Hitachi Inspire the Next

Dio Vista Flood

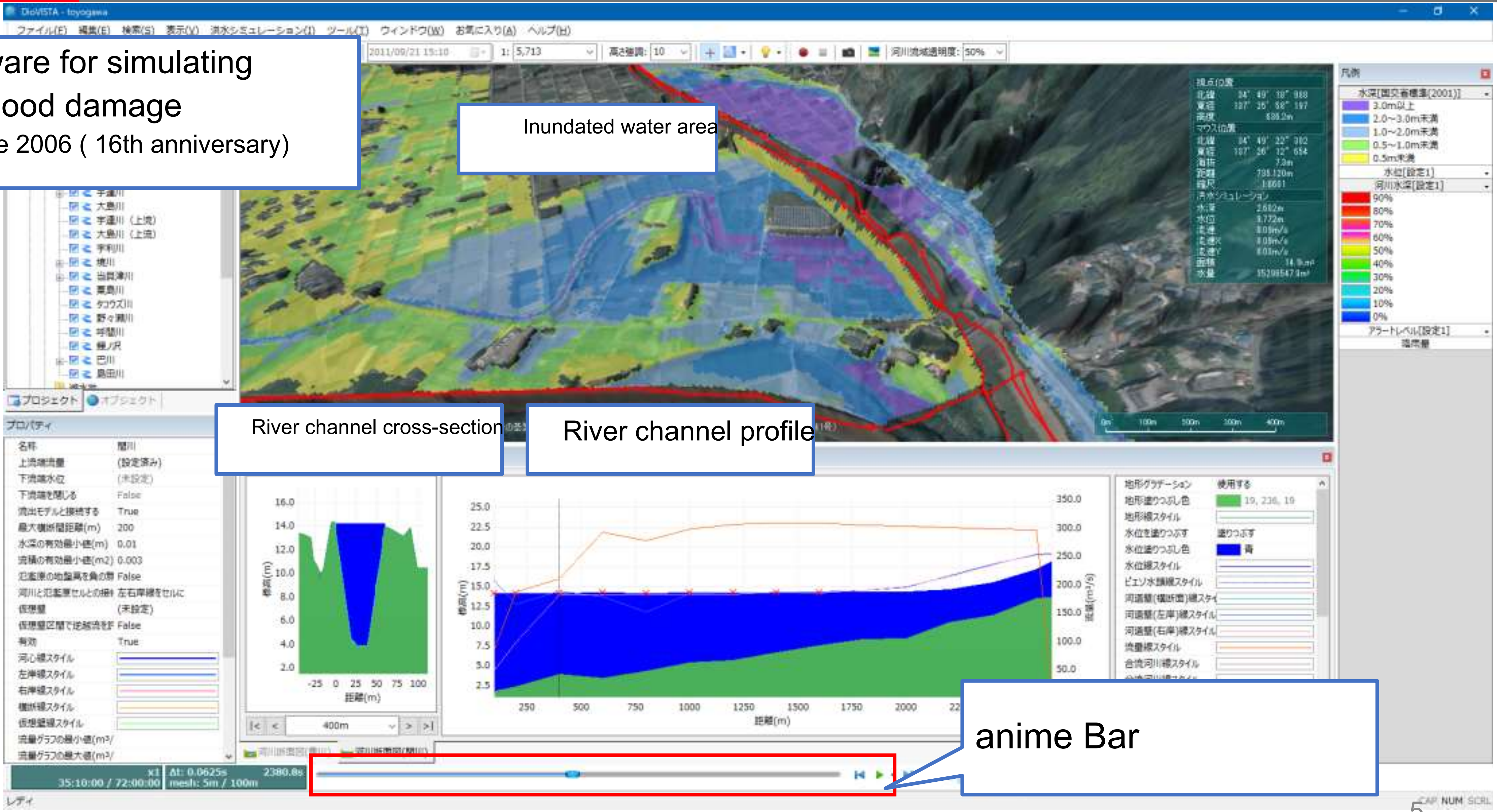
Utilization of DioVISTA Flood for watershed flood control

July 6, 2022Hitachi Power Solutions Corporation

What is DioVISTA/Flood?

HITACHI
Inspire the Next

- Software for simulating flood damage
- Sold since 2006 (16th anniversary)



Mokuji

HITACHI
Inspire the Next

User testimonials ~ Impressions of using

HITACHI
Inspire the Next

Calculation speed is insanely fast

It is 10 times faster than the self-developed program . What have you been struggling with so far?

Easy to use.

As you use it, you can grasp how to use it.

Can be used for business.

Analysis and data output in accordance with various manuals of the Ministry of Land, Infrastructure, Transport and Tourism are possible.

I want to use it for various tasks.

It is also used for overseas projects.

I decided to introduce it at my new job.

Be proactive and be able to bid.

User Voice ~ Application

What kind of work do you use it for?

- Construction Consultant
  - Map of expected flooding areas (national management, prefectural management, small rivers)
  - Evaluation of investment effects of flood control projects (Flood Control Economic Survey)
  - Drainage station and drainage channel development plan
  - Post-flood surveys
- Property and casualty insurance
  - Risk quantification of client properties (domestic and international)
  - Assistance with customer flood control (BCP)
  - Quantification of mega-risks

Users' Voices ~ Future Developments

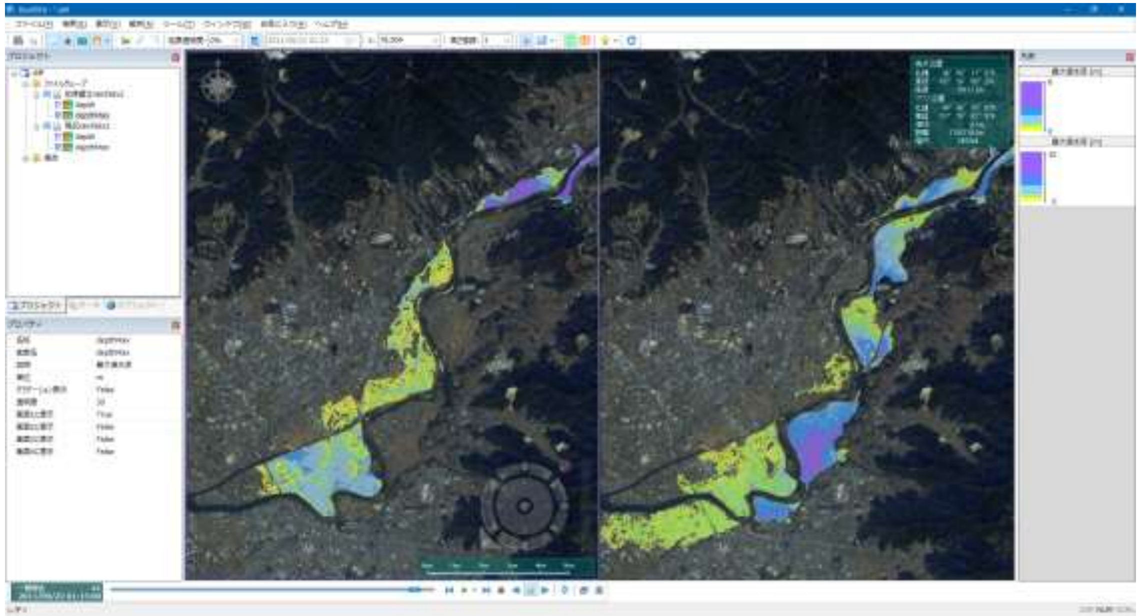
What kind of work do you want to use it for in the future?

- Construction Consultant
  - Examination of river basin flood control, multi-stage flood assumption map, flood damage risk map
  - INTEGRATION WITH CITY DATA, DIGITAL TWIN, PLATEAU
  - Linkage with flood sensors
  - Flood prediction
- Property and casualty insurance
  - Inland flood risk assessment

Image of study of river basin flood control

HITACHI
Inspire the Next

What do you want to do in
"Basin Flood Control"?

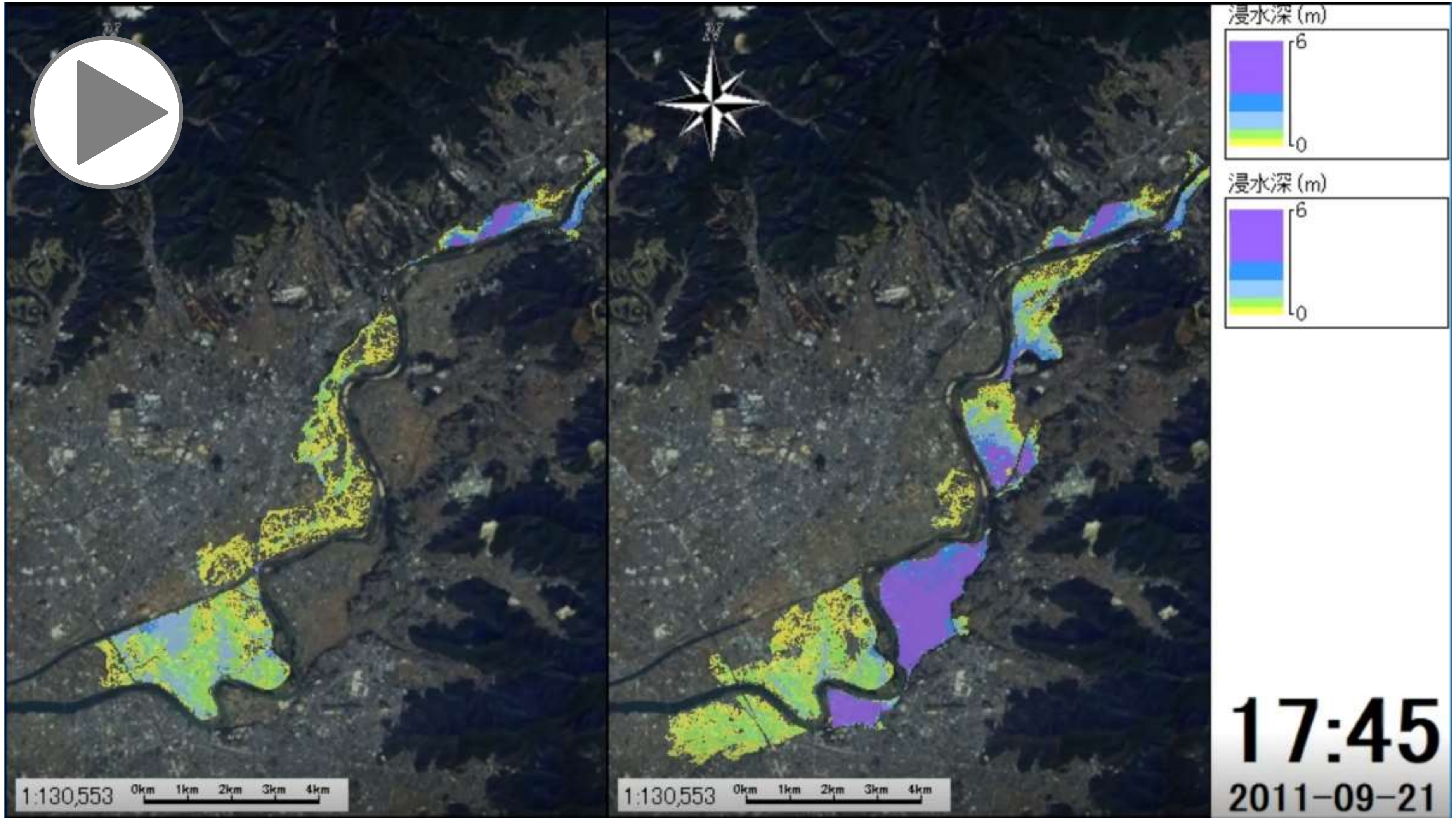


Examination of the flood control effect of the Kasumi levee (comparison of the maximum inundation depth) Left: Abolishment of the Kasumi Levee, Right: Current status

- Quantification of flood control effects
  - Rice field dams, irrigation ponds, agricultural canals
  - Dams, drainage basins
  - Kasumi embankment, road embankment
  - Sewage and drainage stations
  - Rainfall runoff area
  - ...
- DioVISTA will improve the model expressiveness necessary for studying watershed flood control.

Image of study of river basin flood control

HITACHI
Inspire the Next



Examination of flood control effect of Kasumi levee (comparison of inundation depth time series) Left : Abolishment of Kasumi levees, Right: Current status

Image of a digital twin

HITACHI
Inspire the Next

What do you want to do with a "digital twin"?

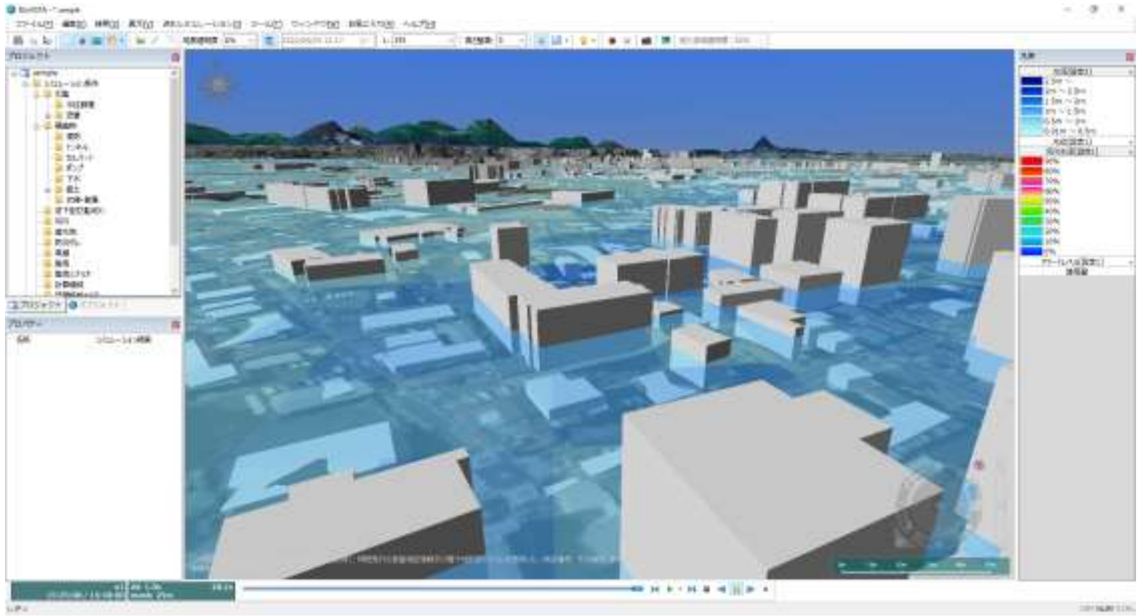


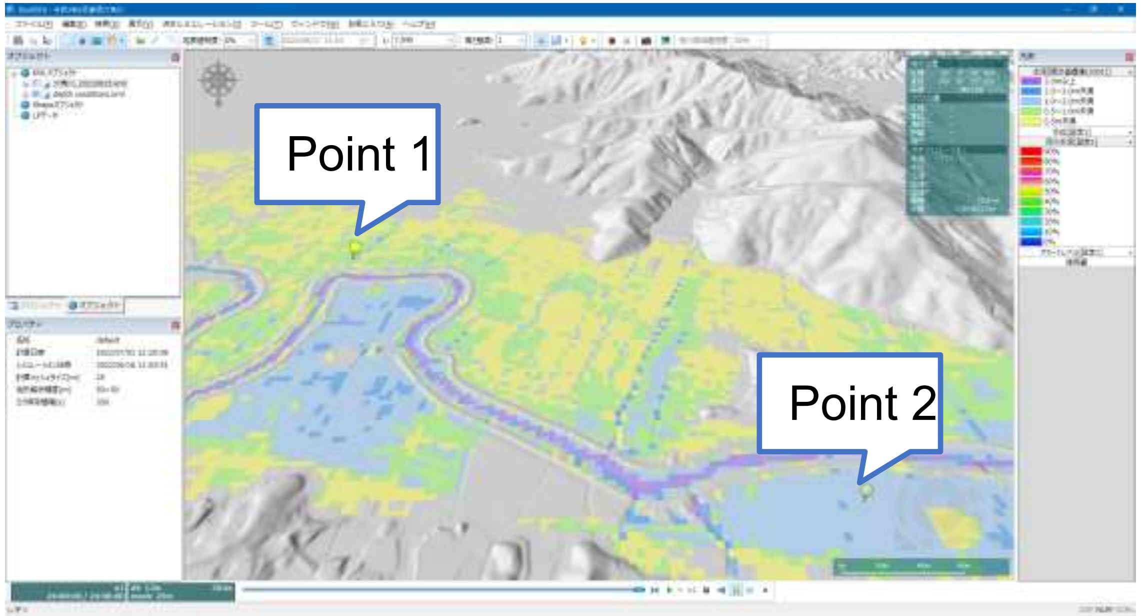
Image of disaster prevention training system using digital twin City data (CityGML) displayed in DioVISTA

- Realistic disaster drills with city data and simulations
  - Simulation under any external force conditions
  - Aggregate the number of affected populations and buildings
  - Extraction of roads to be restricted and shelters to be opened
  - Organize the actions to be taken in a timeline through training
- Aiming to integrate Hitachi's disaster prevention information system with simulation

Image of flood sensor linkage

HITACHI
Inspire the Next

What do you want to do with "Flood Sensor Integration"?

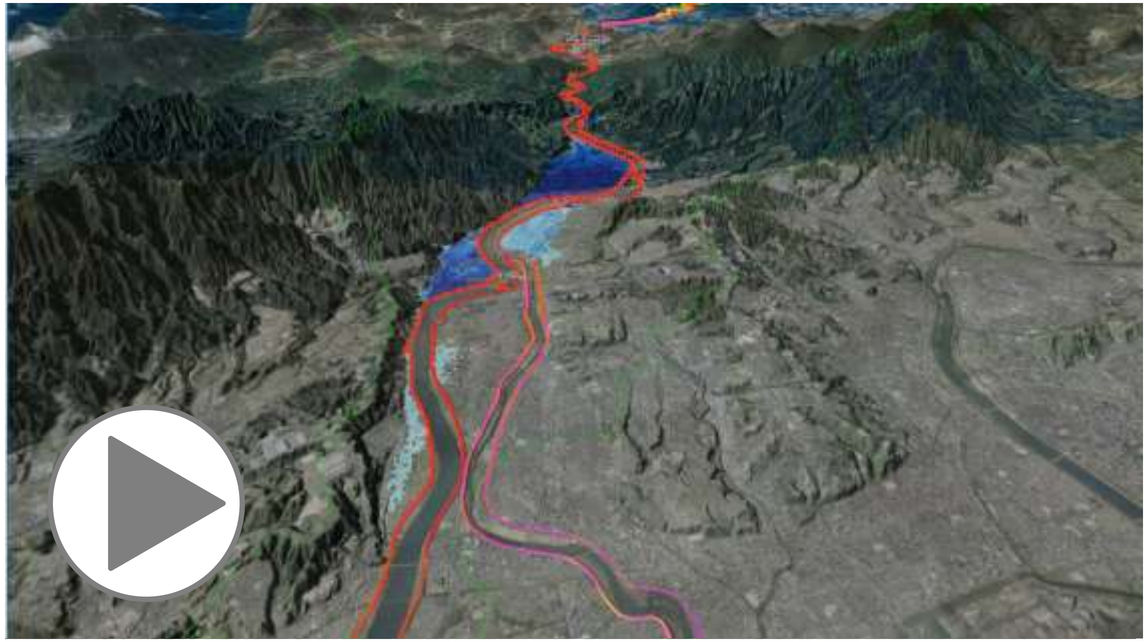


Function to give water depth by point and estimate the spatial distribution of water depth

- Estimate inundation areas from a large number of flood sensors deployed in urban areas
  - Estimate surface information based on the inundation depth of several points
  - Use of information from SNS and other sources
- We are developing technology to deploy location information on surfaces
  - Considering the terrain, etc.
  - Estimate flooded areas in a short time using cloud computers

Image of flood prediction

What do you want to do
in "Flood Prediction"?



