



Water Cycle Management for Water-Wise City/Community

水智慧城市及社区中的水循环管理

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Xi'an University of Architecture and Technology (XAUAT)

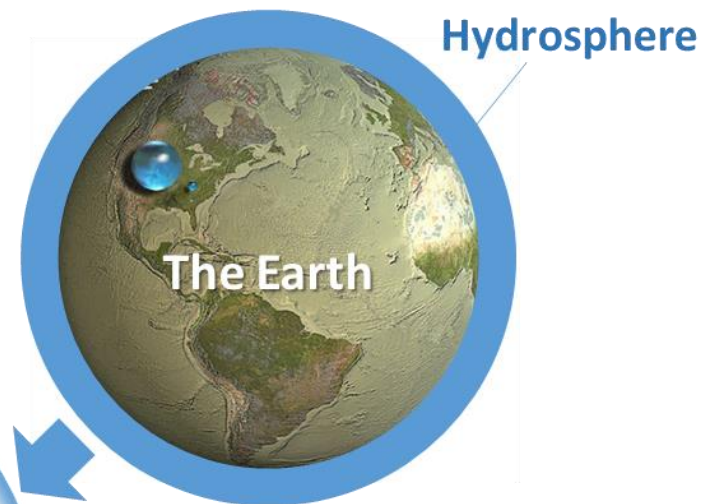
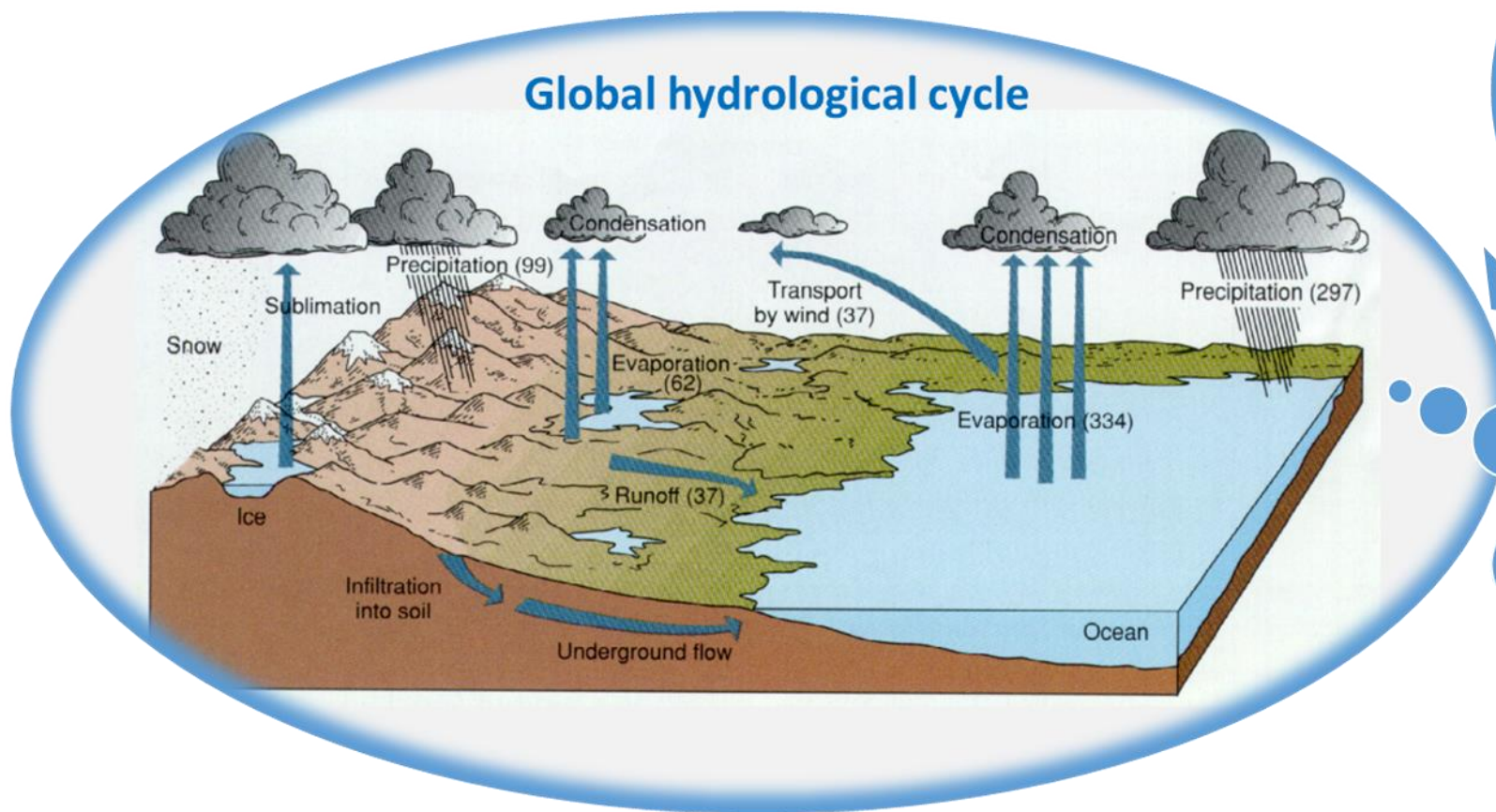
September, 2018

- Things we can learn from the hydrological cycle
(水文循环过程对我们的启示)
- Concept of *Water Cycle Management (WCM)*
(水循环管理的理念)
- Application of *WCM* concept for planning a water-wise city (水循环管理理念在水智慧城市规划中的应用)
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Things we can learn from the hydrological cycle (水文循环过程对我们的启示)



- Global hydrological cycle (全球水文循环)

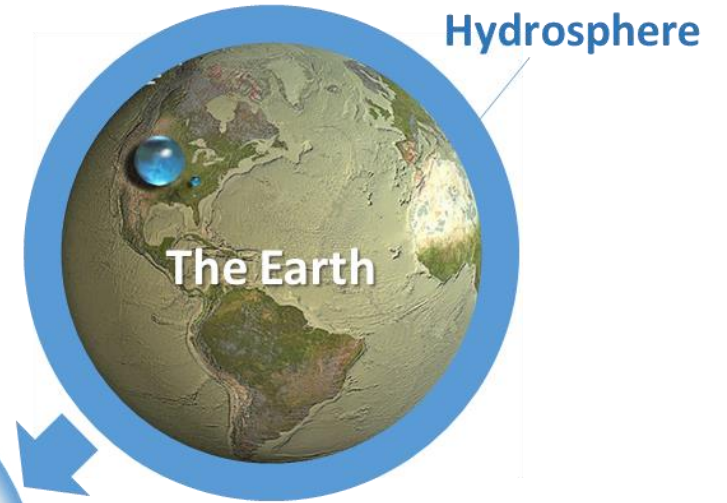
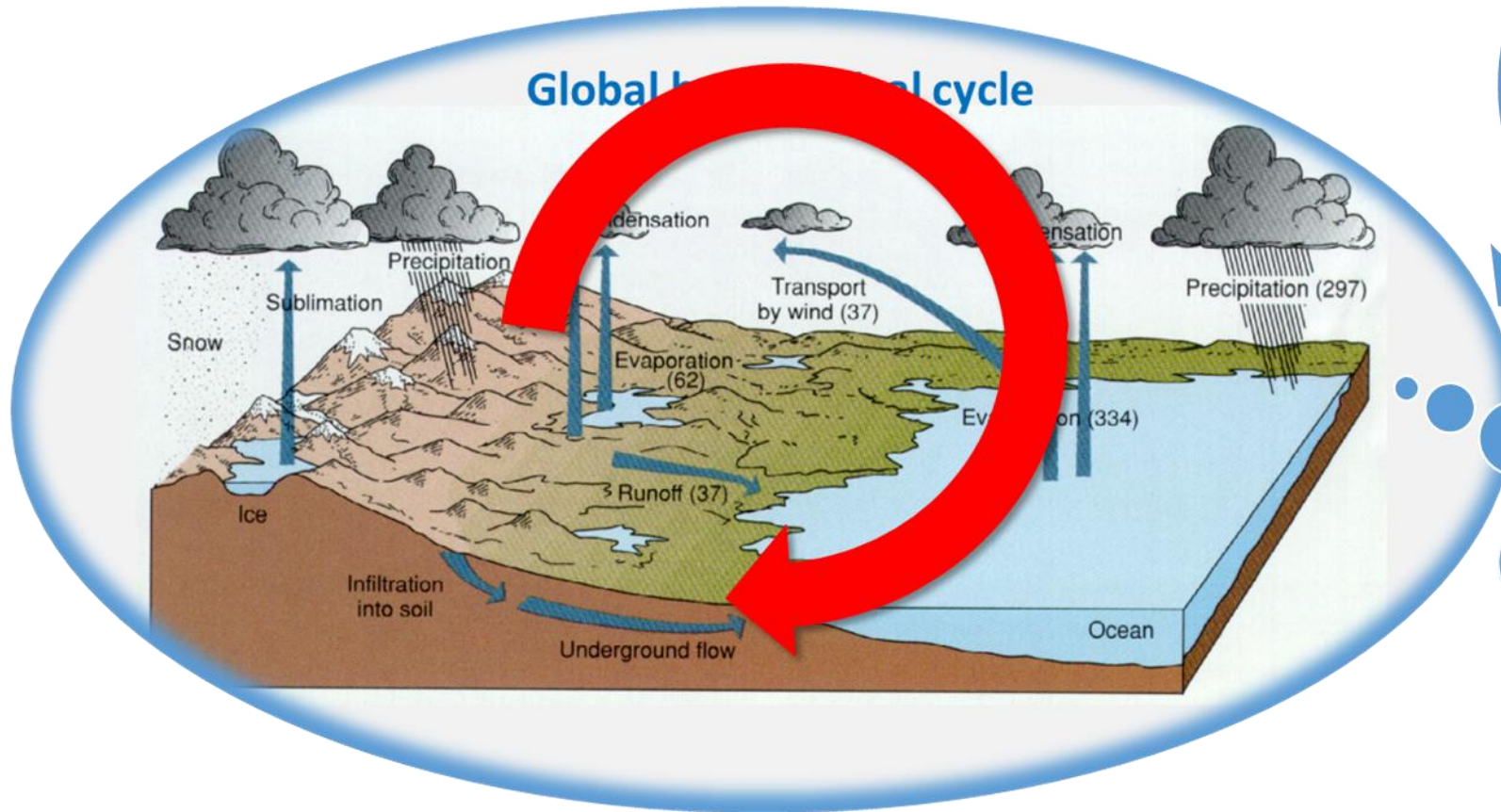


