

***Adaptable Practices of Technology and
Regulation for Ageing Dams in Korea***

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K-water

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Current Status of Korea Dr. Dong-Hoon Shin



Case Study

Mr. Min-Suk Ryou

- **Performance Improvement of Ageing Dams**
- **Rehabilitation Project of Aging Local dams**



Conclusions

I . Current Status of Korea

Safety Issues of Ageing Dams; Awareness, Legal and Institutional System, and Technology

Current Status

Current Conditions

- Ageing Dams ↑
- Threats of Climate Change and Natural Hazards ↑
- Socio-economic costs ↑

KOREA (K-water)

- Awareness of its importance
- Laws-Decrees and Regulations available
- Robust Technologies available

- Awareness
 - Institutional System
 - Science & Technology

Experiences

❑ Tragic Accidents



Natural Disasters (Korea)

❖ 1980-2010

No. of events	71
No. of people killed	3,252
Average killed per year	105
No of people affected	1,733,531
Average affected per year	55,920
Economic Damage (US\$)	14.9 billion
Economic Damage per year (US\$)	0.48 billion

Efforts

- **Establishment of National Safety Unit (KISTEC, 1995)**
- **Legislation on Safety Management and Disaster Management**
- **R&D by Societies; KNCOLD, KSCE, KGS, KWRA, etc.**

Examples

- **Periodic in-depth inspection of major public structures**
 - **Education and Training**
-
- **Special Act on safety control of public structures + Act on safety management and disaster prevention of reservoirs and dams**
-
- **Development of dam inventory/ integrated dam safety management system/ leakage detection method/ etc.**

20 cases : 2002-2014



Yeon-Cheon dam (1996)



Wun-Moon dam (1998)



Jang-Hyun dam (2002)



Dong-Mak dam (2002)



Yang-Chon dam (2011)

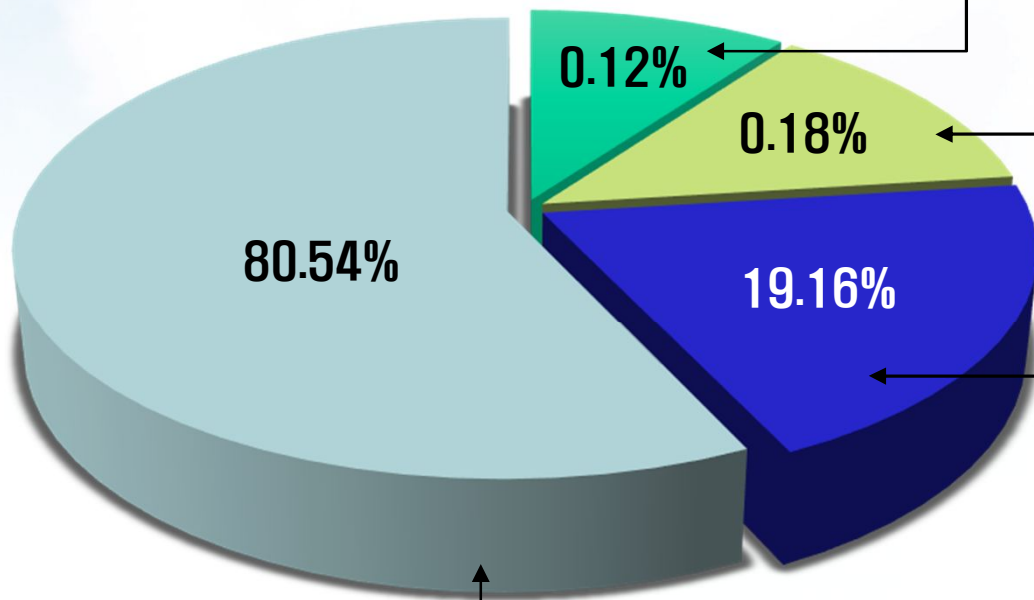


San-Dae dam (2013)

Dams & Reservoirs in Korea

National Dam Inventory

Total 17,597



16 Local governments

- Irrigation : 14,133
- Water supply source : 39



Korea Hydro & Nuclear Power

- 8 Hydropower dams
- 13 Pumped-storage power dams



K-water

- 16 Multipurpose dams
- 14 Water supply dams
- 2 Flood control dams



Korea Rural Community Corp.