System for predicting inundation areas from rainfall prediction

- Predict inundation areas based on rainfall information
  - Using models created for studies of watershed flood control, etc.
  - Demonstrate the effects of watershed flood control to collaborators and beneficiaries of watershed flood control in real time
- Aim to provide information to realize collaboration and disaster mitigation

Mokuji

Features of DioVISTA

HITACHI
Inspire the Next

1. High-speed arithmetic

- highly accurate simulation in a short time
- Apply unique high-speed arithmetic algorithms

2. Easy-to-understand operation

- can simulate it as if you were operating a map.
- Ready to use without being an expert

3. Analysis from rainfall to flooding

- Outflow - River-flood models can be interlocked
- Model structures such as dams and drainage areas

Features of DioVISTA

HITACHI
Inspire the Next

1. High-speed arithmetic

- highly accurate simulation in a short time
- Apply unique high-speed arithmetic algorithms

2. Easy-to-understand operation

- can simulate it as if you were operating a map.
- Ready to use without being an expert

3. Analysis from rainfall to flooding

- Outflow - River-flood models can be interlocked
- Model structures such as dams and drainage areas

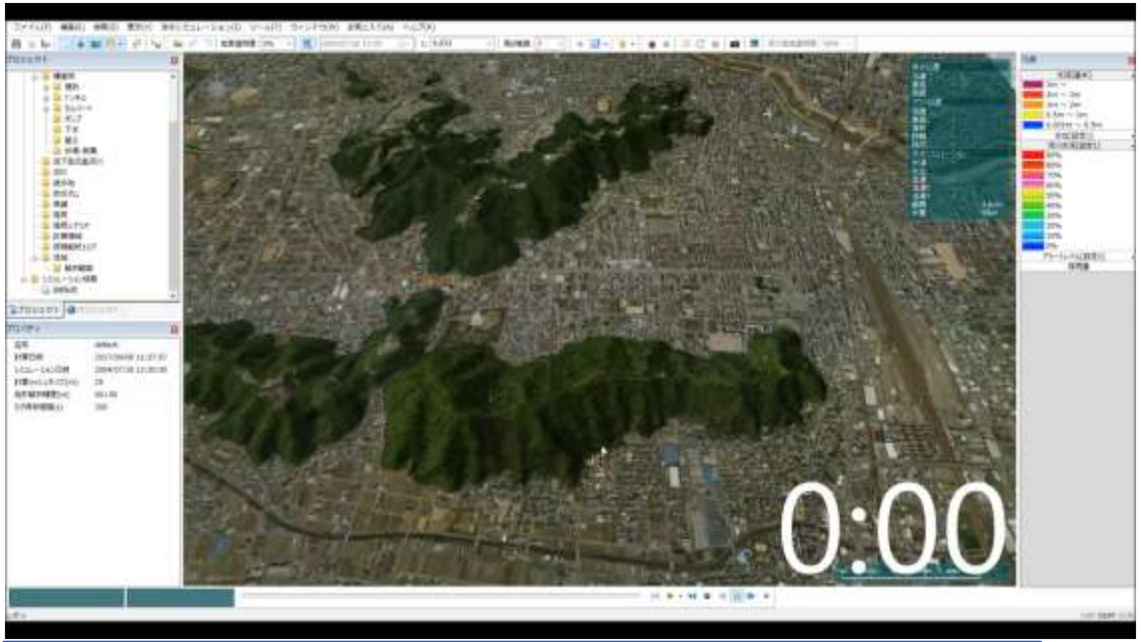
Feature 1 : High-speed arithmetic

- Applied Hitachi's patented Dynamic DDM technology
  - 10 times faster than our company
  - Patents in Japan, USA, China


賞状
発明奨励賞
山口悟史殿
ほか一名
水害シミュレーションの高速化手法
右の発明はわが国科学技術の向上と産業の振興に貢献されました よって令和元年度関東地方発明表彰において本賞を贈りその功績をたたえます
令和元年十一月十三日
公益社団法人 発明協会

Kanto Regional Invention Commendation Invention Encouragement

Award DioVISTA Screen example: Reproduction of the Fukui torrential rain disaster in July 16

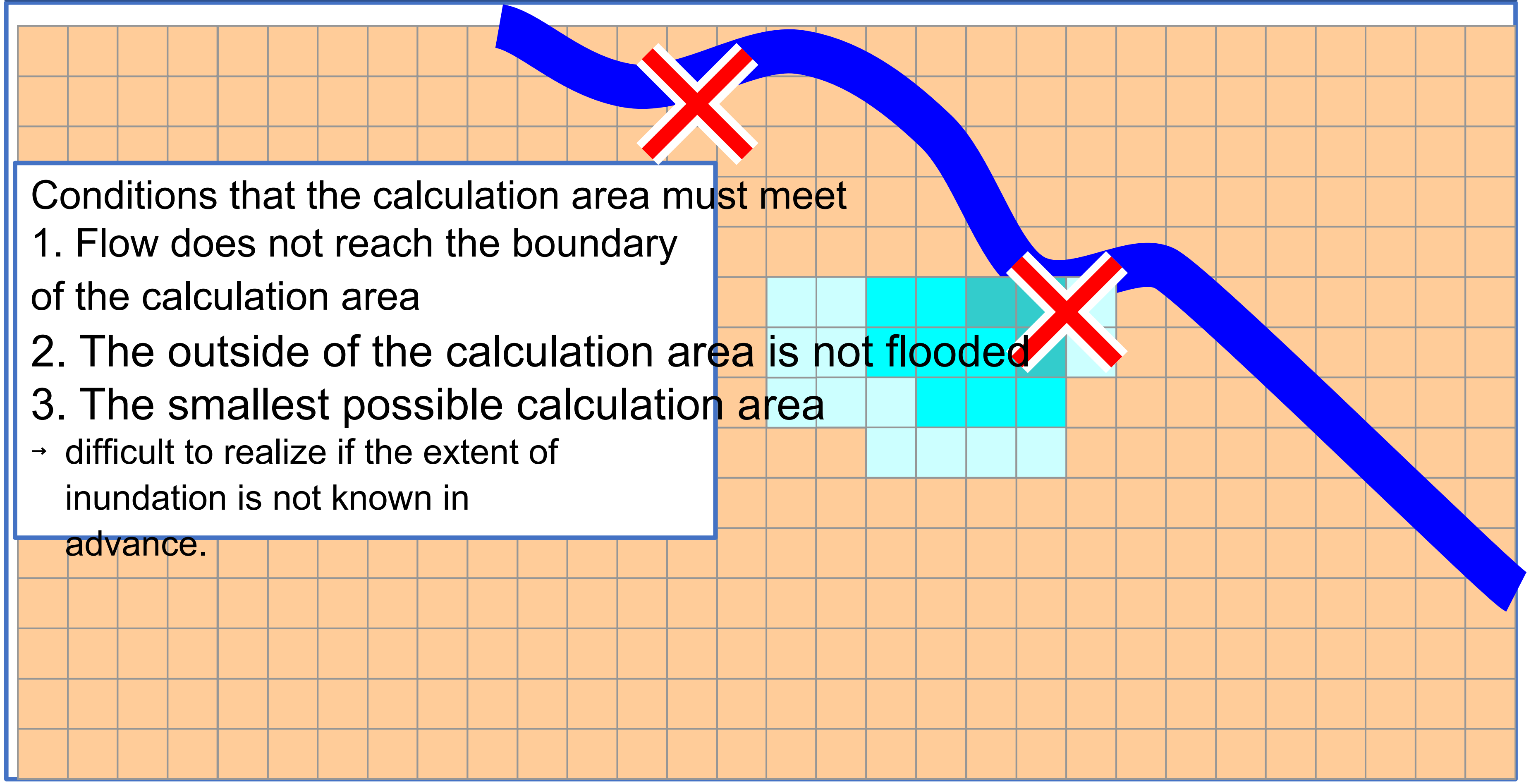


Complete 6 hours of flood analysis in 4 secondsVisualize intermediate results during simulation executionMesh size 25 m

Japan Patent No. 4761865, U.S. Patent 7603263, Chinese Patent PZL200610008661.4 Reiwa, Kanto Regional Invention Award Encouragement Award

Traditional calculation methods

Flood model (conventional method)



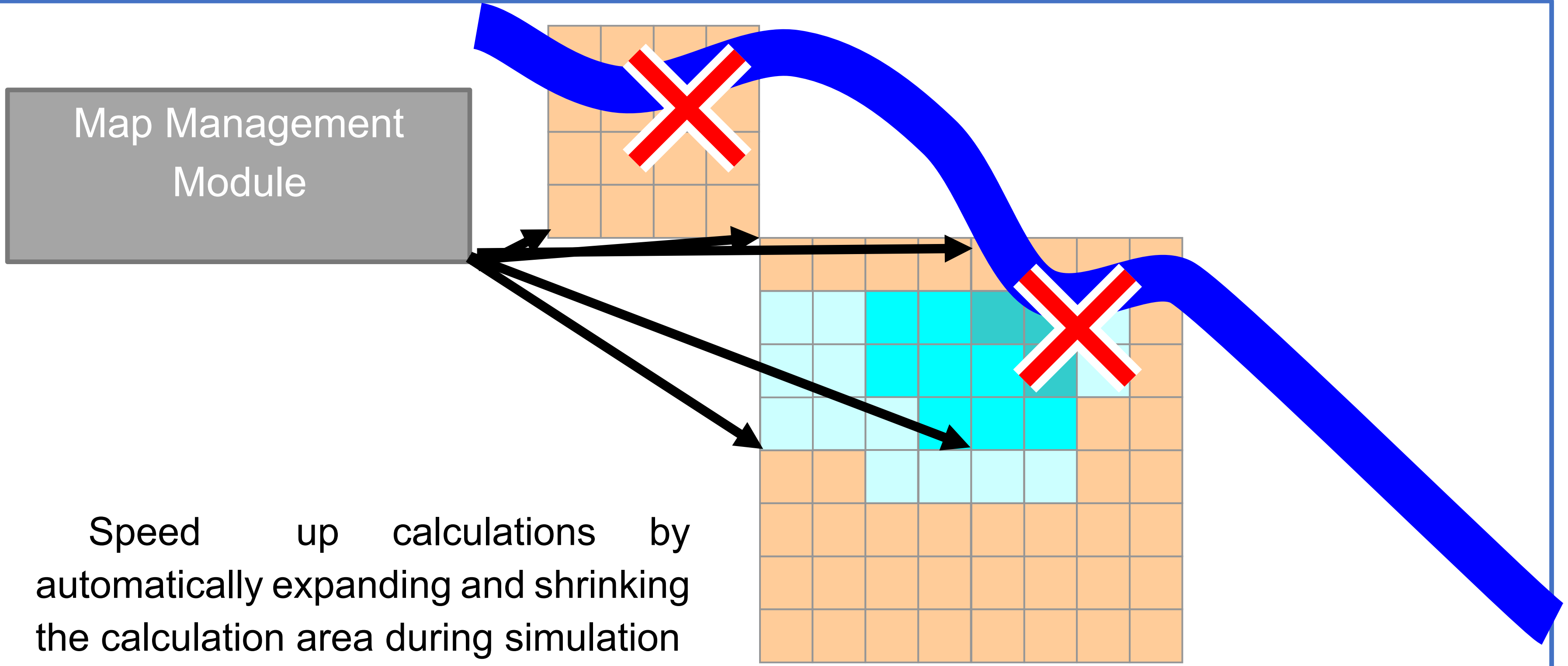
Conditions that the calculation area must meet

1. Flow does not reach the boundary of the calculation area
2. The outside of the calculation area is not flooded
3. The smallest possible calculation area

→ difficult to realize if the extent of inundation is not known in advance.

Hitachi's calculation method

Flood Model (Dynamic DDM)



- Speed up calculations by automatically expanding and shrinking the calculation area during simulation
- Map module automatically loads and unloads small areas

Yamaguchi and Iwamura, Acceleration of Flood Simulation by Dynamic DDM, IPSJ Trans. Mathematical Modeling and Applications, 2007. URL

Features of DioVISTA

HITACHI
Inspire the Next

1. High-speed arithmetic

- highly accurate simulation in a short time
- Apply unique high-speed arithmetic algorithms

2. Easy-to-understand operation

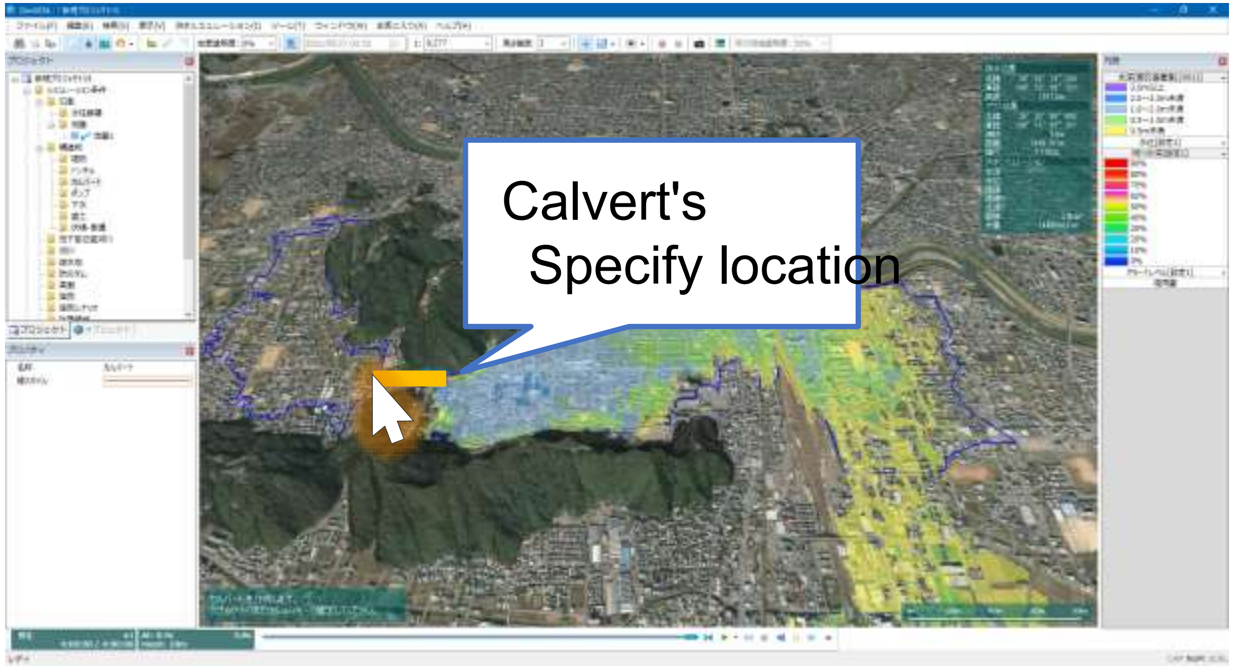
- can simulate it as if you were operating a map.
- Ready to use without being an expert

3. Analysis from rainfall to flooding

- Outflow - River-flood models can be interlocked
- Model structures such as dams and drainage areas

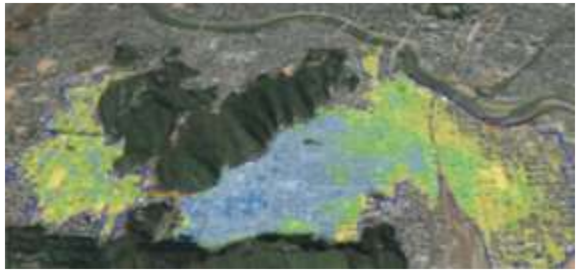
Feature 2 : Easy-to-understand operation

- Simulate as if you were operating a map
  - Advanced simulation is possible even if you are not an expert in hydrological analysis
  - Integration is achieved by developing simulation and 3D map system in-house



No culvert

With culvert



Features of DioVISTA

HITACHI
Inspire the Next

1. High-speed arithmetic

- highly accurate simulation in a short time
- Apply unique high-speed arithmetic algorithms

2. Easy-to-understand operation

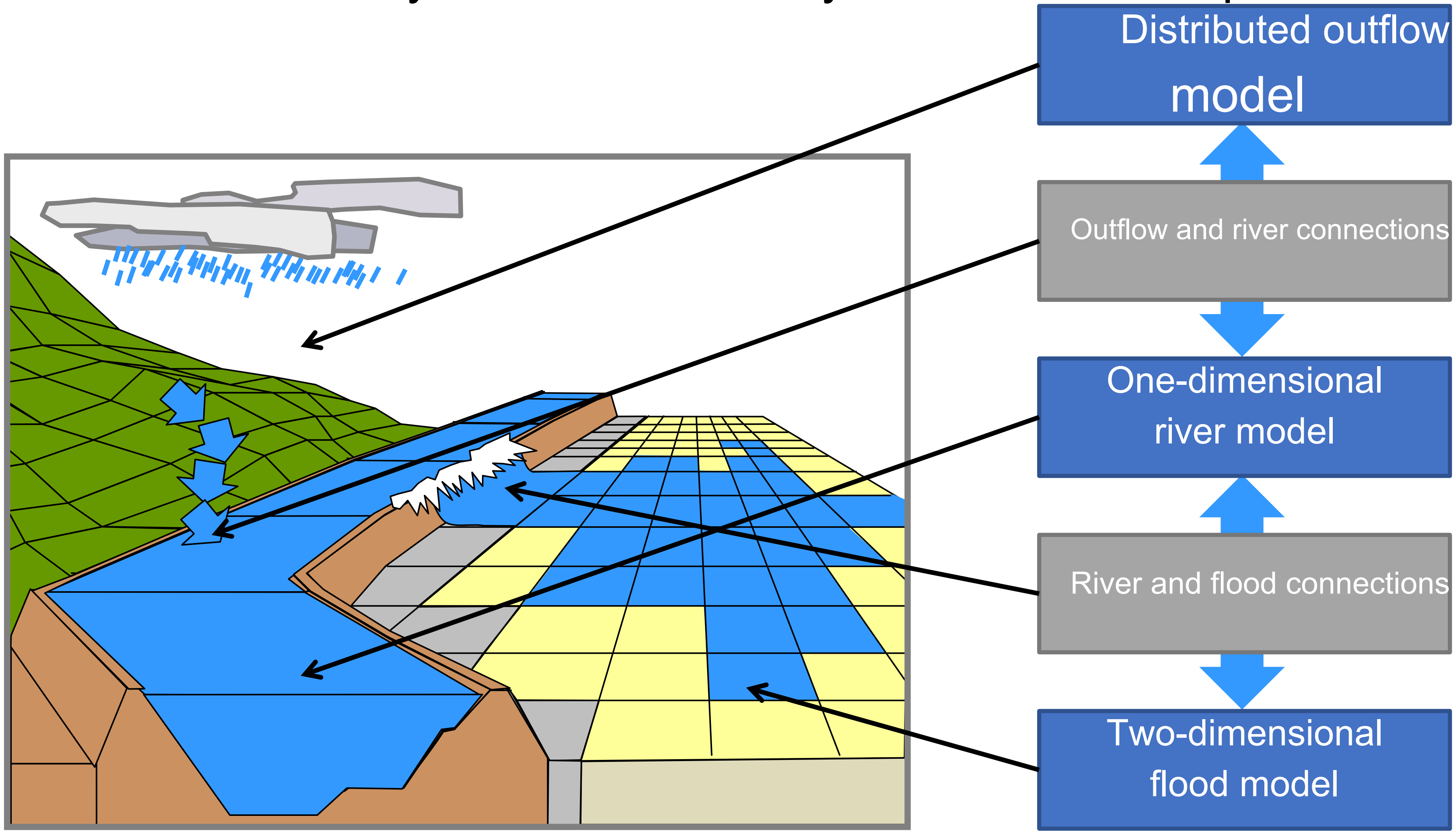
- can simulate it as if you were operating a map.
- Ready to use without being an expert

3. Analysis from rainfall to flooding

- Outflow - River-flood models can be interlocked
- Model structures such as dams and drainage areas

Feature 3 : Analysis from rainfall to flooding

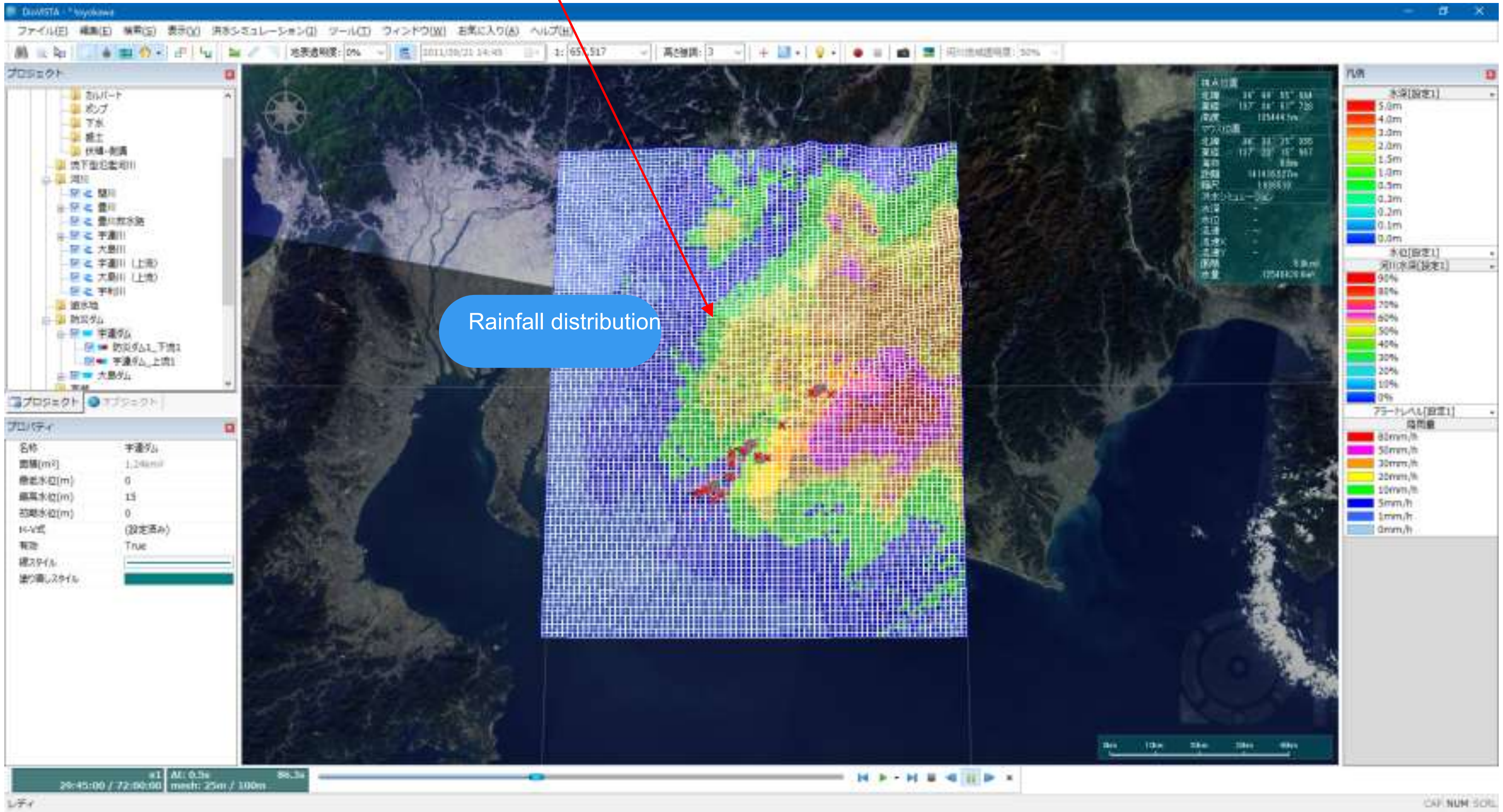
- Integrated simulation of phenomena from rainfall to flooding
- Automatically build the models you need from map data



