Smart Management of Feitsui Reservoir

Taipei Feitsui Reservoir Administration

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The second largest reservoir in Taiwan

Feitsui
Reservoir

Feitsui Dam

- ➢ **Construction：1979~1987**
- ➢ **Total capacity: 4.06 million m³**
- ➢ **Active capacity: 335.51 million m³**
- ➢ **Catchment area: 303 km²**
- ➢ **Water Surface area: 10.24 km²**

Dam Safety

■ **Enhance dam safety monitoring**

➢ **Various warning thresholds at various steps.**

➢ **Apply ANN to safety monitoring.**

Intensified dam safety monitoring

Monitoring every hour

Automatic monitoring and warning of the dam

Strengthen the dam safety monitoring

Improve the safety warning function

Establish the automatic warning system

Set monitoring warning threshold

Monitoring per day

- Actual measured dam displacement
- Upper limit of ANN warning value
- Lower limit of ANN warning value

2016/1/1 2016/4/1 2016/7/1 2016/10/1 2017/1/1 2017/4/1
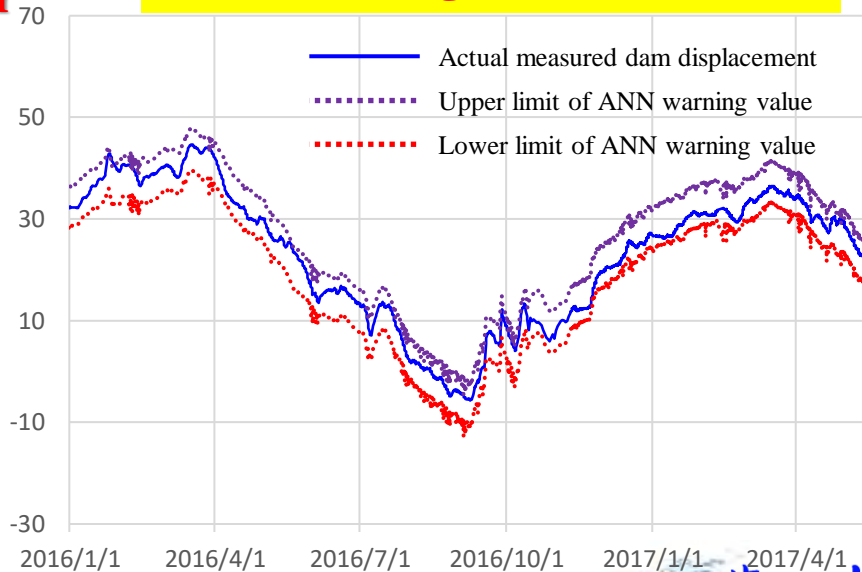
翡翠水庫

Dam Safety

■ **Enhancing the real-time monitoring for earthquakes**

➢**Reduce the responding time from 90 seconds to 5 seconds.**

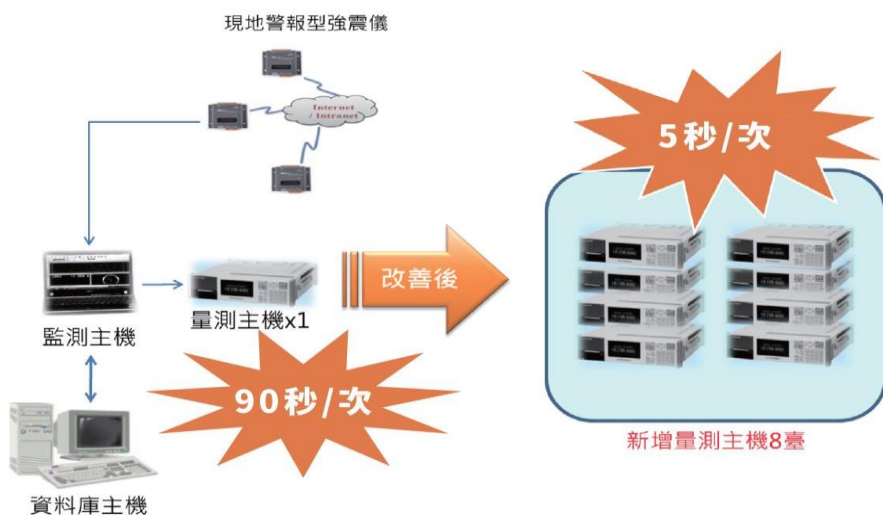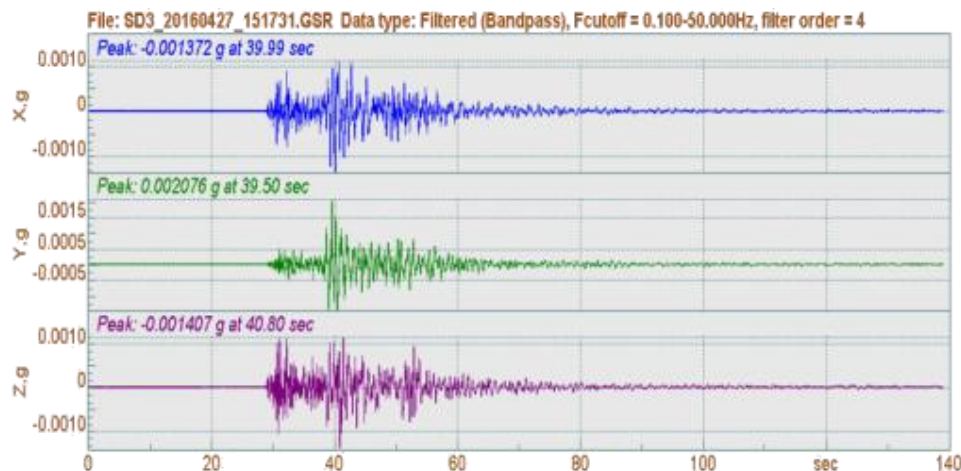**The real-time safety monitoring system of the dam**

Seismogram for earthquake monitoring

Dam Safety

■ **Potential dam failure modes analysis process**

➢ **Conduct failure mode analysis for the dam**

➢ **Identify the influence factors and failure development mechanism**

➢ **Determine prevention control methods and countermeasures**
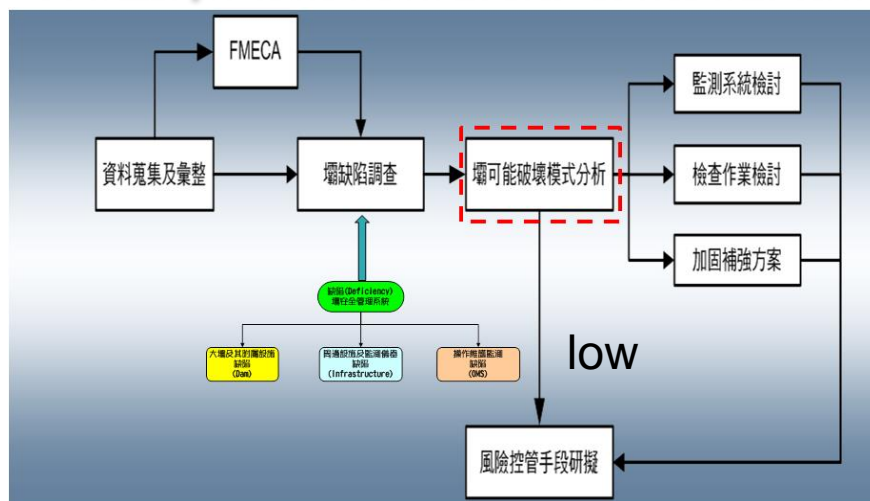
Potential dam failure modes analysis process

