Green Water Purification Plant

Maluan Bay Wetland Park Planning and Design

Project Location: Maluan Bay Regional, Xiamen City, Fujian Province, China

Project area: 710000sqm

Project Statement

The project is located in the northeast part of Maluan Bay regional, Jimei District, Xiamen, Fujian Province, China. The current land use of the site are fish ponds, and it is also the estuary of two urban rivers, which are Shenqing river and Yaoshan river. However, the two rivers have been severely affected by the domestic sewage and industrial sewage of upstream, as well as Irregular rainfall, resulting in insufficient seasonal water flow and poor water quality, which has posed a threat to the aquatic ecological environment in the Maluan Bay regional.

This project aims to address the core issue of urban aquatic ecology through ecological landscape measures instead of constructing industrial wastewater treatment plants. By establishing functional artificial wetlands at the estuary of the rivers to regulate water volume and purify water quality to meet the standards for river water entering the sea, improve the inner bay environment, and promote the ecological function and urban service function of landscape green spaces. Furthermore, based on the project, a new water ecological treatment model can be developed, which can provide a new breakthrough for the future treatment of urban river sewage at the estuary.

01 Project Narrative 1

Project Background

The Maluan Bay Water Ecological Restoration Project is located in Maluan Bay regional, Jimei District, Xiamen, Fujian Province, China. It connected to the East China Sea and facing Xiamen Island across the sea.

The current land use of the site is for fish ponds, adjacent to the Shenqing river and Yaoshan river, which are entering the sea from the site. However, the two rivers have been severely affected by the domestic sewage and industrial sewage of upstream, as well as Irregular rainfall, resulting in seasonal water shortages, that only abundant in summer. In other seasons, the water sources are small amounts of rainwater, domestic sewage and industrial sewage. The water of Yaoshan river is in black and malodorous state, and the water of Shenqing river is also severely polluted, which has a long-term impact on the overall water quality of the Maluan Bay area. Therefore, an effective solution is urgently needed for water purification and ecological treatment to purify the water quality and protect ecological environment of the Maluan Bay regional.

To address the water quality problem, the local government initially intended to build a sewage treatment plant or use industrial-grade sewage treatment equipment to deal with the sewage. However, this approach has many drawbacks, including difficulty in operation during the rainy season, high cost, high maintenance costs, and inability to improve the water ecology along the riverbank.

Design Concept

The upstream discharge of domestic and industrial wastewater is freely released and gathered in the river, and eventually bursts at the estuary of the sea. The contradiction between urban development and the environment protect is becoming increasingly prominent. It is particularly important to use low-cost, low-impact, and high-ecological benefits ecological landscape measures to replace industrial methods to solve urban environmental problems.

This is not only an important research topic for urban development, but also an important direction for the functional application of landscape design. This project attempts to solve the core problem of urban water ecology through ecological landscape methods, while providing the ecological and urban service functions of landscape green spaces, and forming a new water ecological treatment model to find a new breakthrough for urban river sewage treatment problems.

Solution

Firstly, redeployment of water resources to replenish Shenqing river and Yaoshan river in the upstream, while connecting with sewage treatment plants for sewage purification. Secondly, by the research of the two rivers and establishing the water flow model, determining the water supplementation plan and water supplementary volume. The purpose is to guarantee river water quantity, dilute the concentration of sewage, improve the water environment, and control the water quality between the surface water quality class Ⅴ, laying the foundation for the purification of ecological wetlands later.

After the water supplementation plan, the water quality of Shenqingxi can be greatly improved, and the water quality is controlled between class V and class IV. The water quality of Yaoshan river is controlled at class Ⅴsurface. According to the situation, Yaoshan river is the key purification target, and Shenqing river is the mainly supplementary water source for the wetland system. The overall solution strategy is to establish a large-scale aquatic ecological restoration system at the estuary of the two rivers, purify the water quality through multi-measures such as water allocation, water purification, water level regulation, and environmental improvement, to meet the standards of river water entering the sea, improve the water quality of the bay, and thus change the regional ecological environment.

01 Project Narrative 2

Method selection and purification principle

After multi-majors discussions, choosing functional artificial wetland as the core water purification method. The overall hydraulic and water system layout is based on the Yaoshan river, and water flow is controlled by the flap gates into the wetland system. The water first passes through the Natural Sedimentation Pond, pre-treatment the water before entering functional wetlands.

Based on the sewage discharge and water quality testing of the upstream Yaoshan river, the river water is mainly polluted by domestic and industrial sewage, with excessive levels of suspended solids (SS), chemical oxygen demand (COD), ammonia nitrogen, total nitrogen, and total phosphorus. Considering the pollution situation and long-term maintenance costs, the project adopts the Vertical Subsurface Downward Flow Constructed Wetland module to effectively remove various dissolved pollutants in the water. By calculating the pollutant levels and the purification capacity of theVertical Subsurface Downward Flow Constructed Wetland, the required wetland area is determined. Combining the current fish pond layout with the wetland, and using hydraulic models to calculated the scale and elevation of each functional wetland unit.

The design uses two parallel flow paths to reduce the impact of water flow, and extend the retention time of the water in the wetland modules, resulting in better degradation of pollutants and ensuring the water quality meets the standards. Finally, the water purified by the wetland module enters the landscape water surface, where occurring further biochemical degradation and display a wonderful landscape view.

Effects presentation

The current fish ponds not only perform economic functions, but also an important migratory corridor and habitat for migratory birds (Egretta garzetta), various fish species and frog species, having important ecological functions. Apart from the water purification function, the project also needs to meet the ecological function and urban service green space function. The design based on the current fish ponds, and transformed them into a large-scale urban ecological conservation wetland park. By setting different foundational areas such as ecological conservation areas, ecological buffer zones, and comprehensive service and management area, that meet the needs of both animal habitats and urban citizens.

In the ecological conservation and buffer zones, creating suitable habitats for focal species. In the comprehensive service and management area, establishing visitor tour system and supporting facilities. Overall providing a beautiful wetland park, that improve the regional ecological environment and enrich the urban green space system structure.

02 Project Background

The site is located in the northeast of Maluan Bay regional, Jimei District, Xiamen, and is an estuarine wetland where the important rivers in the region, Shenqing river and Yaoshan river, converge into the sea entrance of Maluan Bay.

However, the two rivers have been severely affected by the domestic sewage and industrial sewage of upstream, as well as Irregular rainfall, resulting in seasonal water shortages, that only abundant in summer. In other seasons, the water sources are small amounts of rainwater, domestic sewage and industrial sewage.

The water of Yaoshan river is in black and malodorous state, and the water of Shenqing river is also severely polluted, which has a long-term impact on the overall water quality of the Maluan Bay area.

Project Location

Sources of River Pollutants

The main sources of pollution in the upper reaches of the river are domestic sewage, industrial sewage, agricultural and aquafarm sewage.

Site Climate Analysis

Xiamen has a high temperature and uneven precipitation distribution throughout the year. Before the rainy season from March to May, the river base flow is insufficient, and the water quality of the two rivers in the site has deteriorated seriously.

Average Rainfall (mm Graph for Xiamen)

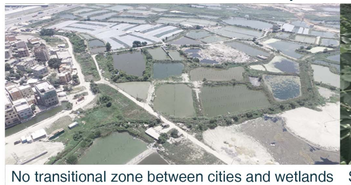
Average Temperature (°c) Graph for Xiamen

03 Present Situation

The core problems of the current present situation are: the threat to the environment of the current fish ponds (wetlands) from the development and construction of new urban areas; the problem of potential river flooding from irregular rainfall; the pollution of wetlands by untreated urban construction waste and mono-vegetation that is not conducive to habitat construction. Together with the pollution of incoming water from upstream, the ecological problems are becoming more and more serious.

Land-use analysis

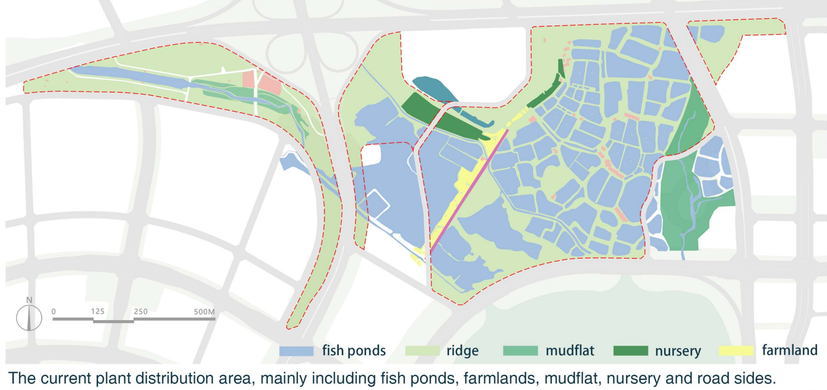
The area of original wetlands that were encroached upon, damaged or affected increased from17.1% to 20.62%.

