The 11th International Symposium on Water Supply Technology
Water Supply Services and their Future – Reliable, Sustainable and Smart

July 9 – 11, 2019
Yokohama, Japan

Japan Water Research Center
Yokohama Waterworks Bureau

Smart Water System of Seoul

How Smart is Smart?
Smart Why vs. Smart What

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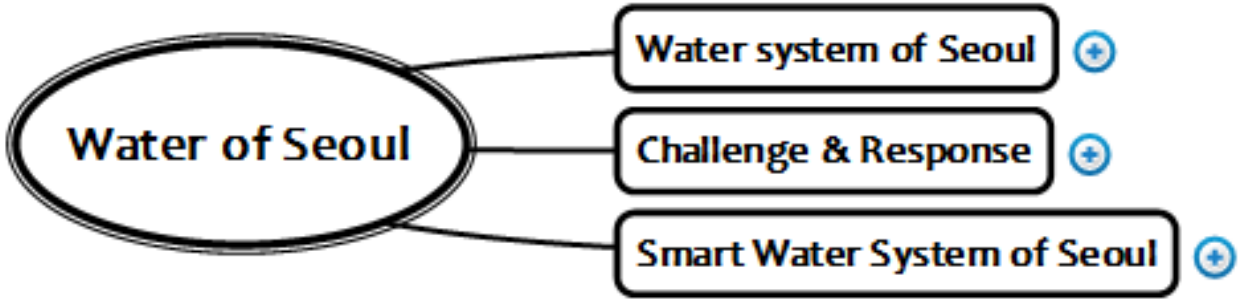

Contents

- Water System of Seoul
- Challenge and Response
- Smart Water System of Seoul

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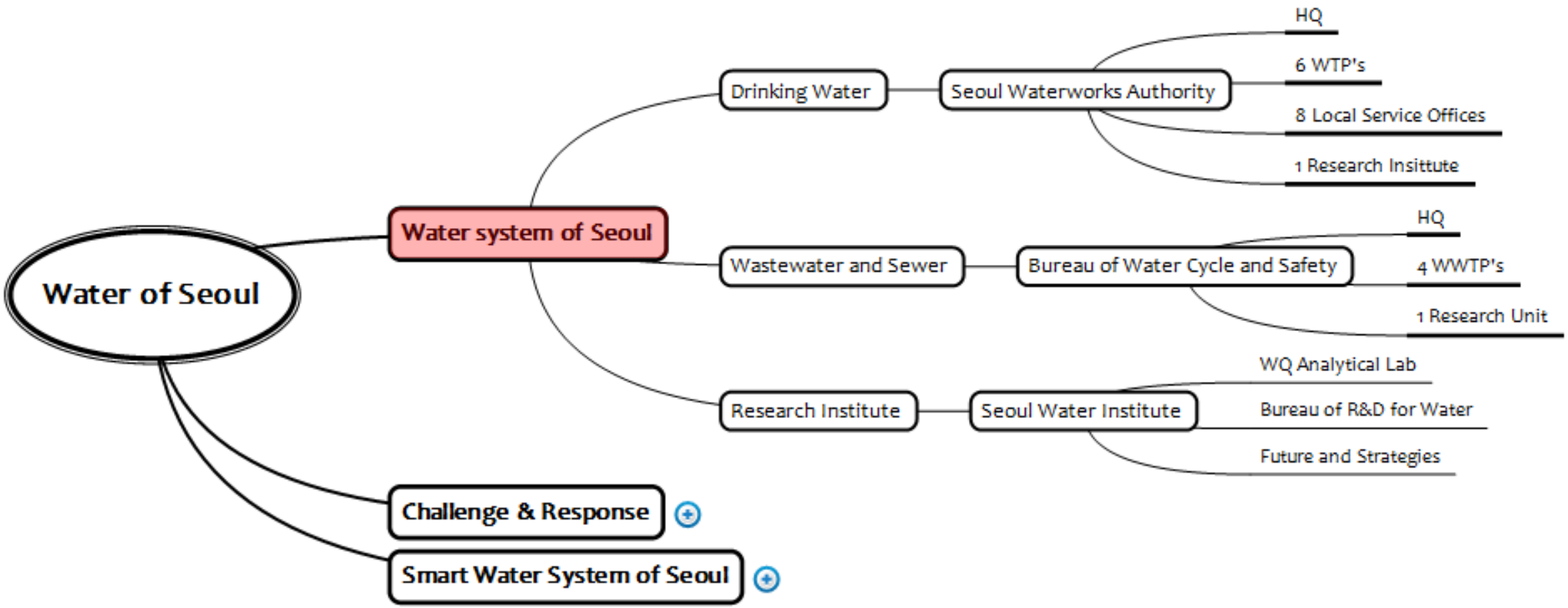


Seoul Waterworks Authority

SWA

Drinking water production and supply
As of Oct. 2018

Organization

- 1 HQ (5 Bureaus)
- 1 Research Institute (2 Bureaus, 1 Center)
- 8 Local Service Offices
- 6 WTP's
- 1 Procurement Center
- 1,896 staffs

Budget: 737 M USD

Production

- Total capacity 4.8 M m^3/day
- Production by advanced process 3.6 M m^3/day
- Average production 3.2 M m^3/day (Max. 3.5 M)

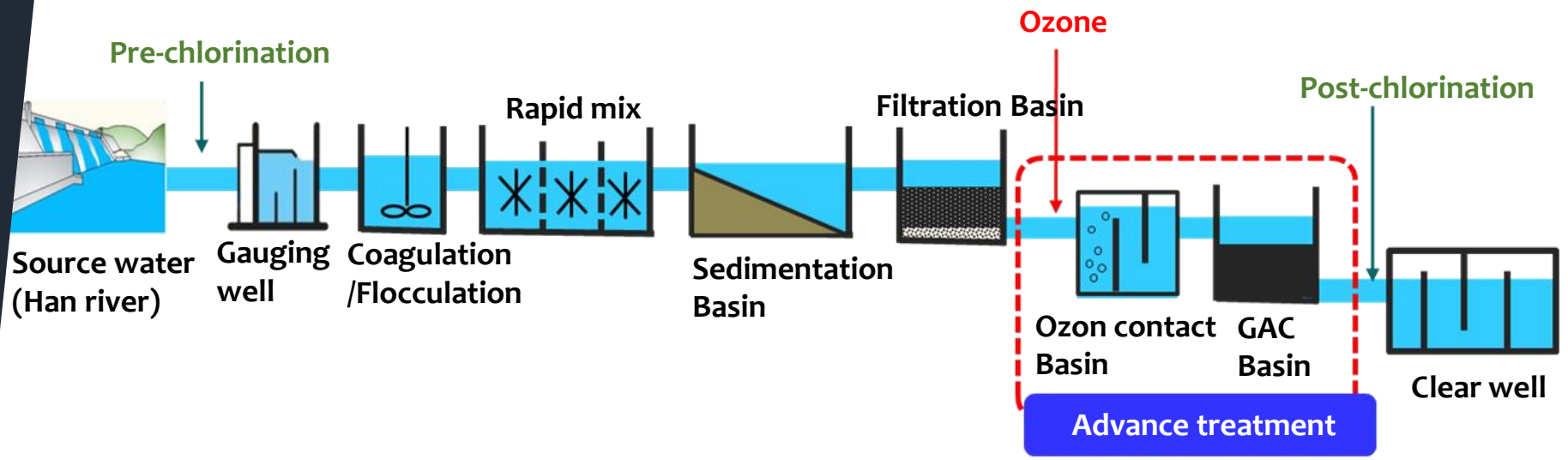
Supply

- Pipe network 13,587 km
- Reservoirs 101 (2.4 M m^3)
- Booster stations 211
- Water posts 2.2 M

Drinking Water Treatment Processes

Advanced WTP

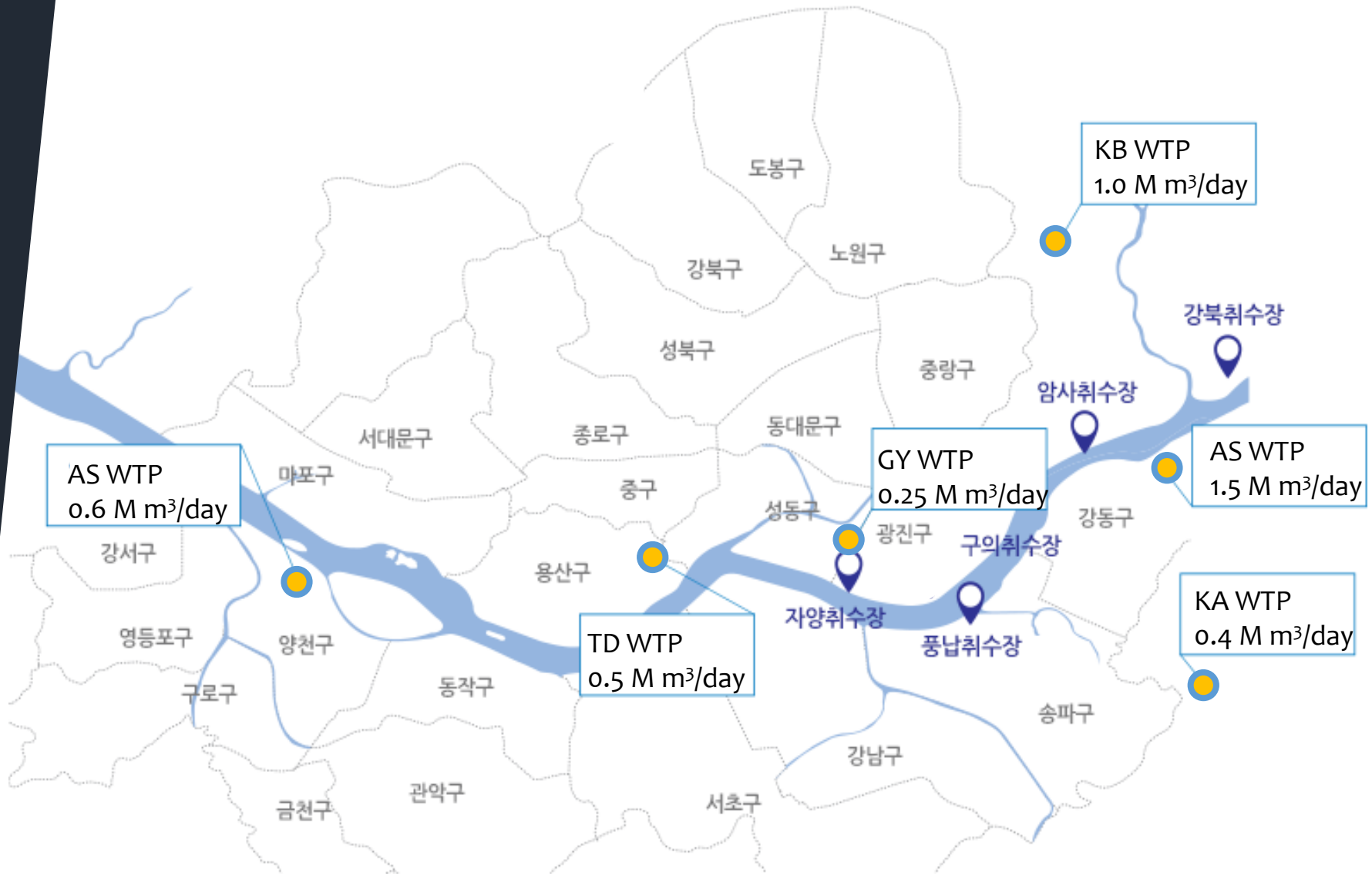
Conventional water treatment processes & Advanced water treatment processes



Source Water Intake Stations & WTP's

5 SWIS and 6 WTP's

The 3 source water intake stations out of 5 are located within the boundary of Seoul.
The 3 WTP's cover the northern part of Seoul while the other 3 for the southern part.



Drinking Water Treatment Plants

6 WTP's

There are 6 WTP's in Seoul. The 3 WTP's cover the northern part of Seoul while the other 3 for the southern part.

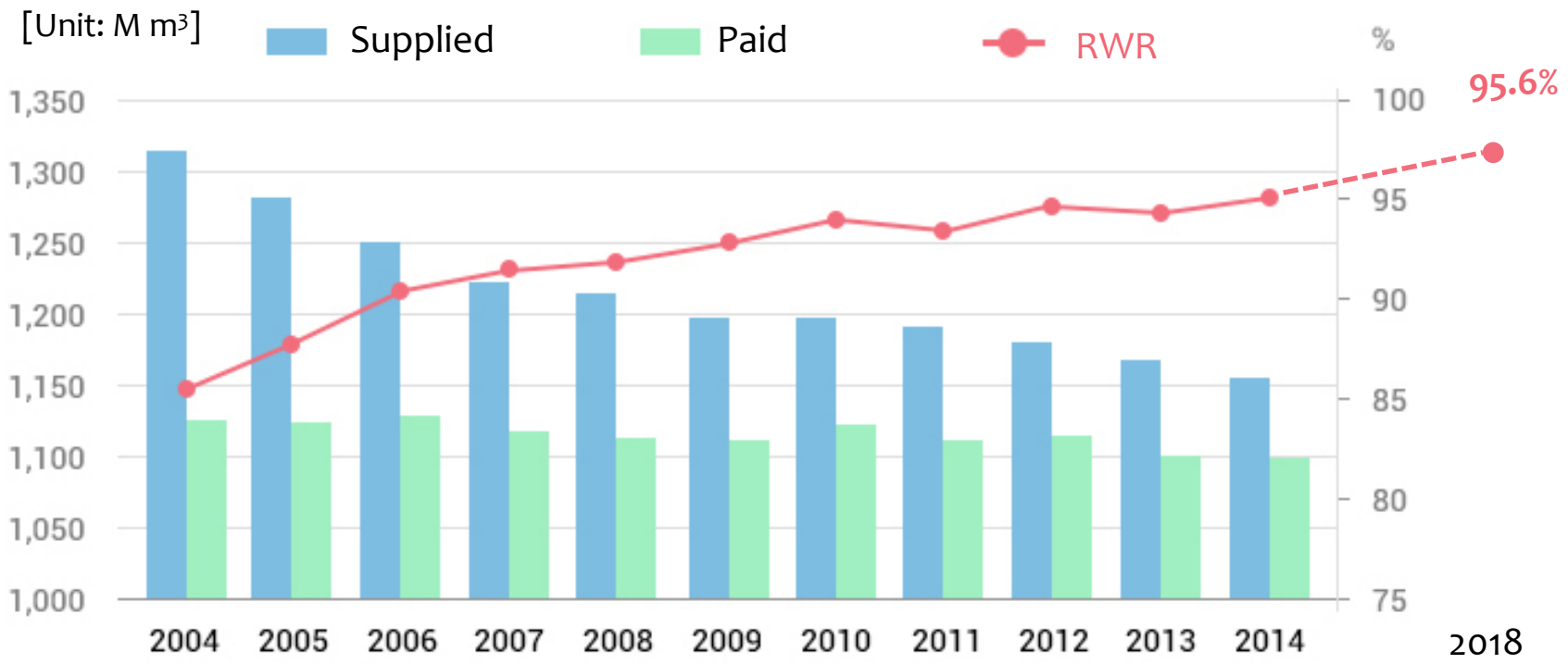
Revenue Water Ratio (RWR)

RWR 95.6% (as of 2018)

The RWR is the opposite concept of the NRW. RWR is widely used in Korea and Japan rather than NRW.