- Irrigation : 3,372

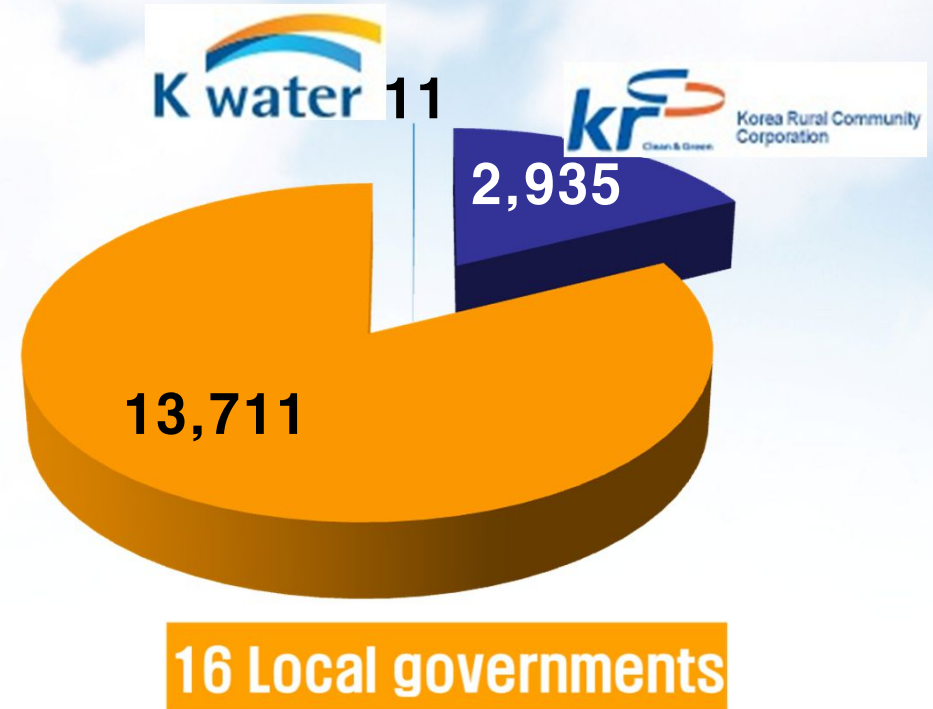
Dams aged and deteriorated

> 50Yrs



69.5% of Total

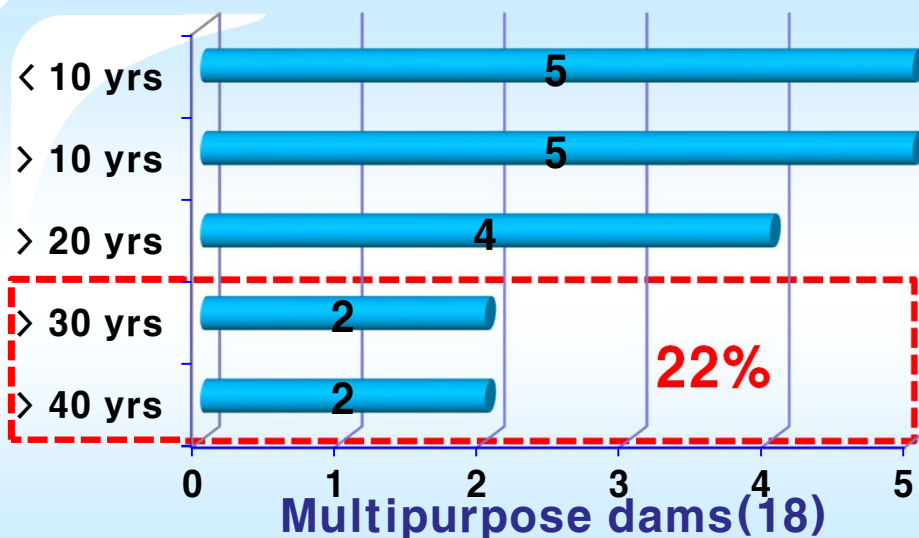
>30 Yrs



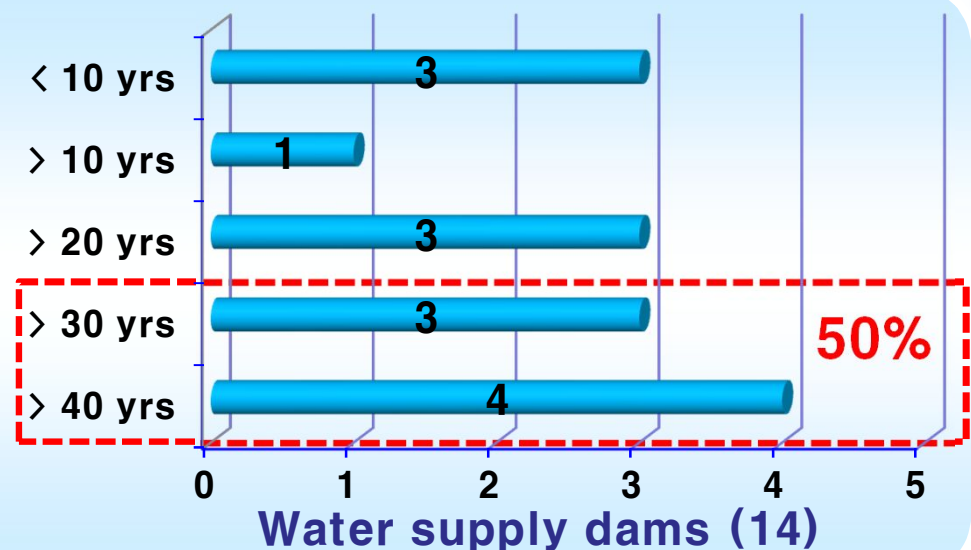
95.1% of Total

K-water dams in operation

- ✓ K-water is operating 32 large dams
 - * 16 multipurpose, 14 water supply, and 2 flood control dams
 - * 22% of multipurpose dams over 30 yrs (50% for water supply dams)
- ✓ K-water dams are in charge of 95% of flood control and 65% of water supply of Korea



