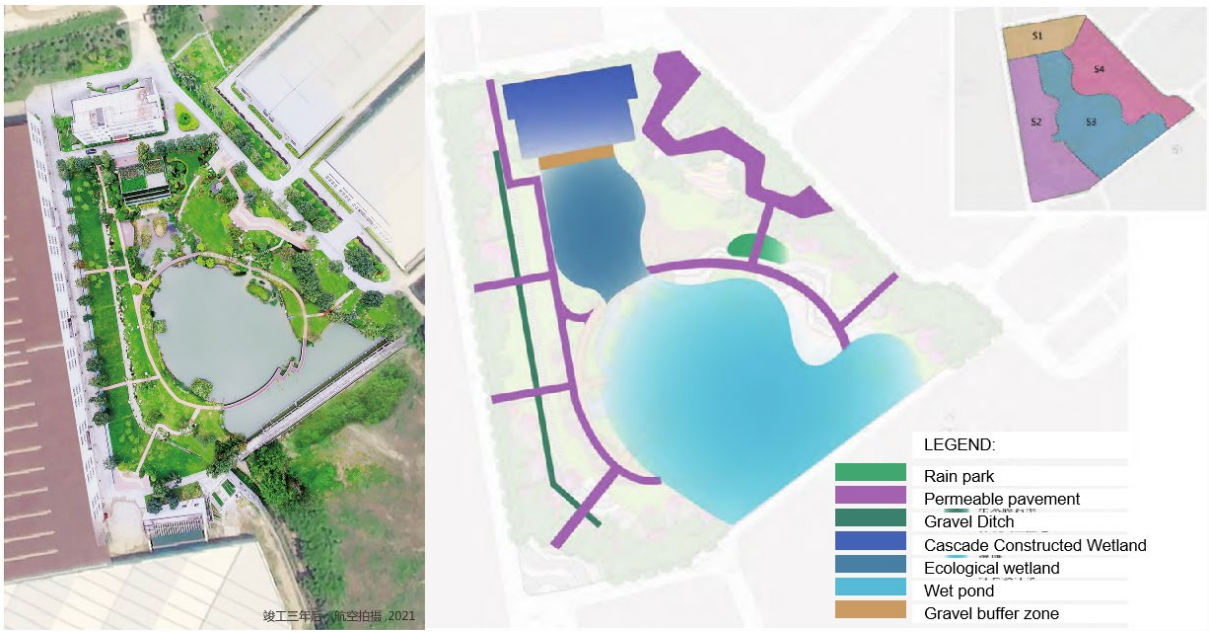


Figure3- 11 Plan and layout

(Source: redrawn from GVL)

3.4.2 Water treatment

Because the site is lower than the surrounding ground, untreated stormwater runoff during heavy rainfall is discharged directly into the Heart Lake, including from the roof and ground, causing a series of water ecological problems such as soil erosion and water pollution on the site. Due to the constraints of geographical location and financial resources, the domestic wastewater of the base's researchers and management staff is discharged directly into the Heart Lake after treatment with a simple secondary septic tank, resulting in the deterioration of the Heart Lake's water quality and the destruction of the water ecosystem year by year. To address these two problems, the design team used the following solutions:

(I) Rainwater component:

Rainwater is transferred, purified and stored in 6 parts: vegetated buffer zone rainwater retention, ecological gravel channel rainwater transfer, permeable pavement, artificial wetland rainwater purification, stepped rain garden and heart lake rainwater storage.

In response to the problem of large difference in site elevation, the design of submerged wetland combined with the site elevation to transform the submerged wetland into a terrace

form, on the one hand, to digest the 8-meter height difference in the base, on the other hand, to maximize the area of the water body, so that the decontamination efficiency of the wetland and landscape display function are played to the optimum. And innovatively change the traditional horizontal layout of filler in the submerged wetland, using vertical layout to increase the contact area of the submerged wetland and sewage, to enhance the purification efficiency.

Ecological gravel drains and rain gardens allow for stormwater purification and increase the retention time of stormwater. Permeable paving is effective in controlling runoff volume reduction, peak flow reduction and peak present time delay for small to medium rainfall events. Artificial wetlands are used to mortgage and purify stormwater runoff from roads, allowing stormwater to flow slowly at an appropriate rate into the central lake area.

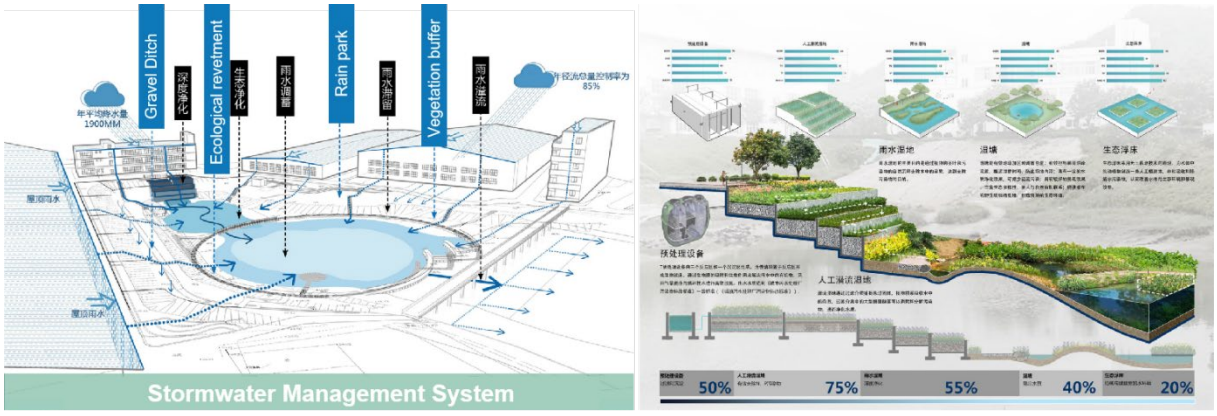


Figure3- 12 Stormwater treatment system and terrace type artificial wetland

(Source: redrawn from GVL)

(II) Sewage component:

The project adopts the way of comprehensive treatment of buried sewage treatment equipment combined with artificial wetland, and the sewage treatment project should be designed to meet the peak demand, with a design capacity of 13 m3/ d. The domestic sewage enters the johkasou after the septic tank, and the main index of the johkasou effluent reaches the Grade A standard, and then flows into the heart lake after reaching the surface Class III water through the enhanced treatment of artificial wetland. The project also uses FK-JHC johkasou treatment technology, which superimposes biofilm technology to reduce the occurrence of sludge in the process, and adopts flat push flow and full mixing mode inside the shell, which greatly inhibits short-circuiting or unnecessary re-mixing of the process.

3.5 Tanner Springs Park, Portland, USA

3.5.1 Project Background

The project is a wetland park of 60 x 60 meters, covering an area of 4000 square meters, located in the Pearl District of Portland, USA. The site was formerly a wetland bisected by Tanner Creek and bordered by the wide Willamette River. The site was formerly occupied by a railroad station and industrial area, and was accompanied by site drainage requirements. Over the past 30 years, the railroad and industrial areas have been replaced with a new community that is young, integrated, cosmopolitan and vibrant. Today the Pearl District has become a commercial and residential area with its three main parks conceptually planned by the landscape firm Peter Walker & Partners. The three parks are located in close proximity to each other, from north to south, The Fields Park, Tanner Springs Park and Jamison Square Park, with Tanner Springs Park designed by Ramboll Studio Dreiseitl and completed in 2010.

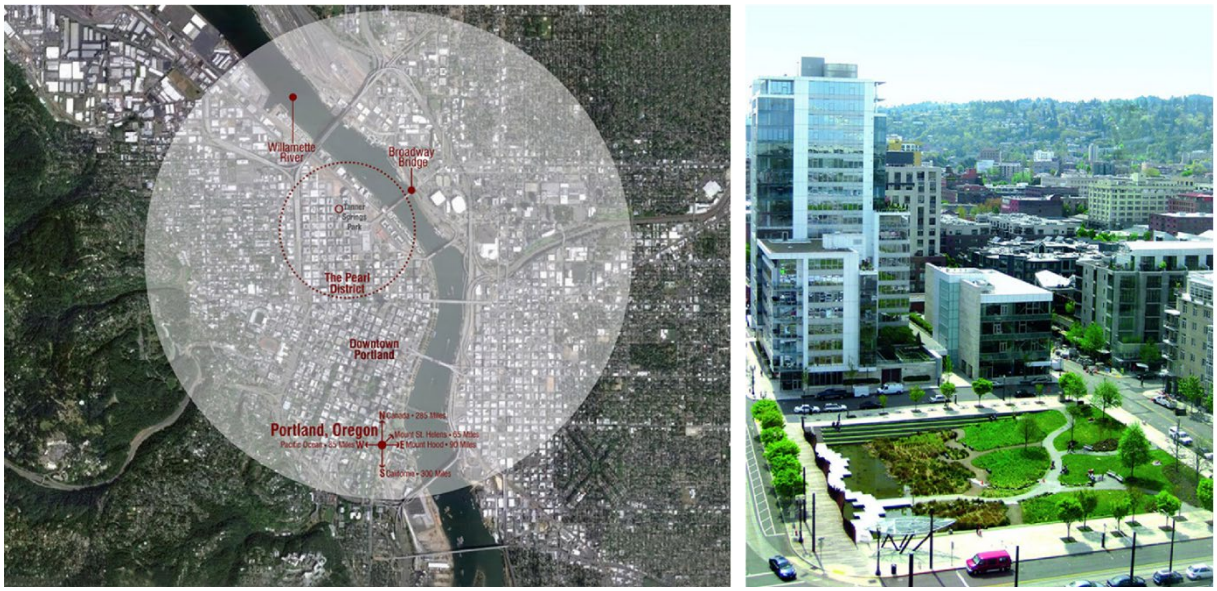


Figure3- 13 Aerial view of the site location and park

(Source: Henning Larsen)

3.5.2 Water treatment

The topography of the park gradually sinks from west to east, with the lowest elevation of the wetland water part and the north and south ends connected to the ground by permeable

terrace green areas, the concave topography can bring together all kinds of runoff around the land to the interior of the site. During weekdays, the water purified by the wetland will infiltrate into the land to replenish the groundwater, and some of the water will be extracted into the landscape pond of the meadow and then into the wetland; during heavy rainfall, the rainwater will be purified by the wetland and discharged into the river through the underground pipe network, thus dissipating the impact of heavy rainfall on the neighborhood.

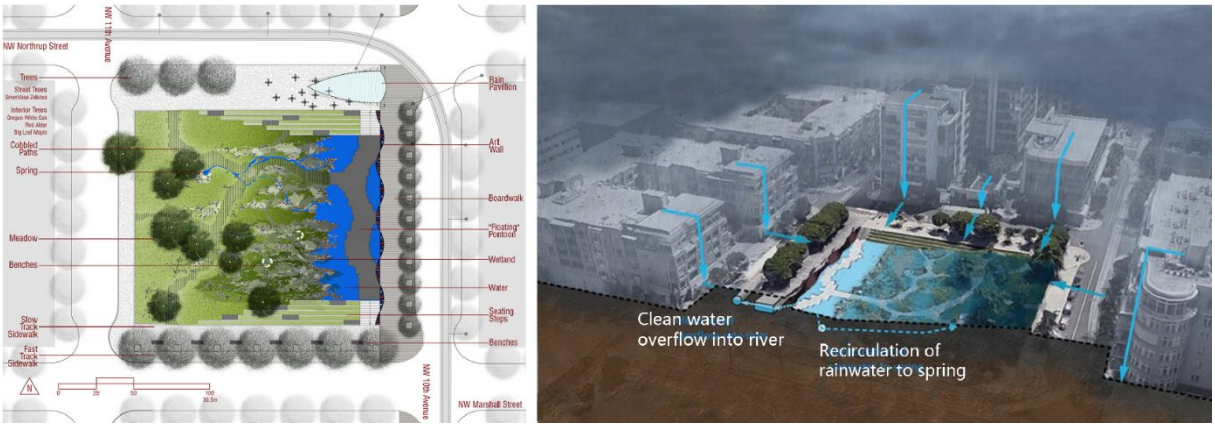


Figure3- 14 Site plan zoning and stormwater flow direction

(Source: Dreiseitl Consulting)

3.5.3 Public Space

The art wall on the east side of the site is made from recycled railroad tracks that swing back and forth to form a wave curve . Herbert Dreiseitl, founder of Dreiseitl Design, himself hand-painted the patterns of the creatures that once lived here on hot molten glass and set them in The "art wall" preserves the memory of the site.

Figure3- 15 hand-painted biometric glass panels forward on an art wall made of old railway tracks

(Source: Henning Larsen)

3.6 Summary of domestic and international case methods and insights

	Singapore Bishan Ang Mo Kio Park	Xuhui Runway Park in Shanghai	Adelaide Botanic Gardens Wetland	Feilai Gorge Sponge Park, Qingyuan	Tanner Springs Park, Portland	Guangzhou Tianhe Wetland Park
Area	62 ha	14 ha	2.6 ha	2.1 ha	4000㎡	46.8 ha
Nation	Singapore	China	Australia	China	USA	China
Water Treatment	1. Riverbank restoration 2. Water purification	1. Artificial wetland 2. Underground storage tank	1. Artificial wetland purification 2. Underground water storage tank	1. Wetlands purify stormwater and sewage 2. Combined with buried sewage treatment equipment	1. Artificial Wetland Purification 2. Water storage in the sunken square	1. Riverbank restoration 2. Artificial Wetland Purification 3. Water storage in the sunken square 4. Water storage in the sunken square 5. Combined with buried sewage treatment equipment
Wetland Protection	1. Variety of plants	1. LED light sources 2. Fast-growing bamboo and wood materials	1. Riverbank restoration 2. Water purification	1. Variety of plants	1. Riverbank restoration 2. Water purification	1. Variety of plants 2. Fast-growing bamboo and wood materials 3. Riverbank restoration 4. Water purification
Public Space	1. Park Connectors Network (PCN)	1. Preserve linear form	1. Observation at different heights 2. Combined with school teaching	1. Squares and various walks	1. Reuse of rail material 2. Make creature drawings	1. Park Connectors Network 2. Preserve linear form 3. Squares and various walks 4. Combined with school teaching

Figure3- 16 Case method summary (self-drawn)

In terms of water treatment, the Bishan Ang Mo Kio Park restored straight hard banks to naturally curved banks and slowed down the slope of the banks to enlarge the water storage area. The Tianhe Wetland Park also has channels that have been de-bent and straightened in earlier years, which can be optimized with reference to this method. The method of using rain gardens for water purification in Xuhui Runway Park can be utilized in the green space of Tianhe Wetland Park. In this case, various types of artificial wetlands are used to purify rainwater, and the design of the Tianhe Wetland Park can be optimized according to different topography and needs. For example, the difference in terrain height can be referred to Feilaixia Park, which utilizes vertical artificial wetlands in the form of steps, and the long strip of land

connected to the road can be referred to Xuhui Runway Park, which is also long and shaped to receive rainwater. Green roofs and vegetated depressions can be used to optimize various types of buildings in the wetland park.

In terms of wetland ecological protection, aquatic plants are planted along the waterfront to provide habitats for animals in all cases, and the Tianhe Wetland Park can be optimized with reference to its configuration and form. Xuhui Runway Park and Tanner Springs Park both use recyclable materials or recycle the original materials, so they can also be referred to in the renovation process of Tianhe Wetland Park. Lighting facilities can use LED light sources and other energy-saving equipment.

In terms of public space design, Bishan Ang Mo Kio Park utilizes greenways and non-motorized paths to strengthen the connection between the city and the park, making it easier for people to access the park. The connectivity of various parks and green spaces is also enhanced to expand the sphere of influence. Tianhe Wetland is located in the urban development zone, surrounded by buildings and complex functions, it can refer to the way of Bishan Ang Mo Kio Park to strengthen the connectivity between the park and the surrounding environment, and at the same time, enhance the ability to penetrate to serve the residents in the surrounding area. Adelaide Wetland Park combines plaza space with science education site, and the practice of compound site function can also be used in the project.

3.7 Summary of this chapter

This chapter analyzes the more mature rainflood wetland park cases at home and abroad, summarizing their design methods in terms of water treatment methods, connection with the city, design of public space, material selection, etc., and providing an important reference basis for the subsequent design strategies. The foreign rainflood wetland parks are also very good at providing urban open public space and science education sites in addition to the ecological functions of rainwater storage and water purification, and have a good relationship with the city.

Chapter 4: The Methodology for Guangzhou Urban Wetland Park under the Concept of Sponge City

4.1 Geographic and climate characteristics and hydrological conditions of Guangzhou

4.1.1 Climatic characteristics

Guangzhou is located in the Pearl River Delta, bordered by the remainder of the Nanling Mountains to the north and the South China Sea to the south, with significant maritime climate characteristics, and both the ocean and the mainland have obvious influence on Guangzhou's climate. The average annual temperature of the city is between 21.7℃ and 23.1℃. The city is rich in rainwater resources, with an average annual precipitation of 1923 mm, annual evaporation of 1700 to 1800 mm, average annual precipitation days of 149 days, and annual sunshine hours of 1800 to 2100 hours[42]. The highest temperatures occur in July and August, and the lowest temperatures occur in January. Rainfall is abundant and the rainy season is pronounced, with heavy rainfall in May and June[43] . Around the Dragon Boat Festival, there are often heavy rainfall events with daily rainfall greater than 100 mm, called "dragon boat water". The scholar Chen Gang pointed out that heavy rainfall lasting for 2 h with a maximum intensity of 30 mmmm/h or more can cause urban flooding in Guangzhou[44].

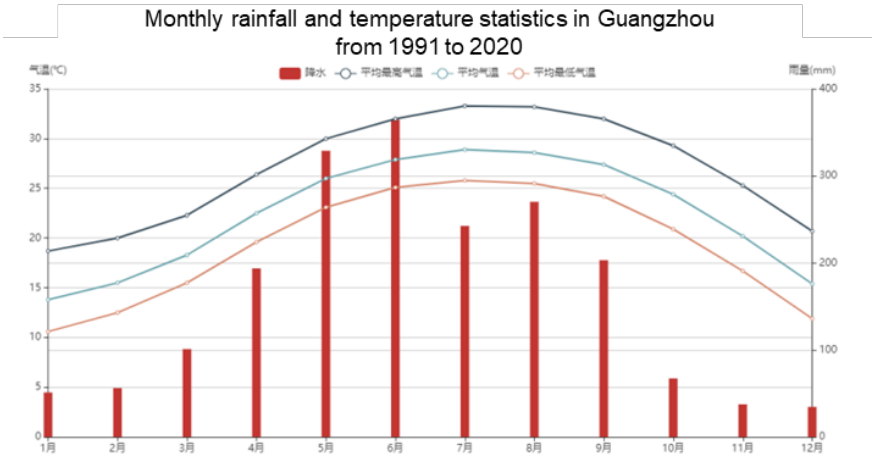


Figure4- 1 Monthly average temperature and rainfall in Guangzhou for the past 30 years

(Source: Guangzhou Meteorological Network)

4.1.2 Geographical features

The topography of Guangzhou City slopes from east to southwest, with a large difference in elevation within the city limits, with the northeast being dominated by mountains, the central part by low and medium mountains and hills, and the south by plains[45]. The central urban area is high in the north and low in the south, with Baiyun Mountain, Huofu Mountain, and Thin Dogling in the north and the Pearl River in the south. During rainfall, rainwater will collect from the mountains in the north to the river gushing through the central urban area and eventually flowing into the Pearl River, but the rise in the water level of the river gushing will have a direct impact on the drainage of the central urban area and will cause urban flooding if the storage capacity of the river gushing is exceeded[46].

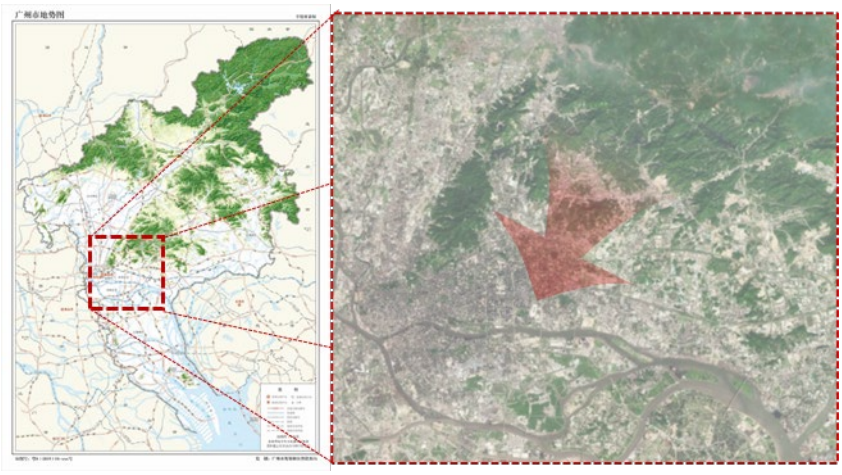


Figure4- 2 Topographic map of the whole region and the central city of Guangzhou (redrawn from the website of the Guangdong Provincial Government)

4.1.3 Hydrological conditions

(i) Natural conditions

Guangzhou is located in the Pearl River Delta, and the rivers in Guangzhou are divided into two categories according to the water flow. One is the rivers north of the Pearl River, which are mostly connected to the reservoir channels in northern Guangzhou and hilly areas and flow in one direction; the other is the rivers south of the Pearl River, connected to the Pearl River and the estuary. This type of river gushing water flows in both directions with the tidal

current[47] .

Pearl River Guangzhou River and Guangzhou central city river Chung are tidal sense river, flood season in addition to the flood from the Liu Xi River, North River and West River, and by the top of the East River flood, but also from the Lingding Ocean tidal influence, flood and tide mixed, traditionally flood and tide disaster-prone areas[48] .

(ii) Impact of Human Activities on Hydrology

In ancient times, the city of Guangzhou was often threatened by seasonal flooding, and the river surges, in addition to the function of navigation, were also responsible for the drainage of water in the city. However, due to natural factors and artificial activities, the Pearl River channel since the Han Dynasty due to the gradual narrowing of the area of the drainage area to reduce the amount of flood water can be accommodated to reduce the possibility of flooding.

Nowadays, high levels of urbanization have had a significant impact on urban hydrology:

① Heavy rainfall increases: Population gathering, close construction, and increased impermeable area increase the soil heat capacity in urban areas, and the ground temperature in the central city is higher than that in the suburbs. For large cities, the "heat island effect" also brings about the "rain island effect". When the rain island effect is concentrated in the flood season, the superimposed heavy rainfall is larger and more likely to form large areas of standing water, causing regional flooding[49] .

②The river structure tend to be simple：In the process of urban expansion in Guangzhou, rivers from the original natural river bank side slope gradually changed to upright bank wall, some of the rivers and even hard bottom. Some rivers are gradually narrowing or even disappearing because of siltation and urban construction "competing with water for land", some rivers are converted into culverts, and some rivers are curved and straightened or arbitrarily diverted to meet the needs of planning land integrity. The modified rivers and streams can hardly cope with the increasingly frequent rainstorms[50] .

③ Rainwater surface runoff increased: Before urbanization, rainfall was intercepted, stored and infiltrated into groundwater due to the certain permeability of the regional substrate, and only the last remaining water formed surface runoff. In contrast, forests, farmlands, and wetlands are continuously developed into residential, industrial, or commercial land during

urbanization, which increases the impervious area in urban areas and decreases the corresponding storage capacity[51]. The hardening of the subsurface makes the watershed less damped and the convergence rate faster, which will advance the moment of flood peak appearance by 1-2 hours[52].

④ Insufficient construction and management of municipal pipe network: The construction of existing drainage facilities lags behind the expansion of urban scale, and the design of urban drainage network is based on the planned population and implemented simultaneously with the road construction. Initially, the drainage network can still meet the drainage demand, but with the further development of urbanization, the construction of urban drainage facilities cannot keep up with the development speed of urban construction and population growth, and the current drainage network cannot meet the rapidly expanding drainage demand. At the same time the current management of urban drainage facilities is uneven, and the maintenance of drainage systems generally suffers from insufficient financial investment, long cycle time, backward equipment, low mechanization, and insufficient maintenance management, leading to the phenomenon of pipeline siltation and clogging of rainwater grates, which has an impact on urban drainage [50] .

4.2 Current situation and existing problems of sponge city construction in Guangzhou

4.2.1 Status of exploration and construction

In June 2017, the Guangzhou Land Resources and Planning Commission issued the "Guangzhou Sponge City Special Plan (2016-2020)"; in November of the same year, the "Guangzhou Sponge City Planning and Design Guidelines - Low Impact Development Stormwater System Construction (for Trial Implementation)" was jointly issued by the Guangzhou Municipal Water Bureau and others; In March 2021, the Guangzhou Municipal Bureau of Water Affairs and others issued the "Technical Guidelines on Sponge City Construction for Urban Development and Construction Projects in Guangzhou - Flood Safety Assessment". In recent years, Guangzhou has formed more than 50 various construction

projects or areas in the city by continuously strengthening the construction of sponge city, such as reading river road wall road, Haizhu wetland, Lingshan Island tip, central knowledge city, etc. During the 14th Five-Year Plan period, the Guangzhou Sponge City Construction Leading Group Office issued the "Guangzhou Sponge City Construction Implementation Plan (2021-2025)", clearly proposing that by the end of 2050 to the end of 2025 more than 45% of the city's urban built-up area meet the requirements of sponge city.

4.2.2 Existing problems of park green space under the concept of sponge city

However, the typhoons and "dragon boat floods" that come at the same time every year in summer still cause flooding of streets in various places in Guangzhou. For the situation that the construction of sponge city is not as effective as expected, the author summarizes the following reasons based on previous research data:

(i) Unsystematic

Individual urban green areas do not play a significant role in the management of rainwater flooding in the whole city, and a network of green area systems needs to be formed. At present, the urban green areas in the old city of Guangzhou are mainly randomly distributed, with the characteristics of small green areas, large fragmentation, high diversity, and no complete network, while the green areas in the new city are large and evenly distributed. In addition, there is a lack of effective connection between park green space, residential green space, protective green space and subsidiary green space, and no green space system network has been formed. With the current spatial distribution of various types of urban green space, it is difficult to cope with the current urban storm water problem in Guangzhou.

(ii) Poor permeability of green space

As the most important permeable layer in urban centers, green space effectively promotes the efficient construction of sponge cities by storing rainwater, reducing flood peaks and rainwater decontamination, and plays an indispensable role in mitigating urban flooding and other aspects. Therefore, rapid soil infiltration becomes the key to urban green space construction. However, studies have shown that green spaces do not play an effective role in mitigating urban flooding. As an important resting place for citizens, urban green space

generally shows that the lower the vegetation cover and the more human trampling, the worse the soil infiltration. Heavy machinery is used extensively to move guest soil and level the ground during the construction of park green areas, resulting in severe mechanical compaction. Secondly, after the completion of the green area, as one of the main places for public recreation in Guangzhou, the flow of people is concentrated, and the frequent human trampling causes the soil capacity of the green area to increase, and it is much higher than the average capacity of natural soil. With the increase of water storage, the soil capacity increases, the total porosity decreases, and the infiltration performance of the green space is gradually degraded. Therefore, how to maintain efficient and sustainable water infiltration in green areas becomes the key to mitigate urban flooding. At the same time, as a large number of green areas in cities are upper convex green areas with higher elevation than urban roads, they cannot accumulate road surface water to infiltrate into the ground when heavy rain comes.

(iii) Insufficient public integration

In cities where land is tight, the facilities needed to deal with stormwater problems need to be both ecological and public in order to deal with water problems without affecting the use of public space. However, this is the direction that urban green areas need to improve and explore, taking into account their own functions and forming a system, with the number of superimposed and effective network, so that urban green areas can make a qualitative leap in stormwater management, thus realizing the city's A virtuous water cycle.

(iv) Lack of targeted strategies for Guangzhou

Although many foreign countries have proposed many theories and methods for rainwater storage, each country is in a different region, climate characteristics, geological characteristics, and national conditions. The rainwater storage methods proposed by them for their own countries and regions cannot be directly applied to China. Similarly, although China has also proposed sponge city as its own rainwater storage strategy, but China is vast, the climate and geographic characteristics vary greatly among regions, if we do not propose targeted strategy modifications for areas with certain geographic and climatic characteristics, the effect of sponge city will be greatly reduced. Guangzhou, located in Lingnan, is hot and humid, with many hilly terrain undulations, and the rainfall problems faced by the flat, dry and water-scarce areas such

as the North China Plain are different, and the focus of the required sponge city design methods will be different, so a more targeted design strategy needs to be optimized for adaptability.

4.3 Design methods of sponge city wetland park for Guangzhou adaptation

Based on the design method used in the case analyzed above, combined with the natural geographical climate characteristics and existing problems in Guangzhou, this paper proposes a design method for wetland parks under the concept of sponge city from three aspects: water treatment methods, wetland ecosystem design, and public space optimization methods , as a design toolbox, providing guidance for subsequent design.

4.3.1 Water treatment method

Because of the large area of the site, the site has many green areas and water bodies, and sometimes includes rivers and reservoirs, so the wetland park is a "big sponge" within the concept of sponge city, different from rain gardens, grass planting ditches and other small technical facilities. Its water treatment can be used for urban flood control and drainage, storage of rainwater around the site, and water purification in three ways.

(1) **flood control and drainage**

① Preserve natural shoreline, increase contact area and slow down flood pressure: Newly developed areas should follow the natural curve of the river during the planning period, preserve natural barges while leaving sufficient greenery buffer zones on both sides of the river banks to increase the chance of rainwater infiltration, slow down the time of water discharge into the Pearl River and reduce flood pressure. For the river that has been changed to three-gloss concrete, bioengineering technology should be used to restore the concrete hard riverbank to natural riverbank. Design graded waterfront trails and platforms according to the water level in different periods to make full use of the waterfront space.

② Preserve the original waters for rainwater storage: Preserve the original waters such as ponds and lakes when planning, and use natural water bodies for rainwater storage. Avoid overfilling waters for land construction due to the pursuit of economy.

(2) Rainwater storage around the site

① Absorb urban road rainwater: use open curbs, grass planting ditches, gravel drains and other facilities to introduce wetland waters after preliminary purification of road rainwater, purify water quality while slowing down the rate of rainwater discharge into the municipal pipe network and reduce the pressure of drainage from the municipal pipe network during heavy rainfall.

②Combining gray and green infrastructure: Due to the above reasons Guangzhou has a serious problem of rain and flooding, and Guangzhou is also trying to use deep tunnels and other facilities to solve the flooding problem. Therefore the surface green water facilities in wetland parks can be combined with municipal underground grey water facilities, so that nature and technology can work together.

③ Combination of trees, irrigation and grass to increase the water infiltration capacity of green space. Plant planting should focus on the combination of trees, irrigation and grass, and appropriately increase the proportion of irrigation and grass to promote soil water infiltration in urban green areas. However, due to the hot and humid climate of Guangzhou, ventilation is very important, so it is necessary to avoid planting towering bushes.

(3) Purification of water quality

① Use of artificial wetlands to purify water quality: the construction of artificial wetlands near the vulnerable waters to purify water quality, you can use topography and gravity to make water flow automatically into the wetlands, but also the use of pumps to pump water to participate in the cycle.

②Green roofs and vegetated depressions: When constructing buildings, green roofs and vegetated depressions can be used to infiltrate, detain and purify rainwater from buildings before it sinks into natural water bodies.