Patent No. 4959346, Yamaguchi et al., Proposal of high-speed coupled simulation method for small rivers , Annual Meeting of Japan Society of Civil Engineers, 2007. URL

Input of rainfall distribution time series

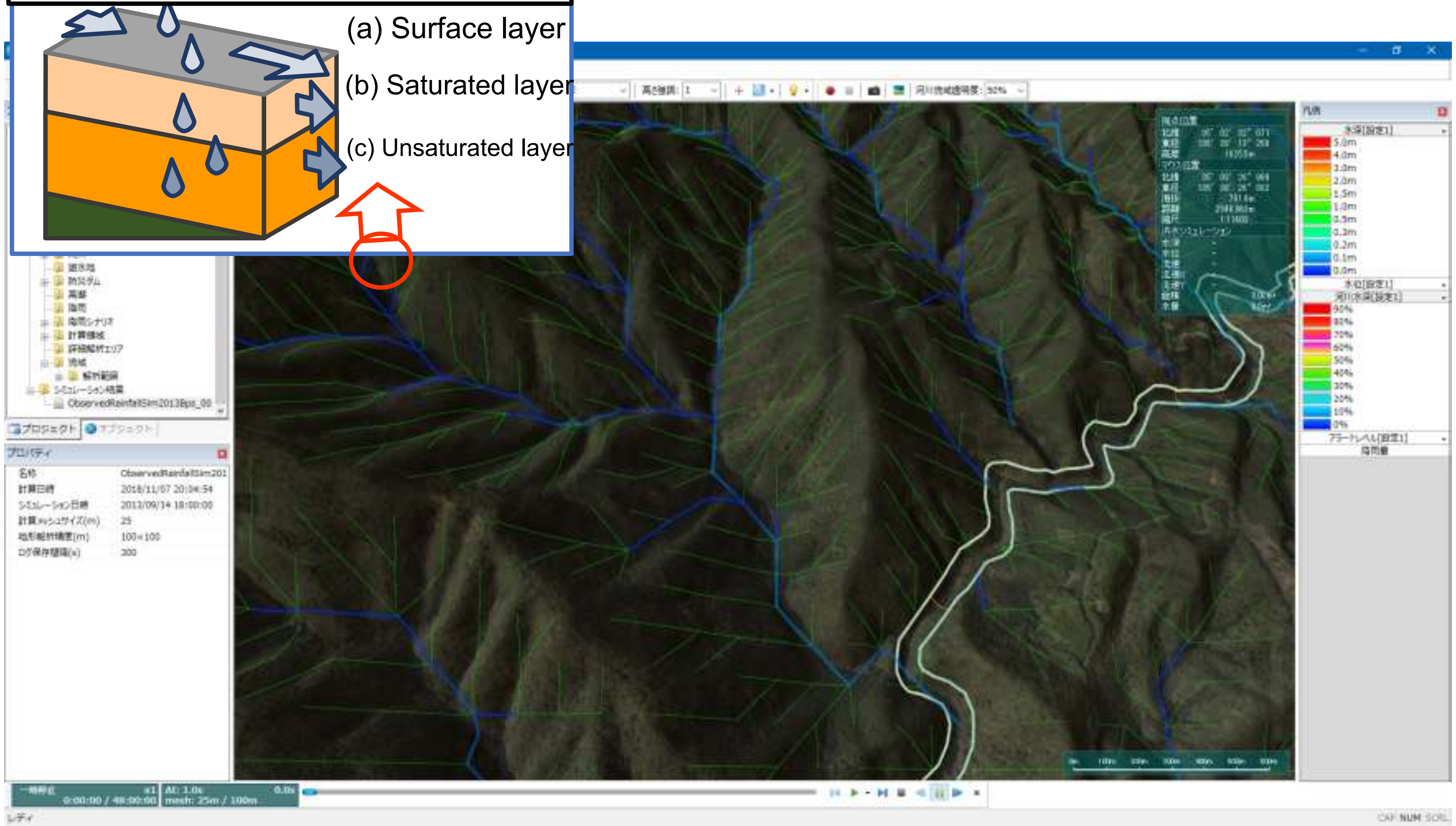
Give historical rainfall distribution (color represents rainfall intensity)



Spillage model

HITACHI
Inspire the Next

Analyze rainwater infiltration into the soil

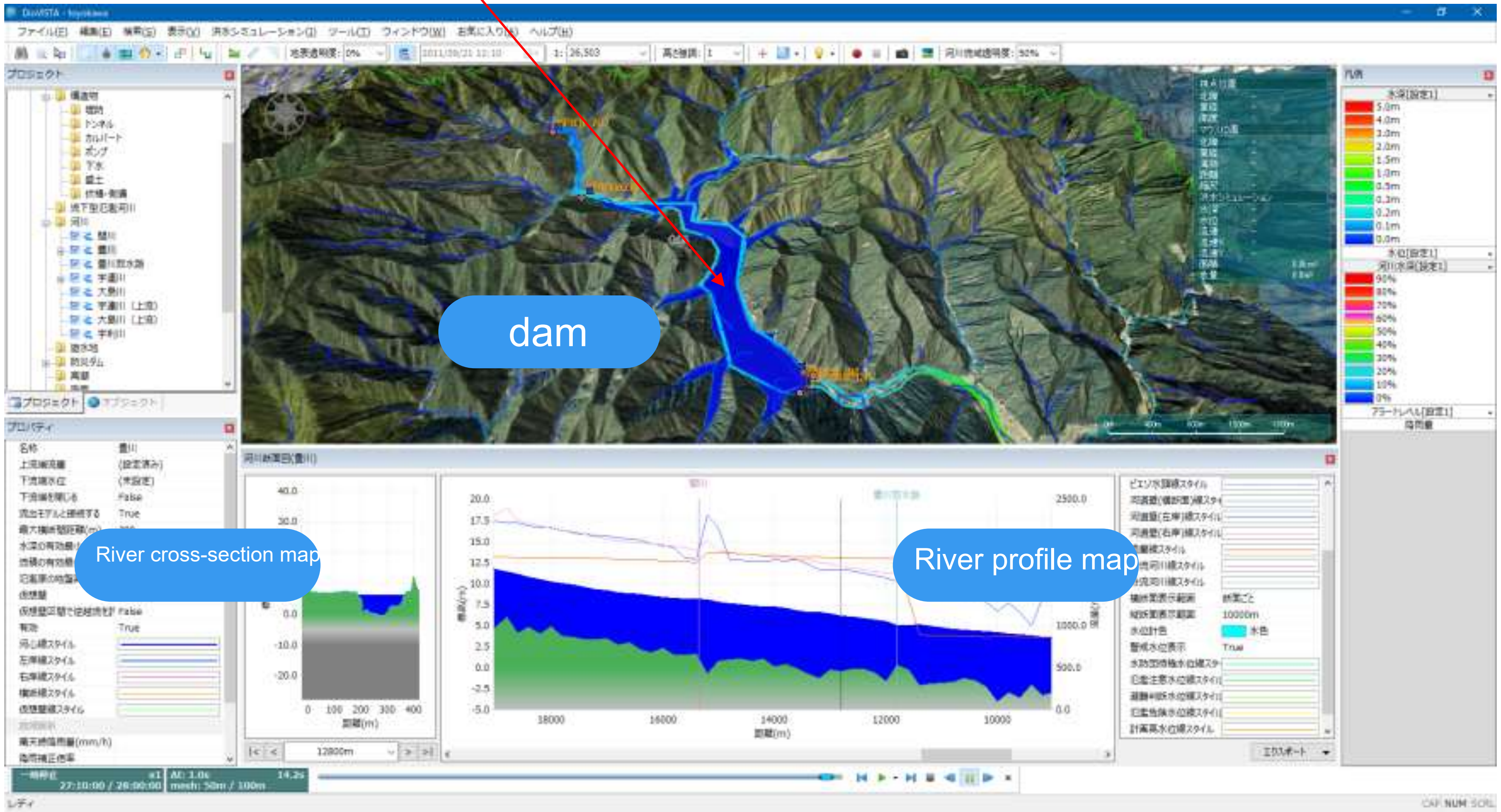


Tachikawa et al., Development of Flow Flow Product Equation Introducing Mechanism of Saturated and Unsaturated Flow , Journal of Hydraulic Engineering, 2004. URL

Dam and River Models

HITACHI
Inspire the Next

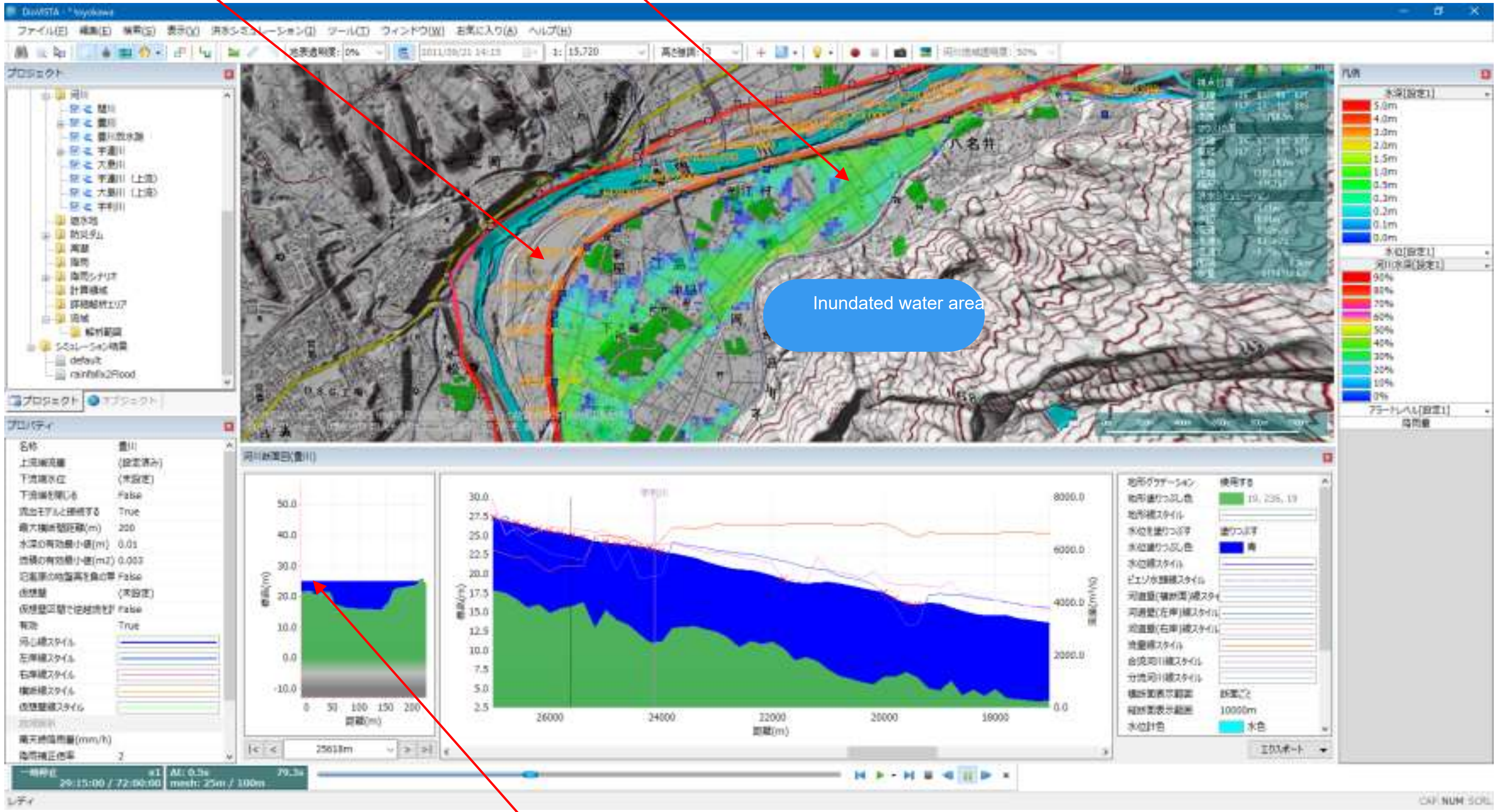
Dam (color changes to blue → red depending on the water level)



Flood Model

Rivers downstream of the dam

Flooded areas



The river water level exceeds the height of the embankment

Types of models available

HITACHI
Inspire the Next

- Outflow model: Distributed 3 layers
- River channel model: 1D irregular flow
- Flood model: 2D indefinite flow
- Dumb model: HV type, main operation
- Overflow model: overflow formula
- Others: Drainage basins, river confluences, river diversions, drainage stations, gutter gates, weirs, lateral inflows, wall stands, embankments, culverts, siphons, gutters,gutters, 、...

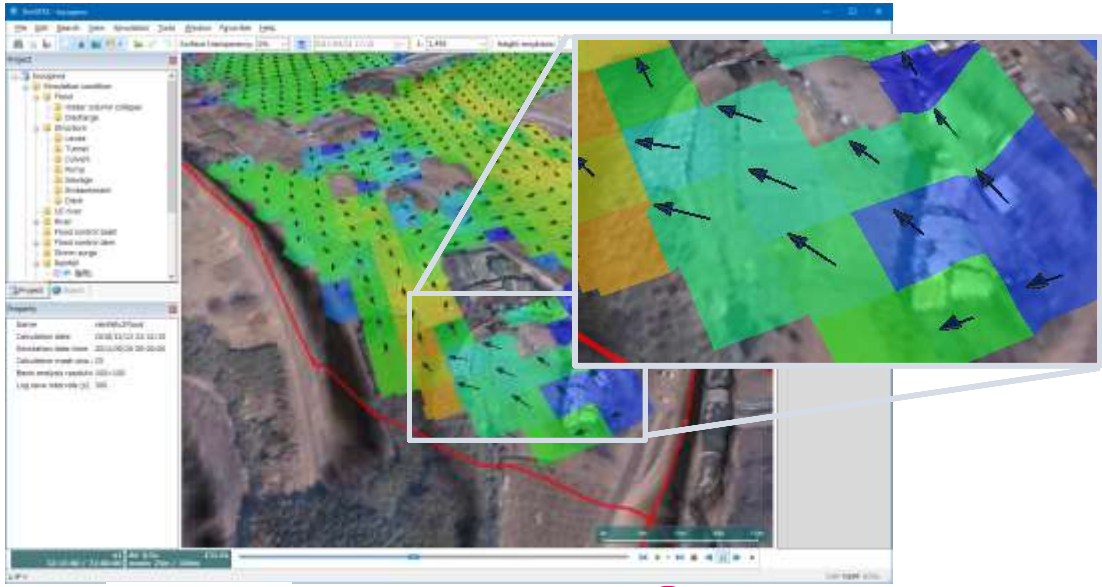
DioVISTA's contribution to watershed flood control

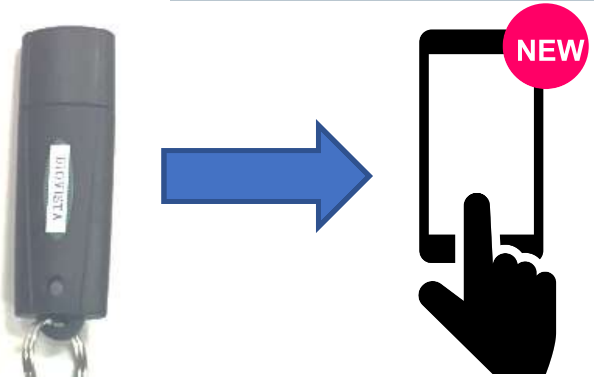
- Be able to quantify the effects of various flood control measures
  - Rainfall can be given and integrated analysis of internal and external water
  - Simulate dams, drainage areas, embankments, rice fields, etc.
- Low analysis cost
  - Numerous scenarios can be analyzed on a Windows PC
  - Conditions can be set as if you were operating a map.
  - Calculation results can be obtained in a short time
  - Simulations under different conditions can be performed without special training
- Reproducible
  - If you are using DioVISTA, you can take over the analysis results even if the analysis company changes.

DioVISTA Flood Upgrade

HITACHI
Inspire the Next

- Previous (February 2022)
  - Arrow indication of flow velocity
  - Initialize river water level with irregular flow
  - Output river water levels and dam water levels to a CSV file (batch processing)
  - Academic license authentication is now online and can be shared by multiple users
- What's next
  - Option to turn off automatic adjustment of time step width
  - Specify the point depth in chronological order, etc.





Switching Academic Activation from Dongle to Online Activation

DioVISTA Flood Upgrade

HITACHI
Inspire the Next

- Planned features
  - Improvement of model expressiveness of basin flood control
    - Rice field dams, reservoirs, runoff areas, etc.
  - Improvements related to flood prediction
    - Option to set the rationale value of "Flood Expected Area (Flood Flow) such as House Collapse" to a continuous value of 0~1 instead of a binary value of 0/1
  - DioVISTA for web browser
    - Simulation condition input and result display in the browser
    - Run simulations in the cloud

Mokuji

HITACHI
Inspire the Next

Dam operation optimization

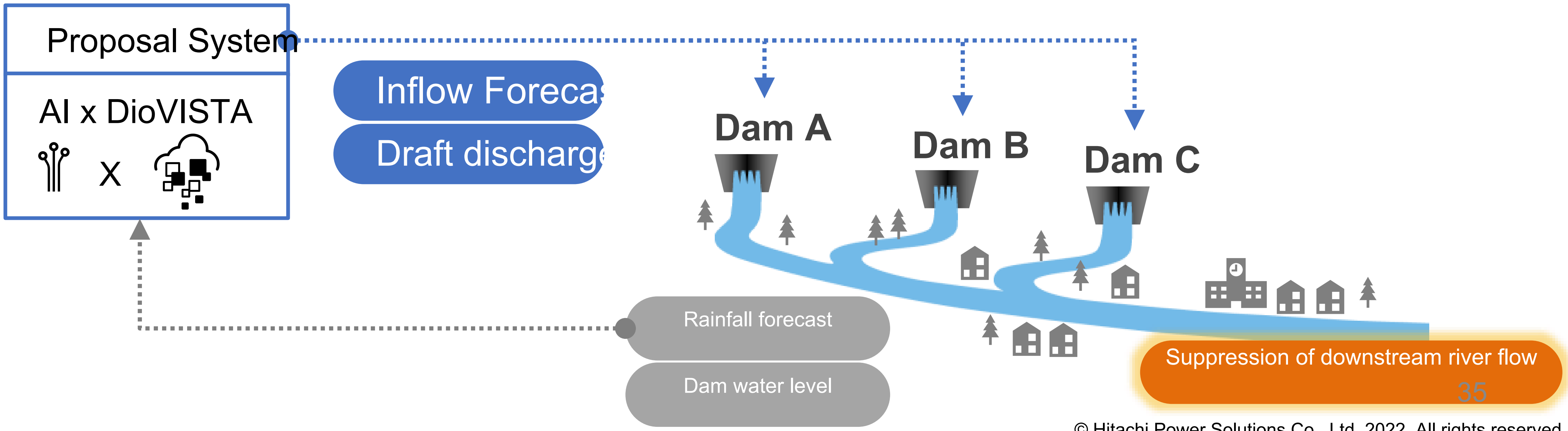
HITACHI
Inspire the Next

- New ways of operating dams are required to minimize flood damage.
  - Conventional: It is common to use "basic operation" to determine the current discharge rate based on the current dam inflow.
  - Future: Maximize use of dams for flood control in emergencies
  - From 2020, pre-discharge of water use dams based on flood control agreements begins.
- Pre-discharge realizes flood damage countermeasures equivalent to 50 Yatsuba Dams
- Optimizing dam operations has a significant effect

Nikkei Business, Special ReportChief Cabinet Secretary Yoshihide Suga Asks the Government's Flood Control Measures Inside the "50 Hachiba Dams ", August 17, 2020 , p. 48-49, URL.