■ **Risk matrix**
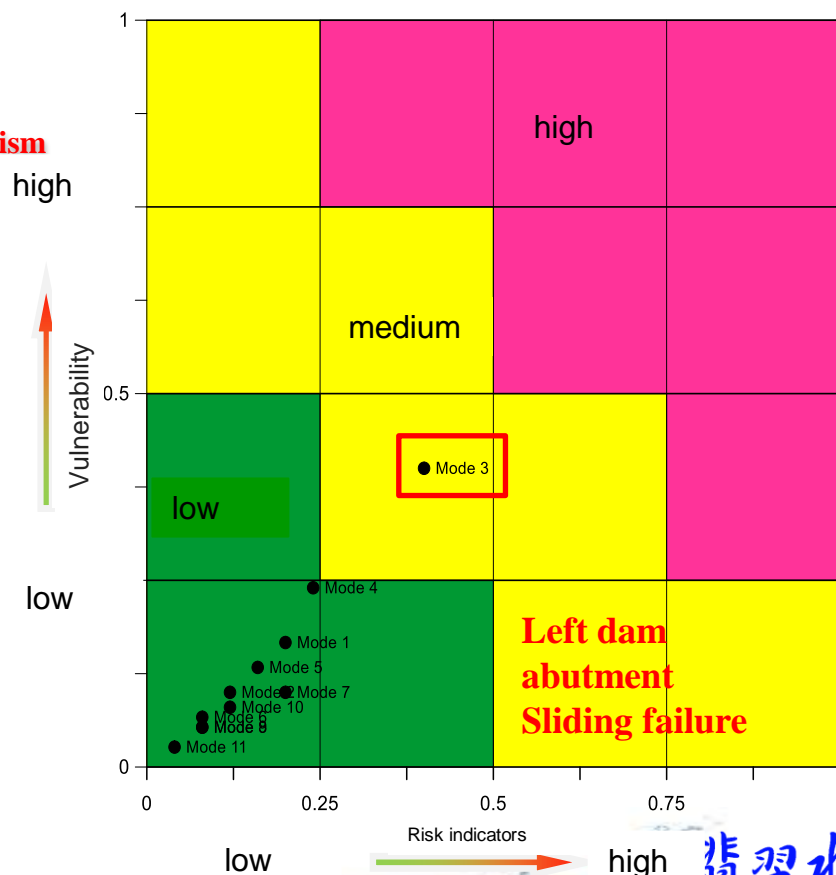
Dam Safety

■ **Construction of the automatic warning system of the left abutment (1/3)**

➢ Two inclinometers installed in the left abutment.
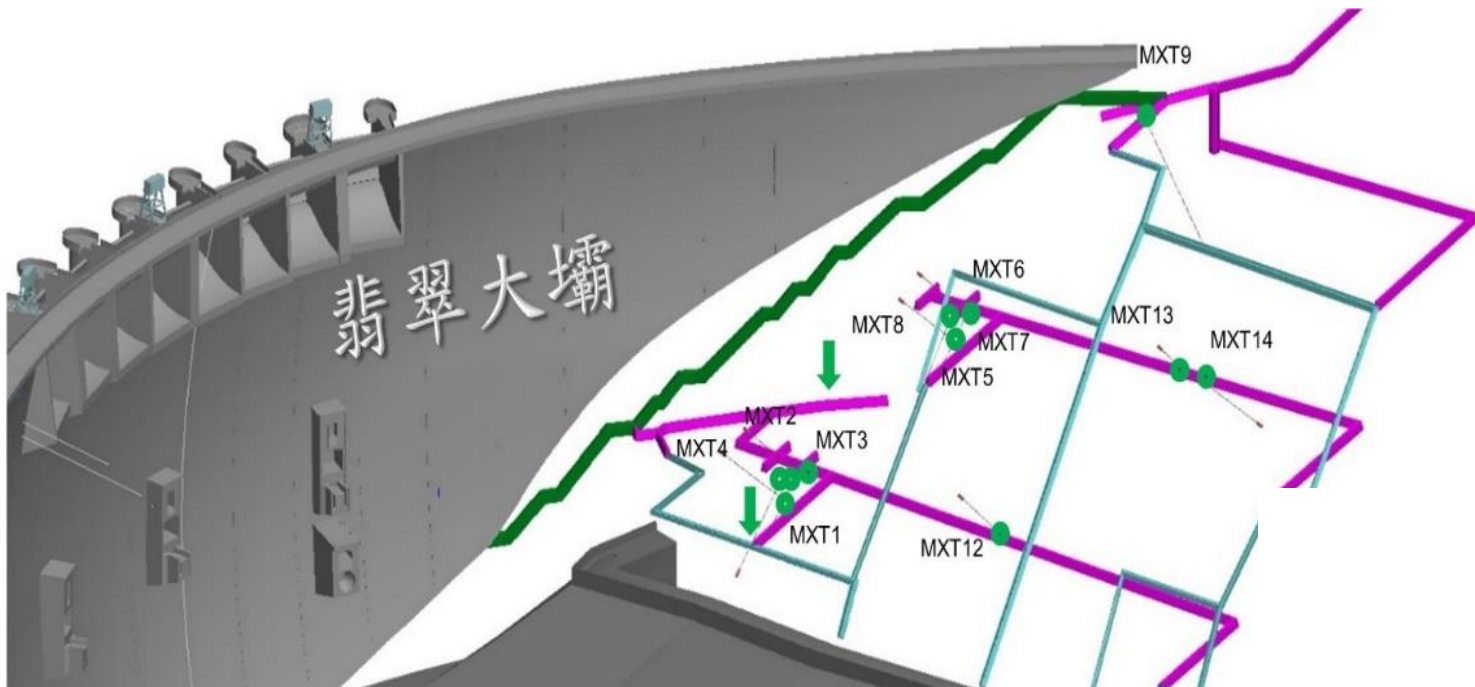
⬇ inclinometer location

Dam Safety

■ **Construction of the automatic warning system of the left abutment (2/3)**

➢ Two sets of automatic seepage meters in the left abutment.

➢ Automatic data collection per hour.

➢ According to the monitoring data (1995—2019) , the warning threshold was set at 1.5L/min, and the alert threshold was set at 2.8 L/min.

Automatic seepage meters in the left dam abutment

Location of the automatic seepage meters in the left abutment

自動化滲水量V.S人工滲水量測值

自動化滲水量   人工滲水量
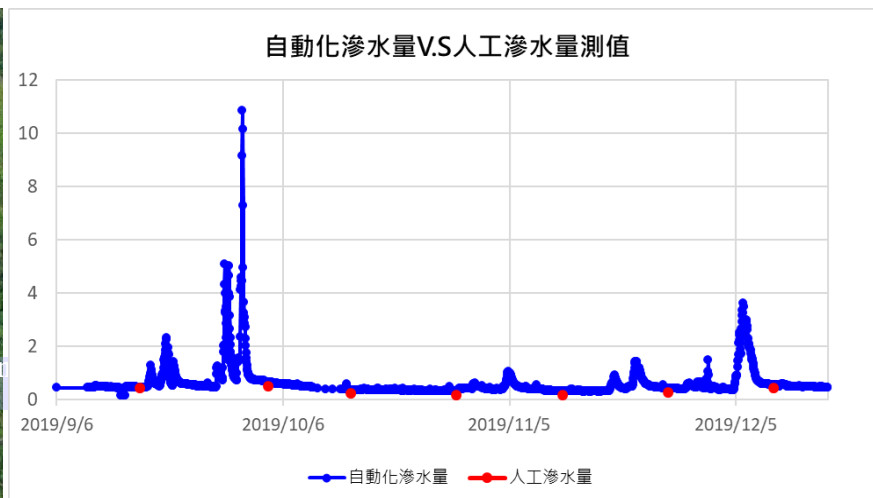
Comparison of both manual and automatic collecting data