Revenue Water Ratio (RWR)

- The ratio of the volume of water paid by the customers to the volume of water supplied to the customers



Bureau of Water Cycle and Safety

BWCS

Wastewater treatment plants
Sewer system
Urban drainage system
Stream management

Organization

- 1 HQ (4 Bureaus)
- 1 Research Bureau
- 4 WWTP's
- 646 Staffs

(The local sewers are managed by the local autonomous government)

Budget: 1.1 B USD

Treatment Capacity

- Total treatment capacity 5.0 M m^3/day
- Average treatment 4.3 M m^3/day

Sewer system

- 10,616 km

Urban drainage system

- 16 Drainage Areas with 239 Unit Drainage Areas

Wastewater Treatment Plants

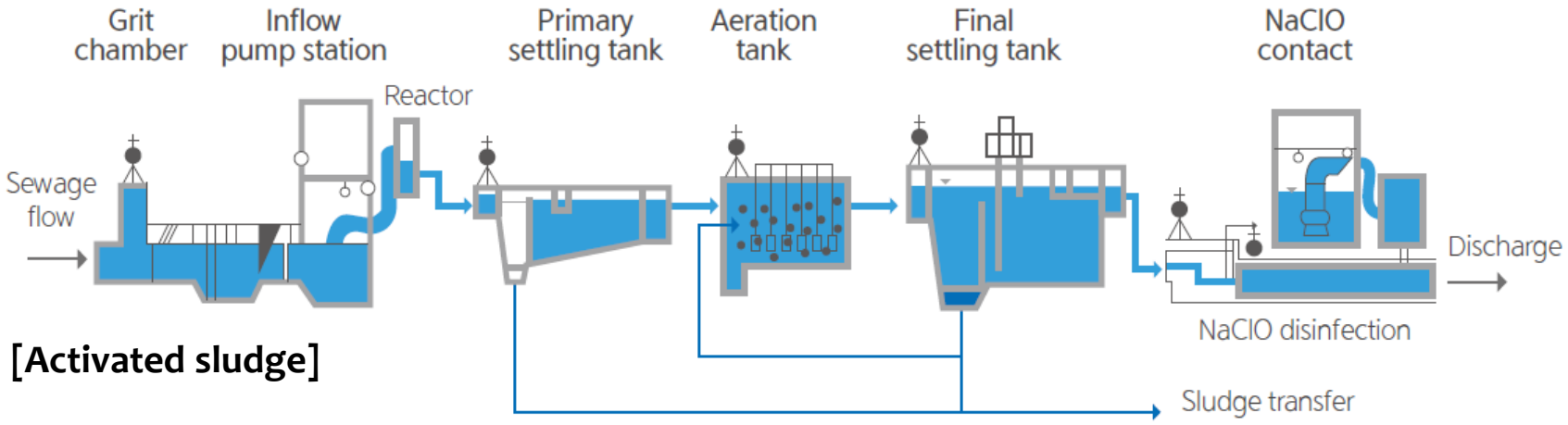
4 WWTP's

There are 4 WWTP's in Seoul, which has 12 M population including the commuters and tourists. Each WWTP is huge.

Wastewater Treatment Processes

Advanced WTP

Activated Sludge
A2O
MLE
BNR
Biomembrane



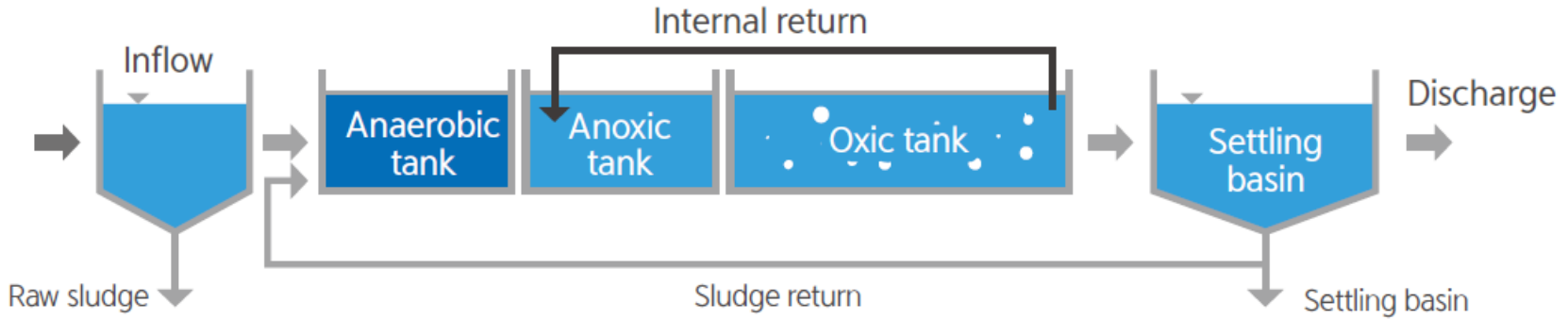
[Activated sludge]

WWTP [M m3/day]	Treatment Capacity	Treatment Process			
		A2O	MLE	4-S BNR	Biomembrane filtration
Joong Rang	1.59	0.46	0.88		0.25
Nan Ji	0.86		0.86		
Tan Chun	0.90		0.90		
Seo Nam	1.63		1.27	0.36	
Total	4.98	0.46	3.91	0.36	0.25
	100%	9%	79%	7%	5%

Wastewater Treatment Processes

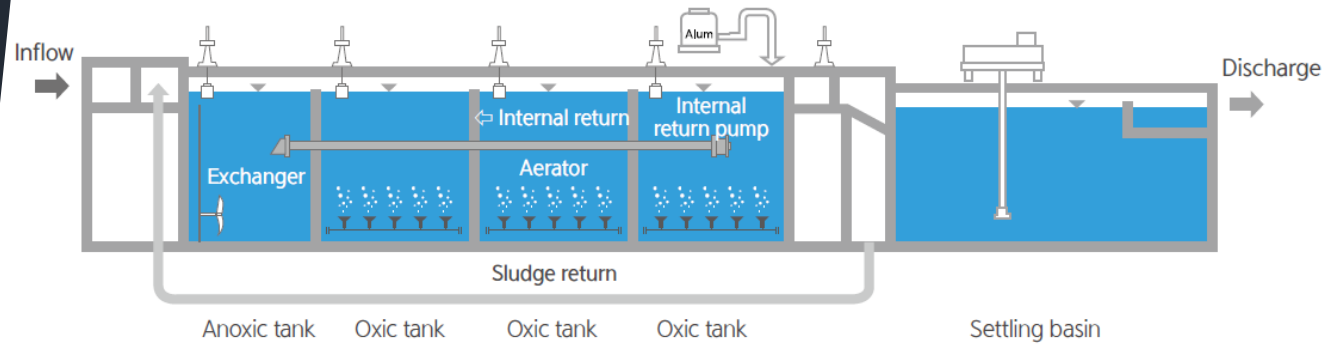
Advanced WTP

Activated Sludge
A2O
MLE
BNR
Biomembrane

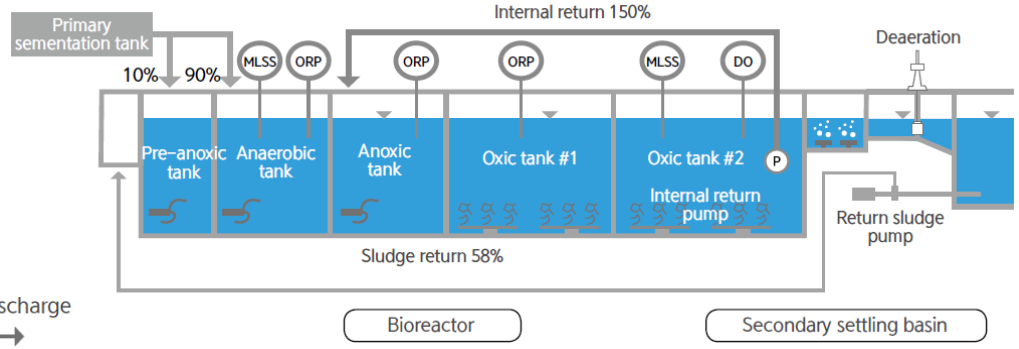


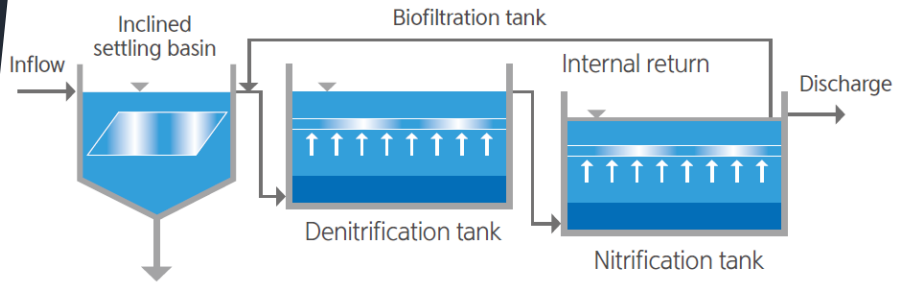
[A2O]

[MLE]



[4-Stage BNR]





[Biomembrane]

Wastewater Treatment Plants

4 WWTP's

There are 4 WWTP's in Seoul, which has 12 M population including the commuters and tourists. Each WWTP is huge.

Joong Rang WWTP
1.60 M m³/day

Nan Ji WWTP
0.86 M m³/day

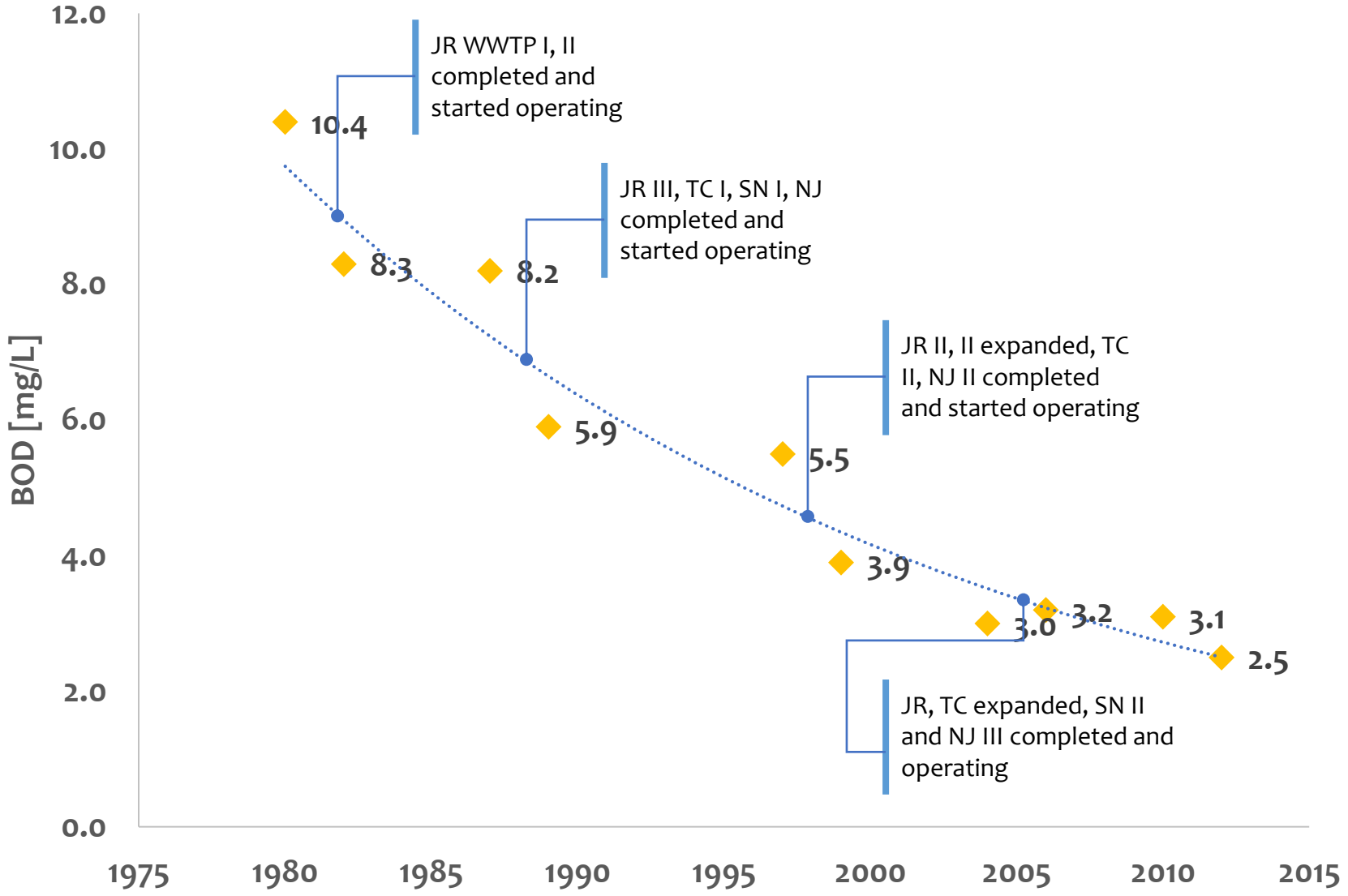
Tan Chun WWTP
0.90 M m³/day

Seo Nam WWTP
1.63 M m³/day

Water Quality of the Han river

BOD of the Han river

The river water quality was monitored at the mouth of the Han river.
The water quality seemed to be closely related with the capacity of wastewater treatment plants.



Urbanization

Impervious surface

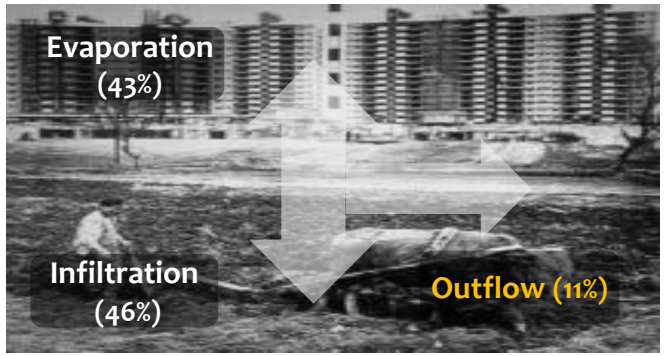
As the impervious surface in Seoul has increased from 7.8% in 1962 to 48.9% in 2015, the runoff of stormwater increased from 11% to 52%, which also increased the risk of urban flash flood.

Population of Seoul
Population increased by 4.1 times compared to 1960 (2.44 mil.)