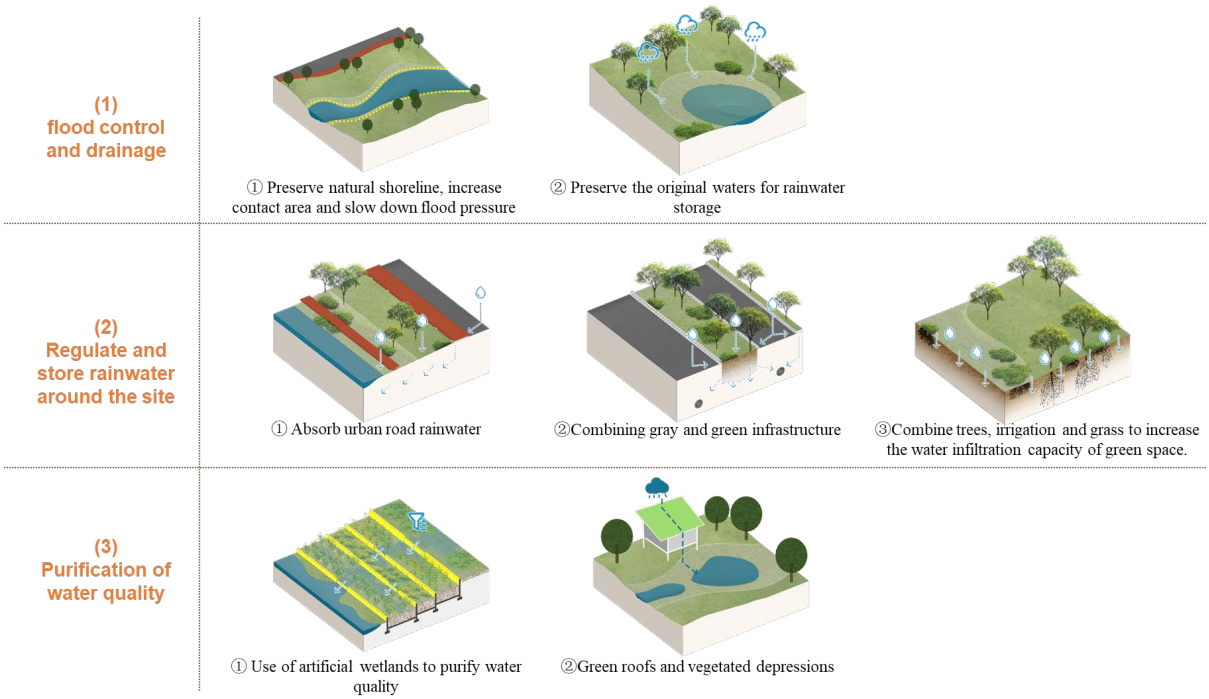


Figure4- 3 Water treatment methods (self-drawn)

4.3.2 Wetland ecosystem design

Urban wetland parks should follow the principles and methods of wetland ecosystem design.

(1) Proper functional zoning

The functional zoning of urban wetland parks is divided from private to public needs into wetland protection areas, wetland buffers, wetland tour areas, and service areas.

(2) Good spatial form of water area

① Layout form should be mainly gathered and supplemented by division. Wetland water form on the basis of respect for the status quo, in different forms such as large, small, open and closed, planning and design of different scales of water surface, reflecting the integration and penetration of water bodies and cities.

②curved water edge. According to the design of the topography of the undulation and zigzag, the water surface boundary is meandering, and the area of intermittent flooding is increased appropriately, so that the rich and diverse shoreline provides more habitat space for

wet organisms. In addition, the zigzagging of the water body's shoreline is conducive to reducing the velocity of water flow and reducing the damage to the water shoreline during the flood season.

③Lakes designed with islands, dikes and bridges. Islands, embankments and bridges are important elements to divide the water surface of open water, while islands, embankments and bridges connect water and land traffic, with beautiful forms, often become visual focal points, not only increasing the space of diverse habitats in the water, but also enriching the water body landscape

(3) Plant selection

①Giving priority to native tree species. The planting planning and design is based on the study of the dependence of the integrated species of local vegetation and native tree species on plant species and habitat, so that the park has clear local regional characteristics. The extensive use of native plant species in wetlands and the selection of plants that are easy to survive with can simulate natural habitats as much as possible, reduce maintenance costs and water consumption, and enhance purification capacity.

②Ensuring Biodiversity. The principle of native does not mean that exotic species cannot be selected. Appropriate selection of exotic species can optimize the landscape effect and increase the landscape diversity.

③Priority of lush branches and well-developed roots. Plants with lush foliage and well-developed root systems generally have deep roots, dense root systems, strong purification ability, and high ornamental qualities. The selection of such plants in urban wetland parks can play a role in rainfall runoff absorption, infiltration, slow release, filtration and landscape improvement during rainfall.

④ Priority of perennial plants. Priority is given to long-lived perennials, which are usually cared for in a sloppy manner, saving labor and material resources, not requiring frequent replacement, and having the characteristics of "sustainable growth".

4.3.2 Public space creation

As an important part of urban public space, the space of wetland parks can be divided into

two parts: the relationship between the site and the city, and the site service facilities to propose optimization strategies.

(i) The relationship between the site and the city

①Build blue-green network: By constructing green belts linking urban residential areas and scattered green spaces and waters in various parts of the city, a track network is formed so that the urban and natural environments are intertwined and residents can access the parks and green spaces and waters by walking or using non-motorized vehicles.

②Free shuttle: the urban wetland park is open and unfenced, and the park is free to shuttle, providing a green, natural and comfortable urban shuttle for the public and encouraging non-motorized travel.

③ Interpenetrate with urban functions: With many work and residential areas often clustered near urban wetland parks, the parks provide a place for people working in nearby buildings to get in touch with nature. The park's cool shade and comfortable seating also provide a place for the surrounding workers to take a lunchtime break. Dining and recreational facilities needed for wetland parks can also be placed in the urban space bordering the park, ensuring the use of the facilities while preserving the park's natural environment.

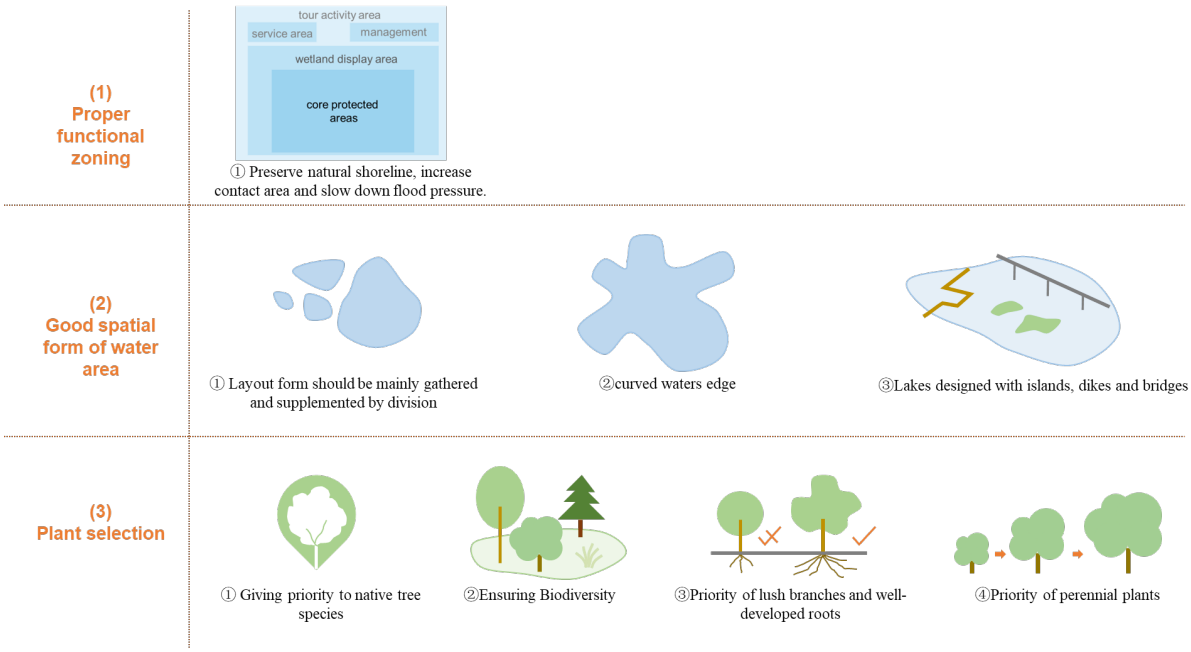


Figure4- 4 Wetland ecological protection method (self-drawn)

(B) Service facilities on site

①Sports and fitness: With the development of the times, sports and fitness have gradually become a major purpose of people going to parks, and proper sports and fitness facilities and the required auxiliary facilities are a necessity in parks.

②Camping and picnic places: Due to changes in living standards and perceptions, the demand for camping and picnicking has also emerged in the country, so the lawns in the wetland parks also need to be designated as areas for picnic camping.

③Science education: Wetland parks can make use of their own qualities to allow people to observe and learn in nature and make use of the use of scenes for science education.

④Memory of the site: Preserve the original memory and historical story of the site by retaining the old elements, materials and spatial characteristics of the site.

⑤ Shading and rain-proof facilities: Guangzhou is hot and rainy in summer, and the next moment when the sun shines brightly may be a rainstorm, so it is important to provide users with space for shading and rain-proofing.

(6) Convenience facilities: As an urban park, it is necessary to provide users with reasonable basic convenience facilities such as toilets and direct drinking water, which should be designed in such a way as to reduce their pollution impact on the wetland system.

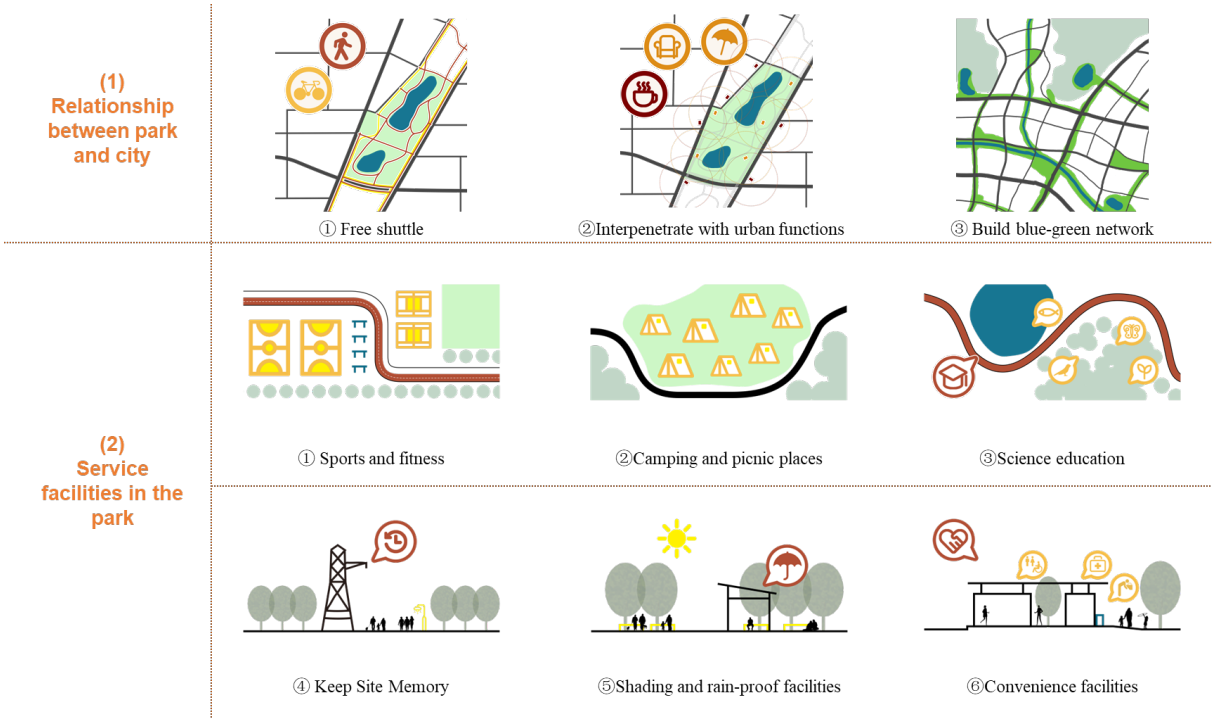


Figure4- 5 Public space requirements (self-drawn)

4.4 Summary of this chapter

Guangzhou is prone to internal flooding during heavy rainfall due to its subtropical monsoon climate with high rainfall, high topography in the north and low topography in the south, and the presence of tidal water from the outer rivers. At the same time because of urbanization will be in, water system, runoff have different degrees of impact, coupled with municipal pipe network construction and maintenance is not in place, exacerbated the situation of waterlogging. In Guangzhou, despite the existence of sponge city planning, very little construction has been put into place and the operational effect is poor. Therefore, this chapter summarizes the various design methods of urban wetland parks in Guangzhou under the concept of sponge city from three aspects: water treatment, wetland ecosystem, and public space creation, based on the above theories and design methods of the case, and provides an important reference basis for subsequent specific design enhancement programs.

Chapter 5 Tianhe Wetland Park Research and Analysis

5.1 Project Basics

5.1.1 Project background and location

The Tianhe Wetland Park studied in this paper is a wetland park in Tianhe Smart City of Guangzhou, located near the easternmost part of Tianhe Smart City and the junction with Huangpu District, covering an area of about 46.8 hm^2. Tianhe Wetland Park is located in the northeastern part of Tianhe District, with Science City in the east, Baiyun District in the west, the new central axis of Guangzhou in the south, and Yankou Mountain in the north, and adjacent to the Furnace Mountain Forest Park and South China Botanical Garden in the west.

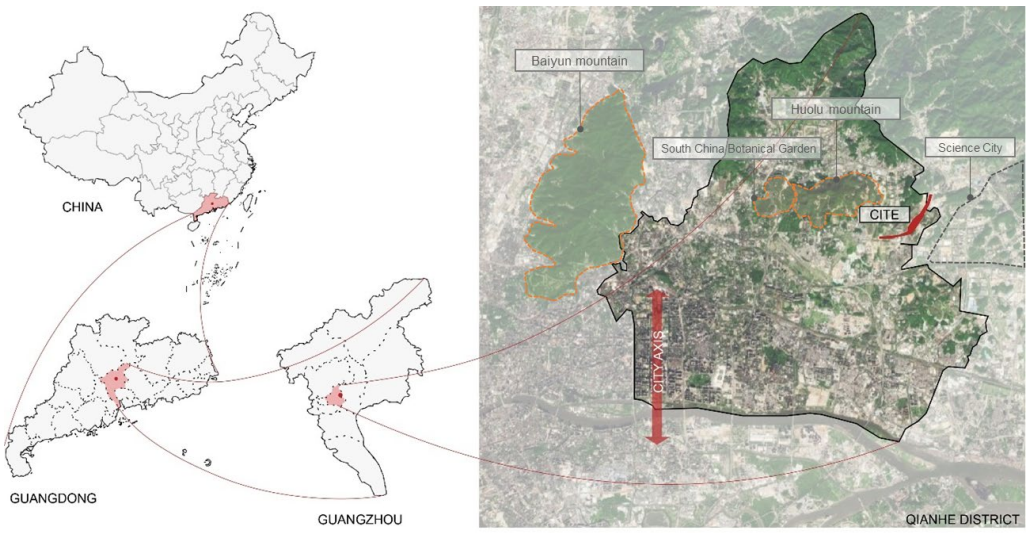


Figure 5- 1 Location of the site area (self-drawn)

Before the concept of sponge city was formally proposed, in 2011, the Tuoren design team led by Prof. Yu Kongjian proposed the construction of an urban green sponge system for Tianhe Smart City, covering three stages, from master planning, detailed construction planning to landscape design. On this basis, the Tianhe Wetland Park was designed. The construction of the wetland park started in September 2013, completed in June 2015 and officially opened in July 2016, and has been in operation for 8 years now. It is the first landmark ecological landscape in Guangzhou built in accordance with the concept of national "sponge city" pilot project.

This paper takes Tianhe Wetland Park as the research object, and its goal is to understand

whether the sponge wetland park can realize an efficient sponge park with dual functions of ecology and publicity. Therefore, the research will be conducted in two parts: the implementation of sponge city and the use of public space in the park.

5.1.2 Original design concept and zoning

To investigate the construction results of a sponge city wetland park, it is necessary to understand the original design intent of the design team and compare the existing situation to see if the original design goals were achieved. At the time of design, the project faced four major challenges: how to cope with Guangzhou's natural climate, how to improve water quality, how to create a water-adapted plant community, and how to provide an open space that meets the recreational needs of neighboring residents.

In order to cope with the above challenges, the Tianhe Wetland Park utilizes the Xintang Reservoir in the middle of the park to divide the site into three main functional areas of "one nucleus and two wings", with "one nucleus" referring to the Xintang Reservoir and "two wings" referring to the two valleys upstream and downstream of the Xintang Reservoir. The "one core" refers to the Xintang Reservoir, and the "two wings" are the two valleys upstream and downstream of the Xintang Reservoir. Upstream Hundred Flowers Valley Fitness Area, featuring artificial wetland purification landscape and sports and fitness, designing a continuous multi-pond-wetland coupling system with different purification functions, where rainwater is purified through different areas layer by layer and eventually flows into the Xintang Reservoir for storage; middle reaches of the Xintang Reservoir Sightseeing Area, featuring a wide lake surface and a cycling path around the lake; and downstream Eco-Valley Area, featuring artificial wetland landscape and wetland flowers. It is divided into rainwater wetland buffer area and wet pond stagnation area.

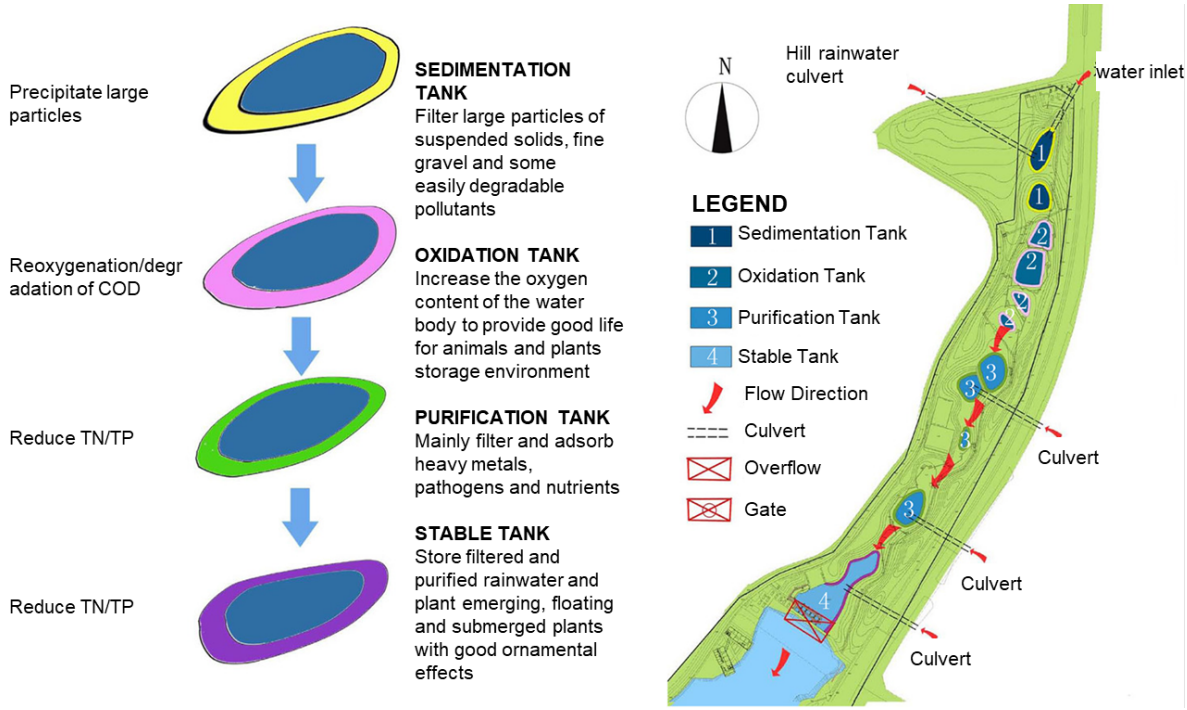


Figure 5- 2 The distribution and function of wet ponds in the original design

(Source: Adapted from "Tianhe Smart City Wisdom Water System (Eastern Water System) Connectivity Phase I Project")

Figure 5- 3 Characterization of the different stream (self-drawn)

The park hopes to form an up-convex green space and a wetland river valley through terrain modification, and the site can collect and store the surrounding rainwater through the natural topography to improve the efficiency of rainwater collection. Technical measures such as wet ponds and rainwater wetlands are applied to retain rainwater within the site and reduce the amount of rainwater discharged externally. The retained rainwater will be used as landscape

water for people's enjoyment and as a water source for plant growth within the site.

5.2 Analysis of the surrounding environment

5.2.1 Traffic

The site is surrounded by science and technology parks, residential areas and commercial complexes. The site is a long L-shape, with a total length of about 3 kilometers. The widest part of the width is the Xintang Reservoir, which is about 260 meters, and the narrowest part is the section of Yangmei River, which is about 50 meters, while the width of the other areas varies from 70 to 120 meters, making it a strip park. The park is divided into three parts by the Xintang Reservoir. The upstream starts from the junction of Tianhui Road and Daguan North Road until the northern end of the Xintang Reservoir, the middle reaches of which are the Xintang Reservoir, with the whole roughly in a north-south direction; and the downstream starts from the junction of Software Road and Daguan North Road until the junction of Gaotang Road and Huaguan Road, with the whole roughly in an east-west direction. However, the downstream is separated by the hotel built earlier to become two separate green areas, the Downstream East Area and the Downstream West Area, due to pre-planning reasons.

The upstream and middle reaches are bordered on the west by Sicheng Road, a two-lane road in both directions, and next to emerging technology parks such as the NetEase headquarters and the Hongtai Wisdom Valley, where a large number of young workers are gathered. On the east side are mainly the Xintang Cemetery and Guangdong Lingnan Vocational and Technical College, and on the northeast is a large residential area, all of which are separated from the park by the six-lane Daguan North Road. The Daguan North Road is now under construction for the Guanglian Expressway.

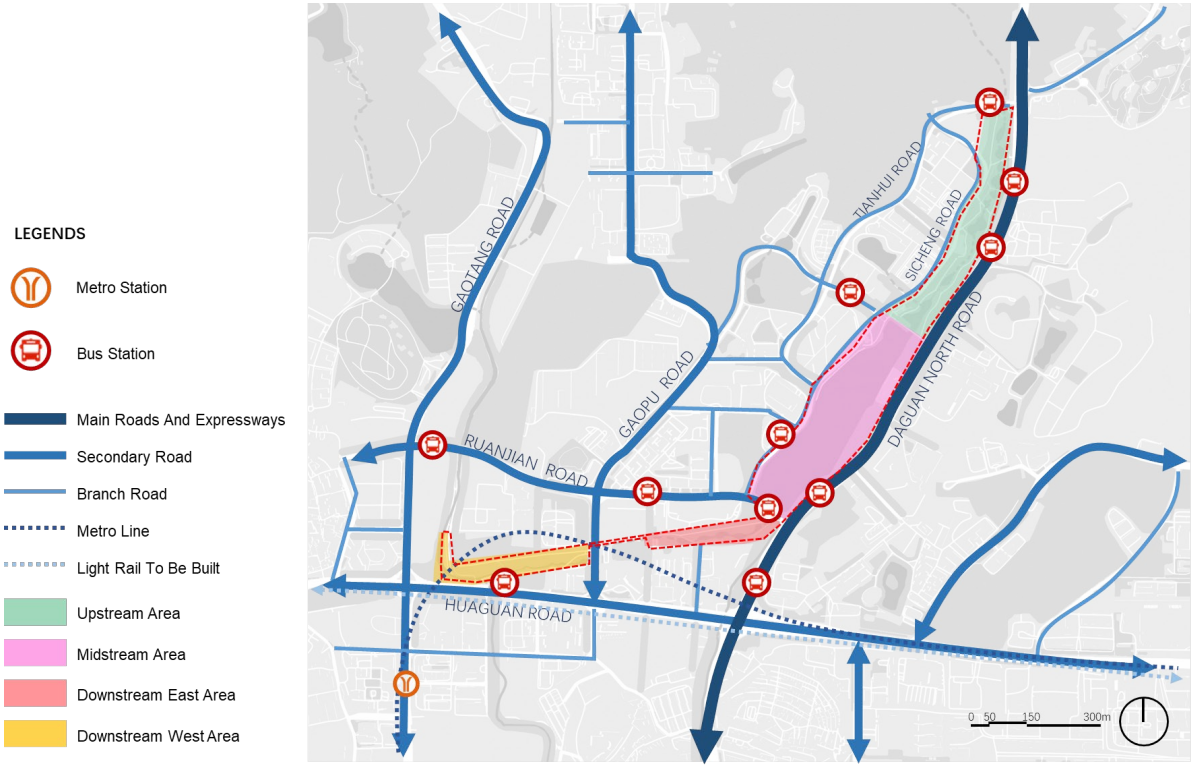


Figure 5- 4 Site Zoning and Surrounding Roads (Self-Drawn)

There are eleven bus stops and one subway station within a five minute walk of the park. A large open-air parking lot is currently located in the area of the high voltage line in the southwest corner of the park.

5.2.2 Land use

Site Surrounding Status Upstream and midstream on the west side are emerging technology parks such as Netease Headquarters and Hongtai Wisdom Valley, which gather a large number of young workers. On the east side are mainly Xintang Cemetery and Guangdong Lingnan Vocational and Technical College, and on the northeast is a large residential area.

The Downstream East Zone is bounded by a science and technology park to the north, and to the south by some factories that have not yet been relocated, which will be converted into commercial land under the current plan. The downstream west area is also a science and technology park and commercial area to the north, and the south area is currently used as the command center of the Gaotang Road Deep Tunnel Project, which will be used as a land for research and industrial construction according to the plan.

The downstream park area cannot be changed in its orientation because it is a green space below the high-voltage power line belt, but the road planning and design did not consider its relationship with it for the convenience of plot cutting. As a result, there is an angle between the existing road and the park, and a number of triangular and trapezoidal plots have been cut. At the same time, the current downstream east and west parks cannot be connected because the functions of the downstream east and west green areas were not considered before the construction of the planned roads and buildings.

The area downstream of the park to the south is Vanke Plaza, a commercial complex with apartment complexes. To the west is another commercial complex and the urban village of Ling Tong Village. About six hundred meters further south you will come to the dense residential areas of Siu San Tong and Sun Yuen San Tsuen.

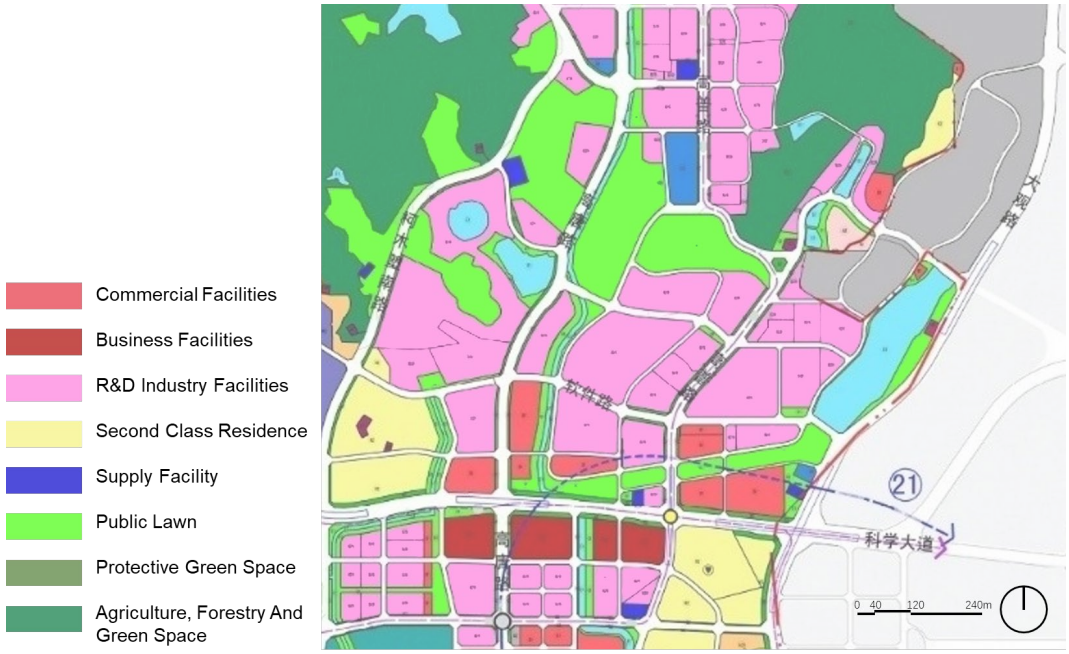


Figure 5- 5 Surrounding Land Use Characterization Map

(Redrawn from: "Detailed Control Plan for the Core Area of Tianhe Smart City")

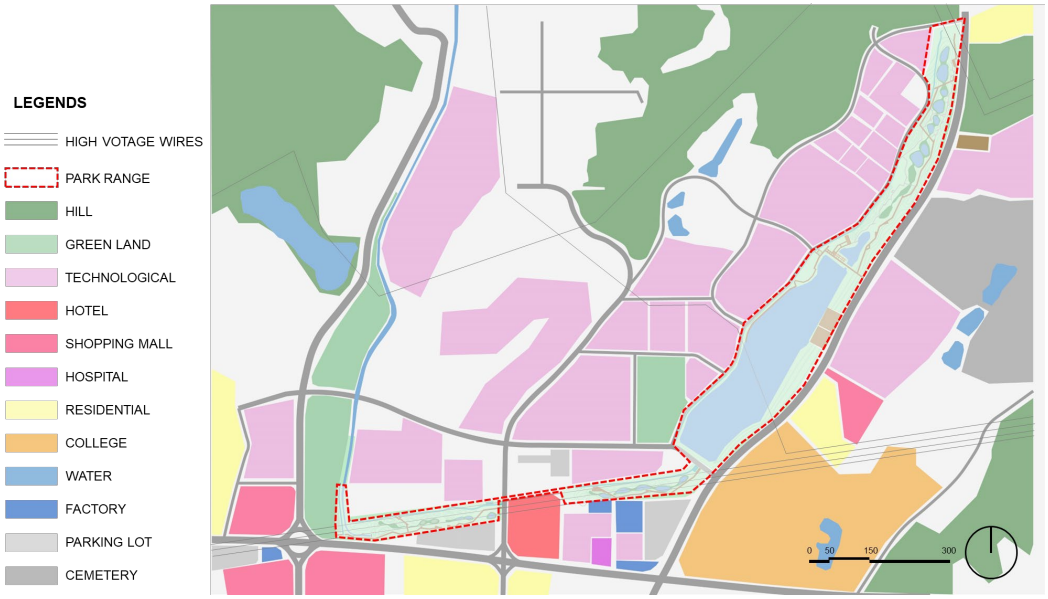


Figure 5- 6 Status of land surrounding the site (self-drawn)

5.2.3 Construction

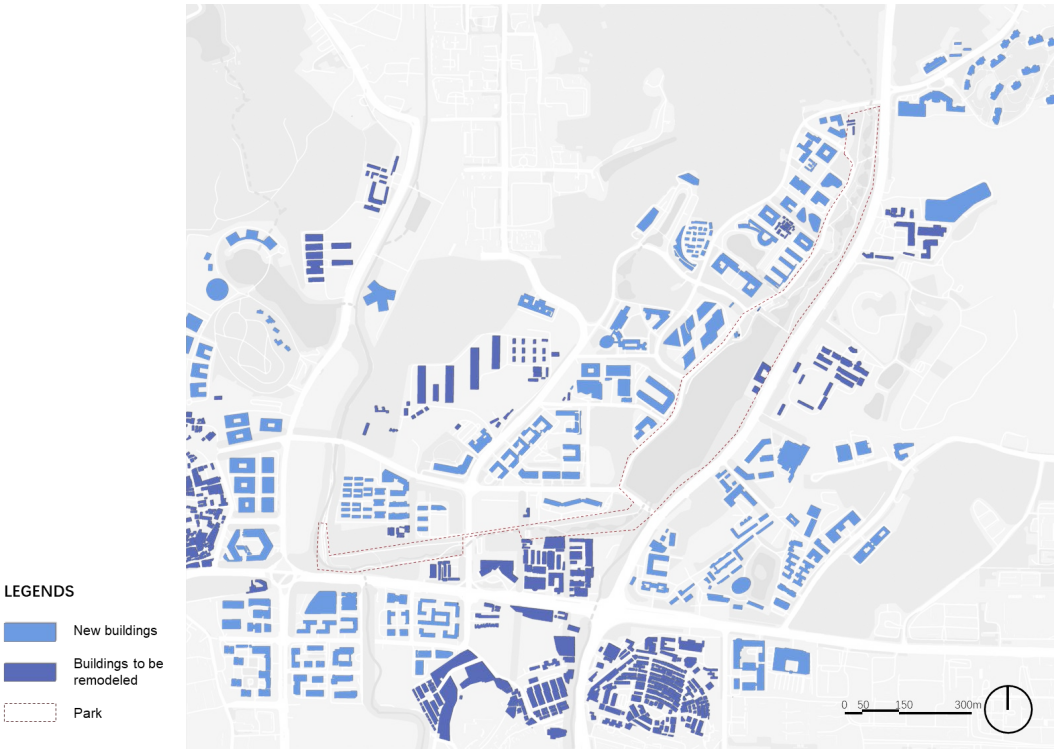


Figure 5- 7 Surrounding Building Mass (self-drawn)

The construction of the lots around the wetland park has been relatively stable, and the buildings near the upstream and middle reaches are all newly built since the last decade, and the construction quality is relatively good. However, there are still some industrial buildings

that will be converted to other uses in the future.