翡翠水庫

Dam Safety

■ **Construction of the automatic warning system of the left abutment (3/3)**

➢ Apply **Global Navigation Satellite System** (GNSS) technology to monitor the displacement of the dam and abutments.
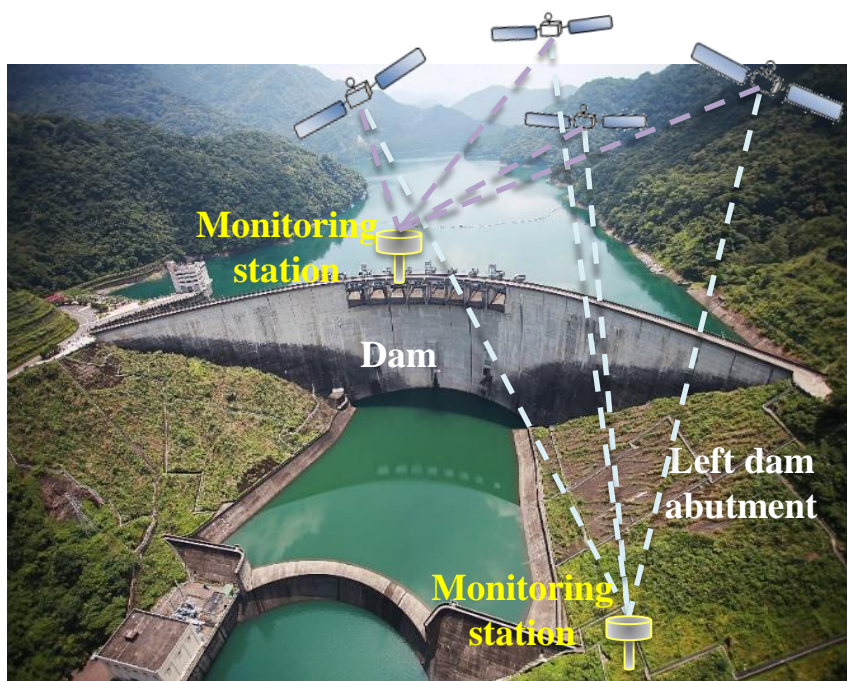
GNSS monitoring station in the left abutment

Reservoir Operation

■ **Smart decision-making system of Feitsui Reservoir**

➢ **Seven major internal system databases integrated in the smart decision-making system.**

➢ **Apply "Big Data" technology in reservoir operation.**
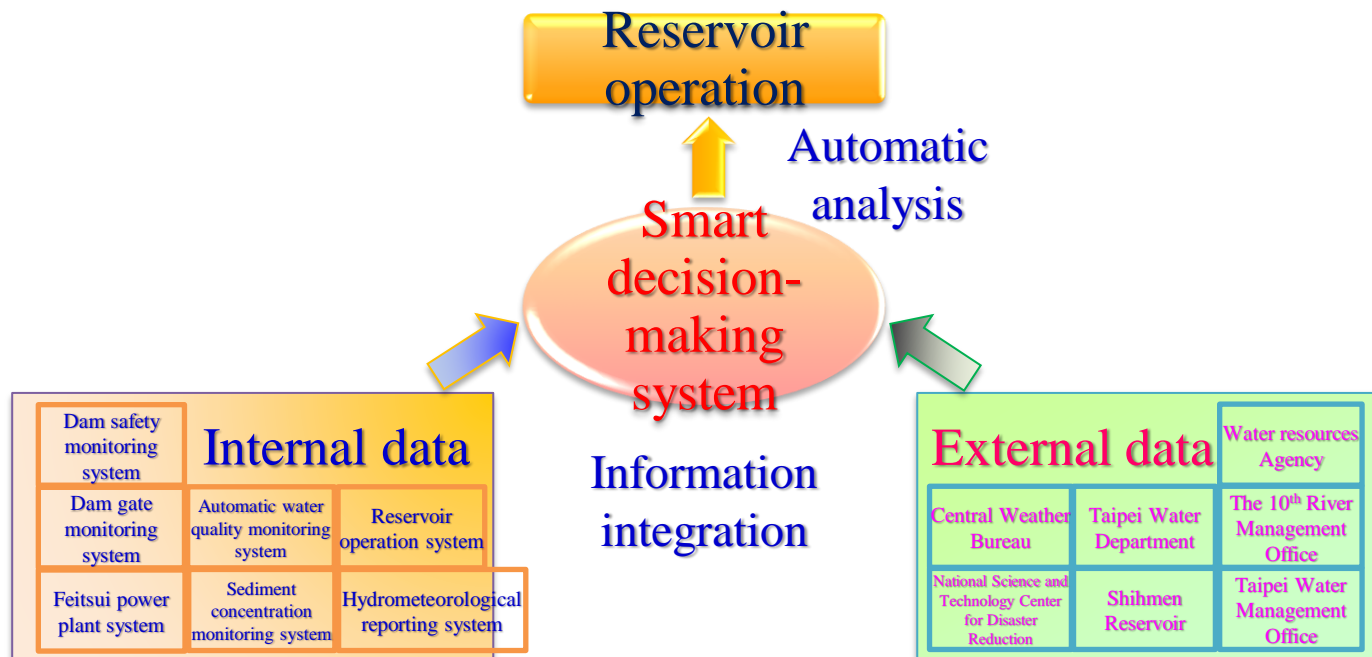
Reservoir Operation

■ **Establishment of the reservoir sediment transport mechanism**

| **Integration** 3 tributary st. and 2 lake st. | **Establishment** Reservoir sediment transport mechanism | **Determination** Determining spatial and temporal changes in turbidity | **Improvement** Hydraulic dredging efficacy |

● Upstream tributary monitoring station
● Water stratification monitoring station

Sediment transport

Muddy water

Hydraulic dredging

Bed
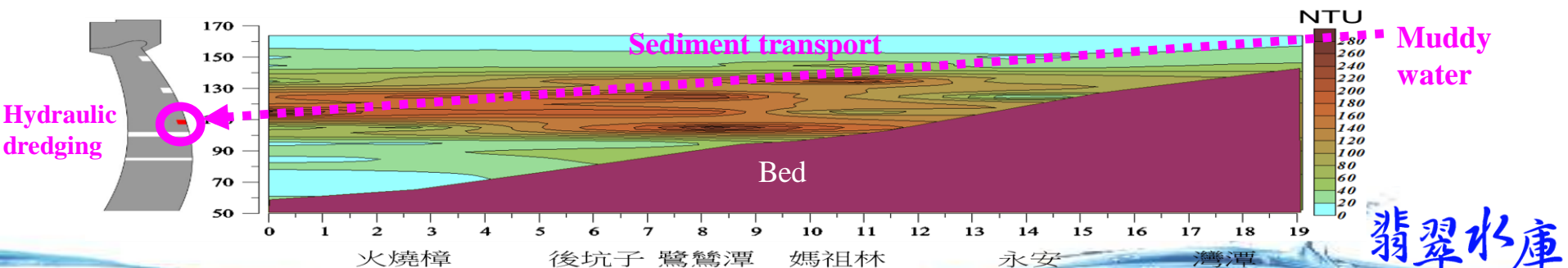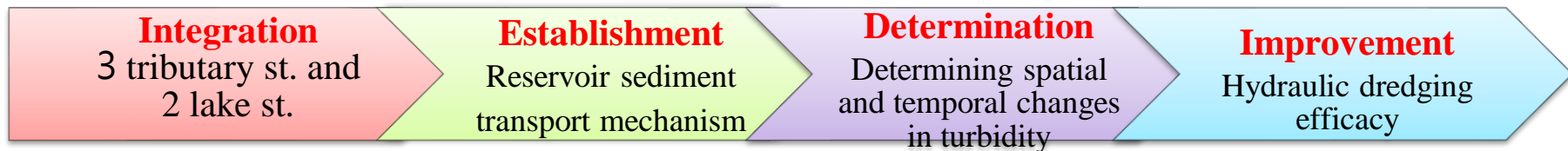
Reservoir Operation

