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Design of a district water and wastewater system under the concepts of DESAR and water metabolism

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Outlines

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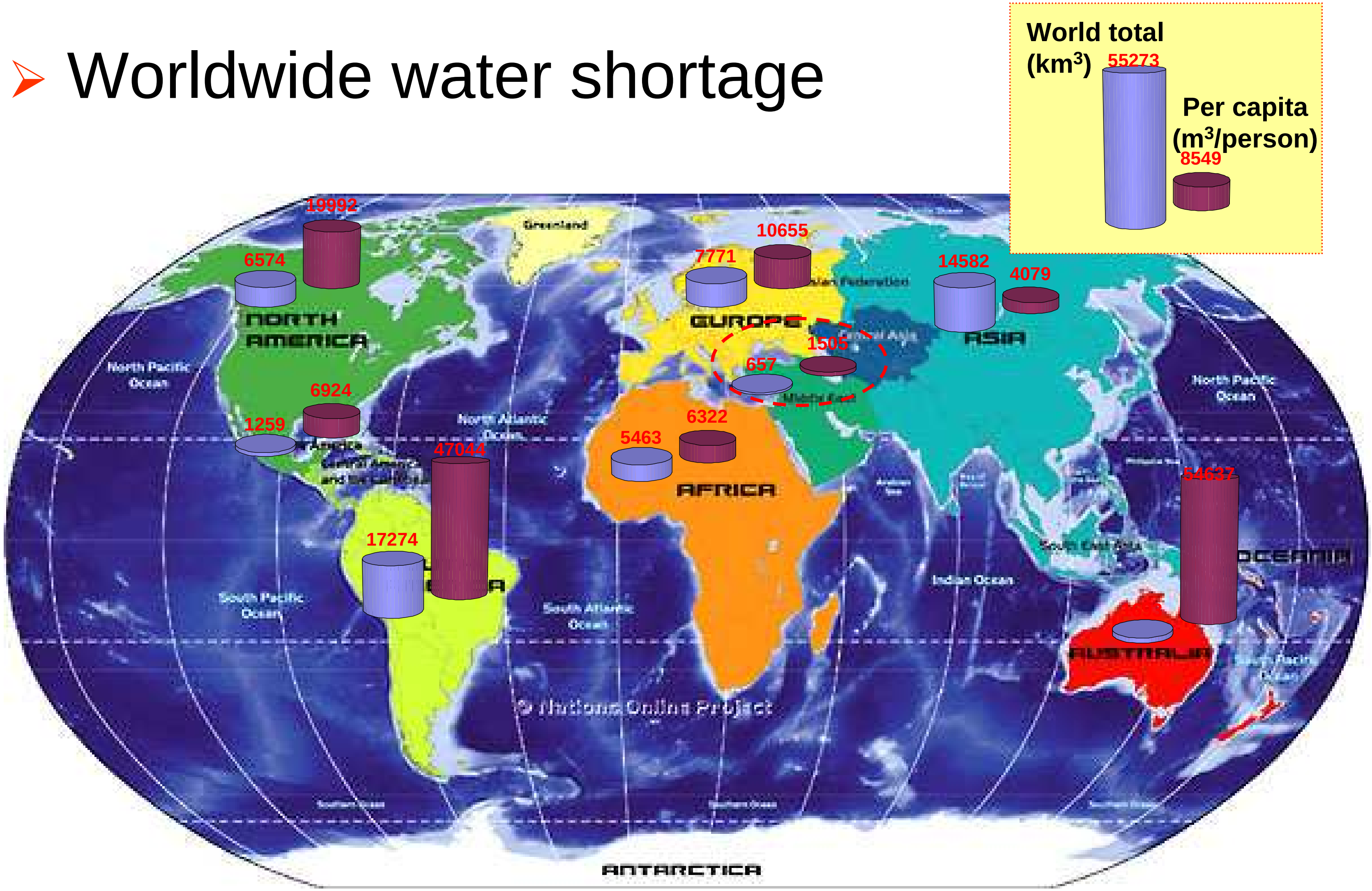
- Theories of urban water metabolism
- Extended concept of DESAR
- System configuration
- Case studies
- Summary and conclusions

Introduction

- Worldwide water shortage



➢ Regional water shortage (Asia)

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➢ Regional water shortage (China)

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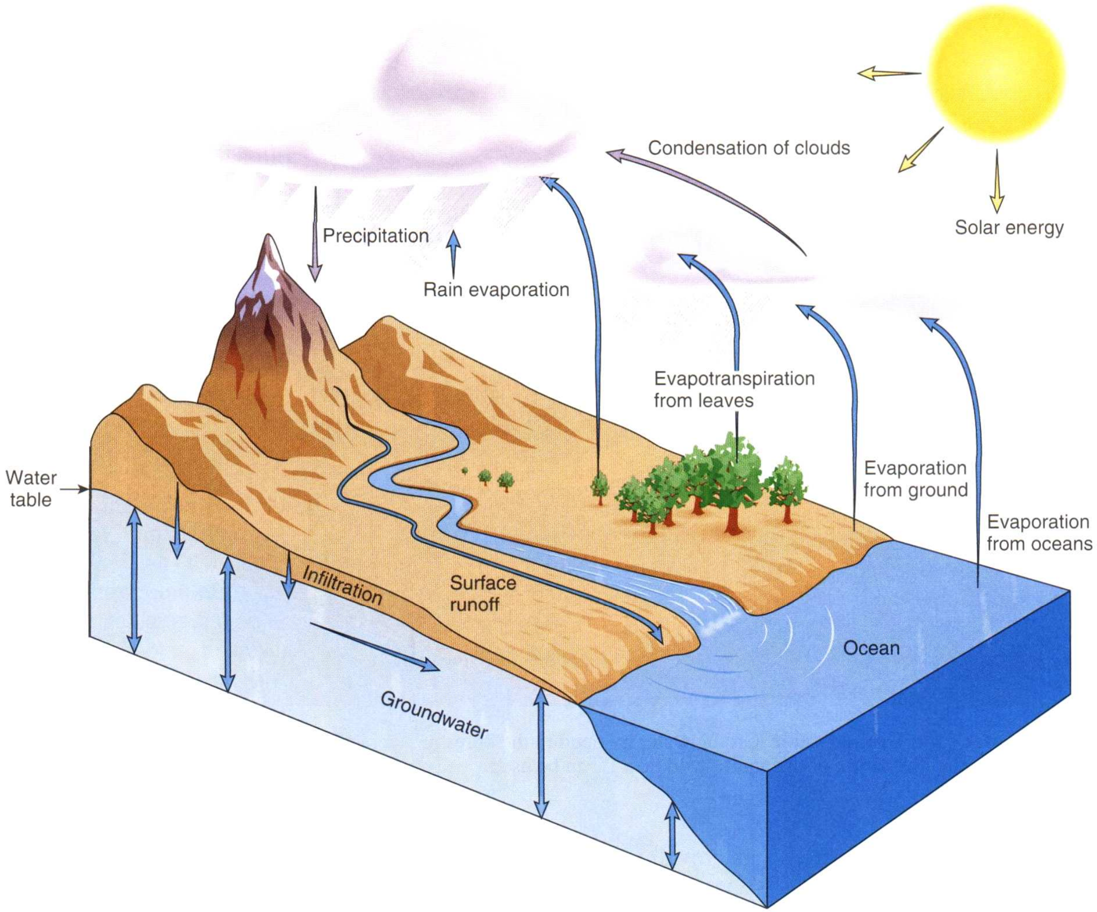
- Requirement for water reuse
  - Motivations for reuse
    - Increasing demand for water supply with population increase and economic development everywhere
    - Absolute shortage of renewable water resources in many regions and countries
    - No other alternative source water with quantity as stable and available as treated wastewater
  - Treated wastewater can/should be reused
    - Water supplied to urban area is only used with less than 1/3 of its quantity for real potable purposes
    - More than 2/3 of the water supply can be replaced by water with quality inferior to potable water
    - Treated wastewater can meet the quality requirement for non-potable uses at affordable treatment cost

