

# Chengdu River status and cause analysis

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Received 1 September 2014, www.cmnt.lv

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## Abstract

Focusing on the basic model of the riverside landscape of Chengdu's five major rivers, this paper conducts contrastive analysis on the model characteristics of urban riverside landscape, location of the city where it locates and the urban construction status and explains in detail about the relation between the formation reasons of urban riverside landscape and the level of urbanization development. It discusses the effect of urban development and residents demand on urban riverside landscape design so as to perfect the design thought about it.

*Keywords:* cause analysis, landscape model, correlation analysis, land property, river status

## 1 Introduction

Water is a resource closely connected to human life and production. Human being is born to be water-loving and "to live by the riverside" and "to build cities in places surrounded by water" was the basic principle of city construction in the ancient time. In nowadays society, urban river is playing a decisive role in urban establishment and development [1]. Owing to the high correlation of urban river with urban development and the lives of residents, human needs and human participation become particularly important in the design and formation of urban riverside landscape.

Focusing on eight most influential rivers which also spread most widely within the urban area of Chengdu, this paper conducts targeted study on the model difference of the riverside landscape models of these rivers and the forming reason of such difference in varied locations in the urban and suburban area. Paying special attention to the development status of urban riverside landscape under the integrative action of various factors such as level variance of urbanization, intra-city location difference and difference of residential demand for rivers, this paper tries to find out the general rule of urban riverside landscape development during urbanization and in the context that the degree of human participation in landscape development increases, and then discusses the development tendency of urban river landscape and the theory of man-water harmony river landscape construction of modern city.

With rainless spring and winter but rainy summer and autumn, Chengdu enjoys ample rainfalls and has a mean annual precipitation of 1,124.6 millimeters. The amount of Chengdu's annual precipitation varies little and the ratio between the maximum and minimum annual precipitation is about only 2:1. Densely covered by waterways, the city has the Minjiang River system in the southwest and Tuojiang River system in the north.

There are more than 40 rivers in the city, covering a water area of over 700 square kilometers. The average annual water resources quantity is 30.479 billion cubic meters, of which 3.158 billion cubic meters is underground water and 18.417 billion cubic meters is transit water, can basically satisfy the needs of life, production and construction of Chengdu people and the requirements of river landscape. The Minjiang River, Tuojiang River and other ten main streams and dozens of tributaries have constituted a cross-linked river system of Chengdu of a density as high as 1.22km/sq.km; in addition to the world famous Dujiangyan Irrigation Project, various reservoirs, pools, weirs and canals are spreading all over the city.

## 2 Research method and definition and division of research scope

**Research method:** The author mainly uses field investigation, literature consultation and comparative research method to conduct a four-season one-year survey on the eight major rivers in the urban area of Chengdu. The visual language of the river landscape is finally made out of pictures and freehand sketching produced based on field shooting and on-spot section and plane drawing of the landscape pattern.

**Definition and division of research scope:** In terms of scope, the research involves all the river basins all over Chengdu. As for the definition of urban area, the eastern, western and northern parts are all limited by cycle-city roads. Since the city center is now moving toward south, the boundary of the southern part is where Fuhe River and Jiang'anhe River meets in Huayang Town. Then the research scope is further divided into four survey regions according to the city pattern: the intra-First-Ring-Road-region, First Ring Road-Second Ring Road region, Second Ring Road-Third Ring Road region and extra-Third-Ring-Road region.