■ **Operation center**

Satellite images from the Central Weather Bureau

information of the reservoir and downstream

rainfall information
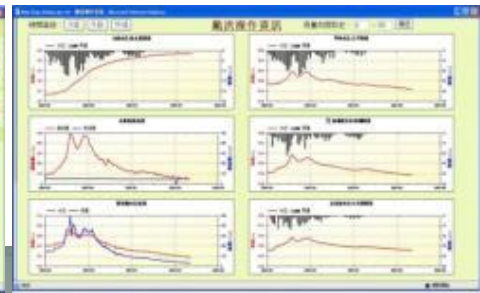
upstream tributaries

Dam safety monitoring

Monitoring vedios

Dam gate information
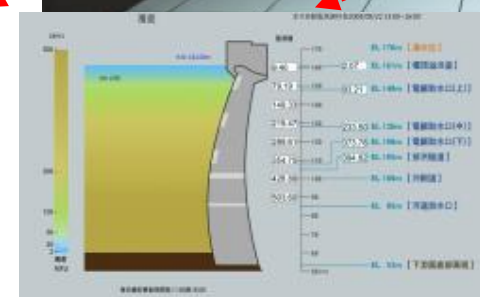
water quality information

All information is integrated in the operation center

Reservoir Operation

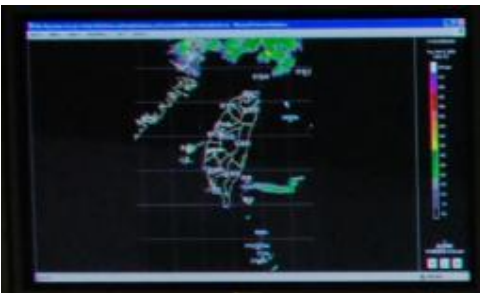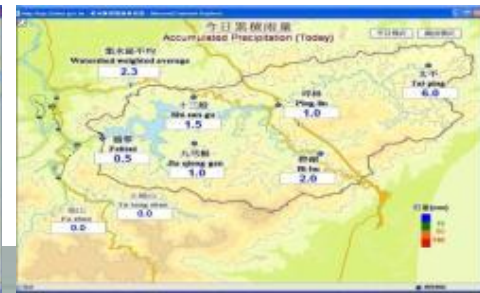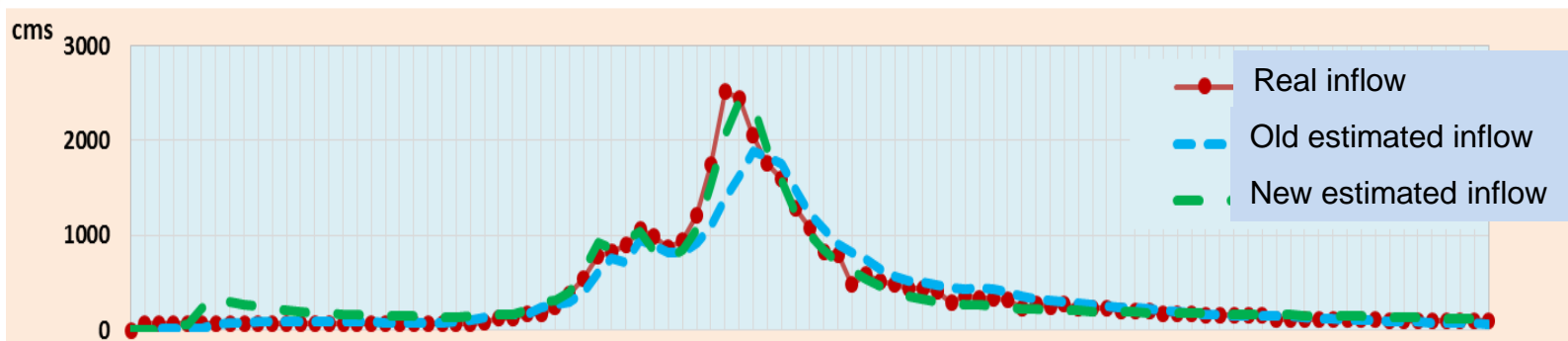The rainfall runoff model was improved, and the prediction accuracy increased by 24%.

Inflow peak 3,870cms

82% water kept in reservoir
(107.45 million cubic meters)

flood peak reduction rate 92%

outflow peak 315cms
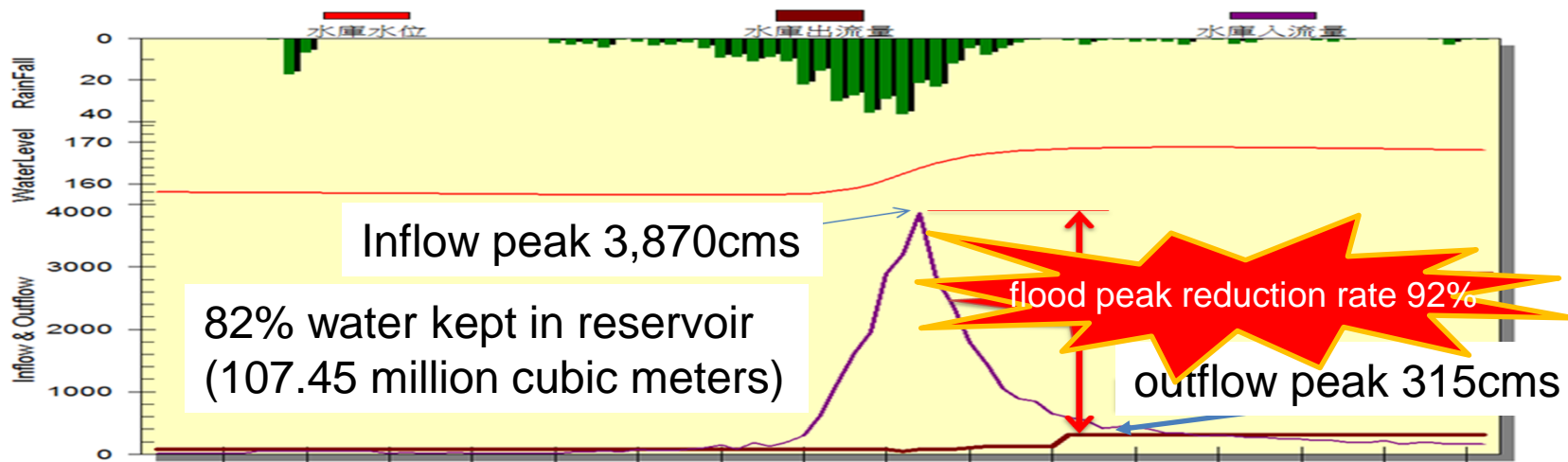
In Typhoon Soudelor, the water was released in advance to increase reservoir capacity. The flood peak reduction rate was 92%(inflow 3,870cms, outflow 315cms).

Smart Feitsui

■ **A novel wireless transmission technology: Long Range (LoRa)**

Advantages of LoRa:

1) Long distance: Transmission range of up to 15 to 20 km.
2) Low power consumption: Extremely low energy consumption.
3) Low cost: Low cost for base station construction.

