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城市水資源與水環境國家重點實驗室
State Key Laboratory of Urban Water Resource & Environment

2018 UK-China Workshop on Water-Wise Cities & Smart Water Systems

Concept of Sponge City Construction

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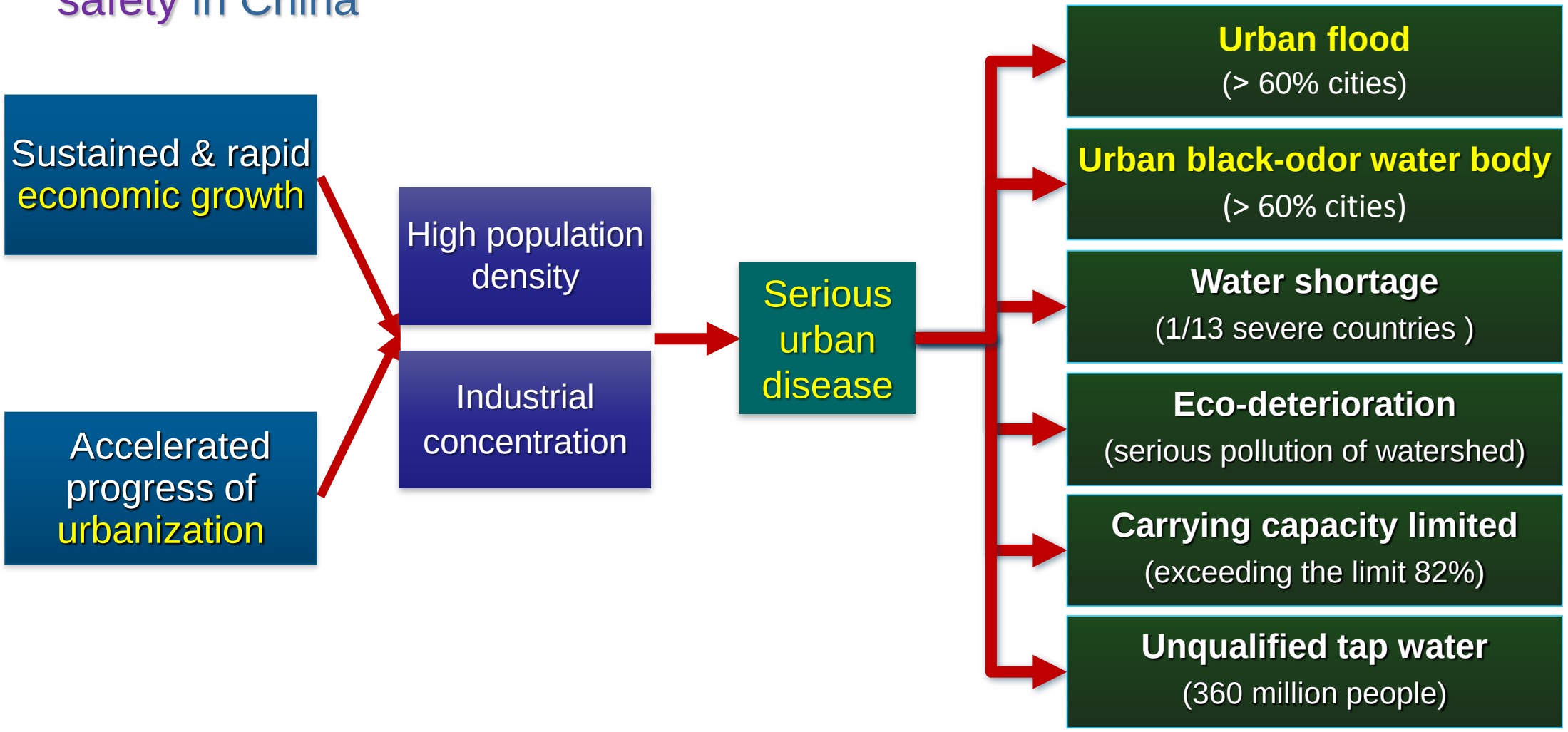
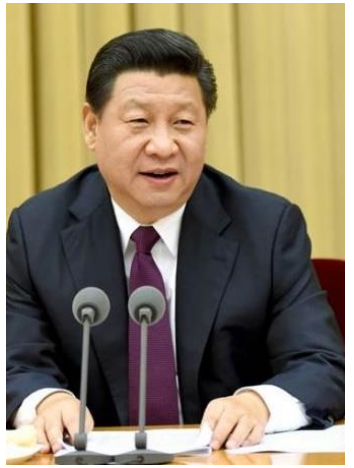
Sep. 11, 2018, in Xi'an

Why Sponge City

- Facing series water resource, water environment, water ecology and water safety in China



Why Sponge City



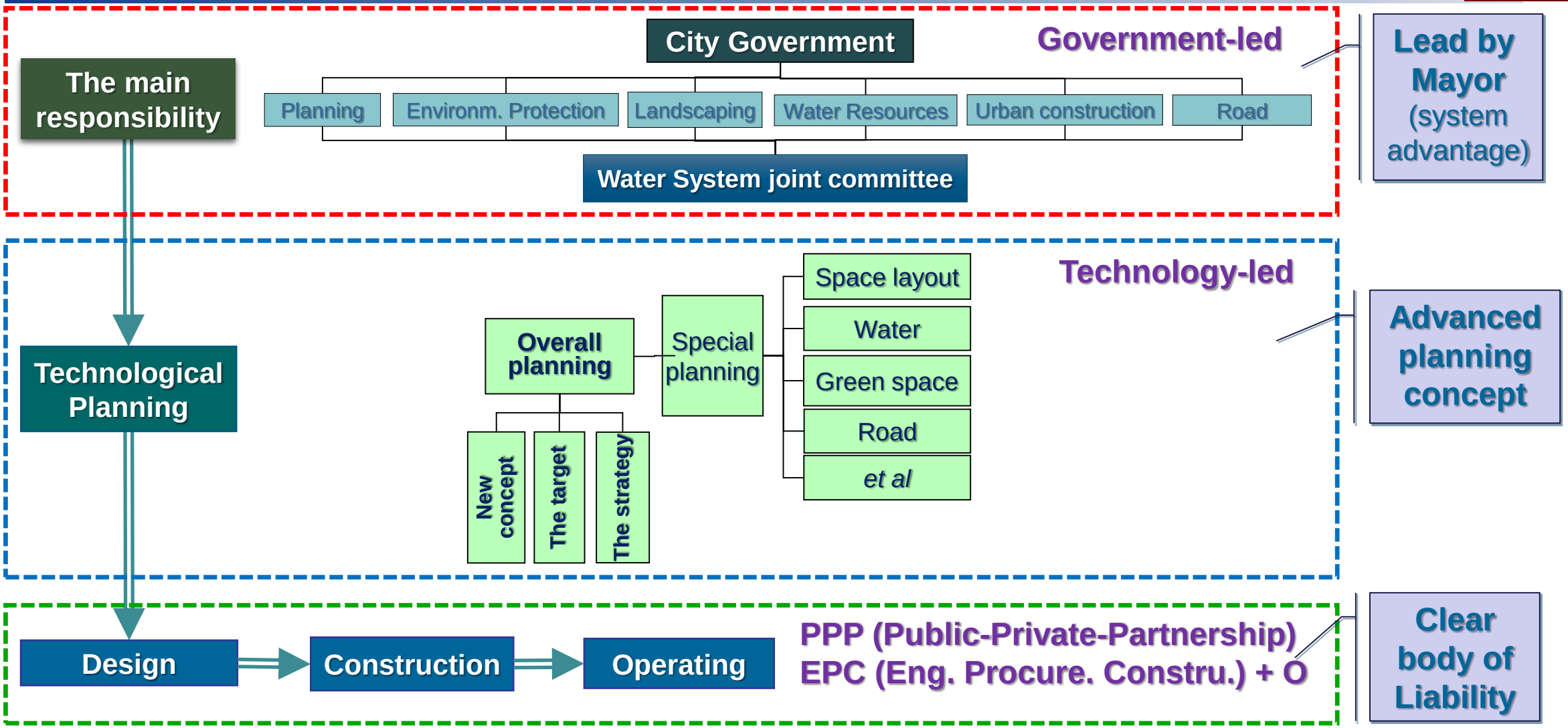
- It is required to consider the influences on nature in every detail of urban planning and construction, and not to break the natural system. … For example, when promoting urban drainage system, it is needed to give priority to reserve the limited stormwater, and rely more on the natural power for water drainage, as well as construct **“spongy city”** with the connotations of **natural storage, natural infiltration and natural purification**.