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**3 Abstraction and classification of river landscape model**

Abstraction of river landscape model: To be specific, the eight major rivers are the Fuhe River, Qingshuihe River, Jiang'anhe River, Shahe River, Dongfengqu River and its tributaries, Xiaojiahe River, Xiaojiahe River and Modihe River. The Fuhe River, Qingshuihe River, Jiang'anhe River, Shahe River, Xijiaohe River, Xiaojiahe River and Modihe River are natural while Dongfengqu River is artificial (illustrated with a drainage map of Chengdu urban area). First of all, according to the spatial difference of the universal space of the riparian green land, the author divides the riverside landscapes of these eight rivers and abstracts the model chart of the landscape types. The model chart includes the planar graph of each landscape type and the sectional drawing of the riverbank [2-13]. 100 models are abstracted in all, including 36 models of the Fuhe River, 24 of the Qingshuihe River, 10 of the Jiang'anhe River, 20 of the Shahe River, 14 of the Dongfengqu River and its tributaries, 4 of the Xijiaohe River, 5 of the Xiaojiahe River and 6 of the Modihe River. The Fuhe River comes from the Shidiyan Sluice of Tuanjie Town, Pixian County. At the upstream, there is the Botiaohe River- the main canal of Dujiang Dam, and the Xuyanhe River-a tributary of Zoumahe River. The water passes through the sluice and is divided into two: the left Pihe River heading the Tuojiang River and the right Fuhe Tributary (the current Fuhe River) of which the discharge capacity is 68m<sup>3</sup> / s. The Fuhe River begins to flow southeastward at the Shidiyan Sluice and is divided into the Dongfengqu River by the left in Anjing township of Pixian County then the water flows southward into the Jinniu District of Chengdu. The monthly average discharge of the Fuhe River by the Gaoqiao reach has maintained stable in the past ten years. In Dongzikou, the water is divided to the Shahe River (which is further divided into the right Zhuantou Bam and the left Xiwa Bam) by the left and Fuhe River by the right. The monthly average discharge of the Fuhe River is 17.0 m<sup>3</sup> / s, which reduces a bit after being split in Dongzikou. In the southeast direction, the river flows across the northern and eastern part of city center and goes through Mengzhuiwan in the east. By the right side at the Nanhe River Estuary in Hejiangting, the river includes the Nanhe River, which comes from the Qingshuihe River, the downstream of the Zoumahe River; then it passes the Jiuyanqiao Bridge and the Wangjianglou Hydrologic Station, covering an intra-regional drainage area of 505 km<sup>2</sup>. The Fuhe River has a monthly average discharge of 45.9 m<sup>3</sup> /s by the Wangjianglou reach. Before the diversion, the average annual discharge of the Dongfengqu River is 59.1 m<sup>3</sup> / s, which reduces to 33.7 m<sup>3</sup> / s with 5.5 m of water level amplitude after the diversion, as shown in Equation (1):

$$Q' = \beta Q, \beta = \sqrt{L/h_a} \sqrt[4]{(2h_a - L)/h_a} . \tag{1}$$

Classification of river landscape model. Rivers within Chengdu urban area are classified by region, i.e., rivers of the intra-First-Ring-Road-region, rivers of the First Ring Road-Second Ring Road region, rivers of the Second Ring Road-Third Ring Road region and rivers of the extra-Third-Ring-Road region. River landscape models are compared within the research scope. Rivers with similar landscape models are included into one category, and there are ten categories of river landscape models in Chengdu.

**3.1 CATEGORY 1**

The typical model of category 1 is as shown in Figure 1. Region: beyond the West Third Ring Road and in the direction of the North Third Ring Road.

Major rivers: Fuhe River, Qingshuihe River & Modihe River.

Status of riparian land: Most lands are villages, towns and farmlands; low level of urbanization.

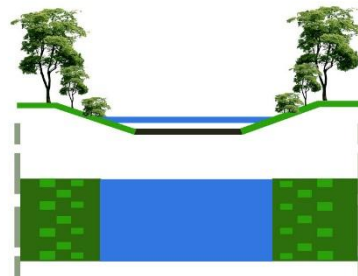


FIGURE 1 The typical model chart of category 1

Status of river: Natural rivers and watercourses; riverbanks are in near-natural status; hardly any manual damming.

