Development of a Water Quality Management Decision Support System Using a 3D Platform and SWAT Model

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Kangwon National University

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COTENTS

Introduction

01 Introduction

❖ Point source pollution and Non-point source pollution in Urban Watershed

대구 금호강에 가축분뇨 배출...위반업체 5곳 적발

(대구 · 경북=뉴스1) 정지홍 기자 | 2018-04-30 15:33 송고

댓글 가

환경부 직원들이 지방자치단체와 합동으로 가축분뇨 배출시설을 점검을 위한 시료를 채취하고 있다.
(뉴스1 DB)© News1

대구지방환경청은 30일 금호강 취수원 상류지역의 가축분뇨 배출시설을 특별점검해 규정을 위반한 업체 5곳을 적발했다고 밝혔다.

대구 동구와 수성구, 경북 경산 일부 지역은 상수원인 청도군 운문댐의 저수율 급감으로 올해 2월부터 경산취수장 인근의 비상공급시설을 통해 금호강 물을 수돗물로 공급받고 있다.

- Problems in water quality management due to point and non-point pollution sources in urban watersheds.

  → Continuous monitoring is necessary.

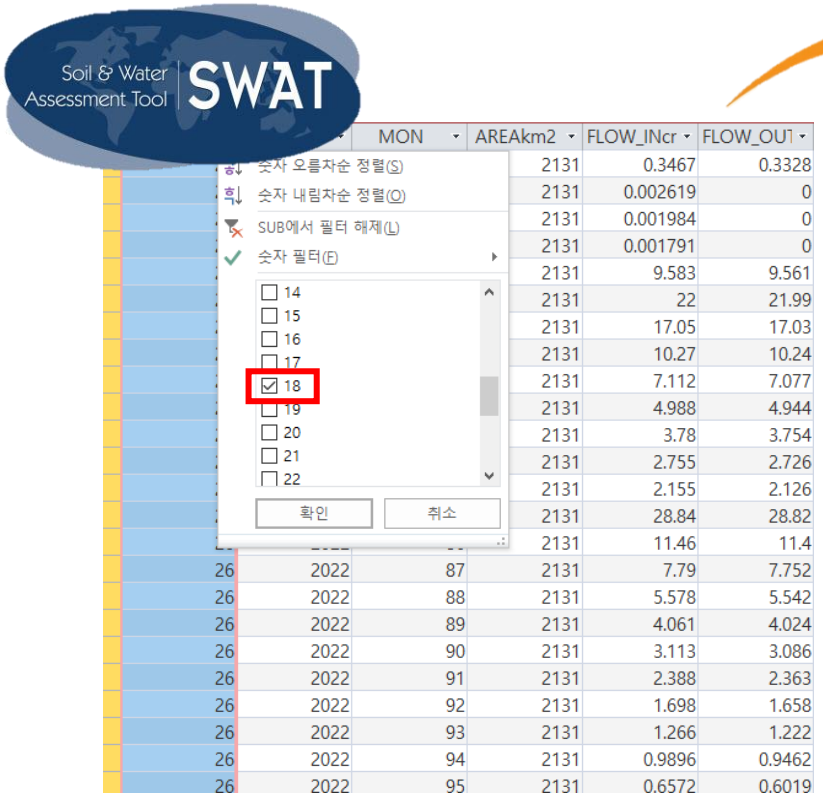
01 Introduction

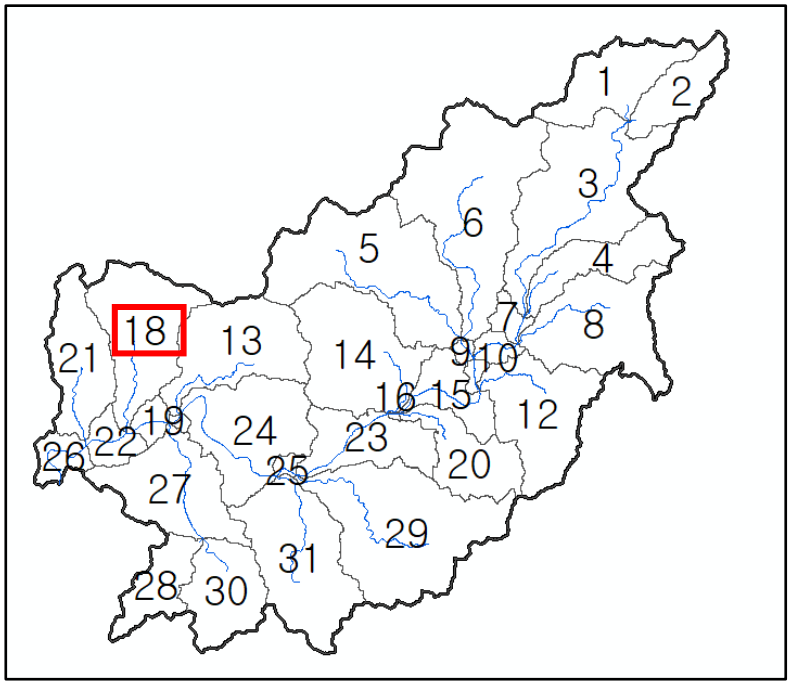
❖ Limits of monitoring

- Due to the high cost required for monitoring, watershed models are used for watershed management.
- Various watershed models (SWAT, HSPF, etc.) are being used for modeling.
- The SWAT model is considered as one of the most suitable models for predicting long-term impacts of land management measures on water, sediment, and agricultural chemical yield in large complex watersheds with varying soils, land use, and management conditions

01 Introduction

❖ Limits of SWAT Results





- While overlaying SWAT results data on a GIS map allows observation the variability of water quantity and water quality in each watershed, it is important to note that this process can be time-consuming and cumbersome, which is a drawback.
- It has a limitation that it is difficult for users who have no experience in the GIS program to proceed.