- Questions to answer
  - Water reuse is one of the important counter-measures to mitigate water shortage, but ***how to reuse it in an environment friendly way?***
  - In a district where reclaimed water is a source for water supply, ***how to plan the district water system with wastewater treatment and reuse as important components?***
  - Centralization of wastewater system was resulted from the industrialization of our world when discharging human wastes away from cities in a sanitary way was the main objective. ***Does it need modification as wastewater becomes a resource?***
  - Human beings have followed the natural ways in many aspects. ***Shall we consider it again in practicing wastewater treatment and reuse?***

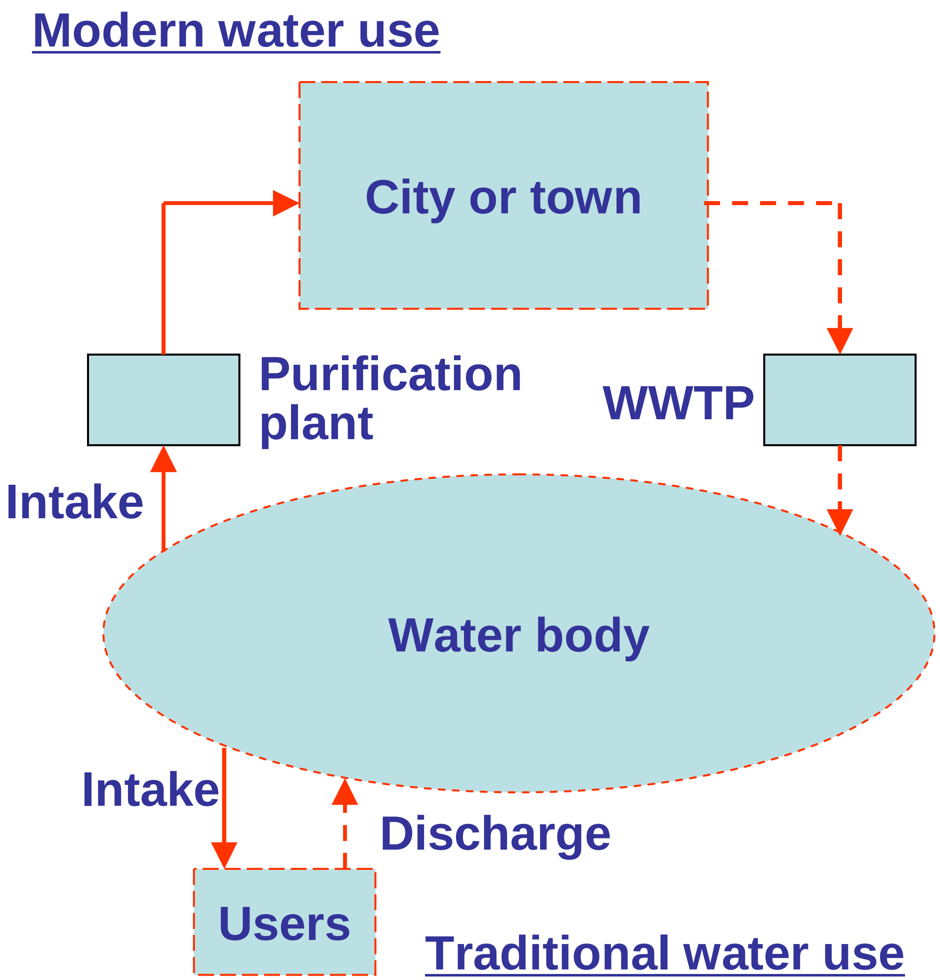
Theories of urban water metabolism

- Natural hydrologic cycle



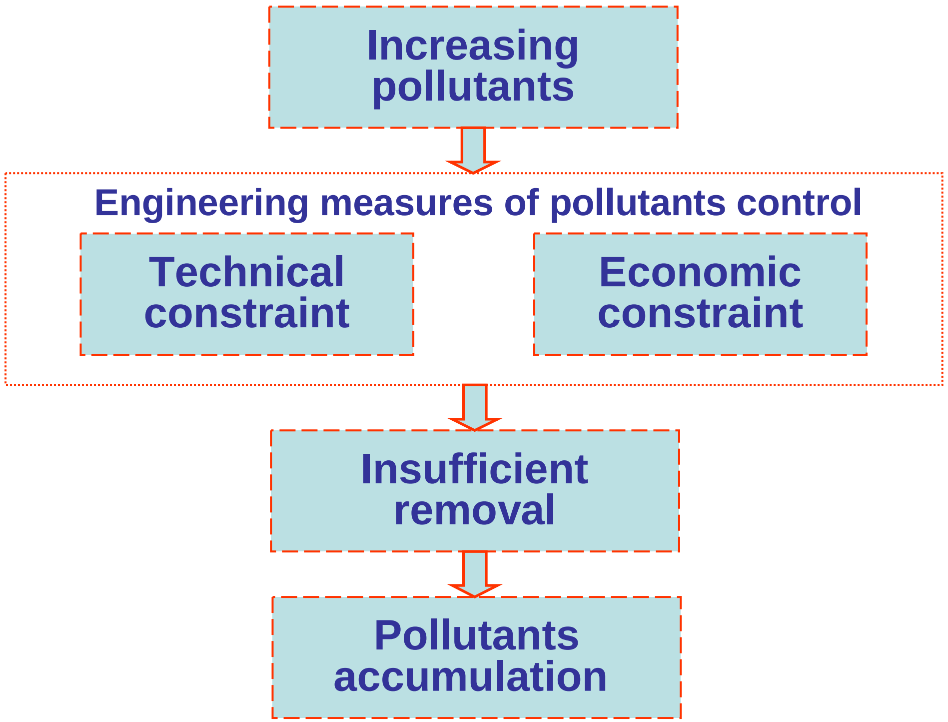
The hydrologic cycle is not only a water cycle but also a process of water purification by many physical, chemical, biological actions in natural ways which have provided safe-guards to our human beings for long. The natural capacity of the hydrologic cycle can be called "Metabolic capacity".

- Artificial water cycles of small scales in addition to the natural hydrologic cycle



Water is used by human beings through various artificial water cycles. The traditional water use depended completely on natural purification while the modern water use took engineering measures for water quality conversion to mitigate human impacts on the natural hydrologic cycle.

➢ Limitation of human ability for safeguarding water quality



<u>**Worsened condition in an artificial water cycle**</u>

An artificial water cycle that depends on engineering measures of pollutants control has limitation for safeguarding water quality due to technical and economic constraints. We have to learn from the nature again to find ways to increase the <u>metabolic capacity</u> of our urban waters.