—Speech by Xi Jin-Ping on *The Central Work Conference on Urbanization* on Dec. 12, 2013

- The first pilot-scale (>15 km^2) demonstration cities of 16 in 2015, the second of 14 in 2016. Meanwhile, more than 100 cities will do it
- Pilot-scale demonstration cities can get >170 millions USD from the central government

For a city, at least 10 or 100 billions USD

Organization & Implement for SCC



How Sponge City

What
Construction concept

How
Construction goal

Urban Water Resource & Environment

City

关于推进海绵城市建设的指导意见（国办发〔2015〕75号）

“拍脑瓜”决策

“科学分析”决策

Content

Successful Experience or Concept in the world

- **Low-Impact Development (LID, in USA)**
  - to describe a land planning and engineering design approach to manage stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. —From Wikipedia
- **Sustainable Urban Drainage System，SUDS**
  - is designed to reduce the potential impact of new and existing developments with respect to surface water drainage discharges. —From Wikipedia
- **Active, Beautiful, Clean Water programme (ABC, Singapore)**
  - The ABC programme is a long term initiative started in 2006, targeted at transforming Singapore's water bodies into beautiful and iconic symbols of Singapore's water landscapes. It strives to beautify and bring Singaporeans in closer proximity to water such that they will better appreciate and cherish water as a scarce resource. —From Wikipedia (Public Utilities Board)
- **Water Sensitive Urban (WSU, Australia)**
  - is a land planning and engineering design approach which integrates the urban water cycle, including stormwater, groundwater and wastewater management and water supply, into urban design to minimise environmental degradation and improve aesthetic and recreational appeal. WSUD is similar to LID. —From Wikipedia

Key Issues and Bottleneck

- From the above, the most of the other concept mainly focus on urban stormwater and flood, rain water collection or landscaping

Key Problems in China

- Waterlogging control of urban stormwater
- Improvement of urban water resources & environment

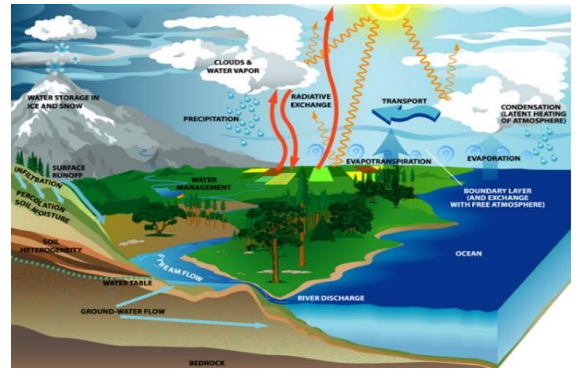
→ **Natural Cycling & Social Cycling of Urban Water System**

Spongy City Construction (SCC)

=?

Other Concept in the World

Chinese Characteristics



Concept of “Spongy City” in China

- Sponge city construction should solve the current China's specific issues

My understanding on the “sponge city”

- Possessing a good “**elasticity and resilience**” on response to environmental change and natural disasters, etc.
- Solving the problems of urban waterlog and environment deterioration
- Managing, protecting and utilizing drinking water source, wastewater, ecological water, rainwater and underground water, etc.
- Taking fully consideration of water resources, water environment, water safety, water ecology and water culture
- Mitigating the heat island effect

The essence of Sponge City belongs to the integrated solutions of urban water resources and environment

Key Problems & Goals in China

Water Resources

- Replenishment for underground & ecological use, etc
- Utilization of untraditional water of rainwater & wastewater, etc

Water Safety

- Alleviate waterlog stress, enhance disaster prevention and mitigation
- Quality safety of tap water & alternative water

Water Culture

Livable city

Water Environment

- Elimination of the black-smelly water body
- Point & surface polluted source reduction, process control

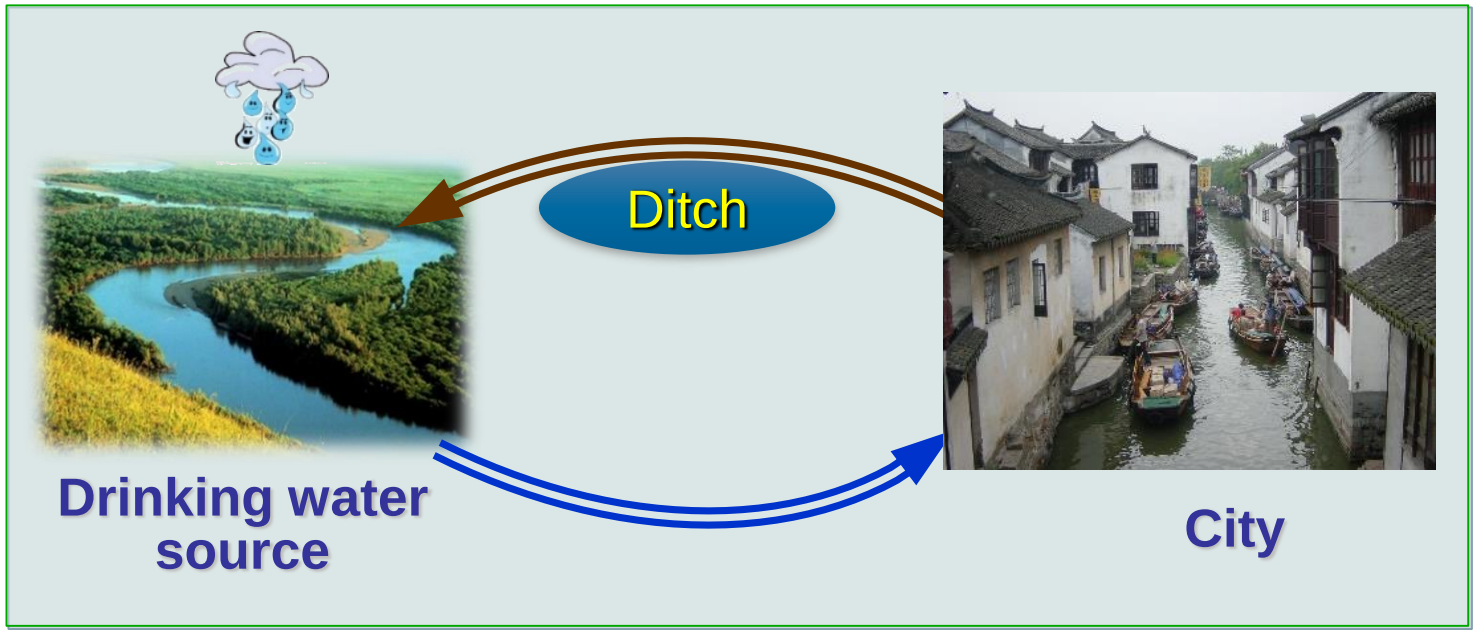
Water Ecology

- Improvement of the biological diversity
- More urban greenbelt area per capita and Less heat island effect