DioVISTA/Dams Dashboard

- Function 1: Dam inflow prediction
  - Realized by a hybrid of AI and simulation
- Function 2: Calculation of discharge plan
  - Calculation of a discharge plan based on the dam inflow forecast

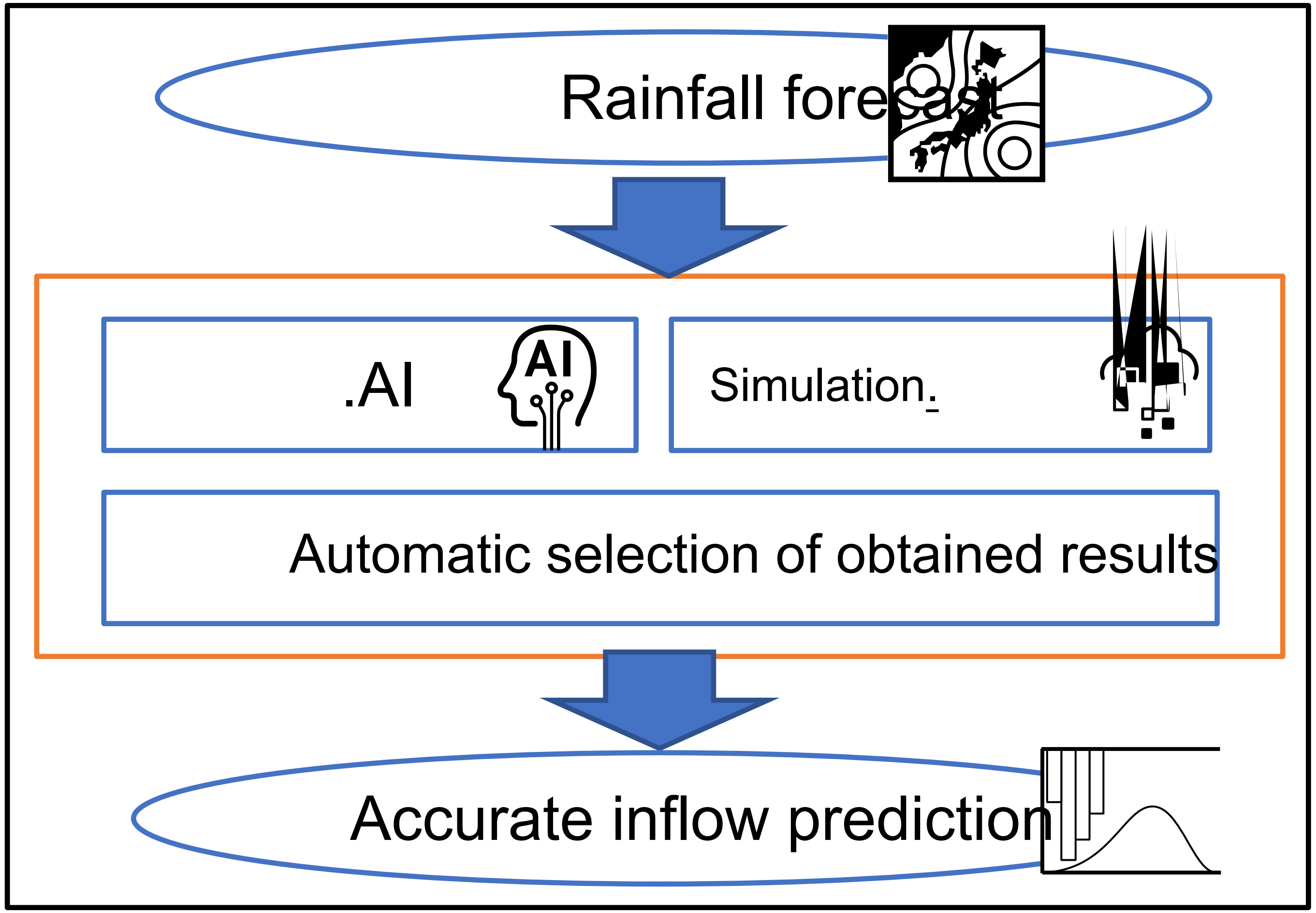


Patent pending

Suggestion: Predict inflow

HITACHI
Inspire the Next

Hybrid AI-simulation predictions

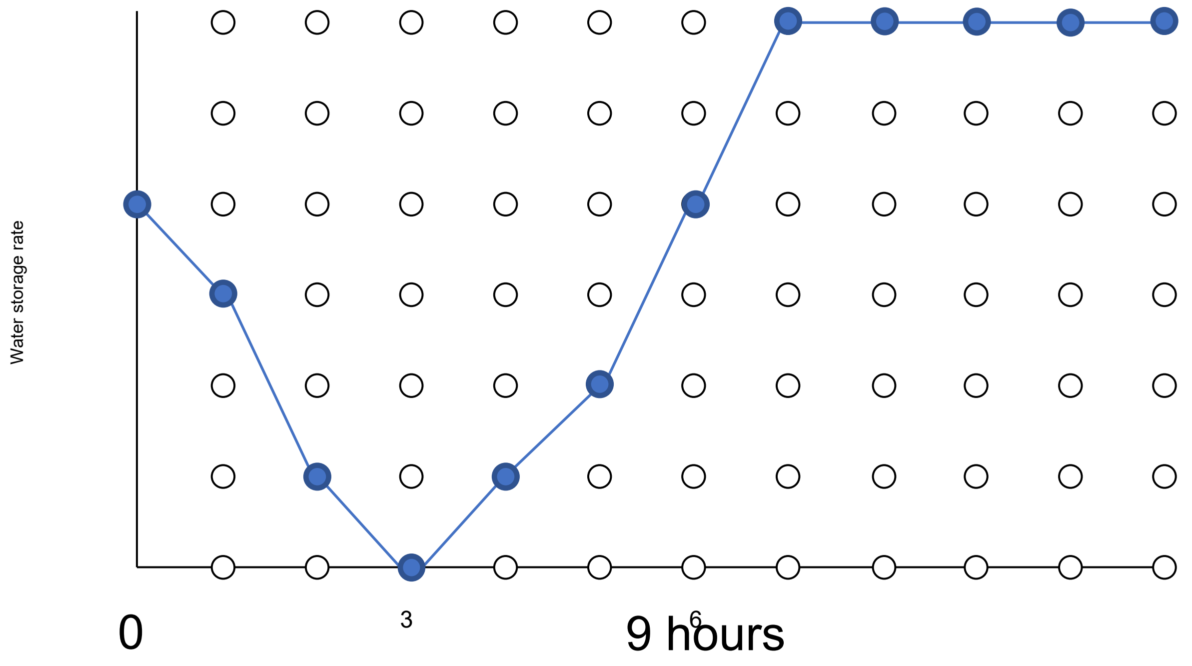


- AI is advantageous for small and medium-sized floods (many cases)
- Simulation is advantageous for large-scale flooding (rare cases)
- Hybrid the two

Patent pending (Japanese Patent Application No. 2019-156573)

Mechanism for planning the discharge of dams

Water storage rate of Dam A



- Determine the water storage rate of a dam at a given time
  - 0 ~ 100% to 0.1% increments: 1000 ways
- Number of combinations considering dam linkage
  - 2 Dams: 1 million ways
  - 5 Dams: 1000 trillion streets
- Repeat this process for up to 1.5 days in advance
  - 1 Dam: 1096 streets
  - 5 dams: 10,540 ways* Most of the operations are unrealistic
- Find a solution in a short time by considering only the operations that look good
  - Developed a unique method "progressive dynamic planning " suitable for dam problems

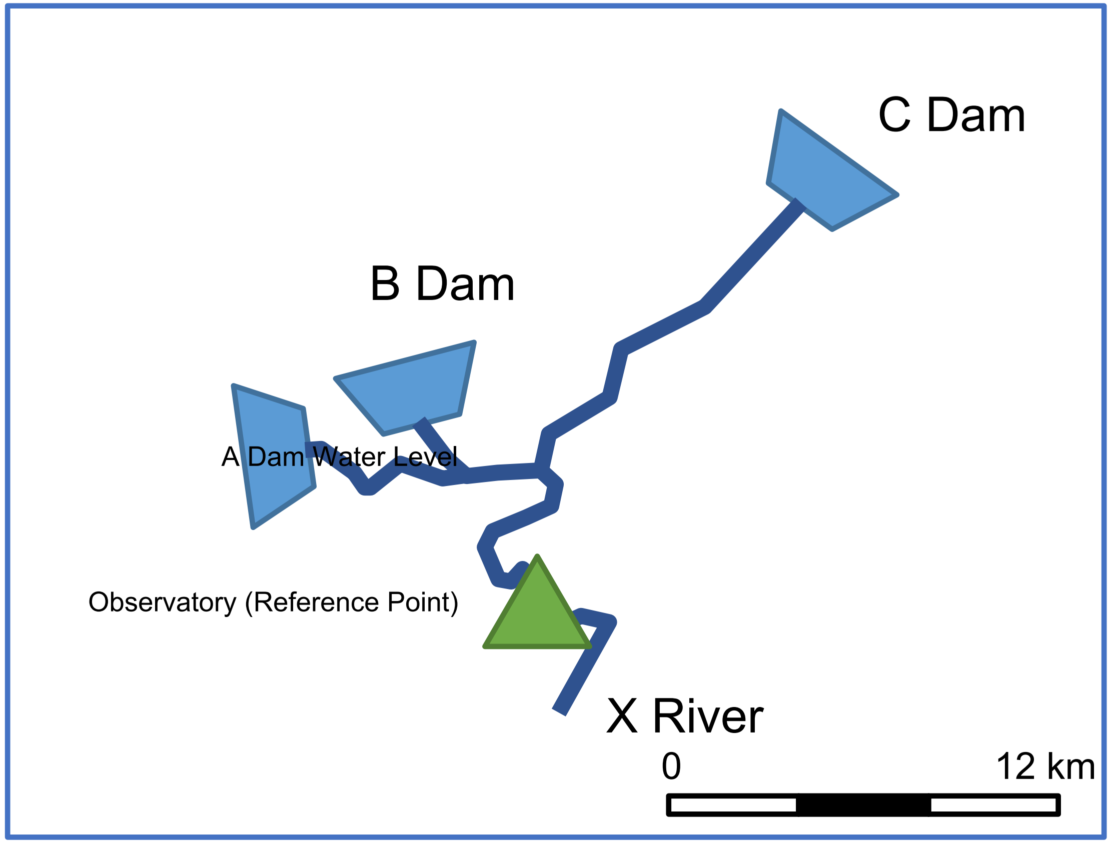
Patent pending; The water storage rate of the dam is optimized in finer steps than 0.1%, but is 0.1% for simplicity.

Experiment 1: X Upstream 3 Dams

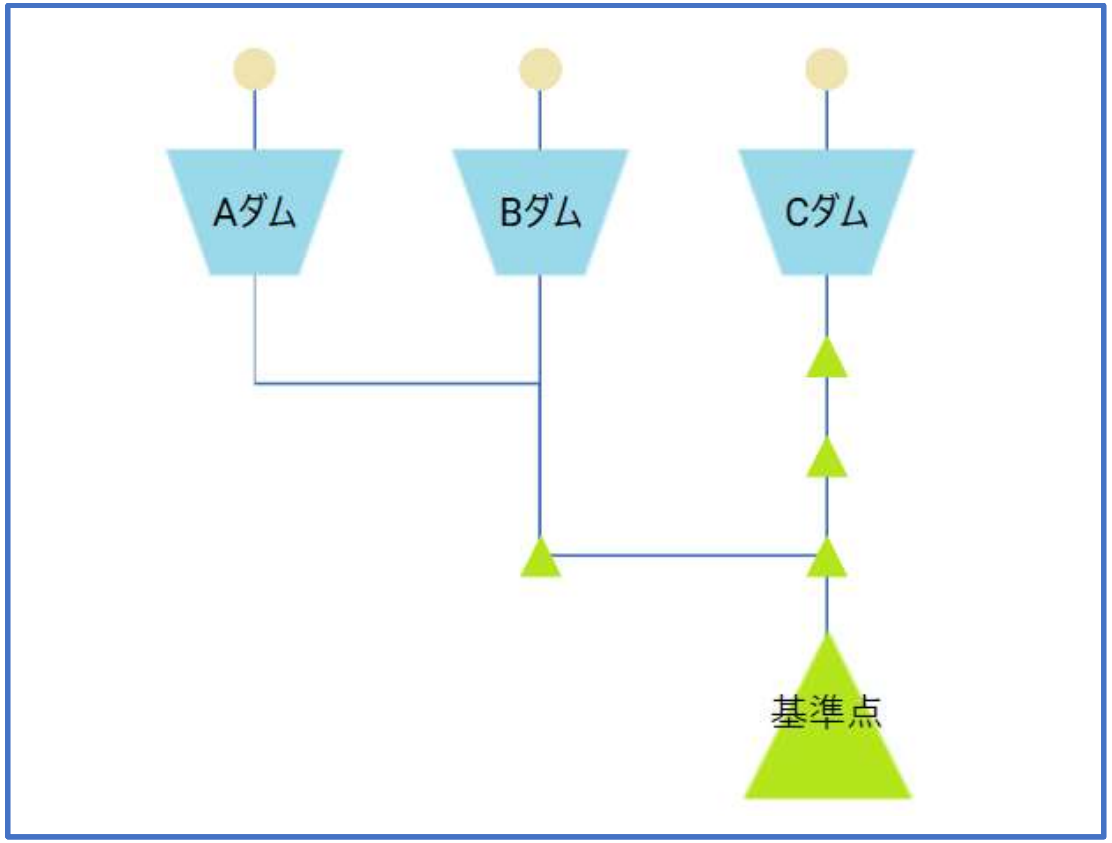
HITACHI Inspire the Next

Purpose: Flood prevention (minimizing river flow at reference points) X

Layout of five upstream dams



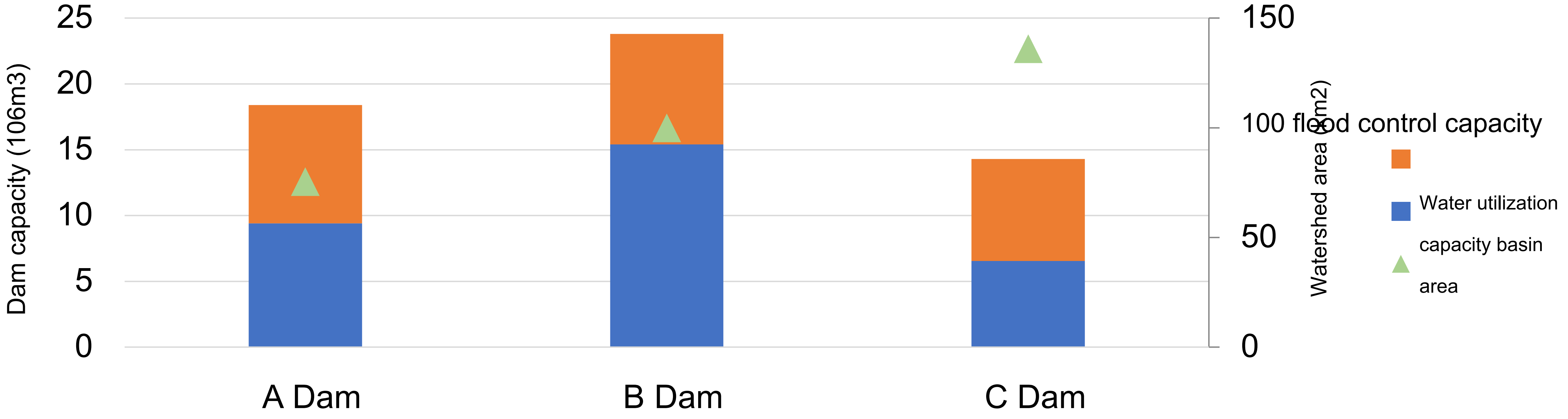
Dams expressed in a model



Yamaguchi and Kusuda, Development and Evaluation of Automatic Dam Discharge Plan Software, Proceedings of the Annual Meeting of the Japan Society of Civil Engineers, 2022. in press.
T. Yamaguchi and K., Development of Progressive Dynamic Programming, Mathematical Optimization Method for Dam Group Linkage Operations , Mathematical Modeling and Applications, 2021. URL.

X Upstream 3 Dam Specifications

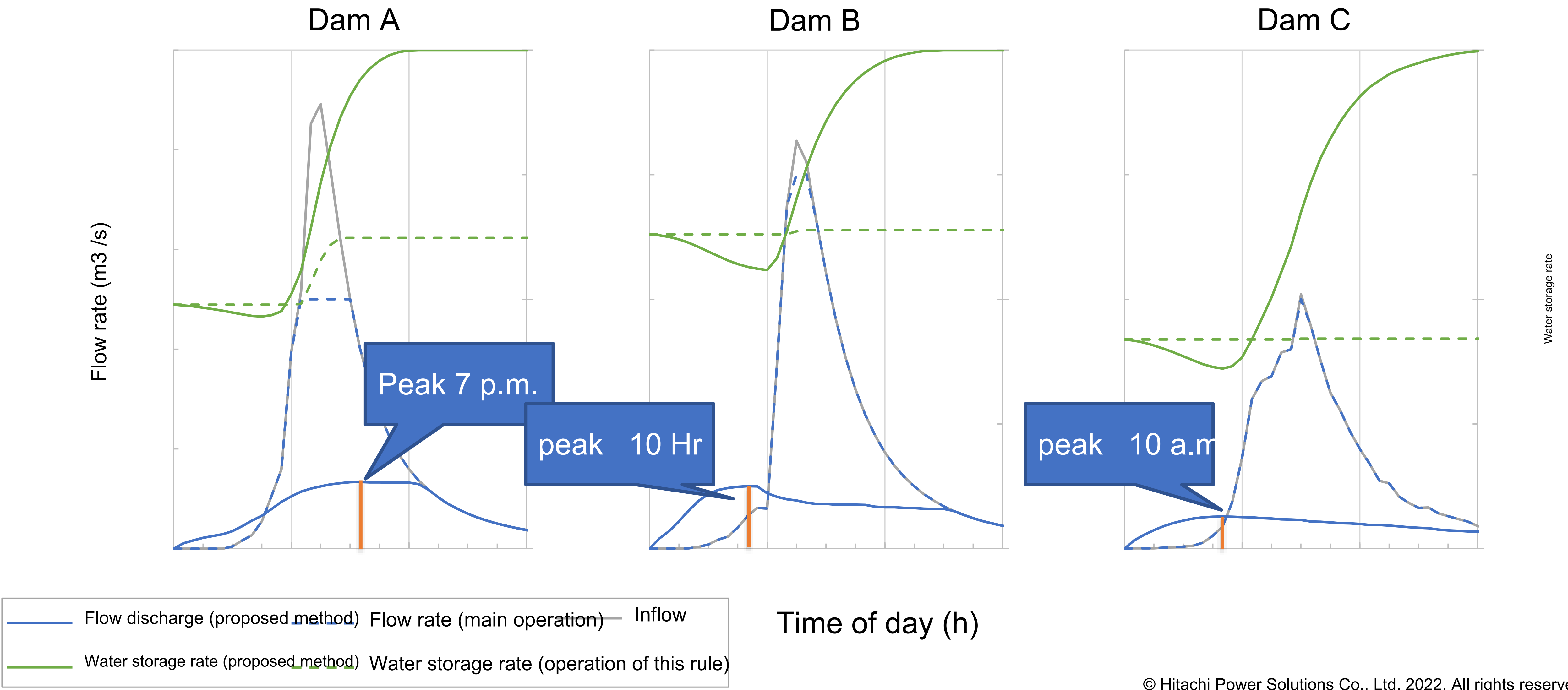
HITACHI
Inspire the Next



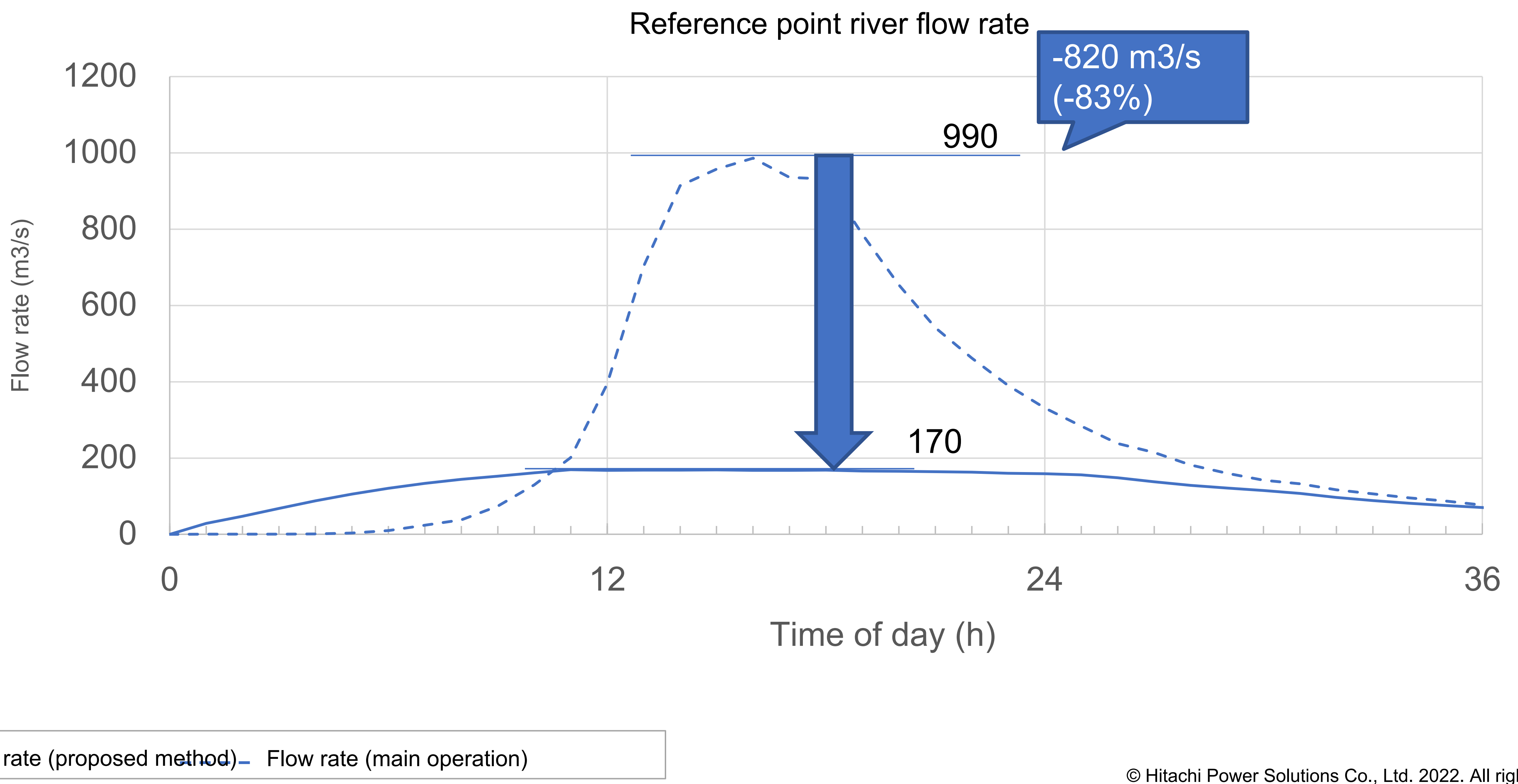
	A Dam	B Dam	C Dam
Effective water storage capacity (106m3)	18	24	14
Flood control capacity 106m3)	9	8	8
Watershed area (km2)	76	100	136