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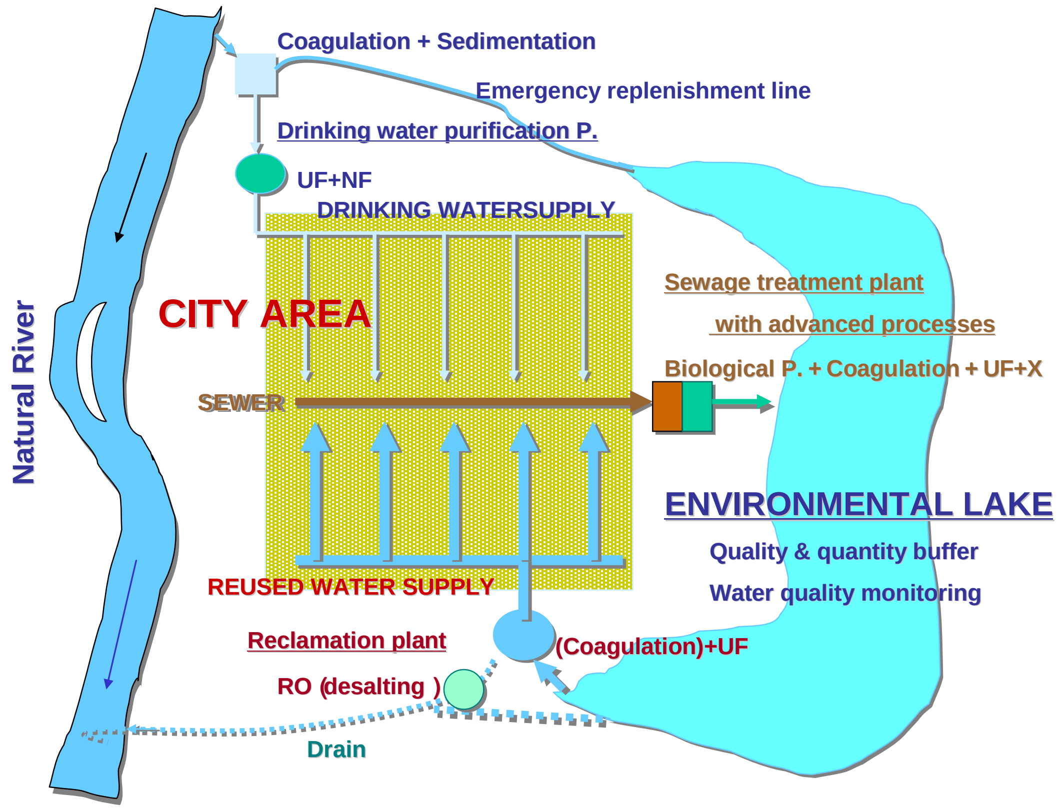
➤ A "water district" combining artificial water cycle with natural hydrologic cycle



Water district for an urban area

(Figure from N. Tambo)

The idea of "Water district"

- ✓ **High quality source water only used for portable purposes to decrease the burden of source water protection**
- ✓ **Wastewater reuse as a component of the water system**
- ✓ **Introduction of an environmental lake in the water system for quality & quantity buffer to increase the metabolic capacity of the urban water system**

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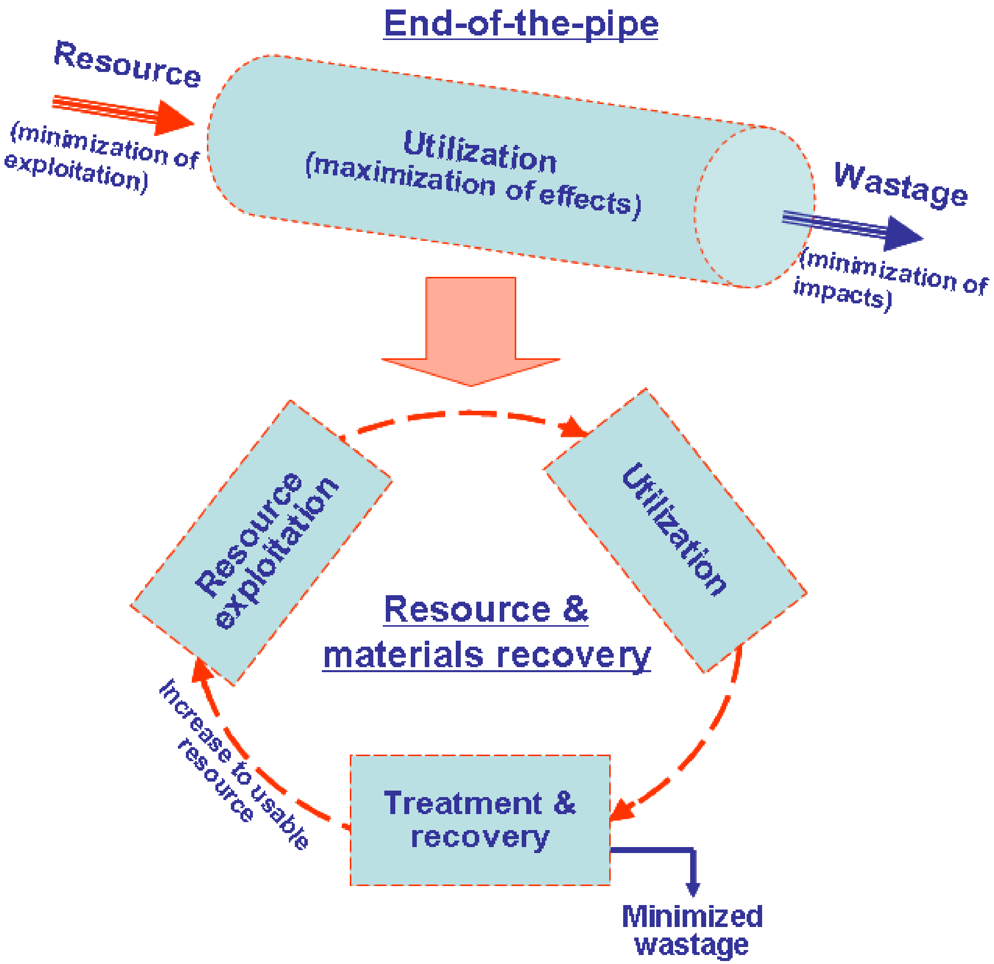
Extended concept of DESAR

- Basic concepts



Change of "end-of-the-pipe" to "resource and materials recovery"

- ✓ **End-of-the-pipe: what the modern technology can perform is to maximize the effects of utilization and meanwhile to minimize resource exploitation and waste discharge**
- ✓ **Resource & materials recovery: usable resources and materials are recovered and reused so that resource exploitation can be much minimized as well as waste discharge**