01 Introduction

❖ Digital Twin

- Digital twin technology creates a virtual replica of an object in reality, allowing for advanced predictions through computer simulations.
- Visualizing analysis results through a digital twin, it enhances visibility and enables intuitive understanding

→ Digital Twin is intuitive

Bradford city centre 'digital twin' model to be unveiled

11 April 2021

GETTY IMAGES

Organisers say Virtual Bradford could also have other potential uses such as creating heritage trails

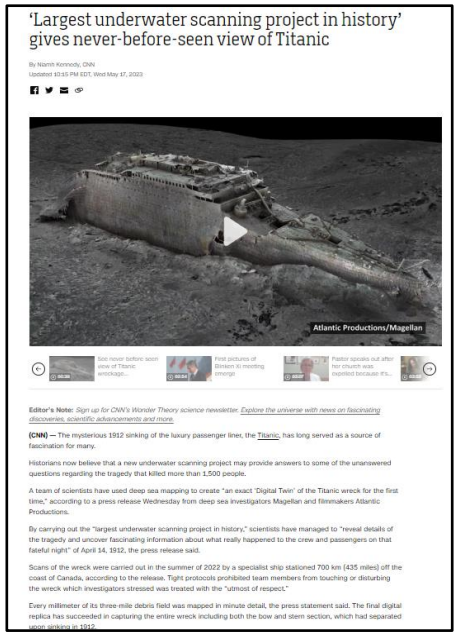
A virtual 3D model of a city is being built which could help with planning, air pollution and traffic management.

University staff are currently creating Virtual Bradford, a high-resolution copy of the city centre.

Due to be unveiled at a conference on Monday, it could be extended out, eventually mapping more than 60 miles (100km) of streets.

Prof Andrew Wilson said it would show "accurate levels of detail".

Part of the University of Bradford's School of Archaeology and Forensic Sciences, Prof Wilson said: "This is essentially a 3D model or digital twin of the city, capable of showing accurate levels of detail for the built environment."



'Largest underwater scanning project in history' gives never-before-seen view of Titanic

By Niamh Kennedy, CNN

Updated 12:55 PM EDT, Wed May 17, 2023

Atlantic Productions/Magellan

Editor's Note: *Sign up for CNN's Wonder Theory science newsletter. Explore the universe with news on fascinating discoveries, scientific advancements and more.*

(CNN) — The mysterious 1912 sinking of the luxury passenger liner, the Titanic, has long served as a source of fascination for many.

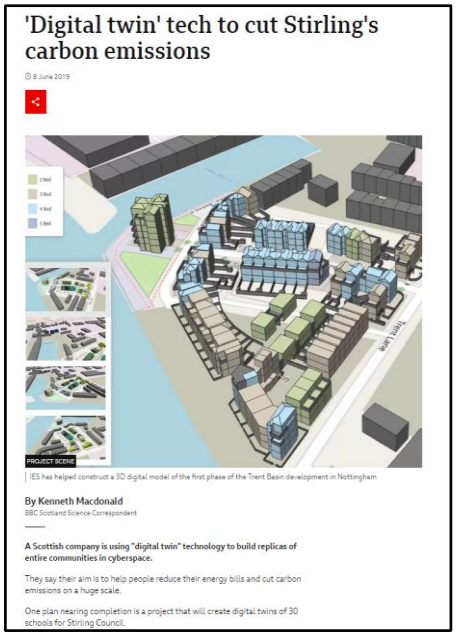
Historians now believe that a new underwater scanning project may provide answers to some of the unanswered questions regarding the tragedy that killed more than 1,500 people.

A team of scientists have used deep sea mapping to create "an exact 'Digital Twin' of the Titanic wreck for the first time," according to a press release Wednesday from deep sea investigators Magellan and filmmakers Atlantic Productions.

By carrying out the "largest underwater scanning project in history," scientists have managed to "reveal details of the tragedy and uncover fascinating information about what really happened to the crew and passengers on that fateful night" of April 14, 1912, the press release said.

Scans of the wreck were carried out in the summer of 2022 by a specialist ship stationed 700 km (435 miles) off the coast of Canada, according to the release. Tight protocols prohibited team members from touching or disturbing the wreck which investigators stressed was treated with the "utmost of respect."

Every millimeter of its three-mile debris field was mapped in minute detail, the press statement said. The final digital replica has succeeded in capturing the entire wreck including both the bow and stern section, which had separated upon sinking in 1912.



'Digital twin' tech to cut Stirling's carbon emissions

8 June 2019

PROJECT SCENE

IES has helped construct a 3D digital model of the first phase of the Trent Basin development in Nottingham

By Kenneth Macdonald

BBC Scotland Science Correspondent

A Scottish company is using "digital twin" technology to build replicas of entire communities in cyberspace.

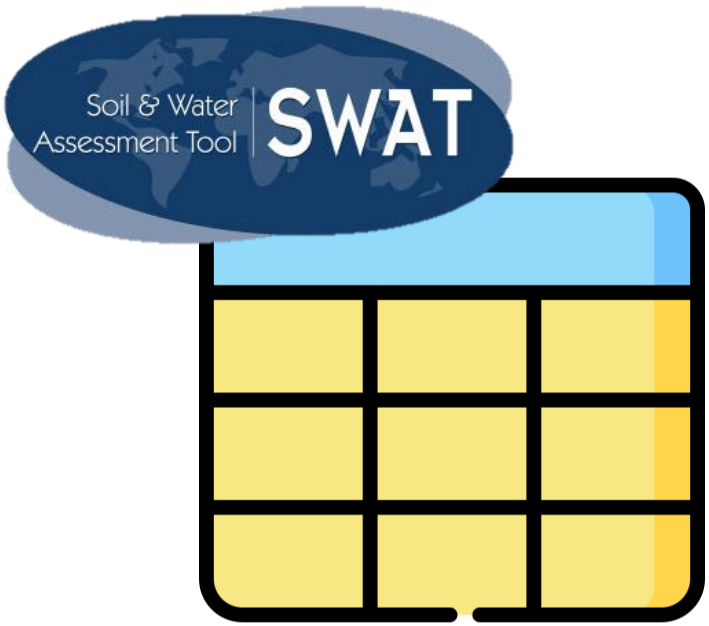
They say their aim is to help people reduce their energy bills and cut carbon emissions on a huge scale.