Status of landscape: The river landscape is essentially natural. Habitat of the patch core is barely affected by human disturbance, and the landscape patch has high integrity, high species diversity low human participation.

Forming reason for landscape: the status of landscape within this region shows the basic human needs for rivers. Irrigation is the only requirement to be met. Hardly any manual treatment has been exerted upon the rivers.

**3.2 CATEGORY 2**

The typical model of category of category 2 is as shown in Figure 2. Region: beyond the East Third Ring Road and in the direction of the North Third Ring Road.

Major rivers: Dongfengqu River and its tributaries

Status of riparian land: This region was the industrial and logistics distributing area of Chengdu in the past. Today it has been transformed into a land for residential construction and commercial finance. It also involves some culture and entertainment (in construction).

Higher urbanization level than the western and northern regions beyond the Third Ring Road.

Status of river: Artificial river courses.

Status of landscape: Simple artificial landscape accessories and high landscape integrity. Although human

participation has been taken into consideration in the landscape design of some reaches, the level is low.

The 117km Dongfengqu River (with 71km from the Wangjianglou reach to Jiangkou reach) is about 14km long within the city and 28km long out of the city, reaching an average gradient of 1/1000. It is about 100m wide from the Shuangliu Dejiang Temple to the Erjiangqiao Bridge and about 150m wide from the Erjiangqiao Bridge to the Huanglongxi. The widest part of the Jiandaoyan Bam reach is 265m. The 27km long Zoumahe River, 38km Long Qingshuihe River, 2km long Huanhuaxi River and 6km long Nanhe River, all together, reach a total length of 73km and an intra-regional drainage area of 305 km<sup>2</sup>. After the integrative waterway regulation of the Duanhe River, the riverbank has got artificially-built vertical stone embankments and three rubber water dams. The Shahe River is an artificial watercourse built in the industrial zone of the eastern suburbs. After the diversion at Dongzikou, it flows along Chengdu's eastern suburbs toward the southwest and falls into the Fuhe River at around Sanwayao. The reach is about 22km. With a monthly average discharge of 16.25 m<sup>3</sup> / s, the Shahe River is the main source of Chengdu industry and domestic water. It spans 55m at its widest part and only 18.58m at the narrowest part. With an average depth of about 4m, the river can be 2m, 5m, 6m or 7m deep. The average annual discharge is 0.49 billion cubic meters. The total hydrologic discharge is as shown in Equation (2):

$$Q = 1.366KS \left[ \frac{L+S}{\lg \frac{2b}{t_0}} + \frac{L}{\lg \frac{0.66L}{t_0} - 0.22 \operatorname{arsh} \frac{0.44L}{b}} \right] \quad (2)$$

Forming reason of landscape.

Human needs for rivers: irrigation and human activities.

With the improvement of urbanization, simple artificial landscape begin to appear by the riverbank; human activity is taken into consideration (artificial trails)

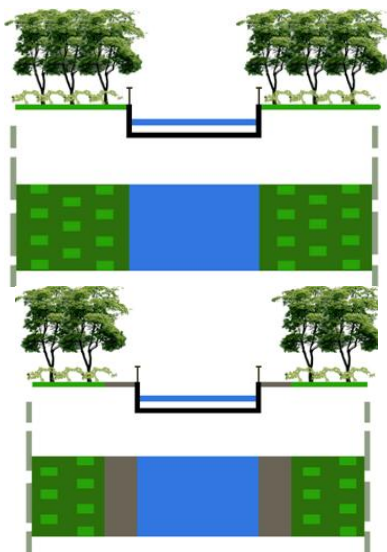


FIGURE 2. The typical model chart of category 2

Due to the factors of regional land property (industrial & logistics distributing area), human requirement for river landscape hasn't been fully considered in the initial landscape setting. Although there is human participation, the level is low.

### 3.3 CATEGORY 3

The typical model of category 3 is as shown in Figure 3. Region: beyond the West Third Ring Road and in the direction of the South Third Ring Road.