Urban Water-Cycling System

System 1.0

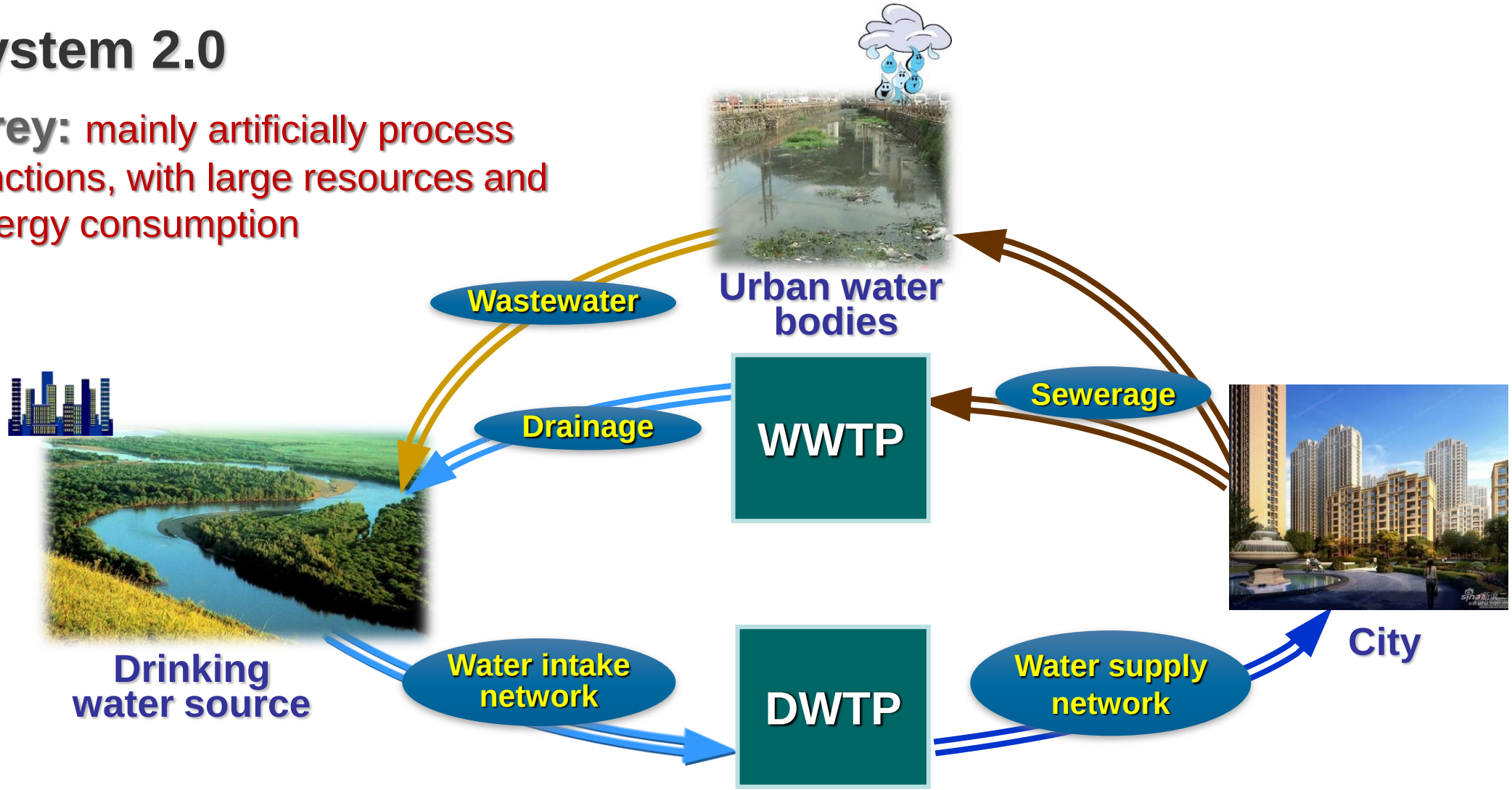
Green: totally natural functions, natural purification



Urban Water-Cycling System

System 2.0

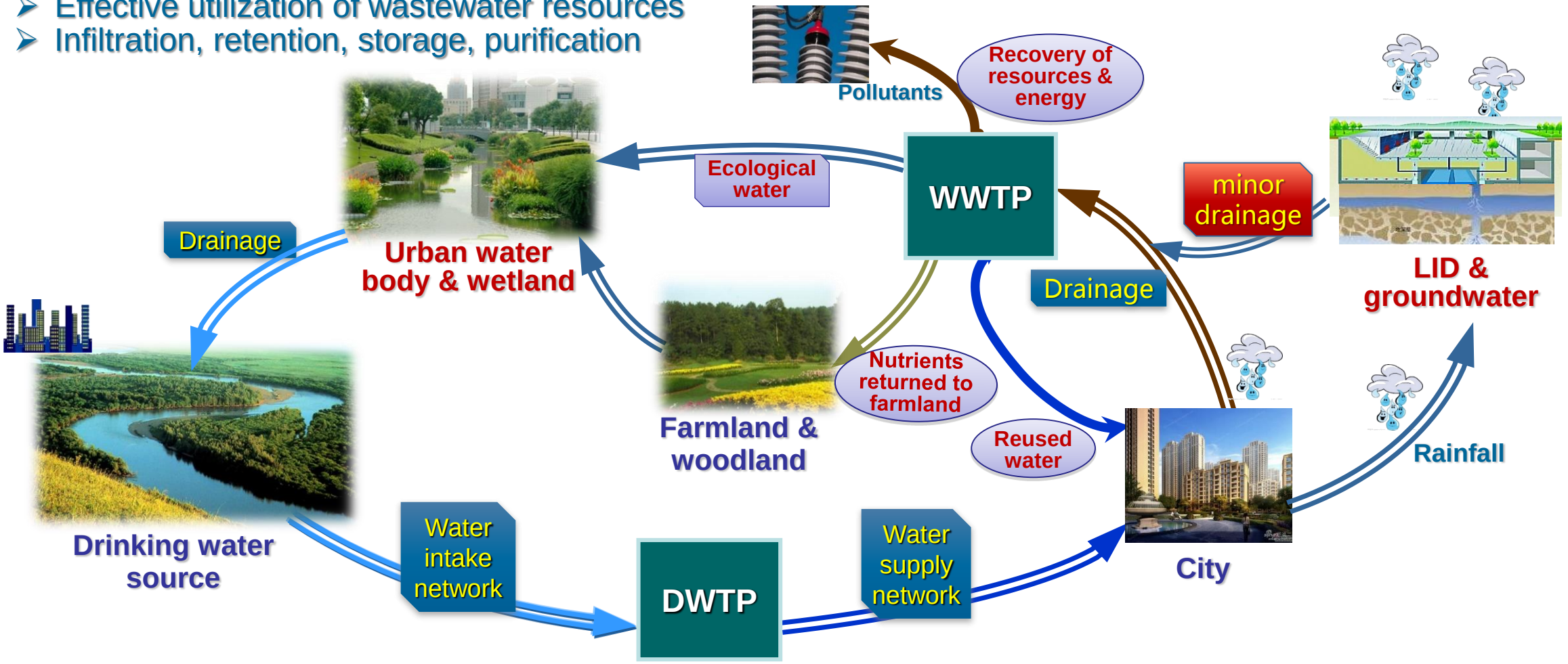
Grey: mainly artificially process functions, with large resources and energy consumption



Sponge City——Urban Water Cycling 3.0

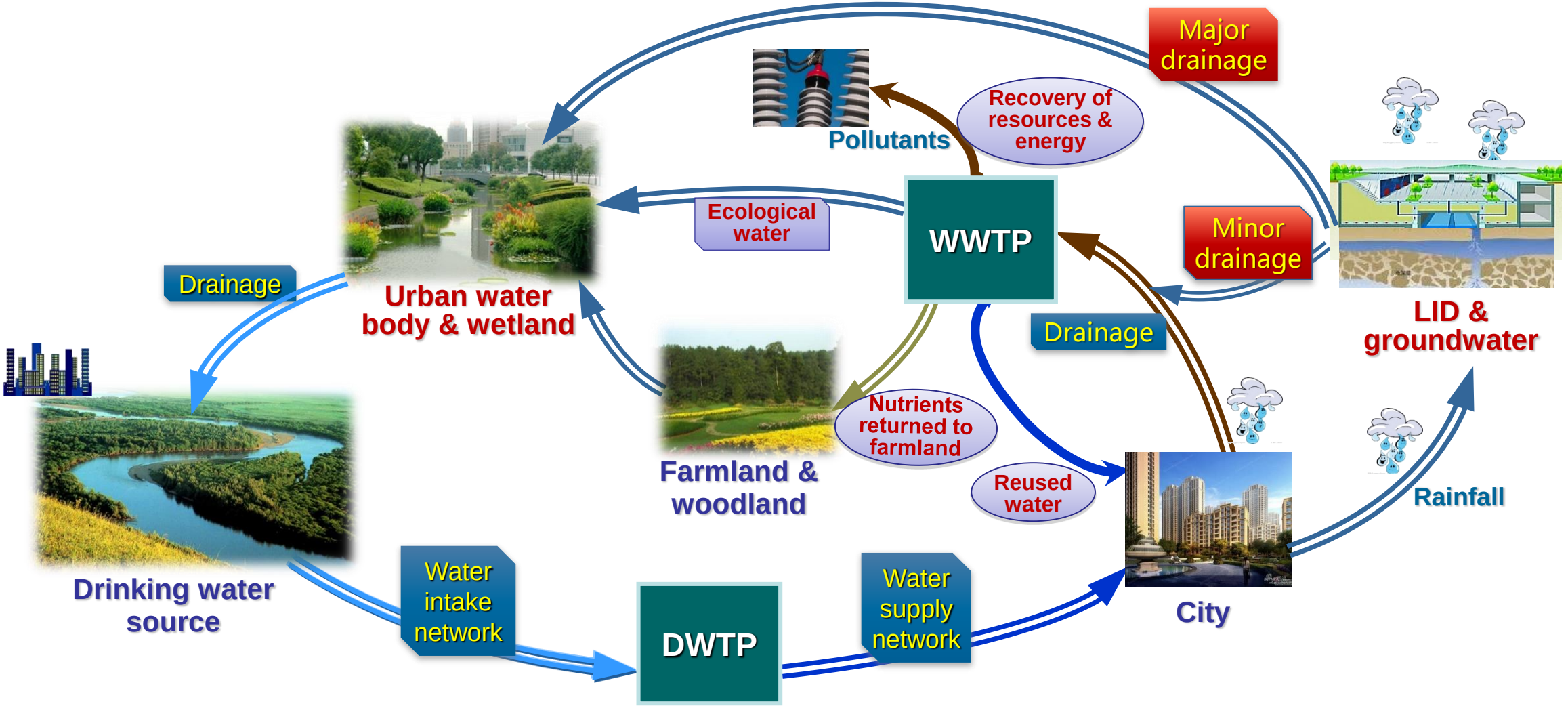
Green+Grey: both functions of natural (LID) and artificial process, achieve the reclamation of resources and energy from wastewater