One plan nearing completion is a project that will create digital twins of 30 schools for Stirling Council.

01 Introduction

Goals

Development of a Water Quality Management Decision Support System integrating SWAT and Digital Twin for simulation of various scenarios.

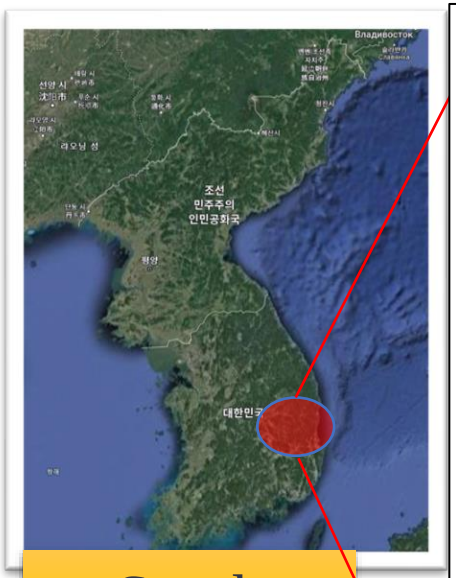


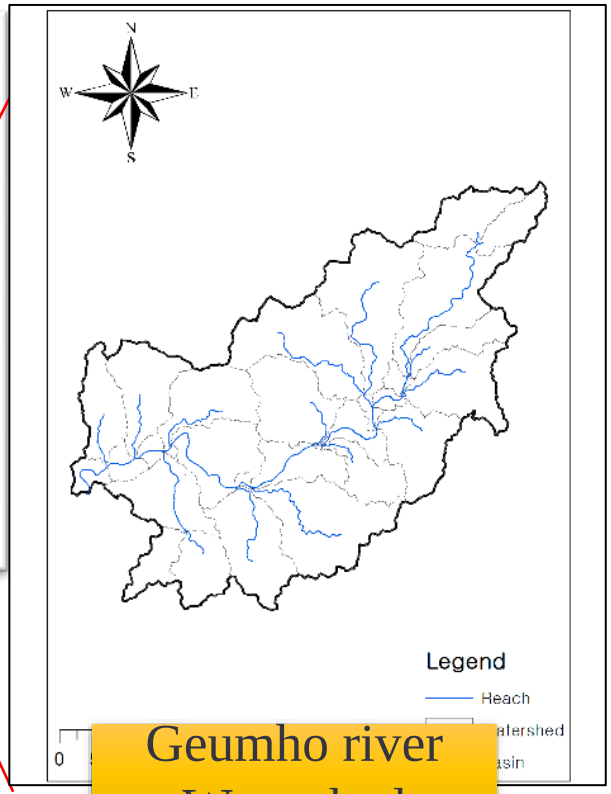
PART 2

Method and Material

02 Method and Material

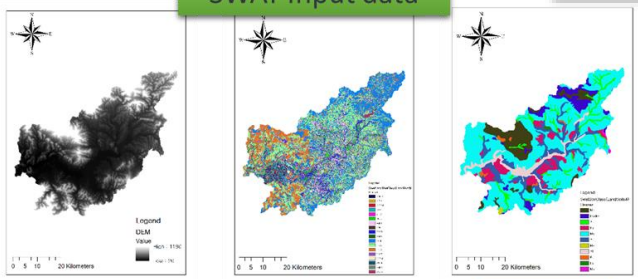
❖ Study Area and SWAT Input Data





- Watershed area : 2,092 km²
- Total stream length : 6,179.43 km
- The water quality of Geumho river has deteriorated due to industrialization and urbanization
- The Korean government is making efforts to solve the water quality of the Geumho River.

SWAT Input data



- Simulation Period: 2015 – 2022
- Simulation Variables: Flow (CMS), Water Quality: T-P (mg/L)

02 Method and Material

❖ 3D visualization platform CESIUM

- CESIUM is open source JavaScript library for creating 3D globes and maps
- CESIUM allows for interactive user engagement and real-time streaming, which is advantageous for time-based analysis

  → Analysis of changes over time is possible

Development of a Water Quality Management Decision Support System

(Visualization Component – Water Quantity, Water quality)

Soil & Water Assessment Tool SWAT

Water Quantity (CMS)

Express flow by changing the size of the point

●	**Fixed minimum size**	**Minimum except for the bottom 5%**
↓		
●	**Fixed maximum size**	**Max value**

Water Quality: T-P(mg/L)

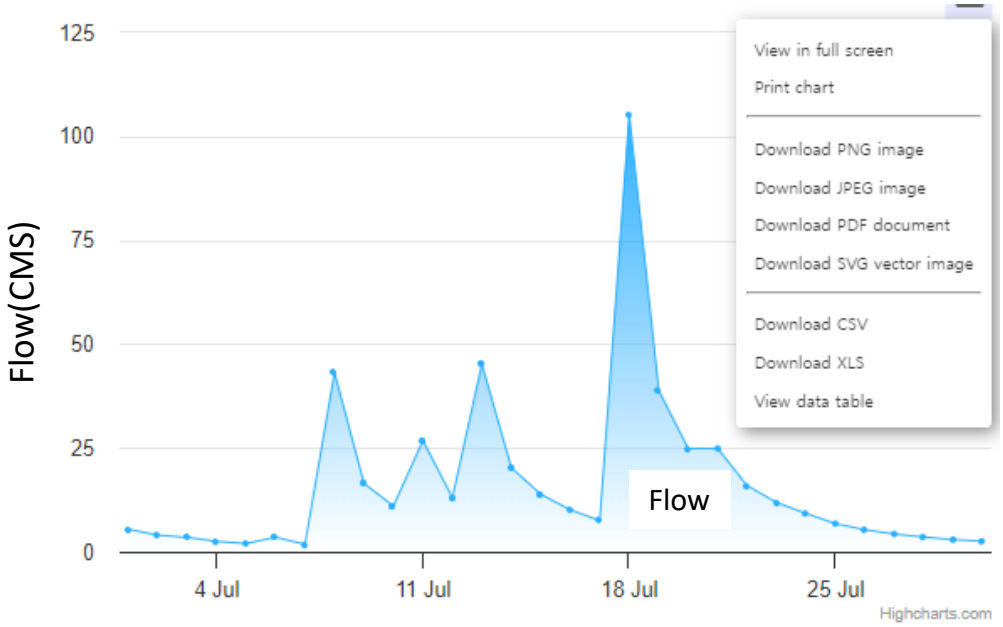
Express flow by changing the color of the point