- Natural processes driven by solar energy
- Under a dynamically equilibrium condition

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Things we can learn from the hydro-logical cycle (水文循环过程对我们的启示)



- Global hydrological cycle (全球水文循环)
 - The hydrological cycle can be viewed as a “Sponge” with sufficient water space (WS) (水文循环本身可被视为具有充足水空间的“海绵体”)
 - Water in each part of the WS is quantitatively and qualitatively stable under a dynamically equilibrium condition (在动态平衡条件下, 各空间部分的水保持量和质的稳定状态)

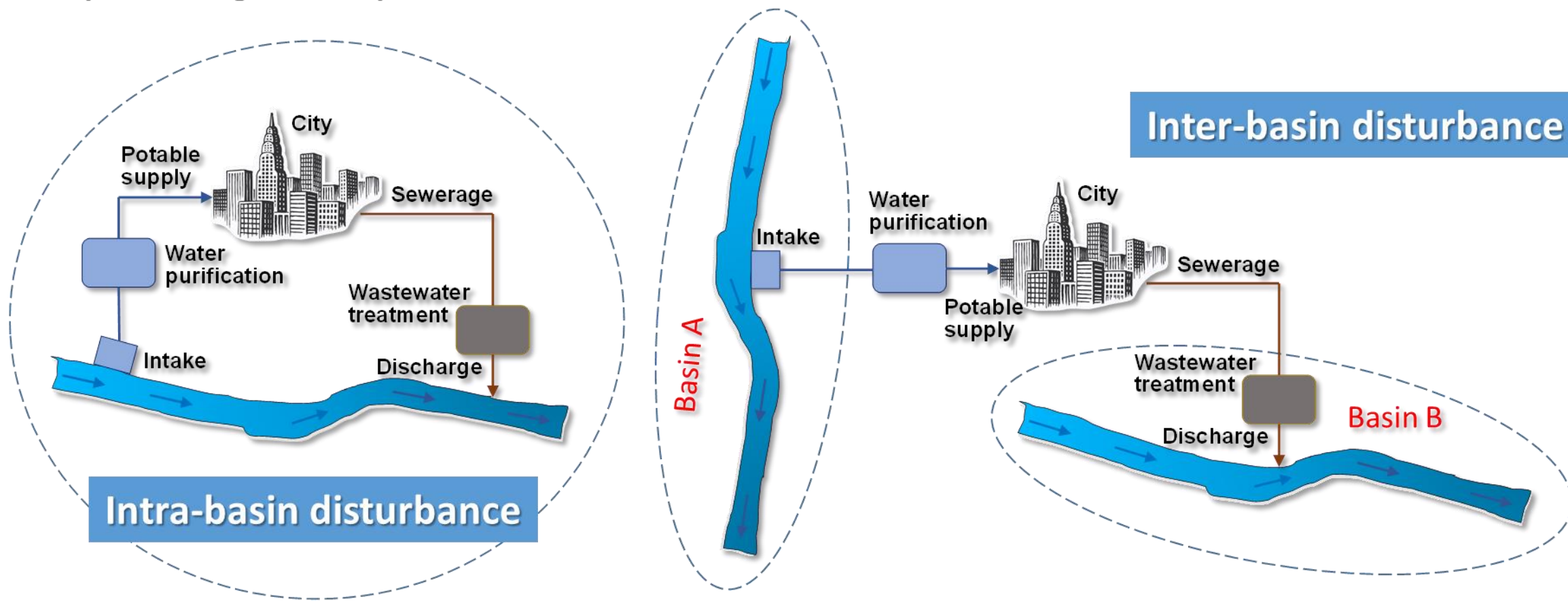
Unit: 10^3 km^3

Waterbody	Fresh water stored	Waterbody	Fresh water stored
Groundwater aquifer	10 530.0	Atmospheric water	12.9
Lake water	91.0	Marsh water	11.5
Soil water	16.5	River water	2.1

Things we can learn from the hydro-logical cycle (水文循环过程对我们的启示)



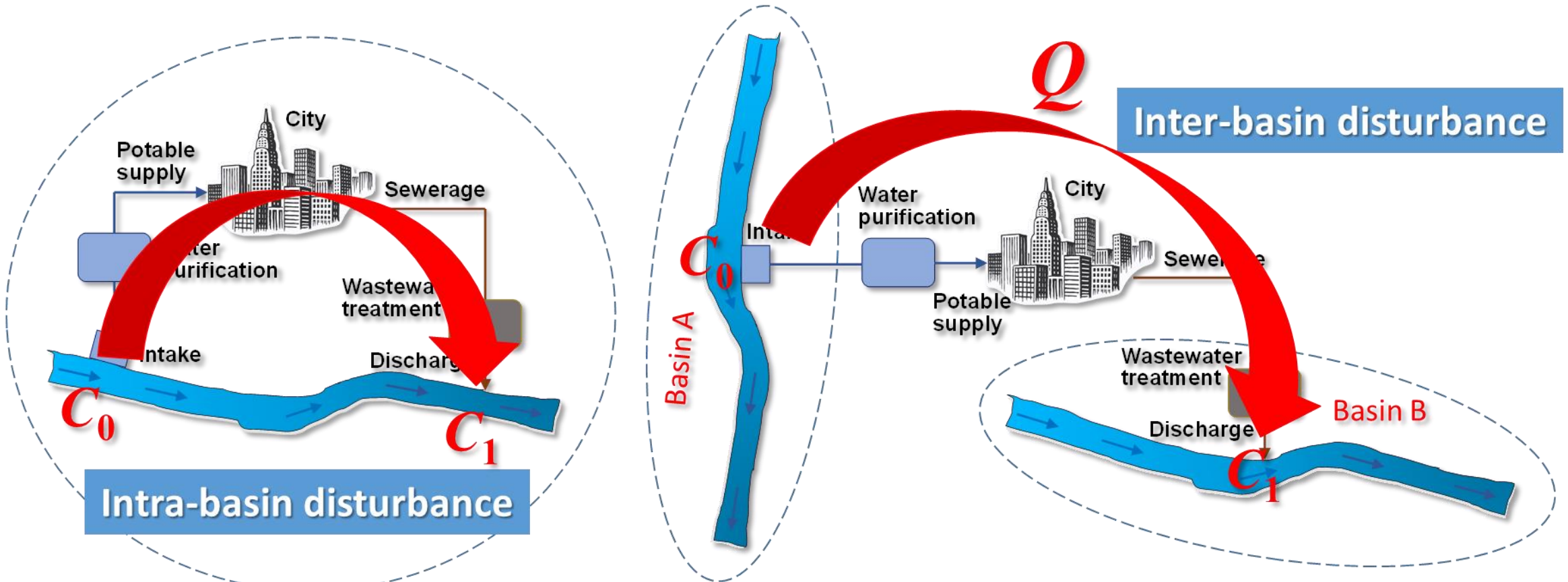
- The process of water use by human beings is disturbing the hydrological cycle (人类取水用水导致对水文循环过程的干扰)