Water Encroachment	Water Pollution	Water Safety	Water Eco-environment
			
Urban road encroachment on water system	Water pollution caused by construction waste	Flat terrain with insufficient hydrodynamic power	Proliferation of invasive species
			
Urban construction encroaches on water systems	Soil matrix pollution	Insufficient ecological base flow of the river	Mainly low shrubs, with a small number of crop varieties
			
No transitional zone between cities and wetlands	Severe eutrophication of water	No flood response strategy	Poor self repair function of plants

Landform analysis

The site is relatively flat overall, with the north side high and the south side low. The fish pond (wetland) part is relatively flat and has insufficient hydrodynamic power. There is a large height difference between the design area and the peripheral urban roads.

Plant analysis



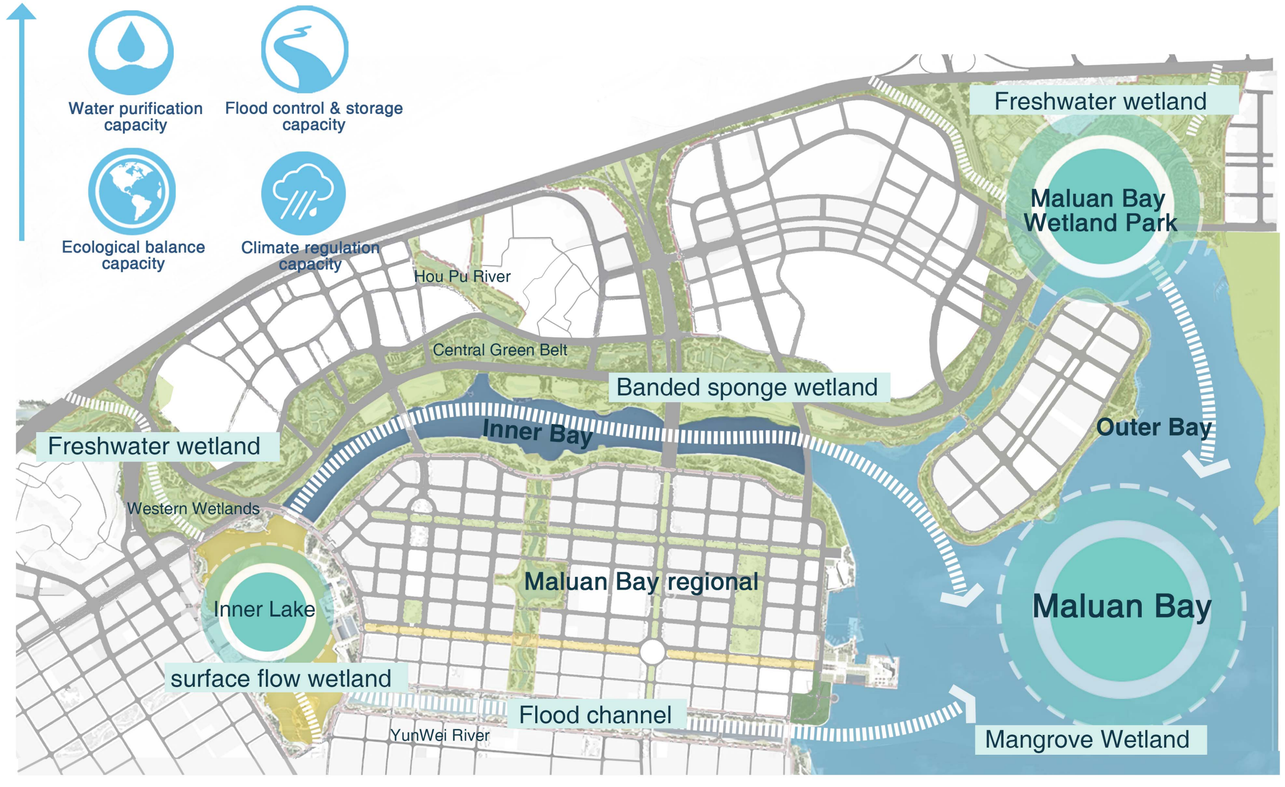
The current plant distribution area, mainly including fish ponds, farmlands, mudflat, nursery and road sides.
Plant growth conditions: vegetation growth is disorganized; eutrophication of aquatic plants is serious; community structure is single, and aquatic animals are insufficient. Poor landscape effect, lack of tree layer and shrub layer, and lack of birds habitats.

04 Development Opportunities

Maluan Bay regional is a new area for the development of Xiamen City, with "low-carbon livable" as the core planning concept, with mountains, water, parks, greenways, coastline, bay area as planning features. In the future, a series of parks and green areas will be set up along Maluan Bay, of which Maluan Bay Wetland Park is the largest green center in the region, which will assume the shallow sea landscape function and tourism, leisure and entertainment functions, as well as the maintenance of coastal wetlands and marine biodiversity.

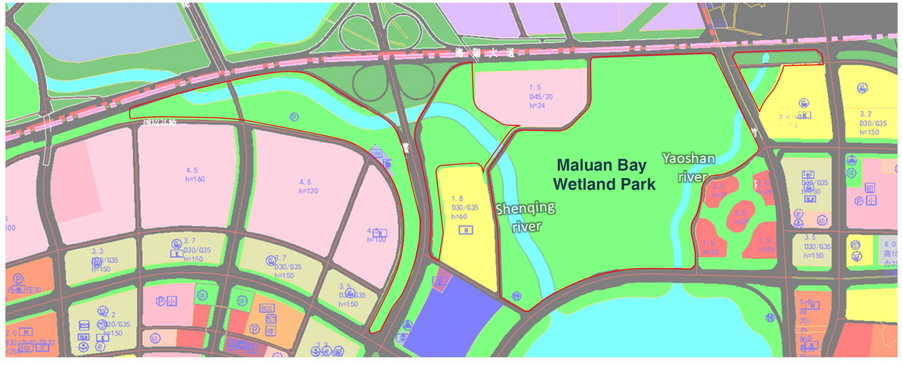
Regional ecological development trend

The Maluanwan Wetland Park project is one of the two major freshwater wetland parks planned for the new city. It improves the quality of regional green space and also serves as a regional sponge, especially for the ecological purification and flood storage functions of land rivers before entering the ocean.



New urban area site planning around the park

Maluan Bay Wetland Park is surrounded by scientific research land, second-class residential land and commercial service land. The park in order to will provide the surrounding residents, office workers, tourists to play leisure, ecological sightseeing function. The park will become a beautiful business card of the new city in the future.



Local Culture

The site is surrounded by existing Minnan-style villages, and the design takes full account of Minnan cultural characteristics, using local architectural forms and construction materials to continue the cultural characteristics of the site.

Minnan Architecture | Ancestral Hall | Preserve villages

05 Overall Strategies

The site water pollution problem is serious, the conventional practice is to use sewage treatment plant for treatment. However, due to the large volume and poor regularity of river water, this solution is costly, with high post-operation and maintenance costs, and poor ecology and landscape. Therefore, this plan uses functional wetland to purify sewage, which has high efficiency in removing pollutants, low cost, and low post-operation and maintenance cost; and as a wetland park can also improve the local ecological environment and provide recreational space for the surrounding residents. This program uses 4 Strategies to solve the various water problems of the site.

Current Site Status

Which water purification method to choose?

Renovated Site

Wastewater Treatment Plant

- ☑ High pollutant removal efficiency
- ☒ Low cost of construction
- ☒ Low maintenance cost
- ☒ Ecological & landscape benefits

Selecting functional wetlands as the main means of water purification

Functional Wetlands

- ☑ High pollutant removal efficiency
- ☑ Low cost of construction
- ☑ Low maintenance cost
- ☑ Ecological & landscape benefits

Strategy 1

Supplementary river ecological baseflow

Strategy1 in water quality purification is the dilution of pollutants through recharge, i.e., replenishment of ecological baseflow. Therefore, the current water quantity and pollutant concentration need to be calculated and the corresponding recharge strategy needs to be proposed.

Strategy 2

Functional wetlands purification

Strategy2 is the core step of water purification, introducing all of Yaoshan Creek and part of Shenqing Creek into the wetland area, after a series of functional wetland modules to purify Class V water into Class IV water to meet the water quality requirements needed for discharge into the bay.

Strategy 3

Flood Management Strategies

Strategy3 is to control the stability of the wetland by regulating the water volume of the river entering the wetland through sluice gates according to the different water volumes of the river in the rainy and dry seasons; combining the dam with the park garden road to realize the landscape of water conservancy facilities.

Strategy 4

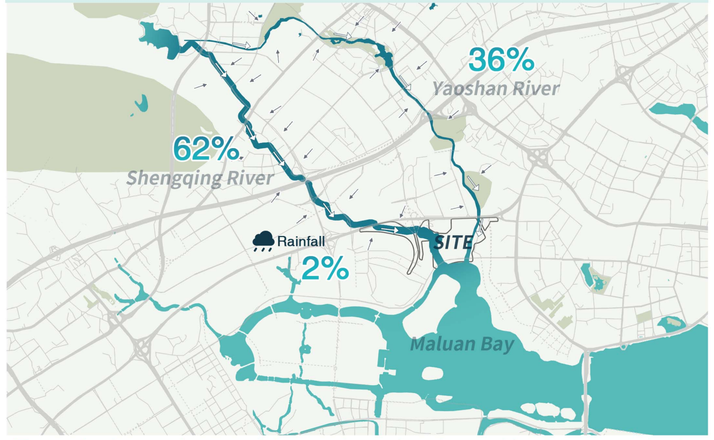
Enhancing Biodiversity

Strategy4 is to create ecosystems of rivers and wetlands, select indicator species and study their habitat preferences; analyze ecological security patterns and guide the delineation of ecological functional areas in the park.