Reproduction of Typhoon No. 17

HITACHI
Inspire the Next

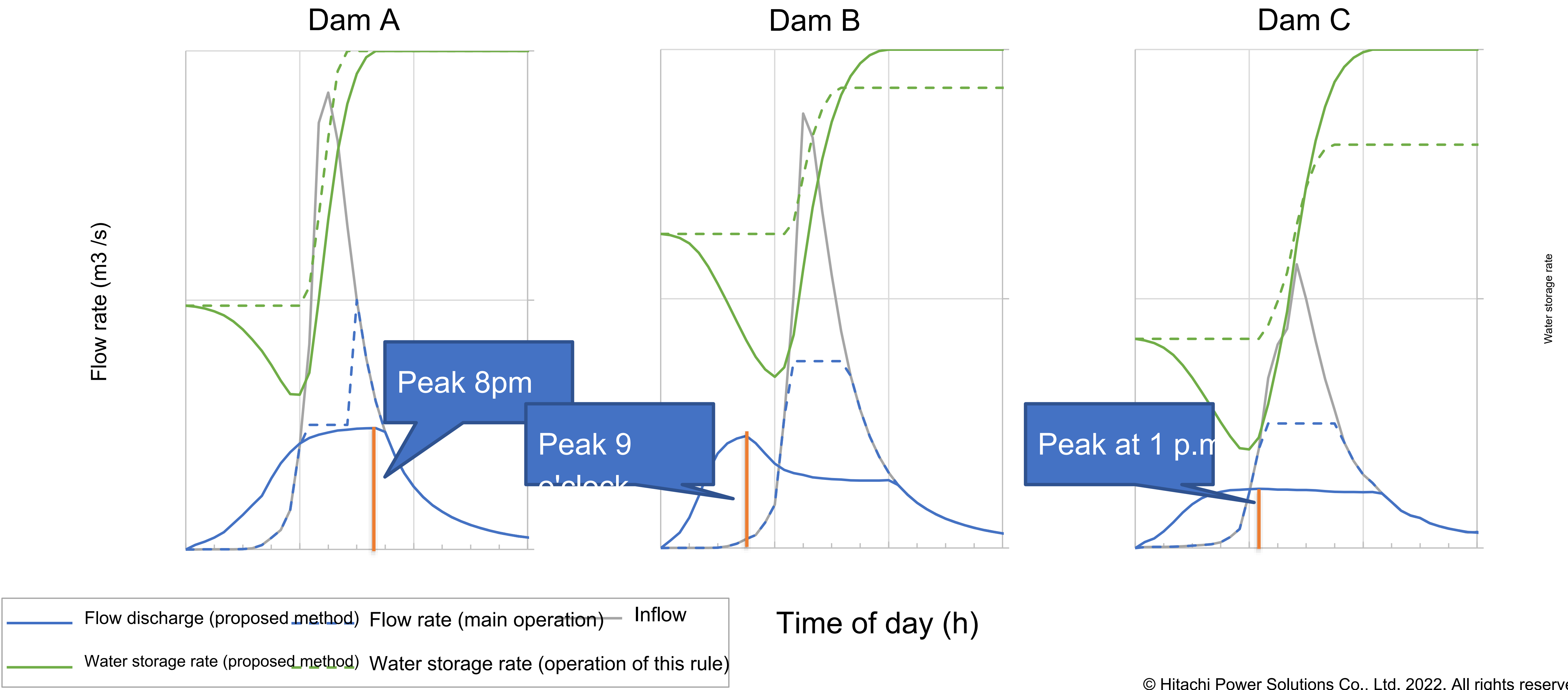


Reproduction of Typhoon No. 17



Flood with a probability of 1/100 years

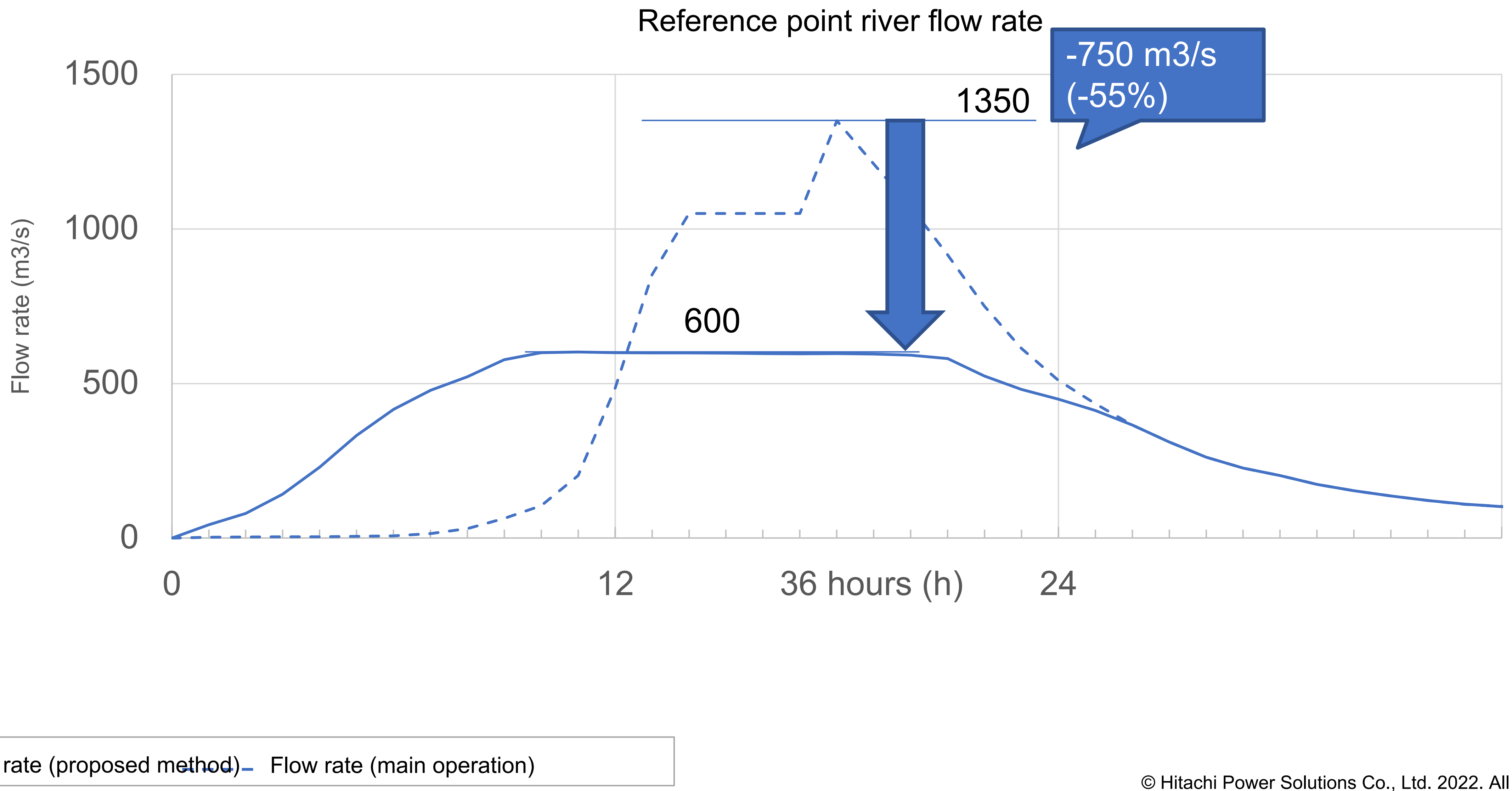
Increased rainfall of Typhoon No. 17 by 1.71 times



Flood with a probability of 1/100 years

HITACHI Inspire the Next

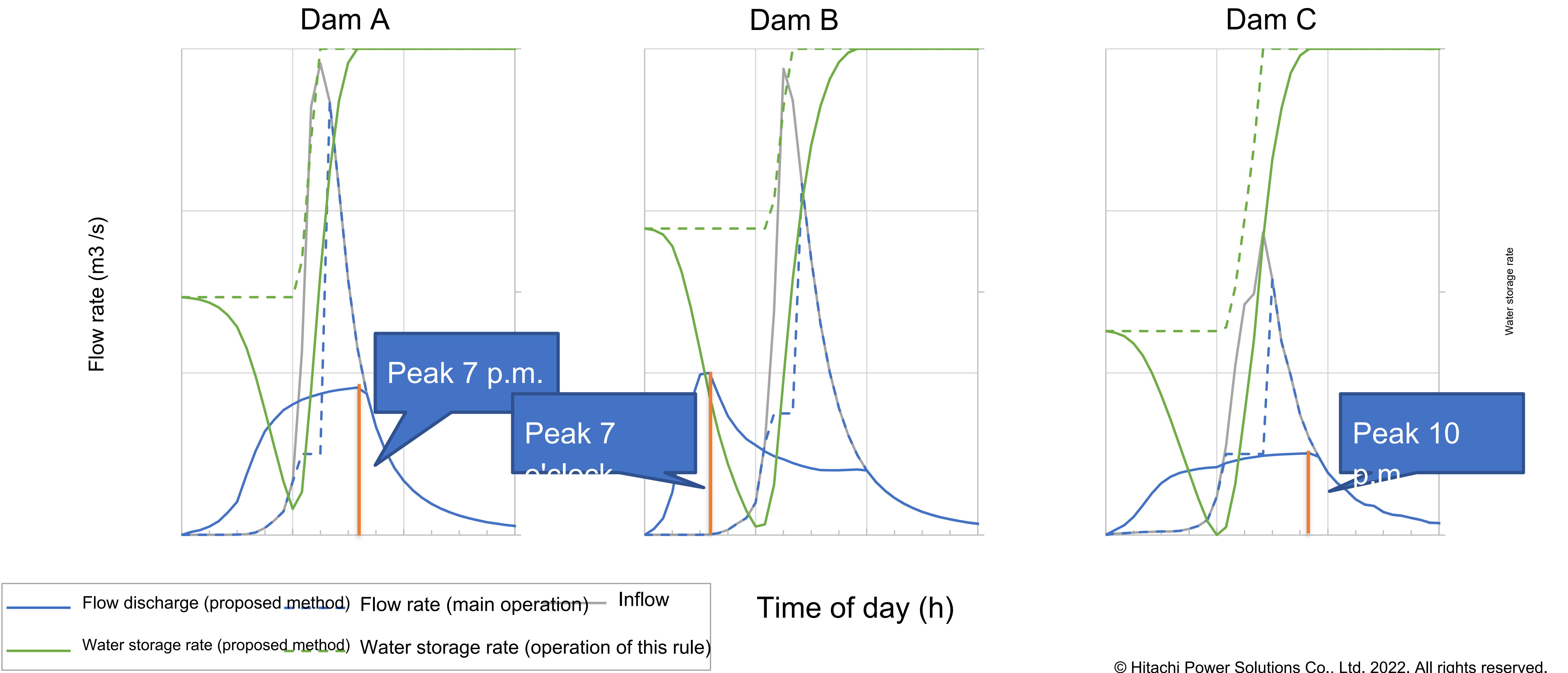
Increased rainfall of Typhoon No. 17 by 1.71 times



Flood with a probability of 1/1000

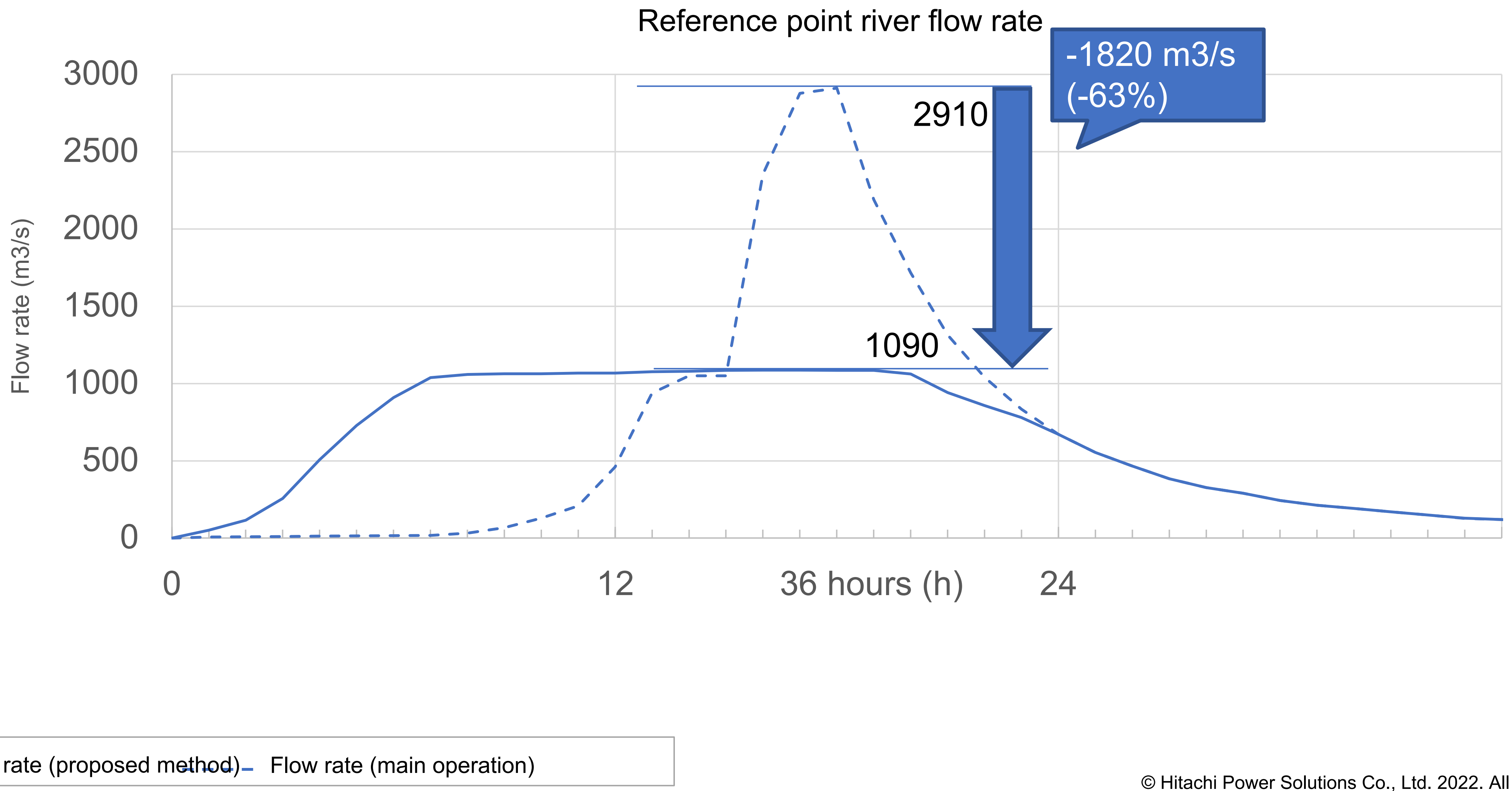
HITACHI
Inspire the Next

The rainfall of Typhoon No. 17 was extended by 2.48 times.



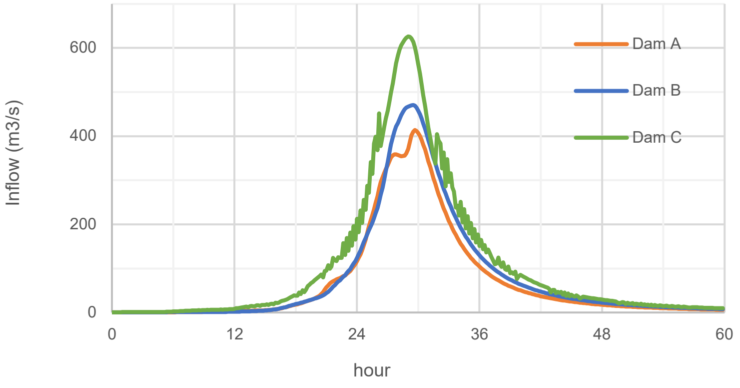
Flood with a probability of 1/1000

The rainfall of Typhoon No. 17 was extended by 2.48 times.