- Natural purification & enhanced functionality
- Effective utilization of wastewater resources
- Infiltration, retention, storage, purification

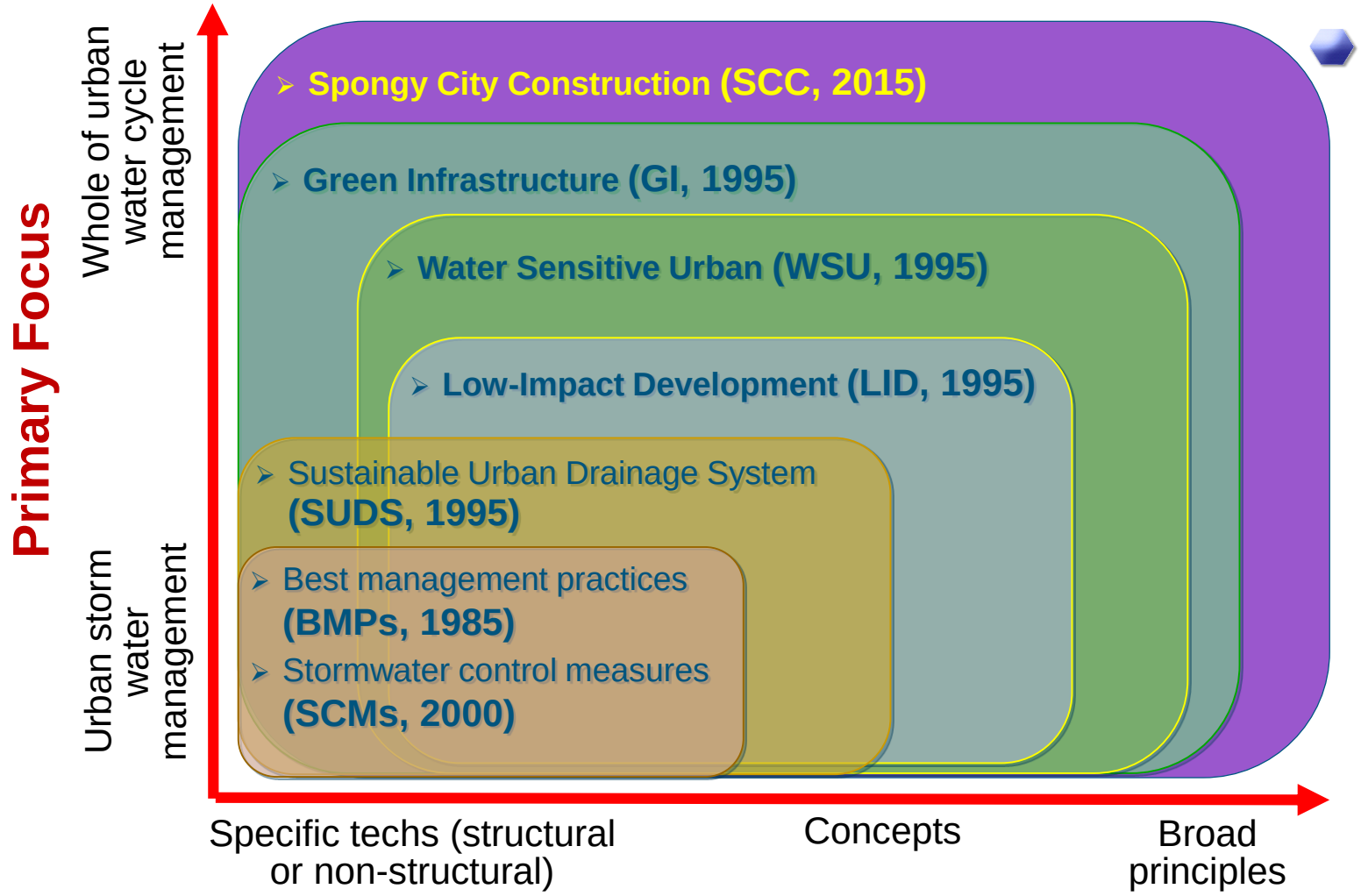


Sponge City——Urban Water Cycling 4.0

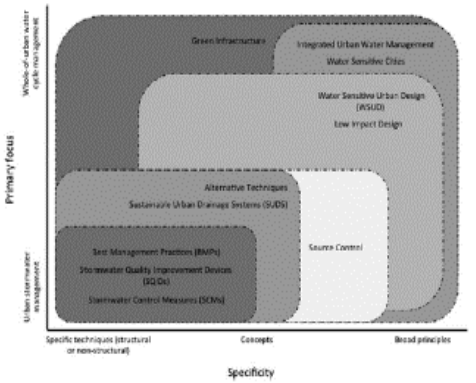
Green+Grey: both functions of natural (LID) and artificial process, achieve the goal of urban waterlog drainage and livable environment



Relationship among Concepts



- Based on the complex demand of urban water resources, environment, safety and ecology in China, sponge city construction must meet the livable city construction, can't simply copy



Drawn from Tim D. Fletcher, et. al, Urban Water Journal, 2014, 12(7)