06 Overall Strategy1: Supplementary river ecological baseflow

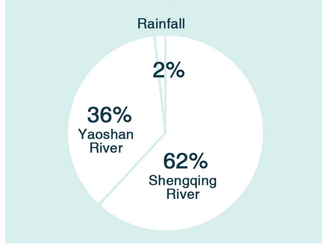
According to the site survey and water conservancy inspection, the regional water resources mainly come from precipitation and stream recharge, Shenqing River and Yaoshan River are relatively low in water volume at present, and problems such as low hydrodynamics and poor water quality often occur due to insufficient water volume during the dry season. The amount of water is increased by means of water diversion and replenishment to maintain the ecological base flow of the two streams, dilute the concentration of pollutants, and provide the possibility of introducing functional wetlands to further purify the wastewater in the subsequent program.

Problem 1: Insufficient ecological base flow

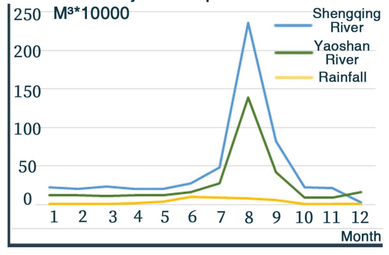


Except for August, the rest of the month requires the combined water supply of Shenqing River and Yaoshan River.

Percentage of hydration sources

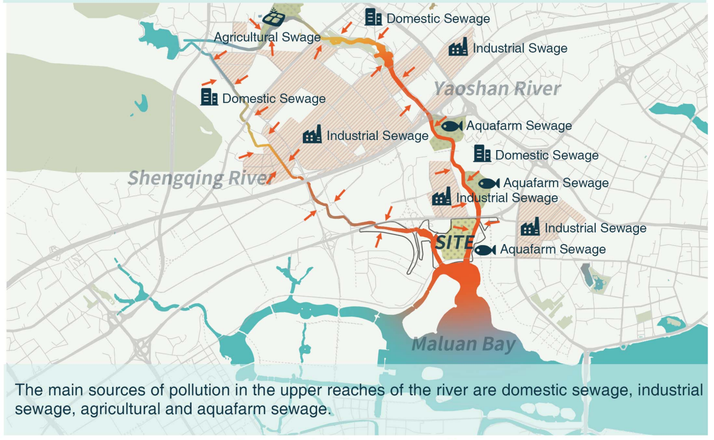


Monthly water replenishment



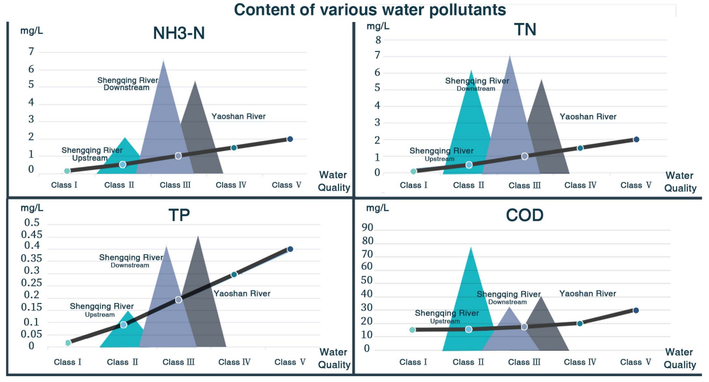
Objectives: wetland waters in the wetland park water exchange rate of 2 months / time (the proposed overall water exchange every two months water flow rate to ensure that the ecological water environment of the wetlands to deal with a healthy state).

Problem 2: Serious river pollution



The main sources of pollution in the upper reaches of the river are domestic sewage, industrial sewage, agricultural and aquafarm sewage.

Content of various water pollutants

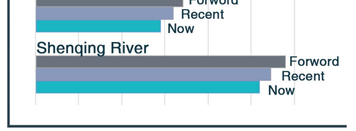


According to the comparison of multiple pollutant standards, the water quality of each river does not meet the Class V Surface Water Standard.

Pretreatment measures: water replenishment

The use of multiple recharge methods, such as the construction of new wastewater treatment plants, new recharge points, and new recharge lines, can effectively replenish ecological base-flow while diluting pollutants.

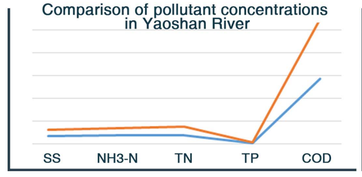
Comparison of water volume



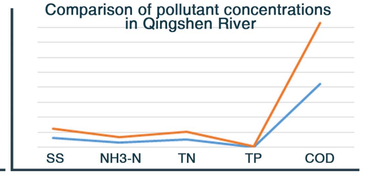
River water supply capacity analysis

Recent annual total: 5.2 million m³
Monthly minimum water volume: 24 thousand m³
Monthly average water volume: 454km³
Recent annual total: 3.2 million m³
Monthly minimum water volume: 92 thousand m³
Monthly average water volume: 267 thousand m³
Recent total water volume: 8.4 million m³
Monthly minimum water volume: 188 thousand m³

Comparison of pollutant concentrations in Yaoshan River



Comparison of pollutant concentrations in Qingshen River



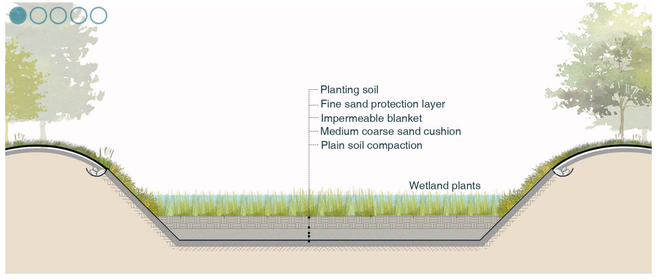
Maintaining ecological baseflow by recharging the river, while diluting river pollutants, offers the possibility of introducing wetland purification in the next step.

07 Overall Strategy2: Functional wetlands purification - Water quality purification process selection

Under the condition that the water quality is basically stable surface V. and the water supply conditions are stable, the functional constructed wetland can play its characteristics of low cost, low operation and maintenance cost in the later stage, and significant purification effect, and provide a core treatment scheme for the ecological treatment of water in Shenqing River and Yaoshan River.In comparison, the Vertical subsurface downward flow constructed wetland is more suitable for this aquatic ecological treatment.

Evaluation of constructed wetlands

Serface flow constructed wetland

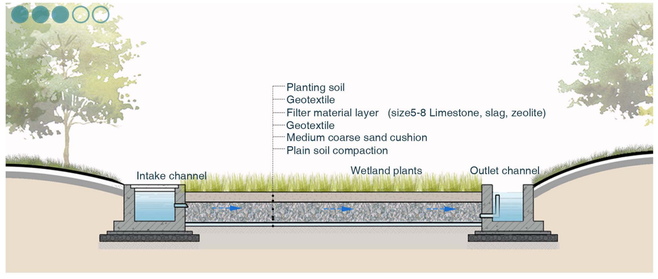


strengths	weaknesses
a Simple structure	a Low purification efficiency
b Flexible form	b Purification of contamnants is limited
c Low construction cost	c Poor stability
d Simple maintenance	

Contaminant removal rate

BOD_5	40%~70%
COD_{CR}	50%~60%
SS	50%~60%
NH_3-N	20%~50%
TP	35%~70%

Horizontal subsurface fiow constructed wetland

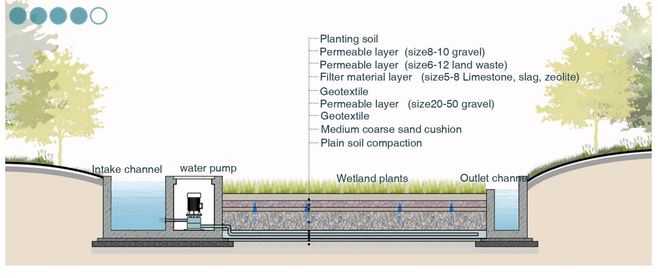


strengths	weaknesses
a High purification efficiency	a Purify a single contaminant
b Stable purification effect	b Complex structure
c Flexible form	c Weak contaminant removal load capacity
d Simple maintenance	d High maintenance costs