Smart City Innovation Application Award (2018)

Reservoir Management

■ **Four LoRa base stations to form a local network.**

➢ **Safety management and transmission of the monitoring data.**
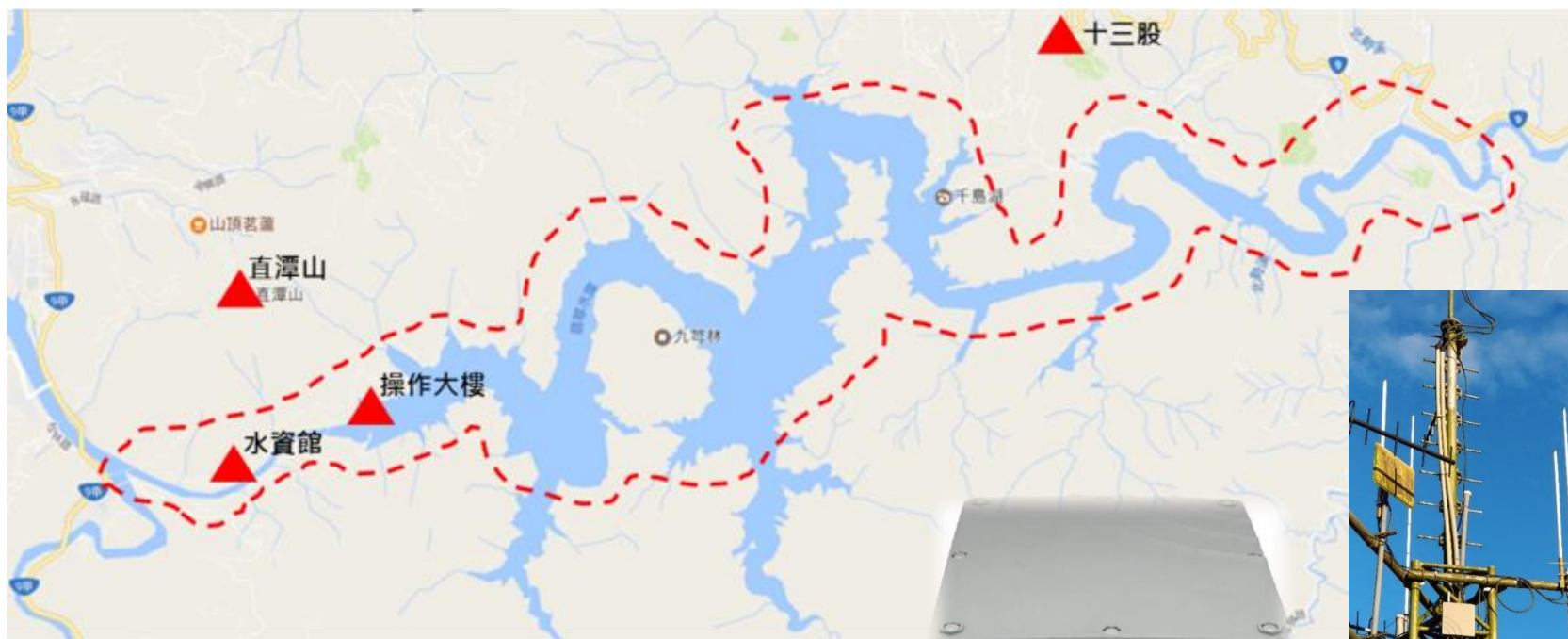
LoRa wireless base station

Reservoir Management

■ **Reservoir safety management**

➤ **Location management of people, vehicles, and vessels**

Vehicle path

Vessel path
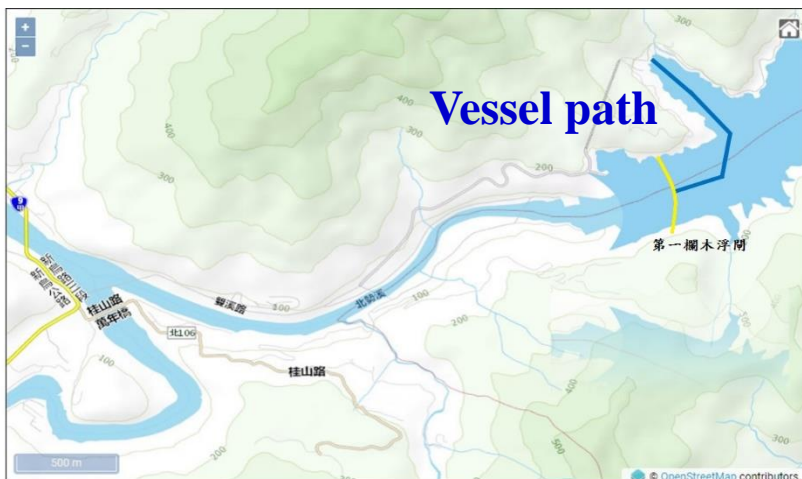
LoRa sensor for people

LoRa sensor for vehicles and vessels

Reservoir Area Management

■ **Reservoir area safety management**

➢ **Access control management (virtual electronic fence)**

Visitor at the checkpoint

Attach the LoRa sensor

If the vehicle enters a controlled area

The trespassing visitor is guided to leave.

The patrol car arrives at the scene.

The trespassing visitor is notified immediately.

Reservoir Management

■ **Reservoir safety management**

➢ **Access control management (electronic fence)**

The second floating boom
Controlled area

Magnetic reed electric fence

Trespassing in the controlled area of the reservoir is avoided
Controlled area

Infrared electric fence
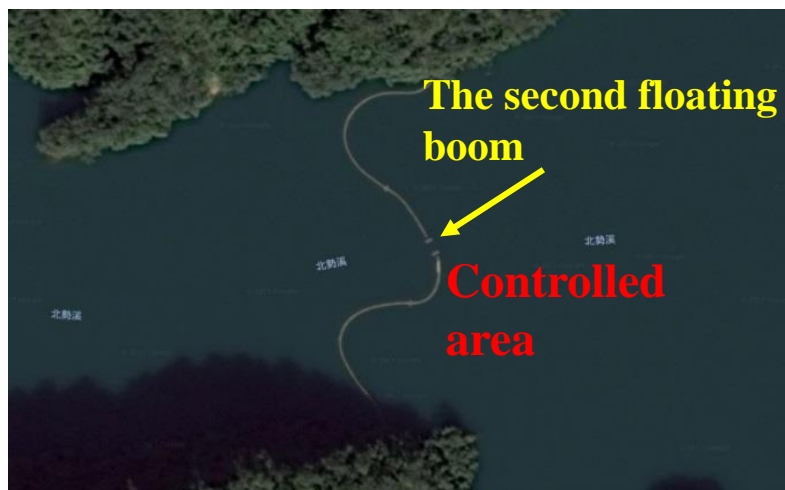
Smart Slopes Management

Slope Inspection

Comprehensive examination of the collapse potentials of reservoir slopes

The examination of 114 slopes with collapse potentials was completed, in which ranges of slopes with collapse potential were identified.

Establishing the Slope Inspection System

Rainfall warning values for mobile patrol inspection were formulated to establish a reservoir slope inspection system for comprehensive slope safety management.

Automated Monitoring

Unmanned Aerial Vehicle Environmental Monitoring Management

Unmanned aerial vehicles are used for aerial photography and image processing to thoroughly examine the changes in the environment and assist in the manual inspection of water slopes, collapse investigation, and crackdowns on legal violation, thereby protecting the water resources.

Automated Monitoring of Slopes with High Collapse Potentials

LoRa, a long range and low energy consumption Internet of Things technology, was employed to establish a wide area network; inclinometer monitors and automatic early warning systems were installed on 3 slopes with high collapse potentials to monitor the statuses of these slopes in real time.