*include 2 flood control dams



Laws / Regulations	Contents
<p>Act on Construction of Dams and Assistance, etc. to their Environs</p>	<p>Construction and maintenance , environmental measures, support to vicinity area of dam</p>
<p>SPECIAL ACT ON THE SAFETY CONTROL OF PUBLIC STRUCTURES (1995)</p>	<p>Establishment of safety control unit(KISTEC), maintenance, diagnosis of entire 1st class public structures, supervision on safety policy of government</p>
<p>RESERVOIR AND DAM SAFETY CONTROL AND DISASTER PREVENTION ACT (2008)</p>	<p>Designation and maintenance of dam in danger, business for the maintenance of dangerous dams, education and training of engineers and officers working in local governments</p>
<p>Regulation on Dam Maintenance of K-water</p>	<p>K-water's internal regulation for safety inspection and maintenance</p>
<p>Guidelines for Dam Instrumentation and Monitoring</p>	<p>Installation and operation of Instrumentation transducers (K-water)</p>

Dam Inspection and Diagnosis

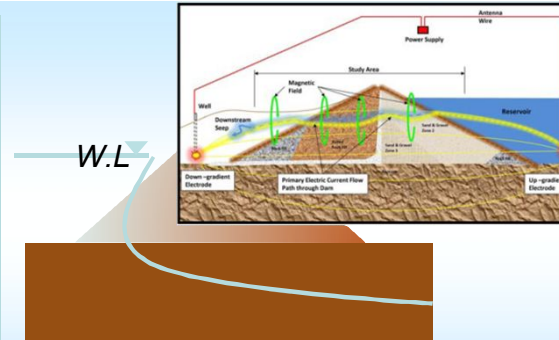
Inspection type		Inspection time	Inspectors
Regular checks		◦ More than once per a half year	◦ Dam owners
Principal Inspection	Initial principal inspection	◦ Before end of construction	◦ Designated specialized safety diagnosis agency
	Before Warranty expiration	◦ Within the period before the date of warranty expiration against defects	◦ Designated specialized safety diagnosis agency
Emergency checks	Damage checks	◦ In case of accident or disaster	◦ Depending on dam owner's decision (owner or other agency)
	Special checks	◦ In doubt of damage, operation restricted structures	◦ Depending on dam owner's decision (owner or other agency)
In-depth Safety Diagnosis		◦ Depending on Safety grade (within 11 years after completion)	◦ Designated specialized safety diagnosis agency

Safety Grade	Principal Inspection	In-Depth Safety Diagnosis
A	More than once/3 years	More than once/6 years
B, C	More than once/2 years	More than once/5 years
D, E	More than once/1 years	More than once/4 years

Safety Evaluation



Large Geotechnical centrifuge



Detection of Leakage



D-SMART

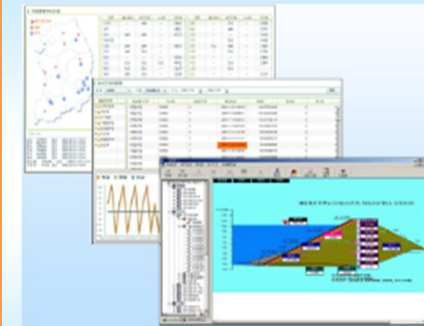
Maintenance management



Early Warning System



Earthquake Monitoring



Safety Management System

K-water is providing a Total Solution for maintaining aging dams

II . Case Study

Performance Improvement of Ageing Dams in K-water

Goals

- To establish Master Plan for performance improvement of aging dams
- Finally, to secure their stable performance and thus extend lifespan



1. Basic survey

- **Collection and review of basic records such as design and constructions report, maintenance report, etc.**
- **Site investigations**

2. Site investigations

- **Observational inspection**
- **In-depth investigations including boring, geophysical survey, lab tests**
- **To find defects which can be considered as vulnerability**

3. Safety Evaluation

- Check up the conditions of emergency discharge pipe
- Re-evaluation of emergency discharge capacity based on the current design standards
- Evaluation of seismic stability
- Examination of stability of water-taking

4. Determination of items to be improved

- Selection of items to be improved based on the results of survey and evaluations
- Review on the impacts and effects of improvement

5. Determination of Priority

- **Organization of technical committee including independent experts**
- **Review of all data including financing plan by technical committee**
- **Determination of priority**
- **Determination of project dams**

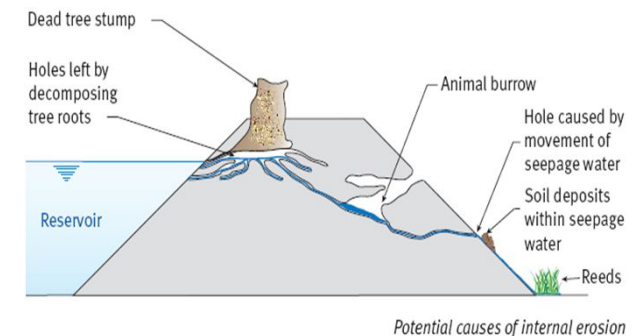
Items to be improved

	Dam Safety	Discharge Facility	Intake Tower	Landscape etc.
Item	<ul style="list-style-type: none"> ① Rip-rap and vegetation ② Seepage measuring device ③ Displacement monitoring 	<ul style="list-style-type: none"> ④ Emergency discharge facility - Establishing criteria of reservoir water level declination time 	<ul style="list-style-type: none"> ⑤ Structural safety and improvement intake function - Aging, selected intake, cold water damage 	<ul style="list-style-type: none"> ⑥ Removal of sediment ⑦ Construction of management office ⑧ Improvement of Landscape and appurtenant facilities