Correlation Concept and Attention Years

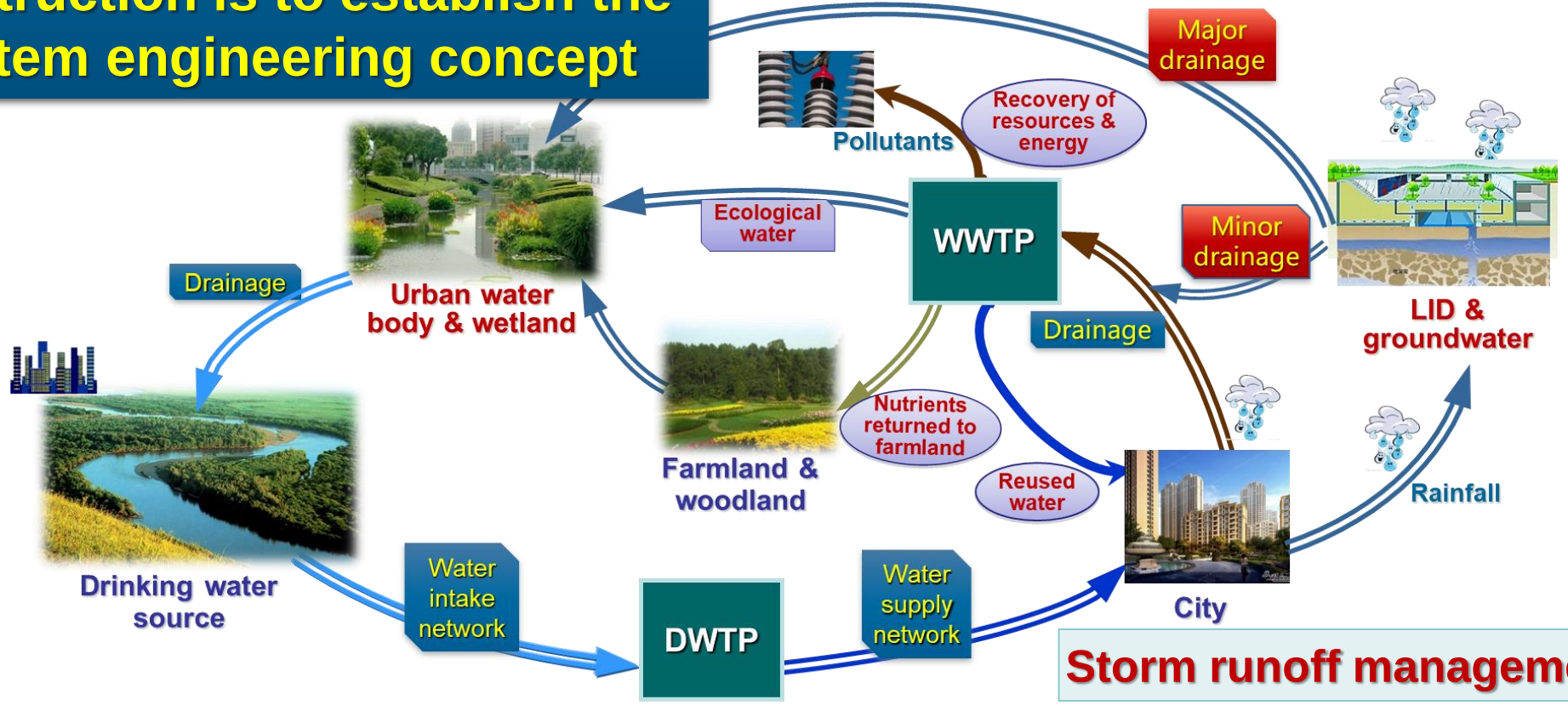
Content

1 Construction concept

2 Construction goal

Key Units of Three

The key to the sponge city construction is to establish the system engineering concept



Storm runoff management

Black-smelly river remediation

WWTP management

Storm Runoff Management— LID Principle

Absorbing function of sponge

Natural infiltration for groundwater conservation

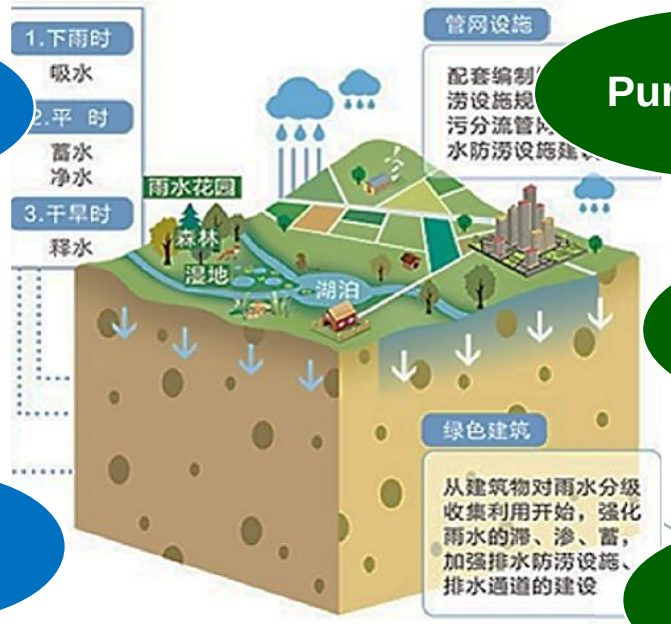
Infiltration

Delaying stormwater peak, reducing peak flux

Retention

Creating favorable conditions for stormwater recycling

Storage



Reducing surface pollution, improving eco-environment

Purification

Sufficiently utilizing rainwater resources

Utilization

Safely discharging into the water bodies

Drainage

Function of resources utilization

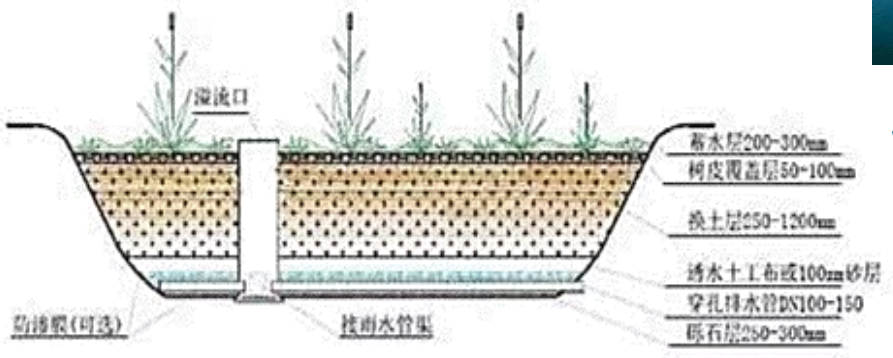
Necessary to make overall plans for urban water recycling and utilization

Storm Runoff Management— LID Principle

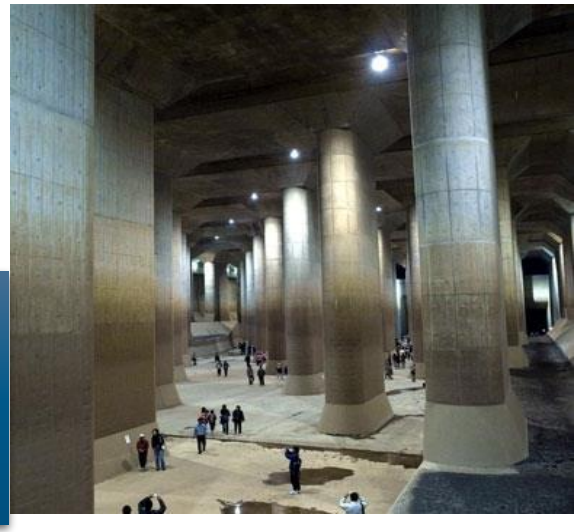
- **“Quantity” control (infiltration, retention, storage)**
  - **Storm runoff management:** reduce runoff volume & delay peak time
  - Improve urban ecological coverage and rain storage capacity so as to **reduce the rainfall volume in the source**