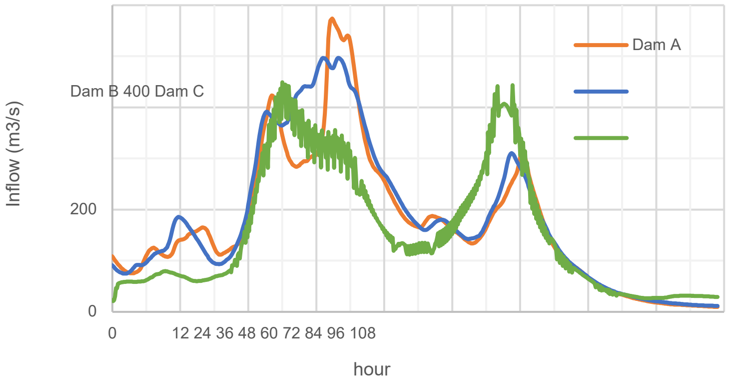


Example of dam inflow time series

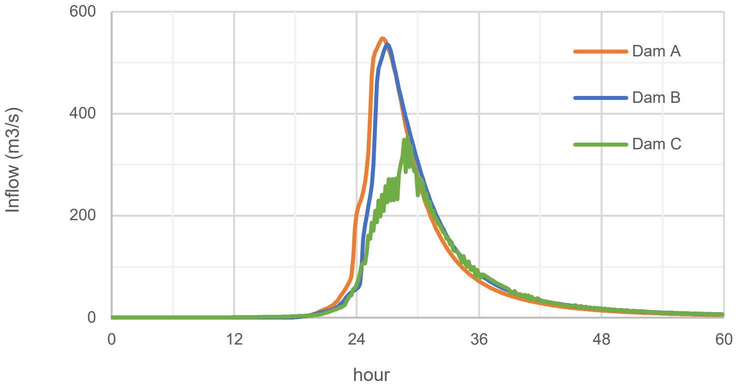
6 flood cases since 2000 (increased to 1/100 occurrence probability)



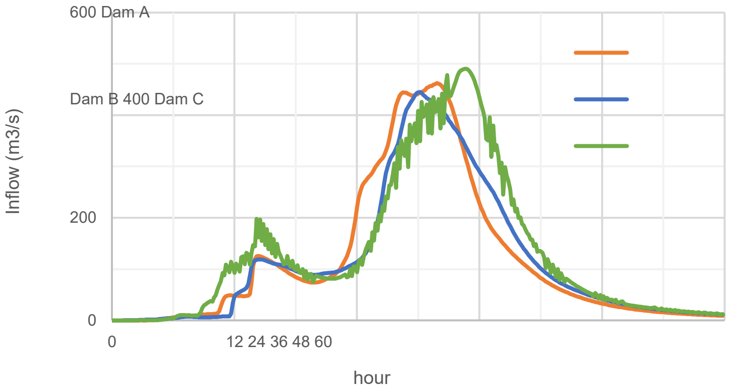
2009/10/16



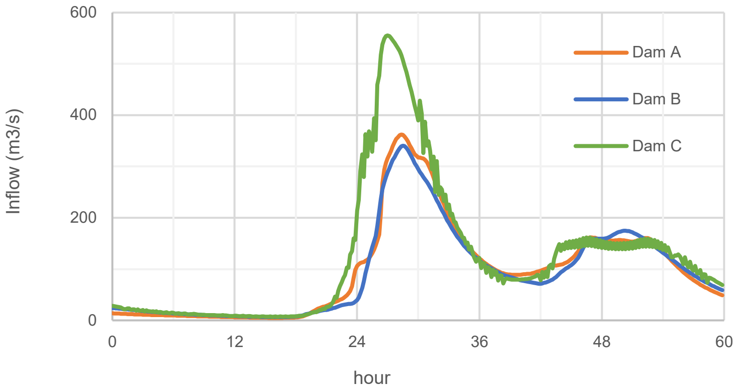
2011/08/31



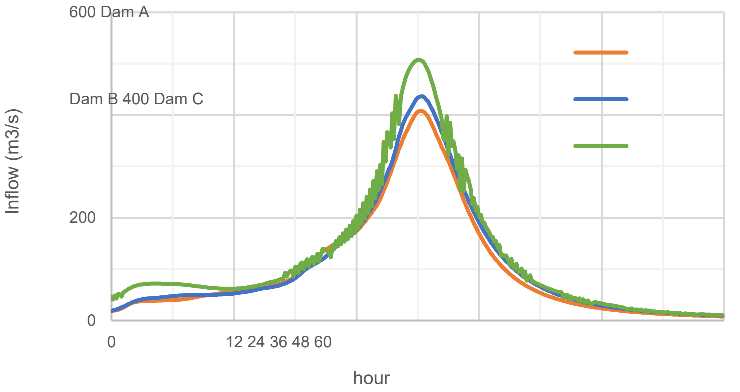
2012/09/27



2013/09/13



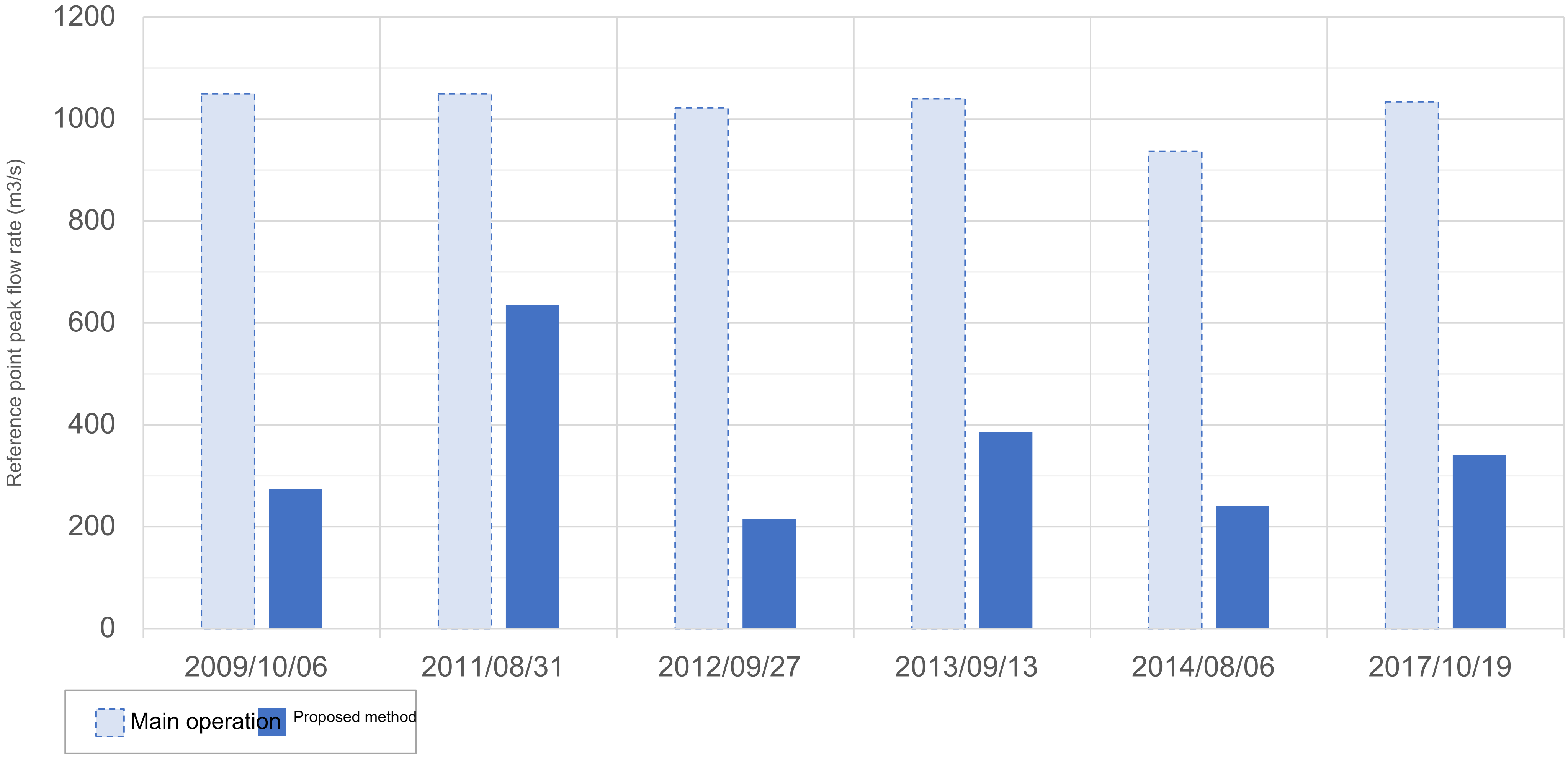
2014/08/06



2017/10/19

experimental results

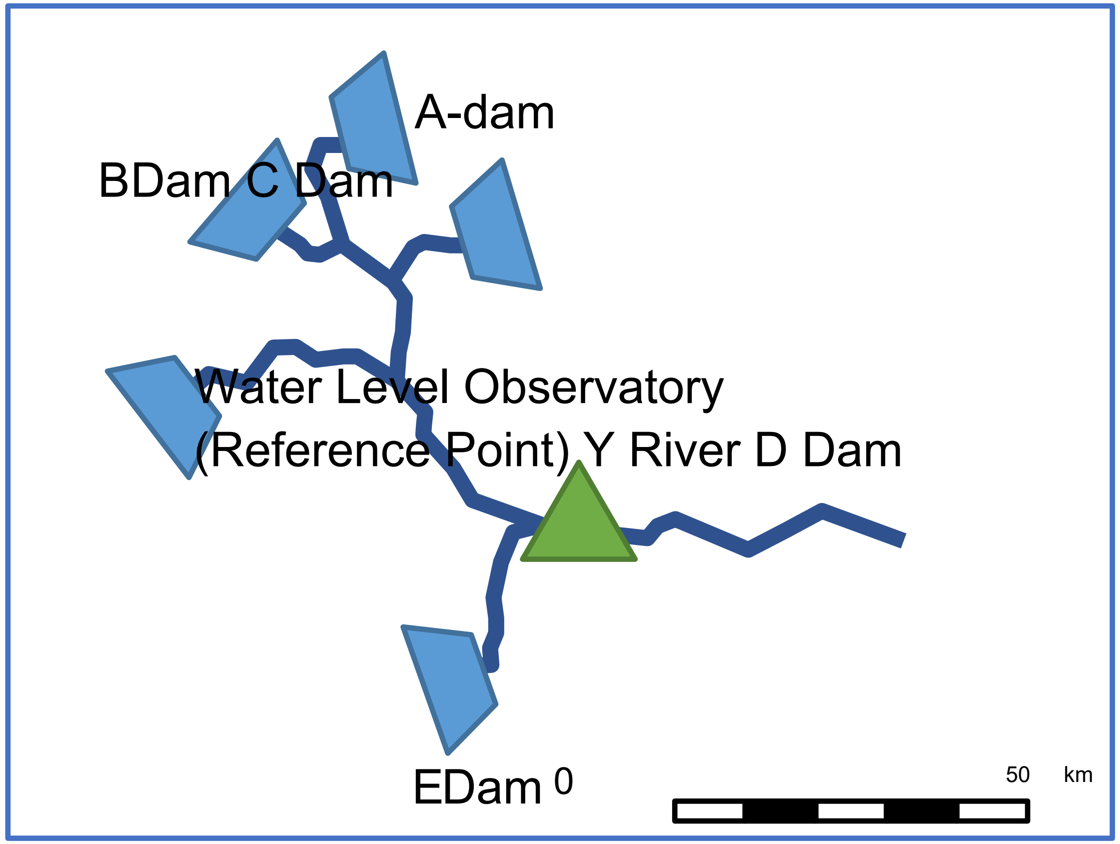
Significantly reduced peak flow at the reference point for various inflows



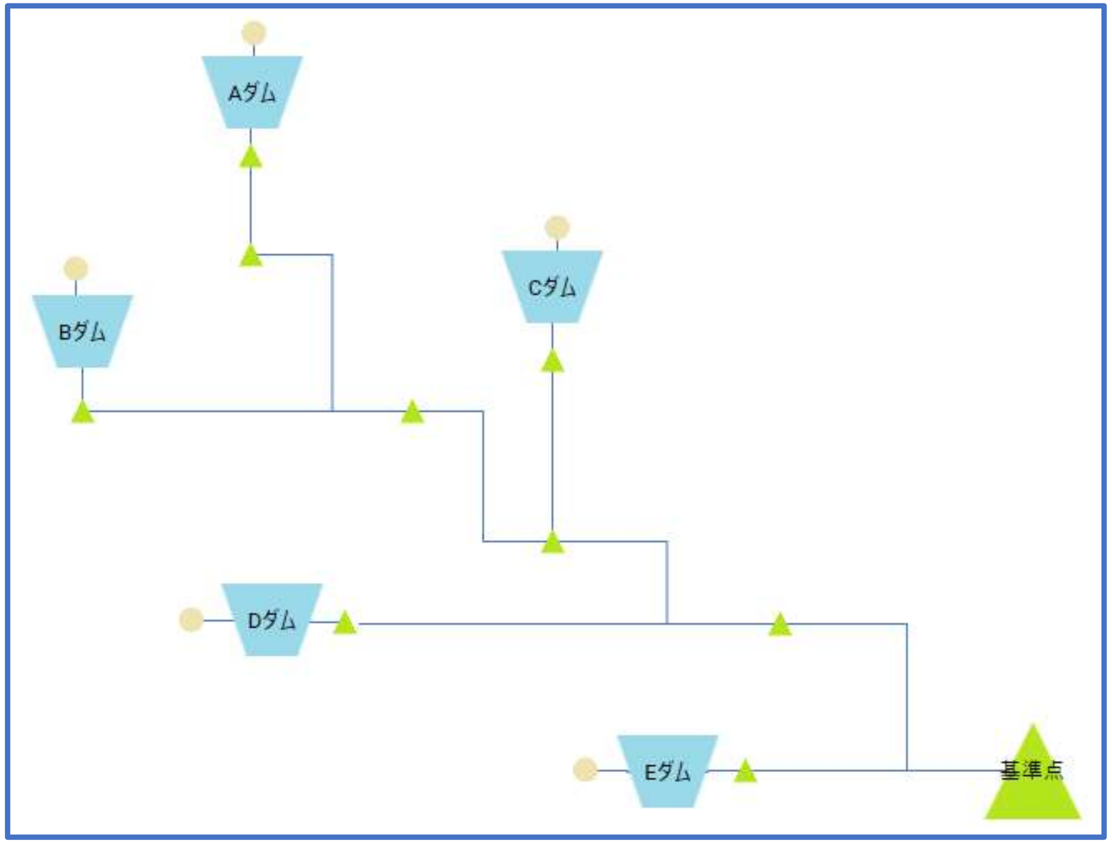
Experiment 1: Y Upstream 5 Dams

Purpose: Flood prevention (minimize river flow at reference points)

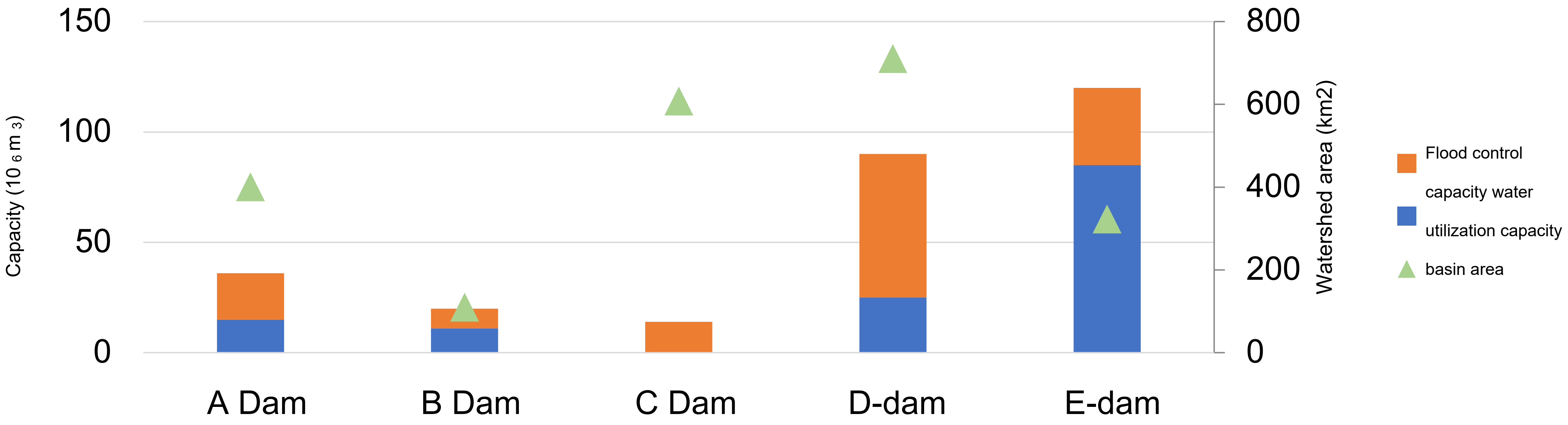
YLayout of the five upstream dams



Dams expressed in a model



YSpecifications of the Upstream 5 Dams

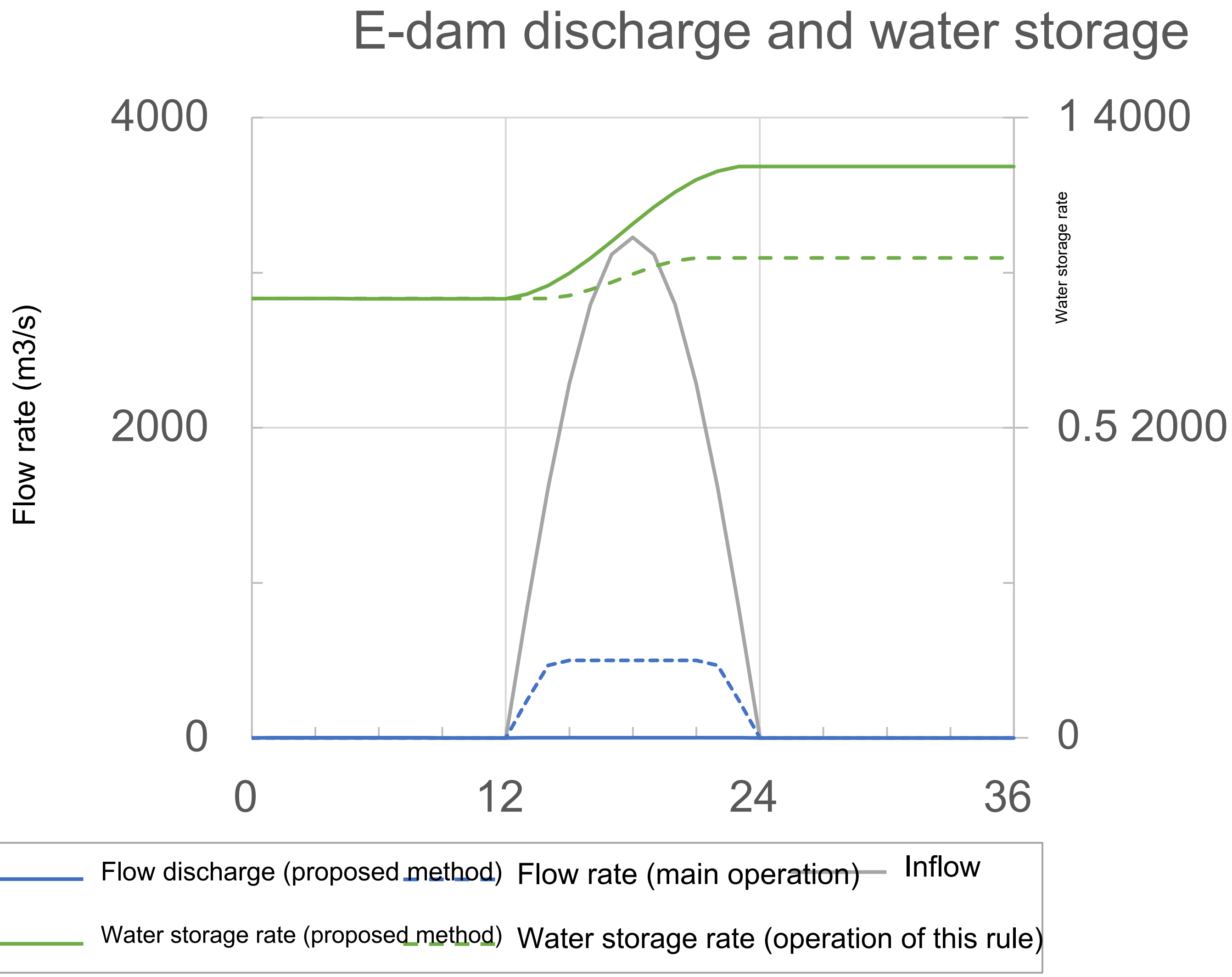


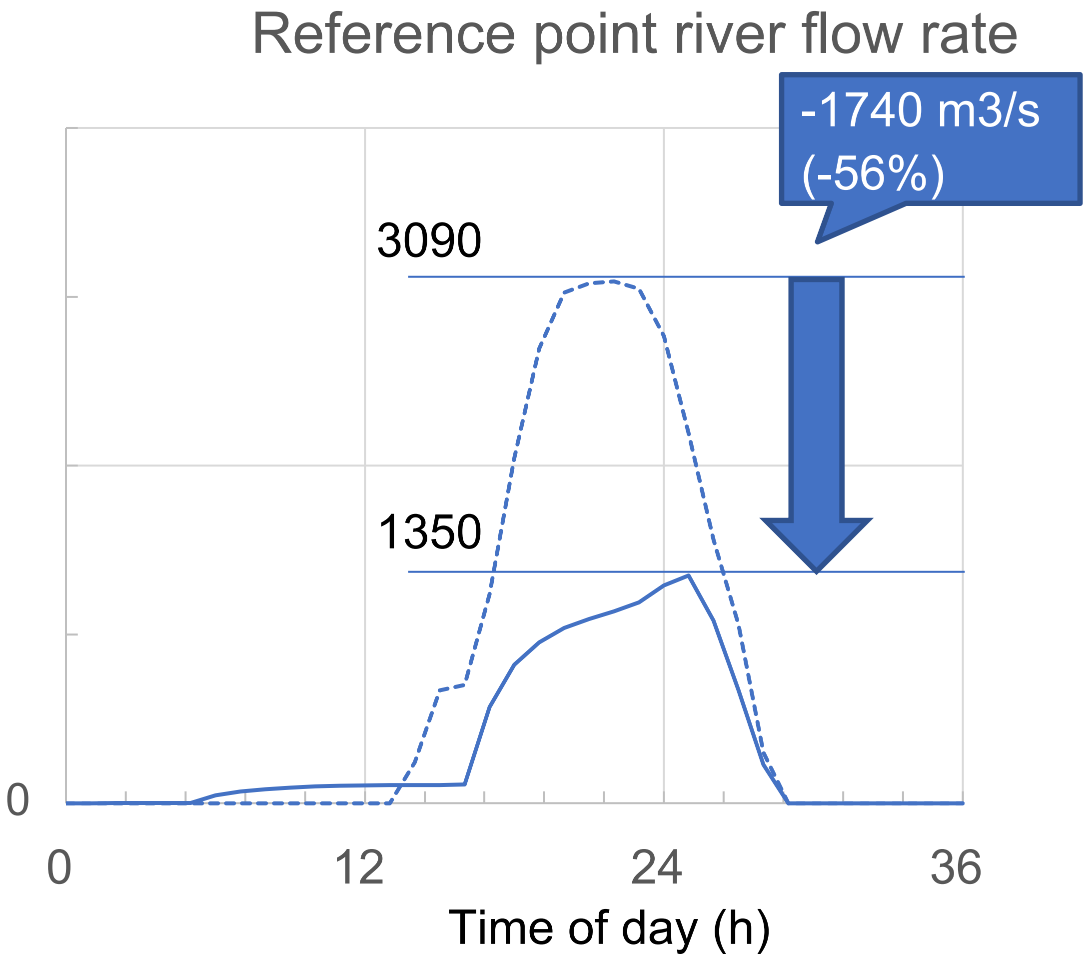
	A Dam	B Dam	C Dam	D-dam	E-dam
Effective water storage capacity (106m3)	36	20	14	90	120
Flood control capacity 106m3)	21	9	14	65	35
Watershed area (km2)	401	110	608	711	323