Contaminant removal rate

BOD_5	45%~85%
COD_{CR}	55%~75%
SS	50%~80%
NH_3-N	40%~70%
TP	70%~80%

Vertical subsurface upward flow constructed wetland

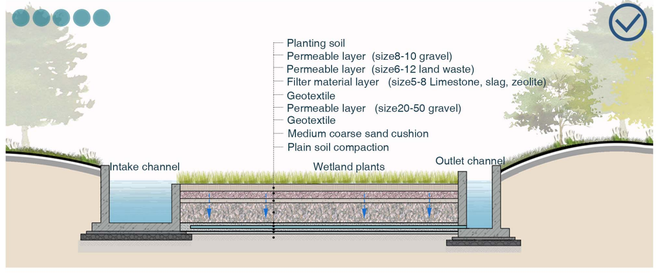


strengths	weaknesses
a High purification efficiency	a Complex structure
b Strong pollutant removal load capacity	b High form requirements
c High purification efficiency	c High maintenance costs
d Small footprint	d High construction cost

Contaminant removal rate

BOD_5	50%~90%
COD_{CR}	60%~80%
SS	50%~80%
NH_3-N	50%~75%
TP	60%~80%

Vertical subsurface downward flow constructed wetland



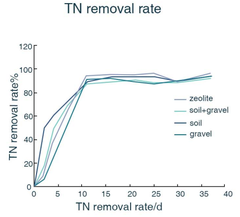
strengths	weaknesses
a High purification efficiency	a Complex structure
b Strong pollutant removal load capacity	b High construction cost
c High purification efficiency	c Large footprint
d Flexible form	

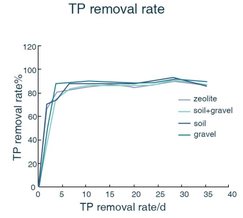
Contaminant removal rate

BOD_5	50%~90%
COD_{CR}	60%~80%
SS	50%~80%
NH_3-N	50%~75%
TP	60%~80%

Wetland filler selection

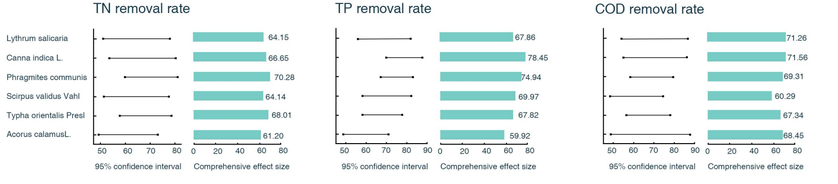
The microorganisms in the filter material layer (zeolite, gravel, volcanic stone, maifan stone) are layered to degrade COD, ammonia nitrogen, total phosphorus and total nitrogen in the water, and at the same time filter particulate matter to improve the transparency of the water body to achieve the purpose of improving water quality.





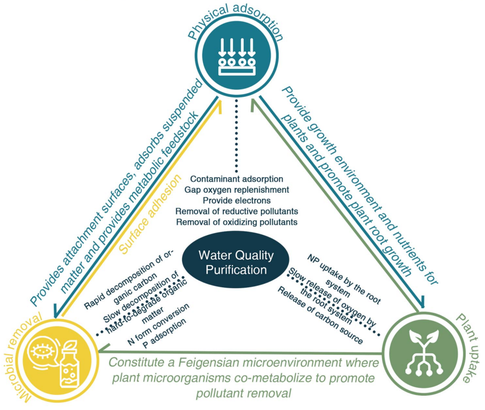
Aquatic plants selection

Reed, cattail, cannaba, onion, cattail and other emergent plants are selected in functional wetlands, and pollutants such as ammonia nitrogen, total phosphorus, and total nitrogen in the water body are absorbed through the root system to achieve the purpose of water purification.



07 Overall Strategy2: Functional wetlands purification - Pollutant purification mechanism

Vertical subsurface flow constructed wetland, which rely on the combined action of fillers, microorganisms and plants to achieve the removal of various pollutants from wastewater. Vertical subsurface flow constructed wetland is then combined with a settling pond, a front purification pond and a landscape water surface in the site to play a comprehensive effect of pollutant purification.

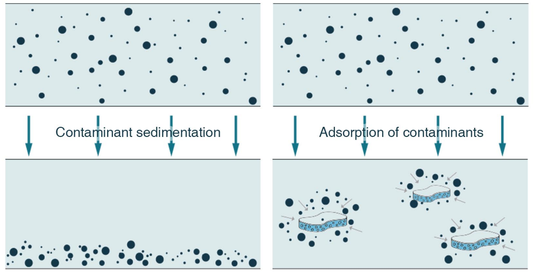


Schematic diagram of wetland pollutant purification mechanism

Downstream submerged wetland as the optimal solution for local wastewater purification, its purification process is divided into three main aspects:

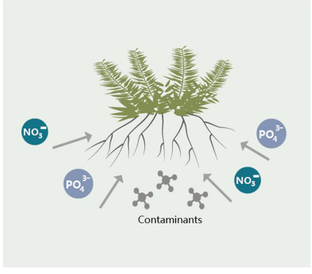
Substrates - physical adsorption and sedimentation

The suitable and most effective bedding substrate allows for direct adsorption and removal of pollutants.



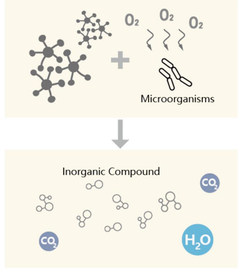
Plants - Biosorption

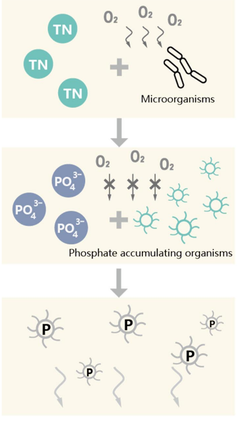
Plant roots trap suspended substances in the water and degrade and transform nutrients in the wastewater.

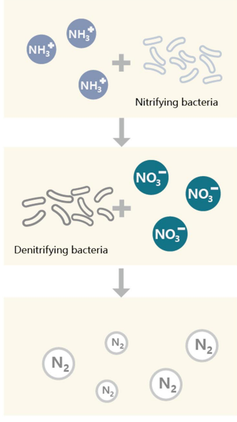


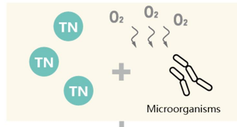
Microbial-chemical reactions

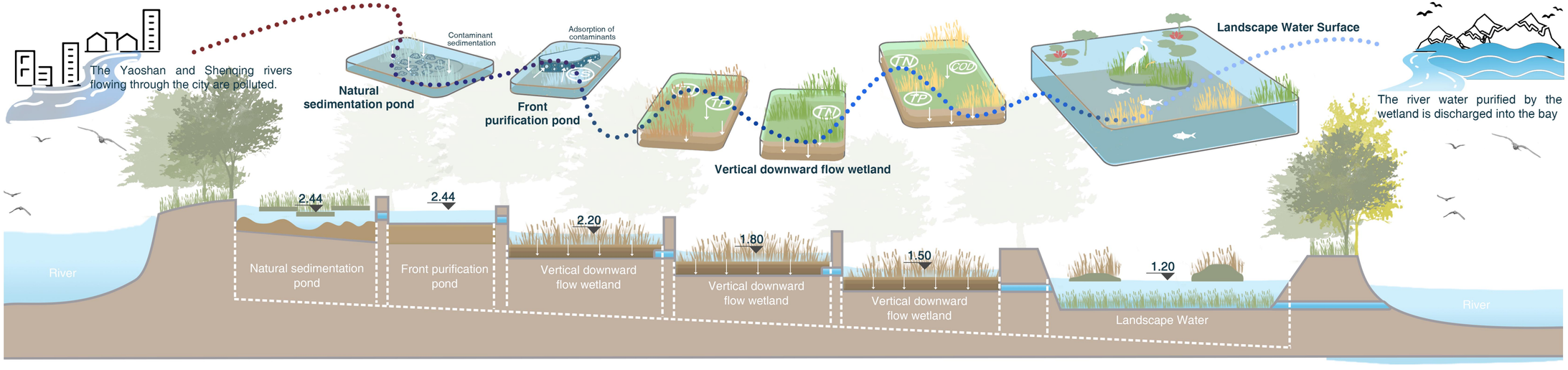
The metabolic effect of microorganisms is the main mechanism of organic matter degradation in sewage











07 Overall Strategy2: Functional wetlands purification - Wetland water purification overall program

This step is the core step of water purification, introducing all river water from Yaoshan river and Shenqing river, and purifying Class V water into Class IV water in a series of Functional wetland modules to meet the water quality requirements for discharge into the bay. Firstly, according to the pollutant degradation capacity of the functional wetlands and the limit of tolerable water quality index, the area of the functional wetlands required by the program and the water intake requirements are determined. Then design the water purification process route, through the combination of various types of functional wetland modules to achieve the required water purification effect.

How to purify river water quality through frunctional wetlands?

Define the purpose

The standard river water quality required to enter the sea - surface water Class IV to Class Ⅳ， needs to be purified by vertical subsurface downward wetlands.

Find methods

Combining the pollutant concentration , the degradation load of pollutantsand the water volume, the formula is brought in to calculate the required wetland area, which guides the landscape design.