●	**Excellent**	0.02mg/L or less
●	**Good**	Above 0.02mg/L 0.04mg/L or less
●	**Slightly good**	Above 0.04mg/L 0.1mg/L or less
●	**Medium**	Above 0.1mg/L 0.2mg/L or less
●	**Slightly bad**	Above 0.2mg/L 0.3mg/L or less
●	**Bad**	Above 0.3mg/L 0.5mg/L or less
●	**Very bad**	Above 0.5mg/L

'Living River Water Quality Standards

Development of a Water Quality Management Decision Support System (Additional Visualization Components – HighChart)

- HighChart is a software library for creating charts.
- Time series data (water Quantity / Water Quality) are displayed using HighChart
- HighChart enables to effectively visualize the time-dependent trends and fluctuation in the data



Flow of Geumho river – 26 sub-basin

Development of a Water Quality Management Decision Support System (visualization component – Drone filming and 3D Model Construction)

- 3D model was constructed using DJI Terra and visualized in CESIUM
- It has the advantage of being able to identify pollutant sources

Constructed 3D model

PART 3

Results and Discussion

03 Results and Discussion

Development of a Water Quality Management Decision Support System Result

Data

DataBase

	obj date	123 1_FLOW_OUTcms	123 1_T-Pkg	123 2_FLOW_OUTcms
183	2015-07-02	0.617	0	0.442
184	2015-07-03	0.442	0	0.324
185	2015-07-04	0.319	0	0.238
186	2015-07-05	0.232	0	0.176
187	2015-07-06	0.169	0	0.13
188	2015-07-07	1.289	1.703	0.83
189	2015-07-08	2.538	2.459	1.636
190	2015-07-09	10.95	105	6.813
191	2015-07-10	6.793	0.585	4.521
192	2015-07-11	4.788	0.013	3.277
193	2015-07-12	7.847	22.64	5.217
194	2015-07-13	5.302	0.164	3.67
195	2015-07-14	3.776	0.004	2.677
196	2015-07-15	2.712	0	1.963
197	2015-07-16	1.961	0	1.444
198	2015-07-17	1.427	0	1.066
199	2015-07-18	1.044	0	0.789
200	2015-07-19	0.768	0	0.586
201	2015-07-20	0.569	0	0.436
202	2015-07-21	0.424	0	0.325
203	2015-07-22	0.316	0	0.243
204	2015-07-23	0.238	0	0.182
205	2015-07-24	0.179	0	0.136
206	2015-07-25	0.136	0	0.102
207	2015-07-26	0.104	0	0.077
208	2015-07-27	0.08	0	0.058
209	2015-07-28	0.064	0	0.045
210	2015-07-29	0.05	0	0.034
211	2015-07-30	0.039	0	0.026
212	2015-07-31	0.031	0	0.02
213	2015-08-01	0.025	0	0.015
214	2015-08-02	0.838	1.296	0.53
215	2015-08-03	0.55	0.004	0.368
216	2015-08-04	0.389	0	0.267
217	2015-08-05	0.278	0	0.195

SWAT result

Reconstructed Flow and Water Quality values in DB

SQL query (user Request data)