1. Surface Conditions

■ Defects

- **(Rip-rap)** Weathered, substandard, aggregate loss, slope irregularities, etc.
 - Difficult to know surface deformation only by visual observation
- **(Slope vegetation)** Non-visual inspection and interfere with equipment check collimation by excessive vegetation
 - Potential penetration paths formed formation of animal habitats



1. Surface Conditions

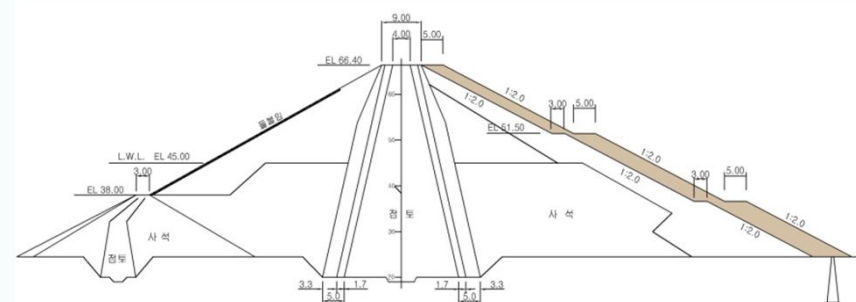
■ Improvement

- Reinstalling riprap and vegetation removal for stable behavior of the dam for maintenance, monitoring, because it is the primary check point for deformation of dam body

Reinstallation of rip-rap (YCdDam, AGDam)



Plan of Reinstalling rip-rap



2. Seepage Monitoring

■ Defects

- No seepage measuring devices installed during construction period.
- Inadequate installation of seepage measuring devices.
=> Safety management on seepage behavior should be modified

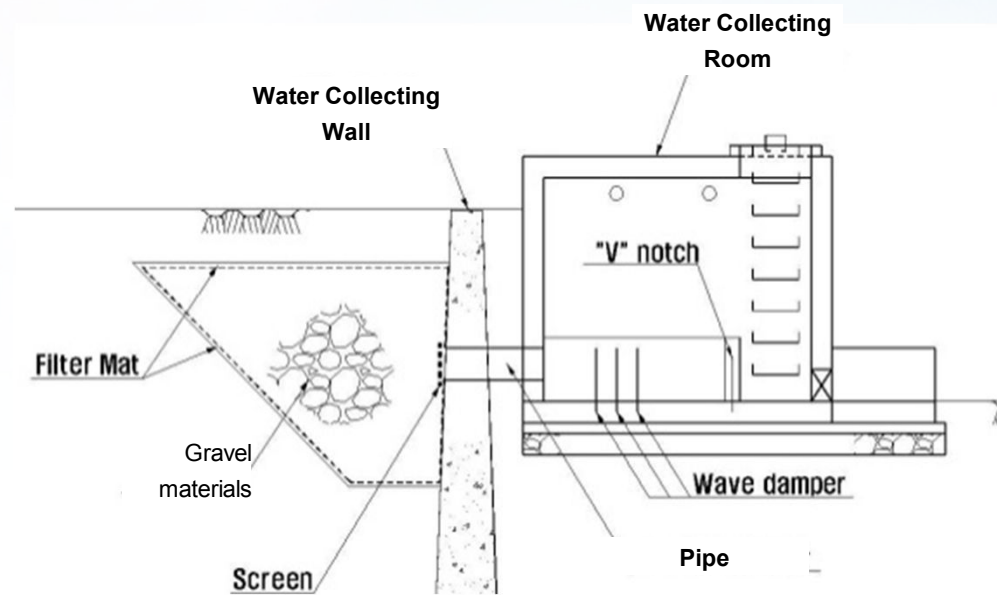
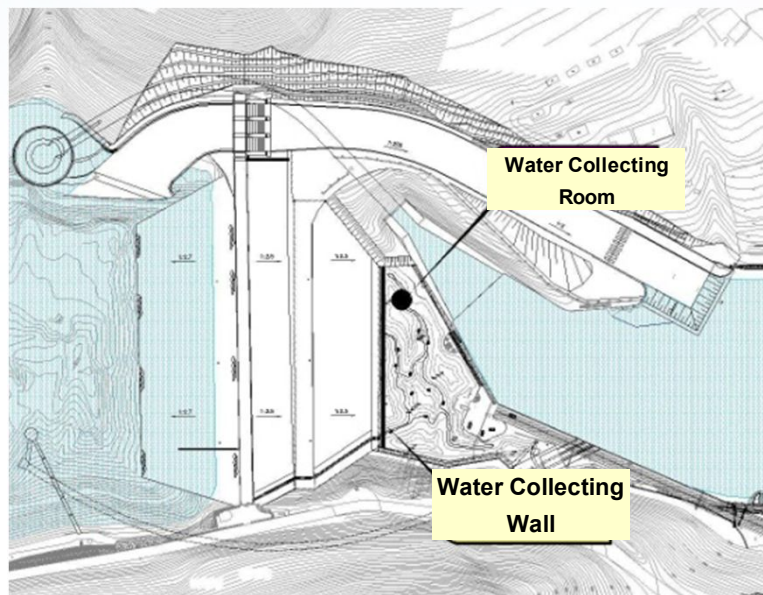
· Status of Seepage Monitoring