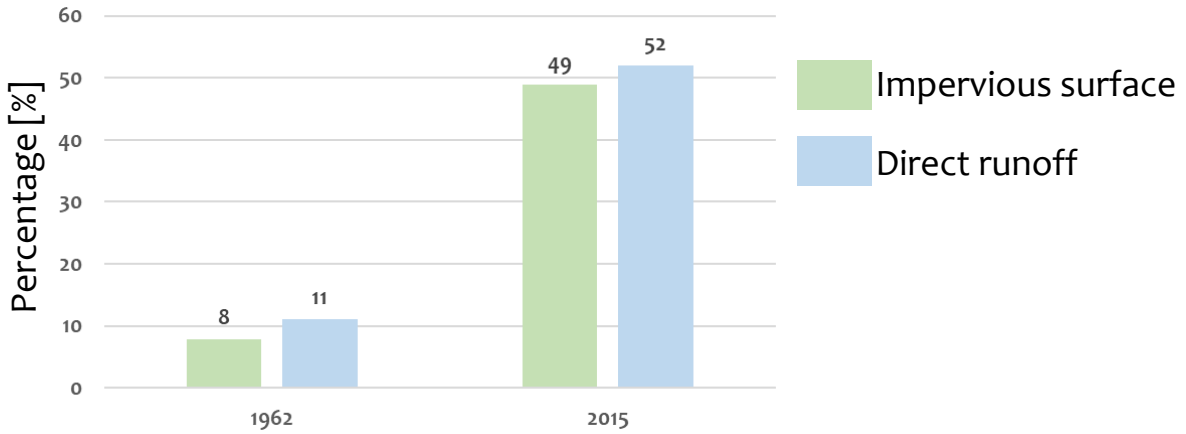
Houses in Seoul
About 0.44 mil.→ 3.78 mil. households

Land of Seoul
30% of city area re-developed

Lives of Seoul Citizens
Rapid increase in number of households due to nuclearization of families



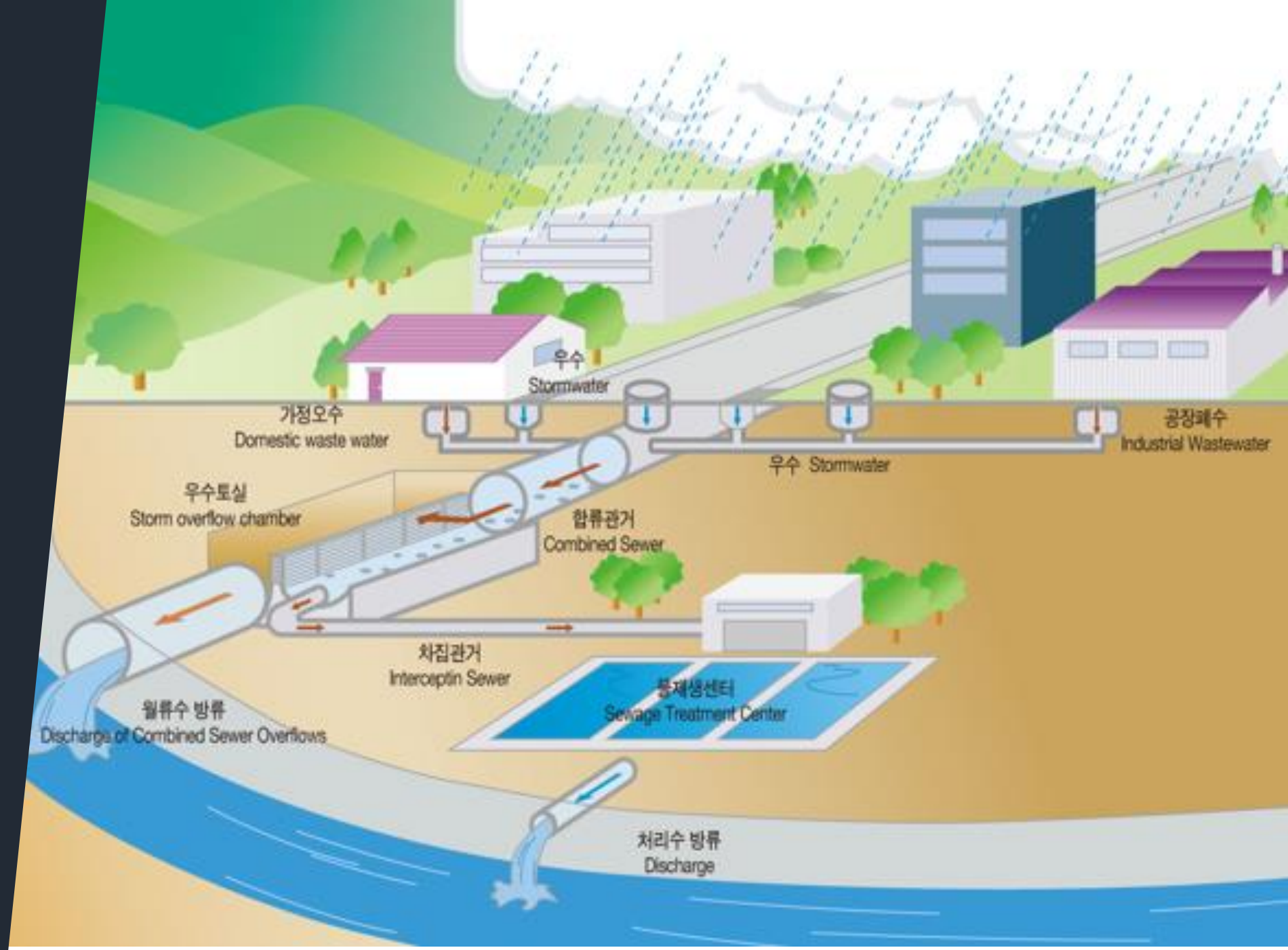
Urbanization



Sewer System

Combined & Separated

The 83% of the sewer system of Seoul is the combined sewer.



Seoul Water Institute

SWI

Analytical Lab
R&D
Planning & Strategies

- Organization
  - 2 Bureaus and 1 Center
  - 11 Departments
  - 91 Researchers and Staffs
- Budget: 5.9 M USD (excluding salaries of the staffs)
- Certified Lab
  - 6 national and international certifications including ‘drinking water quality analytical lab’
- Project
  - 76 Research projects
  - 20 Monitoring and investigation projects
- Plant & Instrument
  - 8 pilot plants
  - 711 analyzing instruments

Water Quality Monitoring

171 WQ Items

The institute monitors 171 water quality items for drinking water and 148 items for the source water

●	Source water 10
●	SWIS 5
●	Branches 10
●	N/S Han river 4
●	WTP 6

Clean & Safe Water

326 WQ Items

The number of water quality items to be monitored:
National standard 60
Seoul's guideline 171
Total WQ items including CEC's 326

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Challenges

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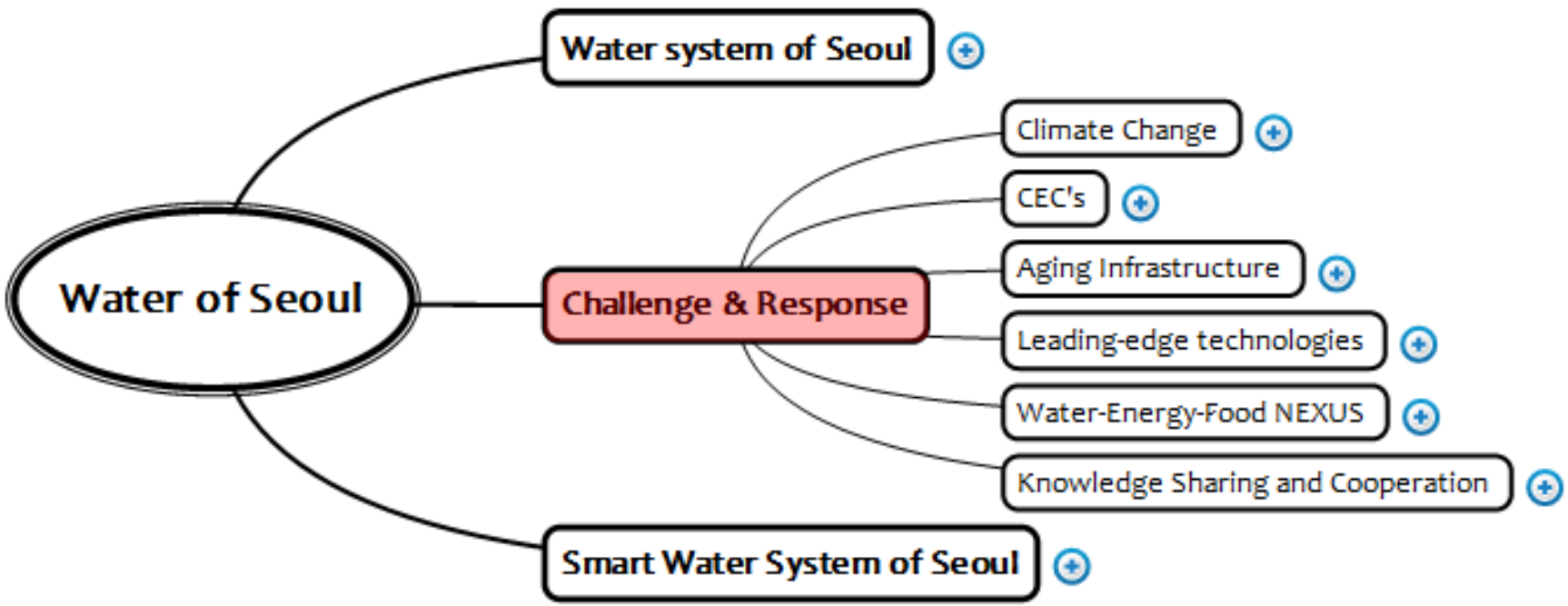
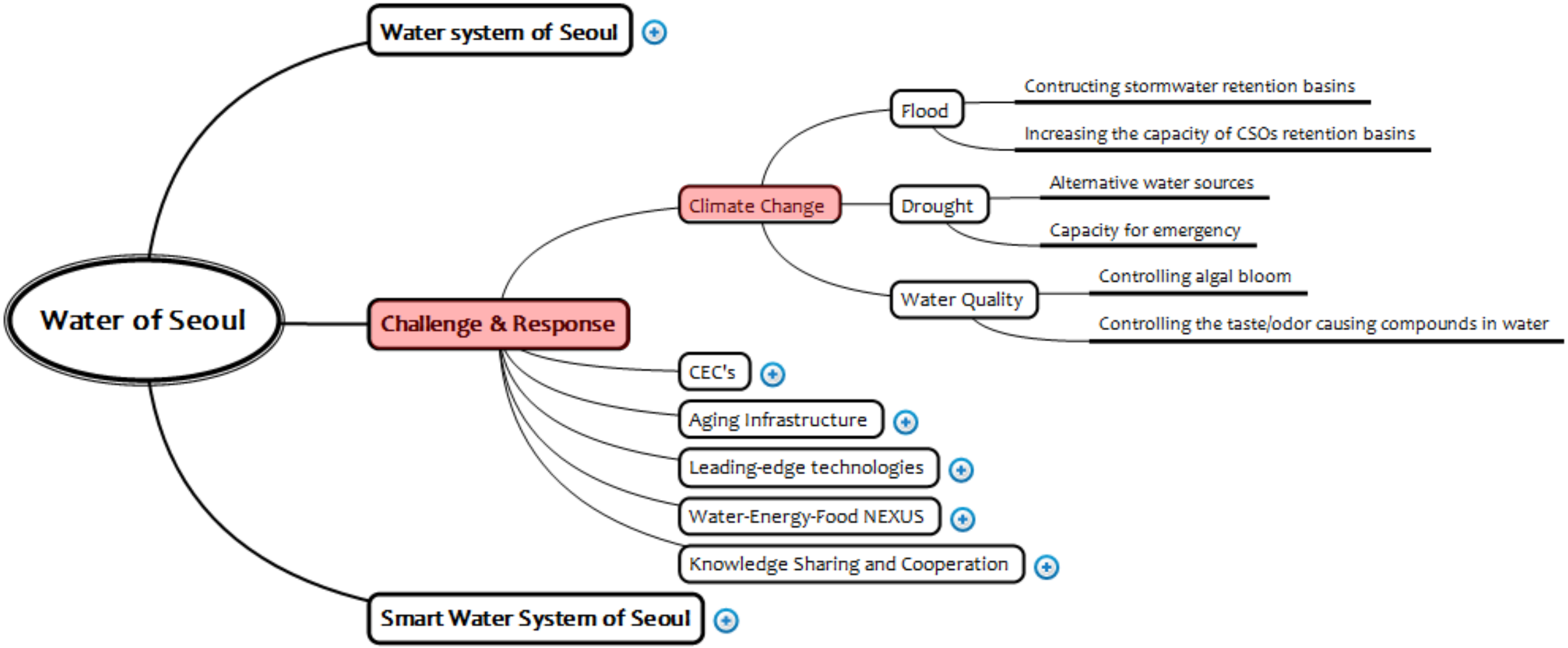


Challenge & Response

Arnold J. Toynbee

Civilizations arose in response to some set of challenges of extreme difficulty, when "creative minorities" devised solutions that reoriented their entire society.

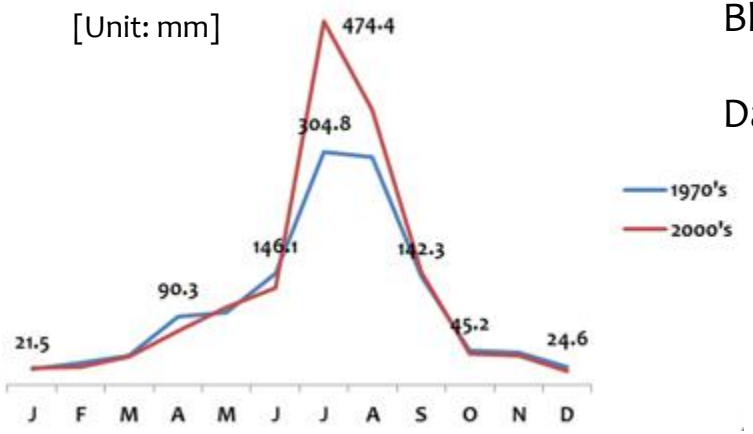
- Climate Change
- CEC's
- Aging Infrastructure
- Water-Energy-Food NEXUS
- Knowledge Sharing and Cooperation



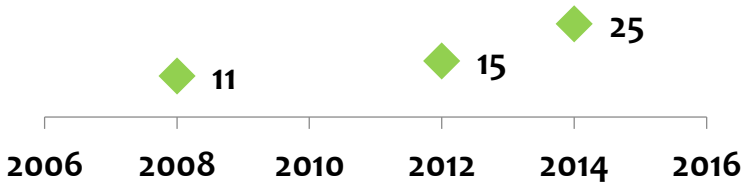
Climate Change

Adaptation/Mitigation

Flood
Drought
Water quality change



Blue green algae (Cynobacteria) [cells/mL]
Alert (10^3~) → Warning (10^4~) → HAB (10^6~)
Days of warning [days]:
11 (2008) → 15 (2012) → 25 (2014) → 89 (2015)