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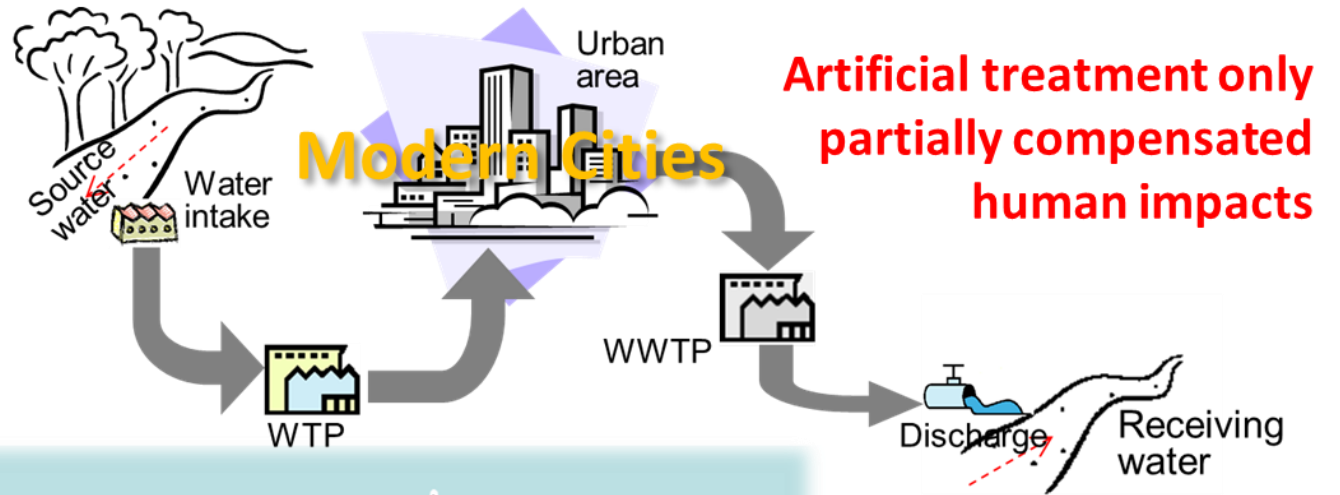
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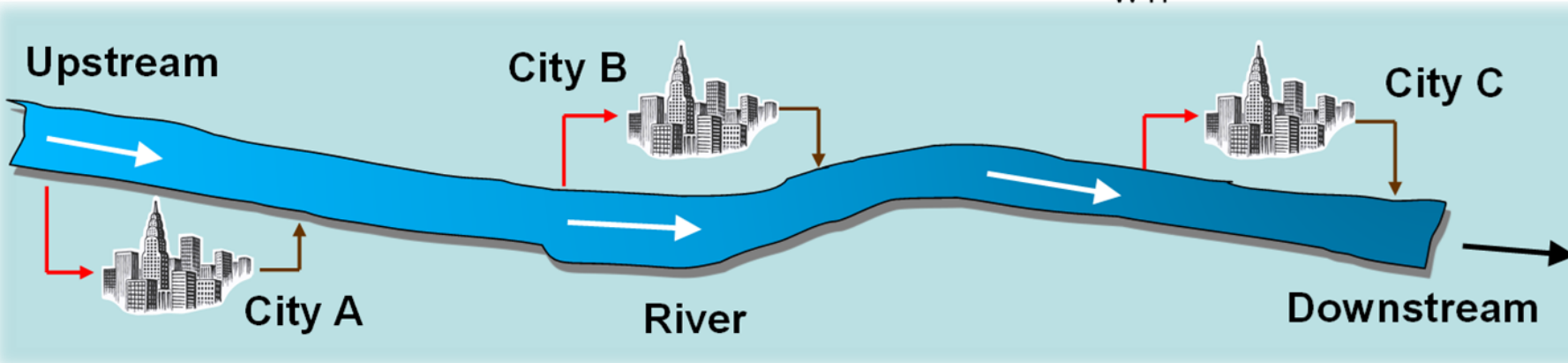
- Sufficient clean water sources are primarily sustained by the natural water cycle (充足的清洁水源主要得益于自然水循环)



Fully depended on natural purification



Artificial treatment only partially compensated human impacts



“De facto” water reuse is acceptable due to natural purification in a “Trans-board river”

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Concept of Water Cycle Management (WCM) (水循环管理的理念)



- Important things lack of full awareness by water professionals (水科技工作者迄今缺乏充分认识的几个重要问题)
 - Most or all water/wastewater treatment technologies are not human inventions but mimicking natural processes (多数甚至所有的水和废水处理技术不是人类发明，而是自然过程的模仿)
 - There are still many natural mysteries related to water environment which need to be explored (在水环境领域还有很多自然奥秘有待于探索)
 - The starting point of urban water system planning and construction must be changed from fully satisfying human needs to following natural laws (城市水系统的规划与建设的出发点已必须从完全满足人的需求转向遵从自然规律)

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Proposal of the concept of Water Cycle Management (WCM)

Concept of Water Cycle Management (WCM) (水循环管理的理念)



- Characteristics of the natural water system (自然水系统的重要属性)

1

Driven by solar energy
– therefore associated
with green processes
(太阳能为动力来源的典型
的绿色过程)

2

Under dynamic
equilibrium condition – a
thermodynamically sound
system (处于动态平衡的
最佳热力学状态)

Concept of Water Cycle Management (WCM) (水循环管理的理念)



- WCM principles (水循环管理的基本原则)



- To maintain the hydrological cycle as it is, as far as possible (最大限度维持水文循环过程的自然属性)
- To follow the nature's manner, as far as possible, in system design and technology selection/integration (尽可能依照自然法则进行系统设计、技术选择与集成)

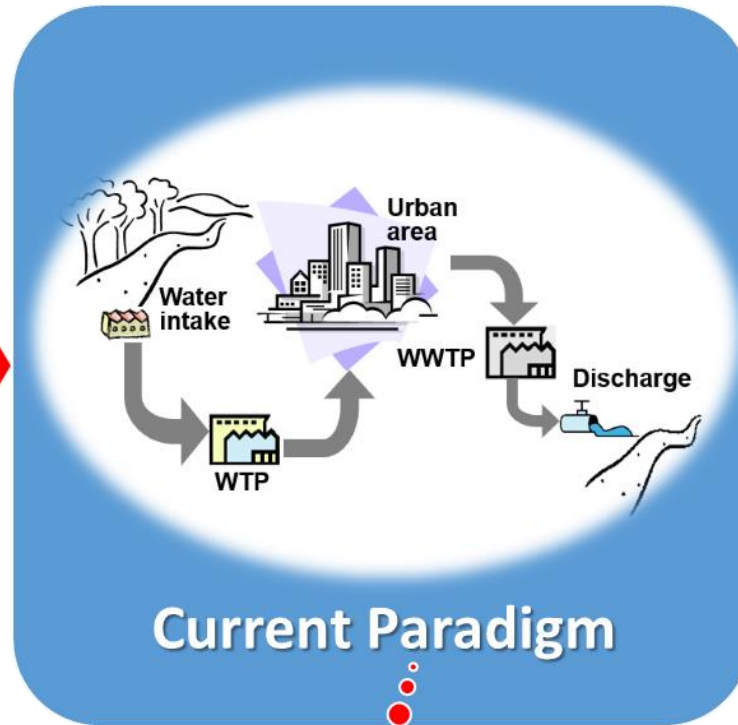
Concept of Water Cycle Management (WCM) (水循环管理的理念)



- WCM can bring about paradigm shift for urban water planning (科学的水循环管理有望带来城市水资源规划的范式转换)