Leakage Weir	Measuring groundwater level
6 dams	8 dams
Sayeon, Daegok, Woonmoon Gampo, Sueo, Pyeonglim	Gwangdong, Dalbang, Yeongcheon, Angye, Daeam, Seonam, Gucheon, Yeoncheon

2. Seepage Monitoring

■ Improvement

- Construct water collecting wall and Install seepage measuring devices of total seepage passing the dam and foundation



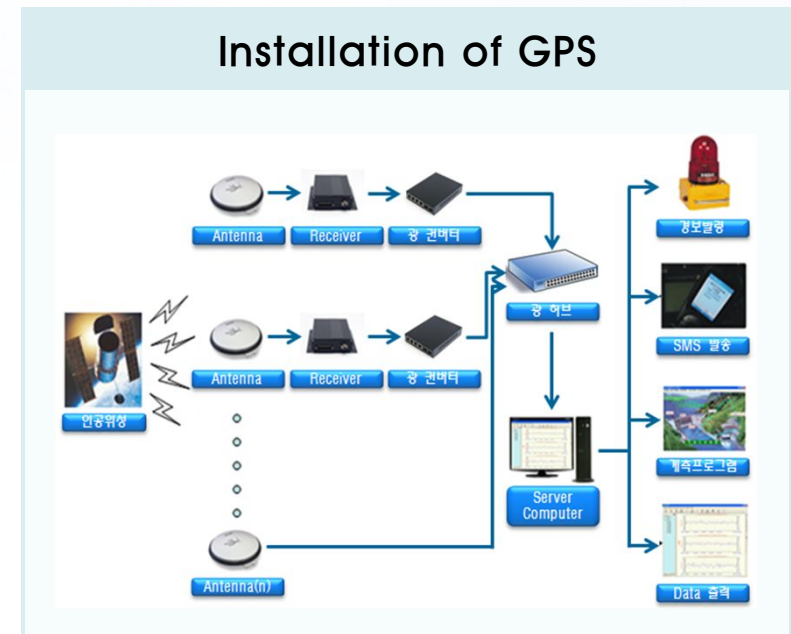
3. Monitoring of displacements

■ Defects

- Measuring displacement by automated total station, with **no stationed dam manager**

■ Improvement

- (Equipment) installing **GPS**
 - Preventing interference by weather etc.
- (Measurement) **check entire dam slope**
 - means of assistance (**3D scanning**)
- (Inspection) Strengthening visual inspection



4. Emergency discharge facility ① *Standard of size-estimation*

■ Defects

- No definite criteria and domestic research.

Suggestion in 'Design Standards of Dam' is only to design it as big as possible

※ Design Standards of Dam (2011, Ministry of Land, Transport and Maritime Affairs, Korea)

10.4 Normal and emergency discharge facility

It will be used as the emergency discharge facility when needed to empty out reservoir at emergency, and which can safely discharge water below spillway weir crest as fast as possible.