"Optimize" result (less than L1)

HITACHI
Inspire the Next

Rainfall expectation: 200 mm/72 h, Basin runoff: 0.4, Rainfall waveform: Sine wave

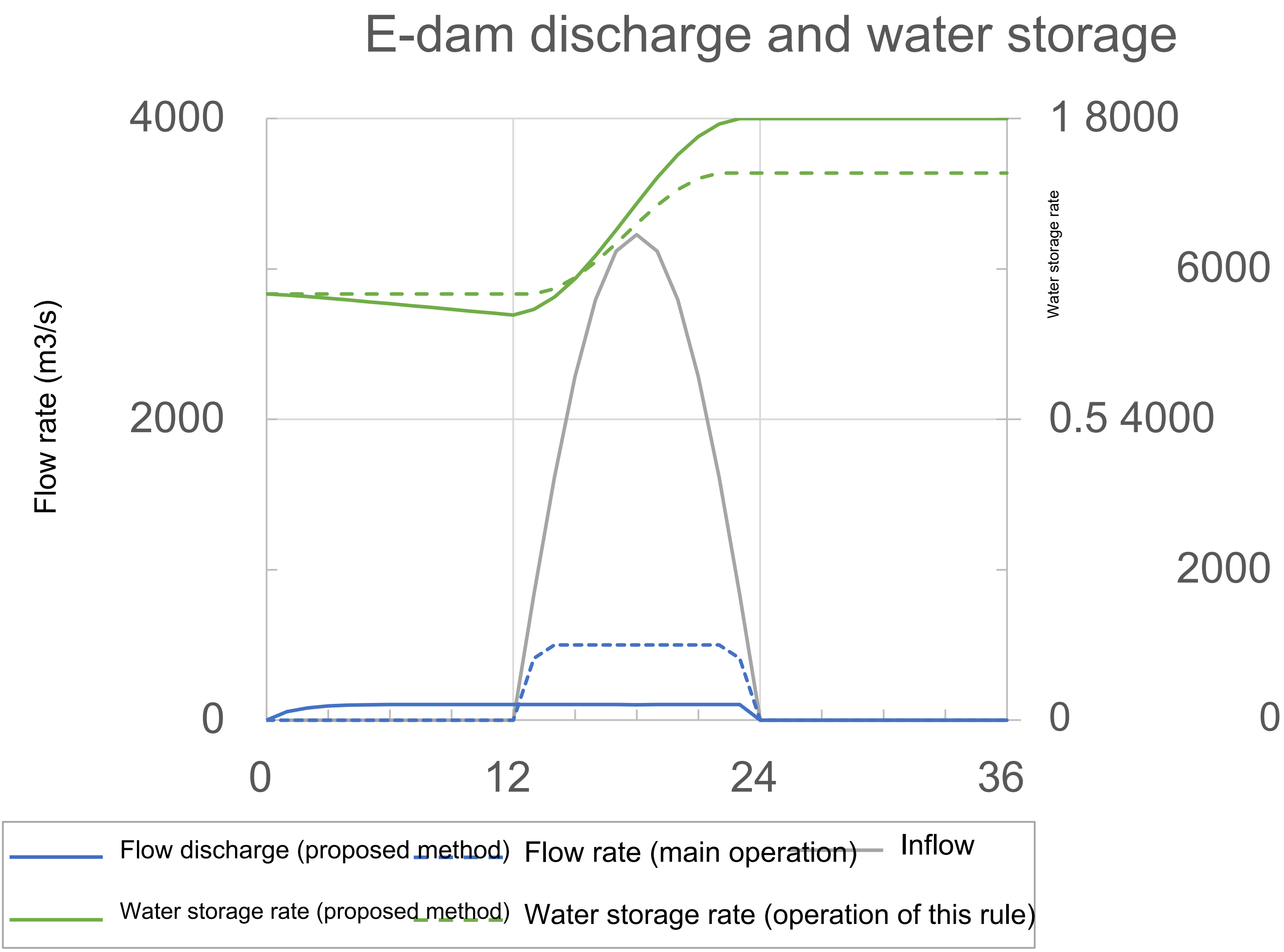


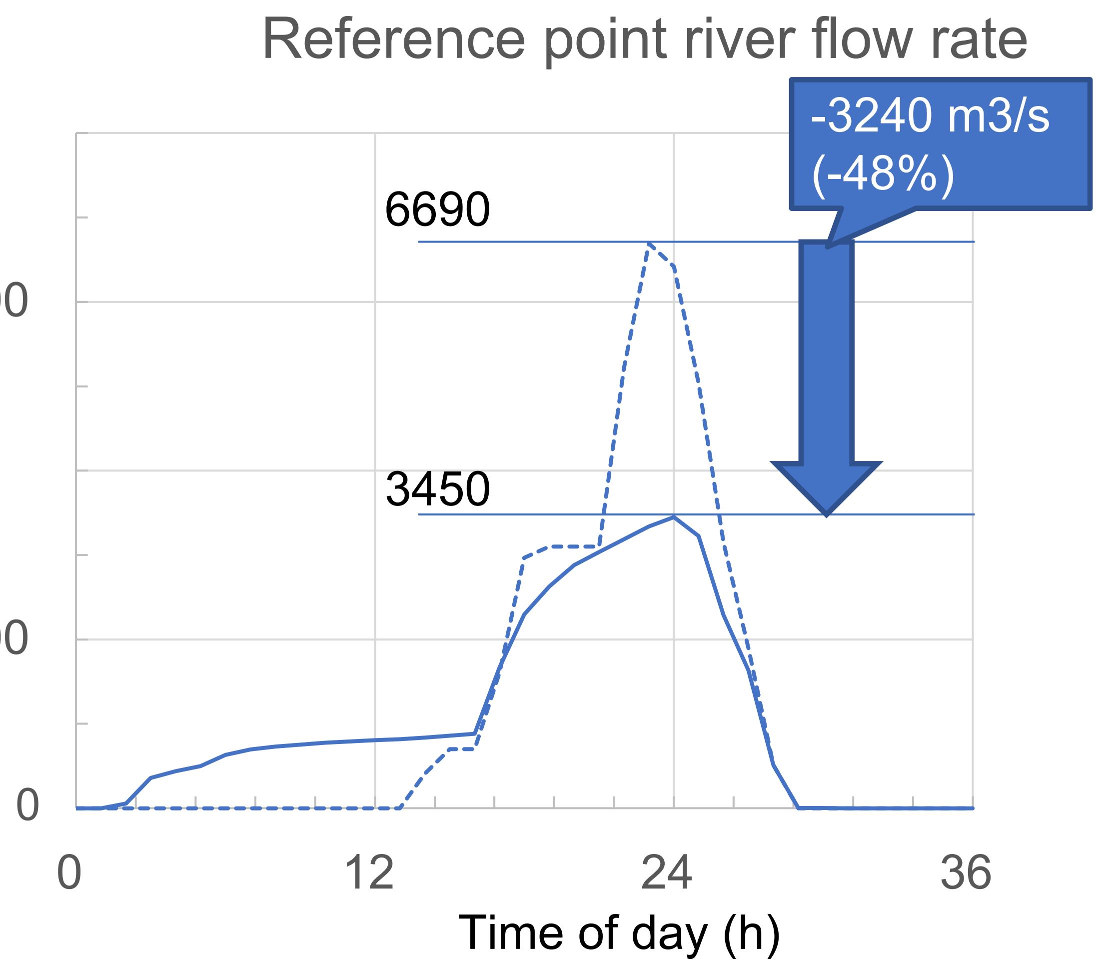


"Optimization" results (L1 scale)

HITACHI Inspire the Next

Rainfall expectation: 336 mm/72 h, Basin runoff: 0.4, Rainfall waveform: Sine wave

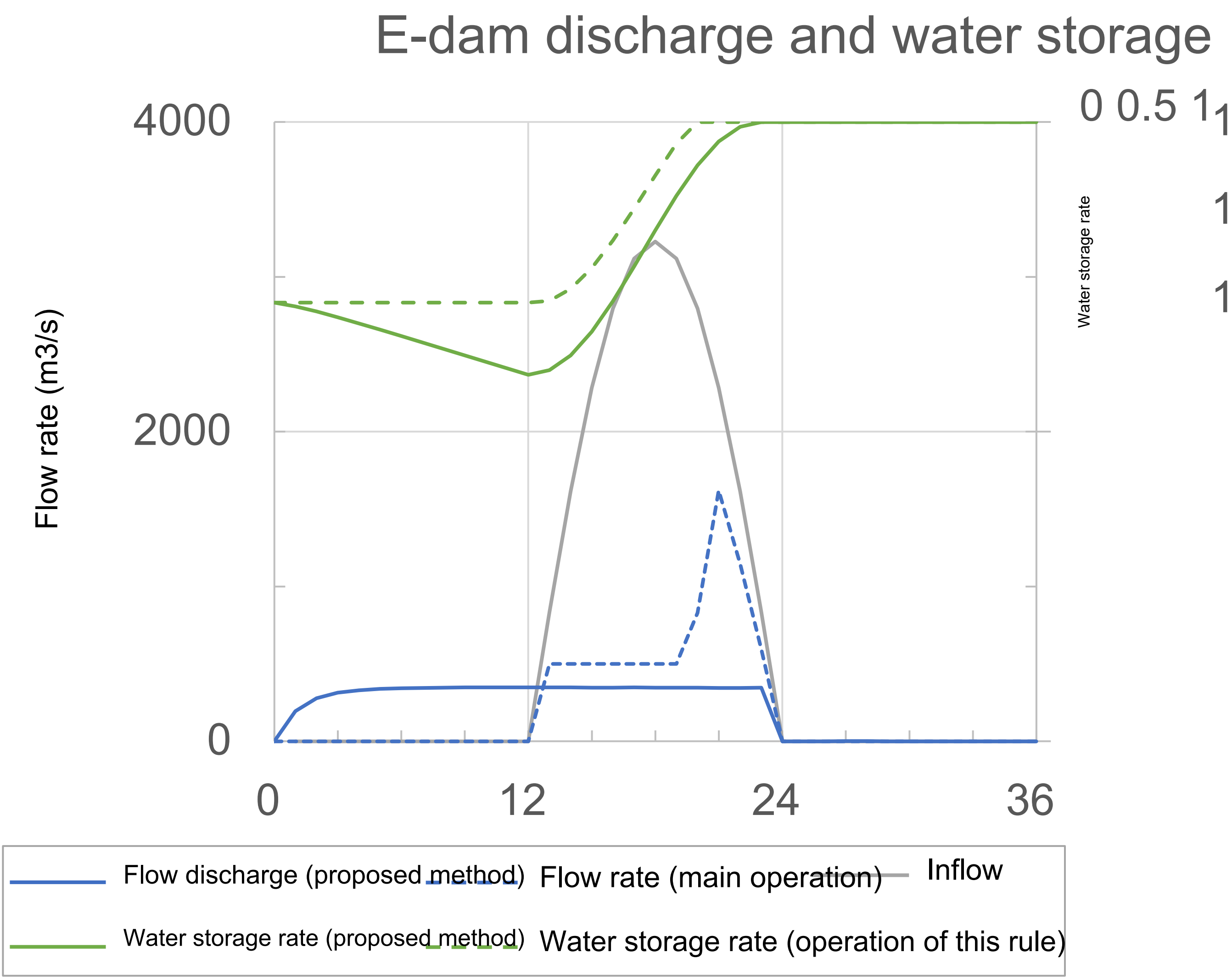


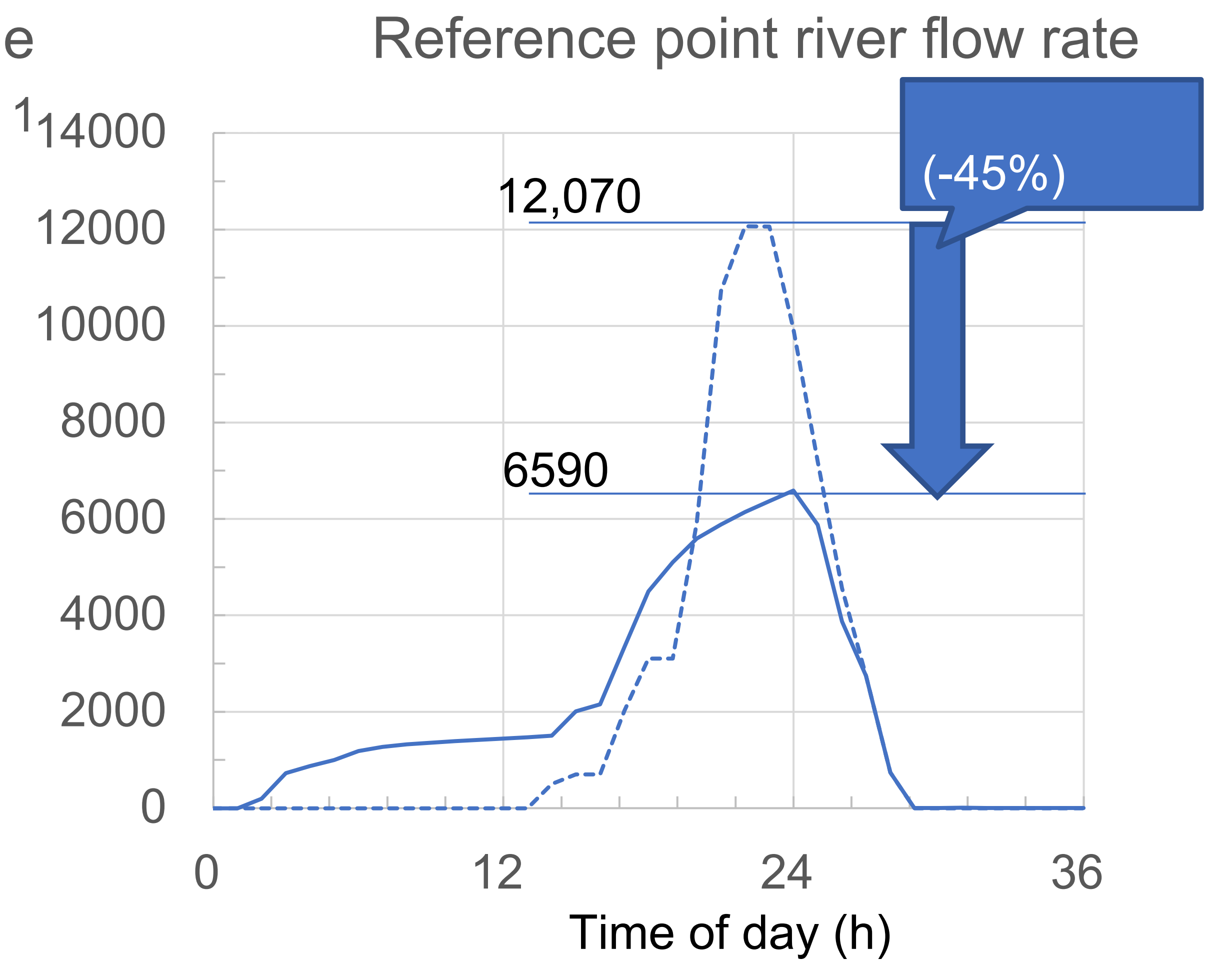


"Optimization" result (L2 scale)

HITACHI Inspire the Next

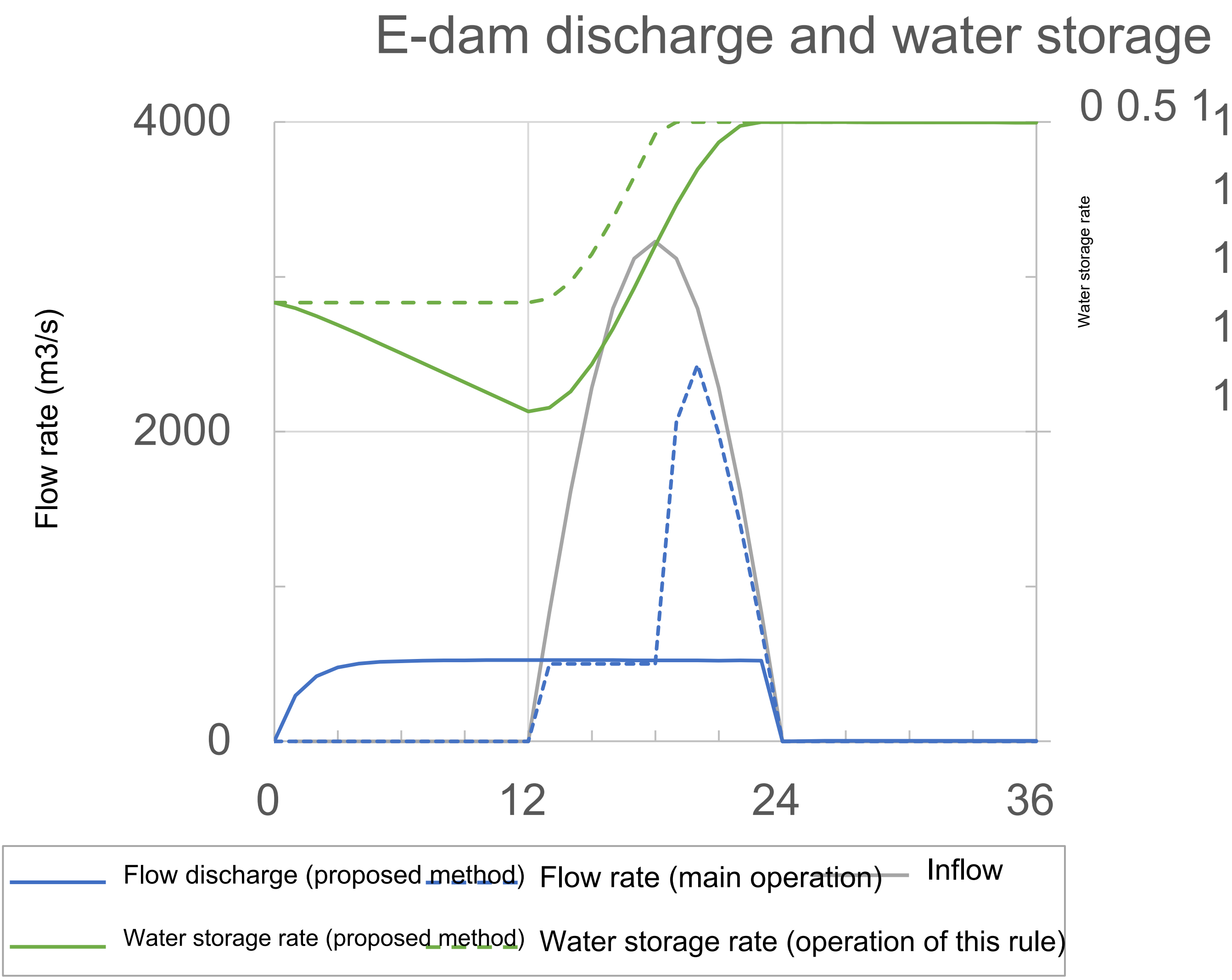
Rainfall expectation: 491 mm/72 h, Basin runoff: 0.4, Rainfall waveform: Sine wave