Real-Time Water Governance

Implementing the Intermediate Soil and Water Conservation Project

Soil and water conservation facilities were constructed in the areas requiring rectification to recover the water conservation capacity of collapsed areas and mitigate surface erosion during torrential rain, thereby reducing the amount of earth and rock entering the water body of the reservoir and retaining its effective water storage capacity.
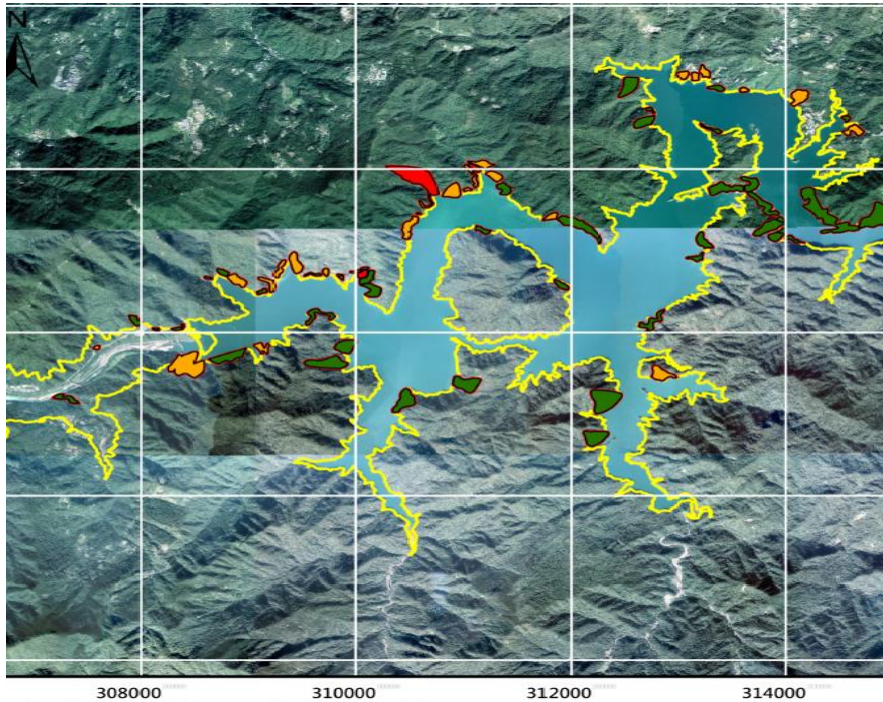
Smart Slopes Management

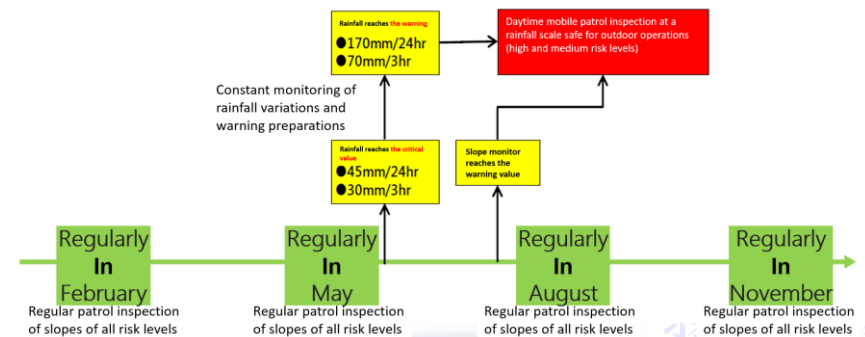## Comprehensive examination to find out slopes w/ potential landslides

| 308000 | 310000 | 312000 | 314000 |

Overall Inspection for 114 slopes

Slope Inspection System

Rainfall warning values for mobile patrol inspections for these slopes were formulated to construct the slope inspection system.

Rainfall reaches the warning
●170mm/24hr
●70mm/3hr

Daytime mobile patrol inspection at a rainfall scale safe for outdoor operations (high and medium risk levels)

Constant monitoring of rainfall variations and warning preparations

Rainfall reaches the critical value
●45mm/24hr
●30mm/3hr

Slope monitor reaches the warning value

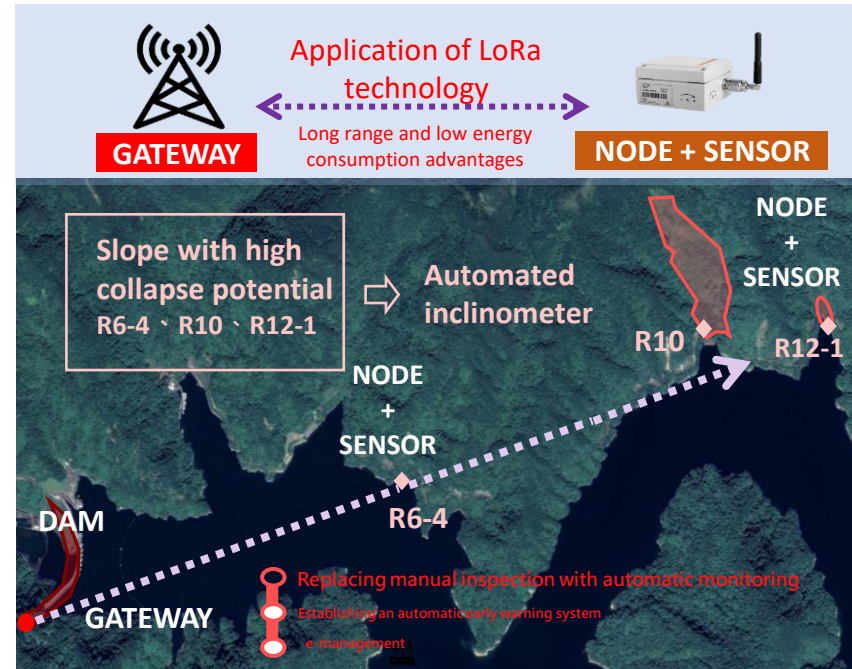| Regularly **In** February	Regularly **In** May	Regularly **In** August	Regularly **In** November
Regular patrol inspection of slopes of all risk levels	Regular patrol inspection of slopes of all risk levels	Regular patrol inspection of slopes of all risk levels	Regular patrol inspection of slopes of all risk levels

Smart Slopes Management

Unmanned Aerial Vehicle (UAV) Environmental Monitoring Management
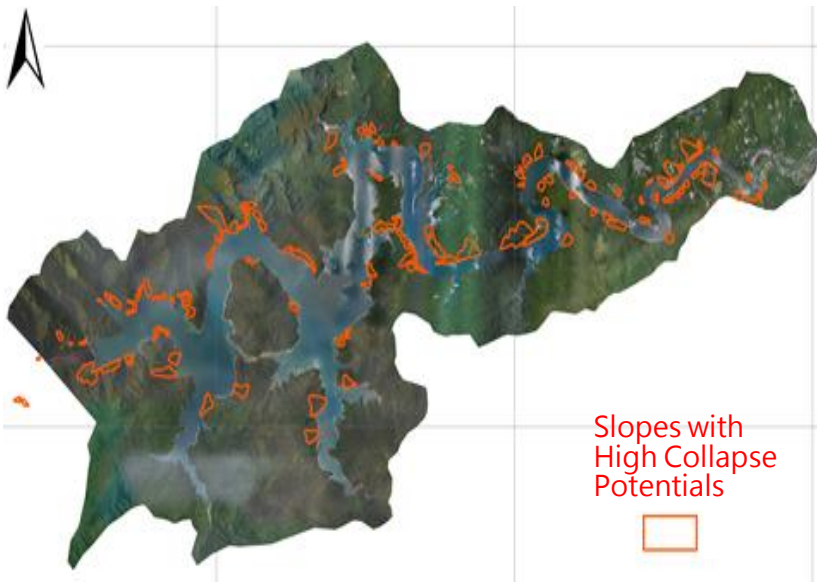
Orthophoto of the reservoir storage area

Slopes with High Collapse Potentials

UAVs were used for aerial photography and image processing.