Building heights are under planning control upstream and midstream surrounding buildings are mainly multi-storey and small high-rise, with a general height of 40 meters and a high point of 60 meters. The downstream neighborhood is surrounded by new slab-type high-rise office buildings, high-rise apartment buildings, multi-storey commercial complexes, ground-floor office parks, and other types of buildings.

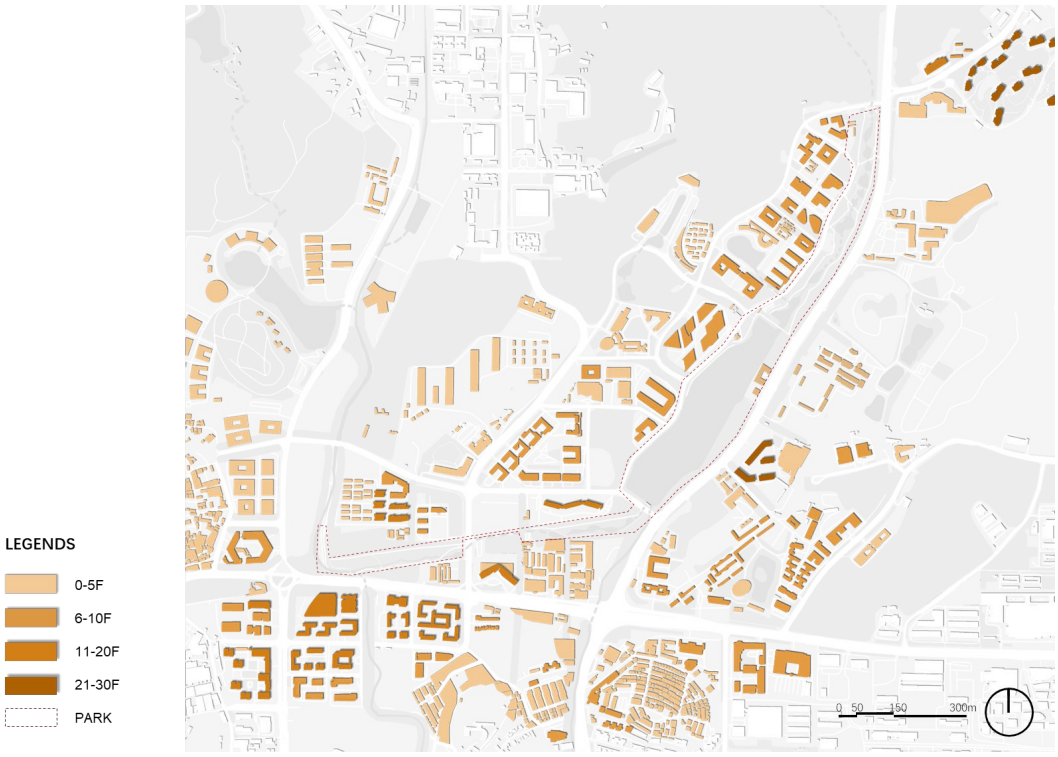


Figure 5- 8 Surrounding building heights (self-drawn)

5.2.4 Plaza space

There are public squares in some of the neighborhoods around the wetland park, including Vanke Plaza and Vanke Cloud City, which are used as commercial areas in the south of the downstream west area, Tianhe Political Affairs Center Plaza in the north of the downstream east area, and the entrance squares of each innovative industrial base in the midstream and upstream west. Among them, Vanke Plaza and the entrance plaza of the innovative industrial park are more closely related to the park, with more active people and higher mutual mobility. The rest of the public plazas are less connected to the park due to the lack of roads or spatial connections.

According to the plan, a large number of plaza-type urban public spaces with close connection to the park will be created in the commercial land around the downstream in the future.

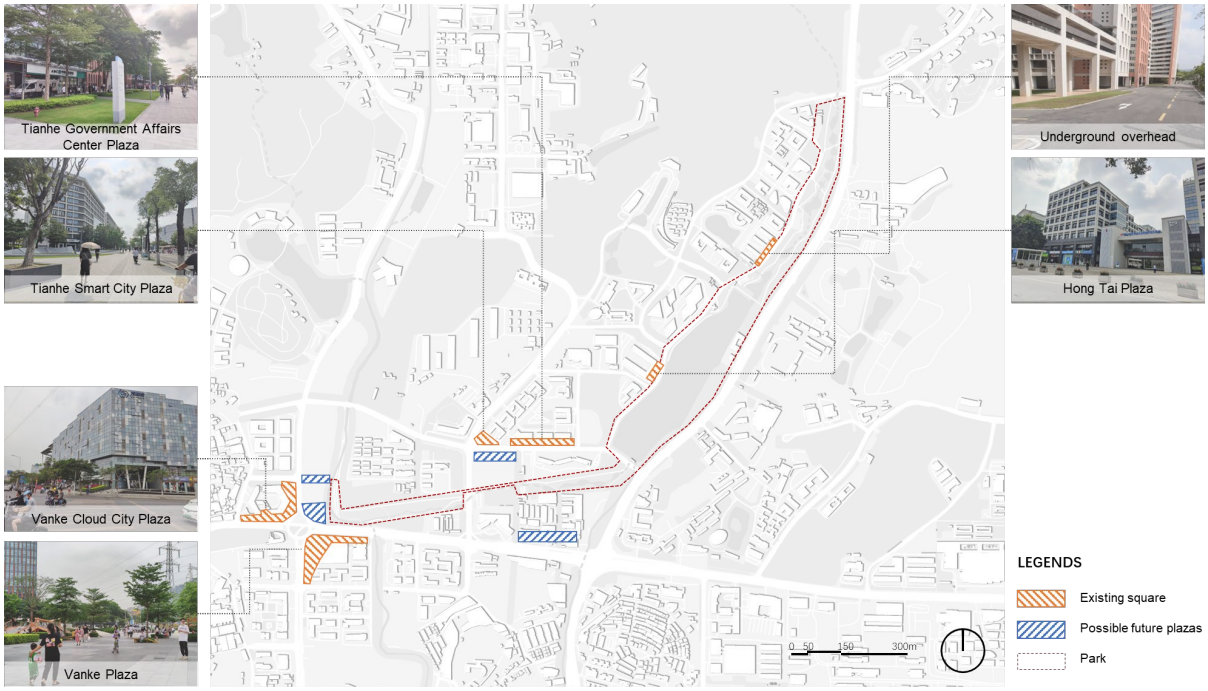


Figure 5- 9 Distribution of squares around the Wetland Park (self-drawn)

5.2.5 Green spaces and water systems

(i) Status quo

Tianhe Wetland Park is at the foot of the hills in the hilly area to the north of Guangzhou, with many green hills around. It is adjacent to Yangjiao Mountain in the north, Furnace Mountain Forest Park and South China Botanical Garden 2 kilometers to the west, and Science City Green Park such as Guangzhou Science City Sports Park and Yushu Park about 3 kilometers away from the east. The Tianhe Wetland Park plays an important linking role in it.

The natural water source upstream of the park originates from the streams in Yangjiao Mountain, which flows through the site into the Xintang Reservoir and finally into Chebeichong. Within the site area, there is also the Yangmei River which originates from the Lanyuan Reservoir under the Phoenix Hill and the Ludong Reservoir in the Fireplace Hill, and passes through the Lingtang Reservoir. Yangmei River flows through Siu San Tong Village downstream before joining Chepi Chung.

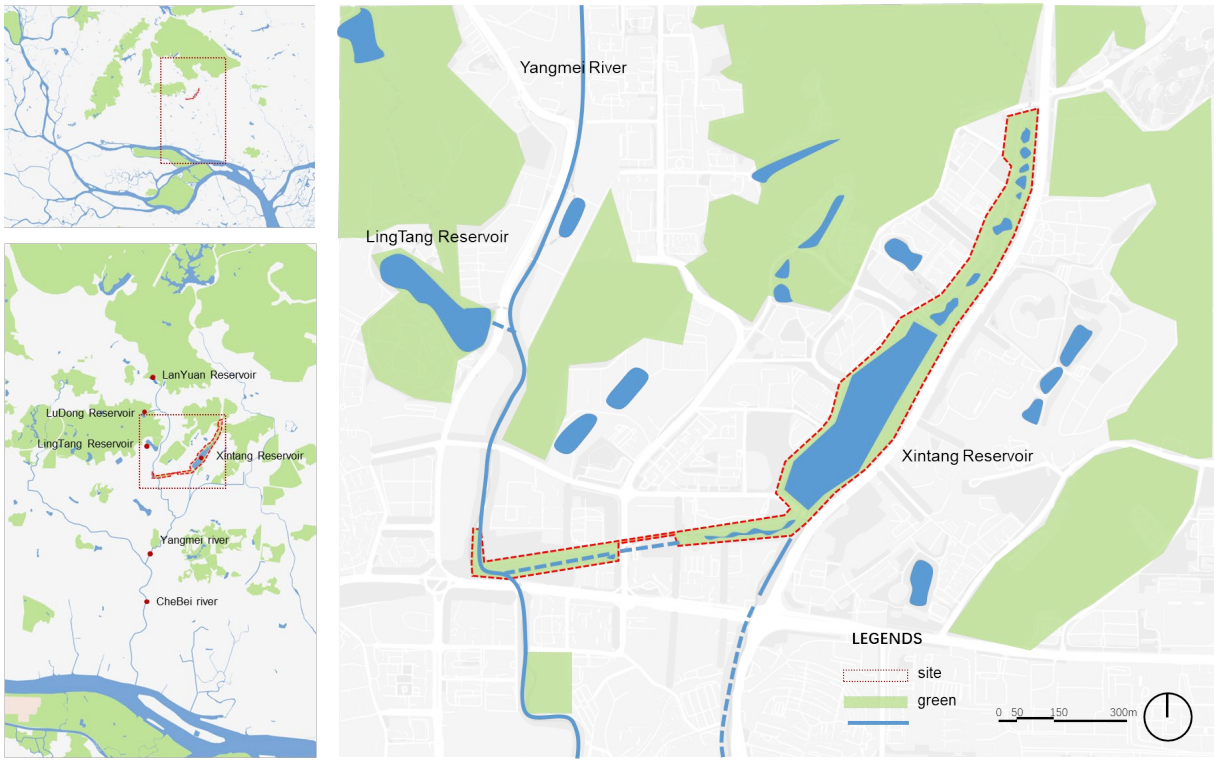


Figure 5- 10 Status of Green Space in Site Watershed (self-drawn)

(ii) Historical changes

As can be seen from the historical satellite map, the upstream parcel of Tianhe Wetland Park was in its original state a number of continuous ponds, which were filled in as a fruit grove in 2007, and opened up Sicheng Road on the west side of the upstream. It was redesigned as a wetland bubble for flooding and water purification in the design and construction of the park that began in 2013, restoring the original ecological function and form of the site in a certain sense.

The area between the midstream New Pond Reservoir and North Grandview Road was originally a green wooded area, which was constructed as various types of factory buildings starting in 2010, and the park design was built to return this area to grassy wooded slopes, but a gas station and auto repair company still remain.

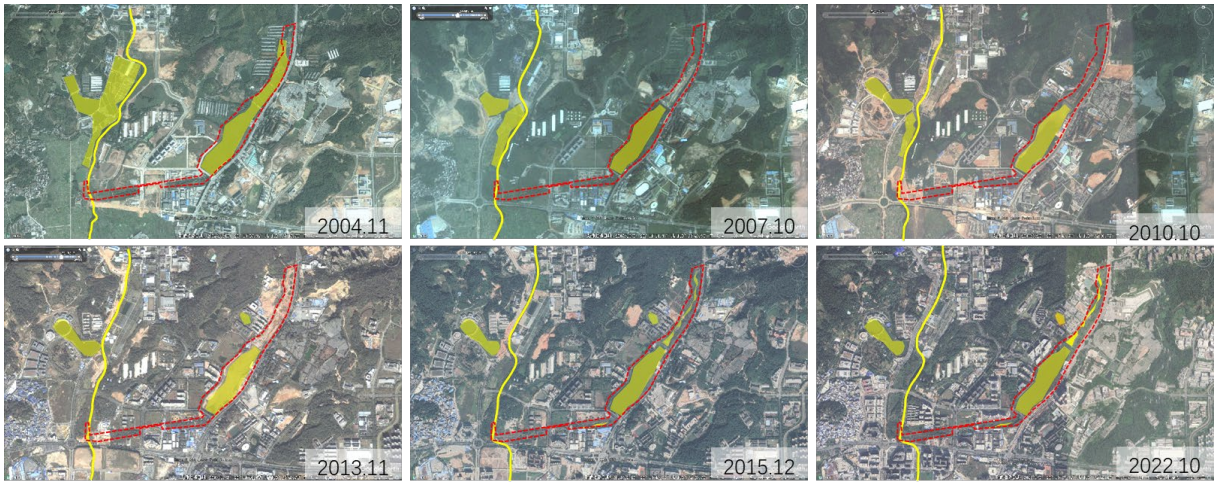


Figure 5- 11 Changes in waters surrounding the site (self-drawn based on information)

Before 2005, the green space on the west side of the downstream of Tianhe Wetland Park was originally a path, farmland and ponds. In 2005, when the construction of Huaguan Road and Gaotang Road started, part of the ponds on the north side of Tianhe Wetland Park began to be filled in and constructed as an agricultural park, and part of the farmland was converted into greenland woods. By 2012, except for Lingtang Reservoir, the reservoirs between Gaotang Road and Yangmei River were completely filled in, and the farmland was completely retired to greenland in 2019, which has not yet been constructed. The area between Yangmei River and Gaotang Road is planned as commercial land as guided by the "Detailed Control Plan for the Core Area of Tianhe Smart City" formulated in 2011.

The Yangmei River section of Chebeichong was originally a free and winding natural river form, which was straightened and rerouted to the east during the construction of Vanke Plaza in 2011 to facilitate the construction of Vanke Plaza. The width of green space on both sides of the river was changed from about 30 meters to 7-15 meters, and some tributaries were filled in. At the time of the park design, the Yangmei River had already been diverted.

5.3 Research on the internal use of the site

5.3.1 Observation of material conditions

Through field research, the construction and utilization of the site is compared with the design drawings to understand whether the wetland park achieves the construction objectives.

This part of the research is a material form research in the site, which is divided into three parts, namely, the construction of profile design, plant planting, and the use of site facilities.

(i) Profile design and treatment with water

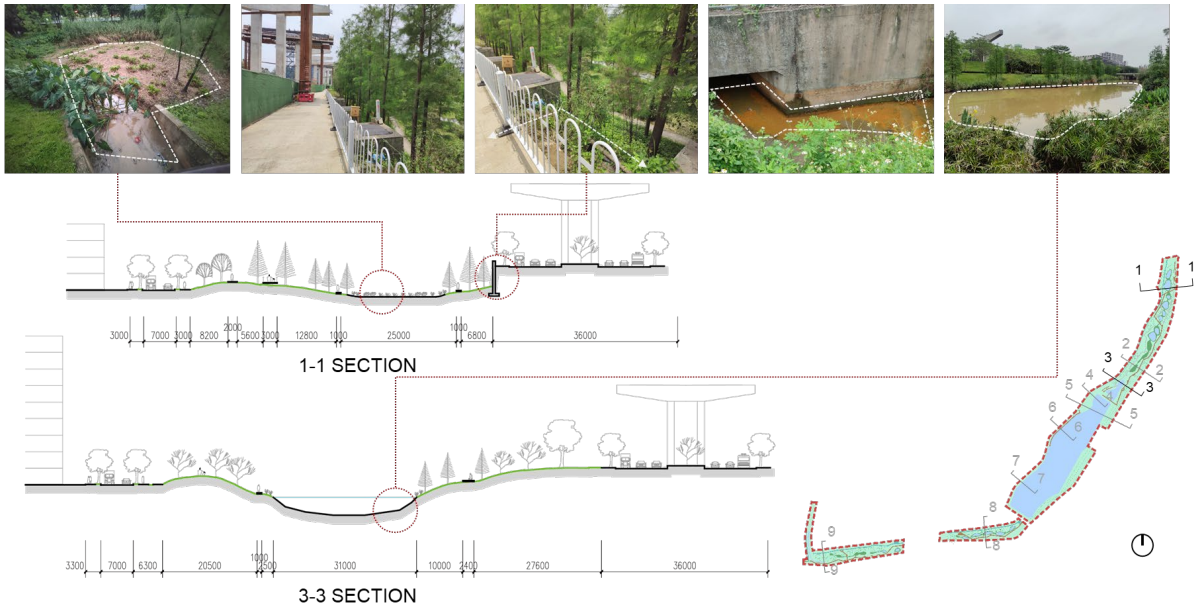


Figure 5- 12 Upstream East Elevation and Water Quality Pollution (self-drawn)

By looking at the site and drawing horizontal and vertical profiles, it is possible to derive the site's vertical design construction, which will affect the stormwater drainage conditions during rainy days while affecting the way people enter and exit the wetland park.

There is a height difference between the grass and sidewalk at the upstream east side where it meets Daguan North Road, and there is a railing already in place before the road is repaired, and the road is of a higher grade, with more vehicles traveling faster, and the park is not as well connected to the road as Sicheng Road to the west. As can be seen from the design drawings, there are multiple culverts on North Grandview Road that discharge roadway stormwater directly into the wetland bubbles and even into the stabilization ponds that have been treated. During the rainy day research, it can be seen that the color of the wet ponds with culverts running directly into them changed to yellow and the water quality went from clear to turbid.

Figure 5- 13 Upstream West Elevation Differences, Roadway Surface Water, and Water Quality Pollution (self-drawn)

The overall height of the east side of Daguan North Road is greater than the west side of Sicheng Road, Sicheng Road, a measure of the park for the continuous convex green space, according to the park's designer, the earthman design, which is digging wetland bubbles dug out of the soil, directly piled up on the bank can be completed to complete the balance of the earth also formed a rich and interesting terrain . However, the upward convex topographic elevation difference makes the wetland unable to dissipate the west side road drainage, the west side road surface water is still directly discharged to the underground pipe network, the catchment area flows from north to south to the software road. As can be seen from the research pictures, the road water level is deeper when it rains, and there is still standing water after the rain stops. Upstream partially interrupted part of the wet pond due to the inflow of untreated sewage, more silt in the pond, water quality is polluted and plant growth is disorganized.

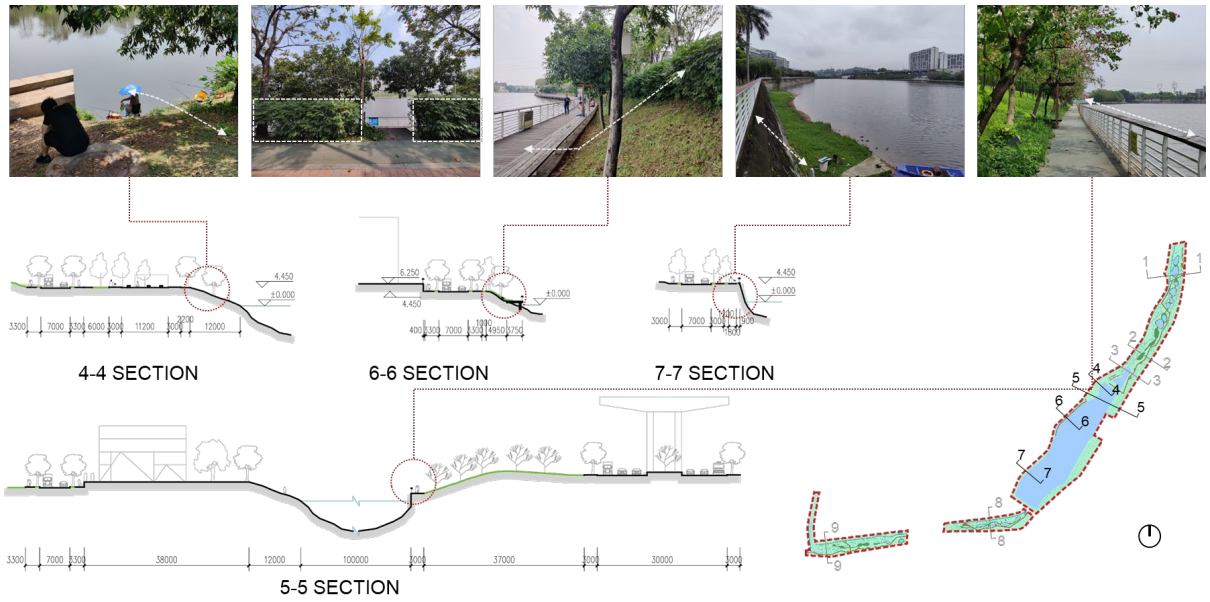


Figure 5- 14 Midstream barge morphology (self-drawn)

The midstream reservoir has concrete vertical barges in all areas except the north side where there are a few free barges. An approximately 250-meter wooden walkway over the water with continuous benches was installed at the northwest measurement and connected to the sidewalk via multiple straight run stairs. The eastern bank was paved as a bicycle path, but due to road construction it was not possible to find an obvious bicycle entrance. A gas station stretches across the bank, breaking the bike path into north and south sections.

The downstream eastern area has only one entrance to the road, and the western entrance is deep inside the plot and is weakly public. There is a height difference of about 1.3 meters between the north side and the Wisdom World Plaza, which is enclosed by a railing. There is no railing between the southern side of the site and the factory building, but the site is planted with shrubs and grasses, and is therefore seldom traversed. On the east side there is a concrete overflow channel from the discharge of the Xintang Reservoir. This area is designed as a stormwater wetland buffer and consists of a series of pits and ponds approximately 0.5m in depth in series. The water in the existing pits is static, turbid, mosquitoes are abundant and the end pits are dry.

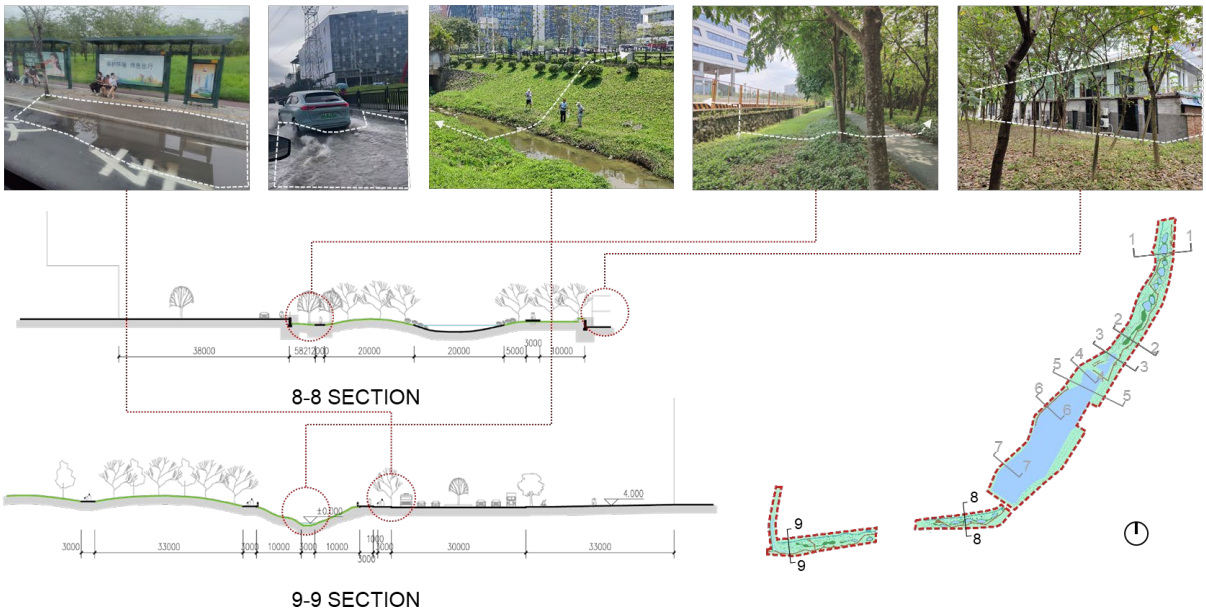


Figure 5- 15 Relationship of Downstream Areas to Surroundings (Self-Drawn)

The downstream west area is the wet pond storage area, which is formed by a series of pits and ponds with a depth of about 1.5m in series, with a permanent volume of water depth of about 0.5-1.0m. The storage volume is the part that performs the function of storage in case of rainstorms, and if it is higher than the saving volume, it will be converged into Yangmei River at the end through a culvert. However, there is a certain terrain undulation in the part connecting with Huaguan Road, which fails to make the road surface rainwater flow into the wetland, and the water on the road surface is deeper in heavy rainstorms, and there is still part of the water stagnant on the road surface after the rain stops.

(ii) Plant cultivation

The grassy slopes in the park, except for the lower concave wetland bubbles, are dominated by arborvitae structures with fewer shrubs. The planting form of tree communities generally forms a transitional landscape from dense forest to sparse forest from outside to inside; the ground cover layer transitions from soil and water conservation-type terrestrial plant communities to purification-type wet aquatic plant communities. The upstream tree species are taller, planted at larger spacing, and well-lit. Lower downstream east zone trees are lower and denser with an increased number of shrubs. Lower downstream east zone has fewer trees and open space.

There are abundant plant types in the wetland bubbles, and the planting of water-

supporting plants, such as plantain, grows luxuriantly, however, due to the lack of care there is a part of wilting.

Figure 5- 16 Growth of arborvitae and aquatic plants in each zone (self-drawn)

(iii) Facilities:

Figure 5- 17 Entrance Plaza Status（self-drawn）

① Main Entrance and Exit Plaza: Except for some areas under construction, all functional

areas are equipped with main entrances and entrance plazas. Most of the plaza is paved with anticorrosive wood flooring, and some areas are designed with permeable concrete. Seats of anticorrosive wooden boards are provided near the plaza.

② Roads: There are three main transportation roads in the park: bike paths, wooden trestles and concrete trestles. There are more loops in the park, allowing people to freely choose their walking routes. There are many resting seats along the wooden and concrete trestles, one every 50 meters on average. The upstream bike path is constructed next to the sidewalk, the concrete trestle is at the closest location to the wetland bubble, and the wooden trestle is often found as a highlight and supplement between the two and at the highest point of the site, utilizing the concrete as a supporting elevation away from the wet. Downstream, there are only wooden trestle and bike path, the bike path is located in the north of the wetland bubble, the surrounding plants are more open. The wooden trestle is located in the south side, with more plants and better shade. Many of the wooden floors are broken and uneven due to the material and Guangzhou weather.

Figure 5- 18 Various types of roads in the park (self-drawn)

③Science popularization signage system: the plaza and rest area will be equipped with

weather-resistant steel plates and engraved lines of the sponge city introduction standing signs and park map signs, and many animal and plant signboards have been set up along the road to introduce the characteristics of plants and animals in vivid detail and guide people to observe the plants and animals in the park. However, some of the signboards are damaged and the fonts and patterns have lost their color due to the sun and rain at their locations; the fonts at the bottom of some of the signboards have been obscured by the lush plants so that the contents cannot be read; and the map guidelines are too few so that people can't tell where they are relative to the park.

Figure 5- 19 Signage in the park (self-shooting)

④ Lamps and lanterns: lamps and lanterns in addition to the main plaza, other areas within the park almost all street lights and ground lights can not function properly, according to the wetland wildlife experts is to protect the animals at night resting environment.

Figure 5- 20 Nighttime light usage status (self-shooting)

5.3.2 Survey and Analysis of User Behavior and Habits

(i) Notes on activities

Activity notation is the use of the researcher to observe actual activity in the park using at least four separate time periods: one weekday and one weekend morning, plus one weekday and one weekend afternoon. A complete record was made of all that occurred in the space during each visit, including people's age, gender, type of activity, and location, and marking the time of day, weather, temperature, and other relevant influences. This work helps to understand elements such as user group attributes, usage preferences, time of use, frequency of use, location

of activities, content of activities, etc., and is an important reference basis for subsequent public space renovation work.

As the Tianhe Wetland Park covers a large area, in order to fully understand the use of various parts of the park, this study chose four days to conduct a full-day research, as shown below:

①Firstly, during the weekday period, the first research was conducted on April 17, 2023, Monday, cloudy, temperature 22-31℃, and visitors' behavioral activities are noted as shown in the figure below, and the second research was conducted on May 22, 2023, Monday, sunny, temperature 23-34℃. The pattern that can be observed by combining the two researches is:

On weekdays, the upstream area is frequented by a number of young people in the mornings and evenings who commute to the Science and Technology Park on the west side of the park on foot or by electric bicycle via the park's bike path. The rest of the day is less crowded, and the applicable population is mainly middle-aged and elderly people walking in the park and workers from the neighboring cafeteria restaurants who come to take a break in the area. Meal times will have take-out workers crossing the bike path to deliver take-out. Some companies do not allow takeout upstairs, and there are also restaurant delivery workers who place takeout on the sidewalk for orderers to pick up.