Nature dependent



Engineering dependent



Engineering in the nature

Outline

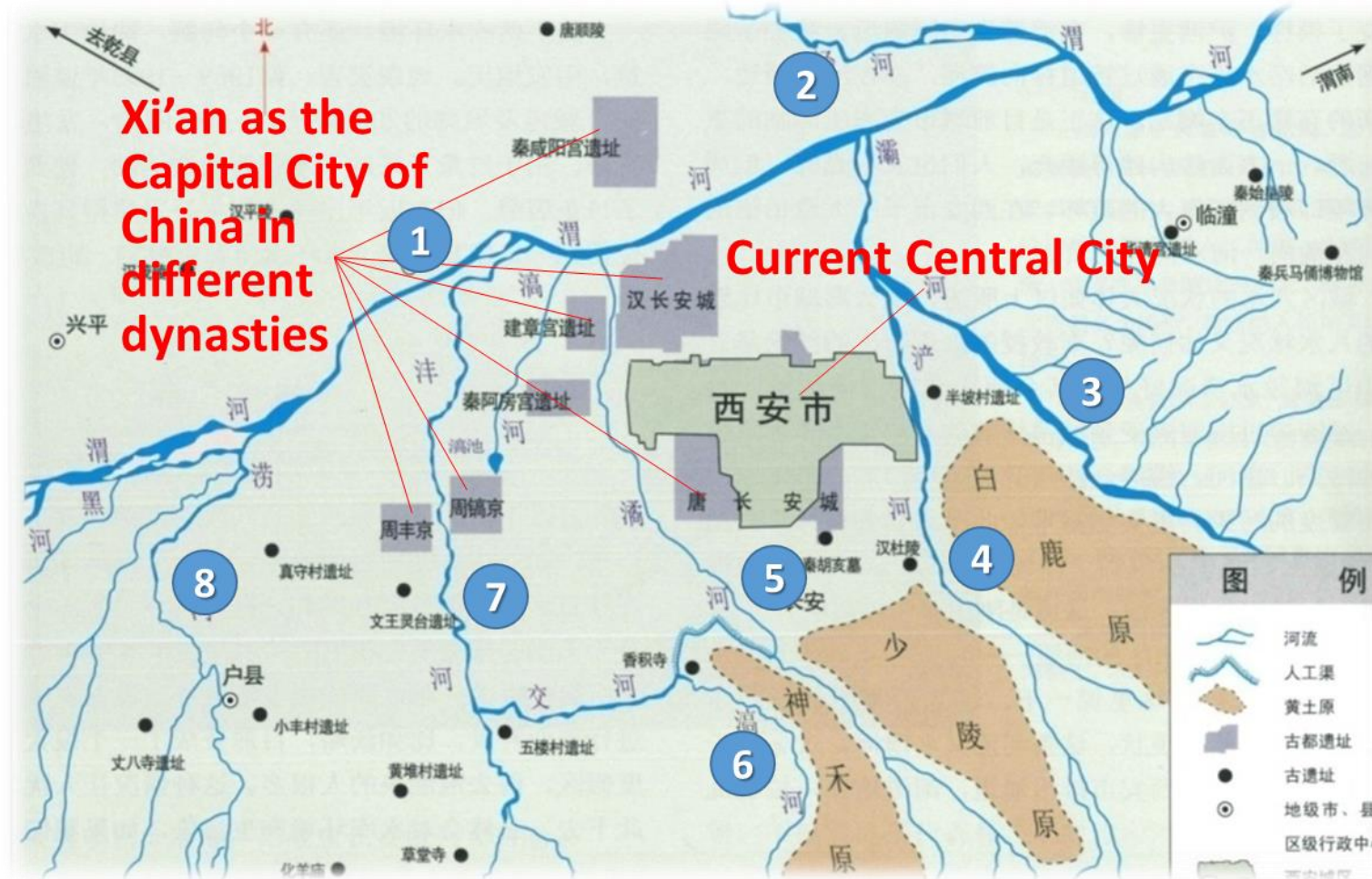


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Application of WCM concept for planning a water-wise city (水循环管理理念在水智慧城市规划中的应用)



- The “Eight-Rivers Regeneration” project in Xi’an (西安“八水绕长安”工程)



Historical view of
“Eight Rivers
Surrounding the
Capital”

Application of WCM concept for planning a water-wise city (水循环管理理念在水智慧城市规划中的应用)



- The historical beauty of a “Water City” disappeared due to (昔日水城不复存在的原因)
 - Climate change resulting in lower precipitations (气候变化导致降水减少)
 - Increasing abstraction of water from river channels for various water uses (各种用水导致河道取水量增大)
 - Unreasonable application of river channels in the past decades (近几十年来河道的不合理利用)

Population growth is in any sense the determinative factor

Population as 1 million in
the most prosperous Tang
Dynasty



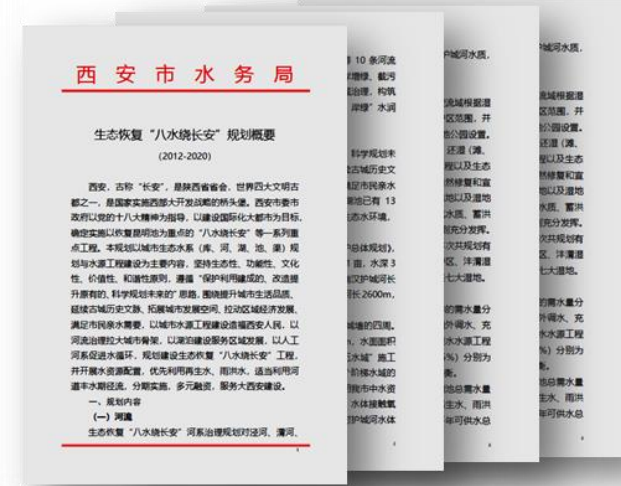
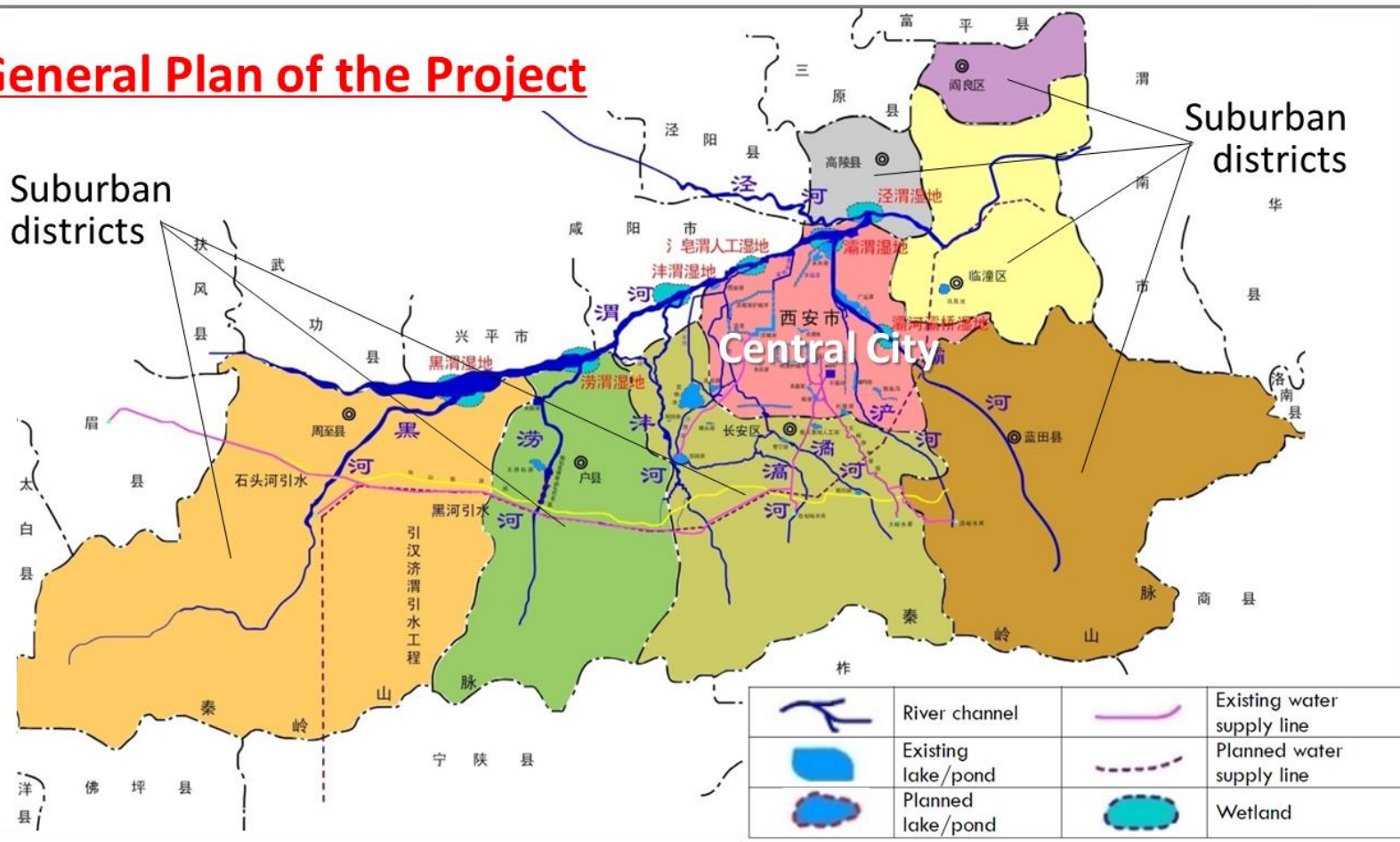
Population as about
9 million nowadays