Determine the formula

According to the Technical Specification for Artificial Wetland Sewage Treatment Project (HJ 2005-2010),the area calculation formula is:

$$A = \frac{Q \times (C_0 - C_1) \times 10^{-3}}{q_{os}}$$

Confirmation data

Q——Water volume(m^3*10000)

Month	Water volume (now)	Water volume (Supply)	Water volume (After)	Water volume (single day)
1	12.4	0	12.4	0.41
2	11.9	0	11.9	0.4
3	11.3	0	11.3	0.38
4	0.8	13.2	14	0.47
5	0	14	14	0.47
6	16	0	16	0.53
7	27.6	0	27.6	0.92
8	139	0	139	4.6
9	42.3	0	42.3	1.4
10	4.5	4.7	9.2	0.31
11	8.3	0.9	9.2	0.31
12	16.4	0	16.4	0.55

C——Concentration of major pollutants

Month	Water volume (single day)	COD	NH3-N	TN	TP
1	0.41	47000	2350	2350	470
2	0.4	47000	2350	2350	470
3	0.38	53000	2650	2650	530
4	0.47	92000	4600	4600	920
5	0.47	460000	23000	23000	4600
6	0.53	140000	7000	7000	1400
7	0.92	31000	1550	1550	310
8	4.6	31000	1550	1550	310
9	1.4	55000	2750	2750	550
10	0.31	41000	2050	2050	410
11	0.31	40000	2000	2000	400
12	0.55	38000	1900	1900	380

q_{os}——Degradation load of pollutants

Pollutants	COD	NH3-N	TN	TP
Degradation load	1.25	0.2	0.2	0.025

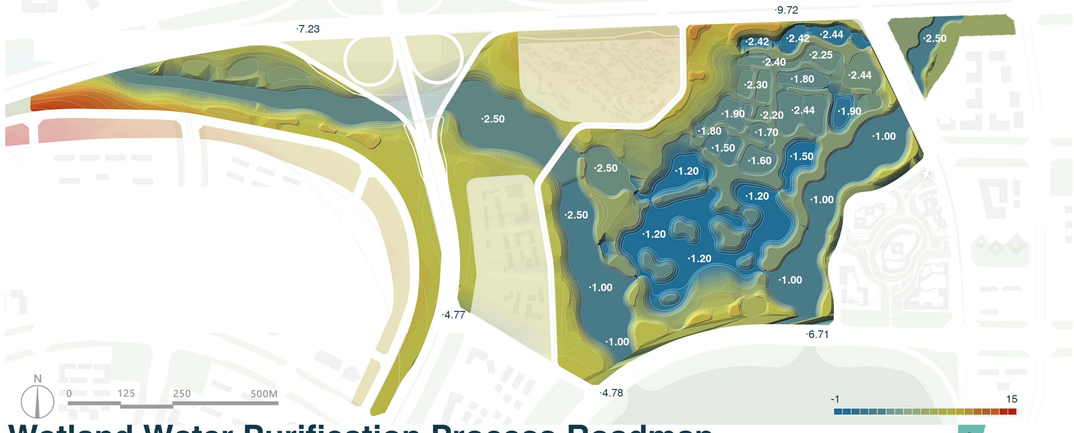
Water volume calculation should choose abundant water period (July-September). August and September have abundant precipitation and low pollution concentrations that do not require treatment. Therefore, July water volume has been selected as the artificial wetland design standard.

COD is the main pollutant in water, and the change trend is obvious and easy to detect. Using COD content calculate wetland pollutant concentrations. It is calculated that the minimum wetland water purification area needed for the site is 41818 m^2.

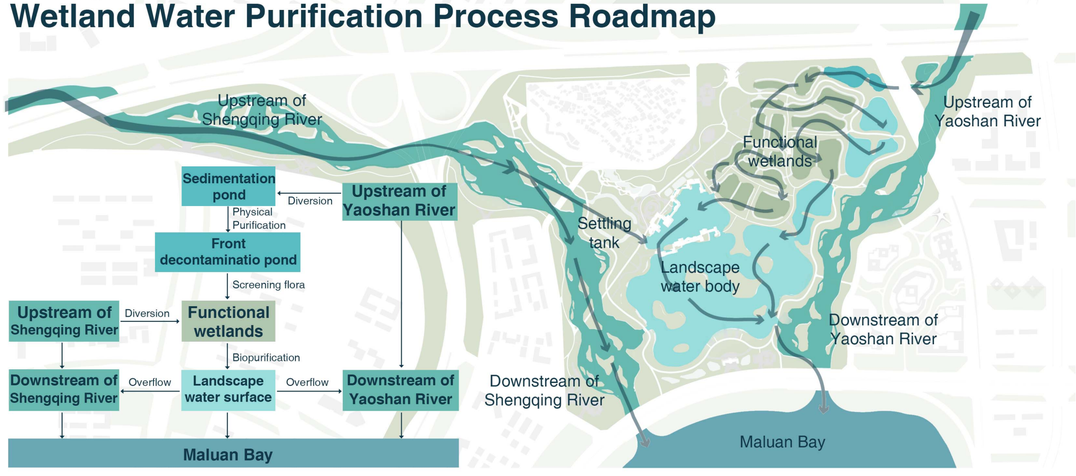
Wetland water purification process route

The water of two rivers is purified by functional wetland and then discharged into the landscape water surface system, and then discharged into the down-streams, which flow into Maluan Bay. Yaoshan River is heavily polluted and its up-stream flows through several functional wetland modules for purification before discharging into the land-scape water surface system. Shenqing River is less polluted, and the up-stream is diverted to a single functional wetland module, and then draining the landscape water surface system.

Wetland vertical design drawing



Wetland Water Purification Process Roadmap



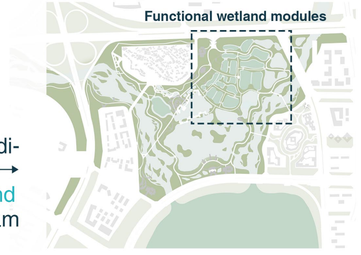
07 Overall Strategy2: Functional wetlands purification - Detailed design of functional wetland modules

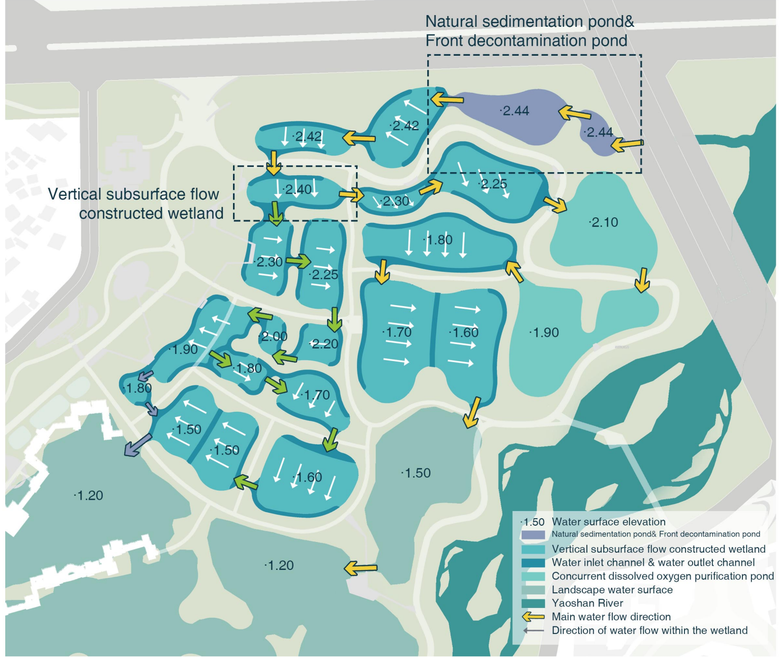
The water quality purification system is centered on a functional wetland module, consisting of vertical subsurface flow constructed wetland, natural sedimentation pond and front purification pond. After the upstream stream passes through a single vertical subsurface flow constructed wetland, it is discharged from the drainage channel and enters the intake channel of the next wetland unit, and the river water is purified through several units in turn, and finally the water quality is improved and upgraded. The entire water flow process is gravity natural flow, in the rainy season or excess water, can quickly pass by the constructed wetland surface to ensure flood safety.