Data

Visualization

HTML

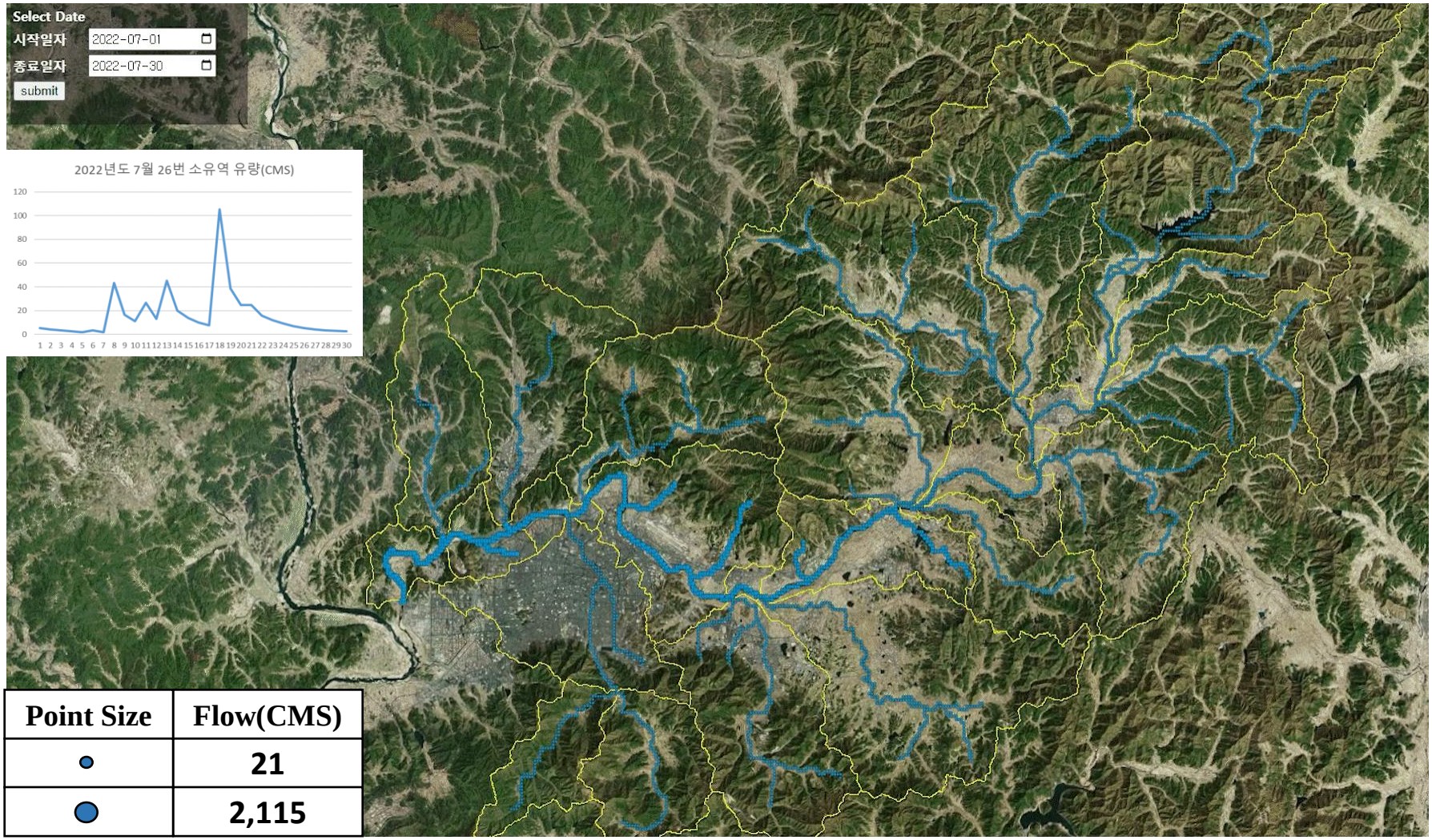
Select Date
시작일자 연도-월-일
종료일자 연도-월-일
submit

Request data

Server

Viewer

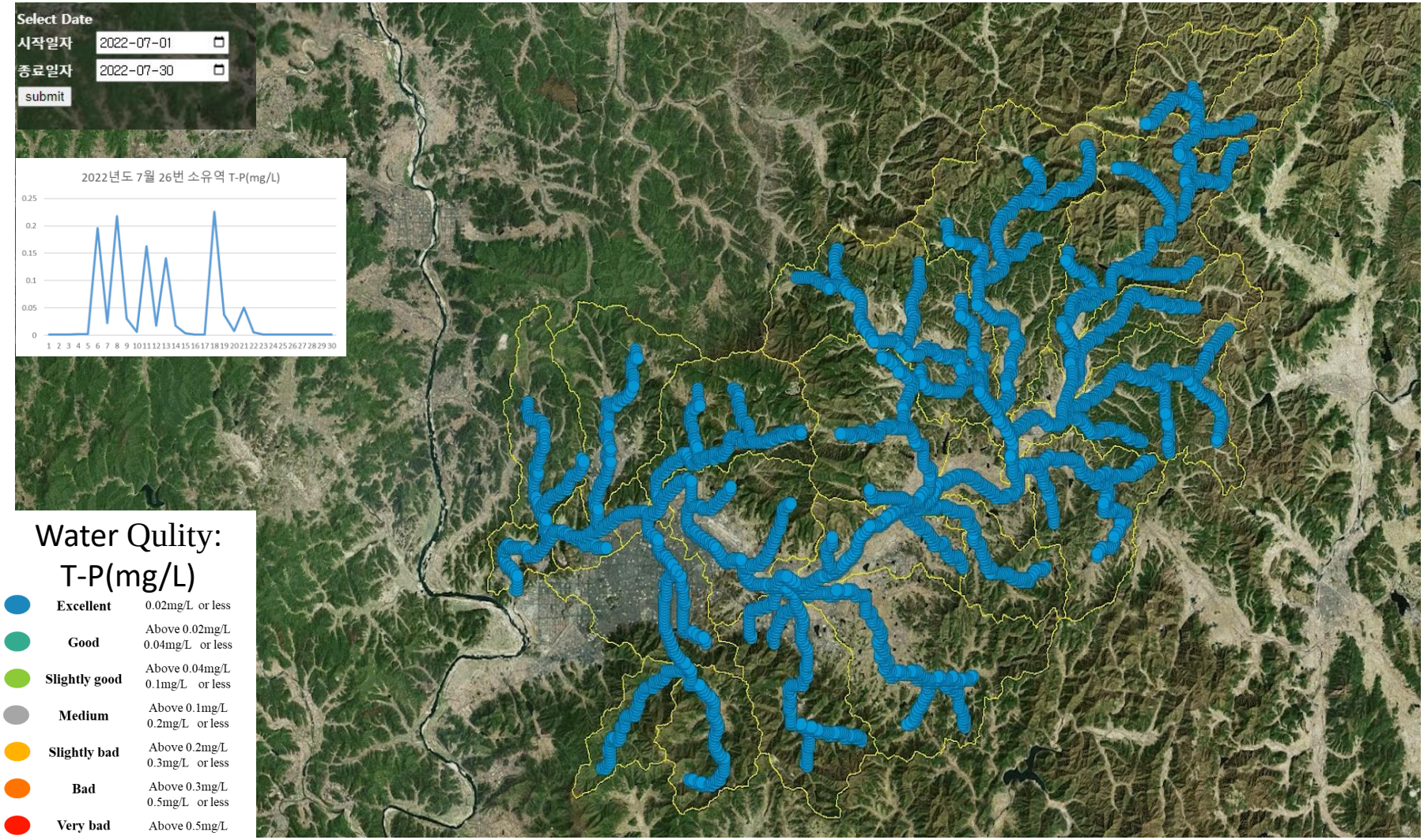
❖ Flow visualization result of SWAT Model