Application of WCM concept for planning a water-wise city (水循环管理理念在水智慧城市规划中的应用)



● “Eight-Rivers Regeneration” project plan (“八水绕长安” 工程规划)

General Plan of the Project

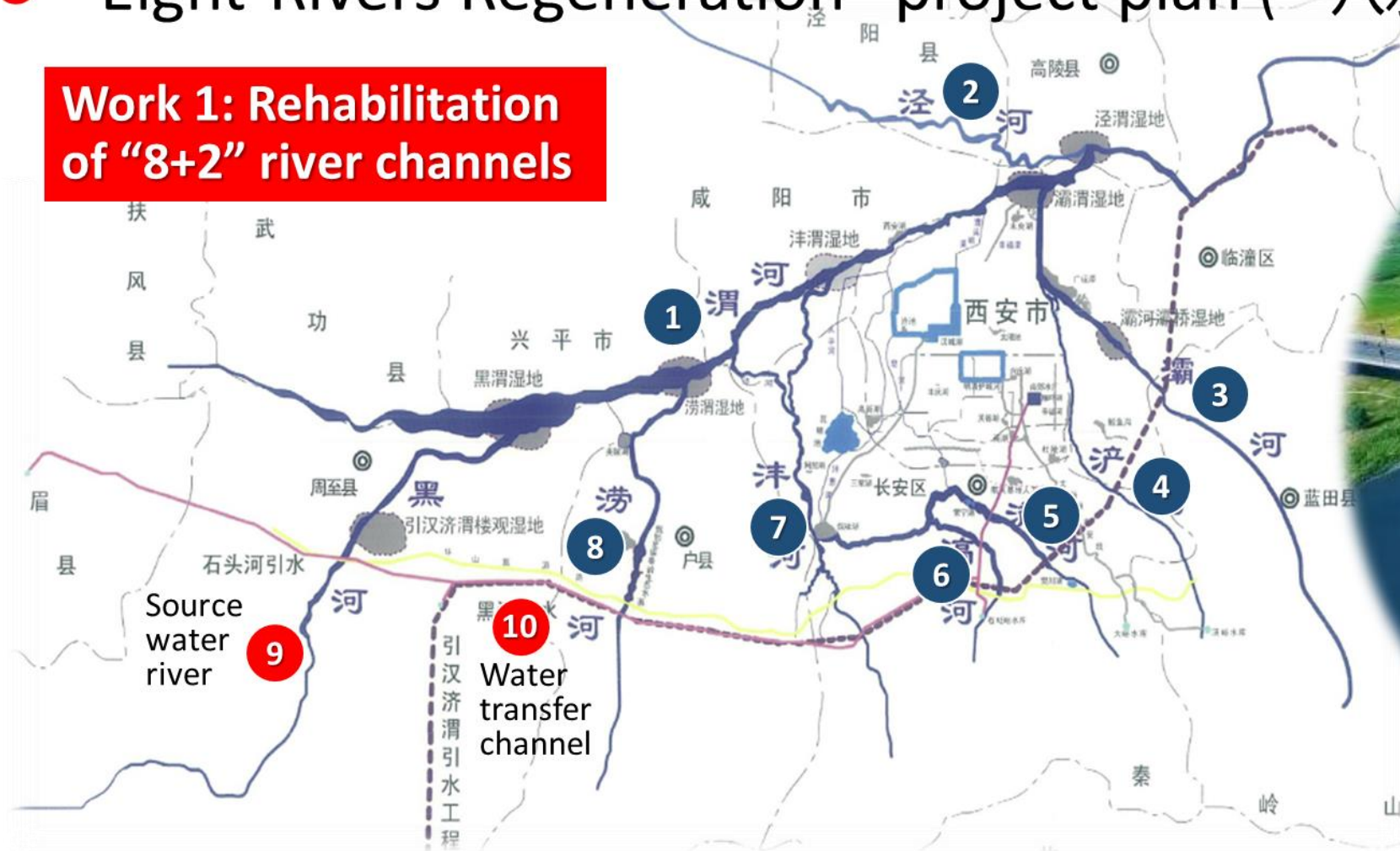


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Work 1: Rehabilitation of “8+2” river channels



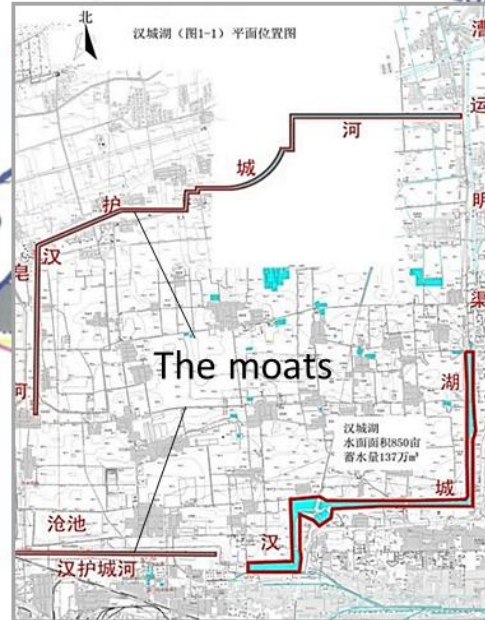
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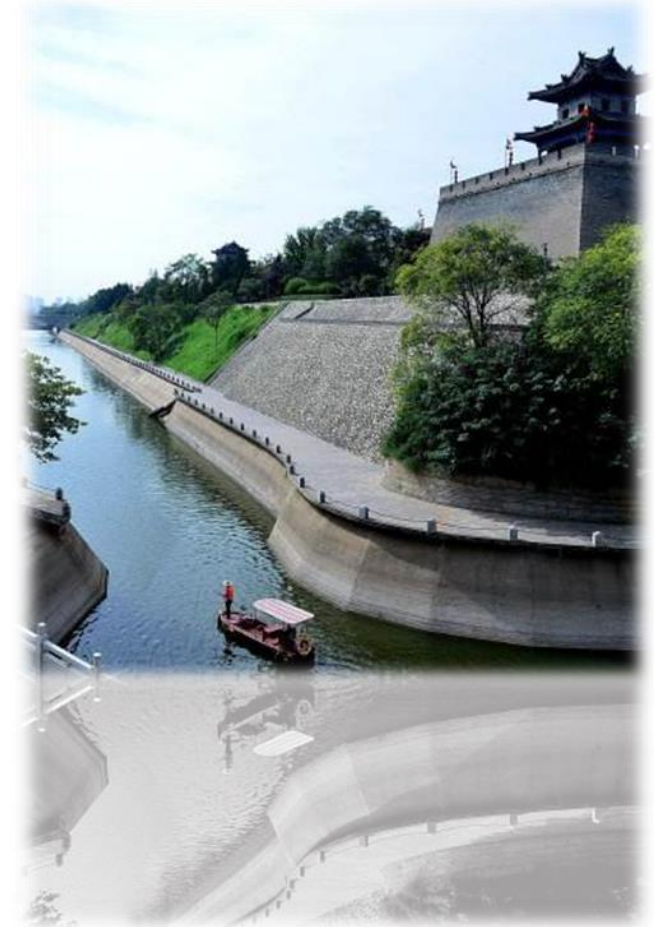
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Work 2: Rehabilitation of ancient moats

- Moats to be restored to the north and south of the ruin of the Han Dynasty Castle
- Total length: 9.8 km



- The moat surrounding the city wall built in Ming Dynasty
- Total length: 14.65 km