Flood

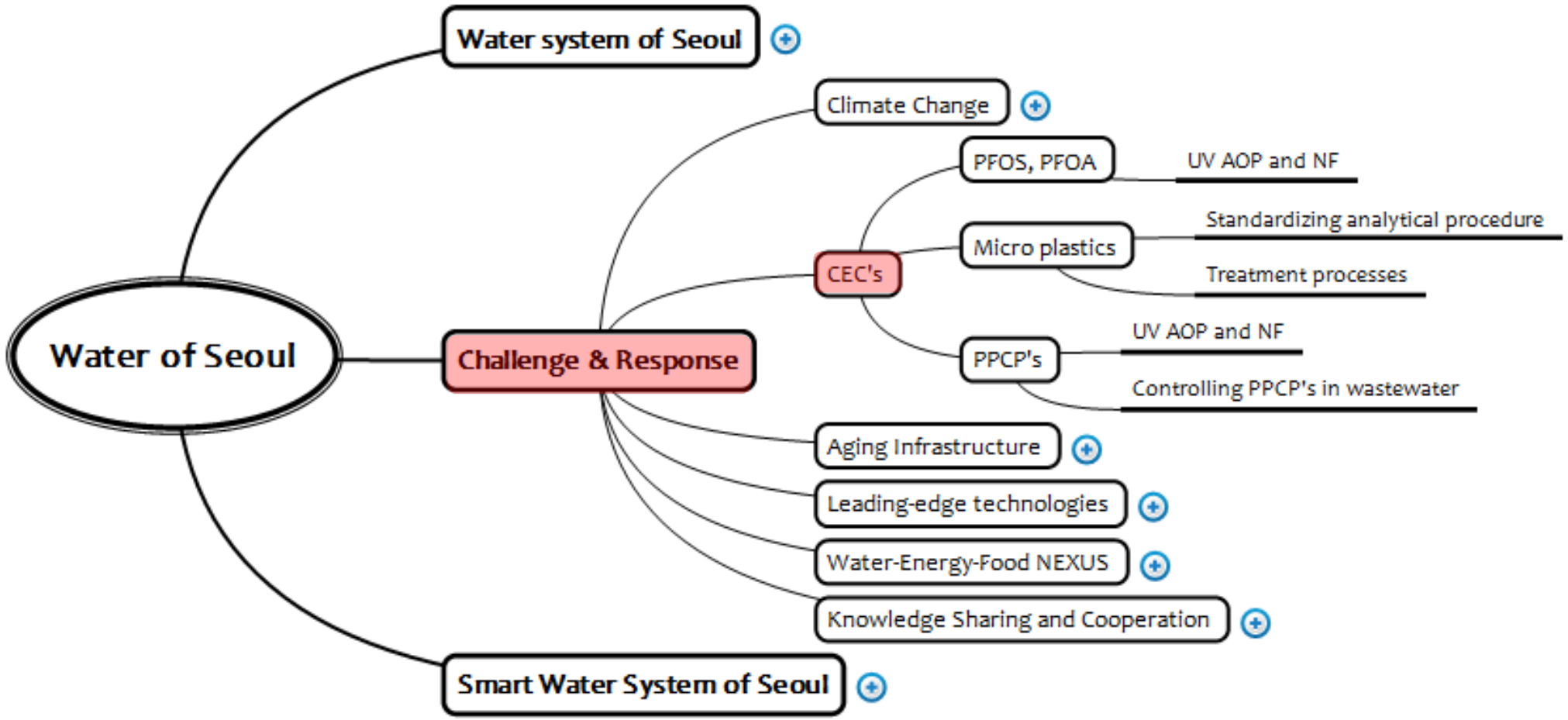
- Stormwater retention basin: 17 (103,564 m^3) → 26 basins
- CSOs retention basin: 2 (11,000 m^3) → 11 basins (361,000 m^3)

Drought

- Alternative water sources
- Water supply capacity for emergency

Water Quality Changes

- Algal bloom
- Taste/odor causing compounds (2-MIB and Geosmin) control

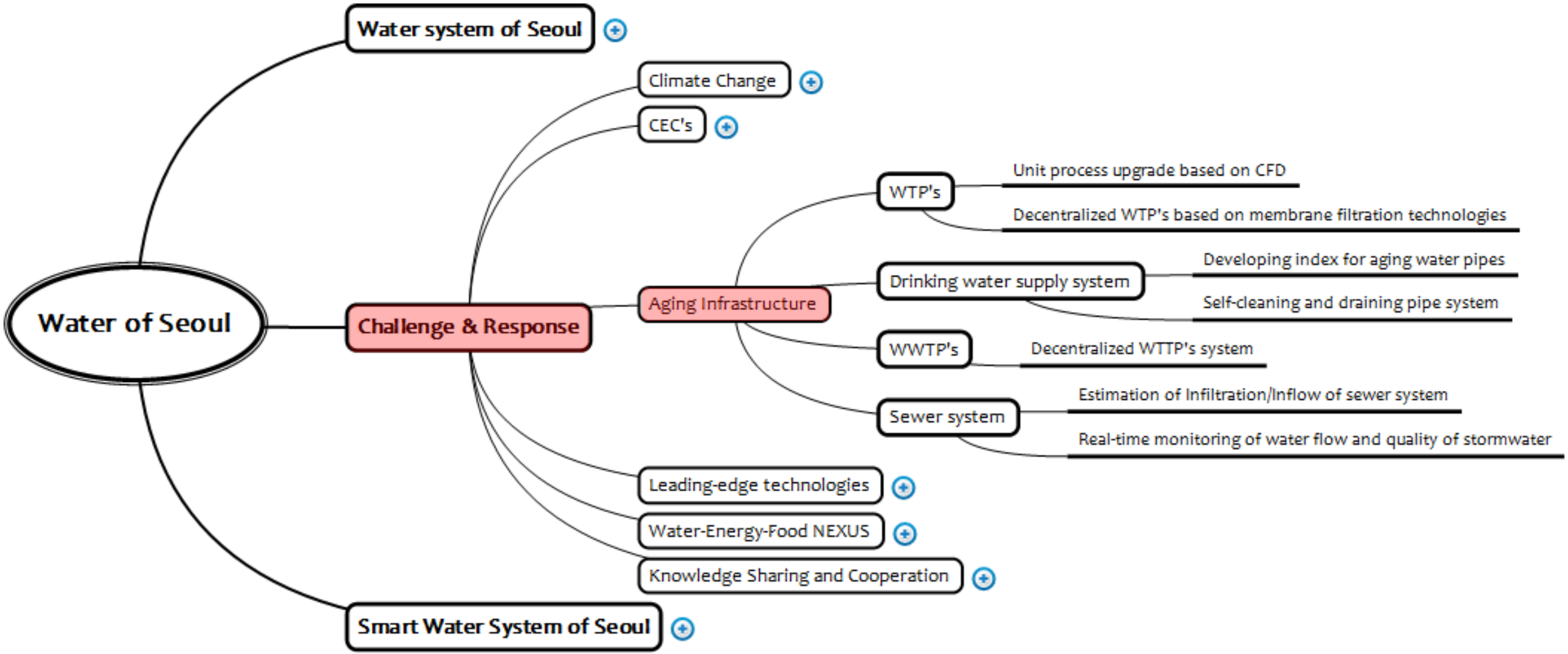


Compounds of Emerging Concern

CEC's

PFC
Microplastics
PPCP's

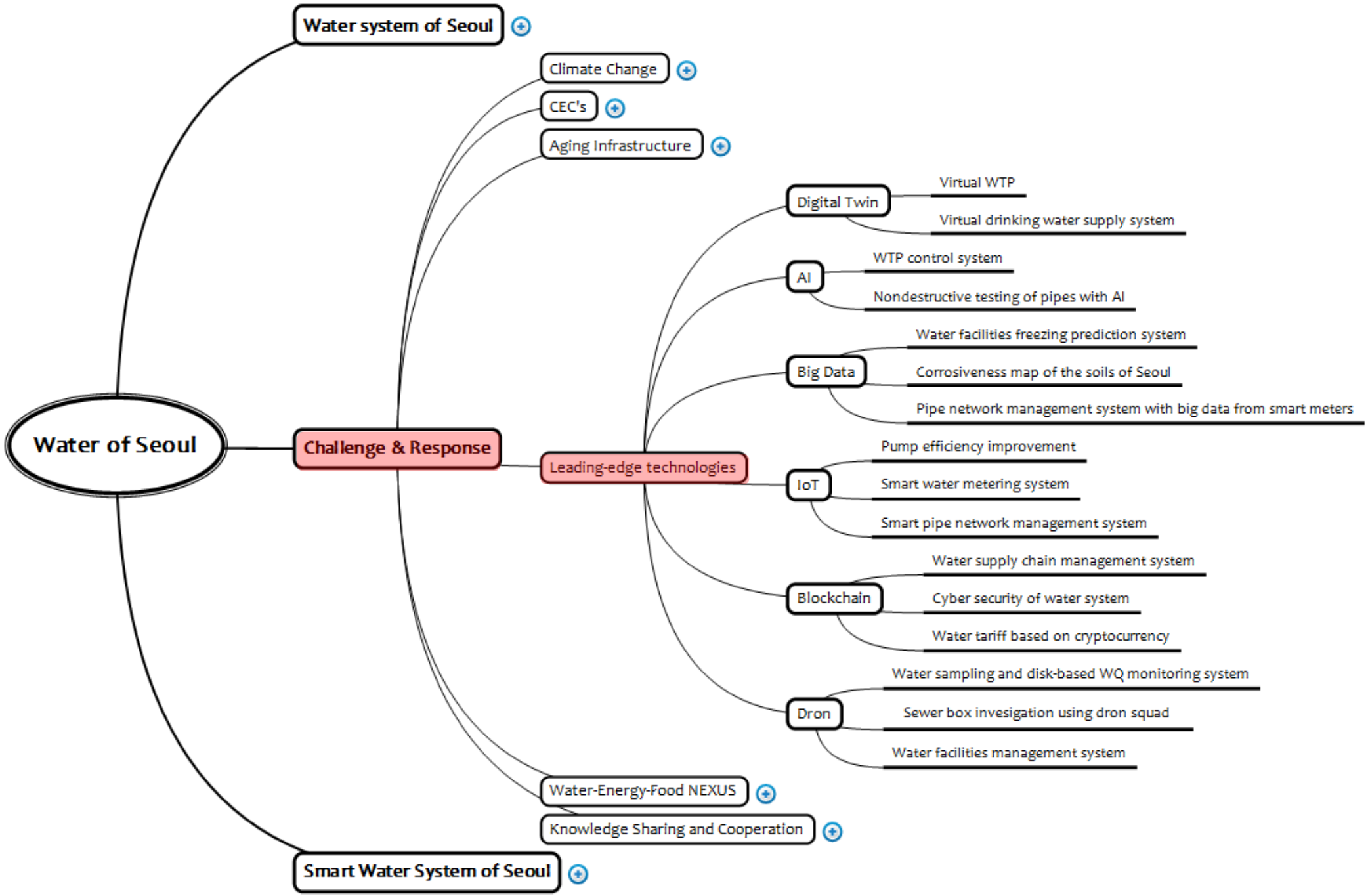
- Perfluorinated Chemicals (PFOA, PFOS)
  - UV AOP and NF
- Microplastics
  - Standard analytical methods
  - Treatment processes
- PPCP's
  - UV AOP and NF
  - Control PPCP's in wastewater

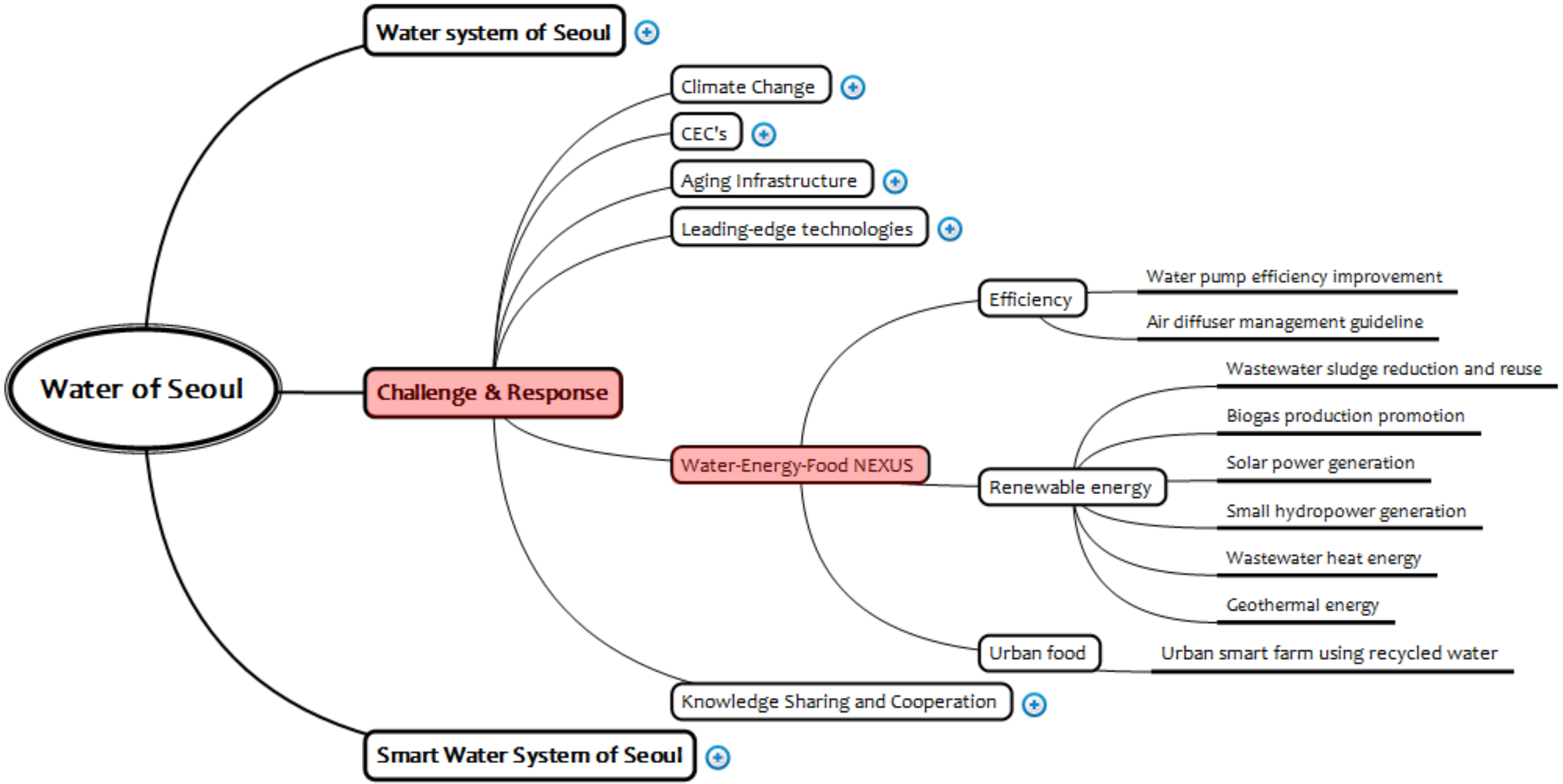


Aging Infrastructure

Renovation

- WTP's
  - Unit process renovation
  - Decentralized WTP's using membrane filtration
- Drinking Water Supply System
  - Index for aging water pipes replacement
  - Self-cleaning and draining system
- WWTP's
  - Unit process renovation
  - Decentralized WWTP's
- Sewer System
  - Infiltration/Inflow of sewer system
  - Water flow and quality monitoring