Point Size	Flow(CMS)
●	21
●	2,115

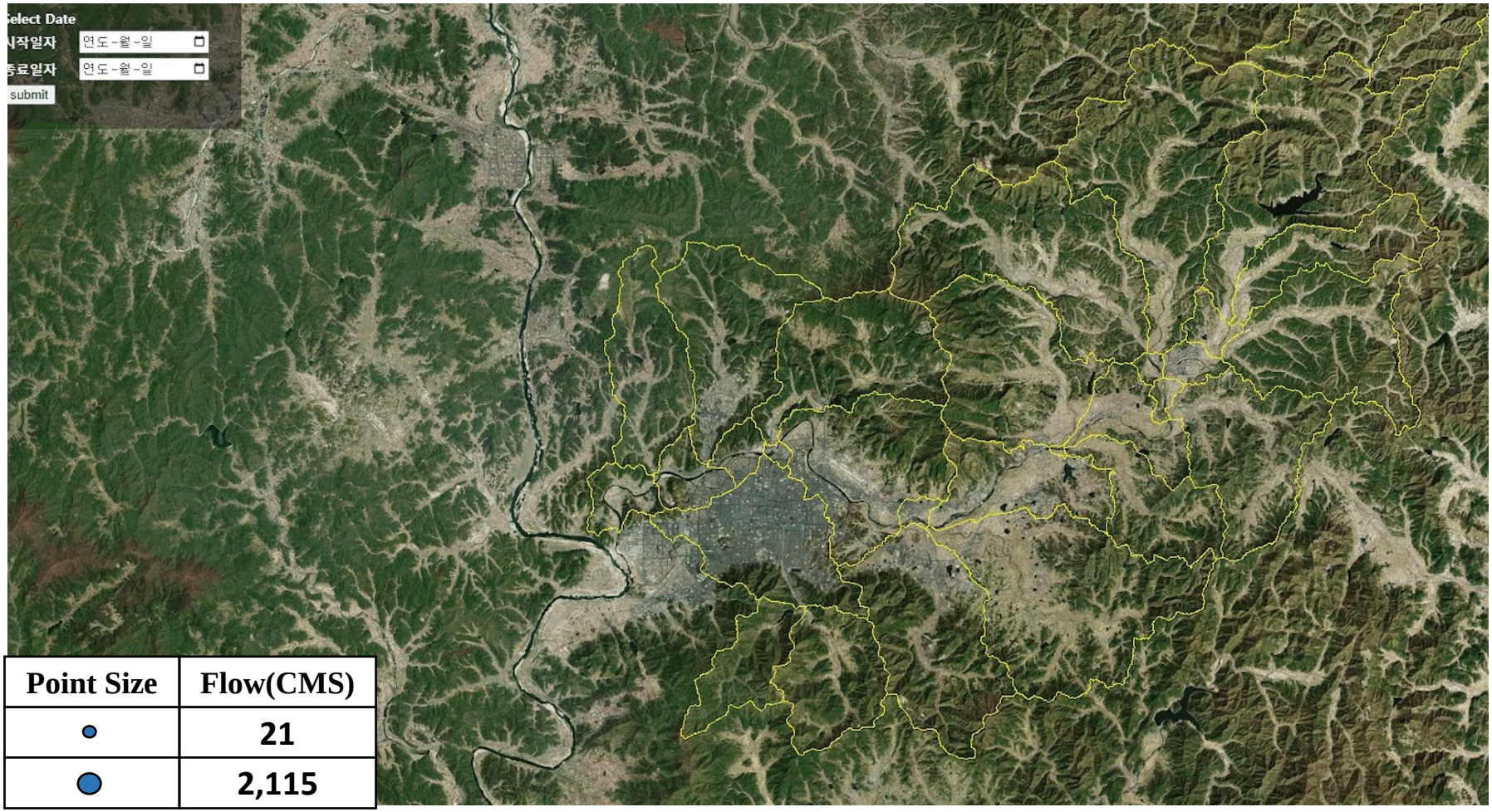
03 Results and Discussion

❖ Water Qulity Visualization Result of SWAT Model



03 Results and Discussion

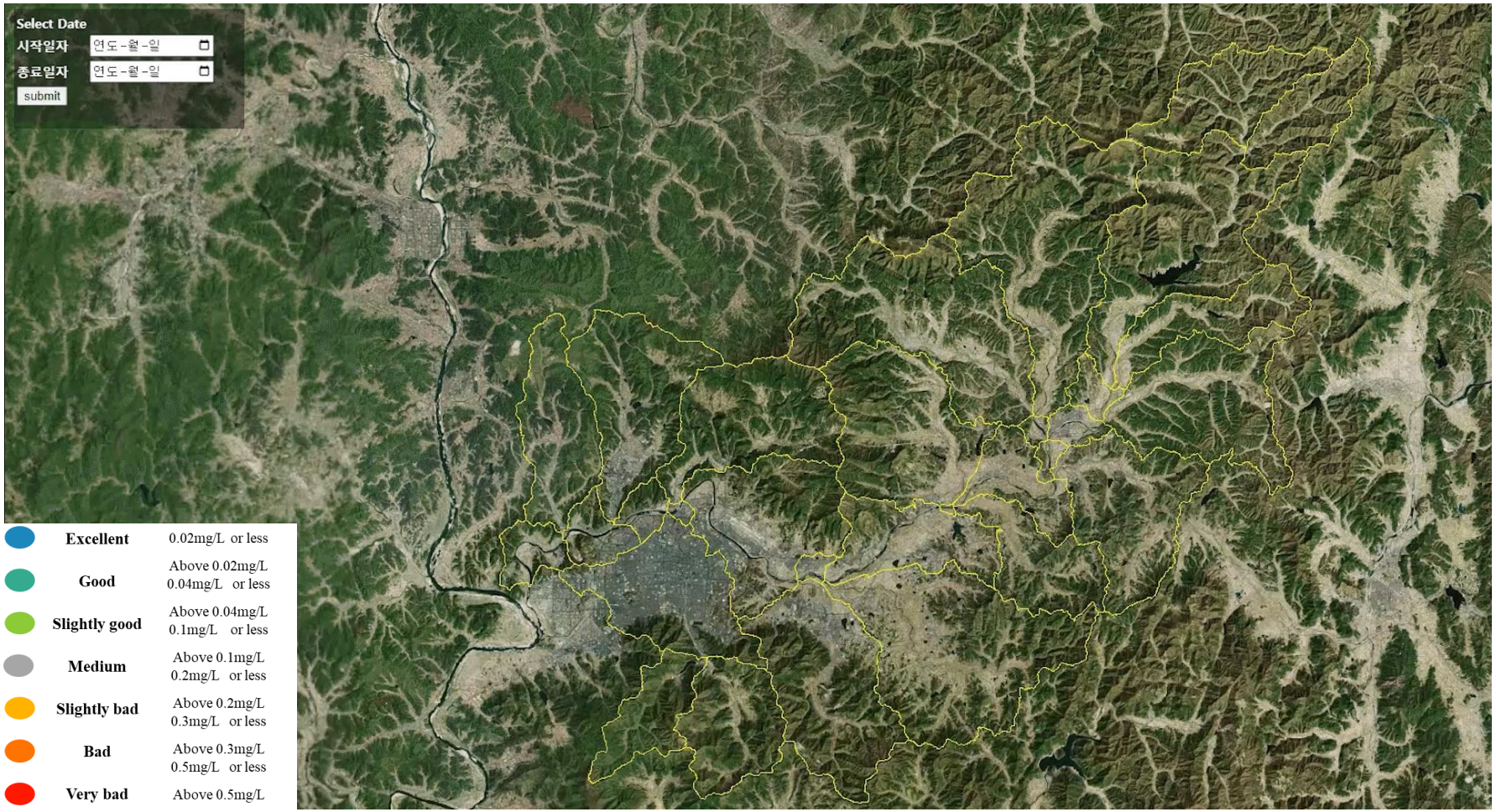
❖ Display of Time Series Flow Data of SWAT Model Using HighChart