■ Improvement

- Develop a suitable time criteria on reservoir water level down

※ **Discharge for 7~10days from spillway weir to top 75% water level**

※ **Discharge for 40~50days from spillway weir to low-water level**

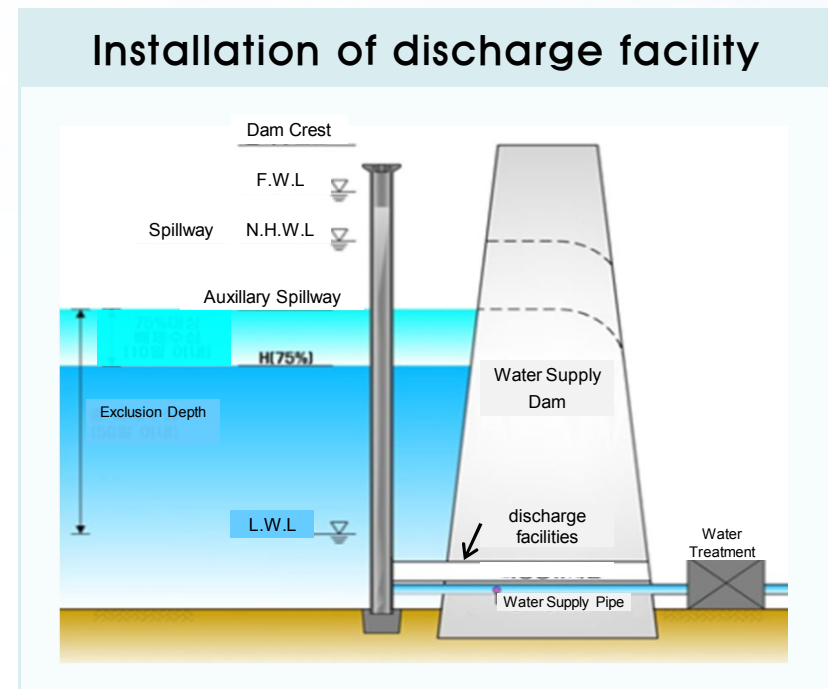
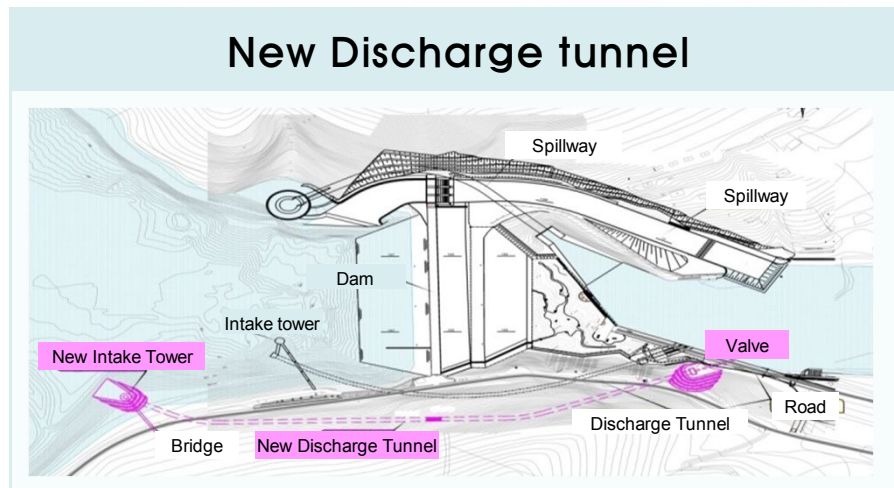
4. Emergency discharge facility_② *Securing discharge capacity*

■ Defects

- Securing supply capacity-centered consideration, no discharge capacity
- It is possible to discharge small water by blow-off valve in emergency

■ Improvement

- Review of discharge capacity and facility plan



5. New intake tower construction and improvement of structure

■ Status and Issues

- Installation and operation of multi-holes type intake tower
- Some intake towers and way bridges don't secure **seismic safety**
- **No replacement facility, difficulty in repair** because of continuous water supply




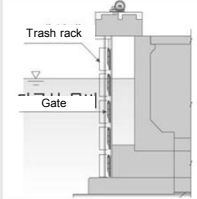
※ It is needed for water supply facilities with water supply dam to establish a plan for stabilizing water intake for continuous water supply.



5. New intake tower construction and improvement of structure

■ Improvement

- Establishing an improvement plan for seismic and functional safety
 - (Earthquake-proof) Alternative intake tower construction or strengthening section
 - (Function) Shifting the intake valve to the outer wall in respect of maintenance
- The type and feature of intake gate

Type	Side wall circular multistage type	Straight line multistage type	Semicircular multistage type	Multi-holes type
Shape				
Feature	<ul style="list-style-type: none"> - Ease of selective intake - Good water tightness 	<ul style="list-style-type: none"> - Ease of surface intake - Bad water tightness 	<ul style="list-style-type: none"> - Economical size - Bad water tightness 	<ul style="list-style-type: none"> - Difficulty in surface intake - Good water tightness

6. Planning to remove sediment

■ Status and Issues

- Considering the size and difficulties in finding alternative water resource, **establish measures need to remove sediment without any water supply problem due to reduce of water resources**
- * Sediment deposition rate in water supply dams is larger than that of multi purpose dams.

· Sediment deposition rate in water supply dams ($m^3/km^2/yr$)

	GD dam	DB dam	YC dam	SY dam	DA dam	GC dam	SE dam	Period
Design	460	746	500	800	800	200	350	
Research	714	1,066	1,534	219	1,184	1,976	428	'04~05

■ Improvement

- **Research for the amount of remove sediment by conducting a sensitivity analysis**
 - * *Conducting two times first 5 years period to increase basic data reliability*
 - ☞ If necessary, establish in facility improvement measures such as installing check dam
 - ※ dredging performance : Gwang-Dong Dam('08), Dal-Band Dam('07)

7. Building management office

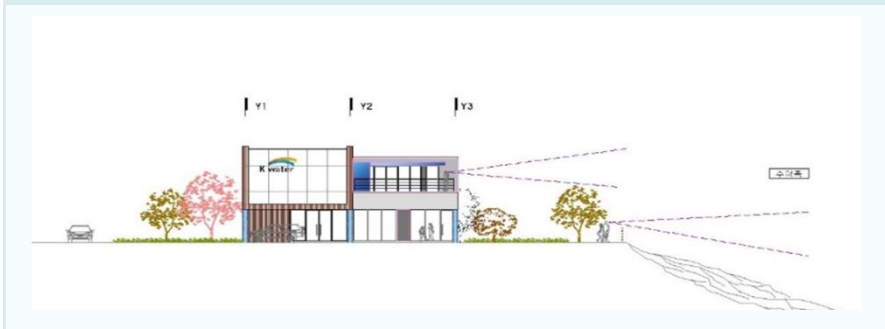
■ Status and Issues

- **Need the space and dam managers** to conduct daily check or emergency work
 - Need to improve the dam managing condition the way to take a look around
 - Need to balance to management system with small multipurpose dams in operation, the size of water resource, water supply etc.