Rain garden

Combination between water landscape and rainwater storage



Low elevation greenbelt – detention ponds

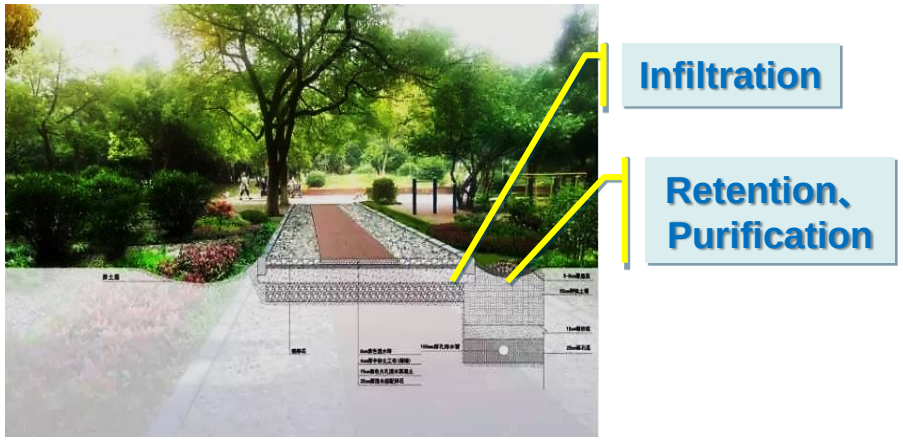


Water resources deficient areas – underground rainwater storage and utilization

Functions: drainage, storage & utilization

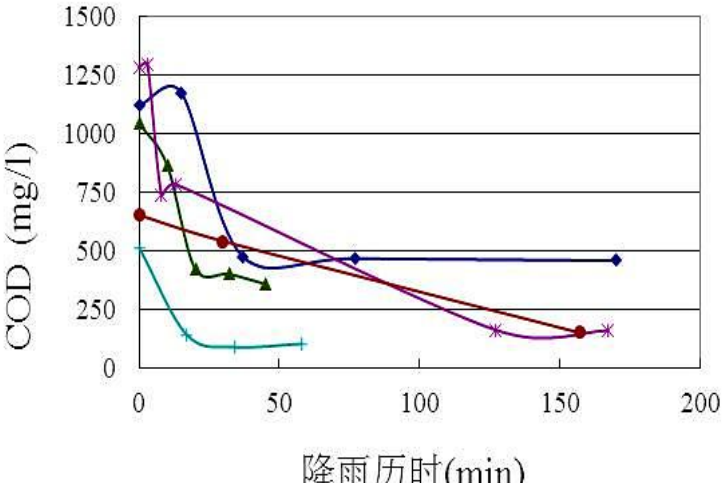
Storm Runoff Management— LID Principle

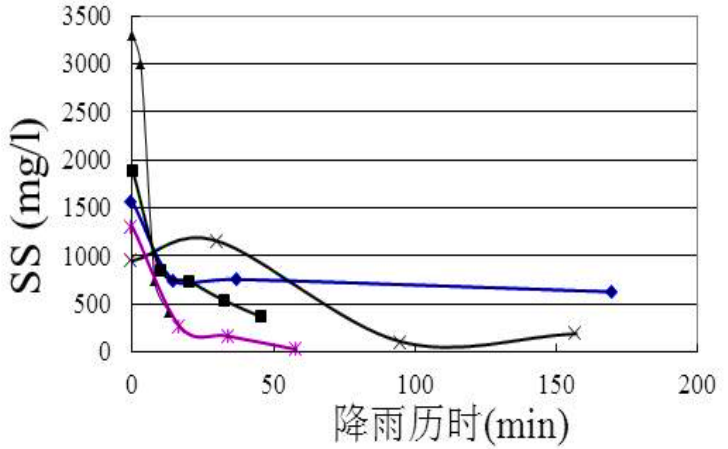
- **“Quality” control (purification)**
  - **Pollution Control of early rain:** most of cities need to consider the influence of black-odor water body caused by first rain pollution. We need to reduce organic and inorganic pollution through first rain storage, filtration and purification
  - **Solving the first rain pollution in the source** through purification and enhancing the water quality



Permeable pavement and grassed swales

Constructed wetland (Self-purification)



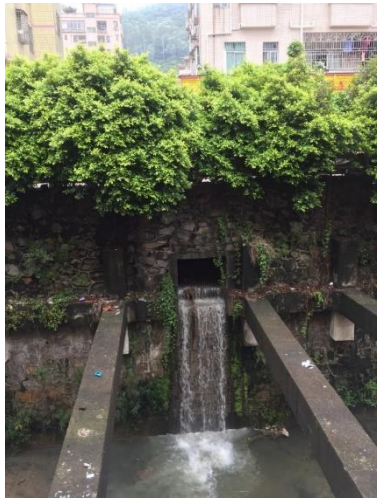


COD & SS concentration of initial rain is higher than sanitary sewage

Black-odor Water Body Remediation

- There are many black-odor rivers in some cities

Black-odor in water; source on bank; core is drainage

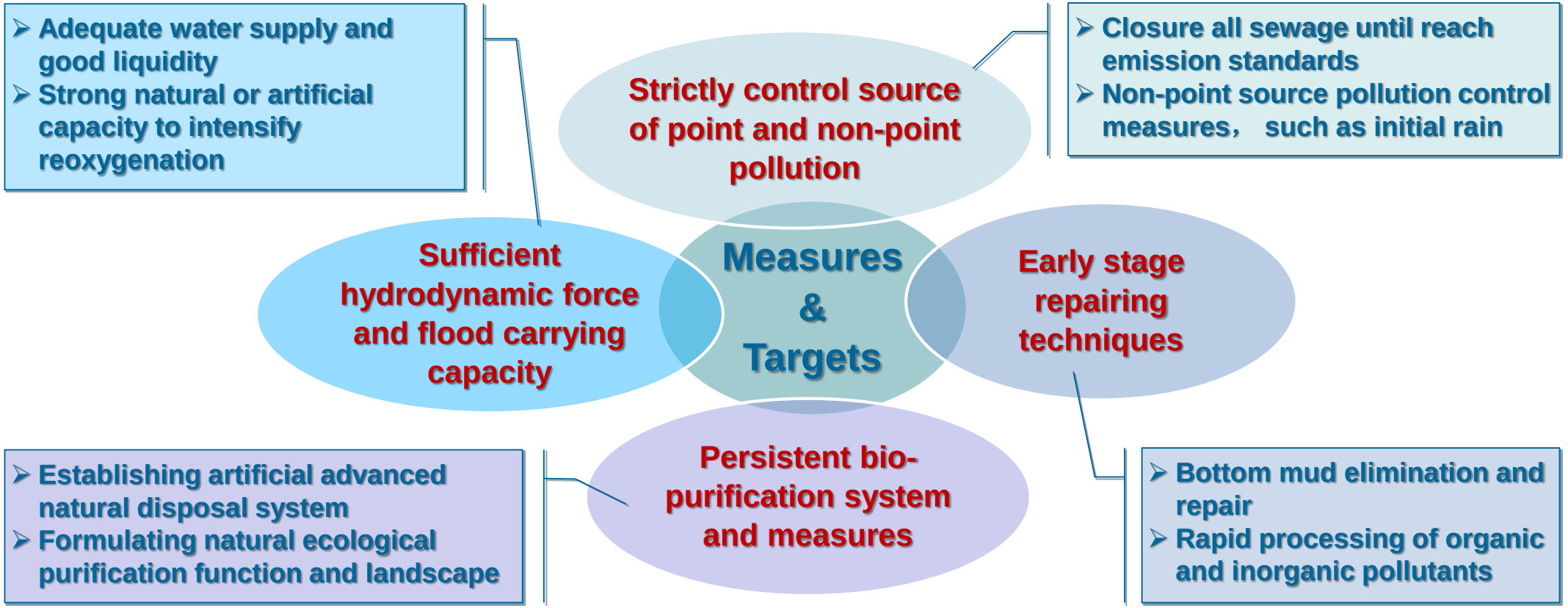


Without control of point source, Urban Black-odor water control equals zero!

Black-odor Water Body Remediation

Systematic Control Principles

Bio-purification; Eco-landscape; Flood and Waterlogging Control



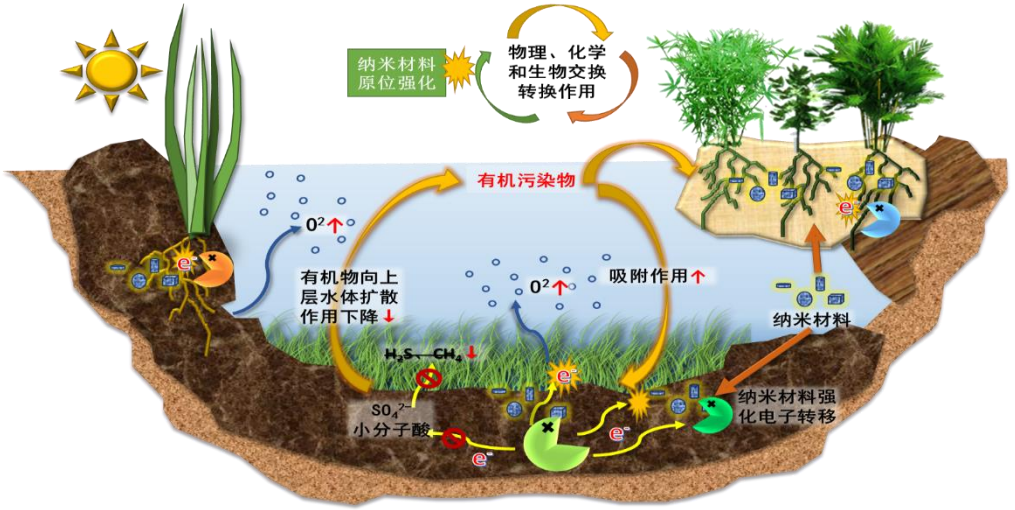
Black-odor Water Body Remediation

Building an ecosystem

Eco-Revetment + emergent Plant + Submerged Plant

Artificial landscape lacking eco-purification

Natural, ecological and livable river

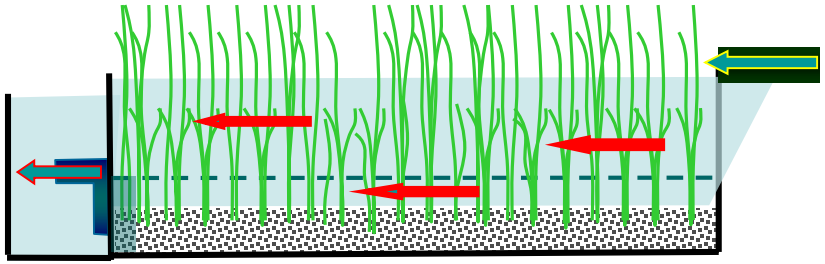


Natural purification

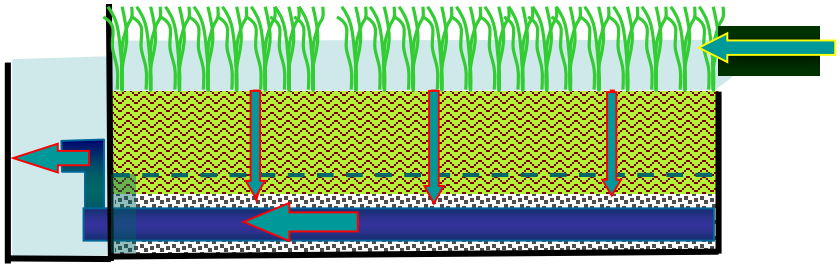
(COD degradation, N & P utilization, heavy metal absorption)