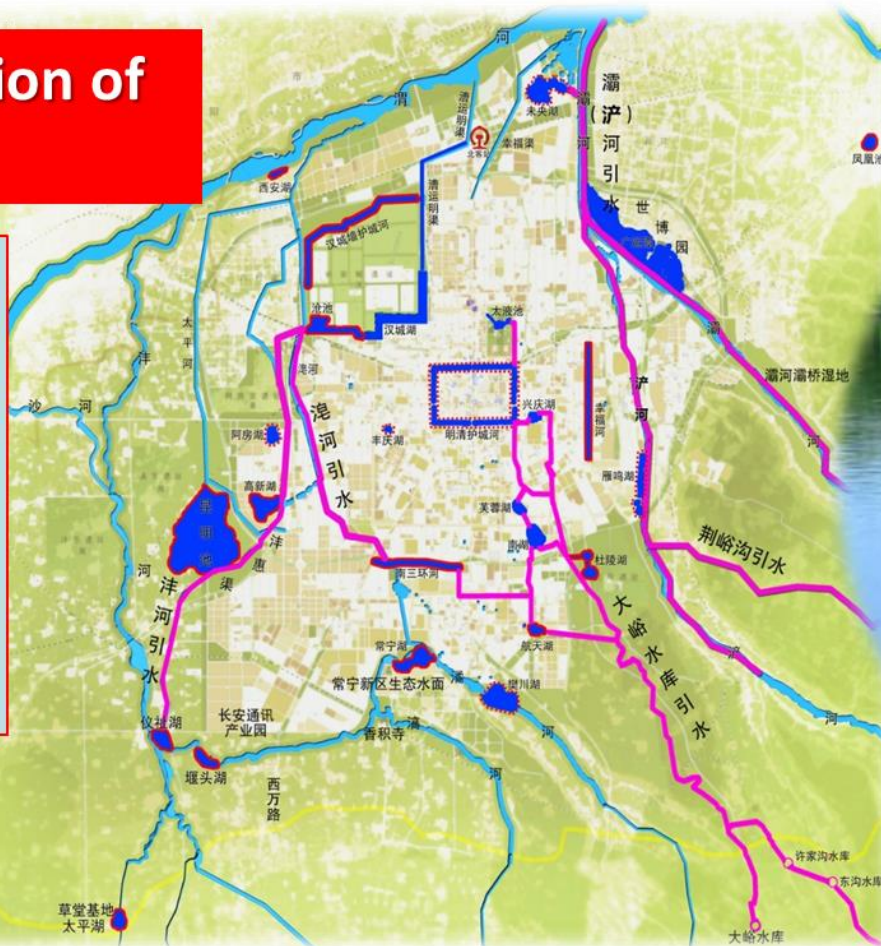
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Work 3: Restoration of urban lakes

- 28 urban lakes to be restored/rehabilitated
- Total surface area: 2070 ha
- Total storage volume: 62.2 million m³

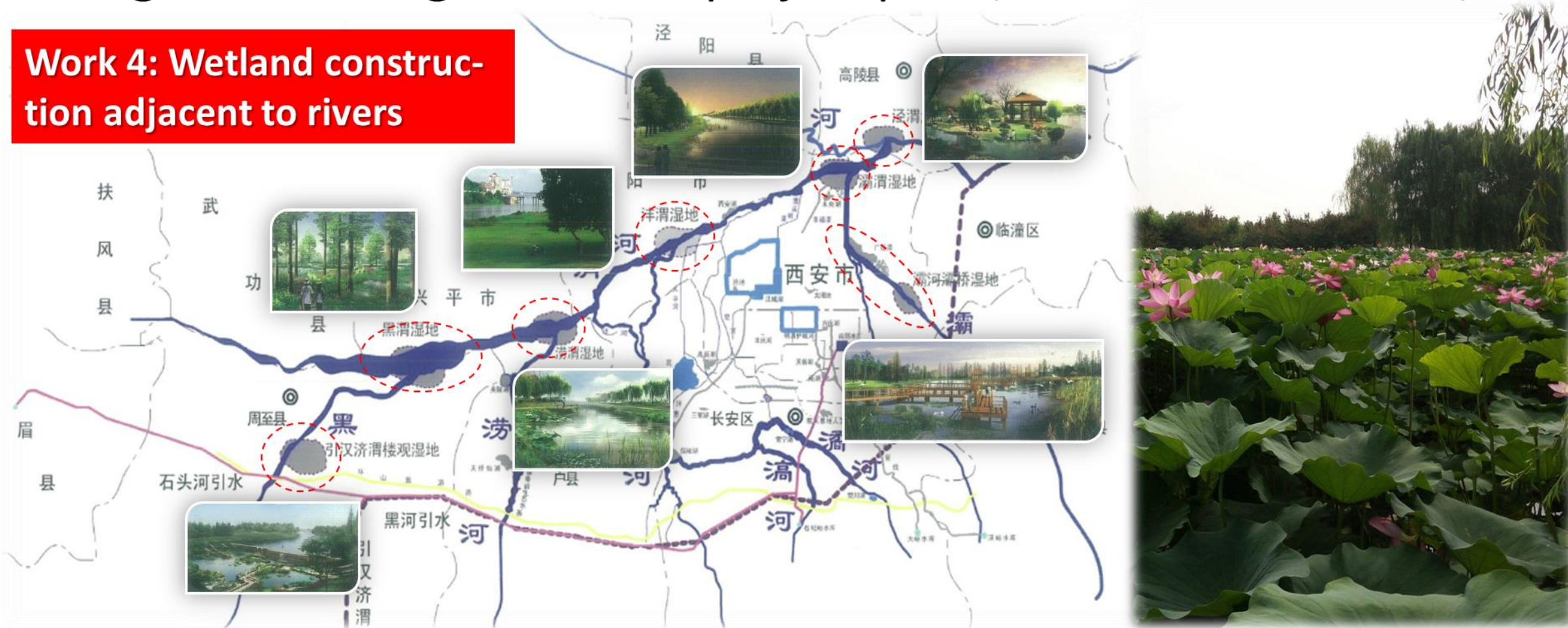


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Work 4: Wetland construction adjacent to rivers



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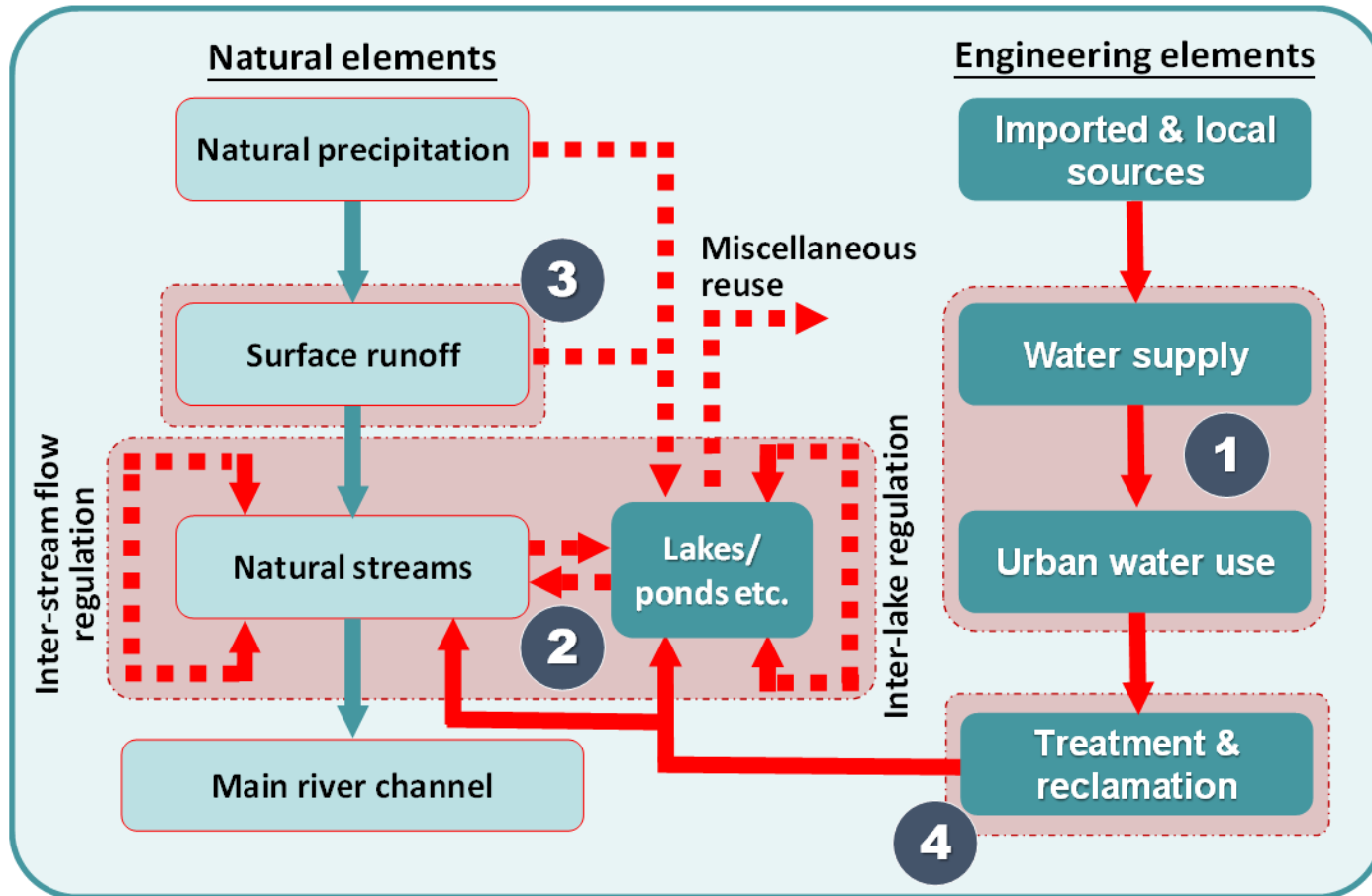
- Restrictions for the project implementation (工程实施的制约条件)
 - Natural precipitations are no longer as plenty as centuries ago (自然降水较若干世纪前大幅度减少)
 - Some rivers do not have perennial flow (一些河道并非四季常流)
 - All the rehabilitated lakes/ponds need artificial impoundment and/or replenishment (重建的湖池塘需人工蓄水或补给)
 - Current water shortage is a critical bottleneck (水资源短缺是瓶颈问题)