■ Improvement

- **Building new small management office or planning remodeling and arranging dam management staff**

Elevation Plan



Flat Plan



8. Landscape and facilities

■ Status and Issues

- **(Landscape)** In the incongruity, poor aesthetics, aging in dam body and parts of it , etc.
- **(Facilities)** Inspection discomfort at dam, utilization & safety needs

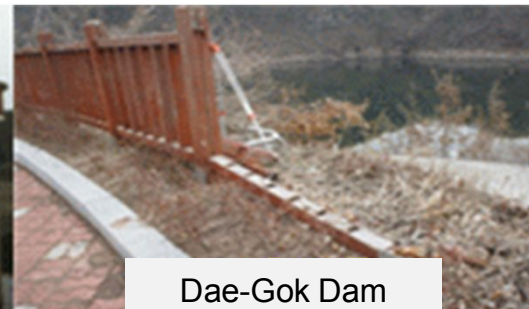
Division	Vulnerabilities in landscape
Dam body	• Large man-made structure and discordant surroundings
Dam Crest	• Disharmony with stainless light pole and fence, etc.
Facilities	• Aging of amenities such as walking deck, fence, bench, etc.



Pyung-Lim Dam



Sa-Yeon Dam

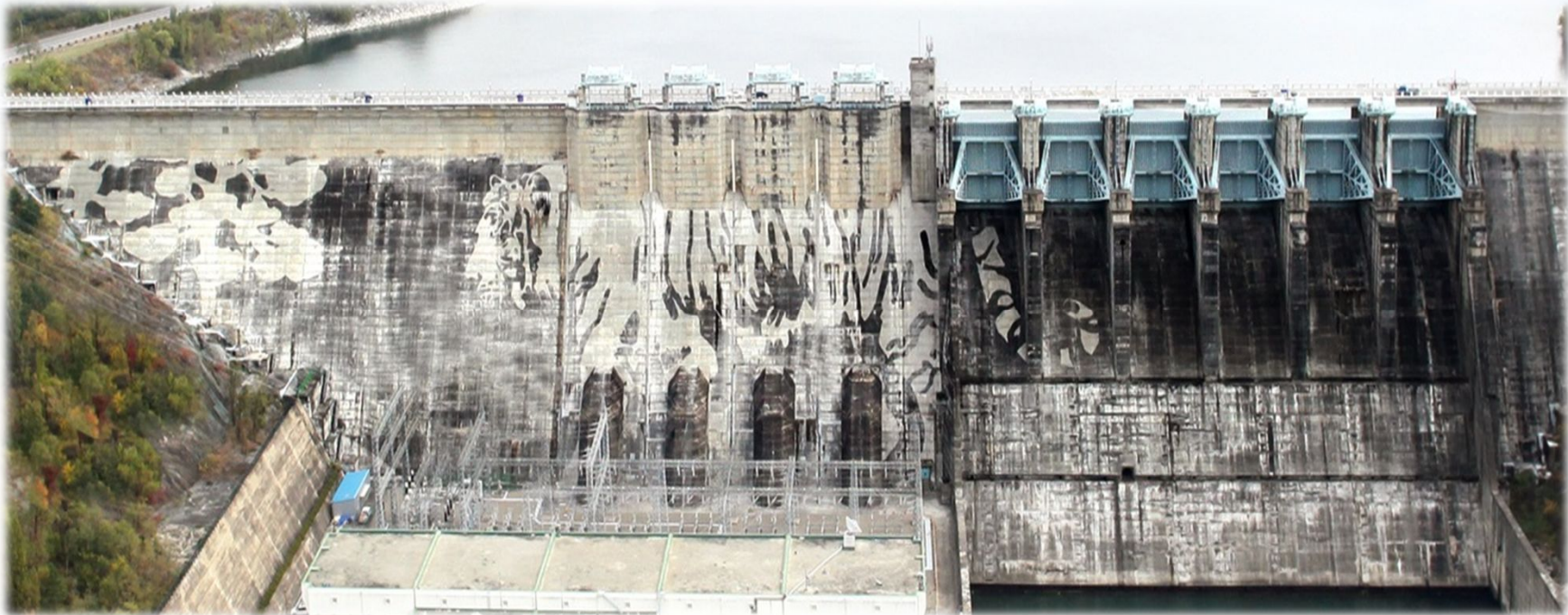


Dae-Gok Dam

8. Landscape and facilities

■ Improvement

- **(Landscape)** Planning Landscape improvement plans to meet dam characteristics



< Chung-ju dam Tiger Mural (2012) >

- **(Facilities)** Planning facility improvement such as railing , checking, and door care, etc.

II . Case Study

Rehabilitation Project of Aging Local dams

Background

- ✓ Collapse of ageing local dam managed by a local government has been rapidly increased every year
- ✓ Dam ageing of local government is being serious
- ✓ Recently, 10 ageing local dam collapsed from 2012 to 2014 due to deterioration



Rehabilitation project of K-water ?