Functional wetland module

Purification target:
Water Standard Class V → Class IV

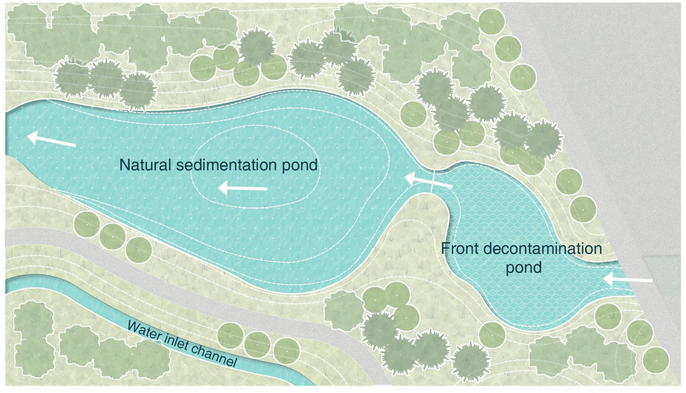
Purification process:
Upstream of Yaoshan River → natural sedimentation pond → front purification pond → vertical subsurface flow constructed wetland → ecological water surface → downstream of Yaoshan River → Malang Bay

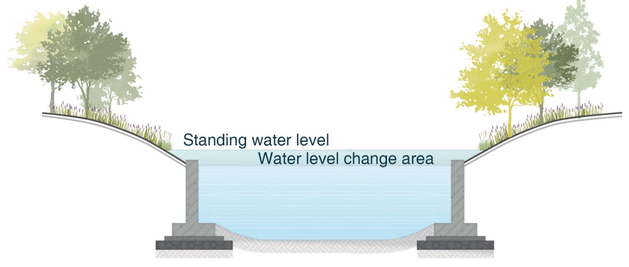




Natural sedimentation pond& Front decontamination pond

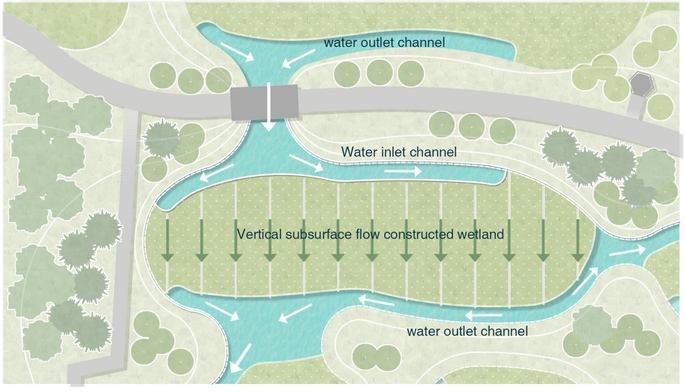
The natural sedimentation pond intercepts and precipitates large particles of pollutants in the upstream incoming water to reduce the turbidity of the water body; the front purification pond screens and cultivates bacteria for subsequent purification.

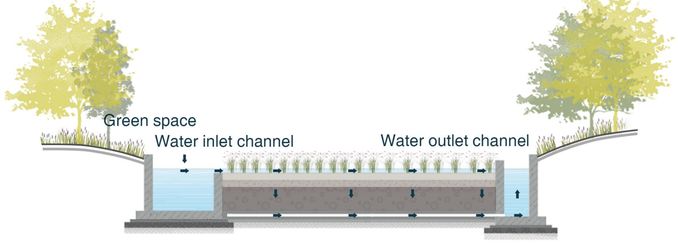




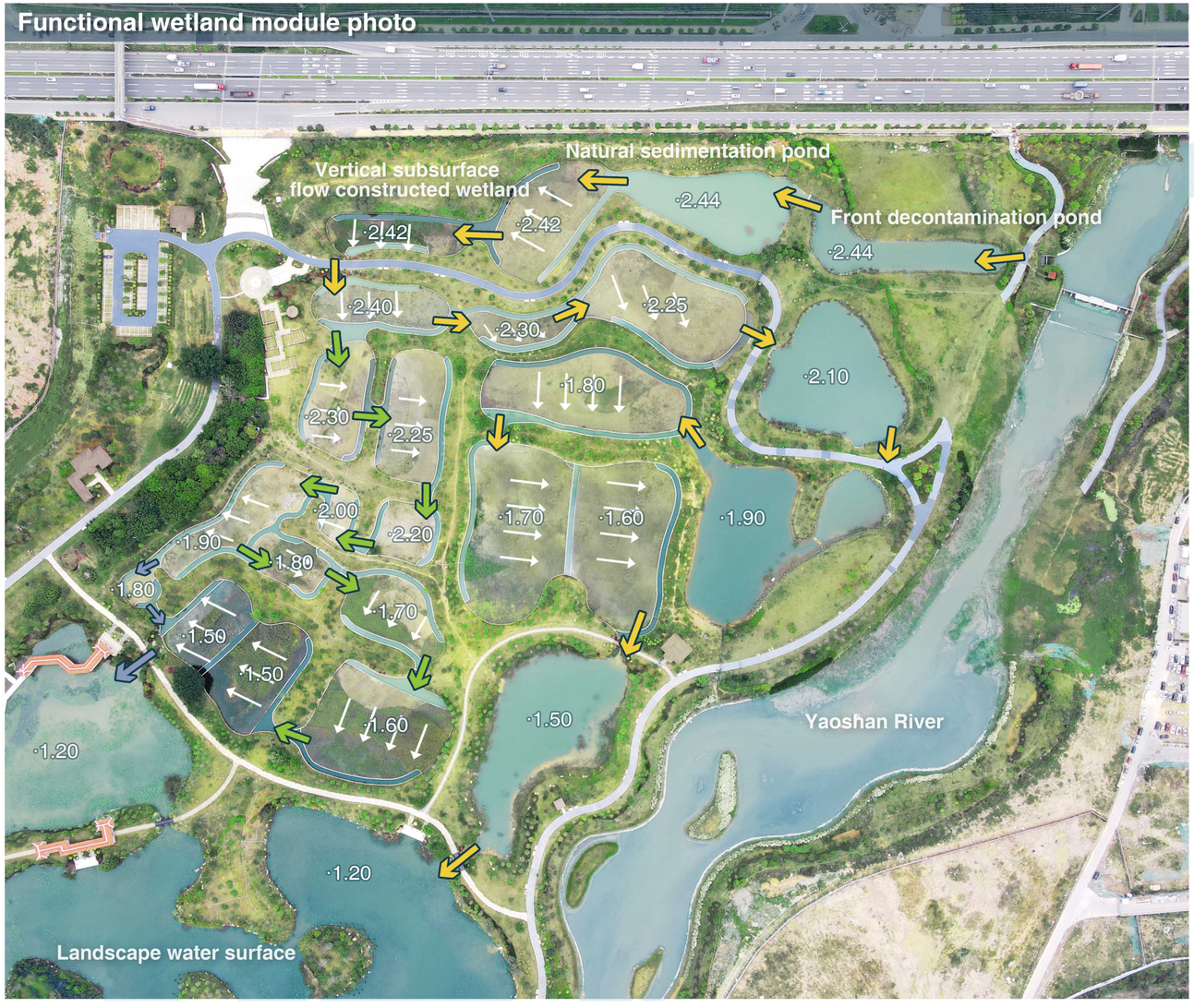
Vertical subsurface flow constructed wetland

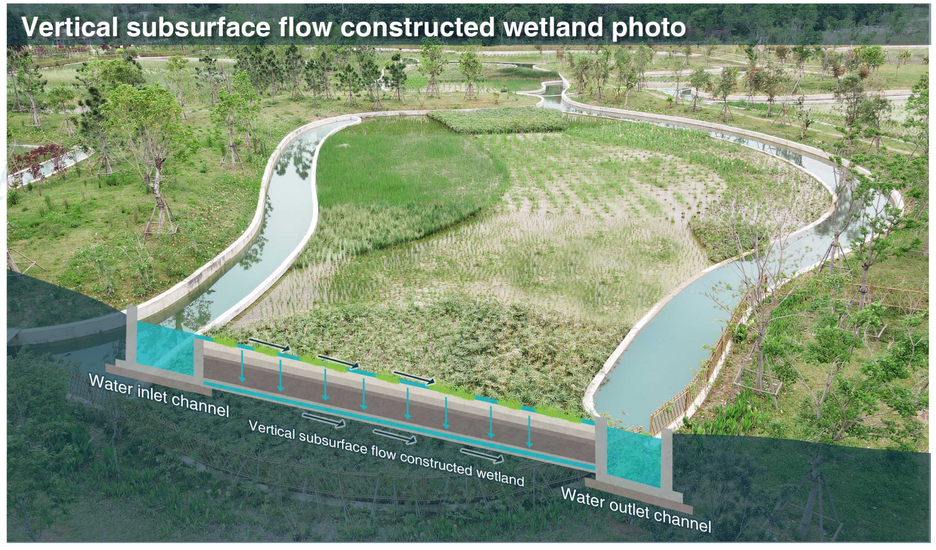
Vertical subsurface flow constructed wetland rely primarily on the combined action of fillers, microorganisms and plants to achieve the removal of various pollutants from wastewater. Multiple units can be connected in series until the purification goal is achieved.





07 Overall Strategy2: Functional wetlands purification - Detailed design of functional wetland modules





08 Overall Strategy3: Flood Management Strategies

According to the 50 Year Flood, carry out the water management strategies design. Analysis of water flow routes of 4 period: drought period, average period,Abundant Water Period and flood period. Landscape transformation of river banks to meet flood management needs while being more aesthetically and with ecologically valuable.

Water Flow Routes

The water flow route is controlled by opening and closing the flap gate. Gates are installed at the mouth of the river to prevent seawater from backing up.