Needs for formulating an integrated water management plan to optimize utilization of all applicable water sources

Application of WCM concept for planning a water-wise city (水循环管理理念在水智慧城市规划中的应用)



- Water source enlargement plan following the WCM principle (基于水循环管理理念的水资源扩充规划)



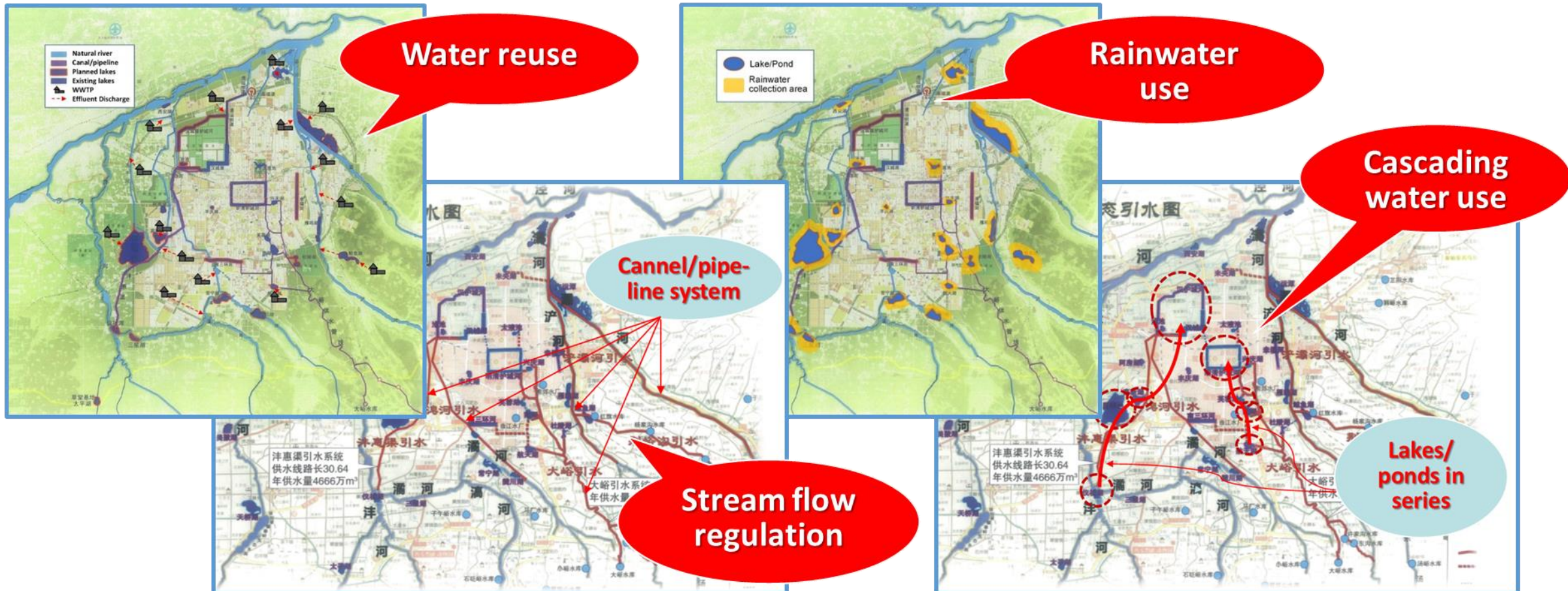
A quasi-natural water cycle with

- 1 Water saving
 - 2 Multi-functional and cascading water use
 - 3 Rainwater harvesting
 - 4 Water reclamation
- as **four pillars** to support integrated water management

Application of WCM concept for planning a water-wise city (水循环管理理念在水智慧城市规划中的应用)



● Engineering plan for source enlargement (水源扩充工程方案)



Application of WCM concept for planning a water-wise city (水循环管理理念在水智慧城市规划中的应用)



- Water supply for lakes/ponds replenishment by various sources (湖池补水水源配置方案)

Water source	Annual supply (million m ³ /yr.)	Percent of supply (%)
Natural stream flow	104.85	41.9
Cascading water use	49.55	19.8
Rainwater harvesting	23.52	9.4
Water reclamation	72.32	28.9
Total	250.24	100

Natural stream flow utilization only takes 41.9% of the total water supply while 58.1% has been covered by alternative water sources

Outline



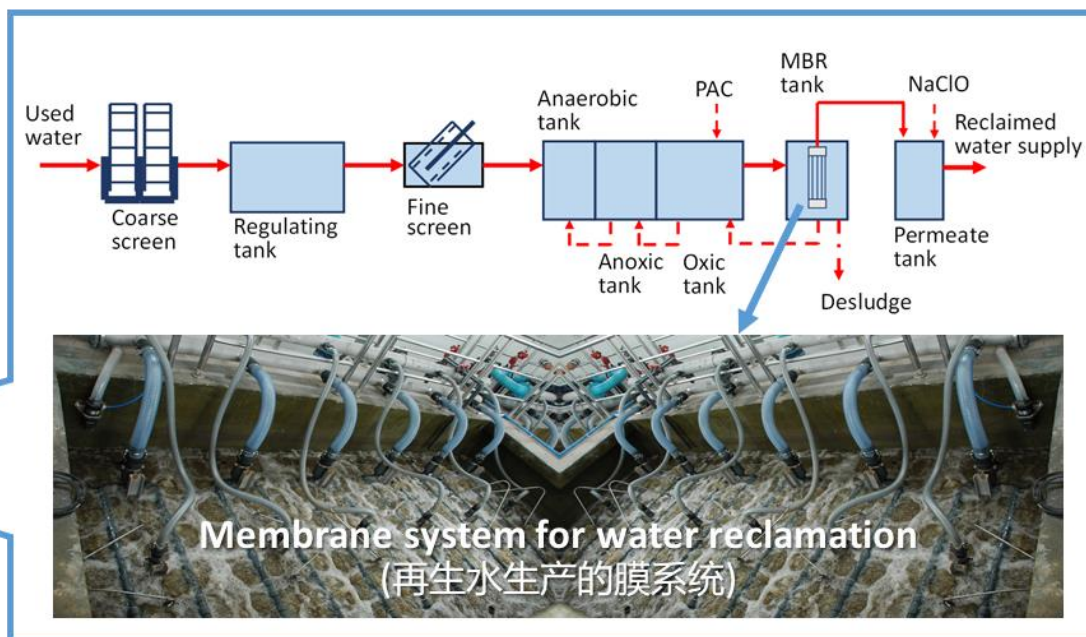
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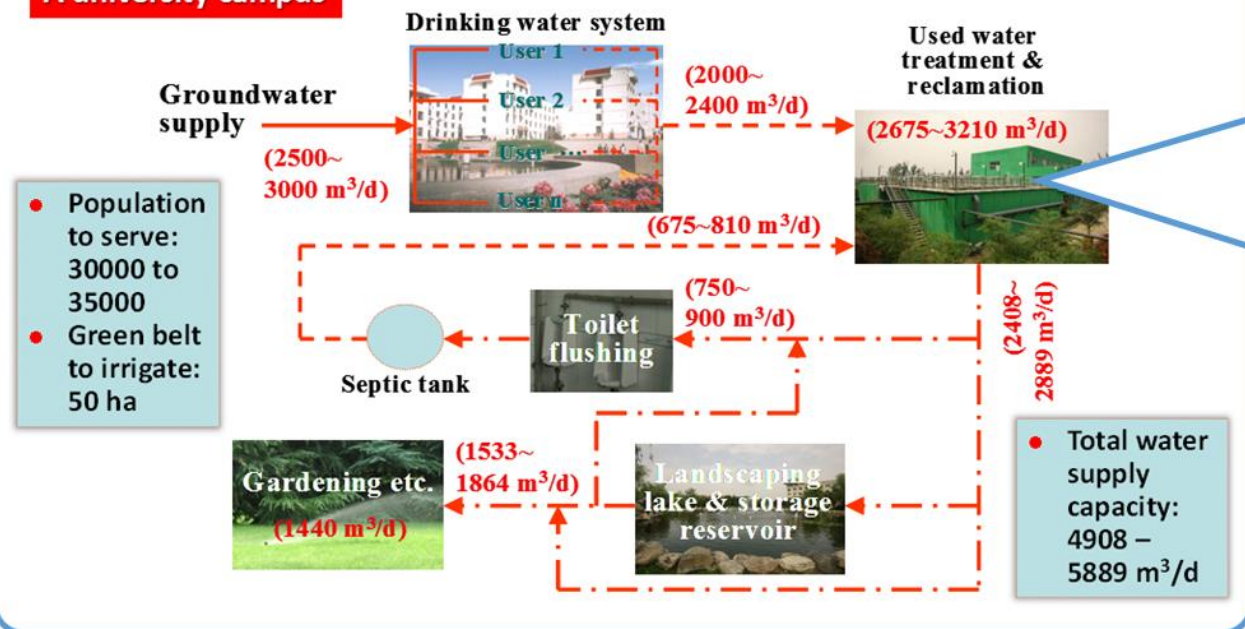