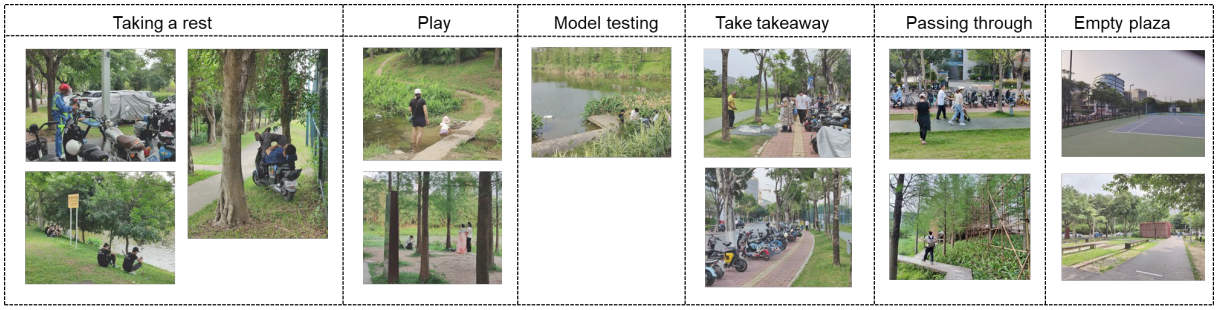


Figure 5- 21 Activity types of upstream crowd on weekdays (self-drawn)

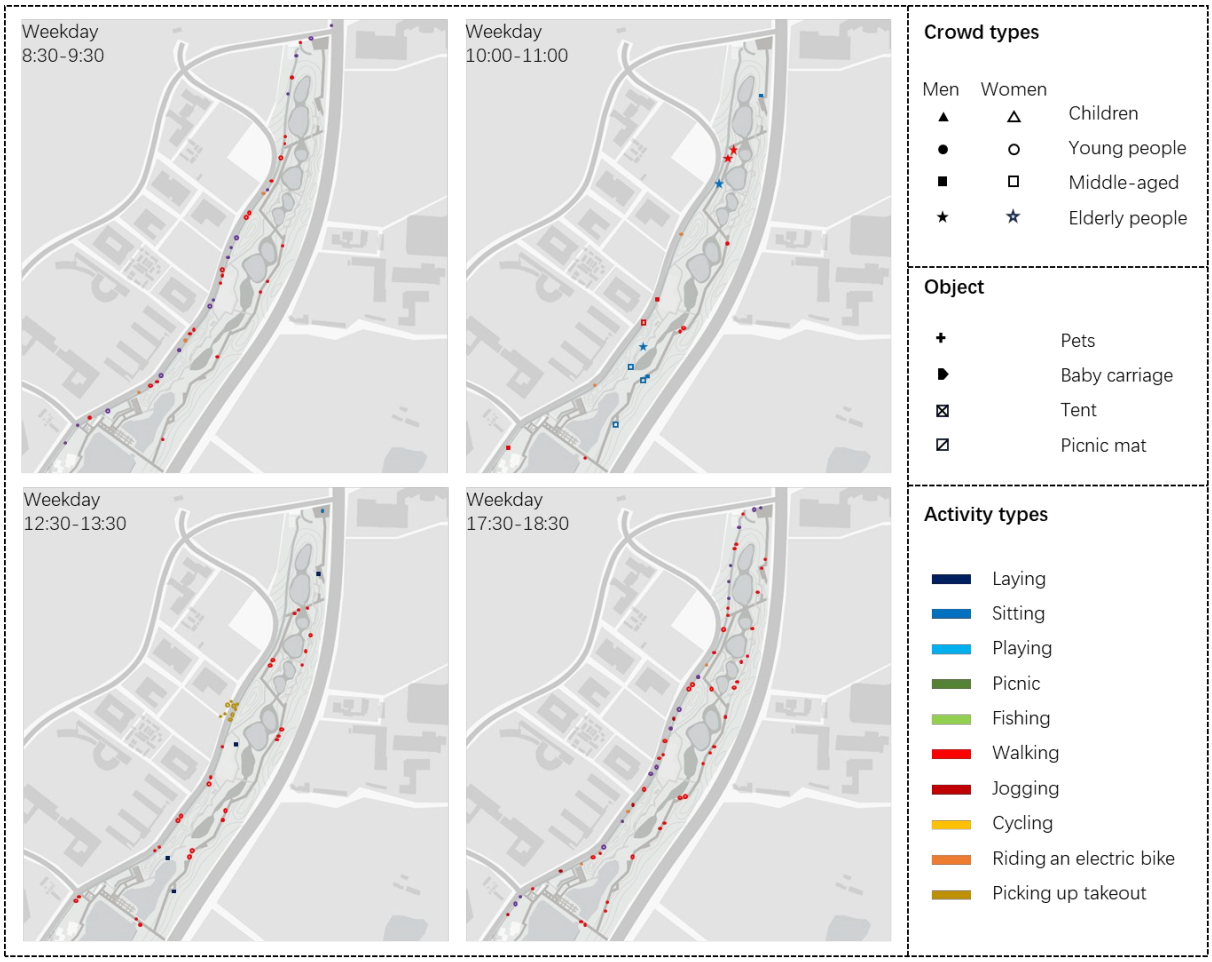


Figure 5- 22 Notes on crowd activities on weekdays in the upstream (self-drawn)

The midstream area is less frequented by anglers and middle-aged people resting on benches, with the majority of anglers being male and the number of resting people being equal between men and women. Anglers stayed here for a longer period of time, usually lasting more than two hours. Due to the sunshine, there were more anglers on the east bank in the morning and more anglers on the west bank in the afternoon. Most of the resters are employees of the neighboring restaurants, who come here in the morning and late afternoon when the restaurants are not open for business to sit, chat and play with their cell phones, and then lie down to sleep and rest in the afternoon. Some of the resters are residents of nearby villages and jobless people, who usually come here on foot or on electric bicycles. They prefer the shade of the trees on the north bank to the covered seats.

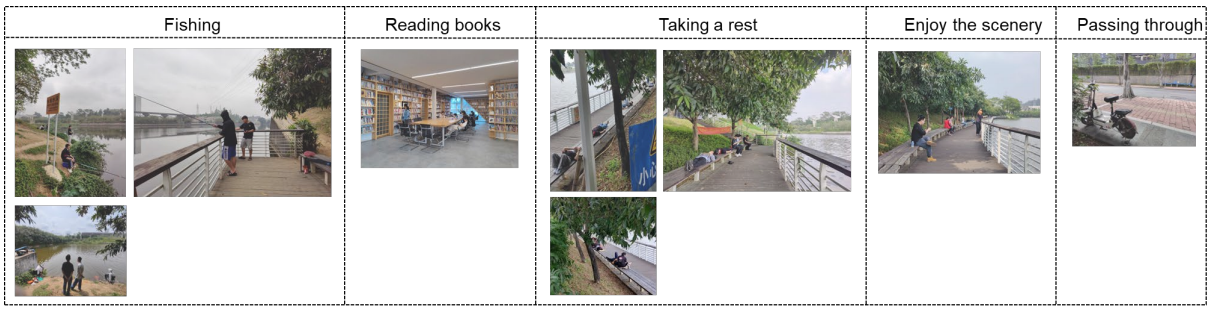


Figure 5- 23 Activity types of midstream crowd on weekdays (self-drawn)

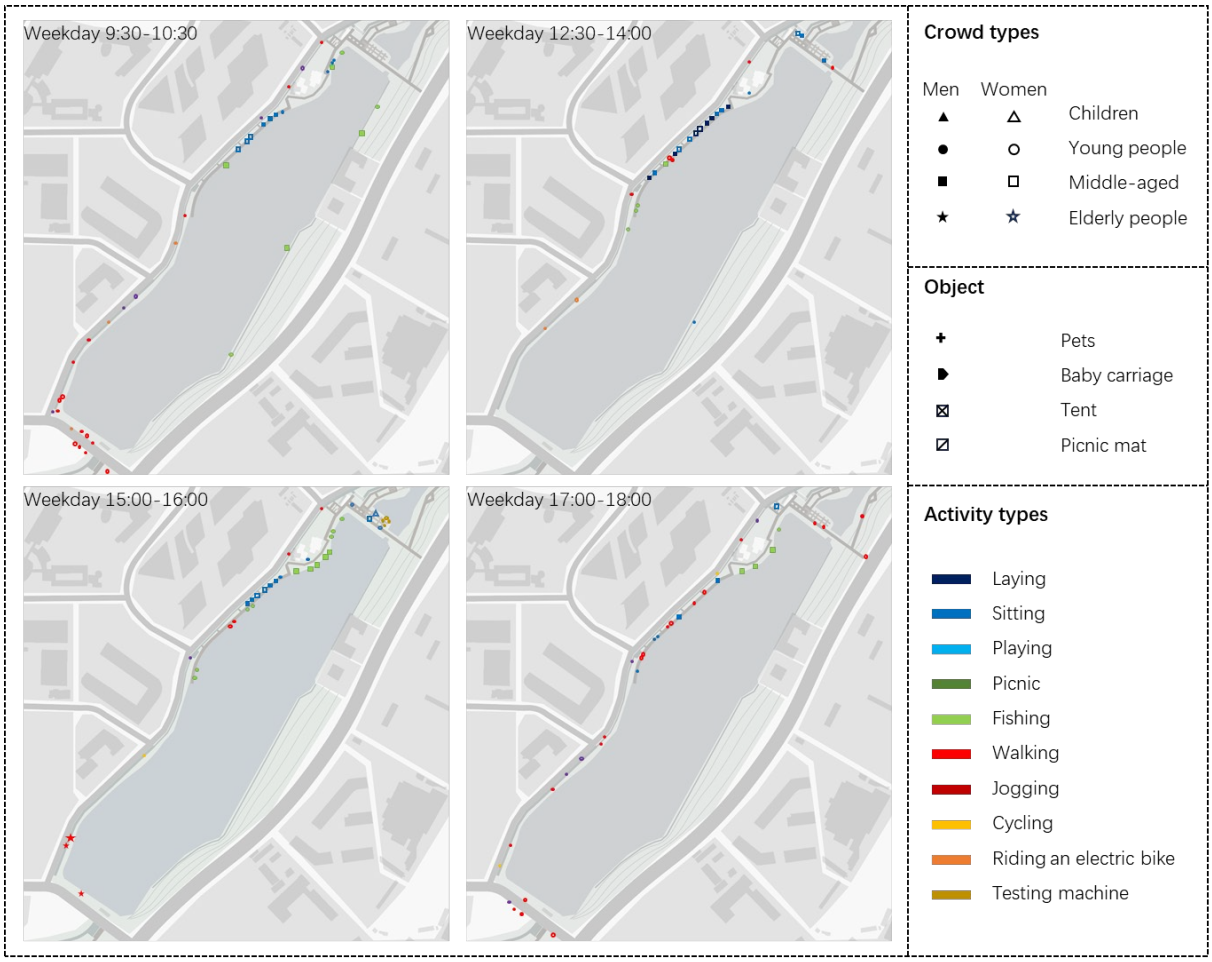


Figure 5- 24 Notes on crowd activities on weekdays in the midstream (self-drawn)

The downstream area will have young people running in the morning before work on the east side, which is quieter and has more shade. During working hours, there will be a large number of people crossing the wooden trestle in the west area to reach the company in the north for work. There are middle-aged and elderly women playing Tai Chi on the well-lit upper convex green area of the park. At noon, many people cross the west wooden path to go to the south commercial area for lunch and after-dinner walks, and take-out workers also use the bike

path for delivery. In the afternoon, there are middle-aged workers lying on benches in the shade, sometimes with electric cars or bicycles parked next to them. Less crowded in the afternoon, there are young people playing musical instruments and walking their dogs on the grass. The number of users in the garden increases from the evening after work time, and the activities are mostly running around the site for exercise and crossing the site to go to the bus and subway.

Figure 5- 25 Activity types of downstream crowd on weekdays (self-drawn)

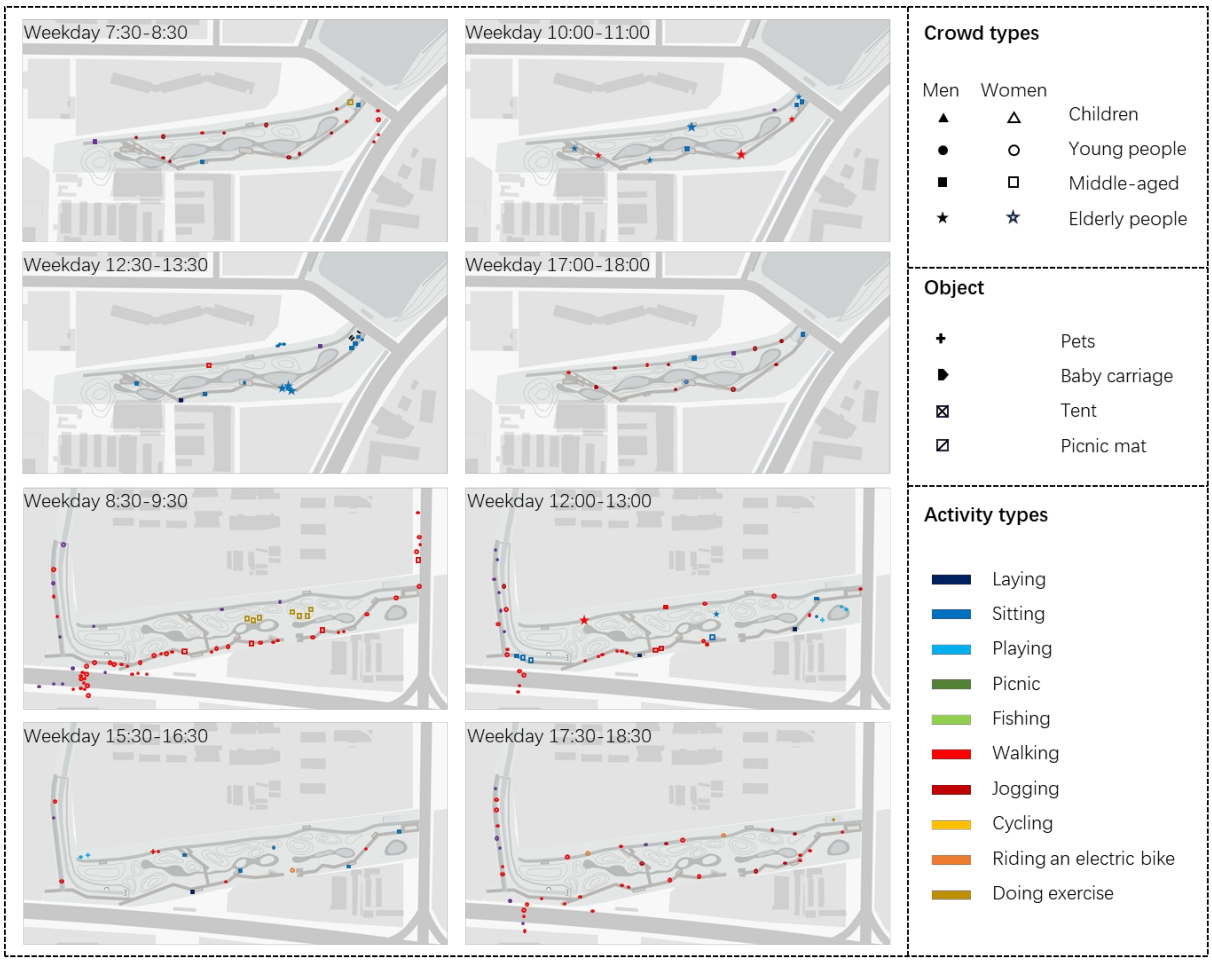


Figure 5- 26 Notes on crowd activities on weekdays in the downstream (self-drawn)

②Secondly, during the holiday period, the first research was conducted on April 16, 2023,

Sunday, sunny to cloudy, with a temperature of 20-33° C; the second research was conducted on April 22, 2023, Saturday, cloudy to thundershowers, with a temperature of 23-27° C. The behavioral activities of tourists are annotated as shown in the figure below. The synthesis of the two researches can be observed:

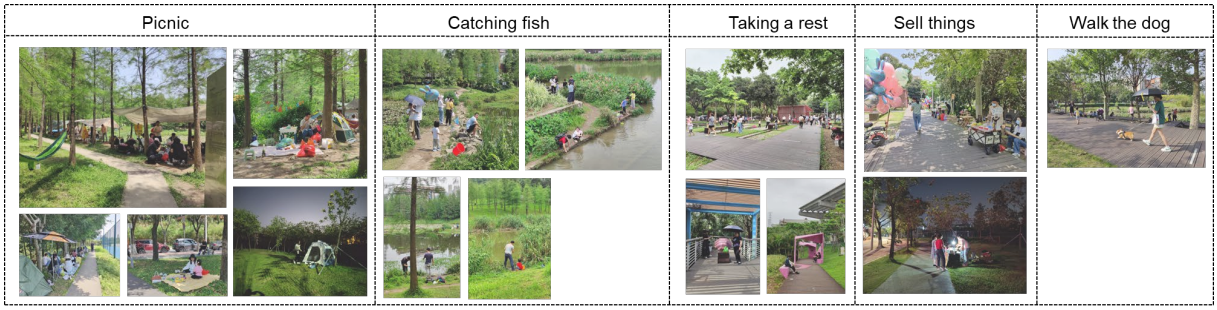


Figure 5- 27 Activity types of upstream crowd on weekends (self-drawn)

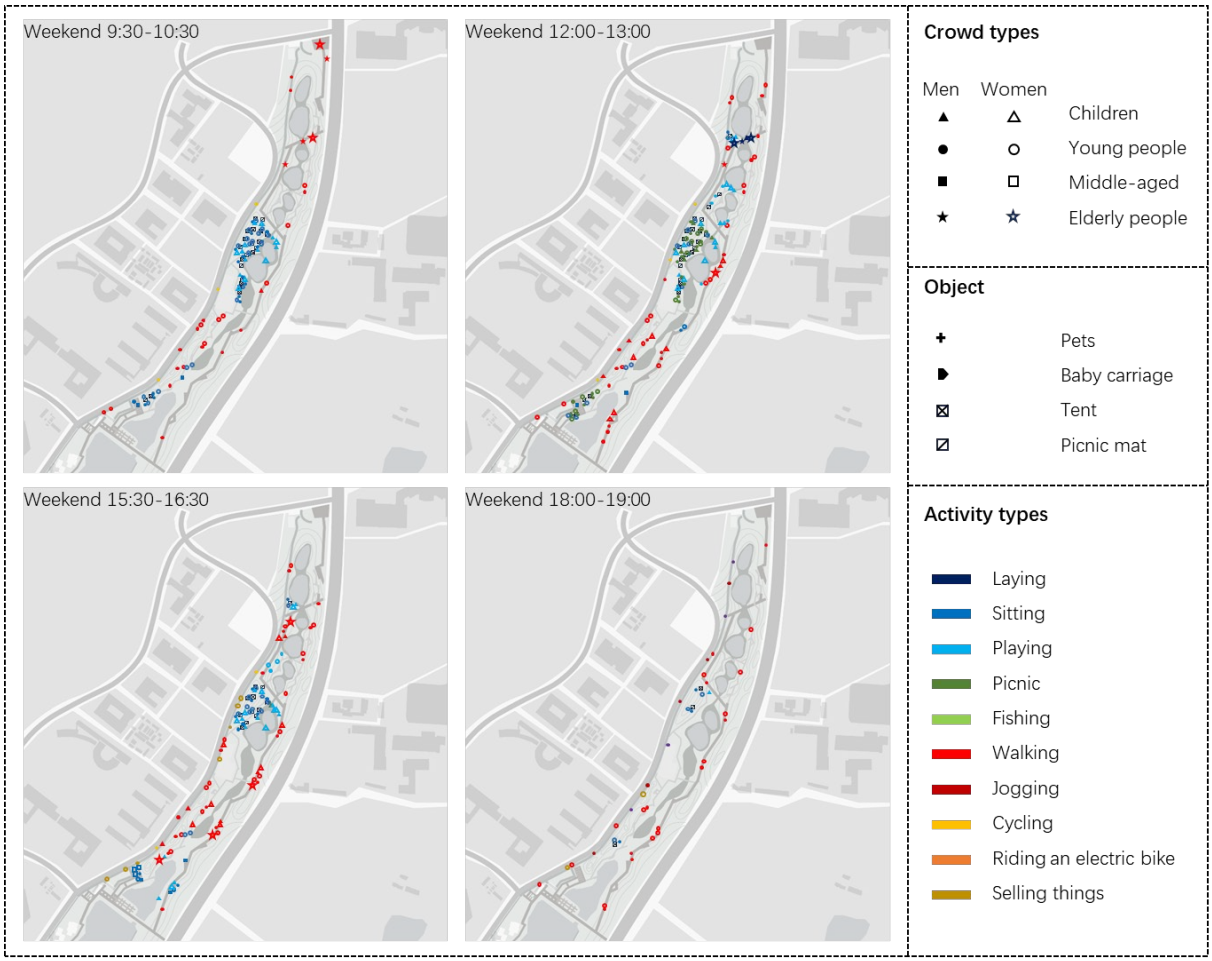


Figure 5- 28 Notes on crowd activities on weekend in the upstream (self-drawn)

On a weekend with sunny weather and comfortable temperatures, visitors began to enter the park around 8:30 a.m. The number of visitors increased dramatically around 10:00 a.m. and

continued until noon, with some of those who had been in the park for a long time leaving the grounds in the late afternoon, but there were new visitors entering one after another. The number of visitors to the park began to decrease at 5:30 p.m., but the number of runners and walkers on the bike path increased, and after dark there were almost no visitors to the park, only people running at night on the bike path. Vendors also entered the park around 10:00 a.m. to set up stalls selling drinks, toys, or food such as barbecued sausages and tofu puffs, and the number of vendors multiplied from around 3:00 p.m. onward. After the sun went down, they began to sell their unsold items at low prices and left the area.

Figure 5- 29 Activity types of midstream crowd on weekends (self-drawn)

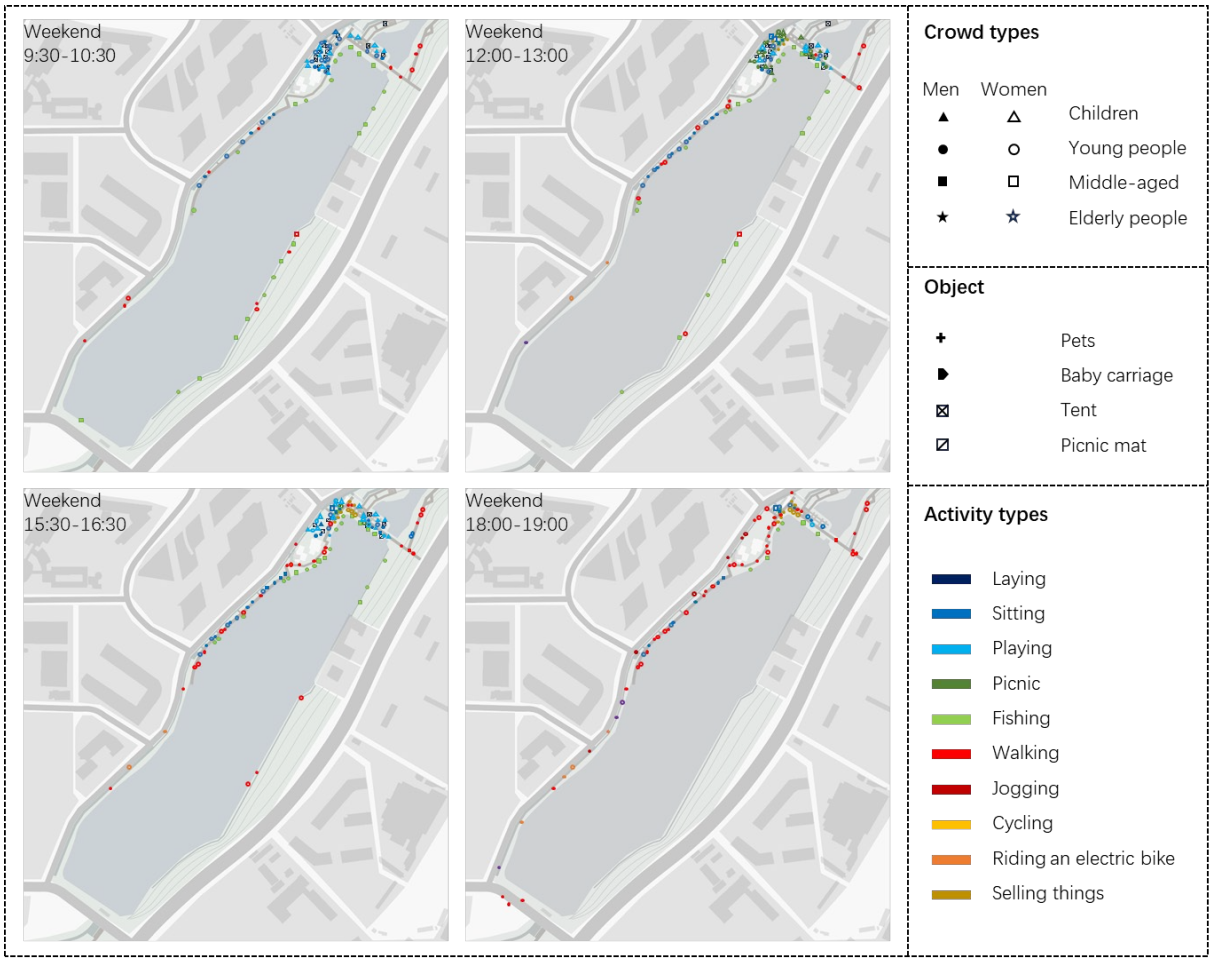


Figure 5- 30 Notes on crowd activities on weekend in the midstream (self-drawn)

Visitors like to gather for picnics on the upper convex woodland in the middle of the upper wetland that is heavily wooded and has wide water views. The further north you go, the fewer users there are, and the North Gate Square is extremely under-utilized due to the lack of landscape. Picnic visitors are basically families, with parents and elders bringing their children or two or more families traveling together. Some picnickers are couples or friends. Picnic stay time is proportional to the number of people traveling, the more people traveling, the longer the stay. Generally by parents stationed picnic mats, tents, canopies and even stove tables and chairs, children accompanied by some of the adults in the pond fishing, catching bugs, the rest of the parents stay in place to prepare food. The source of food is usually their own fruit and bread or cooked on site, some people also choose to call for takeaway. There were also a number of young visitors taking photos of the Lotus Pond and the Larch Grove in the grounds.

The main activity of the crowd in the middle reaches continues to be fishing and resting. On sunny weekends there are many more people fishing than on weekdays, especially on the

east bank of the reservoir. Compared to weekdays, there are also many more people walking on the trestle, who typically stroll to the south end station in the evening after a trip upstream.

Figure 5- 31 Activity types of downstream crowd on weekends (self-drawn)

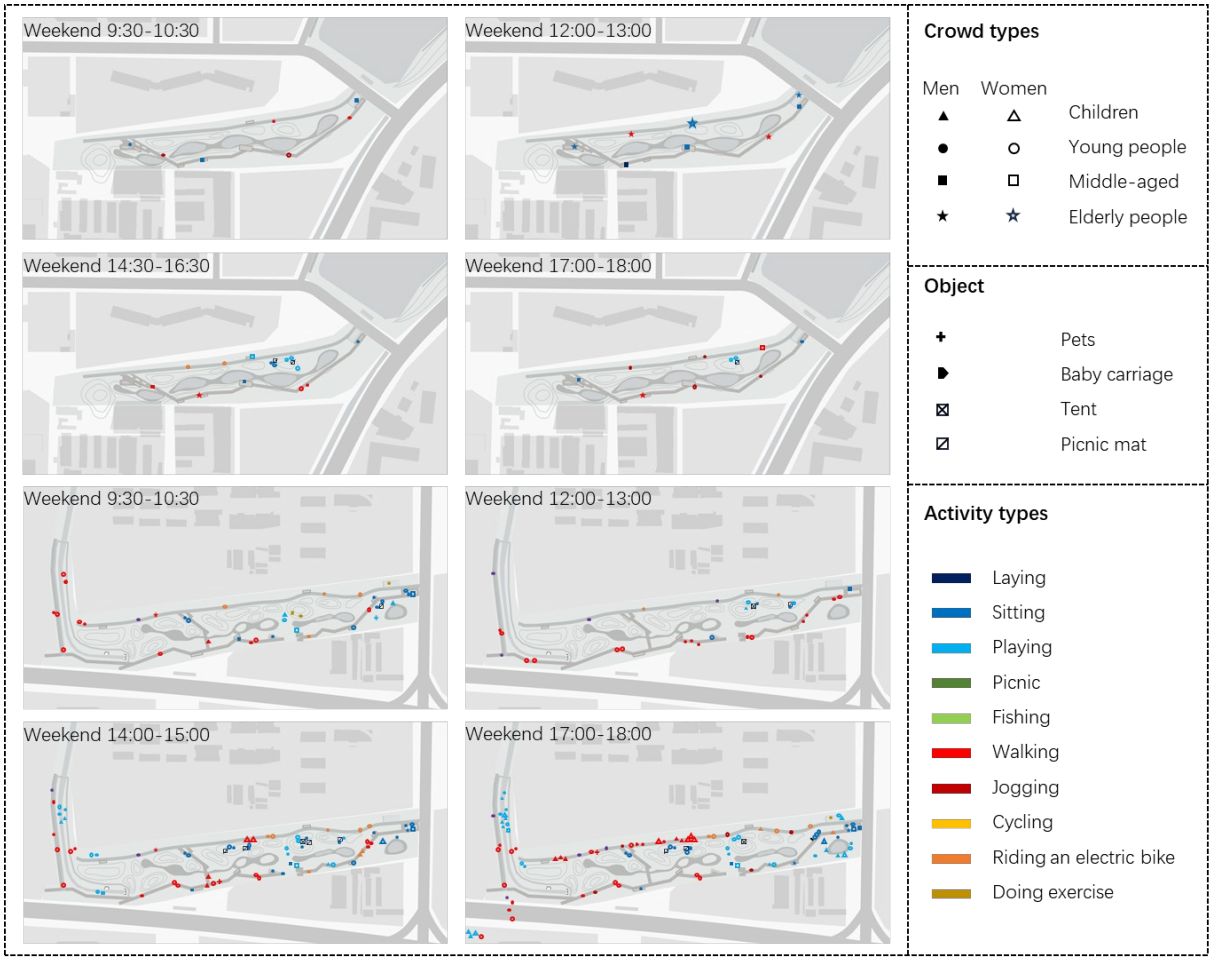


Figure 5- 32 Notes on crowd activities on weekend in the downstream (self-drawn)

The downstream two zones had much less weekend use compared to the upstream. The downstream west zone was again more crowded than the east zone, and the park became active in the afternoon. People were taking circular walks, walking their dogs, running, and biking on the trestle and bike paths, while relatively static activities such as jumping rope, stretching, and

resting were taking place in the plaza. Some others played badminton in the stomped-out open spaces. And there are also people camping and picnicking and taking photos in areas with fewer trees and more sunlight.

(ii) Behavioral trace records

Behavioral trace observation refers to the inspection by walking through the whole park and carefully observing the behavioral traces left by users in the environment, which is used to judge the user's habit of use and serves as an important basis for the subsequent spatial transformation. There are three kinds of traces on the site: the first is the accumulated traces, i.e. traces gradually accumulated from material debris, such as cigarette butts, empty beer bottles, sugar paper, etc.; the second is the worn traces, such as stepped paths, peeled paint, loose equipment, etc.; the last is where there should be traces but there are no traces, such as no footprints in the sand pool.

The author recorded the behavioral traces of Tianhe Wetland Park on March 22 and May 7, 2023, observed the behavioral traces left by the users in the garden, and drew the following drawings. As can be seen from the drawings, the main traces are wear and tear type traces due to less hard paving and more plant greenery in the park, as shown below:

In the upstream area, people will step out on their own in grassy areas that need access but are not paved. Since there is not much east-west access between the west sidewalk and the trestle, visitors often step directly onto the grass to enter and exit the park, and some parents traveling with infants will carry their strollers out of the park from the concrete walkway. Some of the walkways are designed to be too zigzag in order to solve the problem of elevation difference, and people tend to take shortcuts, so they will choose to step on the grass slope directly to their destinations. There are a number of wetland bubbles upstream, and many visitors like to walk to the edge of the wetland bubbles for activities such as fishing and playing in the water, so almost every edge of the wetland bubbles will be trampled with path marks. At the same time, because not every wetland bubble has a trestle connecting the east and west sides, many tourists choose to cross the grass between the wetland bubbles directly to form a road.

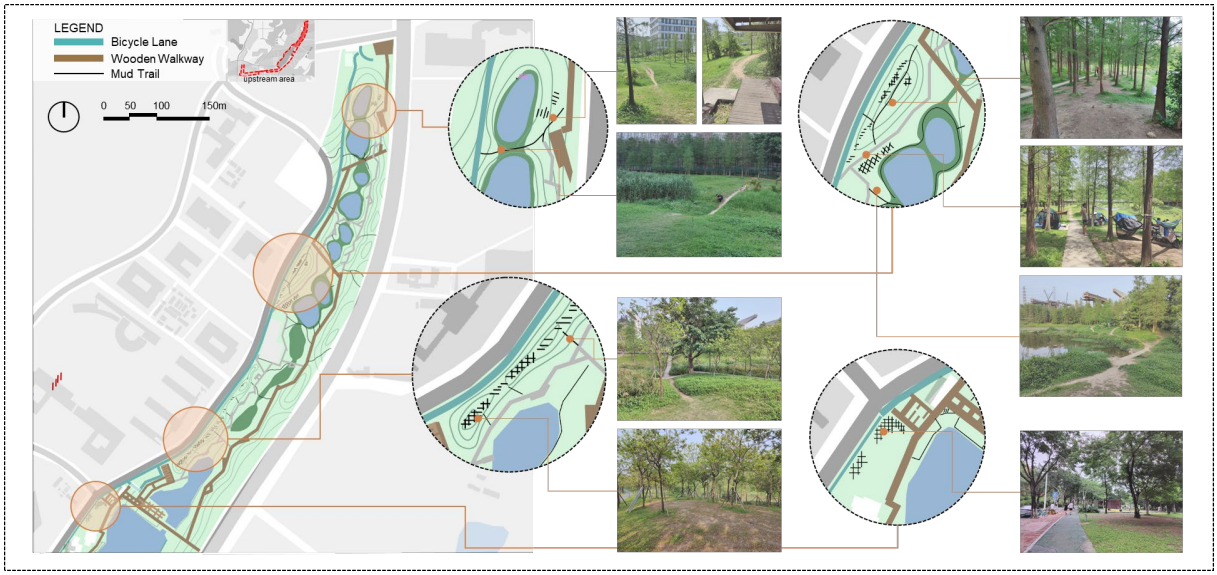


Figure 5- 1 Upstream Behavioral Trace Notation (Self-Drawn)

As a number of visitors like to bring their own picnic mats, camping tents, etc. for picnic activities, the location is usually chosen on the west side of the upper convex grassland, so the top area of the grass slope is more often than not trampled bald. Some people trample the grass and compact the soil, which reduces the ability of the grass to infiltrate rainwater. Some visitors celebrated their birthdays by having picnics in the woods, and the plastic fragments from the firecrackers they brought along were scattered on the grass, making it difficult to clean. On the whole, however, the sanitary environment of the park is relatively good, and there is little garbage in the grass and woods.