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Basic concepts

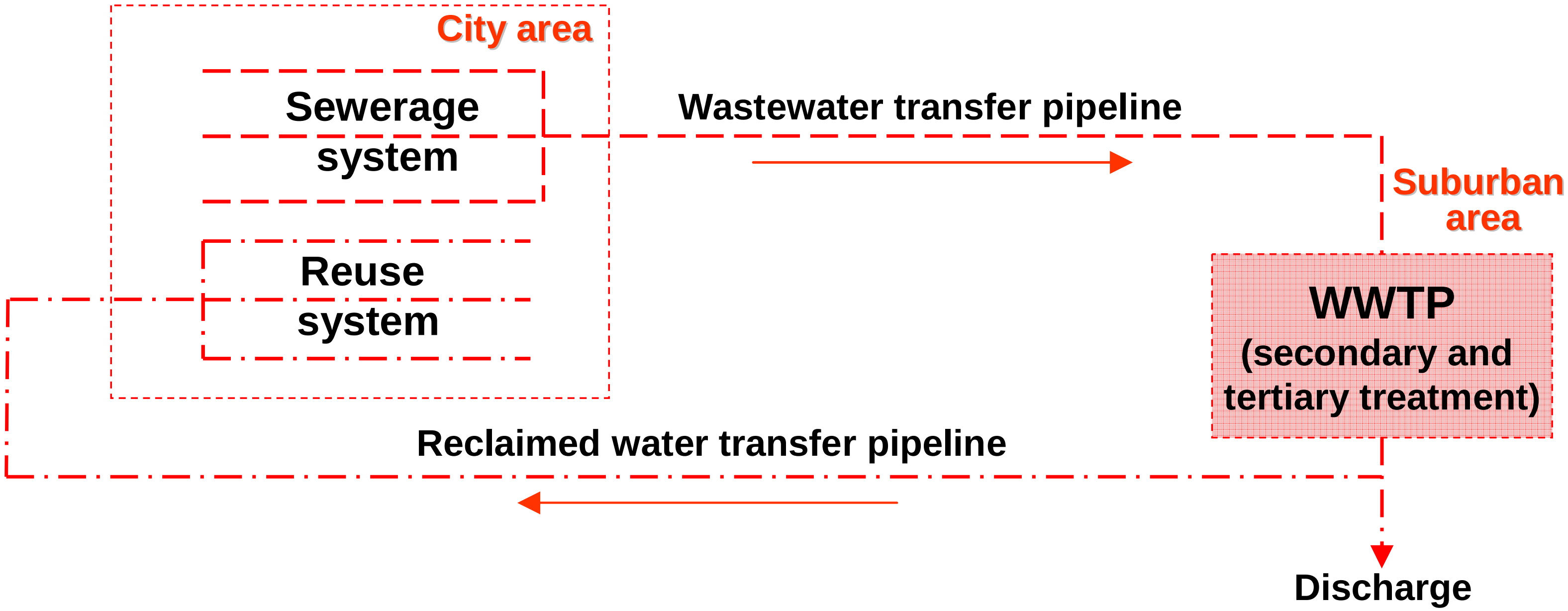
✓ "Don't mix" as far as possible (Data from Funamizu)

Appliance	Volume	COD	NH_4-N	NO_3-N	PO_4-P	TSS
WC	31%	44%	97%	3.8%	80%	77%
Kitchen sink	13%	23%	0.3%	38%	9.4%	10%
Wash Basin	13%	1.7%	0.1%	11%	1.3%	2.1%
Bath	16%	2.5%	0.6%	15%	1.1%	1.3%
Shower	12%	6.4%	0.7%	25%	4.1%	5.1%
Washing machine	16%	22%	1.2%	7.6%	4.3%	4.0%

Wastes from different appliances differ in quantity and strength. What the modern wastewater collection and treatment system performs is to mix the "dense flow" with "dilute flow" and then to try to separate them again. Such a unwise way of waste proposal should be changed.

➢ Basic concepts

✓ "Don't deliver" as far as possible



In a modern city, the main purpose of the sewerage system is to carry away the wastes in a sanitary manner. Long distance transfer of the collected wastewater to the WWTP outside the city thus becomes a common practice. Another long distance transfer pipeline may have to be provided if water reclamation and reuse it to be practiced. This is also unwise because high construction cost and energy consumption are needed.

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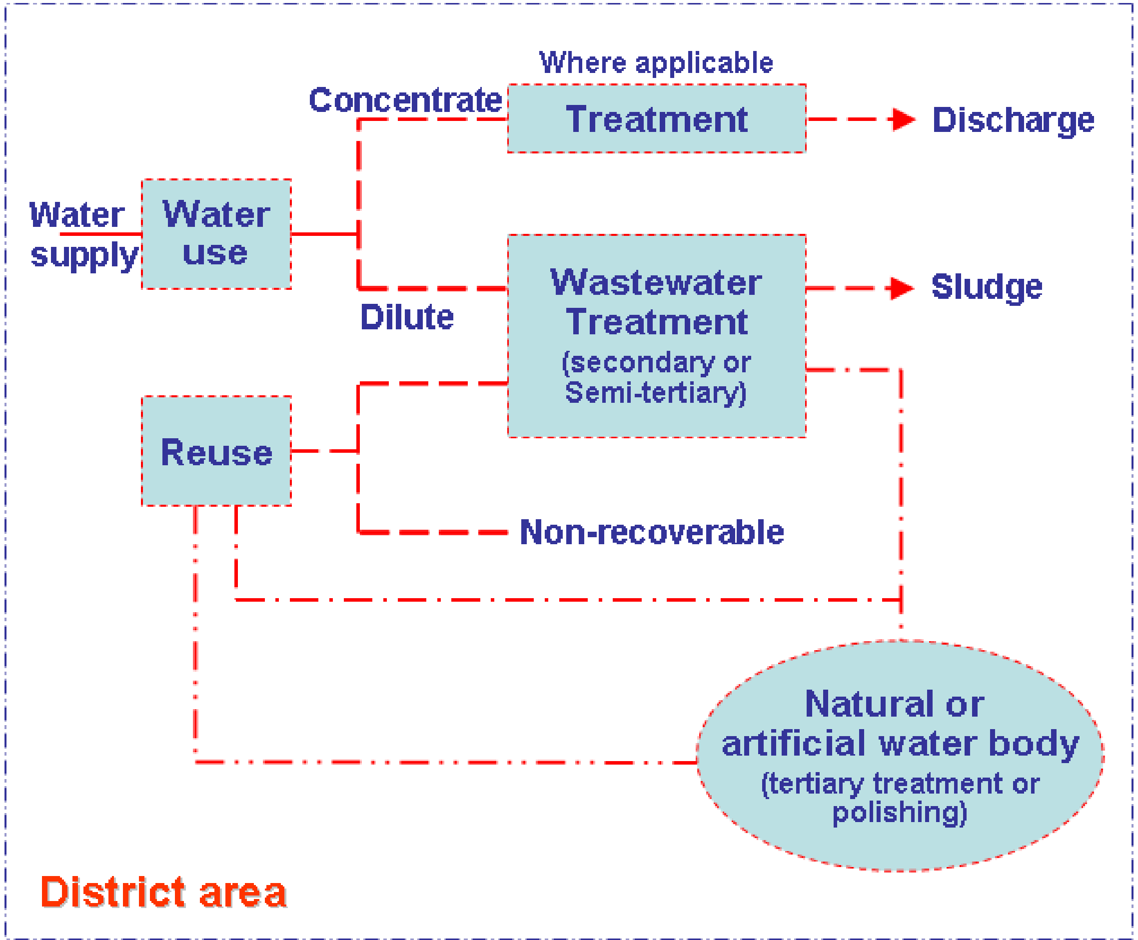
- Extended concept of decentralized sanitation and reuse (DESAR)
  - ✓ A system aiming at resource & materials recovery in addition to sanitation
  - ✓ A system which facilitate separate collection and separate treatment of wastes of different strength
  - ✓ A system which facilitate water reuse at low cost and low energy consumption

As "decentralization" is against "centralization", system scale becomes an important factor and onsite treatment and onsite reuse is generally recognized as the main point of the DESAR concept. Here, we stress the basic concept or principles but not the system scale so that the DESAR concept can be applied to a broader range such as a district water system designed under the same principles.