- A decentralized system for maximizing water reuse efficiency through a water cycle (水再利用效率最大化的分散式水循环系统)

- ❑ Limited groundwater only for drinking (地下水提供饮用)
- ❑ Reclaimed water for all non-potable supplies (再生水提供冲厕、绿化、景观用水)



A university campus



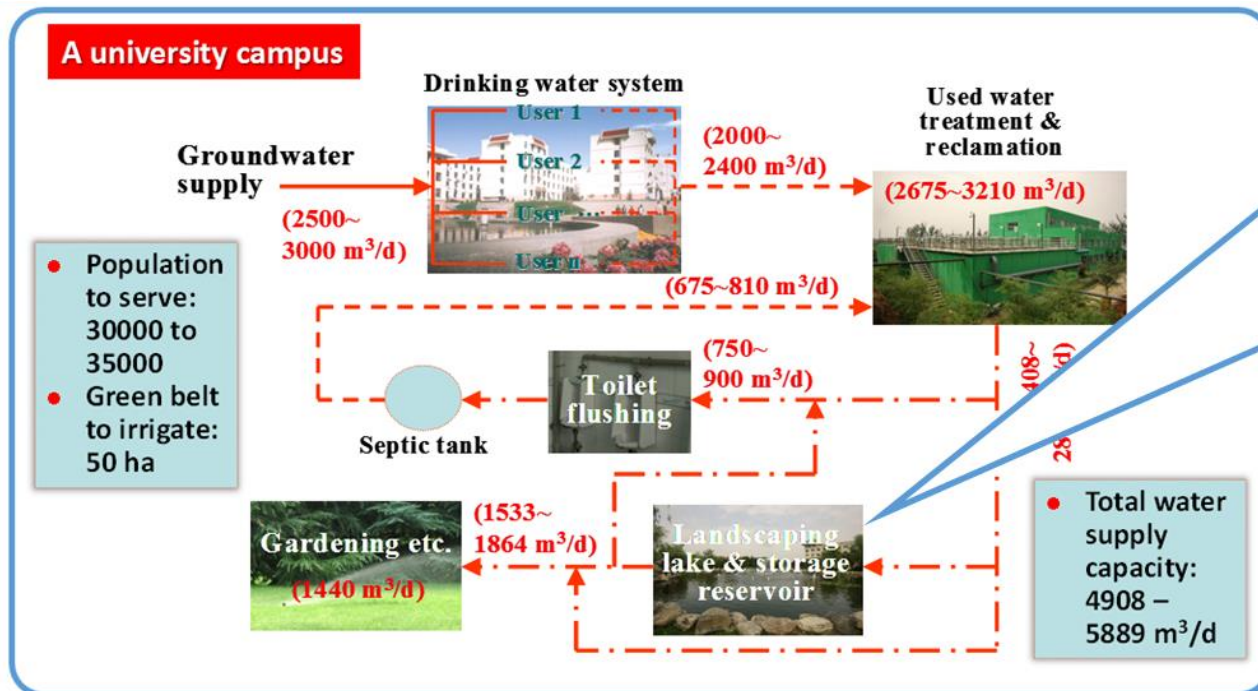
- ❑ Operation started in early 2011 and the system is now still serving the campus (2011年起运行至今)
- ❑ Long term monitoring has continued for 7 years (连续7年长期监测)

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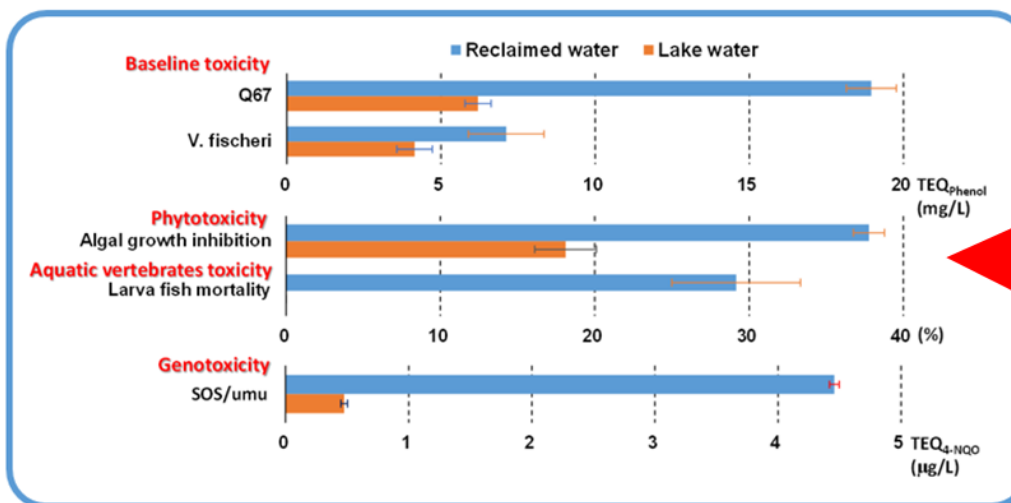
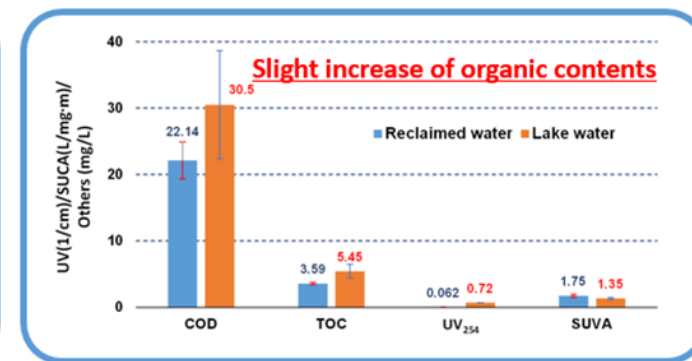
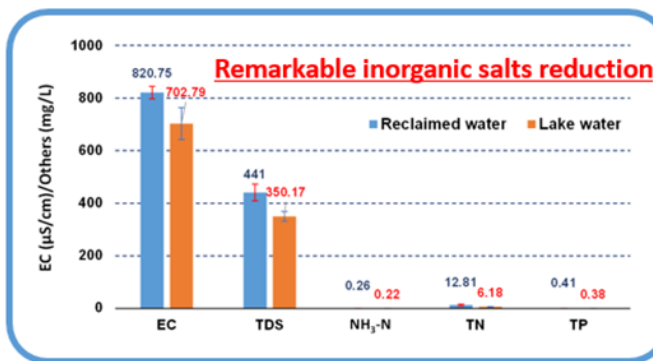
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- ❑ Green campus nourished by reclaimed water (再生水滋润了绿色校园)
- ❑ Safety supply ensured by combing engineering with ecological means (工程-生态组合实现水质安全保障)



Significant reduction of ecotoxicities (生态毒性显著降低)

IWA Global Project Innovation Award 2012
***Green Campus Nourished by Reclaimed
Water – Decentralized System of Zero
Discharge and Maximized Water Reuse***

2012年国际水协会全球项目创新奖
再生水滋润绿色校园
——分散式零排放污水回用系统



Concluding Remarks (结语)



- Cites are water-basin connected and depend on hydrological cycle for water sources (城市处于流域之中，得益于水文循环获取水资源)
- Water cycle management (WCM) can be taken as the basic principle for urban water system planning (水循环管理可作为城市水系规划的基本原则)
- Two principles: (1) to maintain the hydrological cycle as it is and (2) to follow the nature's manner (两个基本原则：维持水循环的自然属性、遵从自然规律)
- Two important roles of WCM: (1) Water source augmentation and (2) Water quality improvement (水循环管理的两大功能：水资源扩充、水质改善)



7hanks!