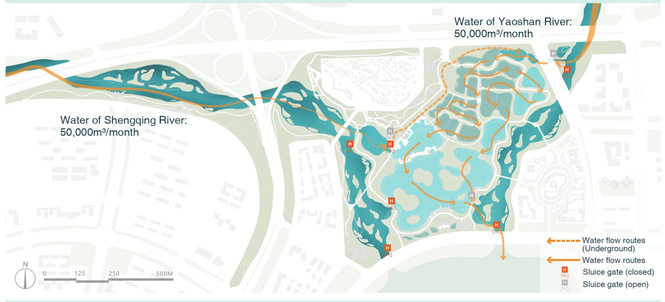
Rainwater storage capacity

Storage area: 41.4 hectares **Effective storage volume:**126,000 m³ **Storm water storage volume(50-year event):** 81,000 m³

Flap Gate

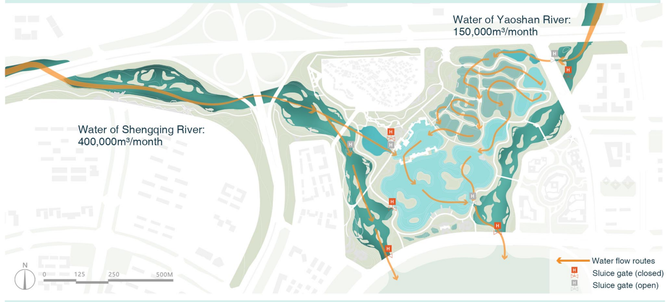
Drought Period（December —April）

The sluice gate is opened to replenish water of the wetland and water body from Yaoshan River, and the shortage is replenished by Shenqing River. The water enters from the north side and flows to the landscape water body through a series of functional wetlands for purification.



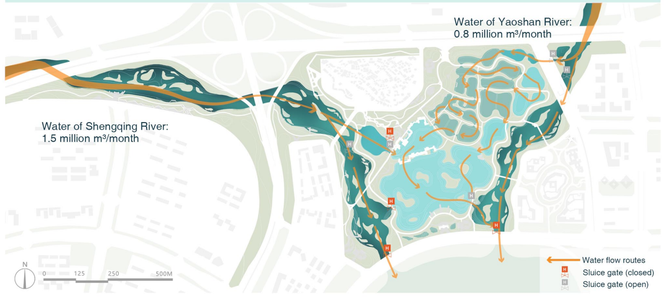
Average Period（June — July，September — November）

The upstream water of Yaoshan River flows into the functional wetland on the north side, and then flows to the landscape water body. The water of Shenqing River recharges the landscape water body, and the excess is discharged into the sea.



Abundant Water Period（August —September）

The route of water flow during the abundant water period is basically the same as that during the average period, except that the gates of Yaoshan River will be opened to allow excess water to be discharged into the sea.



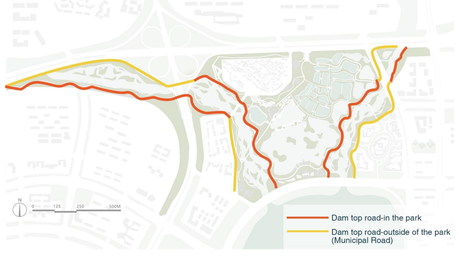
Flood Period

When flooding occurs (the flood storage level of the wetland reaches 2.5 meters), the gates connecting the river to the wetland and the landscape water body are all closed to avoid damage to the wetland caused by excessive sewage. The gates connecting the river to the sea are opened and the water is discharged directly into the sea.

River Embankment Landscaping

The flood prevention standard is 50 years, and the safety elevation of the embankment is 1.05m.

The main road is set at the top of the embankment for visitors to ride and watch on foot, and it can also meet the traffic demand of fire engines and emergency vehicles



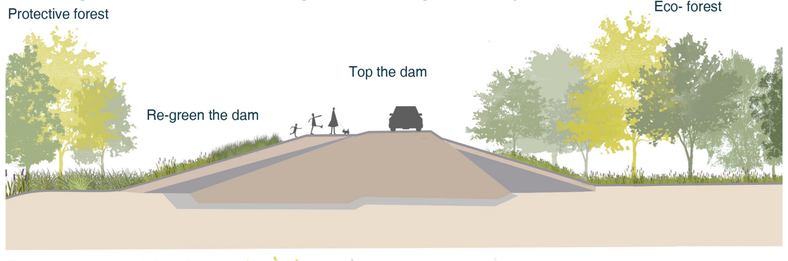
River

Treatment measures: dredging of the river, construction of ecological embankments and ecological slopes.

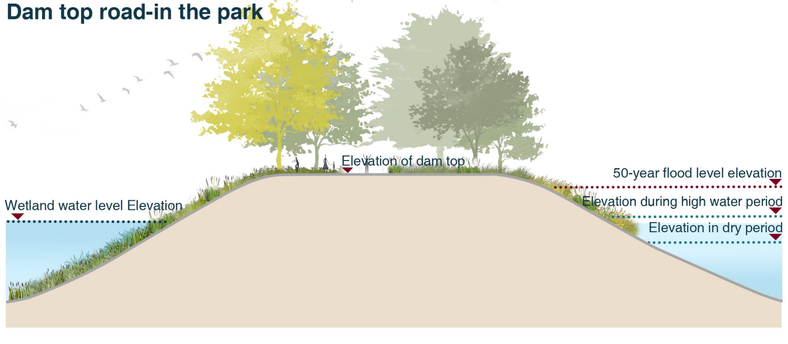
Dams

50-year flood level:
Yaoshan River 2.99-2.90m
Shengqing River4.38-2.90m
Top elevation of dam design:
Yaoshan River 3.99-3.95m
Shengqing River 5.43-3.95m

Dam top road-outside of the park Municipal Road)



Dam top road-in the park

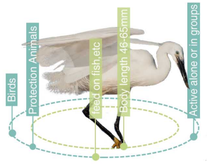


09 Overall Strategy4: Enhancing Biodiversity - Focal species research

Analysis of the types of habitats present in the region and the presence or potential wildlife species in and around the site. Select focal species (*Egretta garzetta* & *Hylarana guentheri*) for focused studies and propose habitat creation strategies for them.

Focal species research

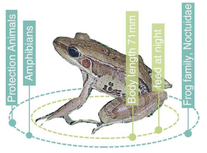
Egretta garzetta



1.They live in shallow water along the rivers and ponds.They are usually active alone or in pairs or small groups.

2.It mainly feeds on fish, shrimp, frogs, insects and small invertebrates. The feeding range is no more than 50 cm deep; radius is about 10 km.

Hylarana guentheri

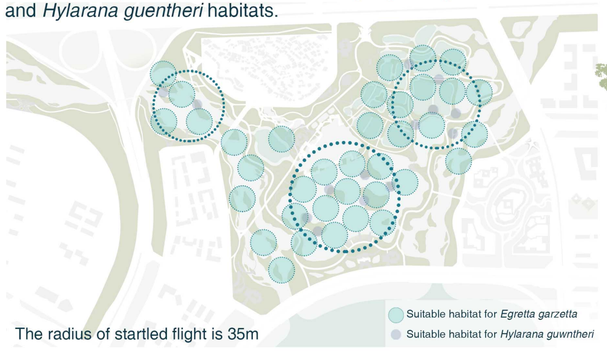


1.They live in plains, hills and mountains at altitudes below 1100 meters. Adult frogs mostly inhabit rice fields, ponds or shallow beaches.

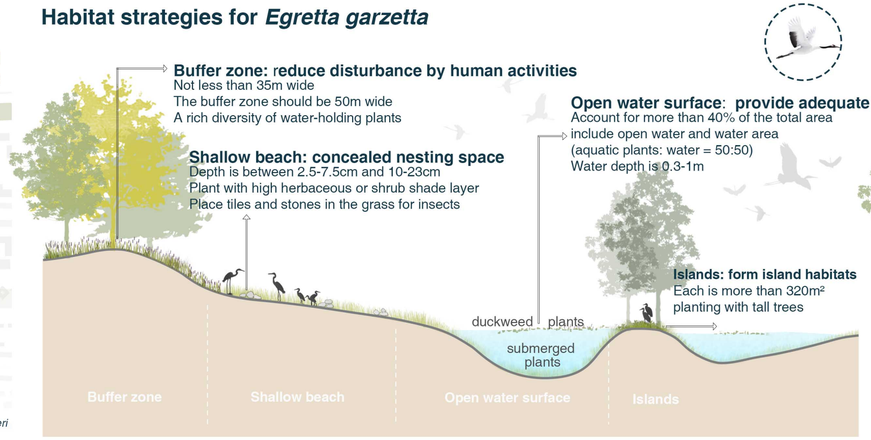
2.They usually go out at night to feed, mainly on insects, but also on earthworms, snails, etc.