System configuration

- General consideration
  - ✓ Minimization of fresh water supply and maximization of treated wastewater reuse
  - ✓ DESAR and water metabolism as the basic philosophy of system design
  - ✓ Priority given to environmental reuse of the treated wastewater
  - ✓ Introduction of the “principles of ecological design” to system configuration
    - Follow nature’s example
    - Moderate and efficient resource use
    - Appropriate technology
    - Green living inspiration

- Basic composition of the district water and wastewater system under the concepts of DESAR and water metabolism



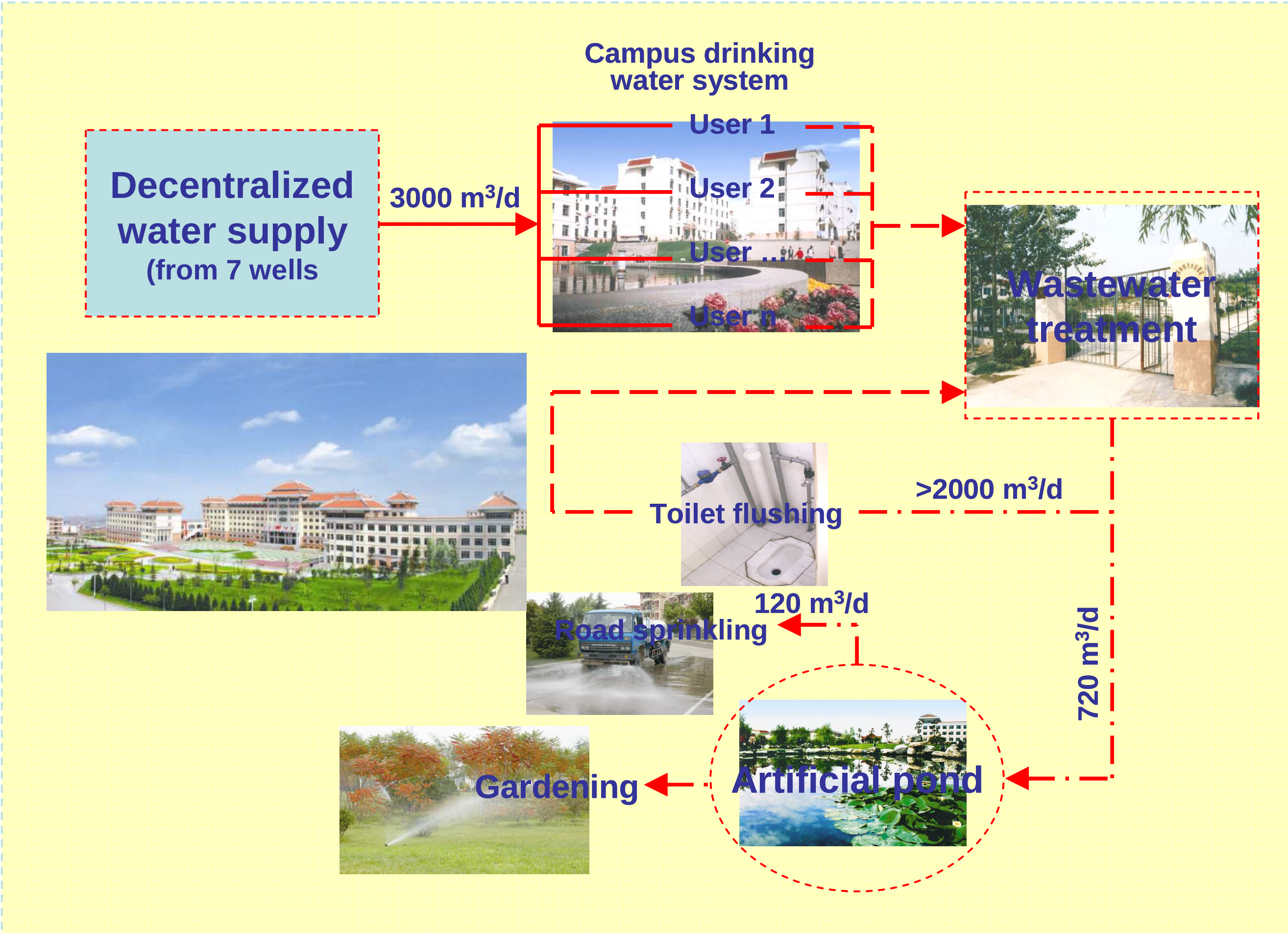
Characteristics of the system

- ✓ Wastewater treatment and reuse within the district
- ✓ Source separation where applicable
- ✓ Utilization of natural or artificial lakes (ponds) for water quality polishing where applicable
- ✓ Minimized discharge from the system

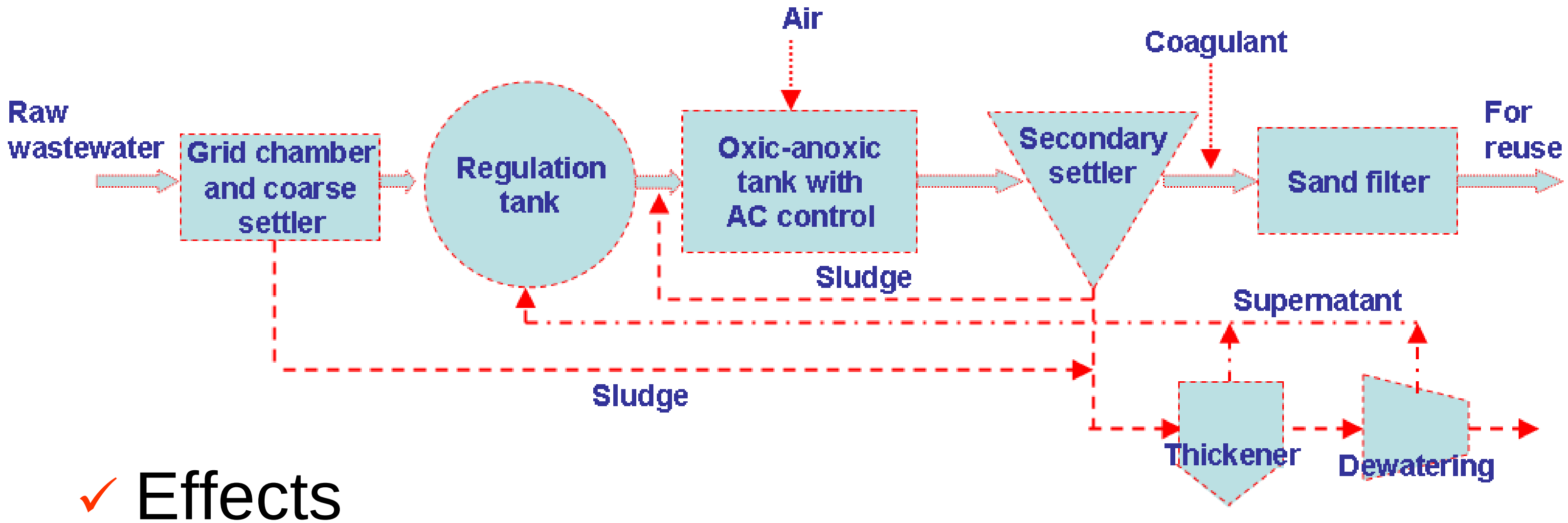
Case studies

- Case 1: Decentralized water and waste-water system serving a college campus
  - ✓ General condition
    - Location: Xi'an suburban area, on top of a hill
    - Population: about 25000 students all living in the campus
    - Available water source: away from city water supply network, only groundwater available
    - Service area:
      - Total 87 hectares
      - Green coverage about 45 hectares
      - Constraints:
        - » Groundwater withdraw can only support drinking water supply
        - » Far away from the city drainage system

- Case 1: Decentralized water and waste-water system serving a college campus
  - ✓ System composition