Major rivers: Jiang'anhe River

Status of riparian land: Most of the city-rounding water runs through farmlands and enters into the city in the direction of southwest before flowing through the residential district. The level of urbanization turns from very low to high gradually.

Status of riparian land: Natural watercourse with both near-natural and artificially treated reaches.

Status of landscape: transformation from static natural landscape to artificial landscape model.

Forming reason of landscape: Human needs for rivers: irrigation and human activities. With the improvement of urbanization, the riverside landscape transforms gradually from static natural model to artificial model. The degree of human participation increases significantly within the landscape patch when the river flows through the residential district.

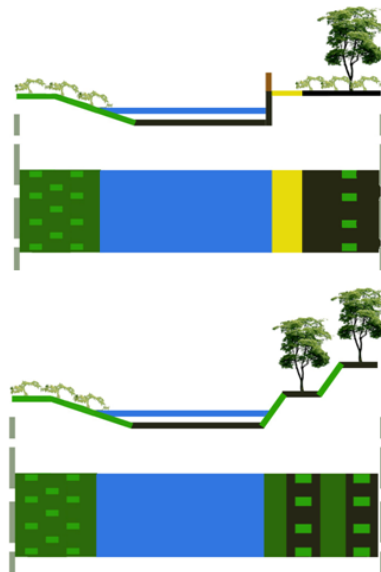


FIGURE 3 The typical model chart of category 3

### 3.4 CATEGORY 4

The typical model of a category 4 is as shown in Figure 4. Region: beyond the Third Ring Road toward the south of the city.

Major rivers: Fuhe River & Xiaojiuhe River.

Status of riparian land: Locating in the High-tech Zone and New Tianfu Zone of Chengdu, it will become the core area of the future urban construction of Chengdu

with integrated function of residence, finance and government administration. Very high level of urbanization.

Status of river: natural rivers and complex artificial landscape after manual treatment.

Status of landscape: Large green area Particularly effective laying in landscape design. Complex landscape structure. Abundant plant species.

Since the landscapes of this region are all artificially developed and the degree of human participation is extremely high, landscape habitat suffers intense interference. Thus, although the landscape patch covers a large and complete area, the biological diversity is low.

Forming reason of landscape: Human needs for rivers: urban style & human participation; The landscape of this region, playing an important role in city image display, is developed based on strongly goal-directed artificial modification of rivers.

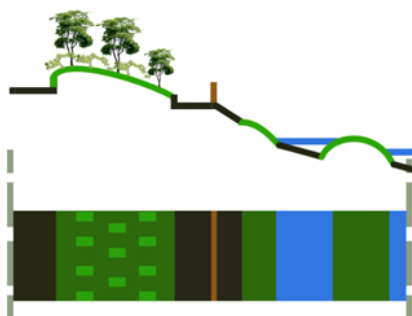


FIGURE 4 The typical model chart of category 4

### 3.5 CATEGORY 5

The typical model of category 5 is as shown in Figure 5. Region: between the North Third Ring Road and the North Second Ring Road.

Major rivers: Fuhe River.

Status of riparian land: Residential communities increase from the Third Ring Road to the Second Ring Road. Wholesale and distributing zone of commodity and building materials. Very high level of urbanization.

Status of river: natural rivers & artificial river landscape.

Status of landscape: Artificial landscape with low degree of human participation. Human participation hasn't been taken into consideration in the landscape design of some reaches.

Forming reason of landscape: Human needs for rivers: irrigation and human activities. Owing to the goal-oriented property of land, human participation hasn't been taken into consideration in the landscape setting of some reaches. Landscape models are mixed and disorderly with low use ratio. There is no effective maintenance for the rivers and river landscape. After flowing into the residential zone, the landscape models tend to be the same and the degree of human participation in river landscape increases.