The middle reaches of the New Pond Reservoir are a large area of water with a small area of grass, but at the intersection location, some of the grass has been stepped out due to the need for some bicycles to cross the arborvitae planting area from the bike path to turn to the west side of the building or the roadway. And also due to people's preference for the approach road, a pavement has been stepped out between the sidewalk and the waterfront walkway, and people have laid tiles on the road to prevent slipping. According to the above observation, fishing rods are placed here for fishing.

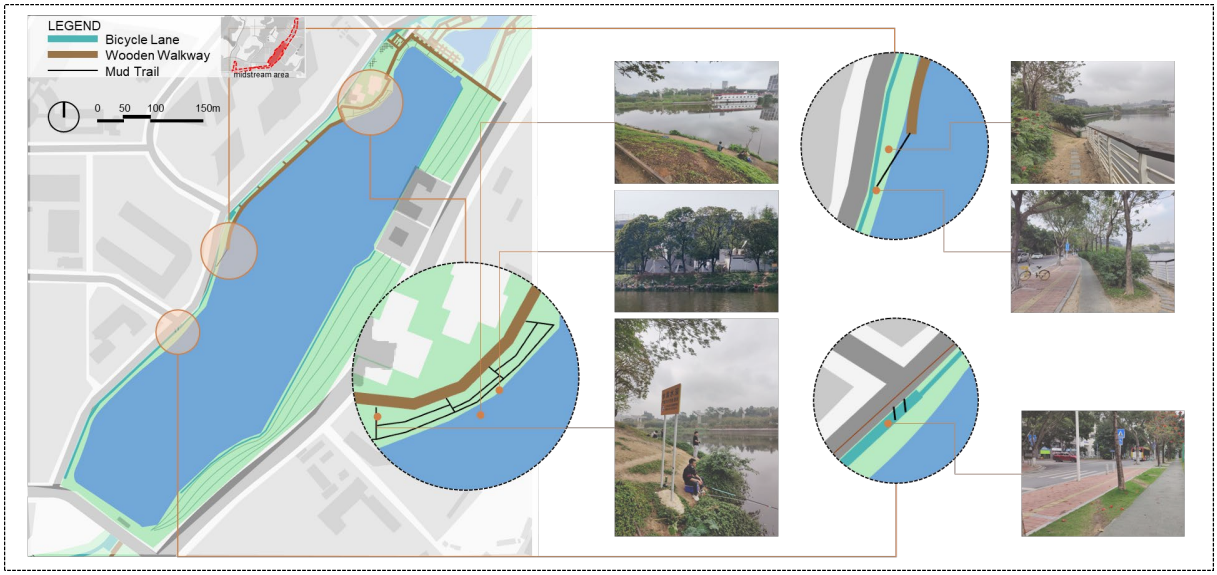


Figure 5- 2 Midstream Behavioral Trace Notation (Self-Drawn)

The lower east side of the park shows fewer signs of trampling because it is less heavily used, more heavily wooded, and has fewer connecting surfaces to external paths. However, since there is only one large loop road in the park, a dirt pathway trail appears in the center of the park loop road that passes by the wet pond and connects the bike path to the north and the wooden trestle to the south. In the open area of the fence at the southeast corner of the Wisdom World Plaza, there is a small patch of grass that has been stepped on because employees of the plaza often gather to smoke and chat, so it can be seen that neighboring employees like to gather here. Due to the blockage of the construction of North Daguan Road to the east, pedestrians stepped out of the path in the eastern corner of the park to enter and exit, so it can be seen that a lot of people need to walk from the south to pass through this place.

The downstream west area is similar to the east area, also due to fewer connections between the bike path and the wooden trestle, with multiple shortcuts connecting the bike path to the wooden trestle appearing. At the same time, due to fewer trees, the open space of the upper convex green space attracts people to move around in this area, making many areas of the lawn have been completely trampled into mud, and deep wheel marks also appeared. In the southwest entrance, due to the lack of entrance paving and a large number of takeaway electric car traffic, the grass has also been stepped out of two obvious mud road. For the convenience of pedestrians, the staff laid tiles on the muddy ground, while electric cars continue to pass on the mud ruts, muddy in rainy days.

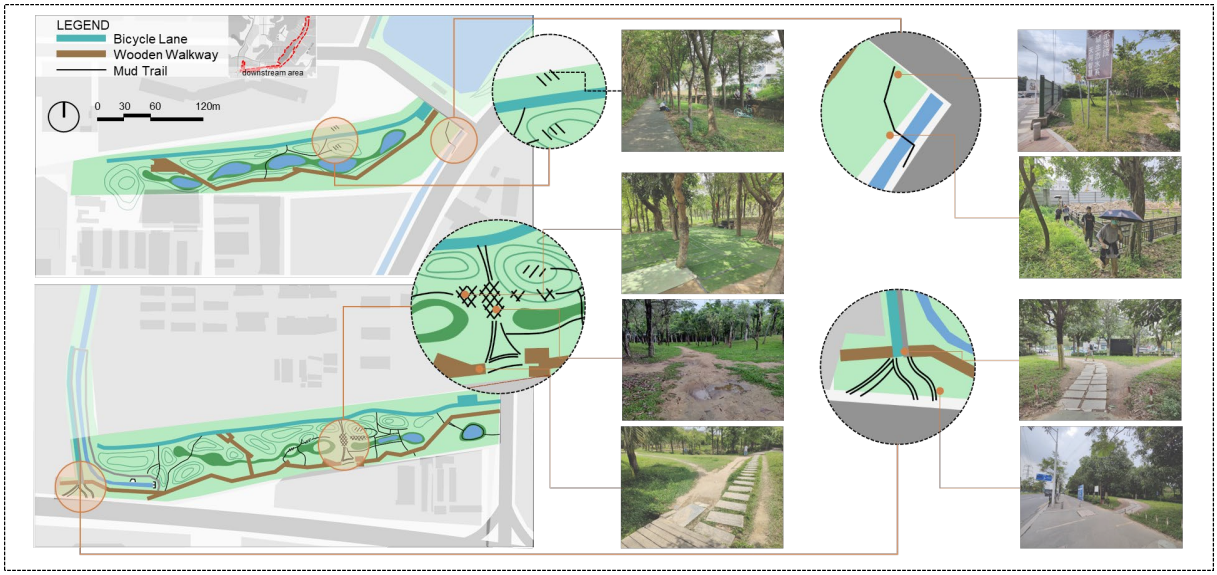


Figure 5- 3 Downstream Behavioral Trace Notes (Self-Drawn)

(iii) Questionnaires

The questionnaire can obtain the evaluation of various aspects of the activity site by a larger number of applicable people in a shorter time to understand the information that cannot be understood in the observation. The questionnaire was developed with reference to previous studies on the relevant requirements of sponge city construction and the construction of evaluation factors after the use of urban parks, and combined with the actual situation of Tianhe Wetland Park.

The questionnaire is divided into three parts. The first part is the basic information of users, including four objective contents of users' gender, age, occupation, and place of residence. The second part is the basic information about the users' use of the park, including eight items: mode of transportation to the park, time needed to come to the park, companions, purpose, length of stay, frequency, preferred area, and frequently traveled road. The third part is the users' satisfaction evaluation of the park, including the natural environment, artificial environment and site management with a total of 21 items, all of which are positive descriptions of the park's evaluation indexes, and evaluated statistically by setting up five grades: strongly agree, agree, basically agree, disagree, and strongly disagree. The last part is an open-ended question for users to fill in what they think needs to be improved in the park.

The questionnaires were distributed in the form of paper questionnaires filled out on-site and collected on-site. In order to ensure the objectivity and accuracy of the survey results, the

research time includes different periods of holidays and working days, and the samples try to cover various types of tourists. Questionnaire distribution time were for April 16, 2023, April 17, April 22, May 22, a total of four days, issued 112 paper questionnaires, 106 valid questionnaires. The statistical results from the questionnaire are as follows:

①Type of user

As the gender and age of the users can be obtained from the above observation statistics, the main concern of this questionnaire about the type of users is the content that cannot be directly observed. According to the statistics of the questionnaire survey, most of the visitors of Tianhe Wetland Park come from Tianhe and Huangpu districts, and the main ways to come to the park are private cars, walking and electric cars. The length of stay is generally greater than two hours for those who come with their families, while the length of stay for those who visit with friends or alone is generally less than two hours.

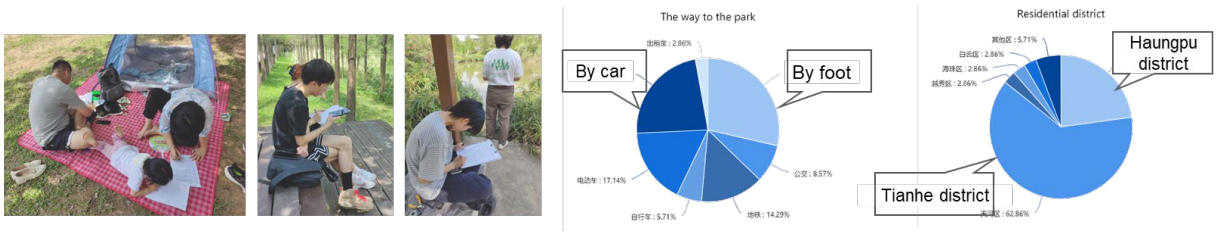


Figure 5- 4 Questionnaire completion and main user types (self-drawn)

②Evaluation of the Park

Visitors to the park overall evaluation of the park is good, the garden plant species rich, fresh air recognition is high, but the garden mosquitoes, shade and rain, the number of restrooms, food service and other four more dissatisfied, while sports facilities and sponge city signs there is still room for improvement.

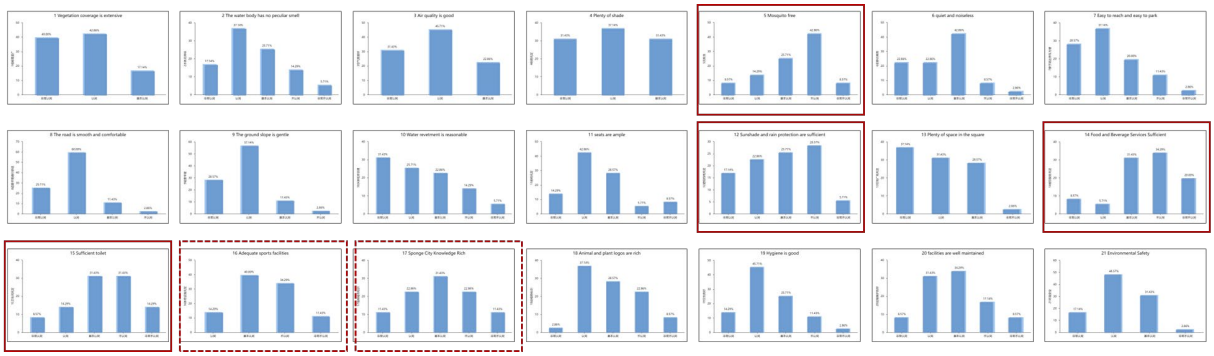


Figure 5- 5 Questionnaire statistics for evaluation of parks (self-drawn)

(iv) Interviews

In order to gain a more in-depth understanding of how different groups of people in the wetland park feel about using the park, ten users and three managers were randomly selected in different areas for free interviews. The ten users included young women picnicking with their children in the upstream, young men selling starch sausages, and middle-aged women selling Yakult; middle-aged men resting and middle-aged men fishing in the middle reaches of the park; and elderly men walking in the lower reaches of the park, elderly women walking in the lower reaches of the park, young women after a run, young men after a run, and young men resting in the lower reaches of the park. The three managers were the former manager of the Park Service, the park cleaner, and the New Pond Reservoir manager.

① Interviews with users

Respondents were satisfied with the green environment of the park, believing that the park was green enough, with a certain degree of shading and cooling effect, and that the air was fresh and suitable for playing, resting and walking and other activities. Respondents in the upper and middle reaches of the park thought the water was clear, but those in the lower reaches thought the water was muddy and had more mosquitoes.

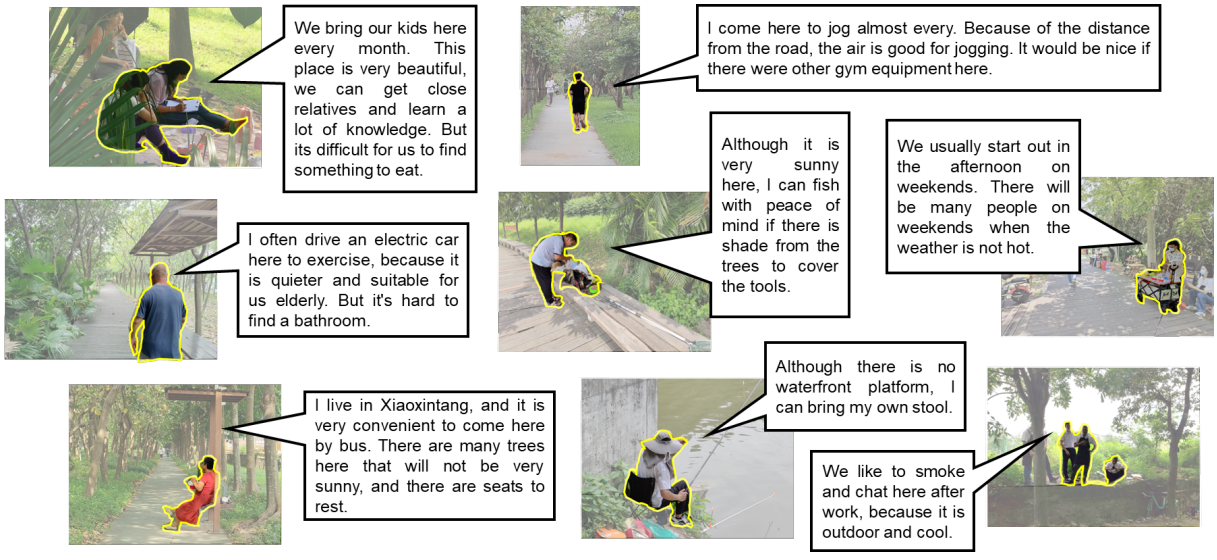


Figure 5- 6 Interviews with different types of users (self-drawn)

Most of the interviewees said that they did not know much about the term "sponge city", and only the interviewees who had picnics with their children said that they would pay attention to all kinds of science signs because they needed to bring their children to know the flora and

fauna, and that they would be able to learn the knowledge about "sponge city" from the signboards. However, they would like to see more detailed and vivid introductions, as there is still a lack of understanding when reading only words and sketches. When asked whether there is a need to increase the children's play area, parents said that they bring their children here because they want them to have more contact with nature and do not want to continue to focus too much on artificial toys such as slides.

For the situation of the park on rainy days, almost every week will bring their children to the park to play parents said that even on rainy days the water level here will not lift too much, when it is drizzling they will also bring their children to feel the rainy day park.

Interviewees exercising upstream described that their running was not limited to the track in the park, but would generally choose to run around the software park on the west side of the park, following Tianshun Road, Tianhui Road, and Sicheng Road for a lap of about 2.2 kilometers. In the section of Sicheng Road they would then enter the park's running track or wooden trestle to run. Respondents exercising downstream, on the other hand, were more likely to choose to run only inside the park, a lap of about 800 meters. And more exercisers preferred to run in the downstream East Zone than in the downstream West Zone because it was less crowded and quieter, and less sunny with dense trees. However, the downstream water body is more turbid and has more mosquitoes, so I hope it can be improved. Respondents all wanted the running paths to be safer and more level, and also suggested that they would like to add simple fitness equipment such as bars for strength exercises. Many respondents exercising downstream said they didn't realize there was a midstream and upstream part of the park to the north, or even that a downstream east end existed, indicating that not enough has been done to mark the park.

Vendors who set up stalls in the garden said that there are significantly more visitors in the garden in cold weather than in hot weather. In the fall and winter, the weather is dry and sunny, and the upstream cedars turn from green to red, which makes for a very nice view and is the most crowded season in the park. Vendors usually start their stalls at 3:00 p.m. on weekends and close them at night when it gets dark. The city police will show up from time to time to manage them, but after a while they can continue to come back to set up their stalls, and the

management is not very strict.

Anglers stayed in the park the longest, generally fishing on the east bank of the reservoir in the morning due to the angle of the sun, while more people chose to fish on the west side in the afternoon. Anglers said that if they had a choice, they would generally choose to place their belongings in a shaded area, but the swing needs to be as open as possible or the line can easily get hung up in the trees. A shaded area is better, but it's also nice to have a seat to sit on, and they typically bring their own folding stools and umbrellas.

The two elderly people interviewed both came from the Xiaoxintang residential area not far away, one came by his own electric car and the other by two buses, and both said it was very convenient for them to come to the garden. They usually choose to walk in the garden in the morning, circling along the bicycle path and wooden trestle. They said that there were more seats in the garden and they enjoyed the quietness, so they chose to walk here even though they knew that the view was better in other areas.

There was a strong desire among respondents, both young and old, for more toilets in the park, especially in the downstream area. Some respondents indicated that it would be more appropriate if there were drinking water facilities in the Park. Regarding the facilities in the Park, respondents generally indicated that the wooden flooring and stenciled seats were badly damaged, and they hoped that the Park could strengthen its management by replacing the damaged wooden boards.

② Interviews with managers

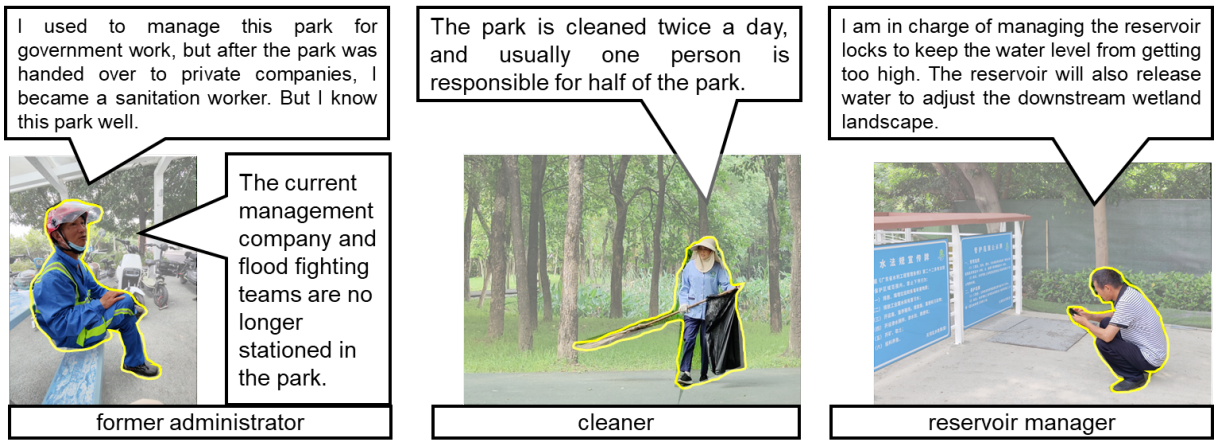


Figure 5- 7 Interviews with managers (self-drawn)

The Tianhe Wetland Park was managed by the Tianhe Wisdom City Management

Committee from the time it was completed and put into use in 2015 until 2021, when the committee handed over the management to two private companies, one responsible for the maintenance and care of the plants and facilities, and the other responsible for the cleaning and sanitation work. The Flood Resistance Brigade, which was originally set up in the central square of the park, has now moved out of the park. Two cleaners are now in charge of sanitation in the park, one for the downstream east and west zones, and one for the upstream and midstream, cleaning once in the morning and once in the afternoon.

Despite the fact that the vast majority of the park's area is free and open to the public, it did not have many visitors for some time after its opening, which is related to factors such as its distance from the city's central district, its low visibility, the unshaped effect of the botanical landscape, and the small number of company apartments built and put into use around the time of its completion. Therefore, the management committee promoted the park through social software such as Xiaohongshu and Jieyin around 2018, and then the number of people visiting the park gradually increased. During the epidemic period of 2020-2023, the number of visitors who brought their own picnic mats, tents and other tools to the park increased due to the decrease in the number of opportunities for people to go out and the increase in the number of people who chose to spend their weekends picnicking and camping in the city's parks and green spaces. However, this also puts a strain on the park's cleanliness and facilities.

The basketball and tennis courts in the upper reaches of the park were popular with young people working around the area, but accidents have occurred due to equipment problems. After the accident, the management committee rebuilt the basketball and tennis courts and adjusted the number of tennis and basketball courts, but they are still not open to the public.

During the management period, the management company would drive away tourists who were found fishing in the New Pond Reservoir. After the change of management company, there are still a large number of tourists fishing at the poolside of the Xintang Reservoir, but the management company no longer drives them away.

The water level in the reservoir is controlled by special inspections and is photographed and reported daily. If there is a rainstorm warning then the gates will be opened in advance to release water to the south spillway, reserving a place for reservoir storage. The water level in

the downstream wetland is also regulated by the reservoir, and if insufficient water is observed in the downstream landscape then another specialized gate will be opened to release water.

5.4 Summary of the situation

5.4.1 Water treatment

(i) Meet certain flooding functions:

Upstream, a number of wetland bubbles were dug out while earth was balanced and piled up on either side, creating a large enough space for water to flow through. However, the downstream wetlands were adjusted by opening the reservoir gates to adjust the water level, which was low and not mobile on a day-to-day basis. Moreover, according to the reservoir manager, the most commonly used method of flood relief is actually to use the flood relief channel at the south end of Xintang Reservoir for flood relief, and the downstream wetland is more of a landscape function.

(ii) Weak capacity to respond to storm water from surrounding sites:

Except for Daguan North Road on the east side of the upstream, which has culverts to discharge the road stormwater into the wetland, there are no piping facilities to drain water into the wetland from the adjacent road surfaces in other parts of the wetland. Due to the convex topography between the road surface and the wetland bubble, the catchment design of Sicheng Road on the west side of the upstream is not designed to divert the water from Sicheng Road into the wetland, but rather from the north to the south through the underground pipeline network into the software road, thus failing to alleviate the drainage pressure on Sicheng Road when the instantaneous heavy rainfall comes, resulting in a certain amount of water accumulation. There are mostly trees and fewer shrubs in the site, and visitors can freely traverse the site and often picnic on the upper convex grassland on the west side of the upstream wetland. The trampling of visitors has compacted the land and reduced the infiltration capacity of rainwater.

The middle reaches cannot discharge untreated road stormwater directly into the site due to the reservoir. The downstream east area is adjacent to research and industrial and commercial

sites to the north and south, but fails to take on drainage from these two sites.

The commercial land immediately adjacent to the north and west of the Downstream West Area has not been developed and is now a weed green area; the south side is connected to Hua Guan Road, but it also fails to undertake road drainage due to the difference in sidewalk heights and the occupation of land by the construction unit of the Deep Tunnel Project. In the event of instantaneous heavy rainfall, it fails to alleviate the drainage pressure on the municipal pipe network, resulting in flooding on the road.

(iii) Poor water purification results:

The water quality of the upstream wetland during the non-rainy season has been improved after sedimentation and purification in a number of wetland bubbles, but the culverts on North Grandview Road are distributed from north to south, which will discharge untreated road stagnant water directly into the stabilized ponds that have already been purified and treated, thus affecting the quality of the ponds' water.

The water source for the downstream wetland is obtained more through the opening and releasing of the New Pond Reservoir, in addition to the rainwater within the site. The water in the Xintang Reservoir is water that has already been purified and does not need to be purified again. As the design flow direction of the wetland is opposite to that of the Yangmei River on the west side, the wetland is unable to introduce the water of the Yangmei River stream for purification, and there is no use of pumping water for purification as in the case mentioned above, so that the purification effect of its artificial wetland for the neighboring streams and rivers can not be realized. The water downstream is static for a long time due to the lack of a stable water source, resulting in the breeding of mosquitoes and poor water quality.

(iv) Not forming a system with other sponges in the city

Tianhe Park failed to form a connected sponge system network with other surrounding green spaces. The connectivity between the water area inside the site and the water area outside the site is interrupted by other urban spaces, and it is difficult to complete the smooth flow of water during the rainstorm. There is no effective connection between park green space, residential green space, protective green space and subsidiary green space, and a green space system network has not yet been formed. It is difficult to deal with the current urban rain and

flood problems in Guangzhou. This is the same problem as other sponge city projects in Guangzhou.

5.4.2 Ecological protection of wetlands

(i) Failure to play a role in protecting waterbirds: Although named a wetland park, the shape is similar to a linear strip, the depth is small, and all four sides are connected with urban roads, so it is not possible to reserve ecological buffer zones and ecological protection zones required for wetlands, and the park as a whole allows people to travel freely, and it only serves as a purification of water and a flood control and drainage, with a weak ecological protection effect on waterbirds.

(ii) Insufficient space for connecting parks with urban green corridors

The park is surrounded by various types of buildings and lacks continuous plant green corridors to guide birds to fly or animals to pass through, which reduces the possibility of water birds or other animals gathering in the wetland park.

5.4.3 Use of public space

(i) Functional use: there is a certain misalignment between the current state of functional use of the zoning district and the original design.

The upstream area originally designed for sports and fitness is now used more as a picnic and flower viewing area, while the downstream area featuring wetland flowers is now used more as a place for people to exercise and fitness. It is necessary to make some adjustments and additions to the functions and facilities to meet the needs according to the current situation and the intention of the users.

(ii) Transportation paths: abundant transportation paths for daily movement and play

The park's internal paths complement the city's slow-moving transportation system, with comfortable walkways and shady trees providing a good walking route for the daily commute of neighboring workers, away from motor vehicle emissions and avoiding the sunshine of Guangzhou's summer days. For visitors, the existing trail loops are slightly too large, and in

some areas there are fewer connecting paths between the two parallel trails, allowing people to spontaneously step out of the path, so the paths need to be optimized to some extent.

(iii) Public space: insufficient connectivity between border areas and the city, waterfront space needs to be upgraded

Some of the boundary space in the park that are connected to the city fail to create a good connection with the surrounding city due to height differences, fences, and flora. Some of the square spaces in the park have a weak relationship with other public spaces in the city. In terms of waterfront space, the number of anglers in the reservoir area is high, but there is a lack of safe platforms and railings in some areas; and there is a lack of waterfront space design on the banks of the Yangmei River. Some optimization of this is needed to maintain the ecology while ensuring the safety of visitors' use.

(iv) Services: Inadequate sanitation, catering and other services:

As a park with a large area, there are no restrooms in some parts of the park, and only two restrooms, one near the North Gate entrance where few people stay, and one in the Central Plaza where many people use. There are only two restrooms, one near the north gate entrance and one in the central plaza, which are used by many people. There are no accessible restrooms and no third bathroom, which is inconvenient for families with small children, who are the main users of park vacations.

(v) Science guides: poor readability of guides and science systems:

The map guides are not clearly labeled, and users are not clear about their relative position to the park, and do not even know that there is another part of the park not far away from the next door. The interactive nature of the science popularization system is weak, the presentation is a bit stiff, the height of some science popularization facilities is not convenient for all ages to read, and due to maintenance problems there are also broken. Therefore, the location of the signage and the form of presentation need to be carefully chosen to enhance legibility, durability and interactivity.

5.5 Summary of the chapter

This chapter analyzes the operation status of Tianhe Wetland Park in Guangzhou by using

various research methods. The site is surrounded by city roads, but some areas are wrapped inside the site and do not have good access to the city. Most of the surrounding site has been constructed and there exist some areas to be renovated. There are fewer public spaces such as city squares, which are mainly concentrated in the downstream surrounding area. Due to the pursuit of economic benefits in the former planning, a number of water ponds around the site were filled in and lost their rainfall and flood storage capacity. The newly constructed Tianhe Wetland Park utilizes the method of excavating wetland bubbles to recreate the original pond form of the site. However, due to the difference in elevation and the imperfect drainage network, the wetland bubbles were seriously contaminated during heavy rainfalls and failed to effectively alleviate the problem of waterlogging in the surrounding sites. The survey on the use of the park found that tourists like to go to the wetland park for picnic, camping, catching fish, fishing and other activities on weekends when the weather is sunny. Visitors were more satisfied with the natural environment of the Park and hoped that the provision and maintenance of public facilities could be further enhanced. Due to the increase in visitor activities, the natural ecology of the park has been affected to a certain extent, with the grass being trampled bald and the soil being compacted, which to some extent affects the rainwater infiltration capacity of the green space. The detailed research in this chapter will provide a strong basis for the subsequent renovation design.

Chapter 6 Optimized Design of Tianhe Wetland Park

6.1 Optimization Strategy

In response to the various problems of the park and the surrounding area identified in Chapter 5, the following targeted optimization plan is formed by extracting the needed and suitable design methods from the design strategy toolbox in Chapter 4.

The proposal is divided into two parts: Optimization Design of the Park and Surrounding Neighborhoods, and the Detailed and optimized design of the park interior, which seeks to simultaneously meet the three major design objectives of enhancing the vitality of the public space, solving the city's water problems, and preserving the ecology of the city's wetlands.

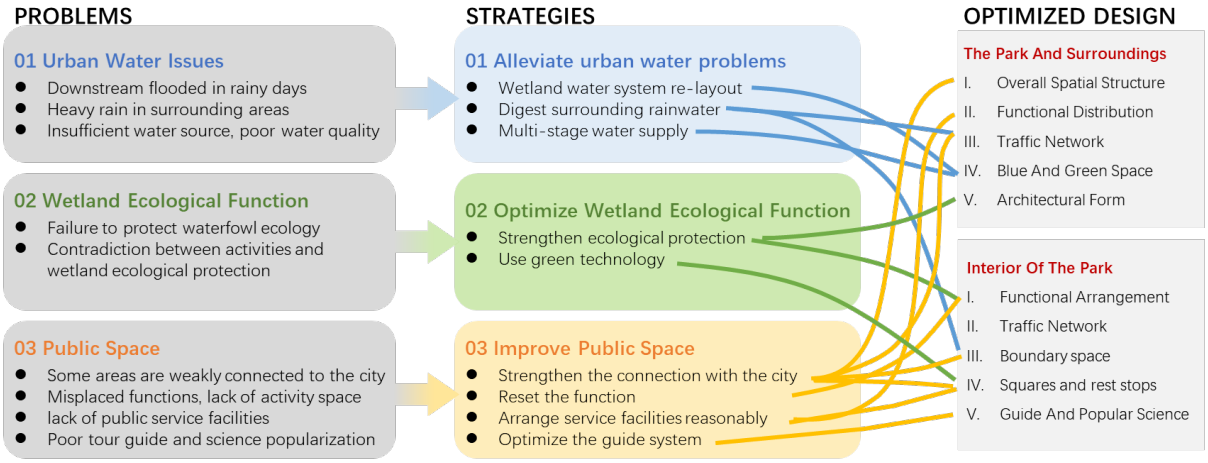


Figure 6- 1 Selected design strategies and corresponding program implementation (self-drawn)

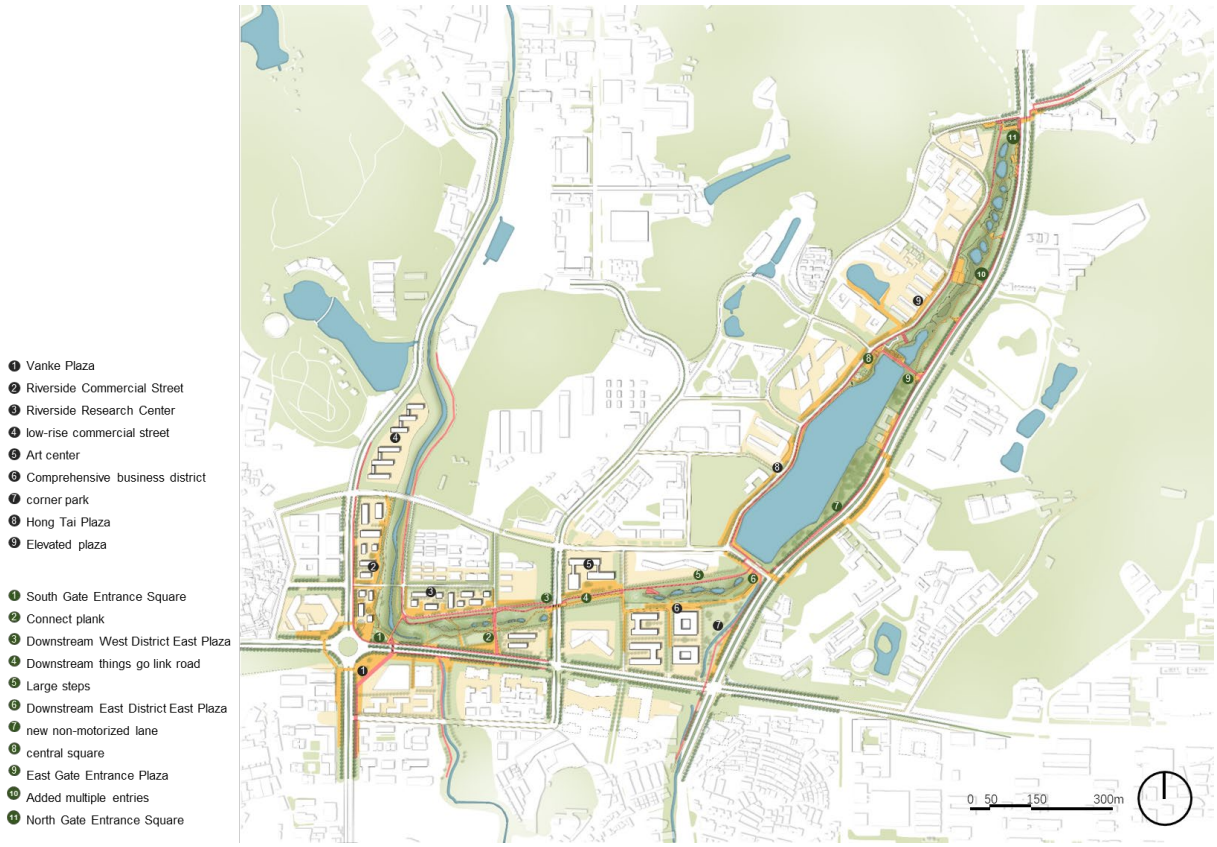


Figure 6- 2 Master plan (self-drawn)

6.2 Optimization Design of the Park and Surrounding Neighborhoods

6.2.1 General spatial structure

The optimized design will strengthen the connection between Tianhe Wetland Park and the surrounding neighborhoods in the longitudinal and transverse directions, enhance the interpenetration of the park's leisure, recreation, and sports functions with the commercial, office, and residential functions of the surrounding urban buildings, and comprehensively enhance the overall vitality of the park and the surrounding neighborhoods.