Water-Energy-Food NEXUS

Energy & Resources

Efficiency of system
Renewable energy production
Urban food supply system

Efficiency of System

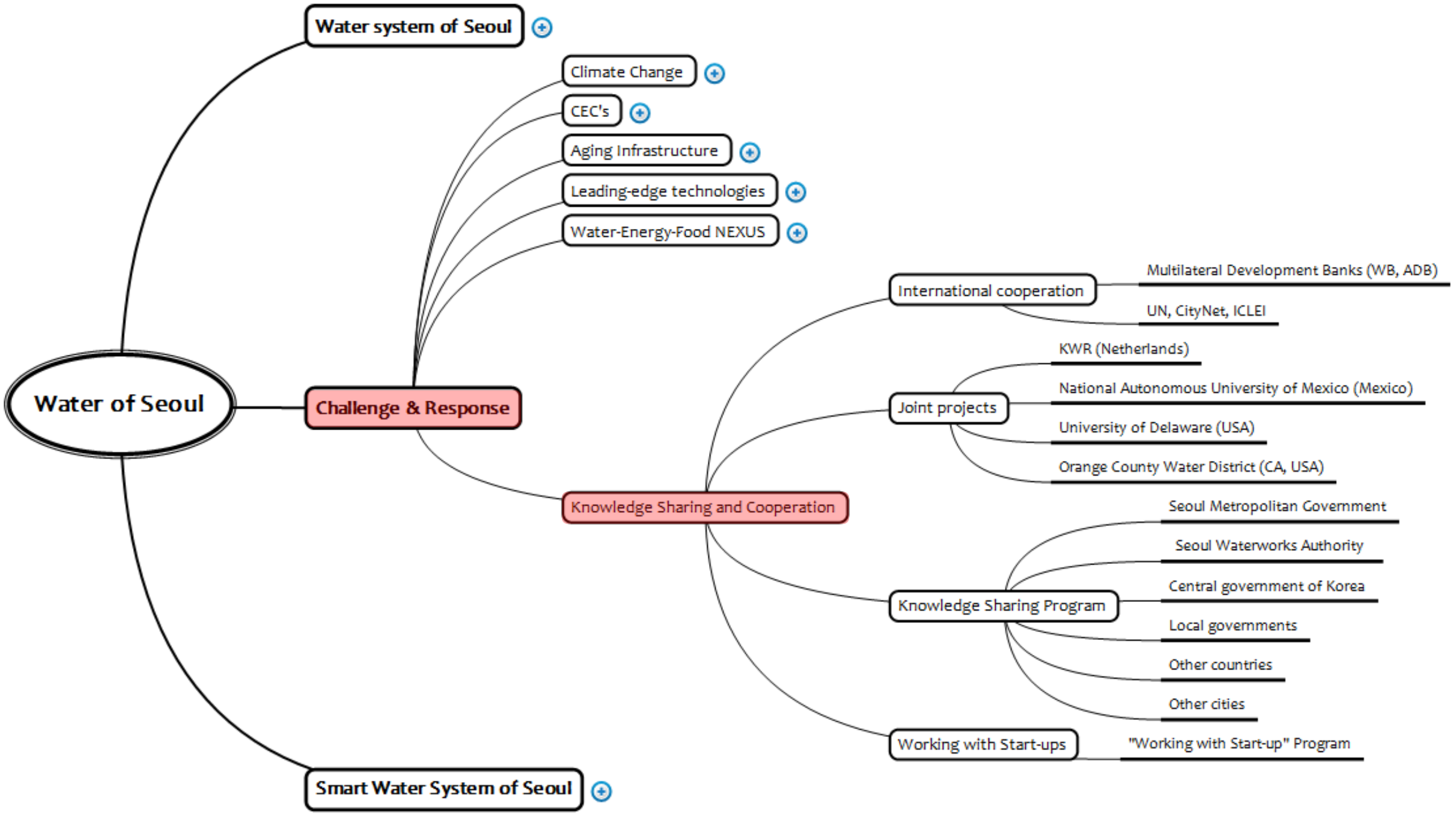
- Water pump efficiency improvement
- Air diffuser management guideline

Renewable Energy Production

- Wastewater sludge reduction and reuse
- Biogas production, solar power generation, small hydropower generation, Wastewater heat energy, Geothermal energy

Urban Food Supply System

- Urban smart farm using recycled water



Knowledge Sharing and Cooperation

W4A, Water for All

International cooperation
Joint projects
Knowledge sharing programs
Working with Start-ups

International Cooperation

- Multilateral Development Banks: World Bank, ADB, AIIB
- UN, ICLEI, CityNet, WeGo

Joint Projects

- KWR (Netherlands), UNAM (Mexico), U of Delaware (USA), Orange County Water District (USA), Tokyo (Japan)

Knowledge Sharing Programs

- SMG, SWA, the central and local governments of Korea, UOS, HRDC of Seoul, other countries and cities

“Working with Startups” Program

- Technical consulting
- Joint feasibility study at the ‘Living Lab’ of Seoul

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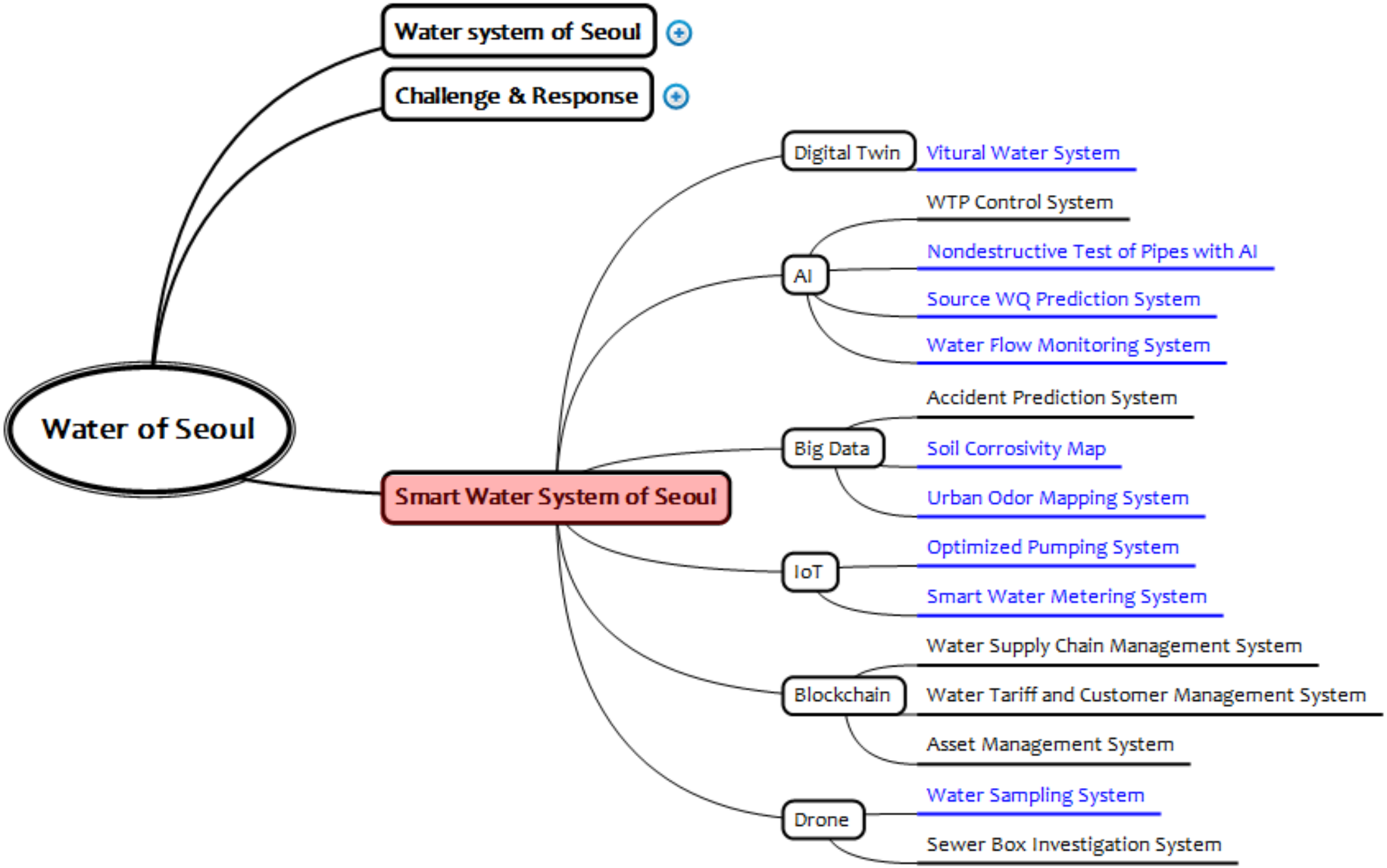


R&D for Smart Water System

The 4th IR Technologies

Digital Twin
AI
Big Data
IoT
Blockchain
Drone

Digital Twin

- Virtual WTP and drinking water supply system

Artificial Intelligence

- WTP control system
- Nondestructive test of pipes with AI
- Source water quality prediction system
- Water flow monitoring system

Joint project with the innovative startup's competition by Kwater and Seoul Water Institute

Big Data

- Accident prediction system
- Soil corrosivity map of Seoul
- Urban odor mapping system

IoT

- Optimized pumping system
- Smart water metering system

R&D for Smart Water System

The 4th IR Technologies

Digital Twin
AI
Big Data
IoT
Blockchain
Drone

Blockchain

NAUM (National Autonomous University of Mexico), University of Delaware

- Water supply chain management
- Water tariff and customer management system
- Asset management system

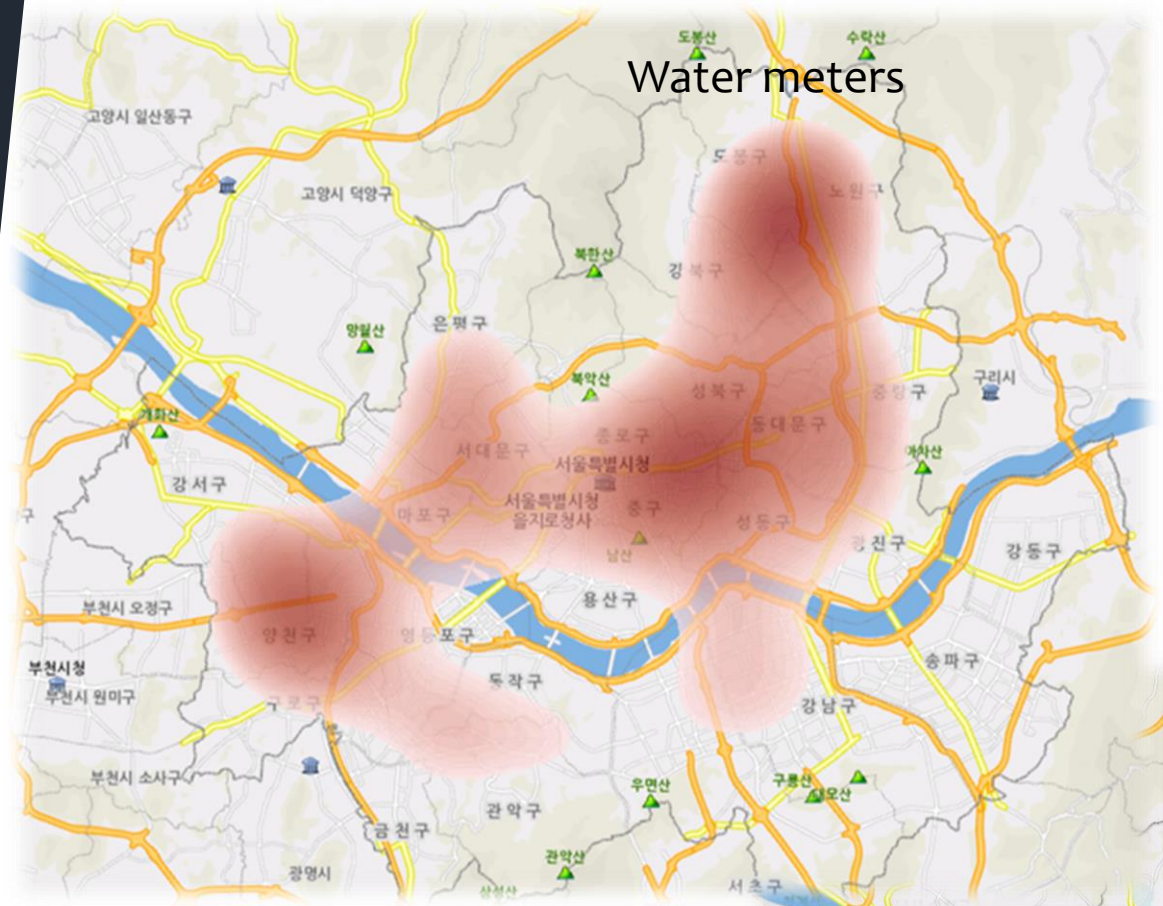
Unmanned Aerial Vehicle (Drone)

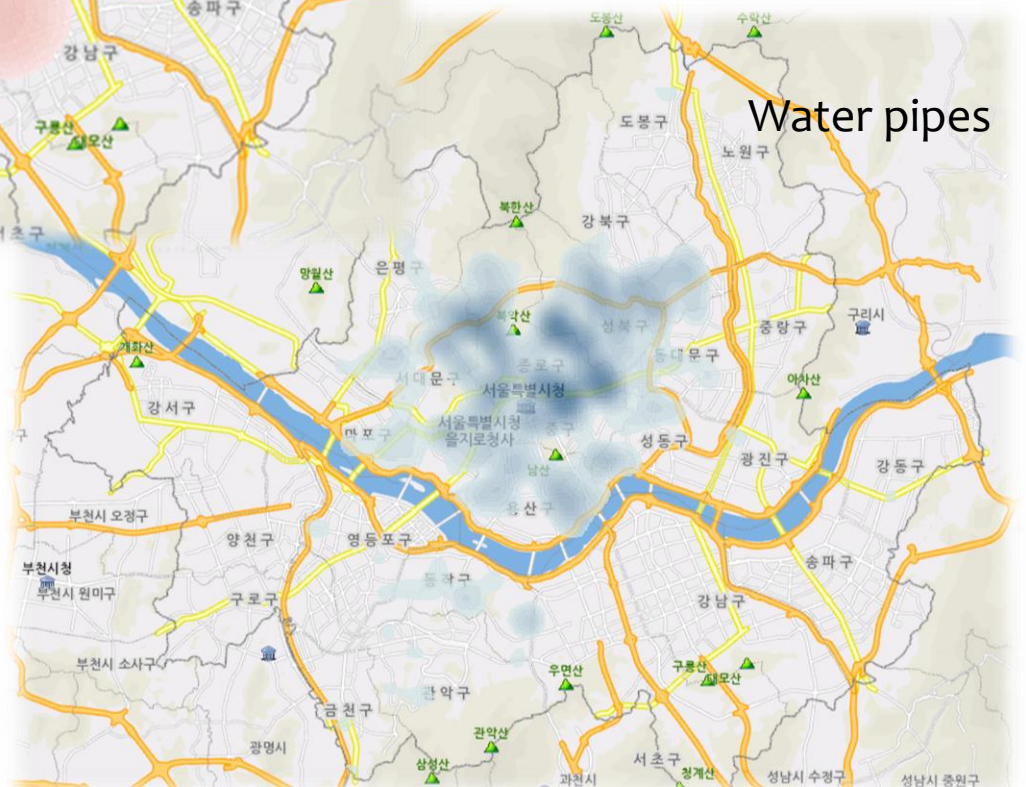
- Water sampling system [Project: Innovation with startup's]
- Sewer box investigation system

Accident Prediction System

Freezing water meter

The air temperature of Seoul in winter time goes down to -20 degrees Celsius.