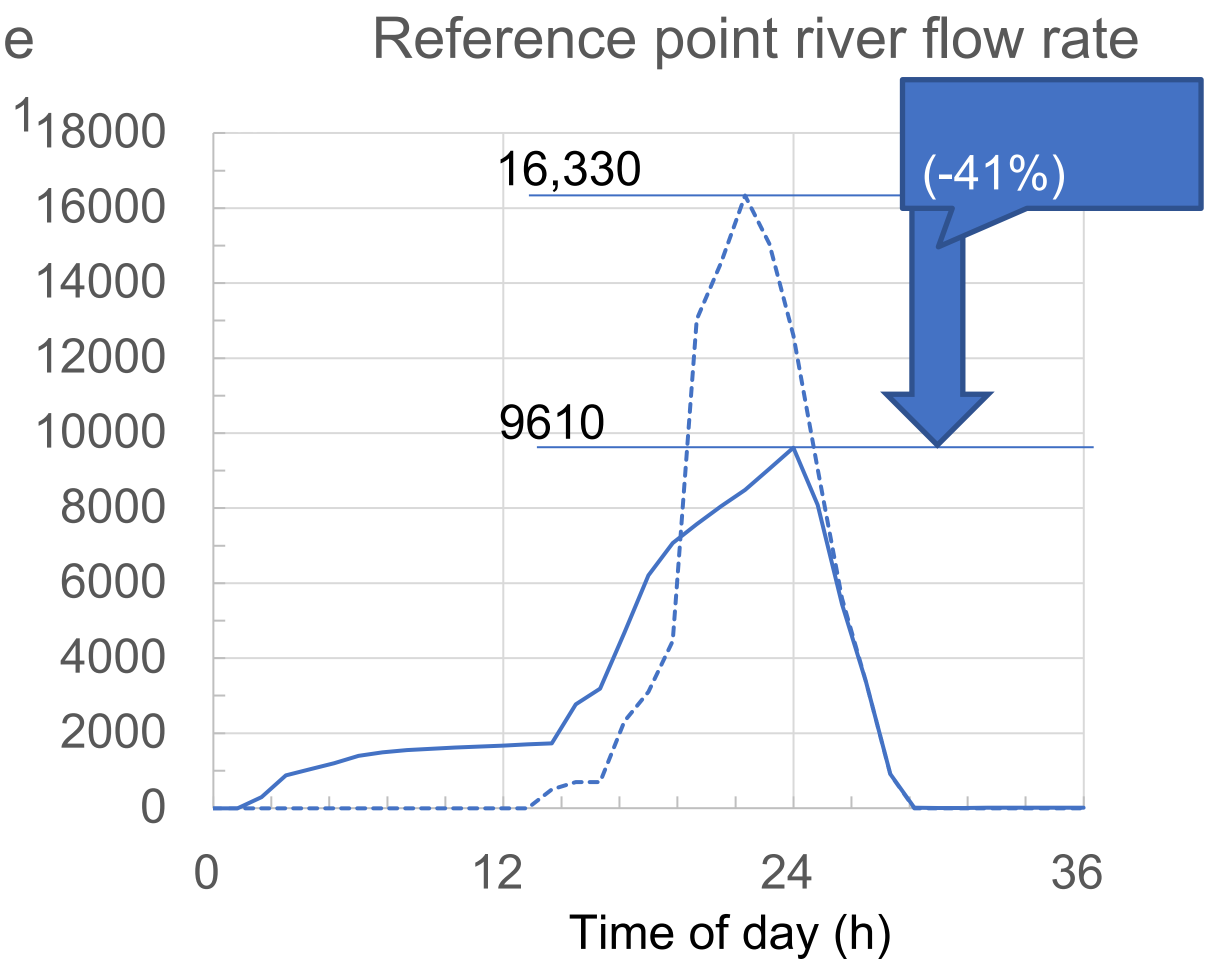




"Optimization" results (ultra-L2 scale)

Rainfall expectation: 600 mm/72 h, Basin runoff: 0.4, Rainfall waveform: Sine wave





DioVISTA/Dams Dashboard screen example

Dam inflow, discharge, and water storage

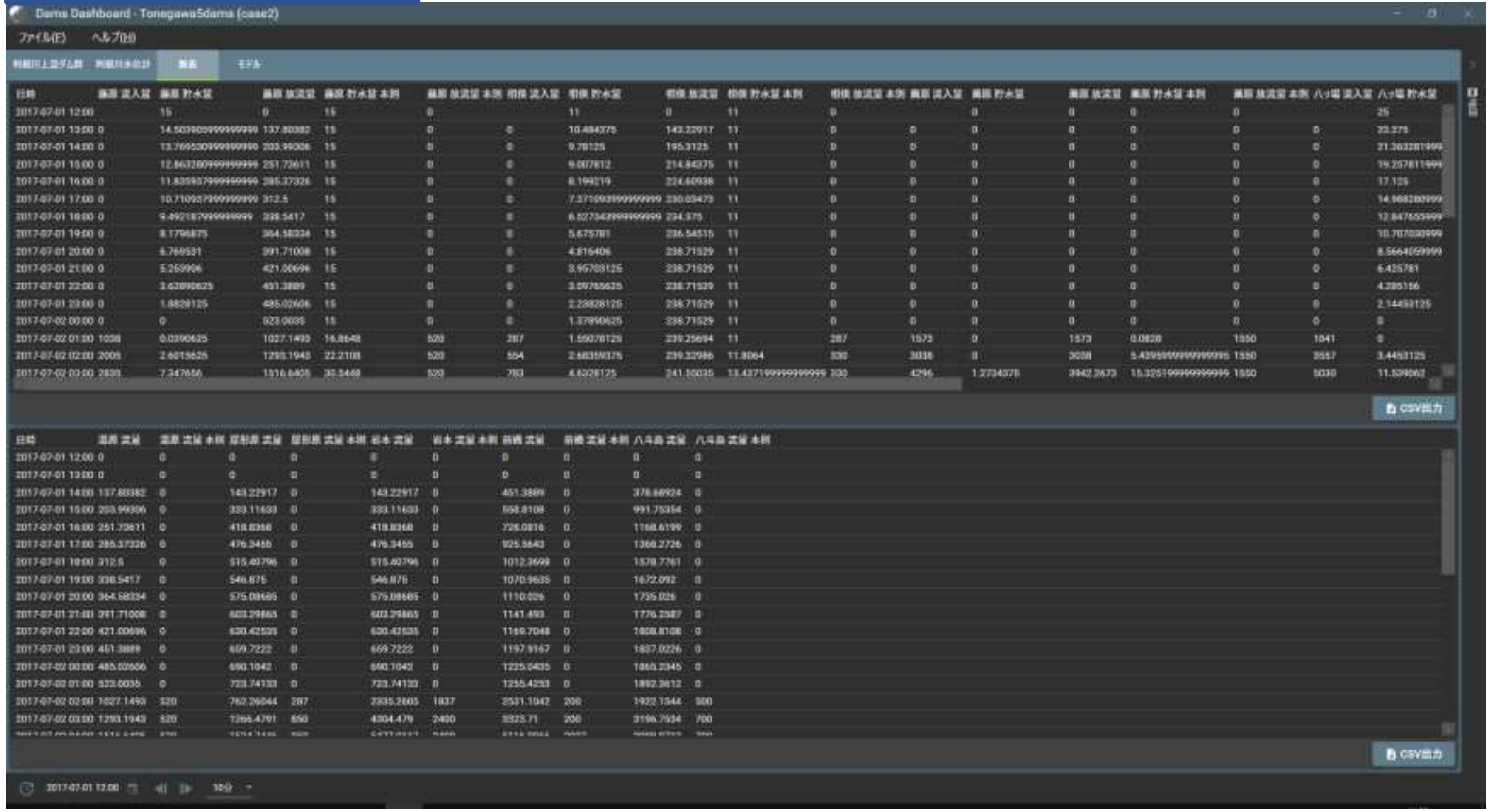
The screen is under development

DioVISTA/Dams Dashboard screen example

Downstream river flow

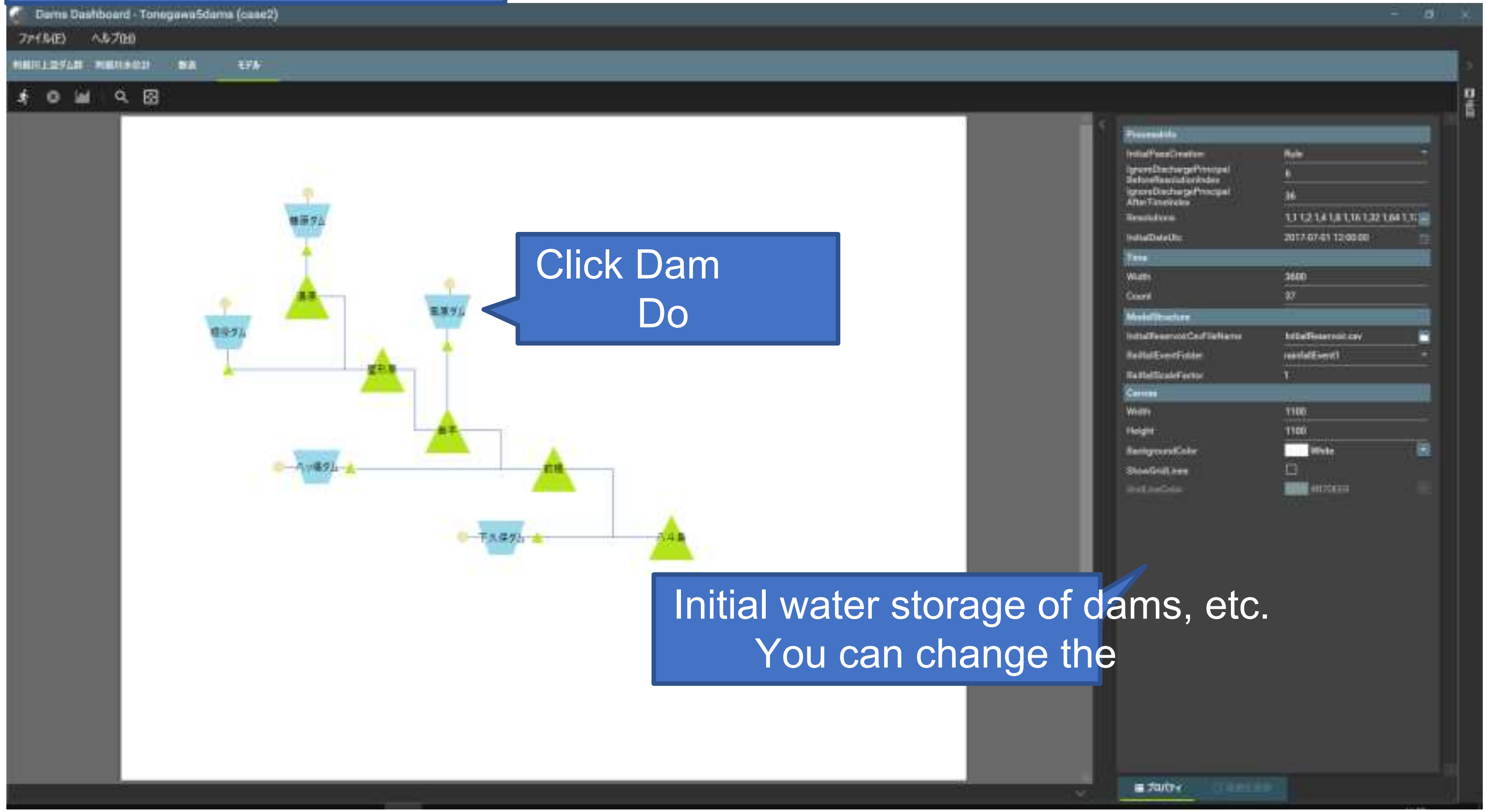
DioVISTA/Dams Dashboard screen example

Table of numbers



DioVISTA/Dams Dashboard screen example

Setting the group of dams to be calculated



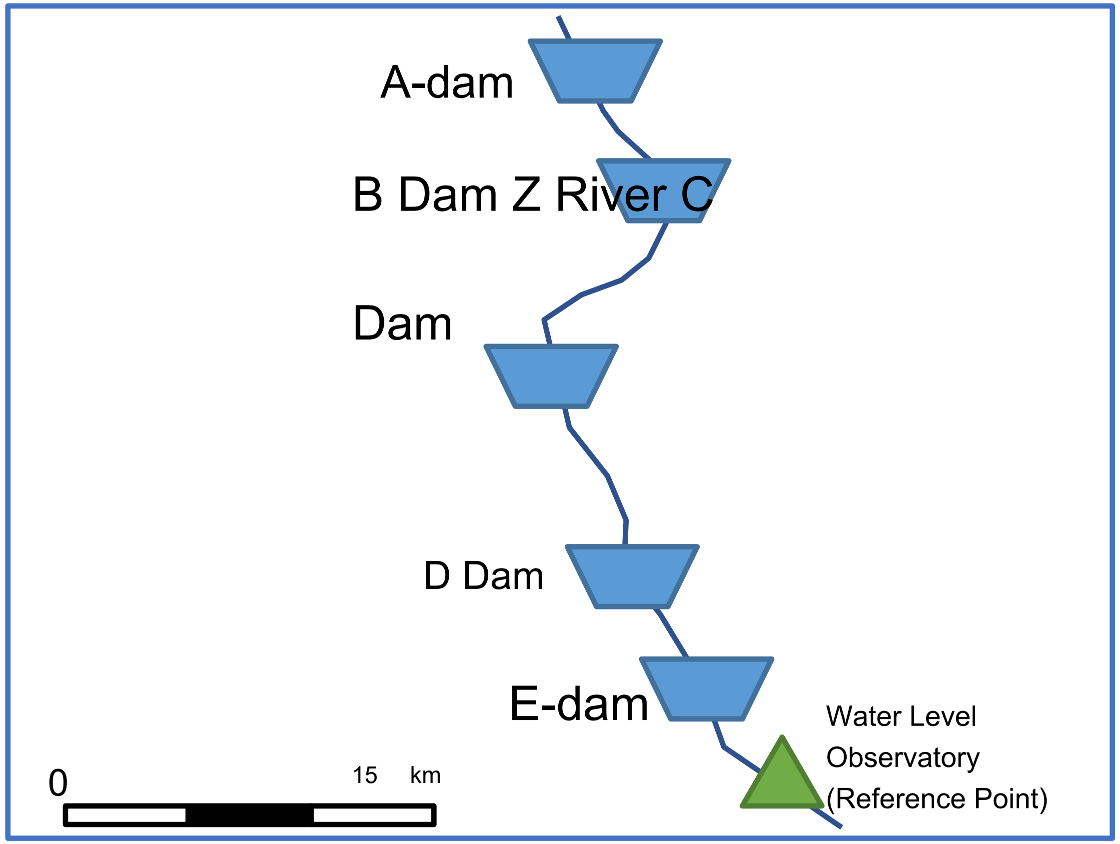
Click Dam
Do

Initial water storage of dams, etc.
You can change the

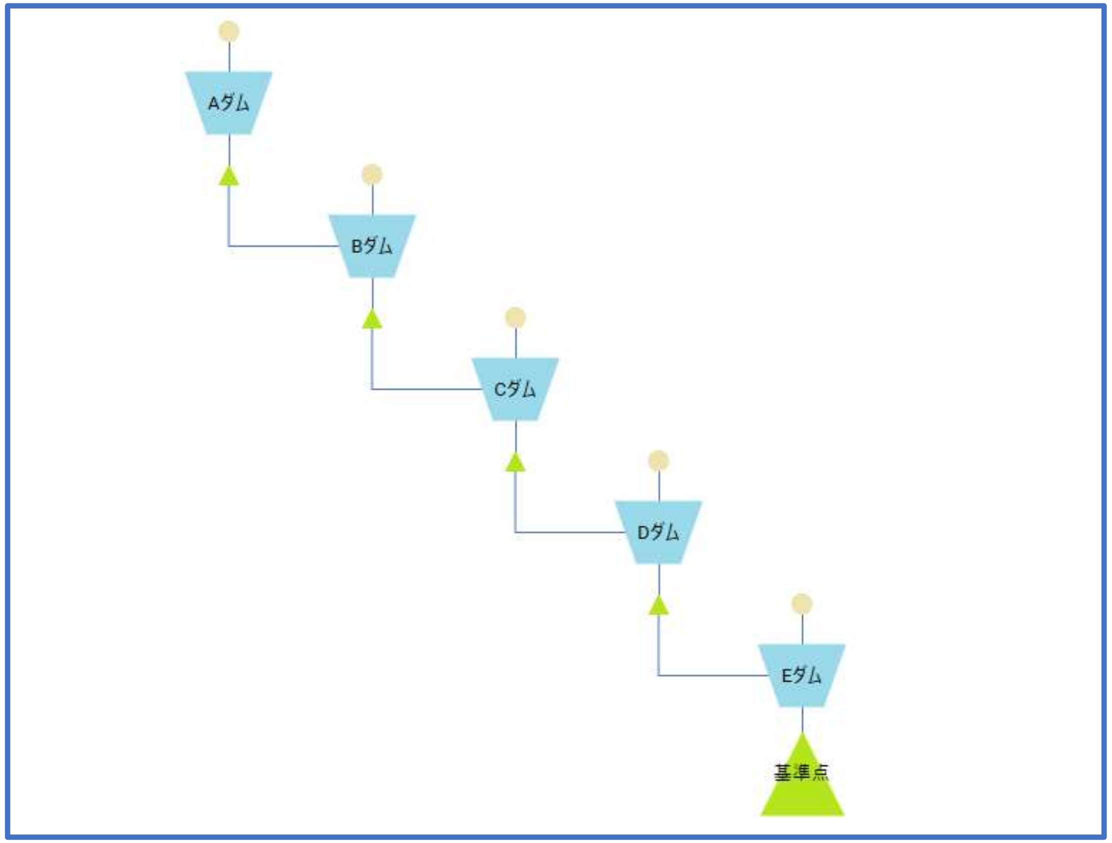
Experiment 3: Z River Upstream 5 Dams

Purpose: Power generation (maximize the total power generation of each dam)

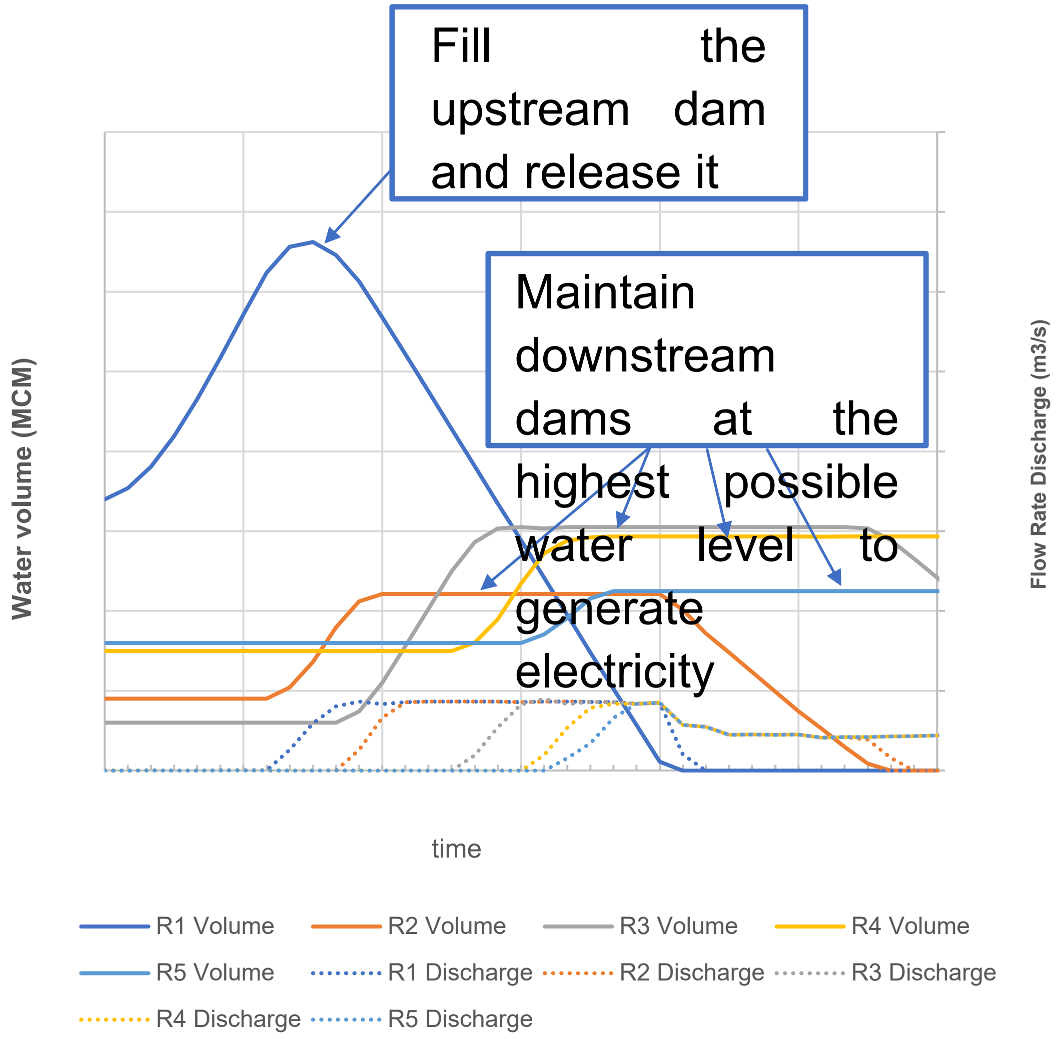
Z Layout of the five upstream dams



Dams expressed in a model



Application to Power Generation Dams (Experimental Results)



- Operational methods to maximize power generation
  - First, fill the upstream dam
  - Release upstream dams to lower the water level and fill the dams directly below
  - Maintain full water level for as long as possible

Mokuji

1. User Voice
2. Introduction to DioVISTA
3. Formulation of dam discharge plan

4. Conclusion

DioVISTA's contribution to watershed flood control

HITACHI
Inspire the Next

- Be able to quantify the effects of various flood control measures
  - Rainfall can be given and integrated analysis of internal and external water
  - Simulate dams, drainage areas, embankments, rice fields, etc.
- Low analysis cost
  - Numerous scenarios can be analyzed on a Windows PC
  - Conditions can be set as if you were operating a map.
  - Calculation results can be obtained in a short time
  - Simulations under different conditions can be performed without special training
- Reproducible
  - If you are using DioVISTA, you can take over the analysis results even if the analysis company changes.

The Future of DioVISTA

HITACHI
Inspire the Next

- In many fields, there are engineers fighting flood damage
  - River, disaster prevention, non-life insurance, education, reporting, dam management, hydroelectric power, logistics, real estate, architecture, agriculture, roads, railways, sewage, urban planning, corporate disaster prevention、...
- Supporting engineers fighting flood damage with IT
  - Analysis and prediction of flood damage: DioVISTA/Flood
  - Assistance with dam operations: DioVISTA/Dams Dashboard

Please contact Hitachi