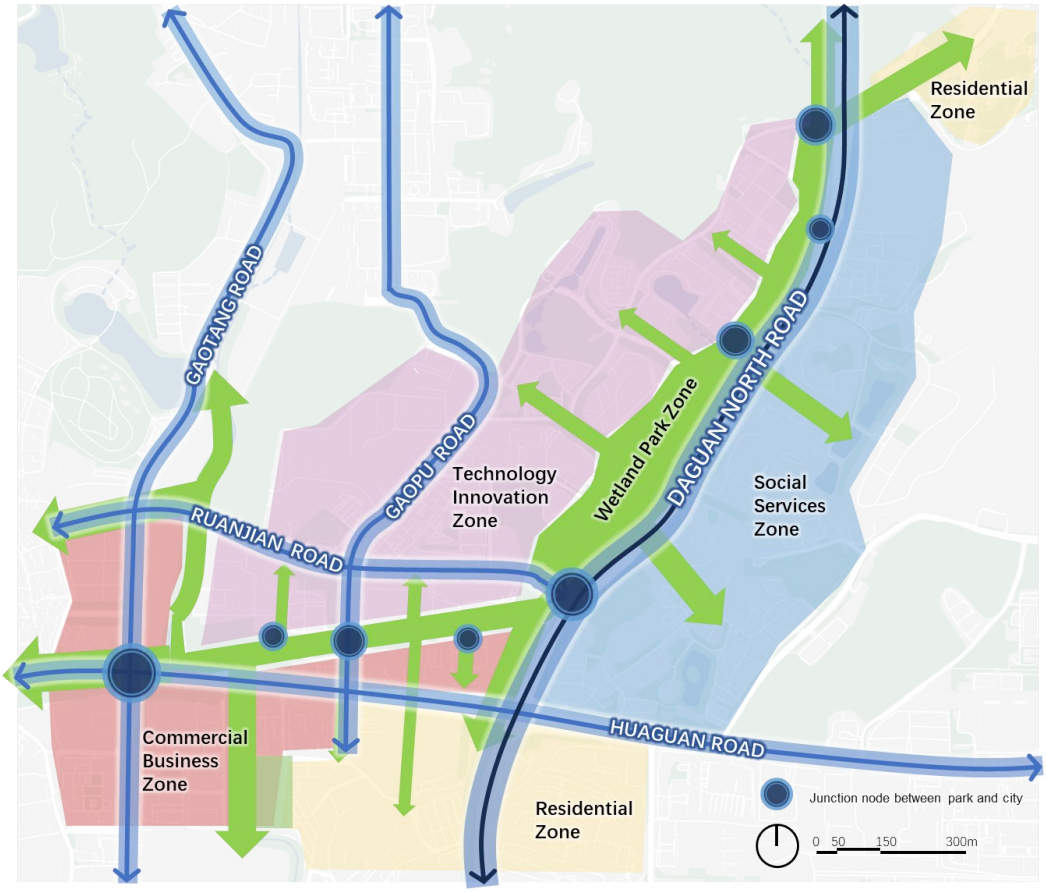


Figure 6- 3 General Structure of the Park and Surroundings (Self-drawn)

6.2.2 Enhanced functional layout

The area enclosed by the road connected to the park is the scope of this part of the optimization design. According to the current construction status and planning requirements, the park is divided into four functional areas. The park serves as a green public space, connecting the surrounding areas and strengthening the interaction between the functions of the areas. The surrounding areas are also interpenetrated with the park, which provides a good outdoor recreational space for the neighboring workers and residents, and the neighboring buildings provide catering and shopping functions for the park.

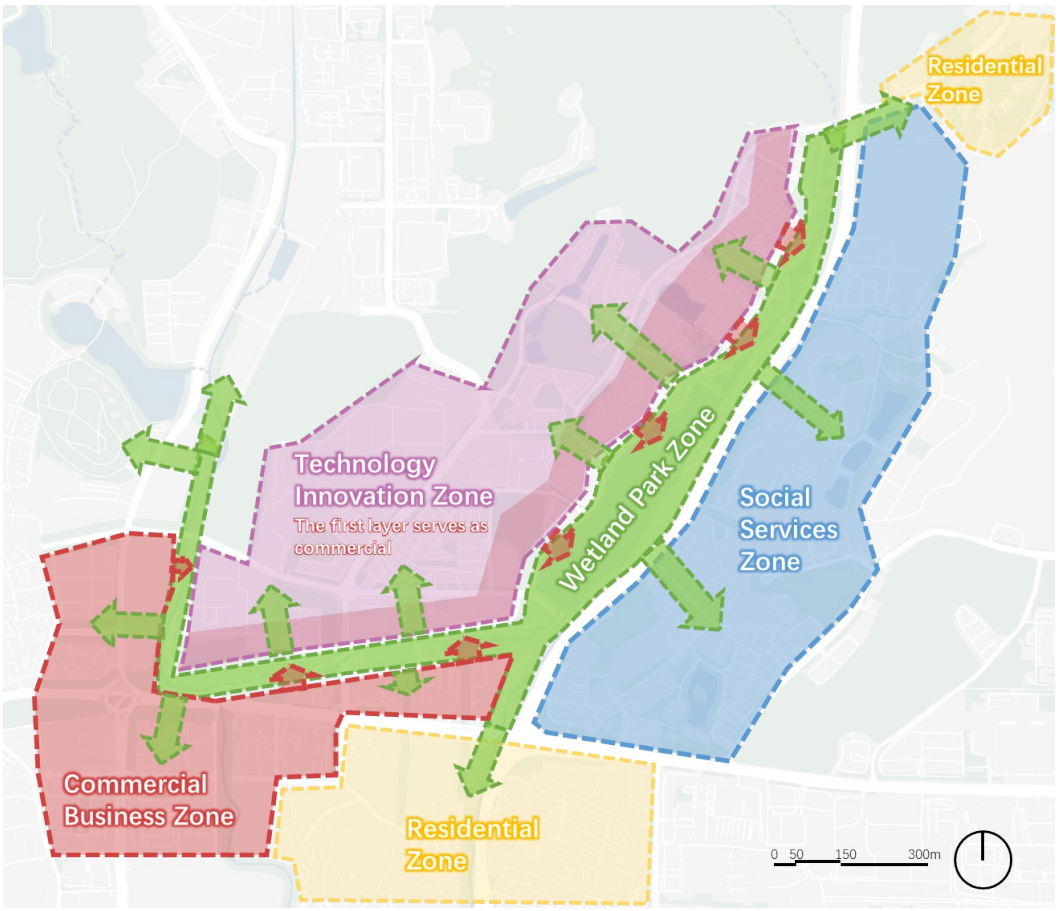


Figure 6- 4 Interpenetration of Parks and Urban Functions (Self-drawn)

For example, the arrangement of catering facilities, as the wetland park requires high ecological environmental protection, it is easy to pollute the environment by building a separate restaurant in the park. And there is a big difference between the park's holiday and weekday flows, making it difficult to form a stable source of visitors. It is difficult to satisfy a large number of visitors with a small number of restaurants during the peak travel season, and the number of visitors on weekdays or during the off-season of travel is too small, which will adversely affect the operation of restaurants.

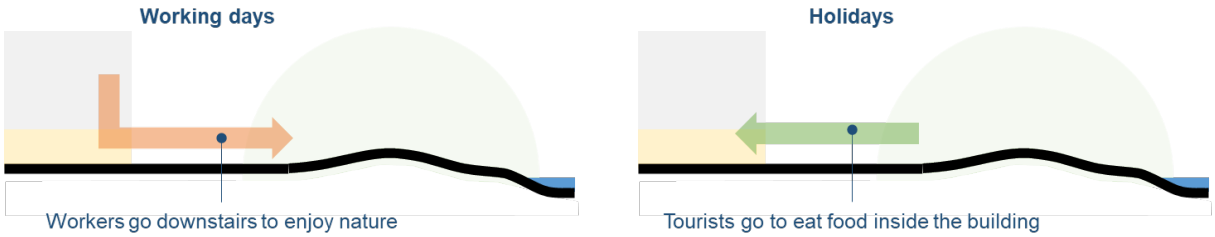


Figure 6- 5 Different activity scenarios for holidays and working days (self-illustrated)

The Tianhe Wetland Park is surrounded by a large number of science and technology parks

and business facilities, so it is possible to develop the ground floor elevated area and stores into a catering area, shifting the pressure of food and beverage services from inside the park to outside the park. As the Tianhe Wetland Park does not require an entrance ticket, visitors are free to enter and exit the park many times. With enhanced transportation connectivity between the park and the surrounding areas, the park is easily accessible on foot.

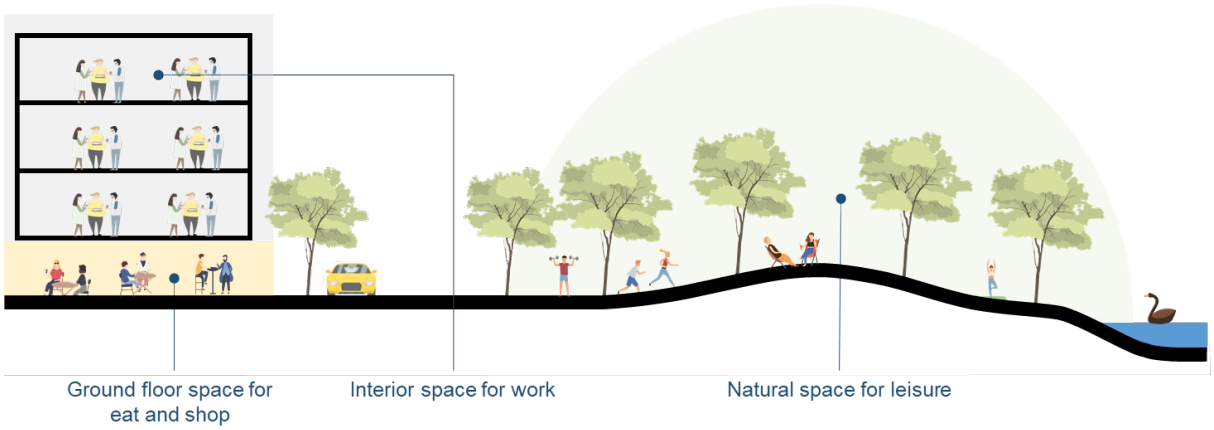


Figure 6- 6 Park's restaurant function placed within a city building (self-drawn)

6.2.3 Optimization of the design of the traffic road network

Tianhe Wetland Park is surrounded by urban roads, and the design of the surrounding roads directly affects the development of the park. The accessibility of the road is directly related to the convenience of people using the park, and the main direction of pedestrian flow on the road determines the main entrances and exits of the park and so on. Therefore, in this design, I optimize the design of the park and the surrounding roads mainly from the following two parts.

(i) Layout of the road network

In terms of the road transportation system, several side roads are added to the downstream part of the park to connect with secondary roads in the city, so as to enhance the connectivity between the park and the public space in the city. Avoiding the park being wrapped up in urban buildings and becoming the back garden of some of them.

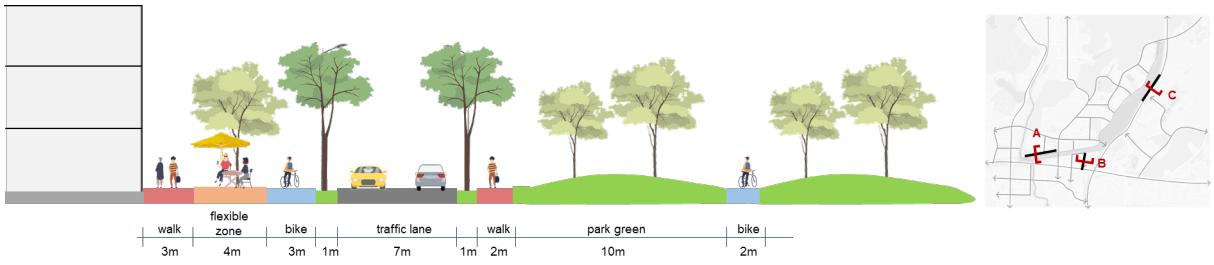
Figure 6- 7 Road Traffic System (Self-drawn)

In terms of the slow-moving transportation system, bicycle lanes and sidewalks are optimized according to the width of different lanes, and bus stops and subway stations are connected to complete the last kilometer from the station to the destination. The system guides people to use "walking/bicycle+public transportation" to alleviate traffic congestion. At conflict points where different modes of transportation are intertwined, priority will be given to walking and bicycling, and barrier-free overpasses and underpasses will be used to build an unobstructed slow-moving network.

Figures 6- 8 Slow-moving transportation system (self-drawn)

(ii) Road section design

The greening design of the road matches the original greening of the wetland park as a whole, and the species and colors of the existing plants in the wetland park are considered for selection. The green belt of the road uses depressed green space or bioretention pond for water storage and purification, and discharges the surrounding road rainwater into the wetland park through the underground pipe network or ground grassing ditch, gravel ditch and other transportation facilities to become the water source of the wetland park and enhance the comprehensive utilization of road rainwater.



Figures 6- 9 A-A New Roadway Cross Section (Self-Drawn)

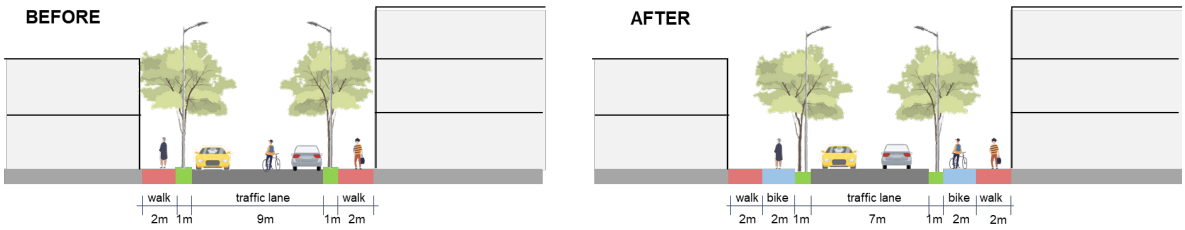


Figure 6- 10 B-B Improvement Roadway Cross Section (Self-Drawn)

For roads adjacent to or in close proximity to parks, increase the percentage of sidewalks and non-motorized paths based on their grade and access needs to enhance the pedestrian experience. For example, as a new road adjacent to the park within the surrounding park site, space for pedestrian, outdoor dining, and bicycle paths can be left between the commercial street and the road to fully utilize the park landscape. As a renovated and added roadway perpendicular to the park, sidewalk and bikeway widths can be increased during subsequent alterations by reducing lane widths and increasing building setbacks. North Grandview Road can be converted from a sidewalk-only area to a sidewalk, separate bike lane and green separation zone by rationally separating existing sidewalks, reducing motor vehicle lane widths, and borrowing green space from the park.

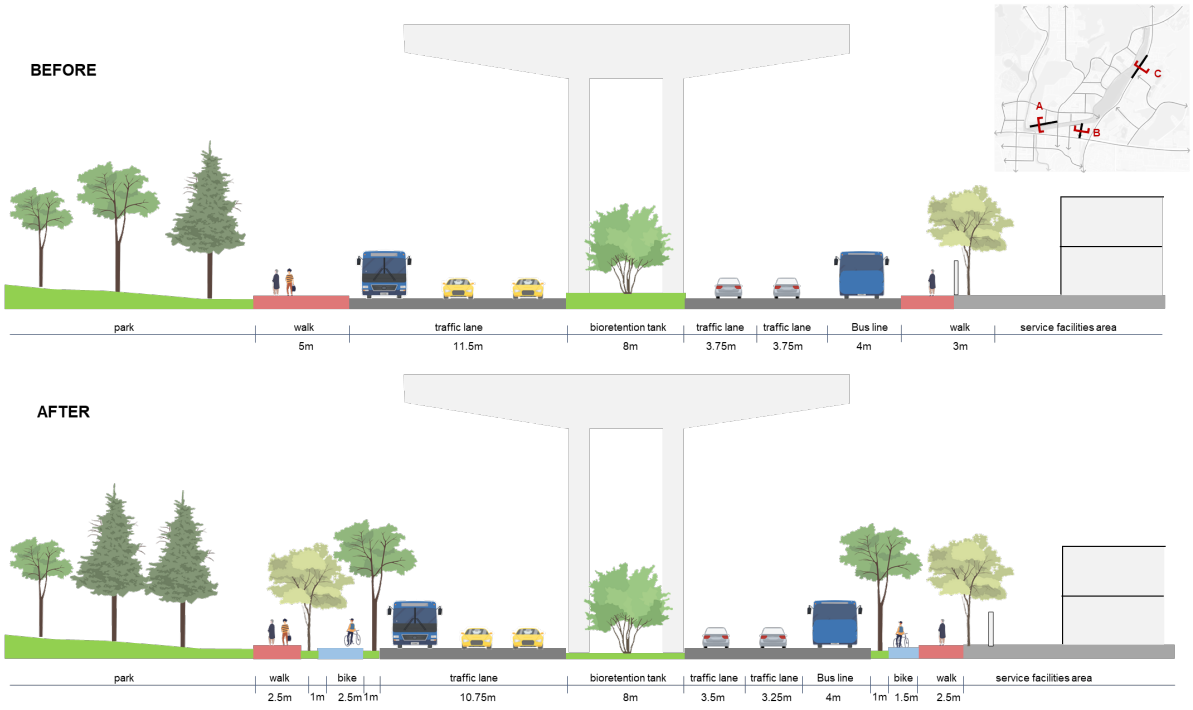


Figure 6- 11 C-C Improvement Roadway Cross Section (Self-Drawn)

6.2.4 Optimization of blue-green space design

(i) Spatial optimization of water systems

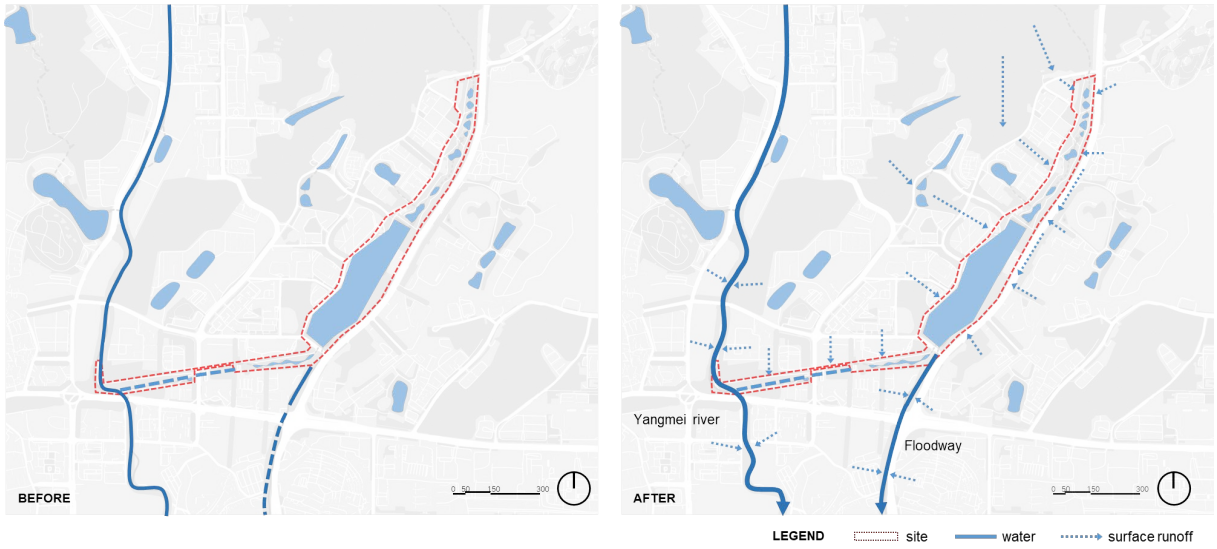


Figure 6- 12 Comparison of spatial optimization of the water system (self-drawn)

The water systems around the site that have a direct connection to the park are the Yangmei River and the Xintang Reservoir spillway. In order to cope with the increasing stormwater runoff, increase the residence time of water in the river, and reduce the downstream drainage pressure when heavy rainfall and flooding come, this design makes the following optimization assumptions.

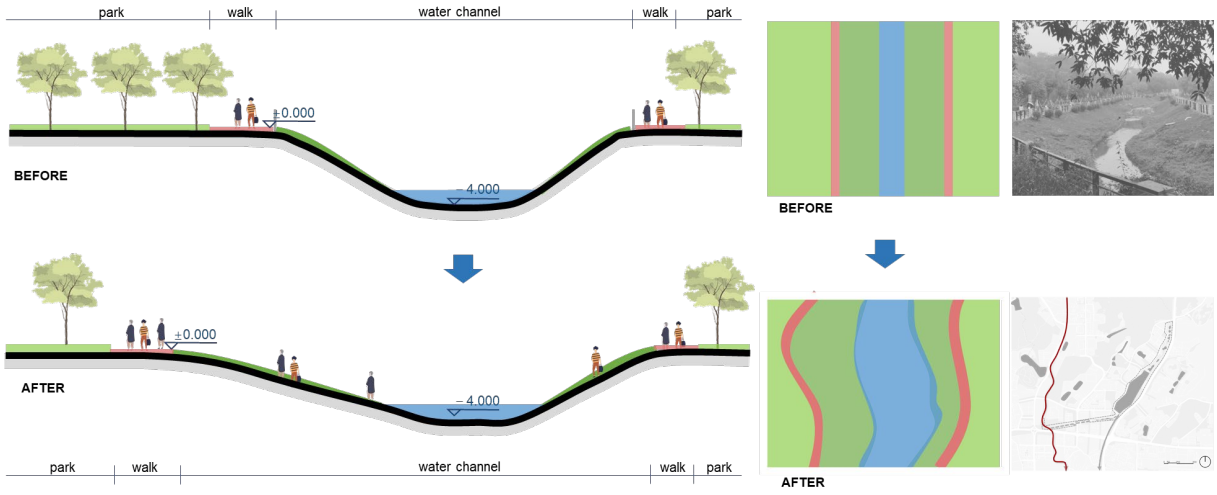


Figure 6- 13 Optimization of the Yangmei River Watercourse (Self-Drawn)

The Yangmei River system retains its natural curves and slopes down to widen the buffer space, slowing down the flow of the river while providing a venue for maintaining ecological diversity on both sides. The slower gradient also makes it easier for people to approach the water body without having to risk slipping and falling over the railings to get down to the river.

Along both sides of the river, green space and plants are used to set up walking and recreational areas, and the shoreline is set up in layers according to different water levels to meet the needs of different water depths.

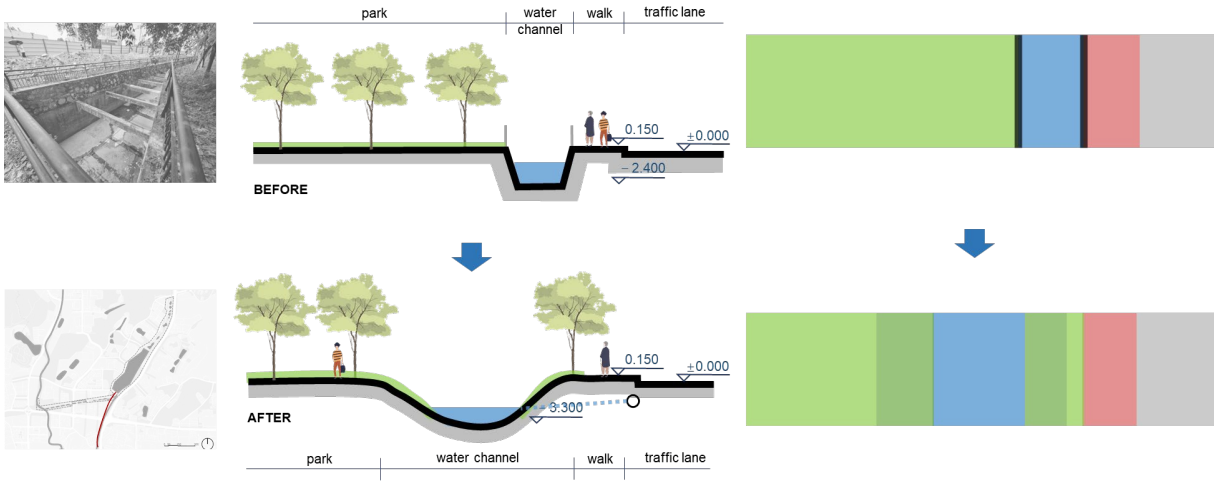


Figure 6- 14 Optimization of Spillway Channel (self-drawn)

The flood relief spillway of the Xintang Reservoir is converted from concrete to a natural river channel, increasing the time of water flow in the transportation process, slowing down the time for water to reach the Pearl River during the flood relief, and reducing the flood relief pressure. The greenway form connects the residential area to the south, providing a good environment for a large number of residents to walk to the park.

(ii) Green space optimization

Figure 6- 15 Comparison of green space optimization (self-drawn)

Through appropriate planting, the park is connected to the neighboring green space

systems and the connection between the park and the outside world is strengthened. The connected green space system provides shade and outdoor space for human beings as well as ecological space for birds. According to the plan, some of the existing buildings will be demolished in the future to restore the urban green space. At the same time, the green space can be embedded to increase the organic integration of green space and architectural space when designing the pending part of the building.

6.2.5 Neighborhood Building Morphology Control

In order to ensure the landscape effect and ecology of the wetland park, and at the same time fit the climate characteristics of Guangzhou, it is necessary to avoid the construction of too high and large buildings around the park. In order to avoid the park becoming a basin surrounded by "concrete forest", and at the same time, affect the birds crossing the green space. Therefore, it is necessary to control and guide the surrounding unconstructed buildings.

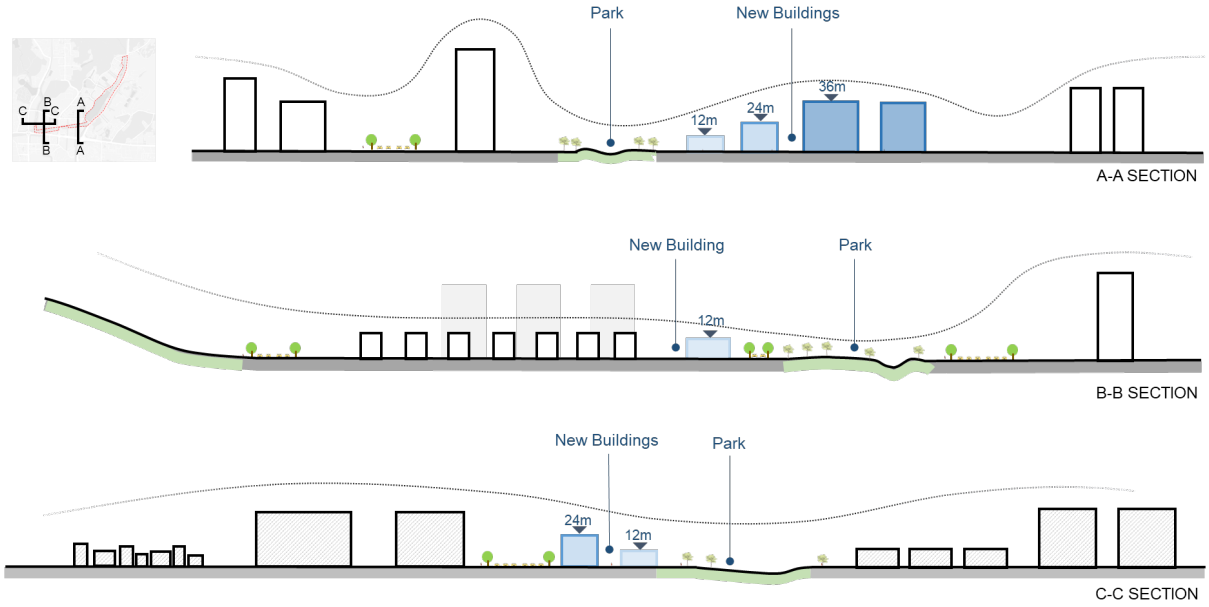


Figure 6- 16 Building Height Controls for Areas to be Constructed (Self-Drawn)

In terms of building height, in order to reduce the impact of high-rise buildings on the landscape and environment of the wetland park, it is necessary to analyze the surrounding building sites through sunlight analysis, line-of-sight analysis, ventilation analysis and other methods, to determine the maximum height of the buildings along the streets around the Tianhe Wetland Park, and the new buildings shall not exceed the height limit.

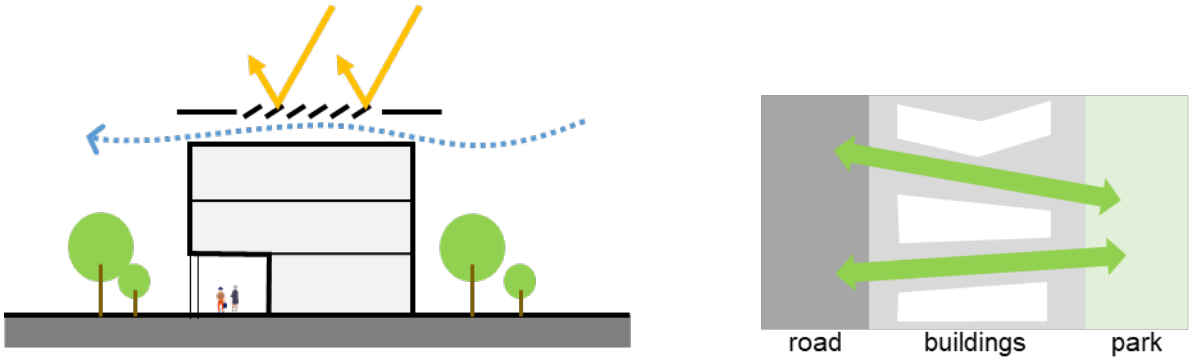


Figure 6- 17 Characterization of the climatic adaptability of building monoliths (self-drawn)

In terms of style and form, Due to the special characteristics and features of the urban wetland park landscape, the style and form of buildings around the Tianhe Wetland Park should not only reflect the local characteristics of Lingnan, but also harmonize with the wetland landscape of the wetland park. The ventilation and heat insulation effect can be strengthened by means of ground floor elevation and double-layer roof. The low-rise commercial street can adopt the form of "riding tower" to provide a more natural and comfortable shopping access for pedestrians. At the same time, the building should leave a view corridor between the park and the road, so as to avoid "privatizing" the park by completely blocking it.