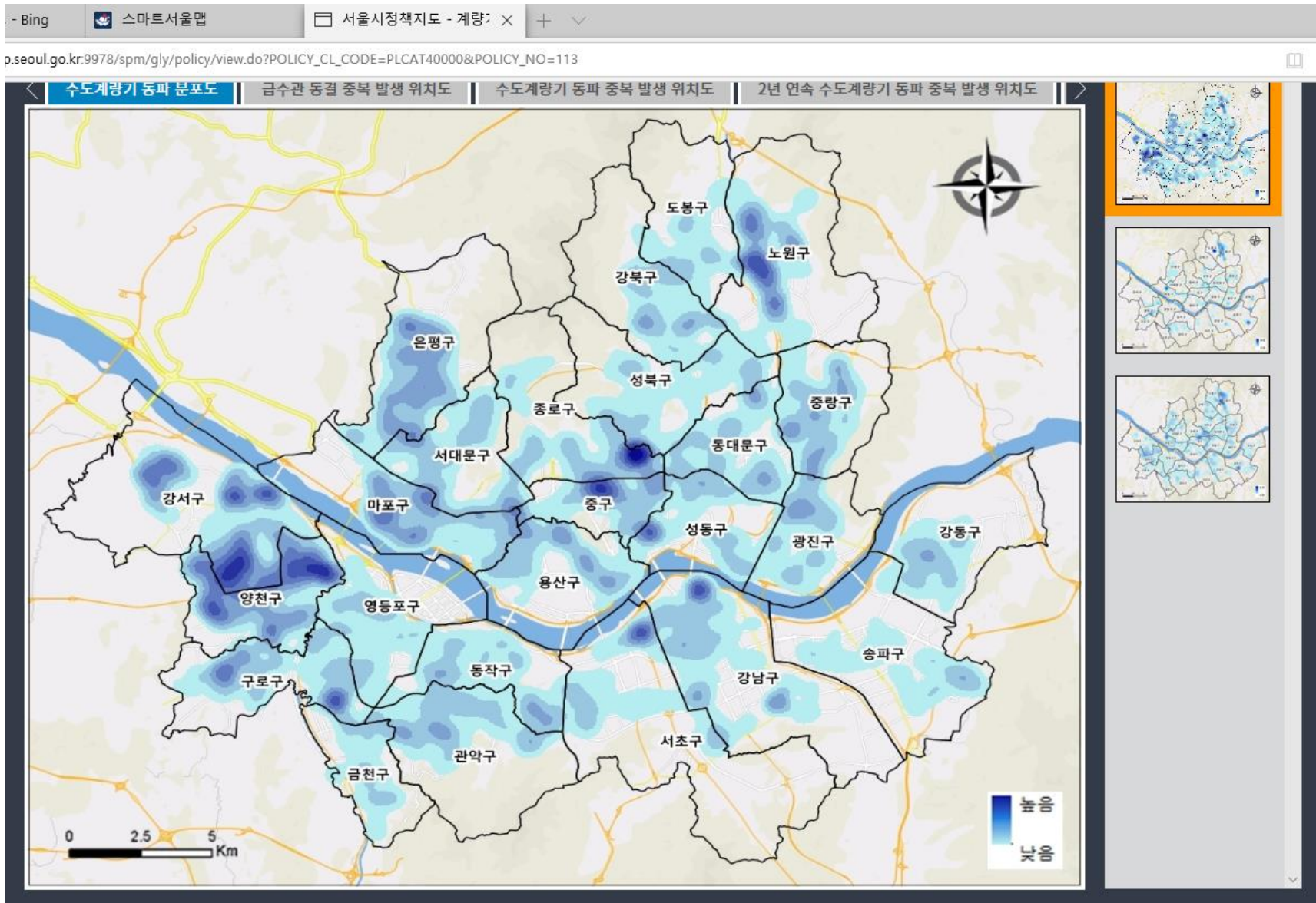


Smart Seoul Map : Water meter free from freezing

Mapping system based on Big Data

The purpose of the mapping system is to predict accidents

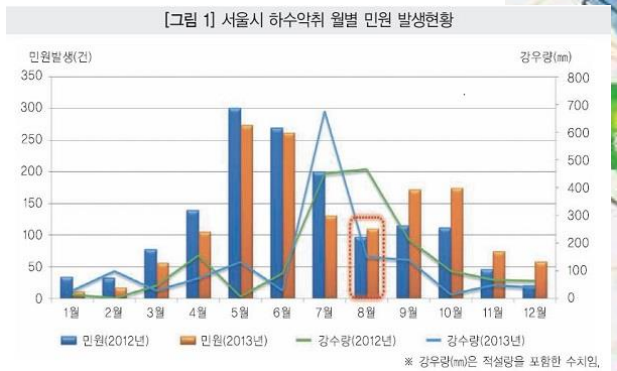
http://map.seoul.go.kr/smgis/webs/main/main.do

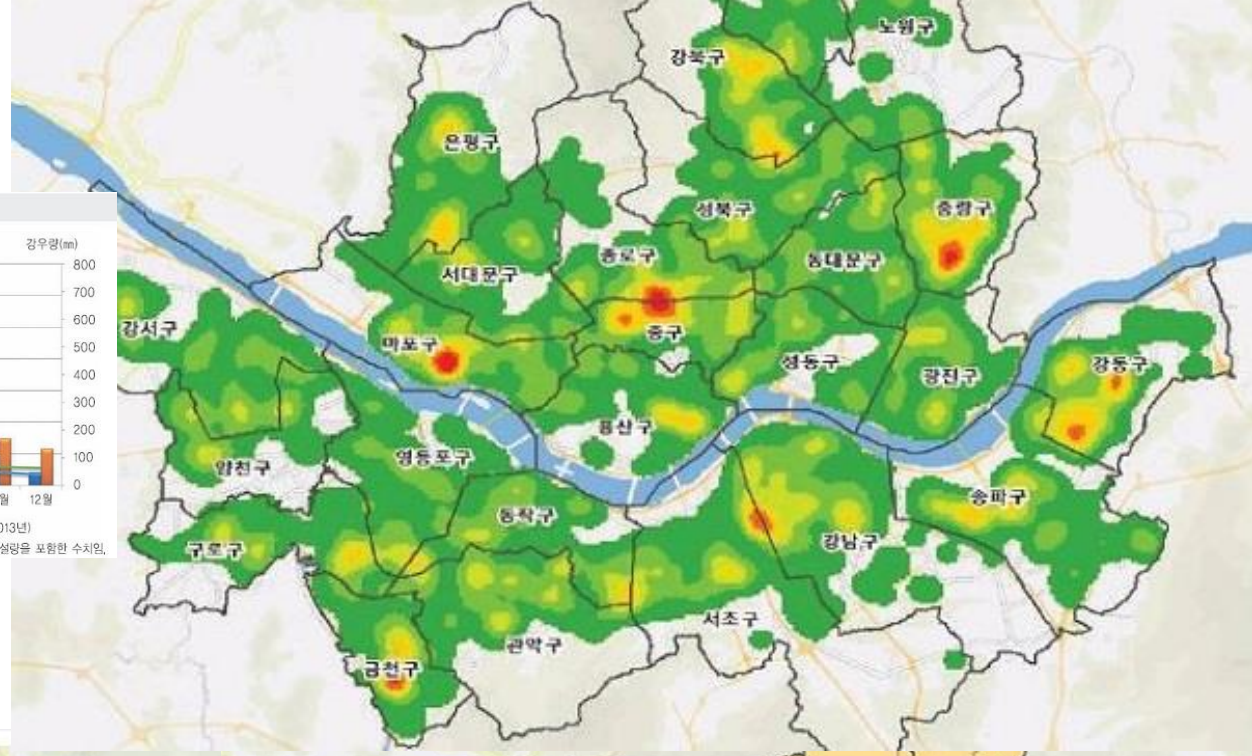


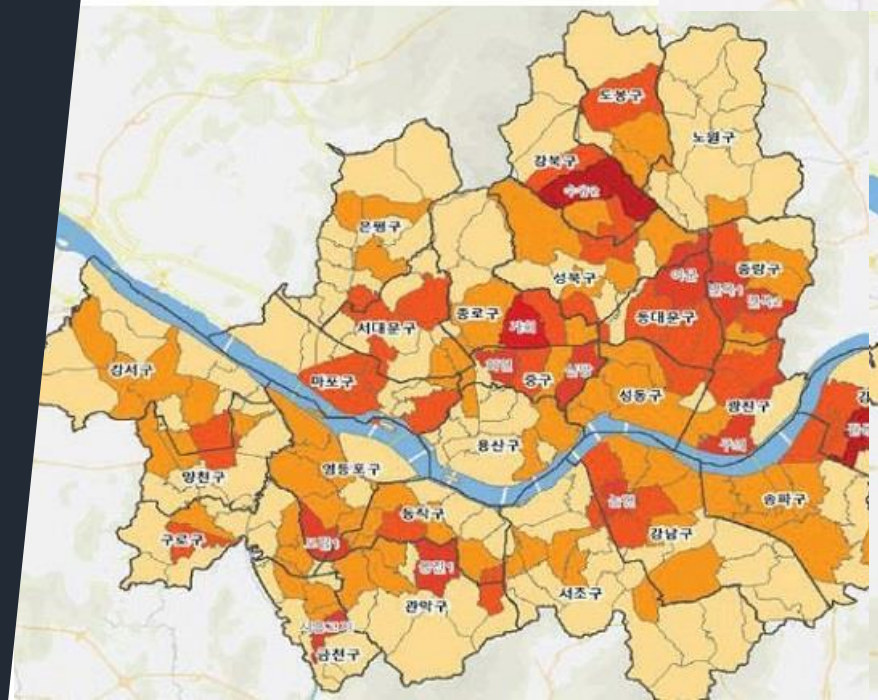
Urban Odor Mapping System

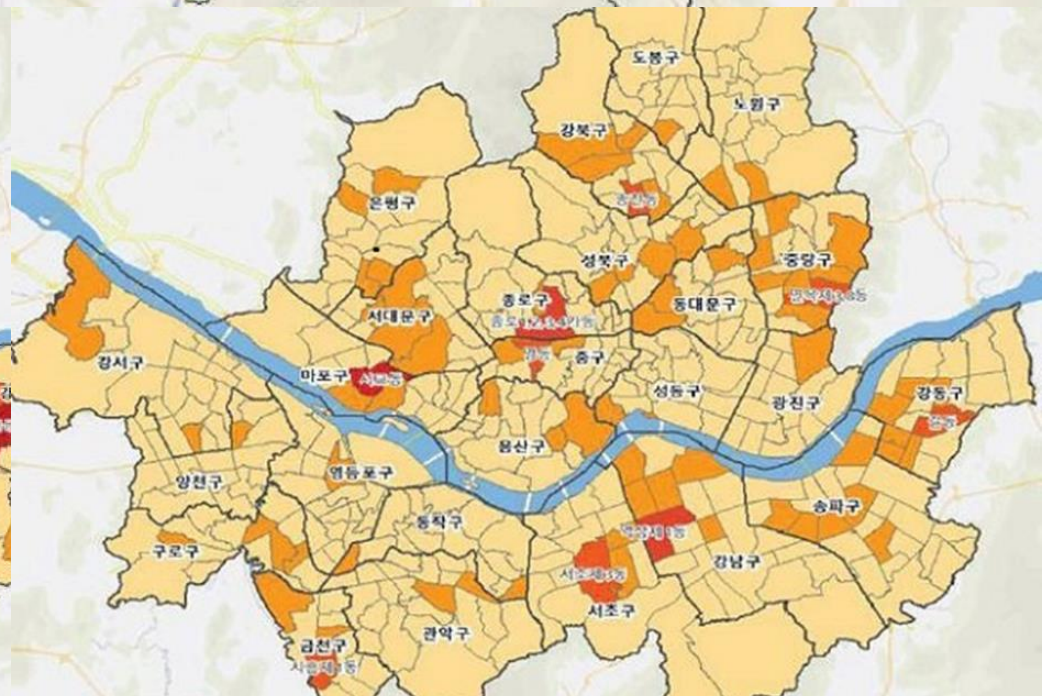
Urban odor control

The city can decide which area has the priority in investment and management for urban odor control









Pump Optimization System

Efficient pump operation

95% of the total energy for the water system of Seoul is for pumping

IoT and Pump Efficiency Improvement

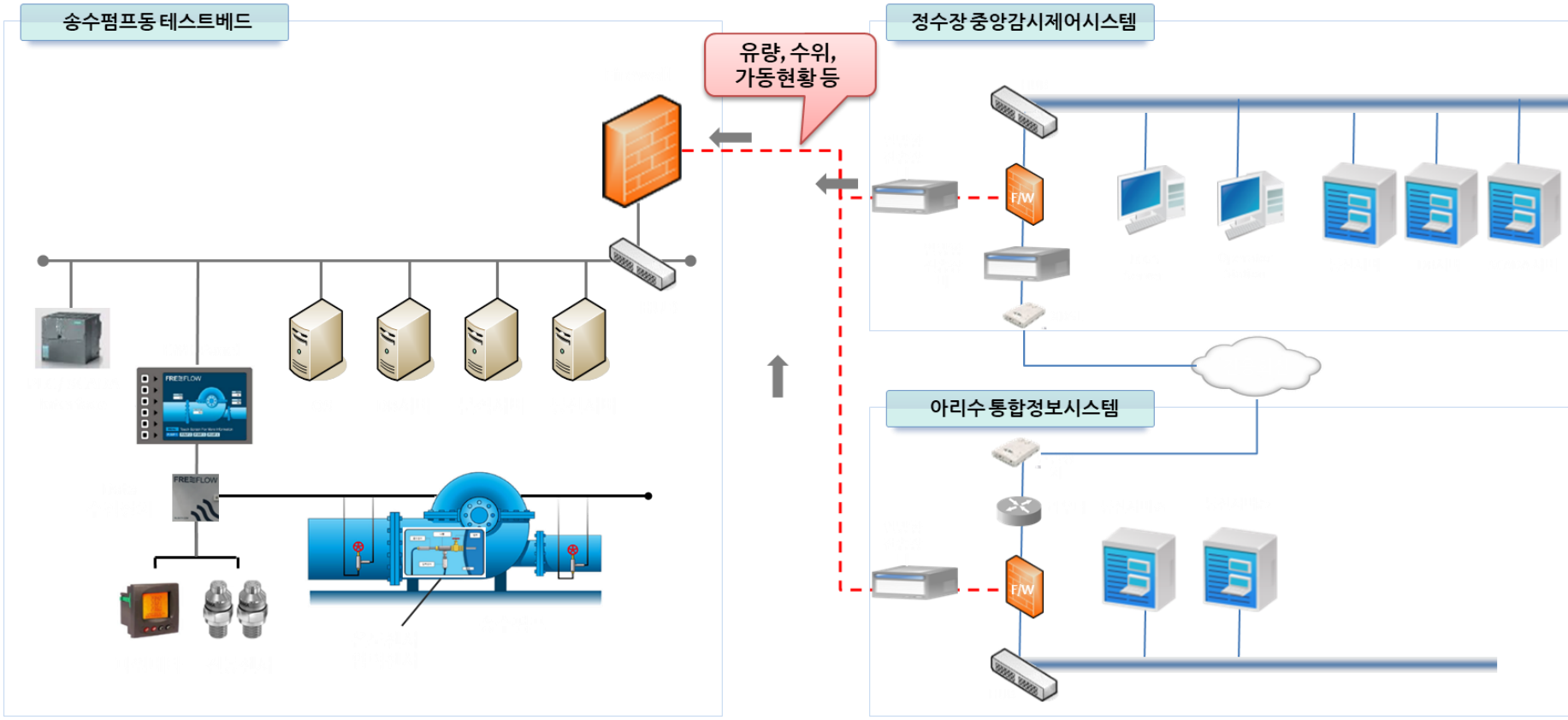
IoT, Big Data, AI

According to the calculation, about 5% of the total energy for pumping system can be saved with the IoT based optimized pumping system