Automated Monitoring of Slopes with High Collapse Potentials

Application of LoRa technology

GATEWAY ⟷ **NODE + SENSOR**

Long range and low energy consumption advantages

Slope with high collapse potential R6-4、R10、R12-1 ⇒ Automated inclinometer

NODE + SENSOR

R10   R12-1

NODE + SENSOR

R6-4

DAM   GATEWAY

Replacing manual inspection with automatic monitoring
Establishing an automatic early warning system
e-management

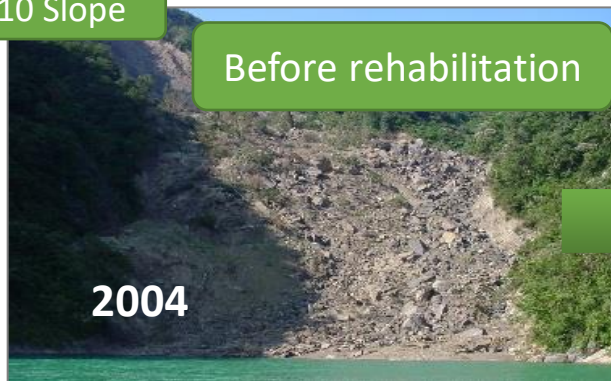| Visual inspection	➡	Automatic monitoring
Setting the management value	+	Automatic warning
Real-time data query		

Smart Slopes Management

Implementing the soil and water conservation project

R10 Slope

Before rehabilitation
2004
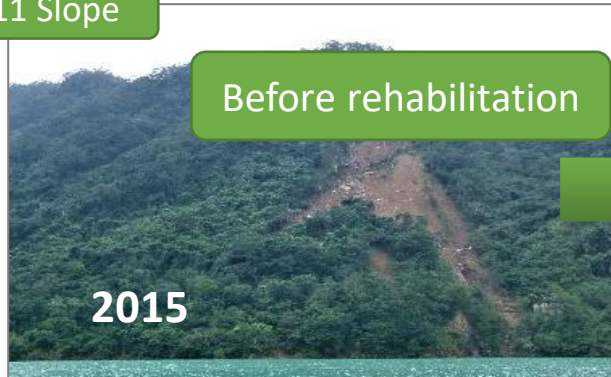
Typhoon Aere in 2004

Post-rehabilitation
2020

R11 Slope

Before rehabilitation
2015

Typhoon Soudelor in 2015

Post-rehabilitation
2020

The soil and water conservation project was implemented to prevent landslides around the reservoir.

Emergency Management

■ **Environmental radiation monitoring station**

➢ Establish the standard operating procedure for nuclear emergency response.

➢ The radionuclide detection and analysis laboratory for rapid water contamination detection.

➢ Disaster drills for nuclear radiation every year.

Close to nuclear power plants nearby

Environmental monitoring station

Radionuclide detection and analysis laboratory
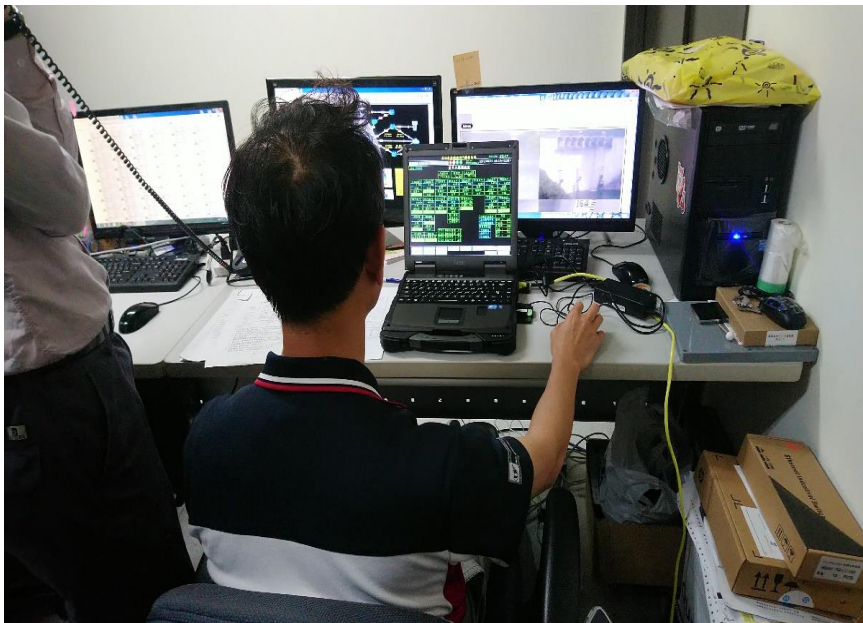

Disaster drills for nuclear radiation

Emergency Management

■ **Remote backup gate control system**

➢ Operate the remote backup gate control system in case of disasters.

➢ Test the remote backup gate control system twice per year.

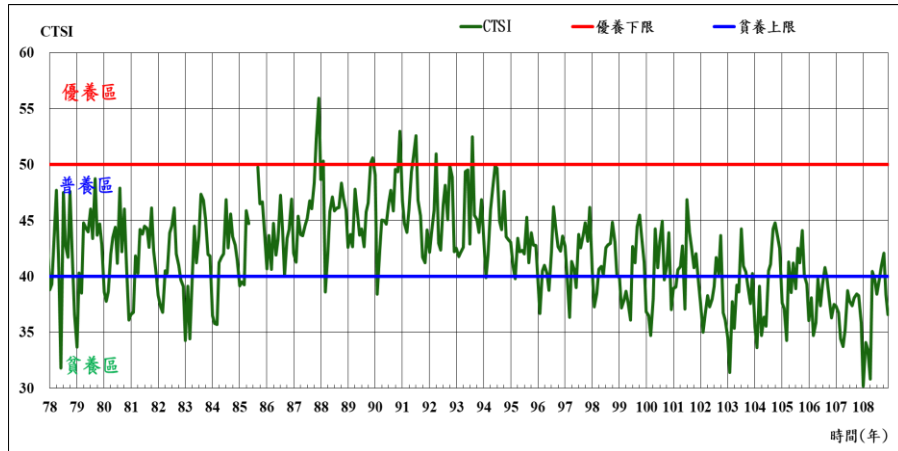Operate the remote backup gate control system