Black-odor Water Body Remediation

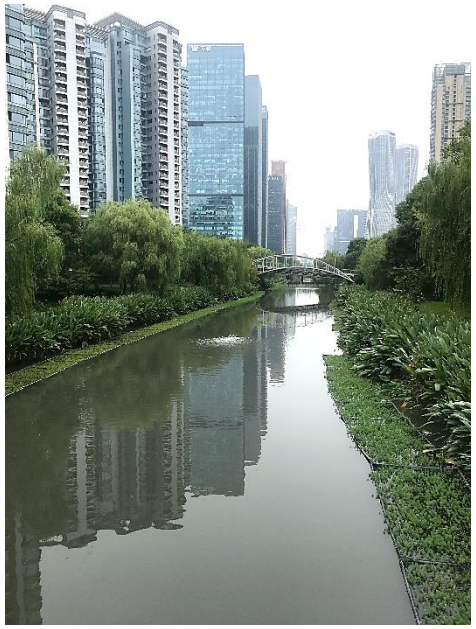
- **Building an ecosystem**
  - Utilizing advantage technology of **constructed wetlands and eco-ponds (oxidation ponds)** to enhance the natural purification for point source and non-point source pollution
  - Making good use of original ecosystem, establishing the functional systems of **purification** and **livable landscape**



Surface flow constructed wetlands

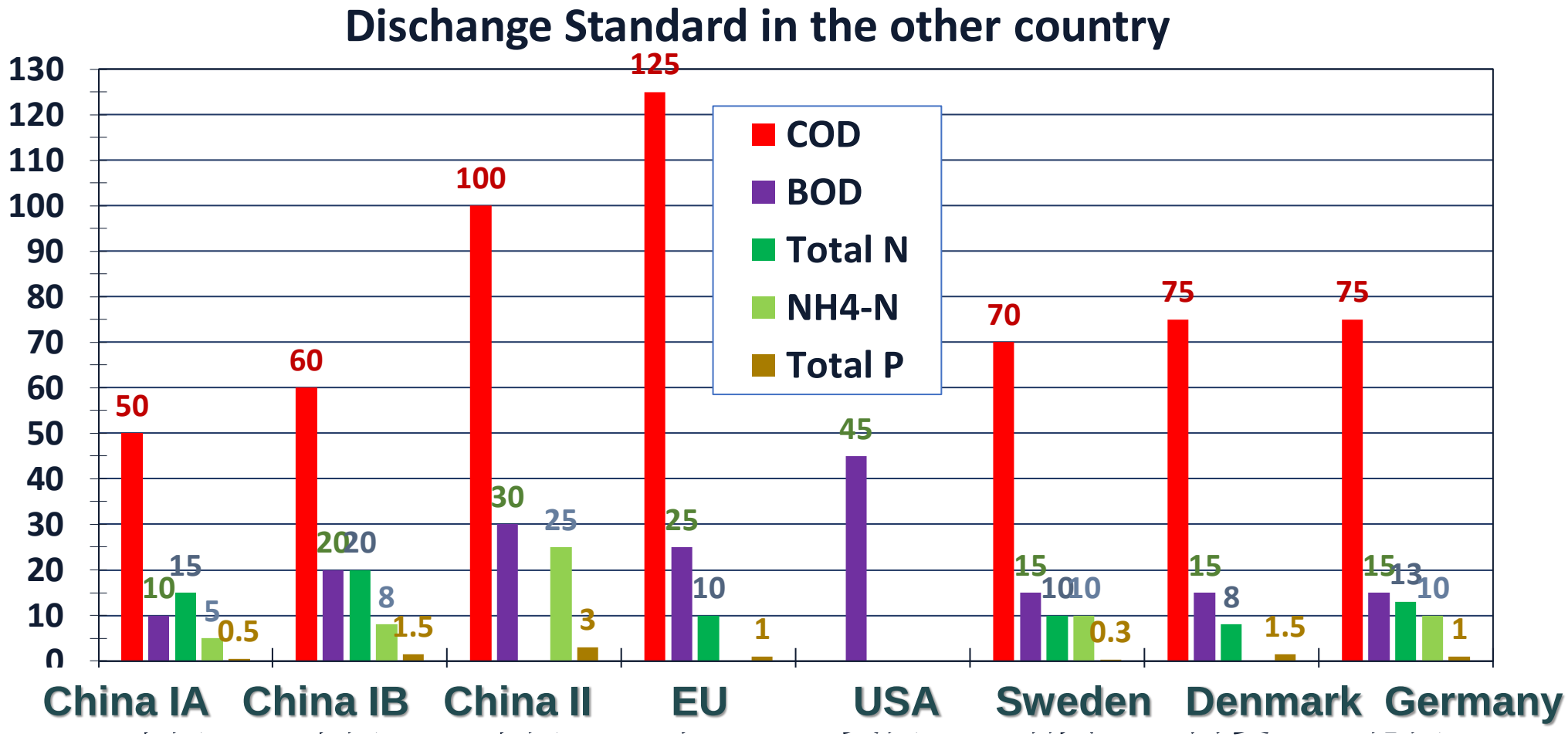


Subsurface flow constructed wetlands



lake in a city of Hangzhou

WWTP management



Note: (1) Sweden use BOD7; (2) The most strict standards in different countries.

WWTP management

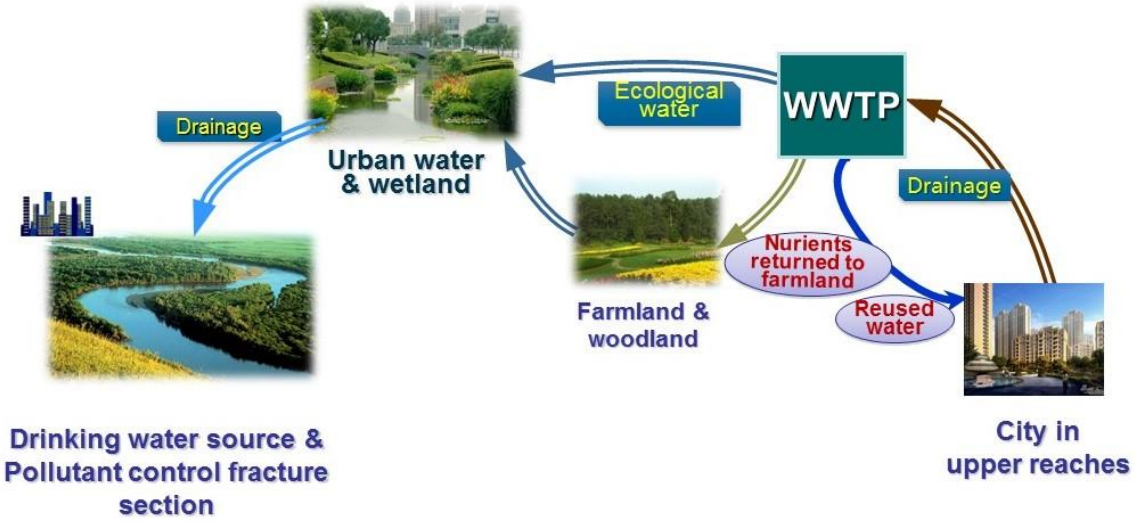
A point in China: higher standard, higher eco-environment quality