6.3 Detailed and optimized design of the park interior

6.3.1 Functional Partitions

Based on the original design, the whole garden is divided into upstream, midstream and downstream based on the Xintang Reservoir, which are divided into three functional zones, which are re-delineated according to the functional characteristics of the surrounding area, the site conditions and the habits of the users.

The upstream is the wetland experience area, mainly used for tourists to observe wetland plants, learn wetland science knowledge, and have fun camping and picnicking. The middle reaches is the Reservoir Ecological Protection Zone, which utilizes the large water area and plant buffer zone of the reservoir to create a wetland protection zone and protect the living environment of water birds and aquatic animals. This is the quietest area in the park. The downstream is a fitness and sports area with a fitness plaza and jogging track, and it also takes

care of the daily commuting needs of the working population in the surrounding area.

In order to ensure the normal operation of the ecological function of the wetland, activity zones, buffer zones and protection zones of the wetland are also delineated according to the current situation and usage habits of the site. The delineation of the zones will affect the trail setting, planting and lighting design inside the wetland.

Figure 6- 18 Functional Zoning and Open Zoning Map (Self-Drawn)

6.3.2 Transportation space

The transportation system plays the role of connecting the whole park, from the above analysis of the current situation can be seen, the existing bicycle path, wooden trestle and concrete trestle system better meets the needs of access and excursion. Therefore, in this design, the existing overall guide remains unchanged, and the existing three types of trails and their distribution intervals continue to be maintained, only slightly optimized in the appropriate location.

The upstream wetland experience area has a large contact area with urban roads, and additional transportation trails, connections and plazas connecting with the urban space are set up according to the use traces, so that it is convenient for people to traverse and carry out recreational activities, and also to avoid uncontrolled trampling of compacted soil.

For the Middle Reservoir Reserve, the east-facing bike path was withdrawn and replaced with a roadway bike path and a suspended bird-watching trestle to ensure access while avoiding human activities affecting the wetland ecology.

The lower part of the city has been improved with a fitness theme, with the addition of

plazas to ensure connectivity with the city roads.

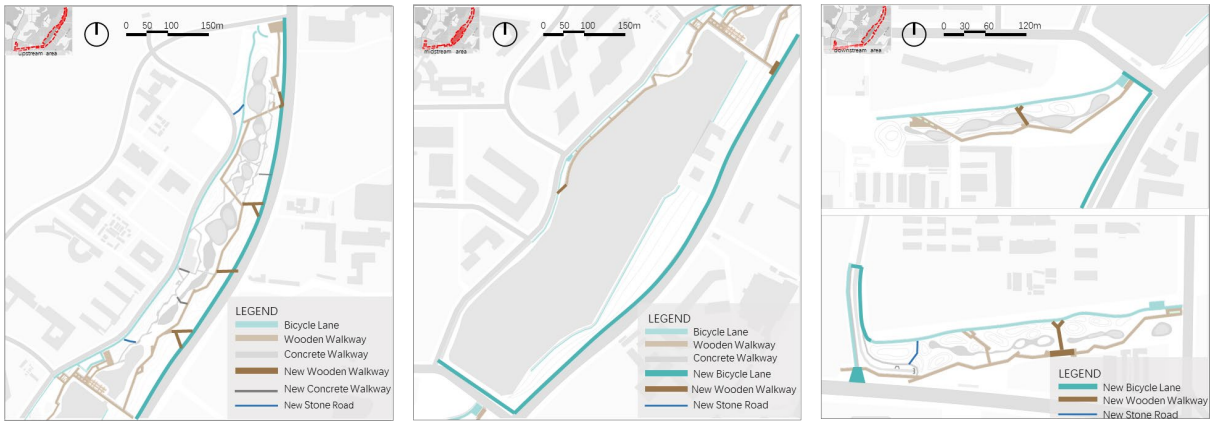


Figure 6- 19 Traffic Route Optimization Map (Self-Drawn)

6.3.3 Boundary space

The park boundary space is the linear area that borders and connects the park with other public spaces in the city. Open boundary space not only allows park users to change from "visitors" to "participants", but also connects itself more closely with urban space and reduces the formation of "islands". Public space. At the same time, as the intersection line between urban roads and parks, it is an important space to undertake the drainage of roads and sites around the city when heavy rain comes, and it is also an area of transition between urban space and natural space. Therefore, a good boundary space design will be able to complete the organic combination of public space, water treatment and ecological protection functions. This design selects three representative boundary spaces in the park to optimize the design.

① Boundary with neighboring land

The downstream north side of the park is bordered by Wisdom World Plaza and the Tianhe Yunhe Yard, which is now an internal roadway between the sites and will become a low-traffic feeder roadway once subsequent development is completed. At the same time, there is a height difference between the north site and the park. In the optimized design, the drainage of the building and the site is discharged into the wetland through rational ground and pipeline design. The terrace-type vertical flow artificial wetland can initially purify the runoff from the site and the building, so that the water pond in the park is not easy to be clogged and polluted. Removing the original railings and combining them with facilities such as large steps to dissipate the height

difference between the inside and outside of the park can also provide resting places for users in the neighborhood and create a good boundary public space. The altered space not only reduces surface stormwater runoff, but also makes people more willing to use the wetland park and improves the park's utilization efficiency.

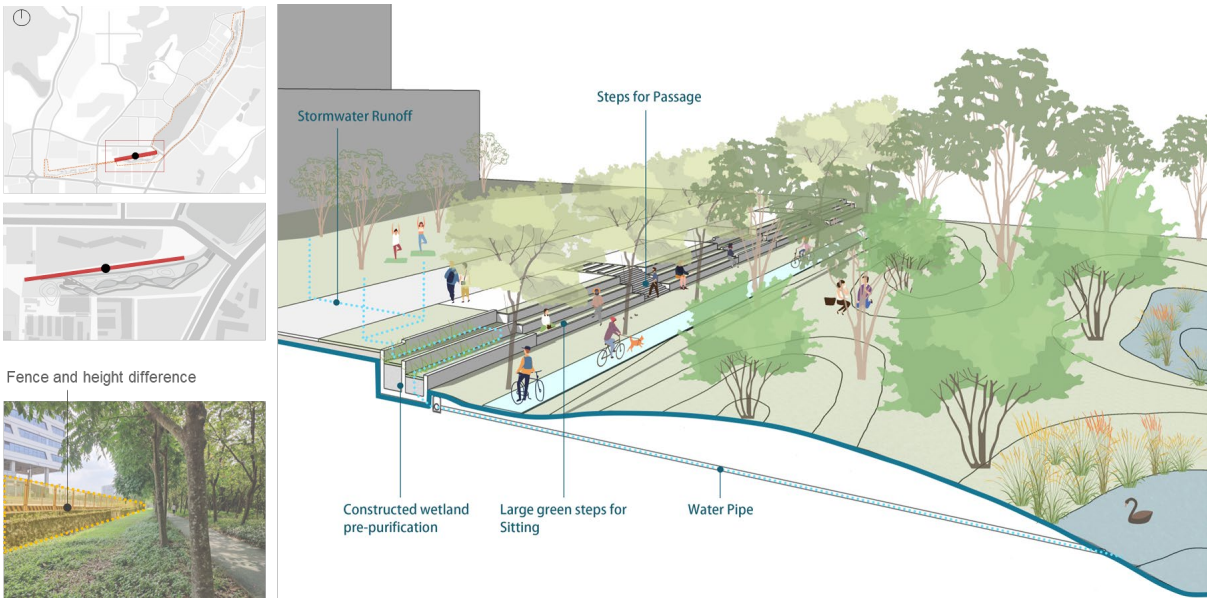


Figure 6-20 Boundary with the site (self-drawn)

②Boundary with major city roads and elevated freeways

Upstream to the east, North Daguan Road is a major urban roadway with an elevated freeway under construction above the roadway. Based on the above road improvement design, the width of the carriageway was reduced and the park space was utilized to add sidewalks, bike lanes and planting space. This will enhance the user experience while increasing the accessibility of the park.

Water treatment is convenient to change the standing edge stone between the road and the planting pool into an open edge stone, and choose the sunken green space to improve the rainwater retention capacity of the protective green space, reduce the amount of runoff from the road surface, and reduce the incidence of waterlogging in urban roads. At the same time, because the road surface of Daguan North Road is higher than that of the wetland park, grass-planted ditches and other sponge facilities with rainwater purification and transfer functions are set up on both sides of the garden road, lawn edges and other areas, and the rainwater is filtered and then transferred to the park's wet ponds to avoid pollutants from polluting the water quality.

At the same time, the transportation facilities constructed on the ground are easy to clean and maintain to avoid clogging of culverts.

The drainage outlet of the elevated highway above the road is more concentrated, and the flow rate of the drainage outlet is larger during heavy rainfall, so the green space below the elevated elevation is designed as a sunken green space or a bioretention facility, and open curbs are set up to accept rainwater on the ground and on the road surface at the same time. All of the above sponge facilities are connected to the municipal drainage network to prevent the rainwater runoff from exceeding the rainwater retention layer of the protective green space and being discharged to the city road during heavy rainfall.

The green space at the edge of the park maintains the existing plant density as a transition area between the park space and the urban road space to minimize the impact of road noise and exhaust fumes on the ecology within the park.

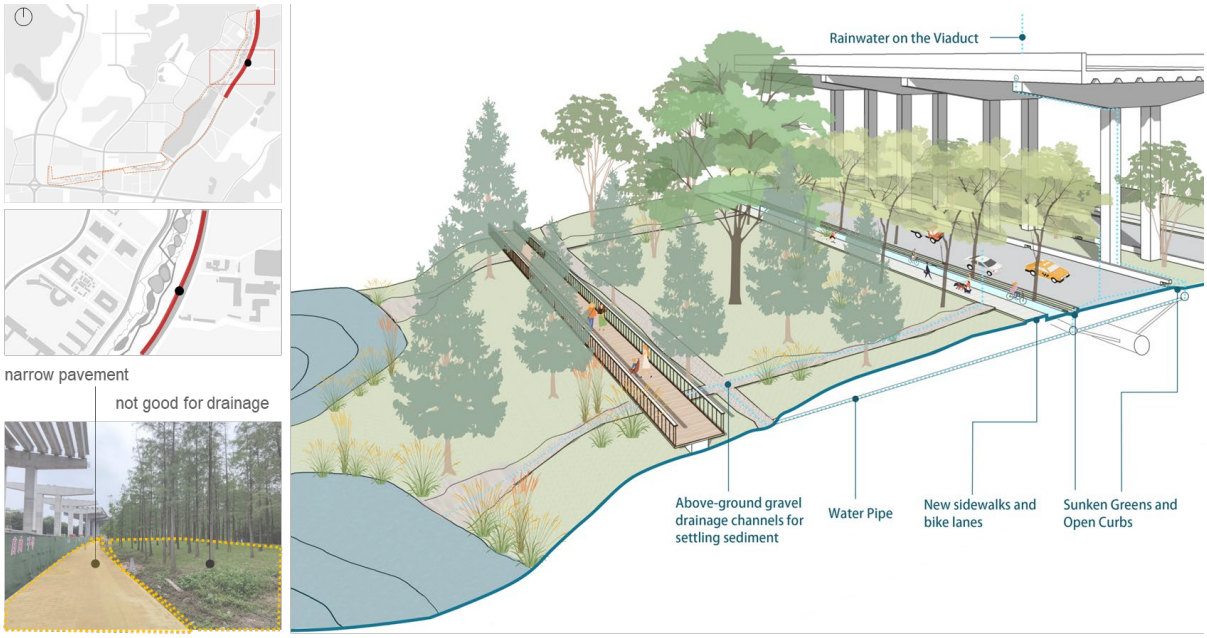


Figure 6-21 Boundary with arterial road (self-painted)

③ Boundary with secondary urban roads

The upstream western boundary with Sicheng Road is relatively open with sidewalks and bike lanes, but the park has a weak capacity to store stormwater from the road due to the topography. Therefore, the optimized design adds rain gardens between the upper convex green space and the road to collect rainwater from the sidewalk and the upper convex green space. A

bioretention pond is added to the sidewalk and non-motorized parking is guided. After initial purification in the bioretention ponds and rain gardens, the rainwater flows into the park's wet pond through underground pipes. The stormwater from the roadway is dissipated while avoiding contamination of the park's water quality by the roadway stormwater.

The buildings around the park utilize the elevated ground level to introduce the green and natural landscape of the park into the atrium of the building, so that the green and nature can permeate the space at the ground level. The elevated space is utilized to set up restaurants, cafes and other social service functions close to the area, and at the same time meets the needs of the people in the building and the park.

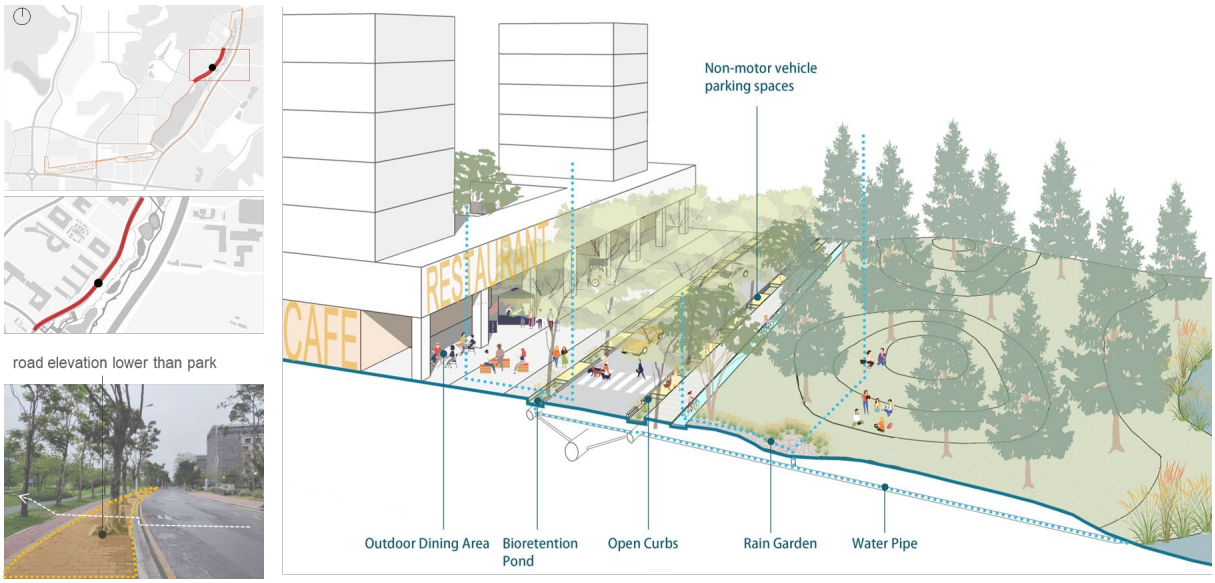


Figure 6-22 Boundary with secondary roads (self-planned)

6.3.4 Plazas and Stages

The entrance square of the park is not only the main entrance of the park, but also an important node connecting the park with other publics in the city, carrying all kinds of activities such as user identification, rest and passage. In the above analysis, we found that some squares have problems such as crowded space, imperfect function and insufficient facilities. Therefore, in this section of the design, three representative squares will be selected for renovation design to solve the existing problems and provide a model for the optimization of other squares.

Before that, we first plan the facilities that need to be unified and optimized in the square: in order to solve the problems of insufficient restroom facilities in the park, lack of drinking

water facilities, lack of depository, and change of function of the existing building, the new design integrates the required functions into the station, selects the appropriate placement in the site based on the 500-meter service radius, and flexibly configures the different areas based on their actual needs.

The functions of a complete station include: men's and women's restrooms, barrier-free restrooms, storage lockers, drinking water facilities, managerial duty stations, and rest seats. Each function is a separate space, and different plazas can be flexibly configured according to their actual needs and area limitations. In order to meet the hot and humid climate of Guangzhou, the station is designed as a double-layered roof, with new energy building photovoltaic panels on the roof, adopting green building technology, and utilizing downpipes with rain gardens to collect and recycle rainwater.

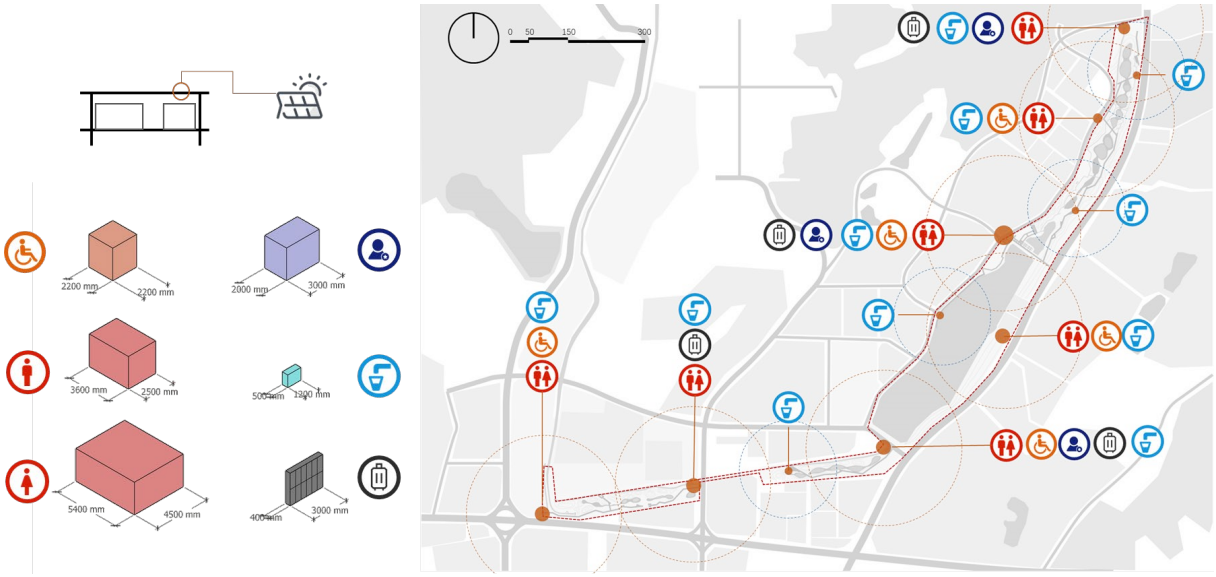


Figure 6-23 Layout of the stagecoach system (self-drawn)

(i) Downstream South Gate Entrance Plaza

The downstream south entrance is not only the southernmost connection of the Wetland Park to the city, but also the necessary way to traverse the north and south sites of the Wetland Park. The original South Gate entrance was not recognizable as the Wetland Park from across the street due to the lack of a plaza. With the development of the neighboring sites and the increase in the number of people who need to pass through, the existing design can no longer meet the needs.

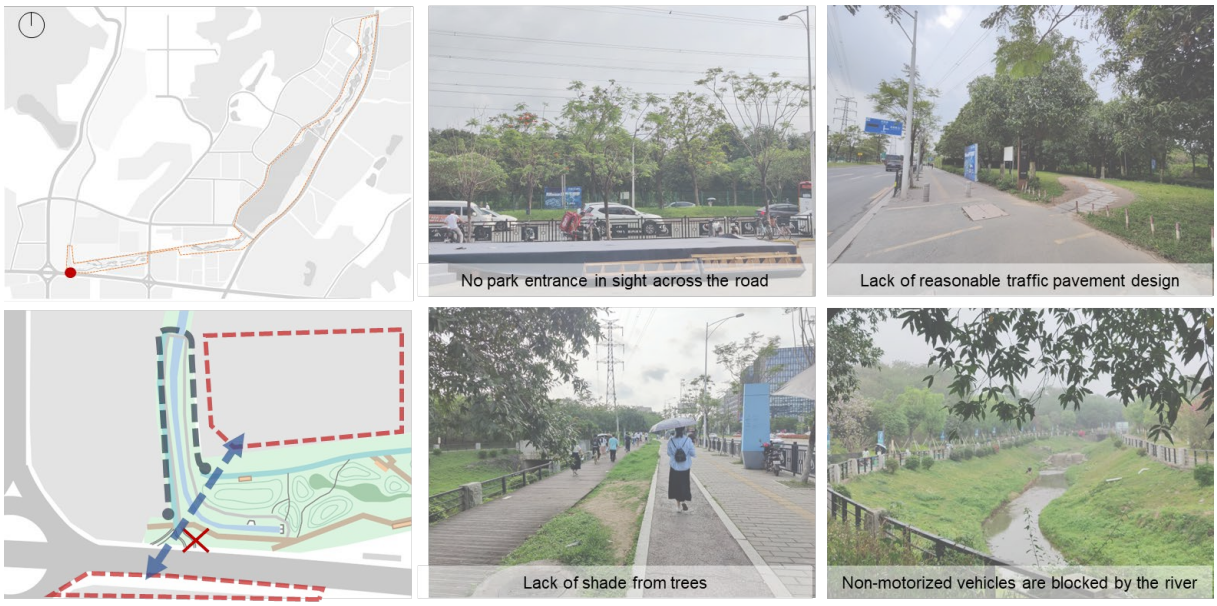


Figure 6-24 Existing Problems at the South Gate Entrance (Self-Drawn)

The optimized south entrance adds a plaza, stagecoach and pedestrian bridge, and adjusts the location of the pedestrian crosswalk across Huaguan Road based on the entrance location, optimizing the park's connectivity to the city. The plaza makes the park entrance more iconic and provides a location for pedestrians waiting at the traffic light. The pedestrian bridge allows for fewer detours for pedestrians and non-motorized vehicles that need to reach the north site. The riverbank was changed to a terrace design to purify stormwater that drains from the roadway to the Youngmead River. The staging area provides the necessary service facilities for those who move through this area.

Figure 6-25 General Plan of South Gate Entrance Plaza (Self-drawn)

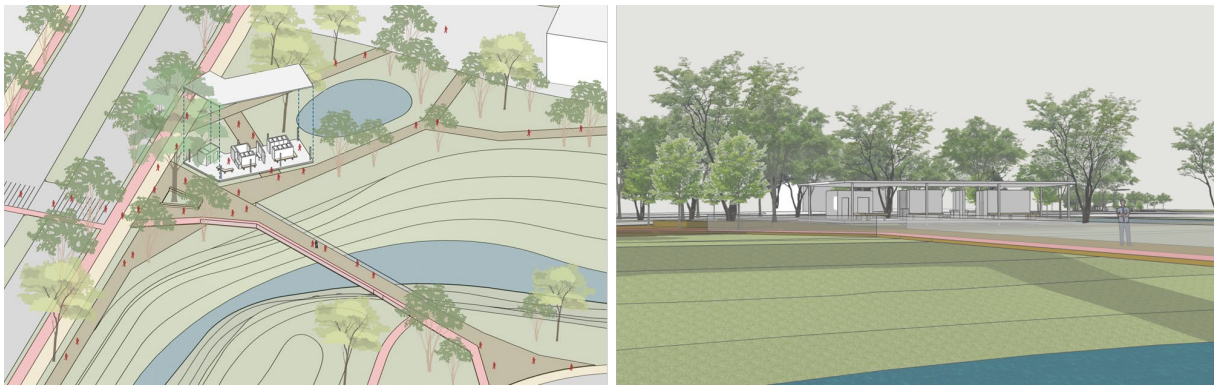


Figure 6-26 South Gate Entrance Axonometric and Human View (Self-drawn)

(ii) Upstream North Plaza

Although the area of the North Gate Entrance Square is very large, the original design of the parking location in the middle of the square, blocking people's access and the landscape surface of the rest space, and a single function, resulting in a low utilization rate. Not far away from the bus stop but lack of rest space for waiting passengers, the distribution of public space is unreasonable. There is a height difference between the square and the road surface, and people are used to walking on the road surface without steps.

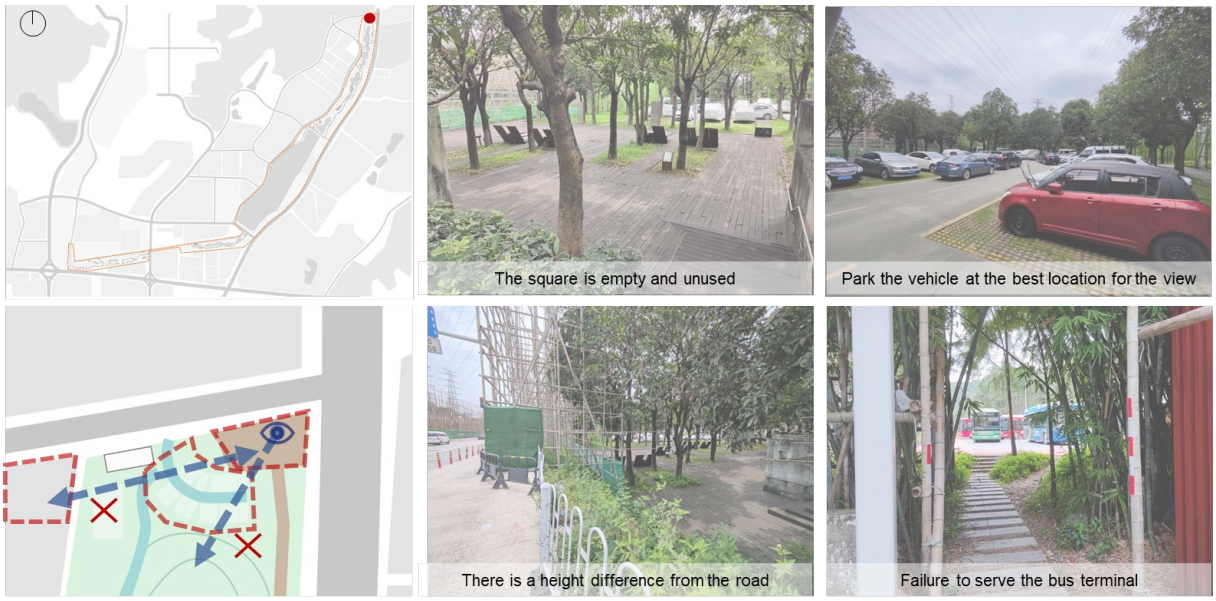


Figure 6-27 Existing Problems at the North Gate Entrance Plaza (Self-Drawn)

The optimized North Plaza repositioned the various functions so that the plaza not only serves the park, but also the adjacent bus stop. After swapping the location of the original parking area with the leisure plaza, the leisure plaza can overlook the entire park from the highest point of the site. There are also fitness facilities and an interactive science installation for the Sponge City Wetland Park in the plaza.

The former non-motorized parking spaces were swapped with the restroom locations, and the stage was placed between the bus terminal and the plaza so that the seats on the east and west sides serve both people waiting for the bus and users of the park. The windows of the driver's lounge allow observation of the inside of the station. The difference in elevation between the plaza and the road is digested using a stepped purification pond, which provides a walking path as well as allowing the rainwater from the road to be pre-purified before being discharged into the pond.

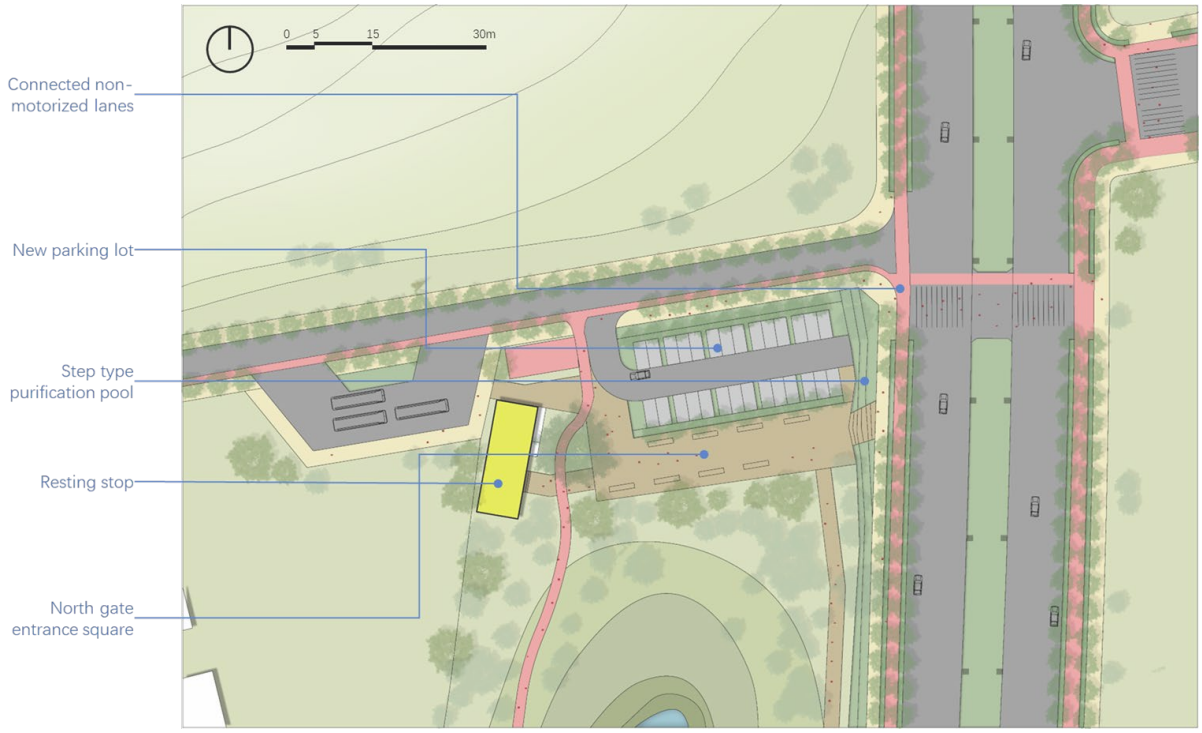


Figure 6-28 General Plan of North Gate Entrance Plaza (Self-drawn)

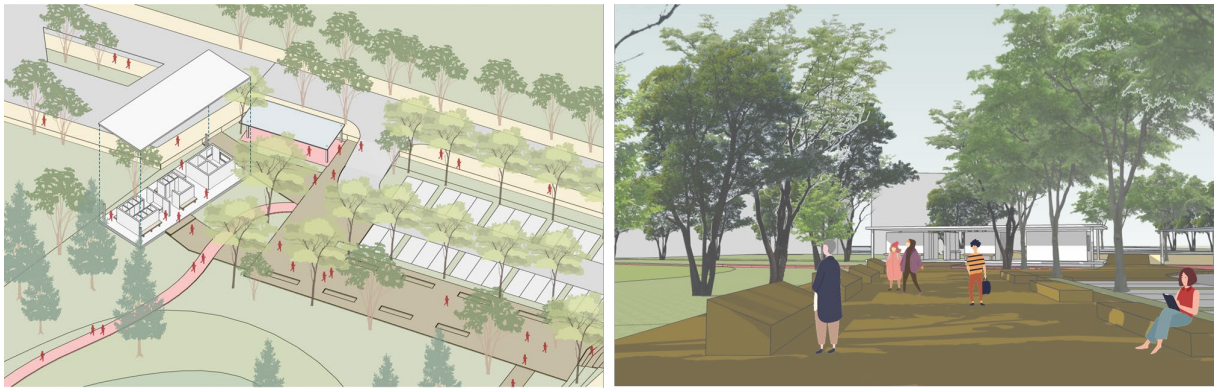


Figure 6-29 North Gate Entrance Plaza Axonometric and Human View (Self-drawn)

(iii) Midstream Central Plaza

The Central Plaza, the most active area of the park, consists of a rectangular seating plaza and a striped waterfront plaza. The existing restrooms and management office blocked the connectivity between the east and west plazas, as well as the view of the park from the outside.