FIGURE 5 The typical model chart of category 5

### 3.6 CATEGORY 6

The typical model of category 6 is shown in Figure 6. Region: between the North Third Ring Road and the North Second Ring Road & between the East Second Ring Road and the East Third Ring Road.

Major rivers: Shahe River.

Status of riparian land: Shahe River Source Region Ecological Preservation Area, Wetland parks (Tazishan Park, etc.), Culture and entertainment industry (Eastern Music Park), Residential zone, Very high level of urbanization.

Status of river: natural rivers & artificial river landscape.

Status of landscape: The landscape patch is large, and the green land area is larger than all the other river landscape patches of Chengdu. The degree of human participation is relatively low; it also has rich tree species, the maximum vegetation quantity and high biological diversity.

Forming reason of landscape: Original ecological (river ecological preservation area) and artificial landscapes (residential zone and city park) are cross-linked. In a natural state under artificial protection and treatment, the landscape of this region is artificial transformation based on the ecological preservation of river landscape.

The model of the landscape environment of this region is as shown in Equation (3):

$$\begin{matrix}
 \begin{matrix}
 \text{Ecological Preservation Area} \\
 \text{Wetland Parks} \\
 \text{Culture and Entertainment Industry} \\
 \text{Residential Zone} \\
 \text{Urbanization}
 \end{matrix} & \cdot & \begin{matrix}
 \text{Natural Rivers} \\
 \text{Artificial River Landscape}
 \end{matrix} & \cdot & \begin{matrix}
 \text{Large Landscape Patches} \\
 \text{Rich Tree Species} \\
 \text{High Vegetation Quantity} \\
 \text{High Biological Diversity}
 \end{matrix} & \cdot & \begin{matrix}
 \text{Original Ecological} \\
 \text{Artificial Landscapes}
 \end{matrix} & \cdot & \begin{matrix}
 \text{Artificial Transformation} \\
 \text{Ecological Preservation}
 \end{matrix} & \cdot & \begin{matrix}
 \text{Landscape Environment Model}
 \end{matrix}
 \end{matrix} \quad (3)$$

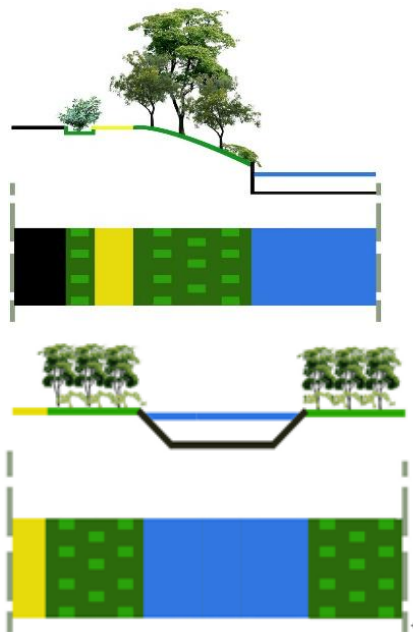


FIGURE 6 The typical model chart of category 6

### 3.7 CATEGORY 7

The typical model of category 7 is as shown in Figure 7. Region: between the South Third Ring Road and the South Second Ring Road.

Major rivers: Fuhe River.

Status of riparian land: Central urban area (mainly residential communities). Wetland parks. New urban zone (mainly residential communities). Very high level of urbanization.

Status of river: natural rivers & artificial river landscape.

Status of landscape: as described in the region within the First Ring Road: Shahe River Wetland Park and New South Zone.

Forming reason of landscape: Conditions of central urban area (within the First Ring Road). Transition from protected natural state to the strongly artificially treated state beyond the Third Ring Road.