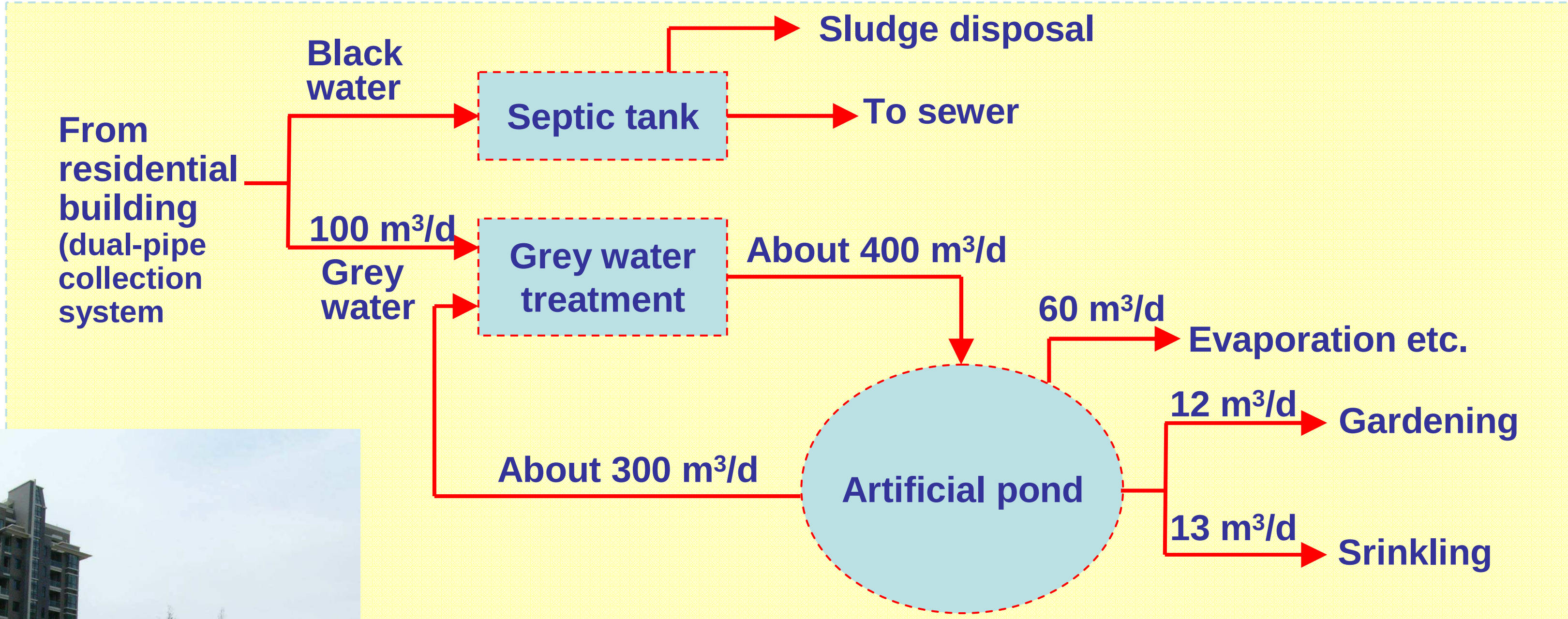
- Case 1: Decentralized water and waste-water system serving a college campus
  - ✓ Wastewater treatment system applied



  - ✓ Effects
    - Zero discharge of wastewater is realized
    - Non-drinking water supply is all covered by the treated wastewater
    - A campus with large green belt is sustained

- Case 2: A newly developed residential area with grey water reuse system
  - ✓ General condition
    - A pilot project supported by local government for grey water treatment and reuse for a newly developed residential area in Xi'an urban area
    - Environmental use (artificial ponds, gardening etc.) as the main purpose of wastewater reuse
    - Basic data:
      - Served population: 400 households, 1200~1600 people
      - Green belt area: 6400 m^2
      - Artificial pond surface: 6500 m^2

- Case 2: A newly developed residential area with grey water reuse system
  - ✓ System composition



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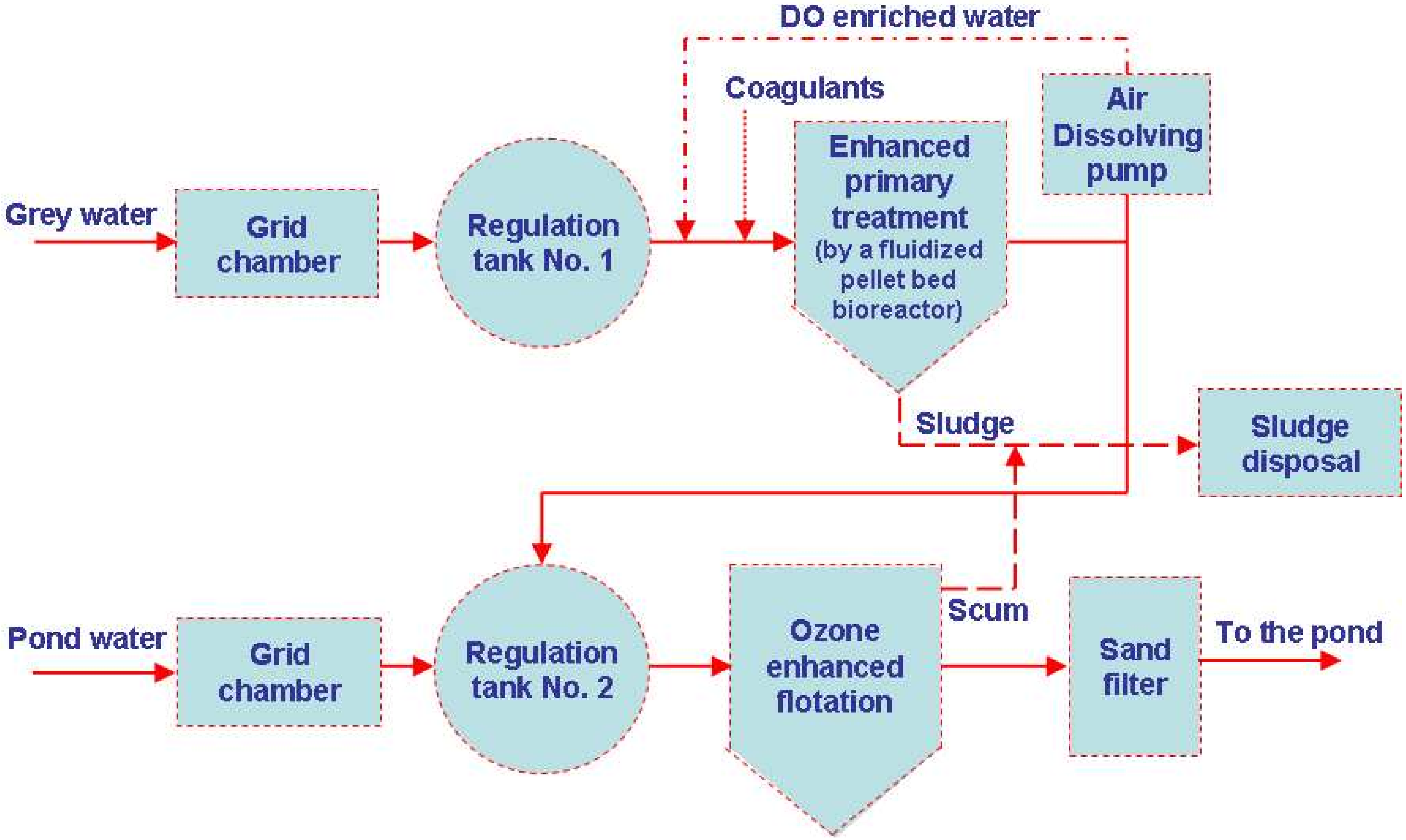
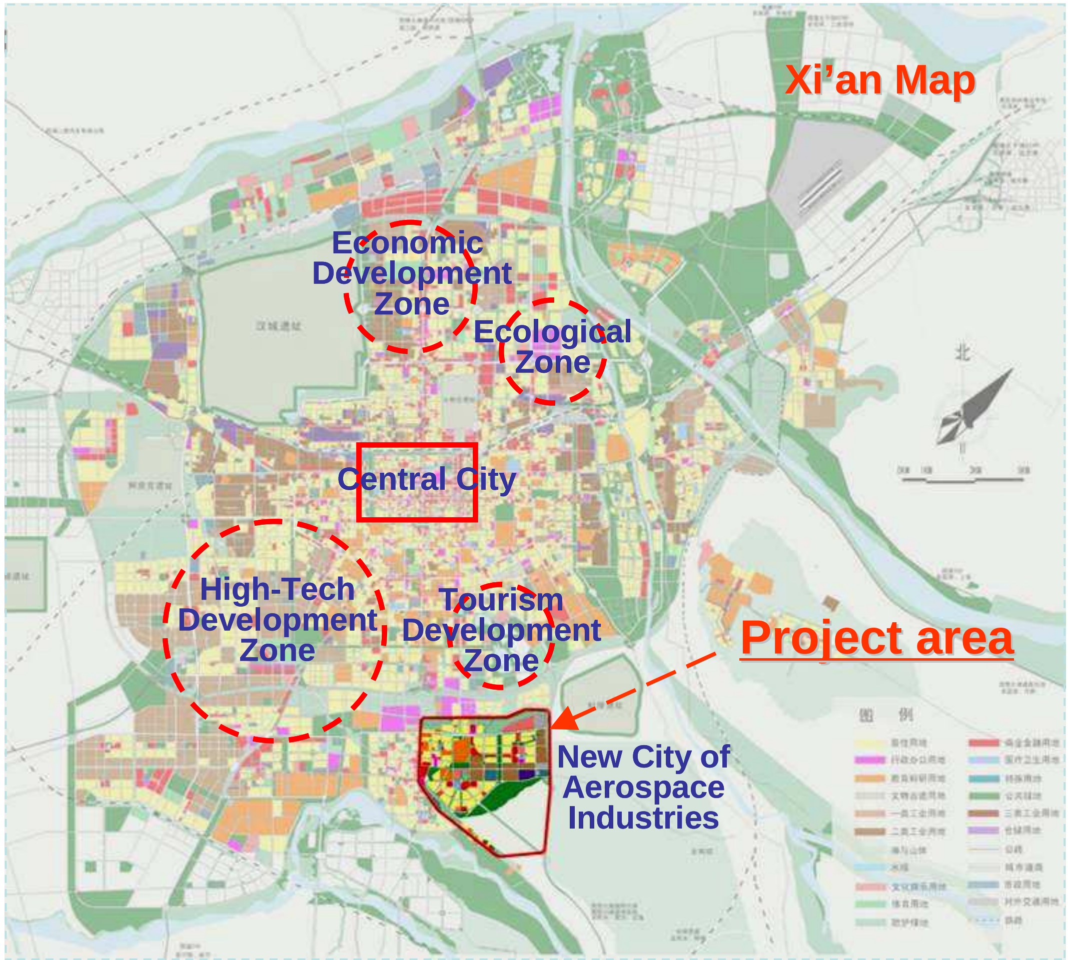
- Case 2: A newly developed residential area with grey water reuse system
  - ✓ Wastewater treatment system applied