Figure 6-30 Existing Problems in the Central Plaza (self-drawn)

The optimized plan is shown below. The new building will be set back to the north and combined to form an L-shape, allowing for sight lines to both plazas and smooth traffic flow. The split box design allows passersby outside the garden to see inside as well. Under the eaves on the east and west sides, there are seats for protection from the sun and rain, and the original trees are retained as a locker area. The protruding management office has a direct view of the park plaza through the windows.

Rain gardens and interactive science installations have been added to the new space set aside so that visitors can learn and experience the role of wetlands while staying on the site.

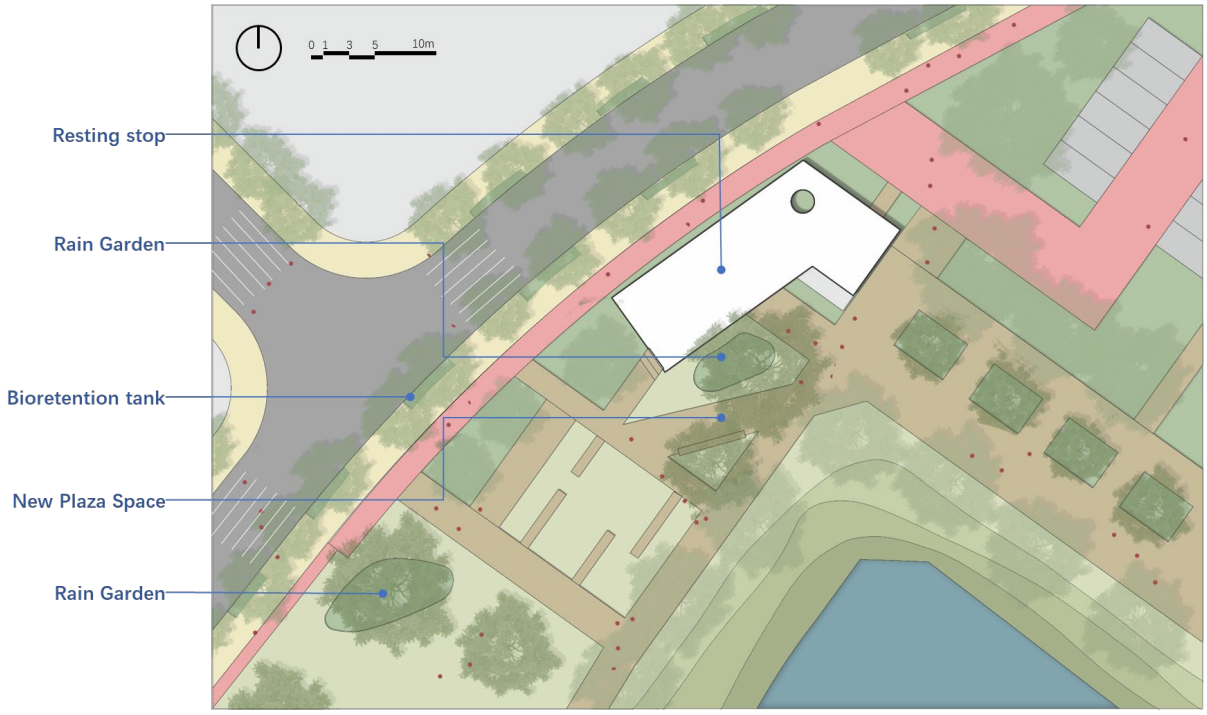


Figure 6-31 Central Plaza General Plan (Self-Drawn)

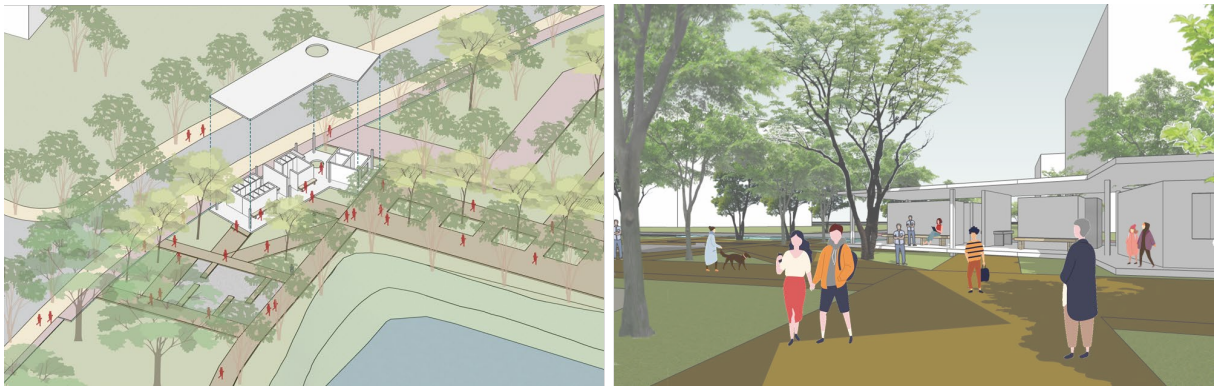


Figure 6-32 Central Plaza Axonometric and Human View (Self-Drawn)

6.3.5 Optimization of guided tours and popular science systems

(i) Optimization of the navigation system

The existing guide system has only textual introductions and lacks clear illustrations of the relationship between the location and the surrounding area. There are a large number of plazas in the park, and the names of the plazas do not have a strong relationship with either the facilities or the surrounding environment, making it difficult to distinguish between them. Existing guide signs only appear at the main plazas, but the large size of the park makes it inconvenient for first-time visitors or users who are unfamiliar with the routes. At the same time, according to

users' feedback, the number of signage in the park is insufficient, the guidance is not clear, and it is difficult to find the whole park if you do not follow the map on your cell phone to navigate. Some users who have been active in a certain area for nearly a year have never realized that there is another landscape area not far away from the park. Therefore, it is necessary to optimize the way of displaying the signage and to increase the number of display locations.

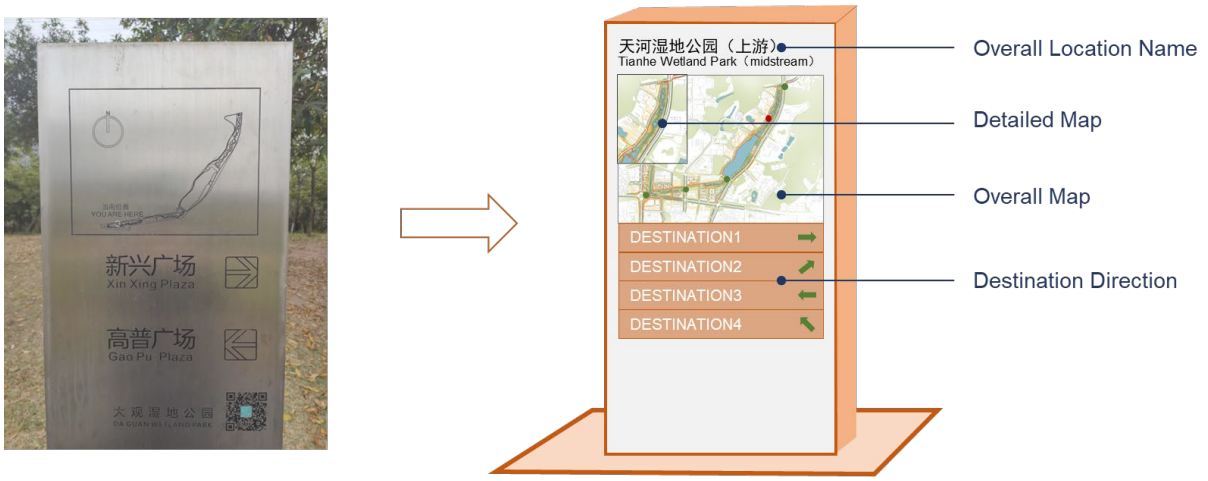


Figure 6- 33 Readability optimization of guide signage (self-drawn)

(ii) Optimization of the science popularization system

The number of existing science signs is relatively large, covering plants, animals, insects, sponge cities and other related introductions, the language has a certain degree of interest, but most of them belong to the reading display, lack of interactivity. And due to the material, there are problems such as color loss and reading inconvenience. In the optimized design, science facilities with a stronger sense of participation such as touching, rotating, turning pages, etc. can be added, and colorful diagrams or engraved pictures on aluminum plates can be used to attract people of all ages to read and enhance the effect of science popularization.

At the same time, the park can conduct joint teaching experiments with nearby primary and secondary schools, with the schools organizing visits and professional teachers giving explanations, so as to enhance the effectiveness of popular science education through language and thinking interactions.

Figure 6- 34 Design and Intentions of the Science and Technology System

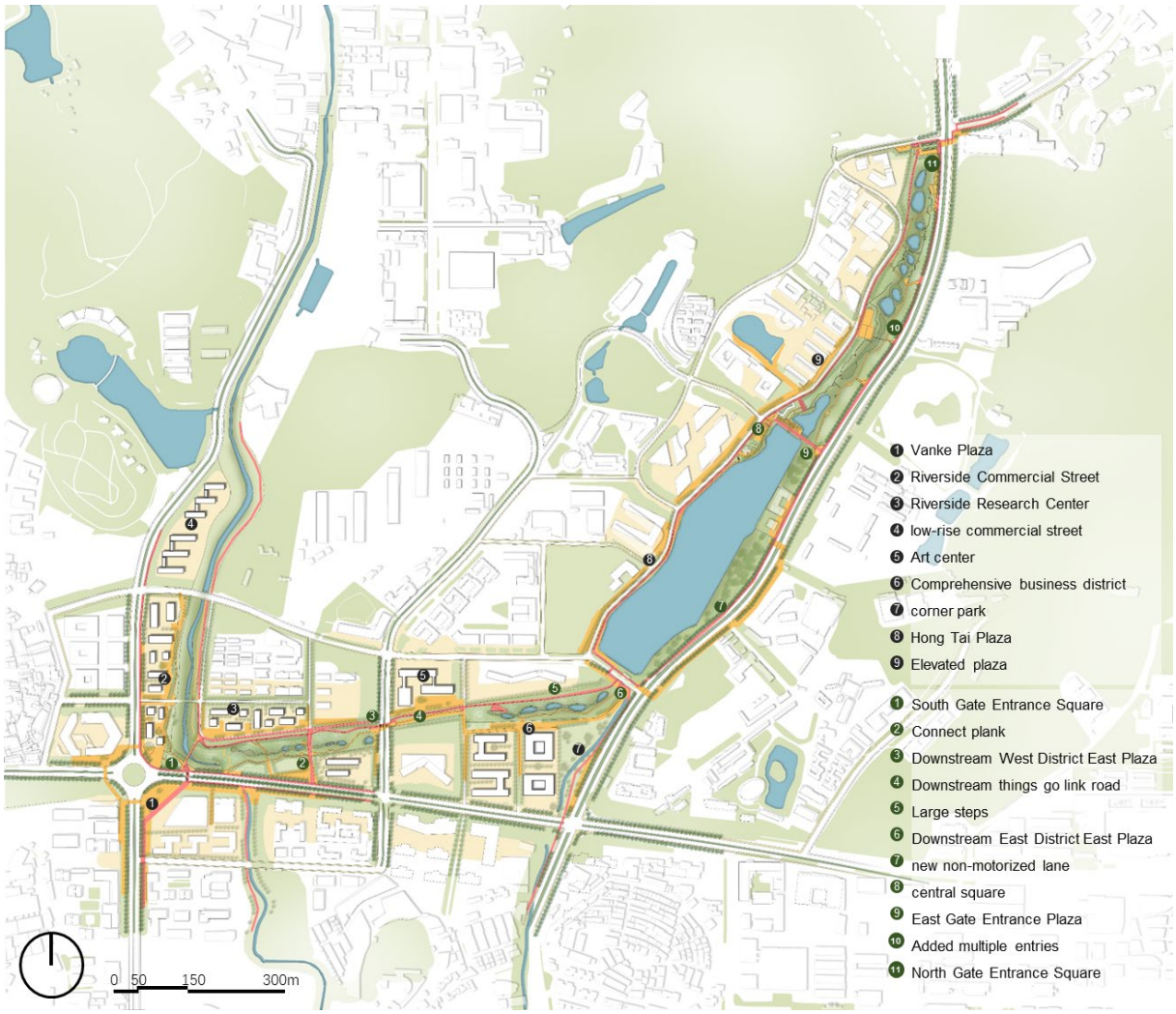


Figure 6- 35 Master Plan (self-drawn)

Summary and Outlook

Summary

Water affects the lifeblood of a city, as well as its public spaces. Finding a way for the city to get along with water can greatly improve the urban environment. This paper is based on the theory of flood storage at home and abroad, and the construction method of classic rainwater wetland parks at home and abroad, combined with the specific geographic and climatic characteristics of Guangzhou:

Compared to other regional approaches, Guangzhou is more suitable for sponge design with a large-scale system of mountains, lakes, and green spaces, which needs to make full use of natural water bodies for rainwater storage, while not excluding gray infrastructure such as deep tunneling projects. Wetland parks constructed with the concept of sponge city need to simultaneously satisfy water treatment, wetland protection and the creation of public space in the park, so that the park can better serve the city. Urban wetland parks are affected by many factors and cannot be delineated with strict protection scope like national wetland parks, but they still need to maintain species diversity and good ecological environment as much as possible to provide living space for all kinds of plants and animals. As a park, an urban wetland park and a city should not be separated from each other, but interactive and integrated. Good design can make the park and the public space of the city mutually reinforcing.

Based on the design objectives and methods derived from the above research, a detailed on-site study of Tianhe Wetland Park was conducted. First-hand information on the current status of site use was obtained through various means such as physical space observation and user interviews, and existing problems and dilemmas were summarized in combination with other information:

In terms of water treatment, the Tianhe Wetland Park adopted the method of on-site soil balancing in the excavation of pits and ponds, which resulted in a rich topography and increased water storage depth in the wetland park. However, this has also led to an elevation difference between the wetland park and the surrounding road surfaces, with the ground elevation of the park higher than that of the road, making it impossible for road rainwater to be smoothly fed

into the wetland park's watersheds and green spaces, and losing the function of storing rainwater from the surrounding roads as it should be.

In terms of wetland protection, the Tianhe Wetland Park was unable to designate a strict ecological protection zone for waterbirds due to the limitations of the terrain and surrounding conditions. However, it was able to utilize plants to create a buffer space between the wetland area and urban roads. It also utilizes methods such as turning off lights at night to reduce the impact of human activities on wetland animals.

The Tianhe Wetland Park provides a comfortable and convenient commuting path for neighboring workers, a venue for daily walks and fitness for neighboring residents, and a natural venue for weekend recreation and relaxation and family outings for citizens in a certain area. Users were generally satisfied with the environment of the Wetland Park, and particularly complimented the unique natural landscape of the park and the opportunity to get close to the water, which is why they chose to come here for recreation. However, the wetland park also suffers from insufficient accessibility to the urban public space in some areas, poor recognition of the park, and insufficient service facilities.

Therefore, to address the above problems this paper takes public space as the carrying point, combines the sponge city water treatment ideas and wetland ecological protection needs, and proposes optimized design solutions from the park and surrounding neighborhoods as well as the park's internal space in an attempt to better complete the balance between ecology and publicity of the wetland park.

In the treatment of the park and the surrounding neighborhoods, the interpenetration of the park's recreational function and the city's commercial function is strengthened; additional or optimized roads are installed to enhance the park's accessibility; the water barges around the park are adjusted to connect with other public green spaces in the city to form a blue-green network, which reduces the risk of rainfall and flooding and at the same time provides a high-quality space for the residents to travel in a green way; the architectural forms and heights of the neighboring land to be constructed are controlled to ensure that the park's Jingjing Landscape The visual effect and ecological environment of the park will be ensured.

In the internal design of the park, the functional zoning is adjusted according to the

characteristics of the surrounding sites and the residents' usage habits to better meet the usage needs; the traffic space is optimized to enhance the access efficiency of the park while reducing the damage to the ecological environment caused by disorderly use; the public nature of the park is improved by transforming the linear boundary space and alleviating the problem of flooding in heavy rains on the roads and sites around the park, so as to ensure the stability of water supply in the wetland park; the spatial quality of the park's entrance plaza is upgraded to enhance the connectivity of the park with the urban space, and additional service posts are set up to meet the basic usage needs of various groups of people; and the readability of the guiding system and the interesting nature of the science system are increased.

Shortcomings and prospects

The design of urban wetland parks involves wetland ecosystems and urban ecosystems from the perspective of ecosystems; it requires both protection and utilization from the perspective of design needs; and it involves hydrological specialties, wetland science, urban design, landscape architecture and other multidisciplinary knowledge from the perspective of disciplines, which inevitably leads to the existence of some limitations and deficiencies in the research.

①The urban hydrological environment requires a large amount of data to support the design. In this paper, due to technical reasons, only architectural methods were utilized to record the current status of the site by on-site field measurements and marking, and the existing problems of the site were summarized through the record of the site conditions in different weather conditions and the network data and optimized by using the appropriate spatial design. It is hoped that more data will be available to support the design methodology in the future with the assistance of related disciplines.

② Due to the limited time and personal ability, although the research found some problems in current situation of the park, only some areas could be selected for optimized design. This design emphasizes the optimized design of the relationship between the park and the city, and fails to take into account all aspects of the whole park.

③ Wetland park itself has the contradictory nature of protection and development and

utilization, this paper can only start from the current situation of users' use, and carry out certain optimization and enhancement of public space and public facilities under the premise of no longer having adverse effects on the natural ecology to try to satisfy the users' needs. However, how to make a good balance between public activities and wetland protection requires more practical experience and joint efforts of other professions.

Reference

[1] 王立新,王健.高度城市化地区水的综合治理方法和实践[J].中国水利,2020(10):1-6.

[2] 兰悦. 基于雨洪管理的城市公园规划设计研究[D]. 北京林业大学,2021.DOI:10.26949/d.cnki.gblyu.2021.000345:15.

[3] 汤大为. 水敏性视角下多层次的城市湿地公园规划设计[D]. 北京林业大学,2021.DOI:10.26949/d.cnki.gblyu.2021.000772:1.

[4] 车伍,赵杨,李俊奇.海绵城市建设热潮下的冷思考[J].南方建筑,2015(04):104-107.

[5] 彭思思,余太平,汪齐等.关于海绵城市建设的思考[J].市政技术,2021,39(04):119-123.DOI:10.19922/j.1009-7767.2021.04.119.

[6] 吴隽宇,关洁茹.“海绵城市”概念及其理论研究进展述评[J].南方建筑,2018(03):34-39.

[7] 俞孔坚.海绵城市——理论与实践(上下册)[M]. 中国建筑工业出版社,2016.

[8] 俞孔坚,李迪华.城市景观之路:与市长们交流[M].中国建筑工业出版社,2003.

[9] 袁大洲. 海绵城市新概论[J]. 现代园艺, 2016(6)1.

[10]仇保兴.海绵城市(LID)的内涵、途径与展望[J].建设科技,2015(01):11-18.DOI:10.16116/j.cnki.jskj.2015.01.003.

[11]威廉·M·马什.景观规划的环境学途径[M].中国建筑工业出版社,2006.

[12]Debo T N, Reese A. Municipal stormwater management[M]. CRC Press, 2002.

[13]张丹明.美国城市雨洪管理的演变及其对我国的启示[J].国际城市规划,2010,25(06):83-86.

[14]余国营.湿地研究的若干基本科学问题初论[J].地理科学进展,2001(02):177-183.

[15]高江菡. 城市湿地公园设计探究[D].北京林业大学,2014.

[16]公园设计规范[附条文说明] GB 51192-2016

[17]李永雄,陈明仪,陈俊.试论中国公园的分类与发展趋势[J].中国园林,1996(03):30-32.

[18]城市绿地分类标准:CJJ/T 85-2002[M]. 中国建筑工业出版社, 2002.

[19]李勇.湿地的生境修复及景观规划设计——以潍坊市白浪河湿地公园为例[J].中国园林,2011,27(08):17-20.

[20]城市绿地分类标准:CJJ/T 85-2017[M]. 中国建筑工业出版社, 2017.

[21]陈竹,叶珉.什么是真正的公共空间?——西方城市公共空间理论与空间公共性的判定[J].国际城市规划,2009,24(03):44-49+53.

[22]Lynch K. The image of the city[M]. MIT press, 1964.
[23]中国建筑工业出版社.城市规划原理[M].中国建筑工业出版社,2010.
[24]裴力. 海绵城市建设下的广州天河智慧城核心区城市绿地规划设计研究[D].华南理工大学,2017.
[25]车生泉.西方海绵城市建设的理论实践及启示[J].人民论坛·学术前沿,2016(21):47-53+63.DOI:10.16619/j.cnki.rmltxsqy.2016.21.005.
[26]车伍,吕放放,李俊奇,李海燕,王建龙.发达国家典型雨洪管理体系及启示[J].中国给水排水,2009,25(20):12-17.
[27]车伍,张鹃,赵杨.我国排水防涝及海绵城市建设中若干问题分析[J].建设科技,2015(01):22-25+28.DOI:10.16116/j.cnki.jskj.2015.01.005.
[28]杨正,李俊奇,王文亮,车伍,俱晨涛,赵杨.对低影响开发与海绵城市的再认识[J].环境工程,2020,38(04):10-15+38.DOI:10.13205/j.hjgc.202004003.
[29]Ellis J B, Shutes R B E, Revitt D M. Constructed wetlands and links with sustainable drainage systems[M]. Environment Agency, 2003.
[30]张所续,石香江.浅谈新加坡水资源管理[J].西部资源,2007(05):48-50.
[31]沙永杰,纪雁.新加坡 ABC 水计划——可持续的城市水资源管理策略[J].国际城市规划,2021,36(04):154-158.DOI:10.19830/j.upi.2019.180.
[32]石磊,樊瀞琳,柳思勉,张津悦.国外雨洪管理对我国海绵城市建设的启示——以日本为例[J].环境保护,2019,47(16):59-65.DOI:10.14026/j.cnki.0253-9705.2019.16.013.
[33]Wu C, Qiao M, Wang S. Enlightenment from ancient Chinese urban and rural stormwater rmanagement practices [J].Water science and technology,2013,67(7):1474-1480.
[34]Budge T. Sponge Cities and Small Towns: a New Economic Partnership[M]//Rogers M F, Jones D R. The Changing Nature of Australia's Country Towns.Ballarat, Australia: Victorian Universities Regional Research Network Press, 2006.
[35]车伍,张鹃,赵杨.我国排水防涝及海绵城市建设中若干问题分析[J].建设科技,2015(01):22-25+28.DOI:10.16116/j.cnki.jskj.2015.01.005.
[36]中华人民共和国住房和城乡建设部组织编制.海绵城市建设技术指南——低影响开发雨水系统构建(试行)[M].中国建筑工业出版社,2015.
[37]王凌,罗述金.城市湿地景观的生态设计[J].中国园林,2004(01):44-46.
[38]Harvey U. Guiding at the London Wetland Centre[J]. Delta Kappa Gamma Bulletin, 2004,

70(4).
[39]张庆辉,赵捷,朱晋等.中国城市湿地公园研究现状[J].湿地科学,2013,11(01):129-135.DOI:10.13248/j.cnki.wetlandsci.2013.01.003.
[40]中国人民共和国中央人民政府网,[EB,OL],https://www.gov.cn/xinwen/2023-02/15/content_5741547.htm
[41]沙永杰,纪雁.新加坡 ABC 水计划——可持续的城市水资源管理策略[J].国际城市规划,2021,36(04):154-158.DOI:10.19830/j.upi.2019.180.
[42]广州市人民政府网,广州年鉴(2022)[EB,OL],https://www.gz.gov.cn/zlgz/gzgk/zrdl/
[43]广州气象网, [EB,OL]http://www.tqyb.com.cn/gz/climaticprediction/static/
[44]陈刚.广州市城区暴雨洪涝成因分析及防治对策[J].广东水利水电,2010(07):38-41.
[45]李志鹏.基于雨水调蓄技术规划广州雨排系统的研究[D].广东工业大学,2011.
[46]吴庆洲.珠江三角洲水灾风险的的上升趋势及减灾对策[J].南方建筑,1995(02):8-10.
[47]周新民,林少礼,侯玉,郑国栋.广州城市河道水环境治理对策研究[J].广东水利水电,2004(04):65-66.
[48]宫清华,袁少雄,陈波.珠江在广州城区河段的演变及其对城市生态环境的影响[J].热带地理,2013,33(04):394-399.DOI:10.13284/j.cnki.rddl.002353.
[49]徐光来,许有鹏,徐宏亮.城市化水文效应研究进展[J].自然资源学报,2010,25(12):2171-2178.
[50]万榆,黄岳文,彭晓春.广州城市内涝原因分析与对策研究[J].广东水利水电,2016(03):27-31.
[51]张建云.城市化与城市水文学面临的问题[J].水利水运工程学报,2012(01):1-4.DOI:10.16198/j.cnki.1009-640x.2012.01.002.
[52]林良勋,吴乃庚,黄忠,蔡安安.广东 2008 年罕见“龙舟水”特点及成因诊断分析[J].气象,2009,35(04):43-50.
[53]王书芬.海绵型湿地景观在实践中的探索——以广州天河智慧城大观湿地公园为例[J].现代园艺,2019(01):126-127.DOI:10.14051/j.cnki.xdyy.2019.01.072.

Appendix

天河大观湿地公园使用后评价调查问卷

尊敬的朋友：

您好！我是华南理工大学建筑学院的研究生，想了解您对此公园现状环境的评价，您的建议有助于未来海绵型湿地公园的规划设计、改造与管理服务提升。请您回答时在适当的选项上打勾，非常感谢您的合作！

一、基本信息（该信息是为了更好的了解公园游客的人群特征）

1. **性别：** □男 □女
2. **年龄：** □0-18 □19-35 □36-50 □51-65 □65 岁以上
3. **职业：** □职员或工人 □教师 □公务员 □个体 □农民 □离退休人员 □学生 □自由职业者 □其他
4. **居住地：** □黄埔区 □天河区 □越秀区 □荔湾区 □海珠区 □白云区 □番禺区 □其它区

二、基本使用情况

1. **来园交通方式：** □步行 □公交 □地铁 □自行车 □电动车 □私家车 □出租车
2. **来园所需时间：** □＜15 分钟 □15-30 分钟 □30-60 分钟 □大于 60 分钟
3. **来园同伴：** □无 □家人 □情侣 □同学/同事/朋友
4. **来园目的：** □游览观光 □休闲小憩 □运动健身 □带小孩 □会友 □路过 □其它_____
5. **停留时间：** □半小时以内 □半小时到一小时 □一小时到两小时 □两小时以上
6. **来园频率：** □每天都来 □每周数次 □每月数次 □很少来
7. **喜欢的区域：** □上游湿地 □中游新塘水库 □下游湿地
8. **常走的路段：** □木栈道 □自行车道 □水泥栈道

三、公园评价

您是否同意下列针对大观湿地公园的描述？请根据您的体验进行选择。

公园评价指标要素的正面描述		满意度评价				
		非常认同	认同	基本认同	不认同	非常不认同
1	植物覆盖广，种类丰富，生长良好					
2	水体清澈无异味					
3	空气清新，空气质量好					
4	树荫充足，阴凉舒适，不晒					

5	无蚊虫					
6	安静无噪音，能听到鸟叫虫鸣					
7	便于到达，停车方便					
8	内部道路通畅平整，通行舒适					
9	地形坡度平缓，便于通行					
10	水体驳岸合理，亲水平台充足					
11	座椅充足					
12	遮阳挡雨空间充足					
13	空地广场空间充足					
14	餐饮服务设施充足					
15	卫生间充足					
16	体育运动设施充足					
17	能学到海绵城市相关知识					
18	动植物种类标识清晰易懂					
19	环境优美，卫生良好，无垃圾					
20	座椅、路面、球场等设施维护良好					
21	园内水环境、治安环境都安全舒适					

期待您的建议：

您希望公园在哪些方面能有所改进？如有建议请写在下方：

_____

_____

_____

问卷结束，非常感谢您的支持!

攻读硕士学位期间取得的研究成果

一、已发表（包括已接受待发表）的论文，以及已投稿、或已成文打算投稿、或拟成文投稿的论文情况**（只填写与学位论文内容相关的部分）：**

序号	作者（全体作者，按顺序排列）	题　　目	发表或投稿刊物名称、级别	发表的卷期、年月、页码	与学位论文哪一部分（章、节）相关	被索引收录情况

注：在“发表的卷期、年月、页码”栏：
1 如果论文已发表，请填写发表的卷期、年月、页码；
2 如果论文已被接受，填写将要发表的卷期、年月；
3 以上都不是，请据实填写“已投稿”，“拟投稿”。
不够请另加页。

二、与学位内容相关的其它成果（包括专利、著作、获奖项目等）

Acknowledgments

At this point, it means that two years of graduate school career will soon come to an end. During this period, there are too many stories worth recording, too many memories worth writing, the completion of the thesis is also inseparable from the help and support of teachers, classmates, relatives, here I would like to express my most sincere thanks to all those who have helped, encouraged and accompanied me.

I would like to express my sincere thanks to all the people who have helped, encouraged and accompanied me. I would like to thank my supervisors, Mr. Sun Yimin, Mr. Li Minzhi, Mr. Wang Lu, Mr. Antonio di Campli and Ms. RoBerta Ingaramo. They spared no effort in providing me with great help during the dissertation writing period. From the topic selection, research, design and finalization of the thesis, each supervisor provided many valuable suggestions and advice based on their own experience, and urged me to strive for excellence and keep moving forward with strict requirements.

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Thanks to my lovely roommates Yingbao, Hanhan and Nuisi, we have formed a deep friendship after two years of living and eating together and having fun with our classmates. Especially during the period of studying abroad, we supported each other and cooperated with each other in life, encouraged each other and made progress together in study, so that I was no longer afraid of facing problems by myself. In addition, I would like to thank every student in my class, especially the class president, Hikari Proverbs, who has put in a lot of effort for the class, and I wish you all a bright future and happiness every day.

I would like to thank my dearest mom and dad for your twenty years of careful cultivation, and for your unconditional support and trust in me, you are my strongest backing. Your daughter has grown up, please allow me to be your support in the future. I wish my family joy, happiness and peace.

Last but not least, I would like to thank Mr. Chen Jiancong for his support and

encouragement over the past two years. He calmed me down when I was anxious, encouraged me to be brave when I was hesitant, and gave me the best help he could in my studies and in life, and I hope that you will always be there for me in the future.

I would like to dedicate this article to my brave and strong self and all the people who have helped me!

Chen Shuyi

September 6, 2023

3.答辩委员会对论文的评语

（主要内容包括：1.对论文的综合评价；2.对论文主要工作和创造性成果的简要介绍；3.对作者掌握基础理论、专业知识程度、独立从事科研工作能力以及在答辩中表现的评价；4.存在的不足之处和建议；5.答辩委员会结论意见等）

硕士研究生陈舒怡所完成的题为《基于海绵城市建设反思的广州天河湿地公园设计研究》的学位论文，选题紧贴我国城市发展问题，具有一定的理论意义和实用价值。作者归纳和研究了一定的相关理论和实践案例，基本掌握了该领域国内外的研究现状、实践情况和发展方向。论文完成了以下研究成果：

1、通过对国内外相关案例的分析，同时结合广州的地理气候条件，从水处理、湿地保护、公共空间设计三方面分析总结出了针对广州城市湿地公园的策略；

2、对广州天河公园的自然情况、使用情况及对周边环境的影响进行了深入的调查，以提升周边城区环境和人们使用感受为目标提出了优化设计方案，为后续广州地区海绵城市湿地公园建设提供参考。

论文概念清晰，结构完整，叙述适当，分析较充分。答辩中作者较好地回答了提出的问题。答辩委员会同意通过硕士学位论文答辩，同意其毕业，并建议授予硕士学位。

论文答辩日期：2022 年 9 月 4 日　　答辩委员会委员 5 人

表决票数：同意毕业及授予学位（5）票

同意毕业，但不同意授予学位（0）票

不同意毕业（0）票

表决结果（打"√"）：同意毕业及授予学位（√）

同意毕业，但不同意授予学位（　）

不同意毕业（　）

答辩成员签名	（主席）		
	Antonio Di Campli（线上参加，秘书代签）		
答辩秘书签名			