Point Size	Flow(CMS)
●	21
●	2,115

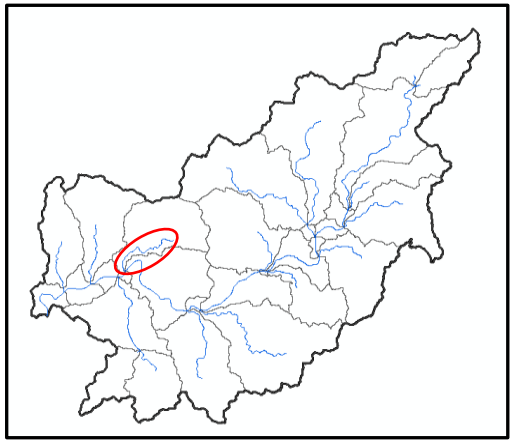
03 Results and Discussion

❖ **Display of time-series water quality Data of SWAT model using HighChart**



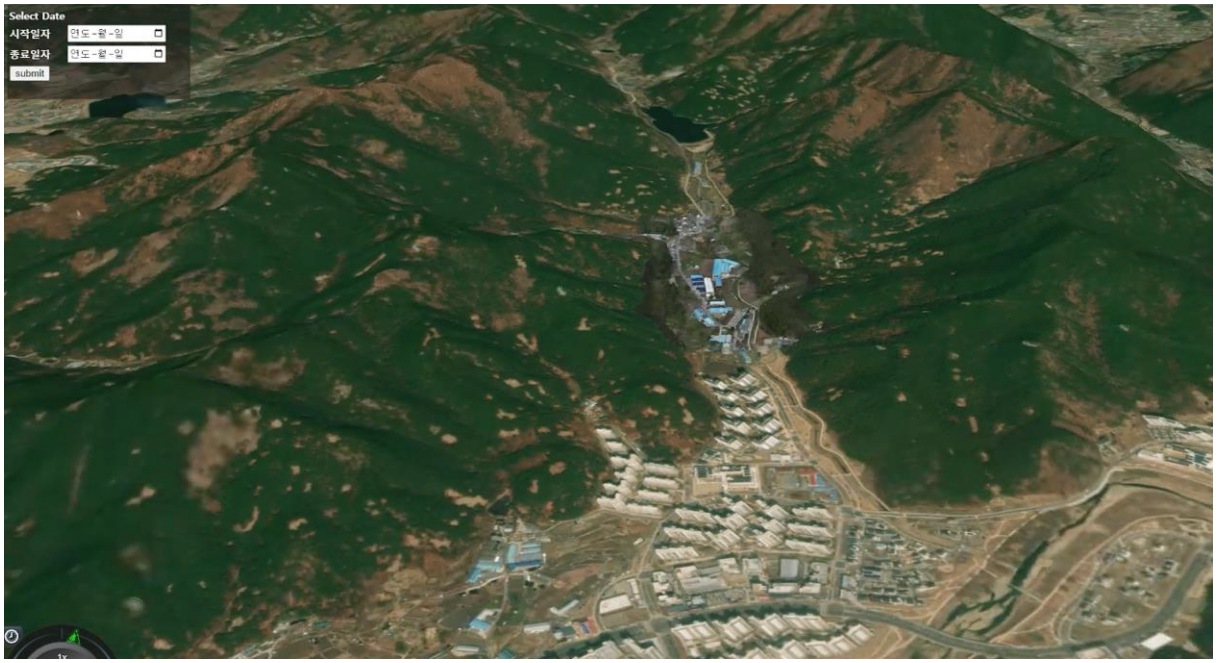
03 Results and Discussion

❖ Construction 3D objects using drones



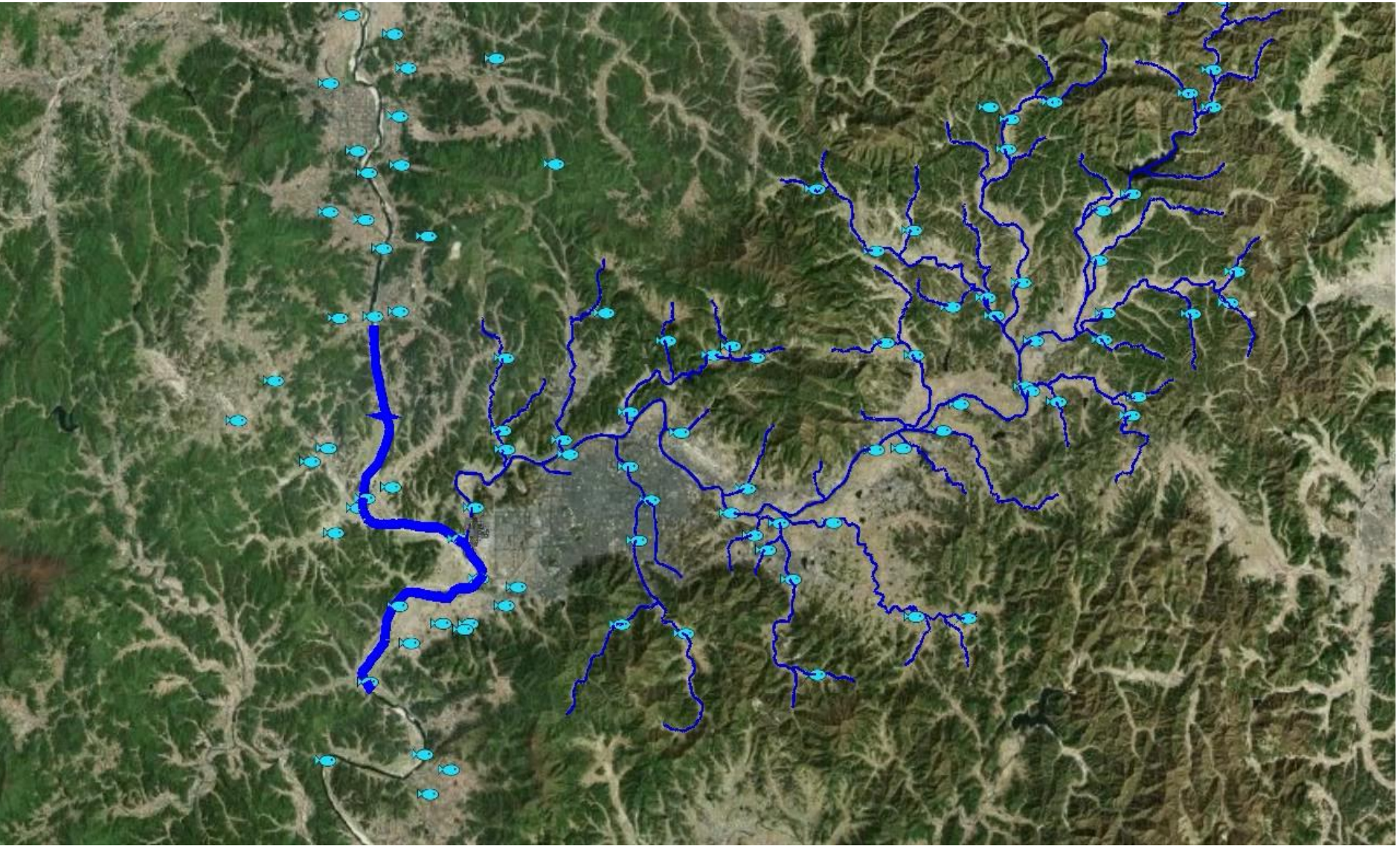
- The drone used for filming (Metrice 300 RTK)

- 3D object model has been constructed using drone filming. This is expected to help identify the source of pollution.



03 Results and Discussion

❖ **Visualization of aquatic ecosystem Observed data in 2022 of the Geumho River**