Over-treatment
- Less contribution
- Heavy cost

Resources Consumption
- Energy
- Resources
- Money

Air Pollution

Greenhouse gas from life cycle

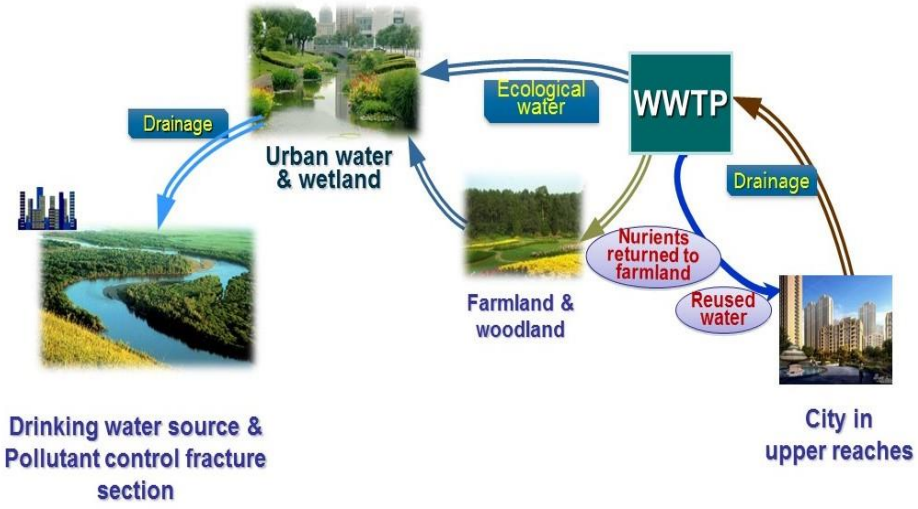


WWTP management

Way in China

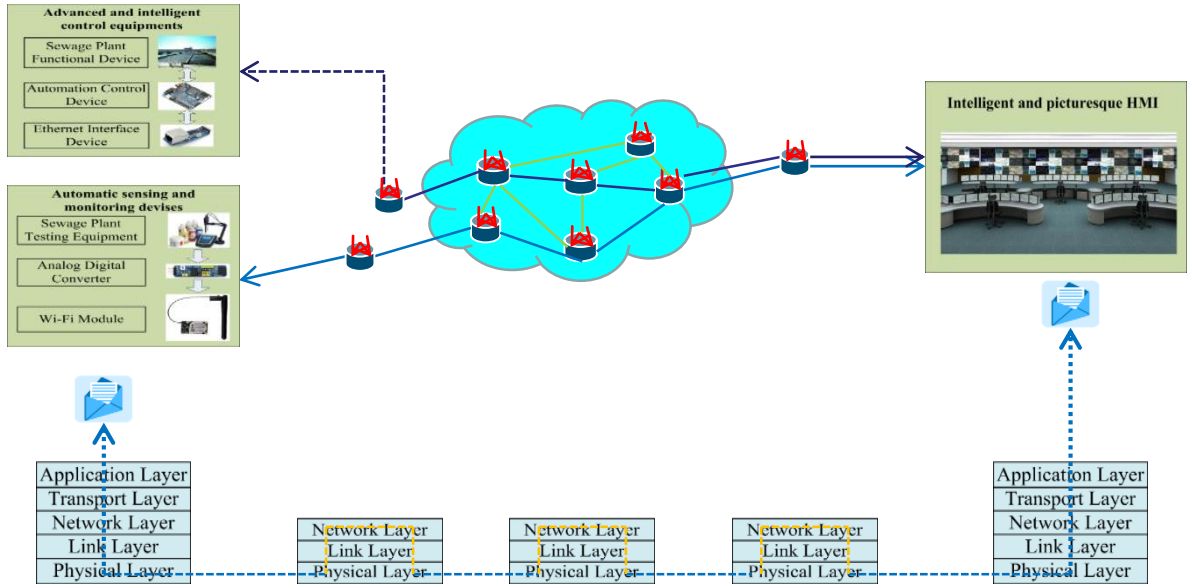
- Discharge Standard of WWTP should adapt to **Used-water Fit for Purpose**
  - Direct discharge: water into the pollution control section of waterbody, satisfies the requirement of basin surface water standard
  - Eco-water: water into the water body and wetland ecological system
  - Reused water: meet user requirements for water quality standards
  - Nutrients returning water: meet the demand of farmland irrigation, spraying green space, etc

Urban Water Management: integrated system among plants, drainage, and lakes



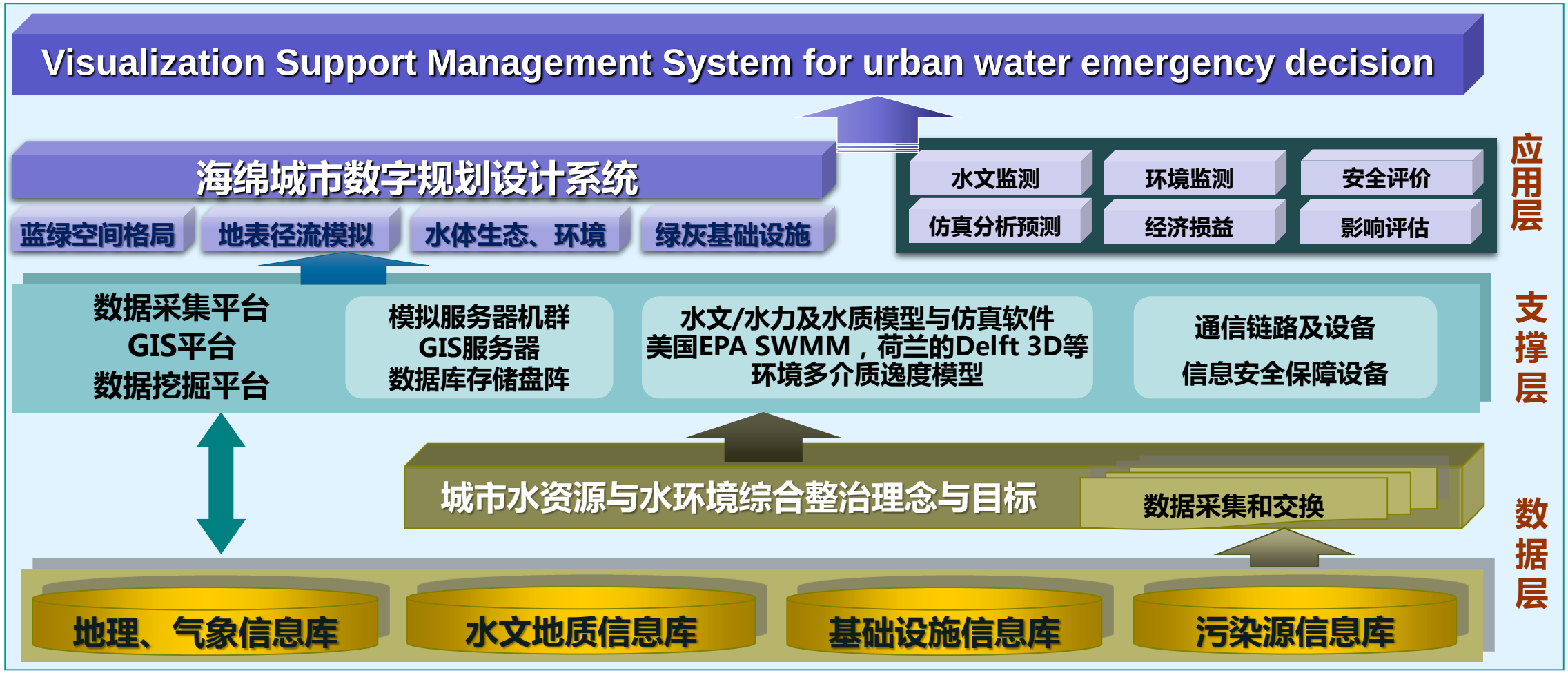
Smart Urban Water System

- Urgently developing numerical modeling and simulation based on bigdata for urban water system
  - Based on water resources and security, **water quantity**, for drinking water source, DWTP, WWTP, the river section, wetland, groundwater and initial rain
  - Based on the water environment and ecology, **water quality**, research the rule of energy flow and material flow, and the system simulation and optimization of pollutant migration
- Based on Internet + Urban Water, guidance system operation control, fault diagnosis, emergency decision-making, et al., and take play to the role of the Internet of things to improve the public's attention



Highest Target

- **Digitalized and engineering planning, smart management**



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Thanks for Your Attention !

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