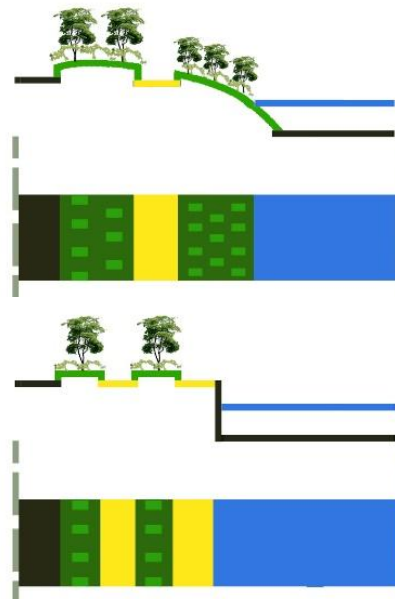


FIGURE 7 The typical model chart of category 7

### 3.8 CATEGORY 8

The typical model of category 8 as shown in Figure 8. Region: between the Second Ring Road to the First Ring Road.

Major rivers: Fuhe River, Nanhe River (the alternative name of the Qingshuihe River within the Second Ring Road) & Shahe River.

Status of riparian land: Central urban area (mainly residential communities). Very high level of urbanization.

Status of river: natural rivers & artificial river landscape.

Status of landscape: narrow green areas and small patches.

Forming reason of landscape: The landscape setting is mainly human-activity and human-demand oriented. Residential land demand leads. On the premise of maximum residential lands and satisfaction of human needs for riparian green space landscape, the landscape model with small green area in landscape patch and high degree of human participation is formed.

The relation between landscape green & degree of human participation and hydrologic data is as shown in Equation (4):

$$\begin{cases} \frac{\partial}{\partial x} (K_{xx} \frac{\partial h}{\partial x}) + \frac{\partial}{\partial y} (K_{yy} \frac{\partial h}{\partial y}) + \frac{\partial}{\partial z} (K_{zz} \frac{\partial h}{\partial z}) - W + Q_i \delta(x - x_i, y - y_i, z - z_i) = S_i \frac{\partial h}{\partial t} \\ H(x, y, z, t_0) = H_a(x, y, z) \Big|_{t=0} \\ H(x, y, z, t) = H_b(x, y, z, t) \Big|_{t \neq 0} \\ K_{xx} \frac{\partial h}{\partial x} \cos(n, x) + K_{yy} \frac{\partial h}{\partial y} \cos(n, y) + K_{zz} \frac{\partial h}{\partial z} \cos(n, z) \Big|_{\Gamma_1} = 0, t \geq t_0, x, y, z \in \Gamma_1 \\ K_{xx} \frac{\partial h}{\partial x} \cos(n, x) + K_{yy} \frac{\partial h}{\partial y} \cos(n, y) + K_{zz} \frac{\partial h}{\partial z} \cos(n, z) \Big|_{\Gamma_{2,3}} = q_1(x, y, z, t), t \geq t_0, x, y, z \in \Gamma_{2,3} \end{cases} \quad (4)$$

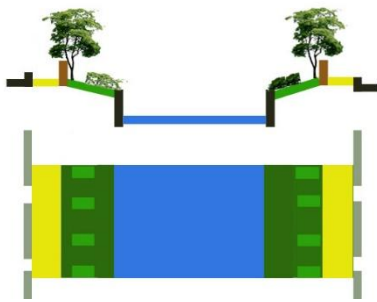


FIGURE 8 The typical model chart of category 8

3.9 CATEGORY 9

The typical model of category 9 is as shown in Figure 9. Region: within the First Ring Road.

Major rivers: Fuhe River & Nanhe River (the alternative name of the Qingshuihe River within the Second Ring Road).

Status of riparian land: Central urban area (mainly residential communities and commercial districts); Very high level of urbanization.

Status of river: natural rivers & artificial river landscape.

Status of landscape: Landscape node accounts the most in landscape setting. It has complex node patches and simpler design of corridor landscapes that connect the nodes.

Forming reason of landscape: the landscape setting is mainly directed at city image display (landscape avenues) and human needs. City style display, landscape avenues, broad greenbelts, exquisite landscape design, abundant vegetation, complex structure and high degree of human participation.