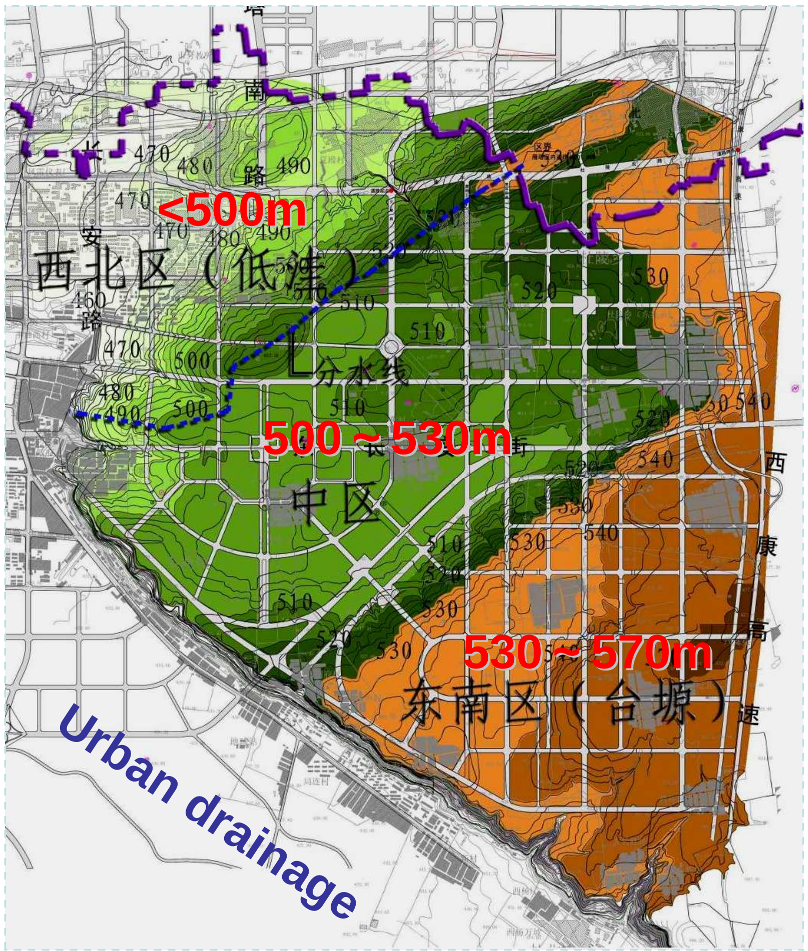


- Case 3: A district water system with reuse of treated wastewater and storm water
  - ✓ General condition