Pump Optimization System

based on IoT technology

Test bed for the Pumping System



IoT and Pump Efficiency Improvement

Sensor network

Temperature
Pressure
Vibration

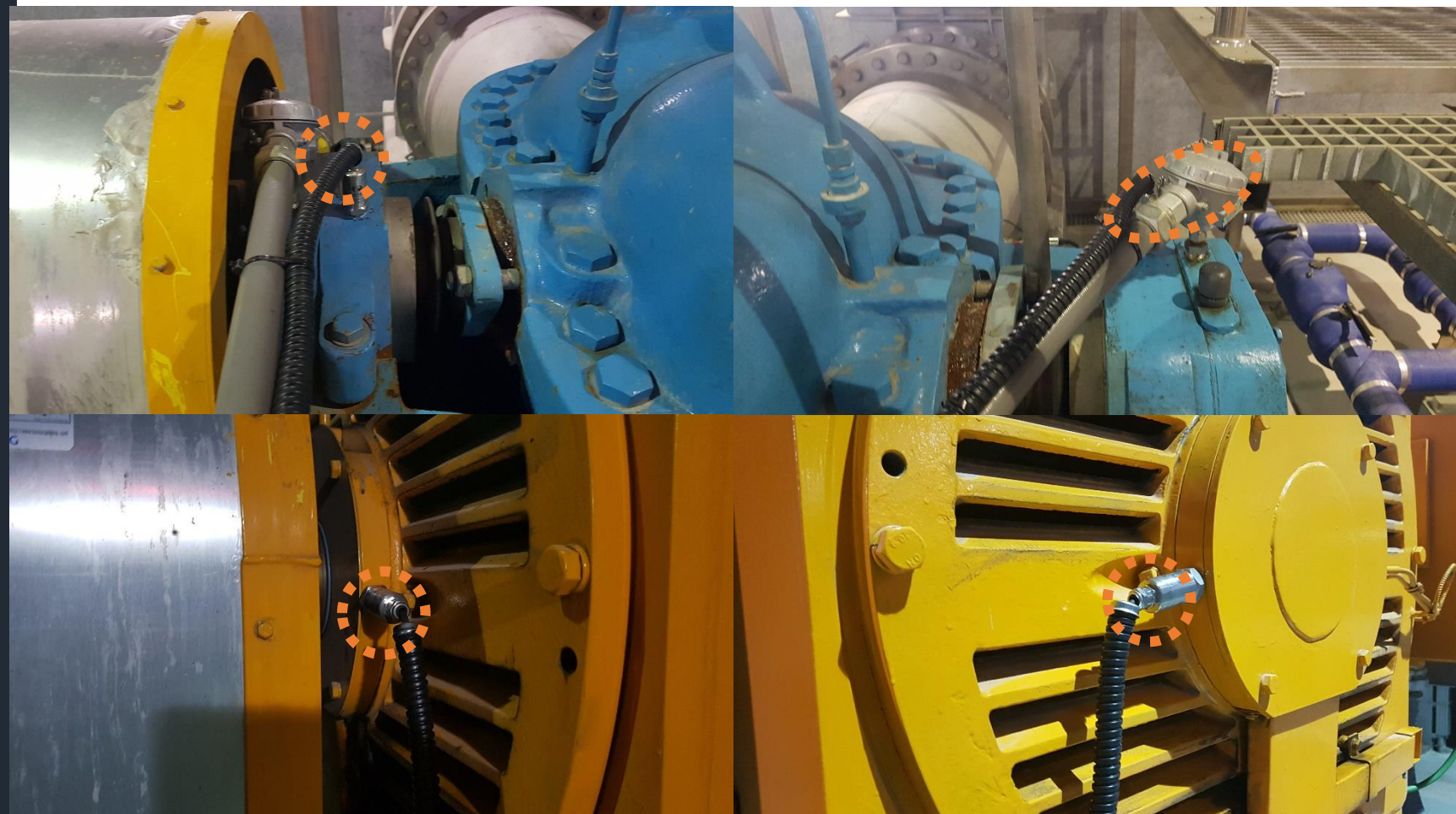
Temperature and Pressure Sensors

IoT and Pump Efficiency Improvement

Sensor network

Temperature
Pressure
Vibration

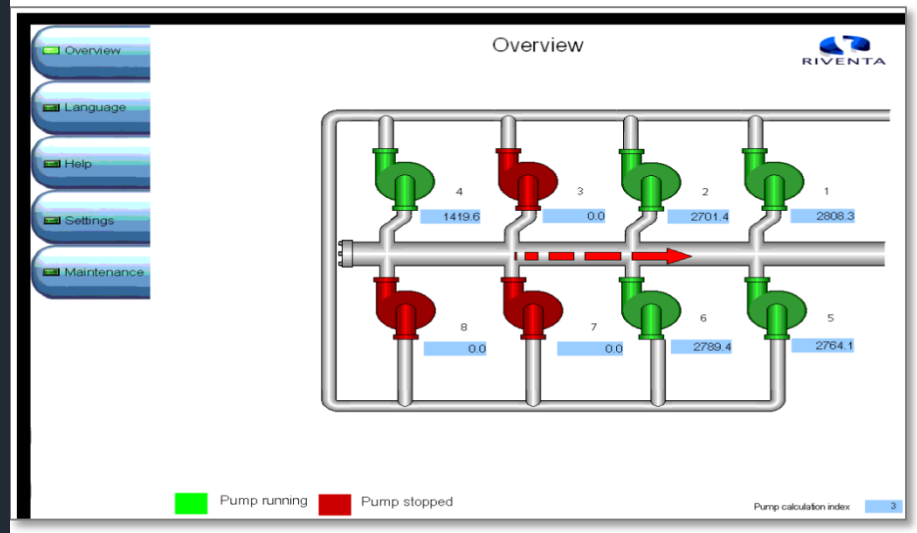
Motion (Vibration) Sensor



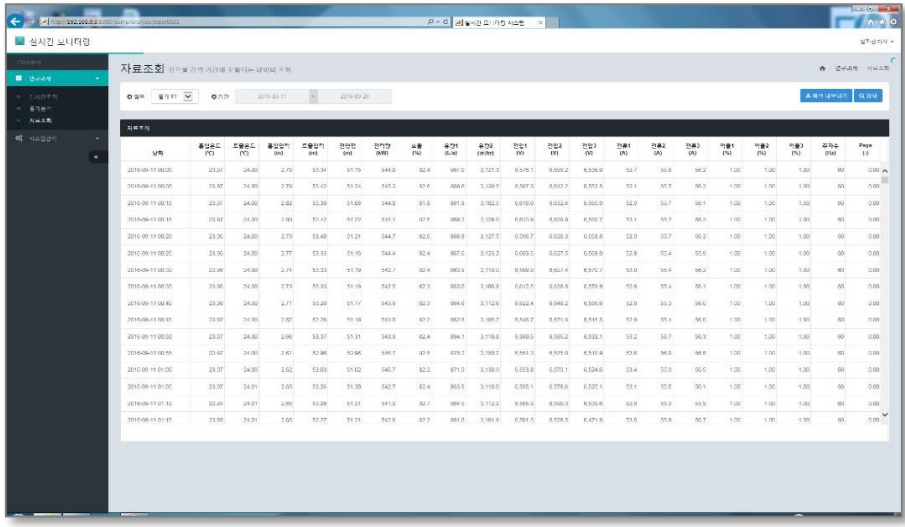
IoT and Pump Efficiency Improvement

Analytic System

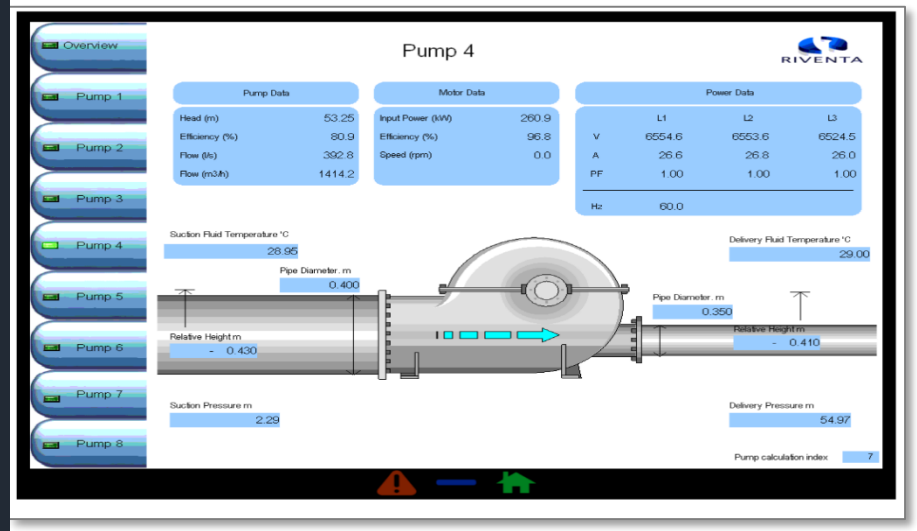
Water level at reservoir
Combination of pumps



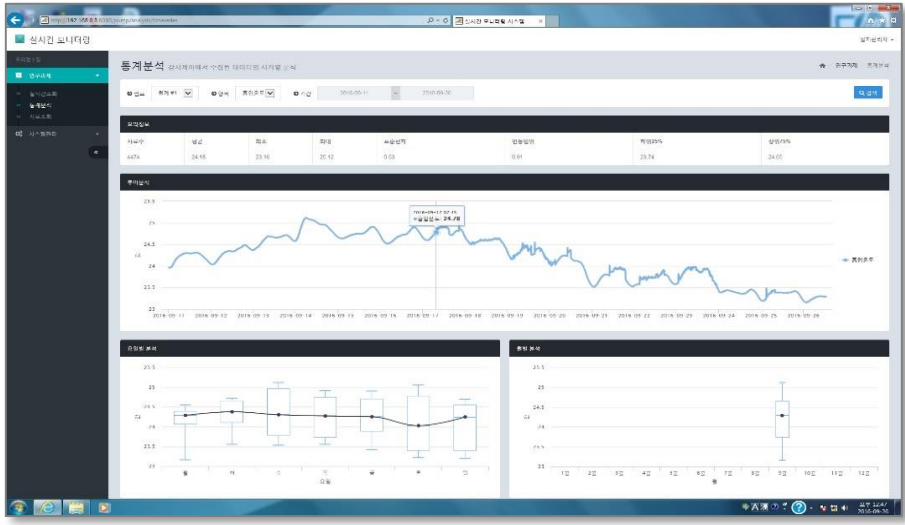
Pumps in Operation



Real-time Data Monitoring

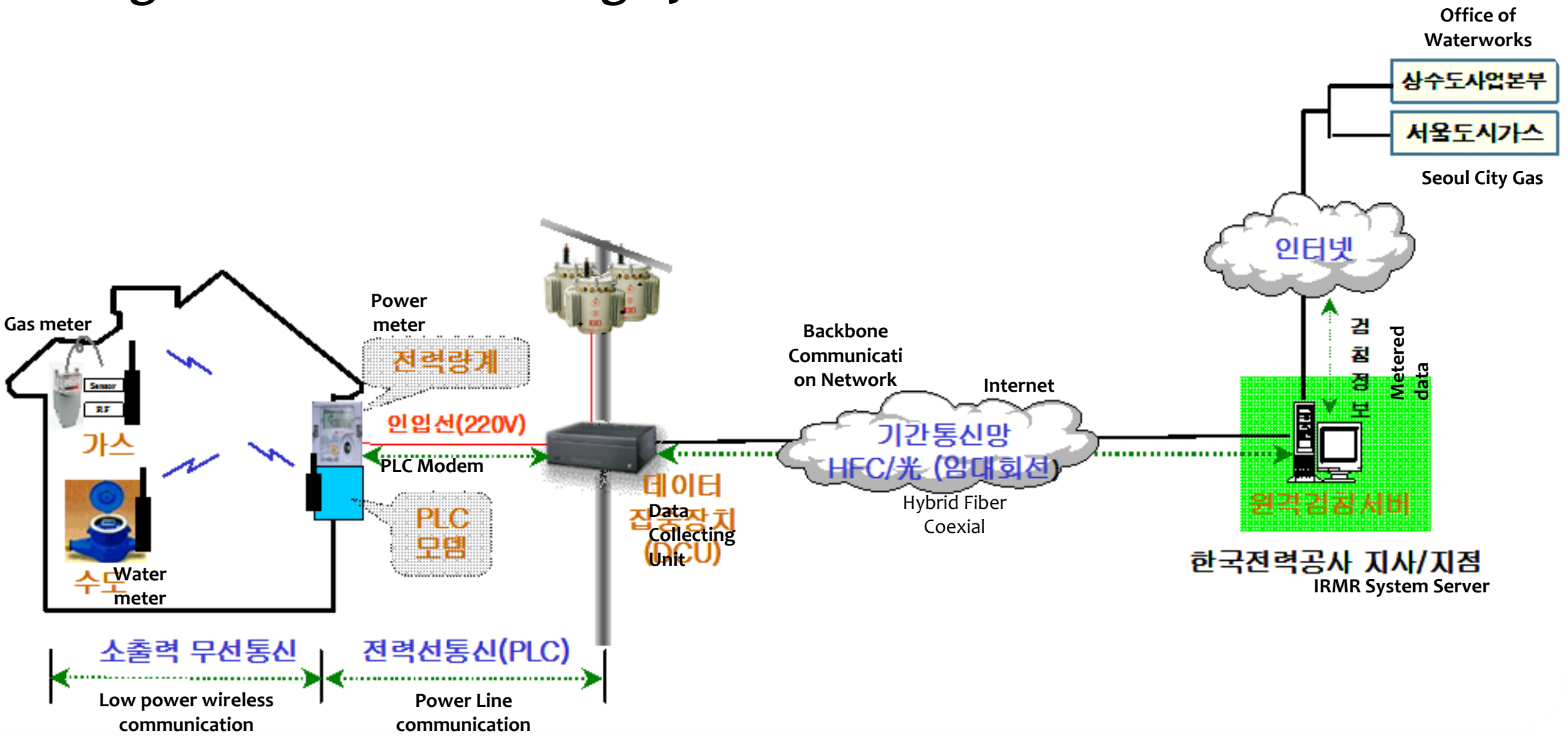


Pump and Sensor Monitoring



Statistics and Analytics

Integrated Smart Metering System



IoT based Smart Metering System

The National R&D Project

Dec. 2017~ Feb. 2019
120 Water posts
A mid-size block

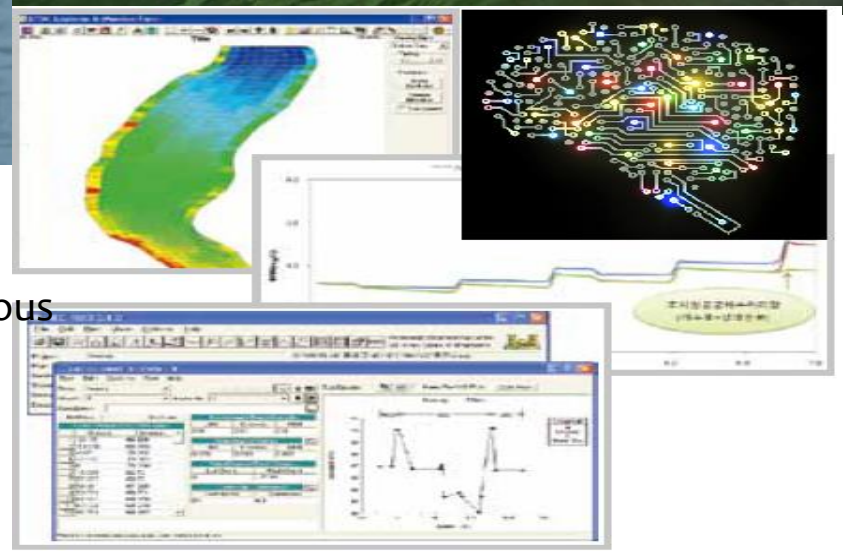
The Model Project

Jan. 2018~Dec. 2018
1,900 Water posts (15~150 mm)
Metering and communication performance
Water consumption pattern