- ✓ 30 years after completion of ageing local dam managed by local government closely check and repair to project for disaster prevention.

Maintenance status

- ✓ Not enough budget to maintain the ageing local dam in local government
- ✓ Reinforcing the local defects of ageing local dam such as rapid repair, etc.
- ✓ Recently, the ageing local dam is especially managed **specifying in the law.**

* Major rehabilitation of aging local dam



Grouting



Dam Heightening



Reinforcing Spillway



Protecting Riprap`

Disaster danger local dam

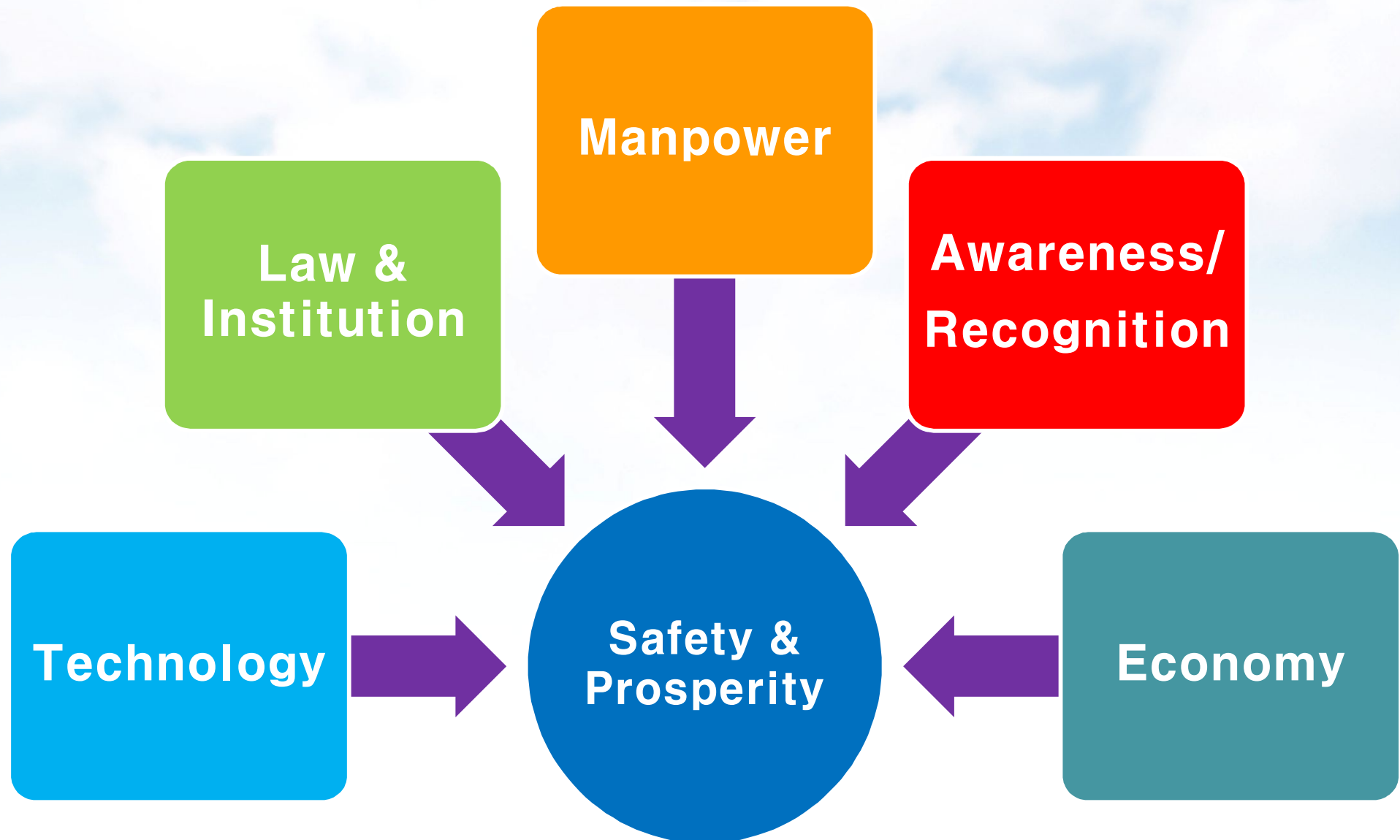
- ✓ Level "D (insufficient)" local dam below the inspection results are managed by law

III. **Conclusions**

- *Awareness* of government and citizens regarding the rapidly increasing challenges of ageing dams suffering from natural and manmade threats is truly important.
- *Legal and institutional system* are essential for better preparedness and mitigating those threats to ageing dams. Korea's acts and regulations on safety management of dams are good cases to refer.

- *Valuable experiences and verified knowledge* on safety management of ageing dams of Korea are decisive strengths.
- Especially, because the diversity in technology and know-how of K-water is very reliable, thus they can be adapted into developing countries by small modification.

- *A place for sharing experiences and knowledge* on ageing dams is required to be prepared by both of developing and developed countries. In fact, the 7th WWF is requesting us to more constructively develop this discussions and implement them for the coming 3 years by the 8th WWF.





THANK YOU