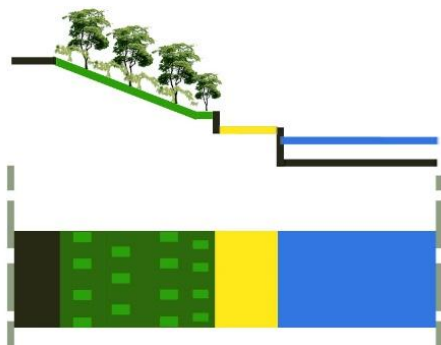


FIGURE 9 The typical model chart of category 9

3.10 CATEGORY 10

The typical model of category 10 is as shown in Figure 10. Region: within the First Ring Road.

Major rivers: Xijiaohe River and its tributaries.

Status of riparian land: Central urban area (mainly residential communities); Very high level of urbanization.

Status of river: natural rivers & artificial river landscape.

Status of landscape: Since both sides of the river landscape are very close from the residential communities, the river landscape is quite narrow. For the landscape setting, there are only very narrow green lands and one or two rows of border tree.

Forming reason of landscape: The primary goal of the landscape setting is to meet the human needs in residence and transportation, thus the width of the riparian landscape is narrow and the landscape is monotonous. The model of this category is as shown in Equation (5):

$$R = \left\{ r_0^2 + 30 \times K \times S^2 (1 + 0.00015r_0^2) \right\}^{0.5} \tag{5}$$

$$r_0 = \sqrt{A/\pi}$$

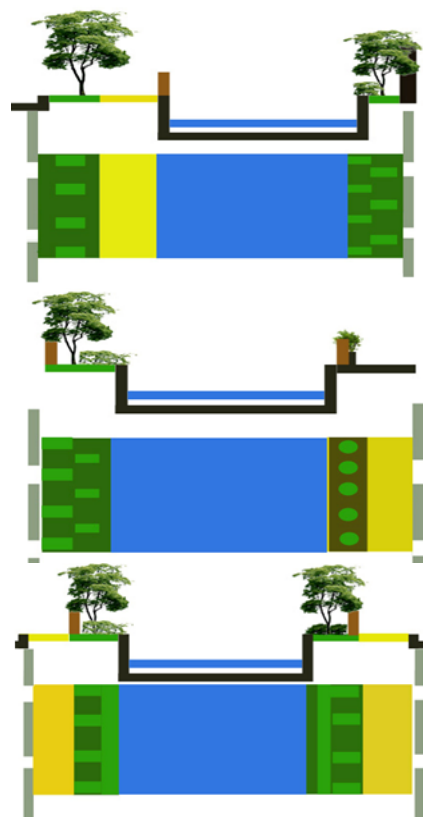


FIGURE 10 The typical model chart of category 10

4 Summary

The landscape model of urban rivers develops gradually with the urbanization process. As city develops, river landscape of areas with low level of urbanization goes through artificial transformation and gradually turns from the original state to a highly artificialized state.

With the improvement of theories of urban planning and urban landscape design, urban river landscape design changes from the old urban center model (Landscape nodes are artificially developed within the First Ring Road, and the links between nodes are weak) to the new city urban center model (large complete landscape).

Based on the correlation analysis between the status of landscape model and the property of the surrounding land, the future river landscape model of a certain region can be predicted.

River landscape models adapting to the property of various urban lands and regions with different levels of economic development can be found out through the study.

## 5 Conclusion

Based on the correlation analysis between the status of landscape model and the property of the surrounding

land, this paper finds out various typical river landscape models under the influence of various land properties and different levels of economic development and explores the formation reasons of these models, so that referable models and practical design thoughts can be provided for the prospective river landscape design directed at different reaches of the city.

## Acknowledgement

This paper is subsidized by the NSFC (Natural Science Foundation of China, No. 51208428).

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