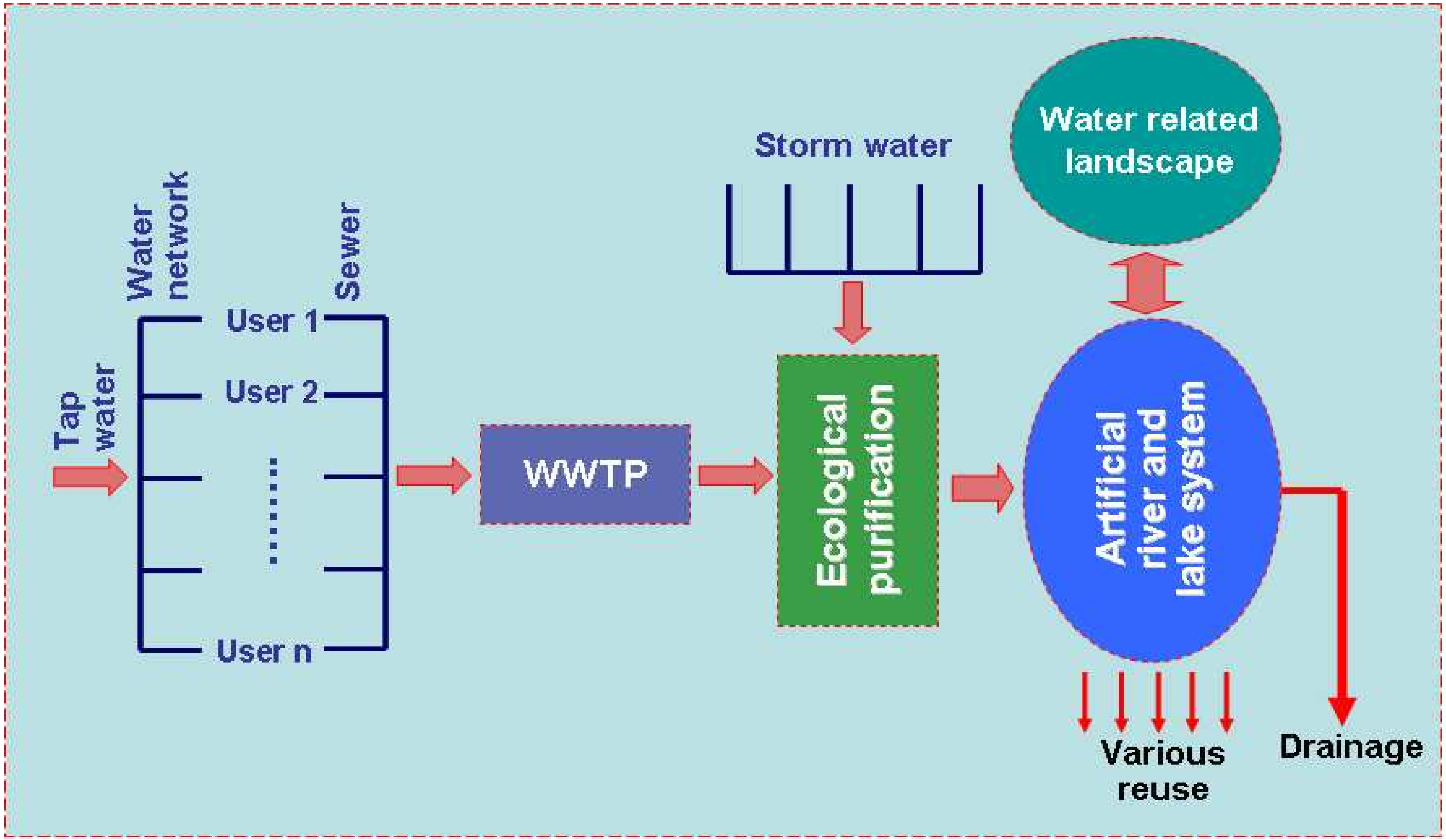


Project name: Water environmental systems for Xi'an New City of Aerospace Industries

- Case 3: A district water system with reuse of treated wastewater and storm water
  - ✓ Current environmental condition of the project area
    - Hilled area covering 22 km^2 and with about 100 m elevation difference
    - No natural streams in the project area
    - Urban drainage outside the project area



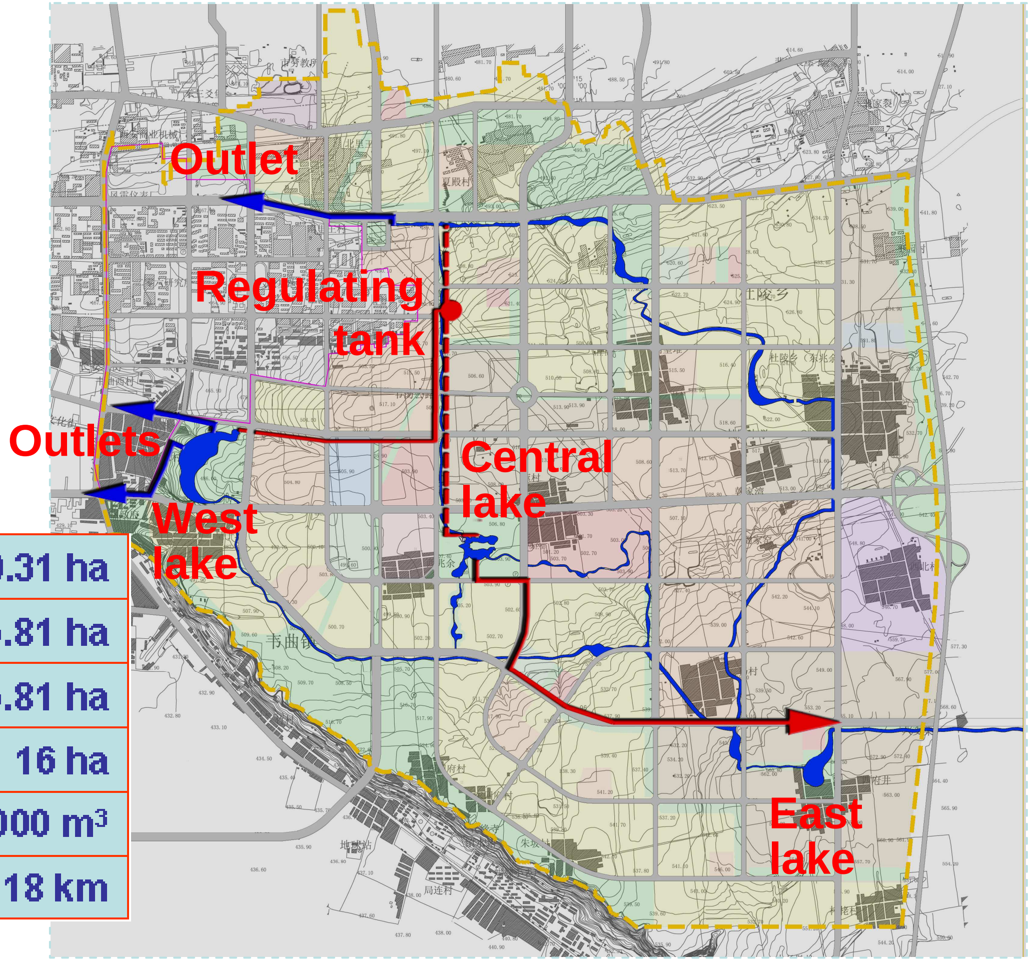
- Case 3: A district water system with reuse of treated wastewater and storm water
  - ✓ Basic configuration of the system with reuse of treated wastewater and storm water



- Case 3: A district water system with reuse of treated wastewater and storm water
  - ✓ System design

An water system with artificial lakes and rivers

Total water surface	30.31 ha
Total lake surface	5.81 ha
Total river surface	5.81 ha
Wetland surface	16 ha
Total water volume	333 000 m³
Total river length	18 km



- Case 3: A district water system with reuse of treated wastewater and storm water
  - ✓ Water balance calculation
    - Water demand for the artificial lakes and rivers system
      - Evaporation: Q_1=820m^3/d
      - Seepage: Q_2=1050m^3/d
      - Gardening etc: Q_3 = 5000m^3/d
      - Ecological base flow of the artificial rivers: Q_4=15000m^3/d
      - Total demand: **Q=21870m^3/d**
    - Estimation of available reclaimed water
      - Wastewater reclamation: 21000m^3/d (from the 30000m^3/d of wastewater treatment in short term)
      - Rainwater harvesting: about 3000m^3/d on average (10% of the rainfall)
      - Total available quantity: **Q'=24000m^3/d > Q**

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- Case 3: A district water system with reuse of treated wastewater and storm water
  - ✓ WWTP combined with the wetland – lake system

Summary and conclusions

- **Water shortage**: its seriousness can be seen from the distribution of per capita water resource of the world or a region.
- **Water reuse**: an indispensable measure to mitigate water shortage.
- **Urban metabolism**: in an densely populated urban area, it is important to learn from the nature again for increasing the metabolic capacity of our water system.
- **Extended DESAR concept**: resource & materials recovery, separate collection and separate treatment of wastes, water reuse at low cost and low energy consumption.

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- **A district water and wastewater system under the concepts of DESAR and water metabolism**:
  - Wastewater treatment and reuse within the district
  - Priority given to environmental reuse of the reclaimed water
  - Source separation where applicable
  - Utilization of natural or artificial lakes (ponds) for water quality polishing (assimilating) where applicable
  - Minimized discharge from the system

Thanks !