WQ Monitoring with UAV

Sampling & Monitoring

UAV (Draon)
Analytic Disk Technology
AI based WQ prediction system



- WQ Monitoring using Drons
  - WQ monitoring where access is dangerous
  - Algae monitoring
  - Accident monitoring
- WQ Prediction System
  - Ultra High Frequency Wave
  - Systematic analysis on WQ Big Data and environmental information
  - Prediction and correspondence on/to WQ change

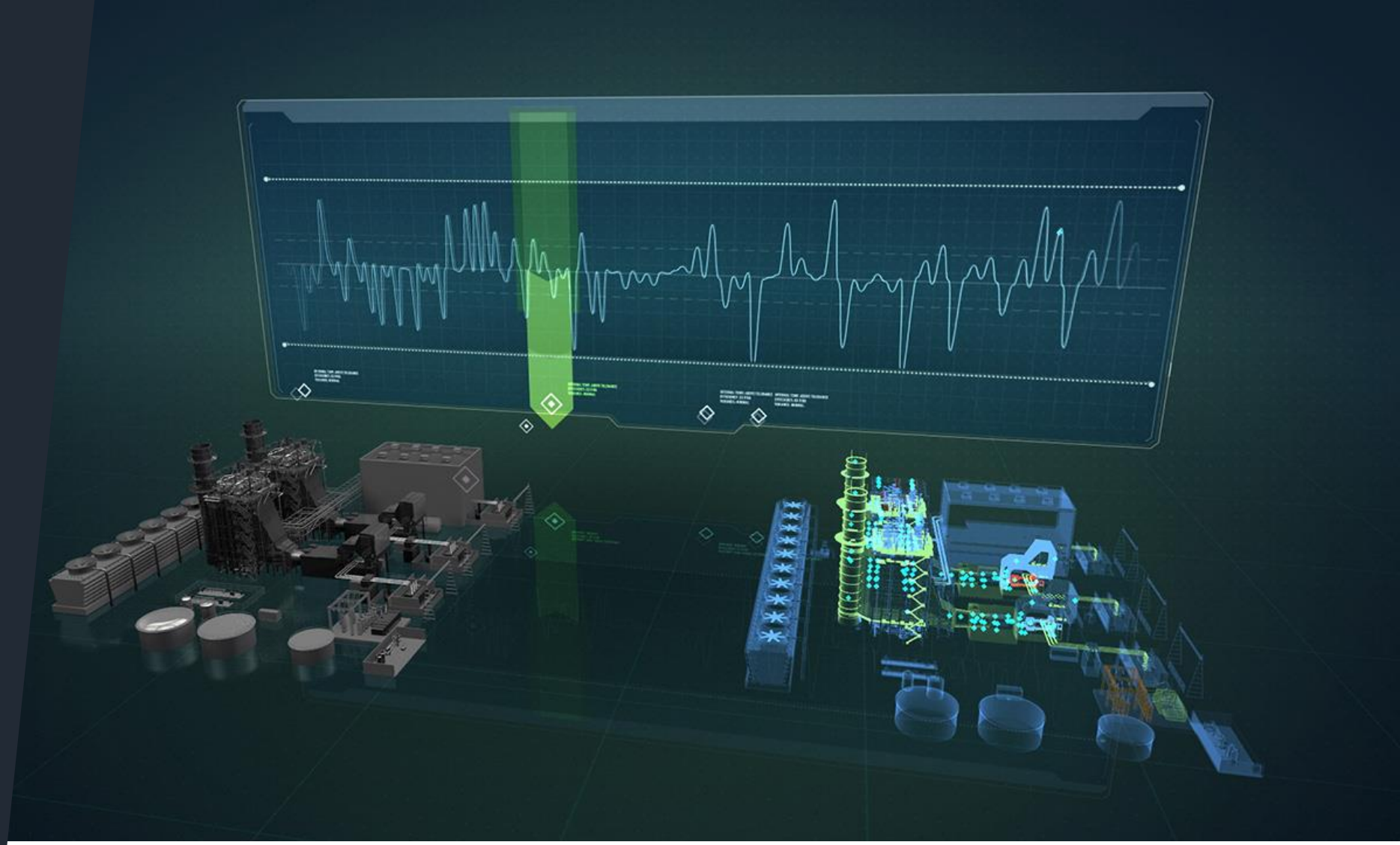
Virtual Water System

Digital Twin technology

https://www.ibm.com/blogs/internet-of-things/wp-content/uploads/2017/05/Facebook_digital_twin.jpg

Virtual Water System

Digital Twin technology

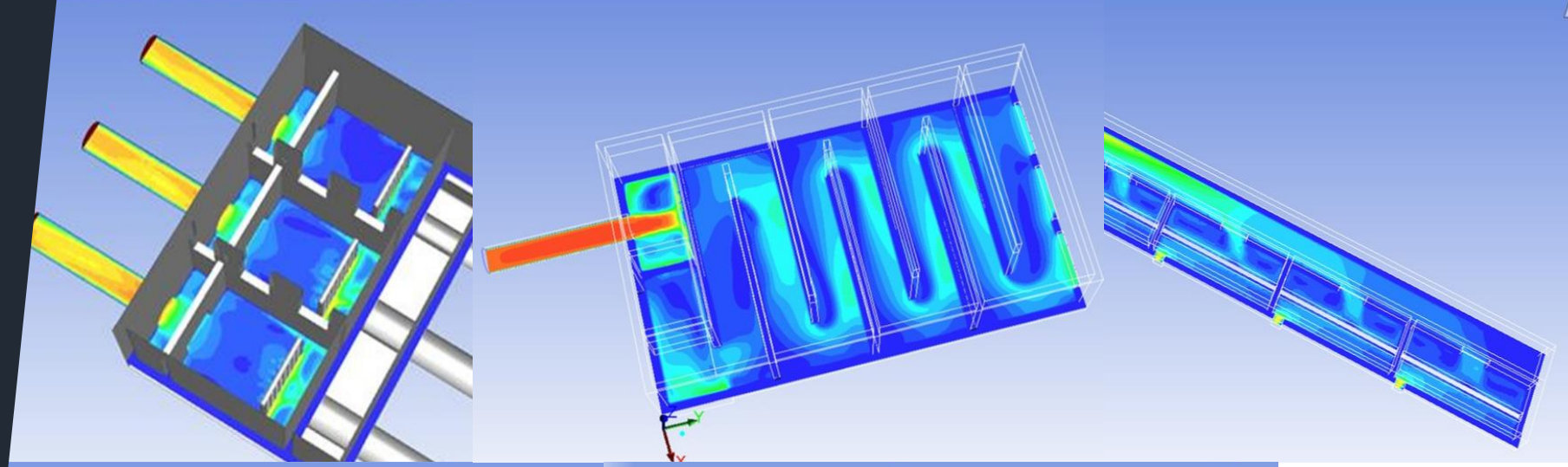


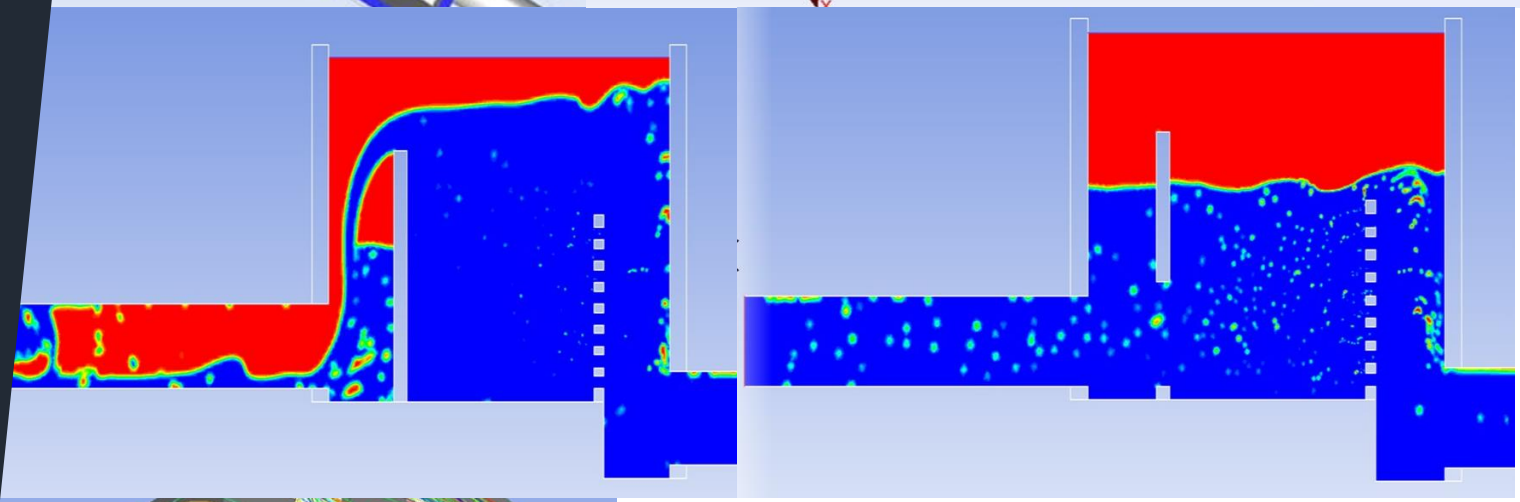
https://www.techiexpert.com/wp-content/uploads/2018/01/How-is-%E2%80%9Cdigital-twinning%E2%80%9D-helping-big-data-IoT.jpg

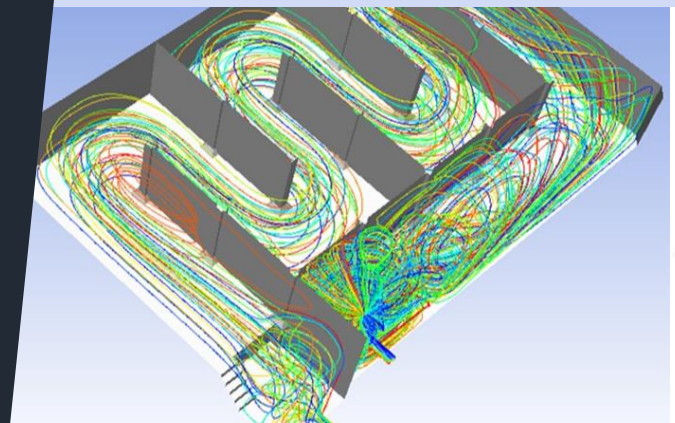
Virtual Water System

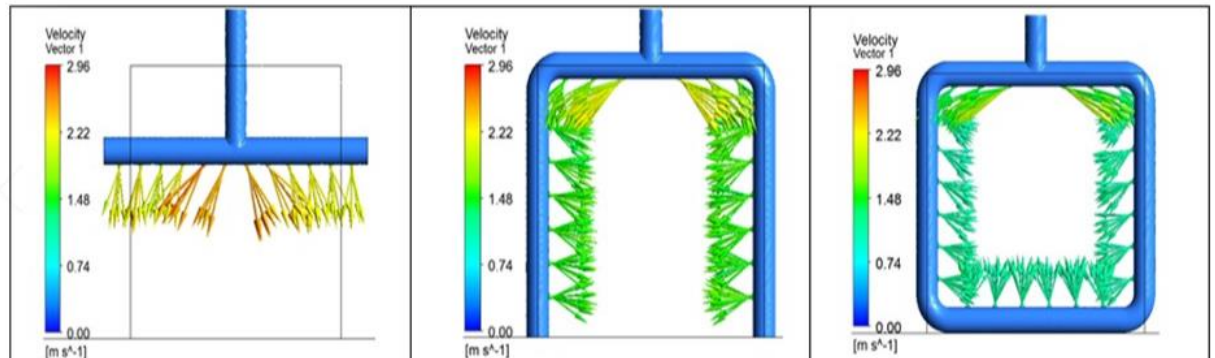
Digital Twin technology

3-D Digitizing
Process modeling
Sensors connecting w/ IoT
Big data analytics w/ AI









Conclusion

Why Smart?

'Smart' is not ICT.
ICT is just a tool for the 'Smart' system,

Smart Why

- Aging society, Aging infrastructure
- Efficient system, Improvement of serviceability
- Climate change, Disaster Risk Reduction (DRR)

Smart How

- Civil demand
- Finance restriction

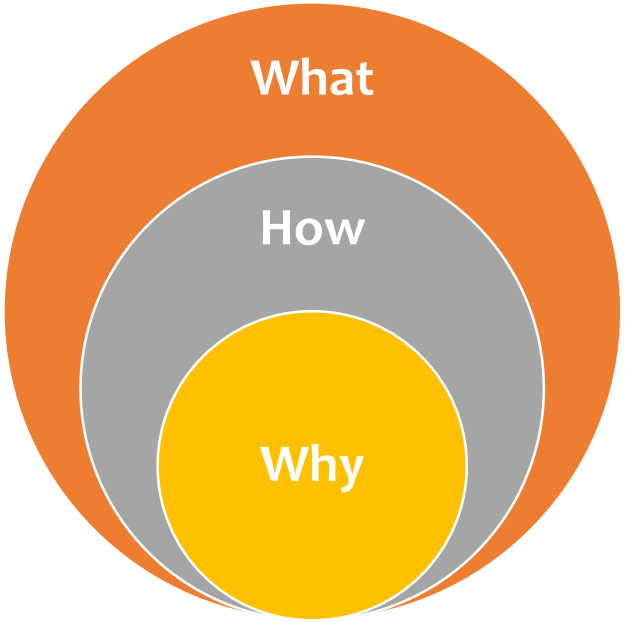
Smart What

- Protocol and regulation
- Culture

ICT is just a tool for the smart system

Participatory Capacity

- Civil governance
- Public-private partnership
- International cooperation



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