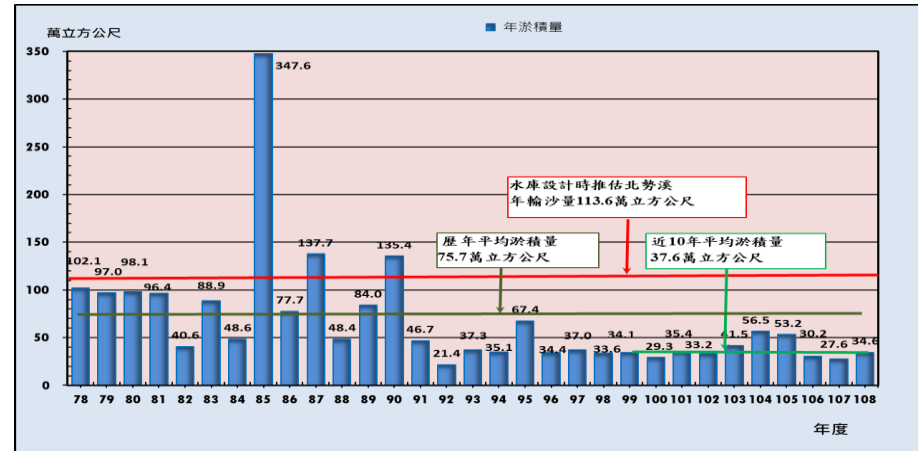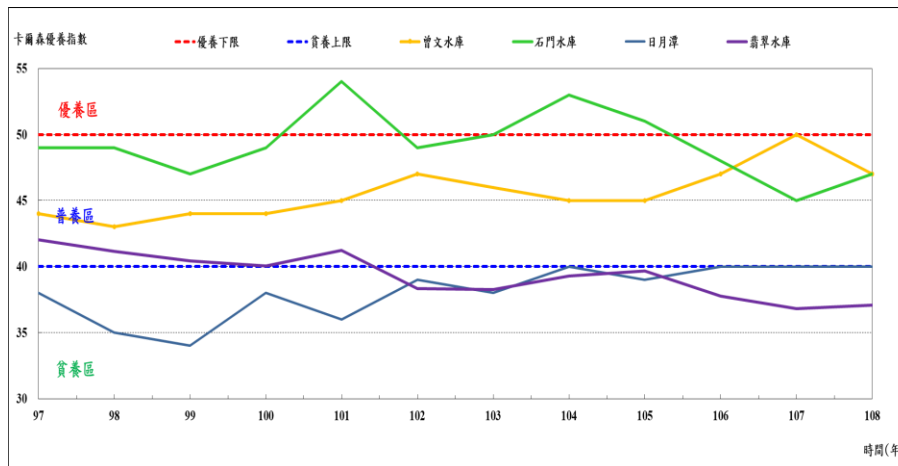Display of the remote backup gate control system

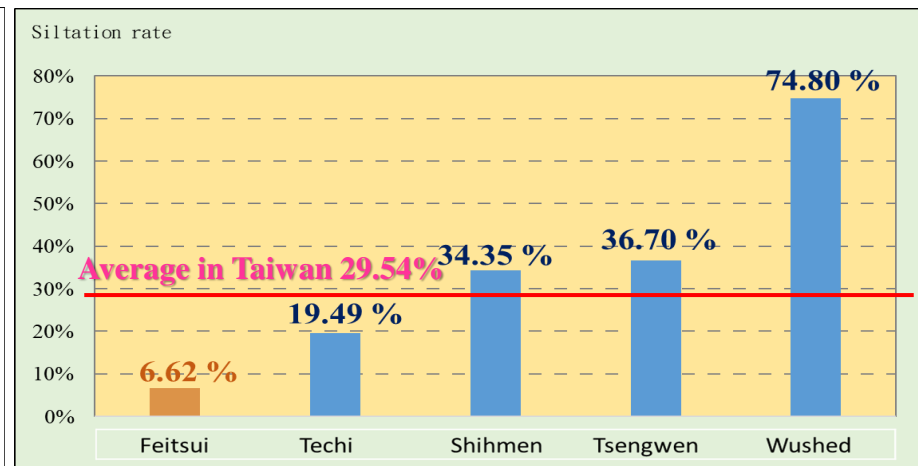# Secure the Water Sources of the Greater Taipei Area

Carlson Trophic State Index of Feitsui Reservoir

Sedimentation of Feitsui Reservoir

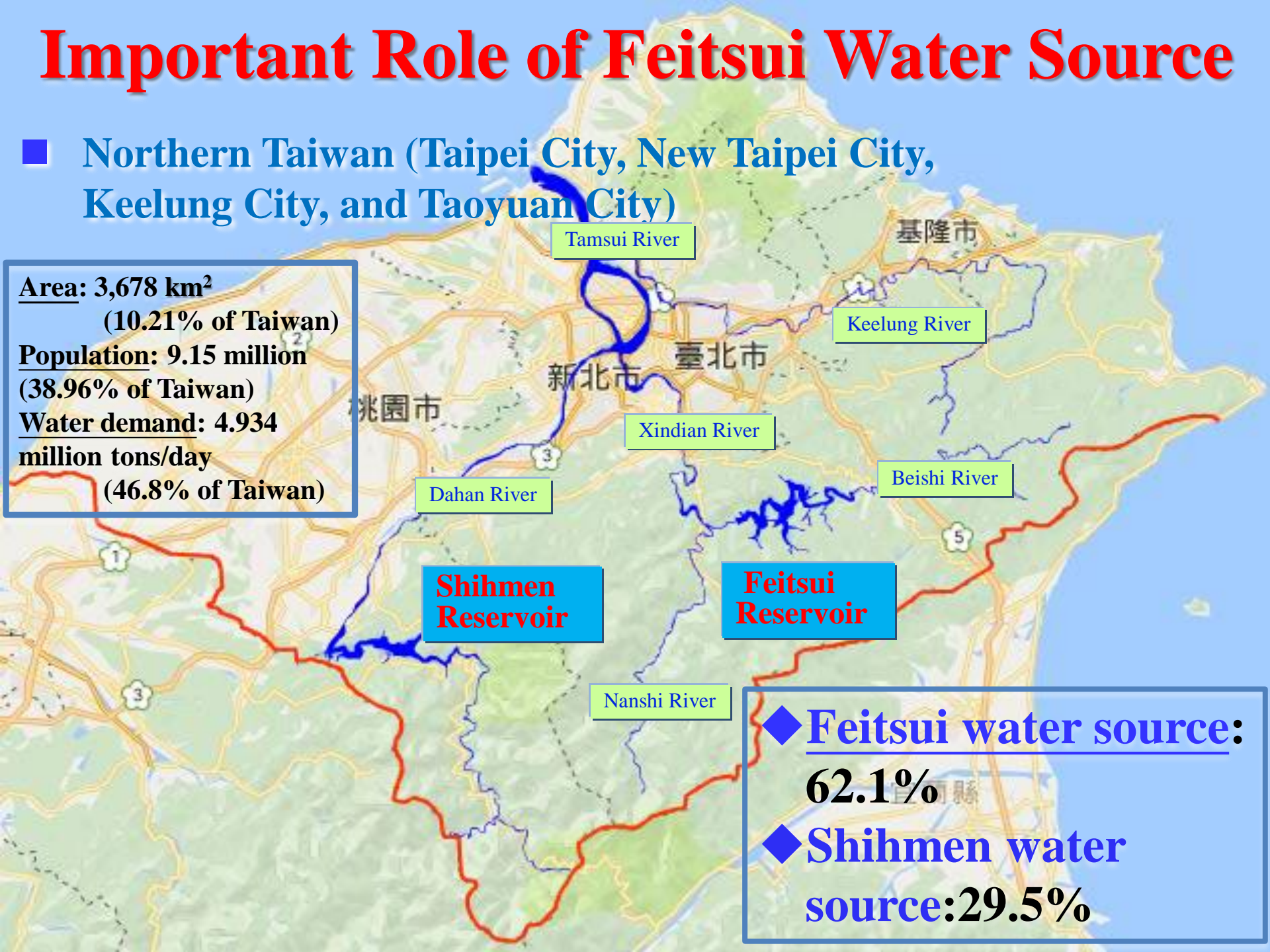**Comparison of water quality among the three major reservoirs**

Sedimentation ratio comparison between Feitsui Reservoir and other major reservoirs

Important Role of Feitsui Water Source

■ **Northern Taiwan (Taipei City, New Taipei City, Keelung City, and Taoyuan City)**

Area: 3,678 km^2
        (10.21% of Taiwan)
Population: 9.15 million
(38.96% of Taiwan)
Water demand: 4.934 million tons/day
        (46.8% of Taiwan)

Tamsui River

Keelung River

Xindian River

Beishi River

Dahan River

Shihmen Reservoir

Feitsui Reservoir

Nanshi River

◆**Feitsui water source:**
62.1%
◆**Shihmen water source: 29.5%**

基隆市

臺北市

新北市

桃園市

Vision

Be a best sustainable reservoir

Thanks for your attention