Map of suitable distribution for focal species habitats

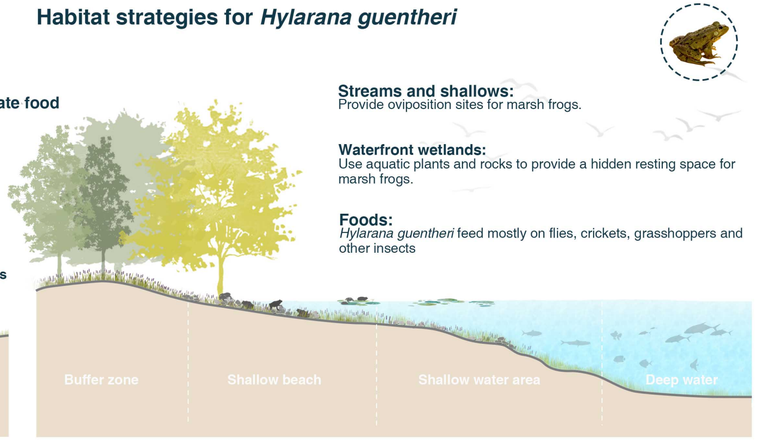
According to the radius of startled flight and the distribution of foraging areas, identify areas suitable for creating *Egretta garzetta* habitats and *Hylarana guentheri* habitats.



Habitat strategies for *Egretta garzetta*



Habitat strategies for *Hylarana guentheri*

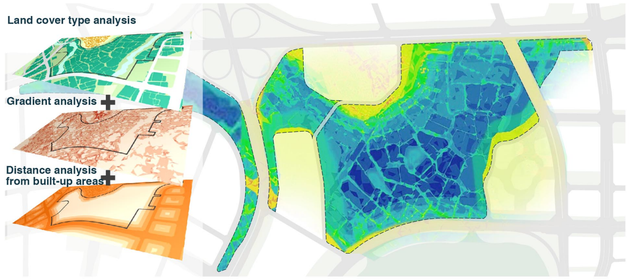


09 Overall Strategy4: Enhancing Biodiversity - Ecological suitability evaluation

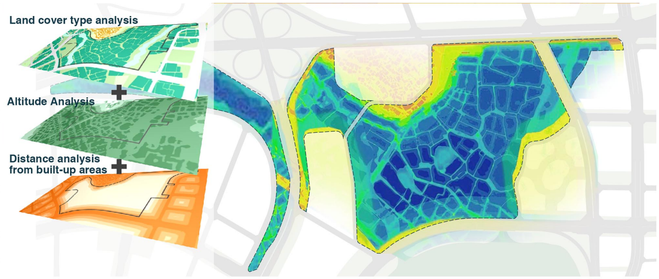
Summarize habitat suitability analysis of focal species-Egretta garzetta and Hylarana guentheri, and synthesize the comprehensive habitat security pattern of birds and amphibians, as a guide for ecological function zoning.

Ecological suitability evaluation of focal species

Ecological suitability evaluation of *Egretta garzetta*



Ecological suitability evaluation of *Hylarana guentheri*



Comprehensive ecological suitability evaluation of birds & amphibians

High Sensitive Areas

Strategies

Strictly limit development
Protection of existing woodlands and reduction of patch fragmentation
Enhance the connectivity of forest land with surrounding natural resources

Ecological Function

- Ecological Protection
- Biological Habitat
- Ecological corridors
- Soil and Water Conservation

Medium Sensitive Area

Strategies

Moderate development restrictions
Integrate natural purification function units
Utilize and optimize woodlands, fishponds, and wetlands to create a multi-connected water habitat

Ecological Function

- Ecological Buffering
- Flood Water Storage
- Water Quality Purification
- Ecological corridor

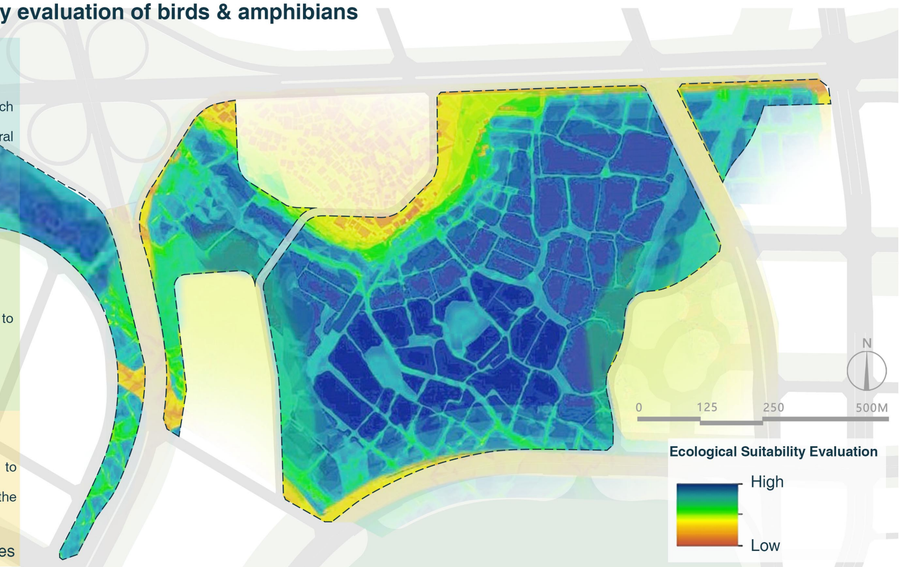
Low Sensitive Area

Strategies

Medium to low restrictive development with attention to minimizing environmental impact
Enhance the ecological function of the area by optimizing the existing agricultural land

Ecological Function

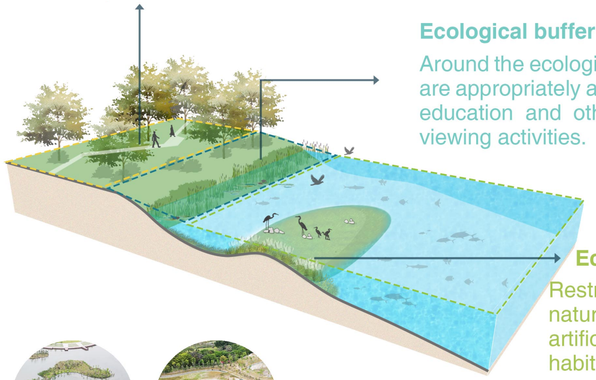
- Ecological Buffering
- Integrated Service Facilities



Ecological Function Zone and Restoration Strategies

The spatial planning is divided into three categories based on the superposition of ecological elements:

Comprehensive service & management area:
Open for touring, the main function is to provide services for visitors, get close to nature and enhance nature experience.

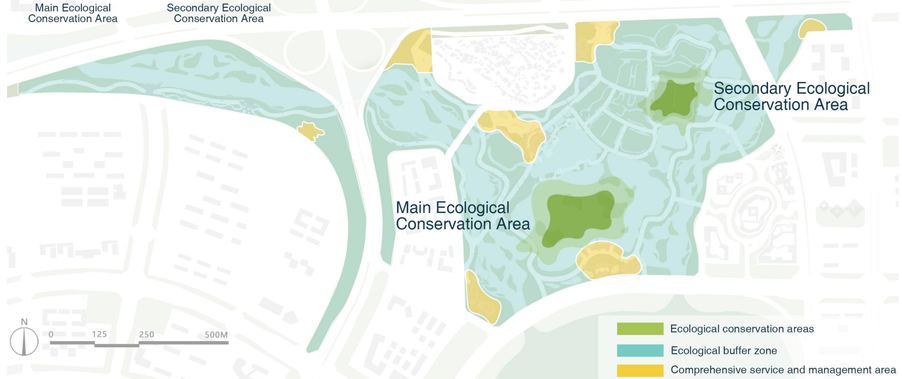


Ecological buffer zone:
Around the ecological conservation area, visitors are appropriately allowed to experience habitats, education and other low-intensity touring and viewing activities.

Ecological conservation areas:
Restrict human activities through natural isolation (water system) and artificial isolation, and provide habitats for birds and other animals.


Main Ecological Conservation Area

Secondary Ecological Conservation Area

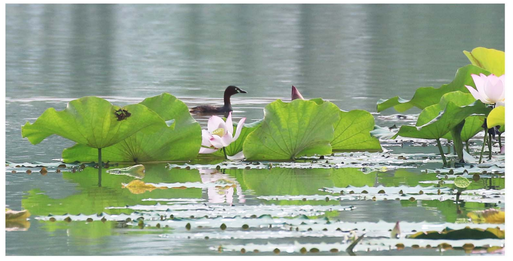


10 Masterplan

1. Main Entrance Plaza
2. Lawn & Waterfront Platform
3. Landscape Water Surface
4. Ecological Island
5. Lotus Pond
6. Minnan Characteristic Pavilion
7. Triangle Plum Square
8. Rainwater Garden
9. Entrance Square
10. Natural Sedimentation Pond
11. Front Purification Pond
12. Downstream Submerged Wetland
13. Concurrent Dissolved Oxygen Purification Pond
14. Landscape Walkway
15. Riverside Walkway
16. Ecological Parking

11 Project Photos 1

Aerial view of the main entrance



11 Project Photos 2

Downstream submerged wetland

Landscape water surface

Ecological Island

Minnan characteristic pavilion

Lawn and water-friendly platform

11 Project Photos 3