Conclusion and Future Plan

04 Conclusion and Future Plan

❖ Conclusions and limitation

- In this study, developed a Water Quality Management Decision Support System based on a watershed model and 3D platform system.
- The system visualizes water quantity and water quality data, which is traditionally presented in table format, allowing for intuitive understanding.
- However, there is an issue where some point source pollution values appear lower than the actual measurements due to the inability of the SWAT model to account for point source pollution.

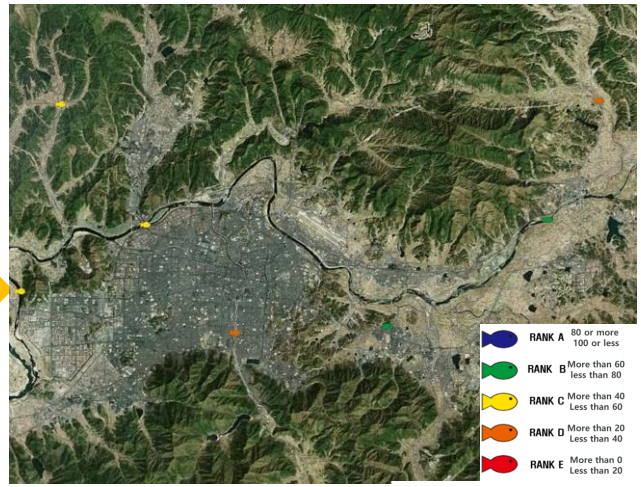
04 Conclusion and Future Plan

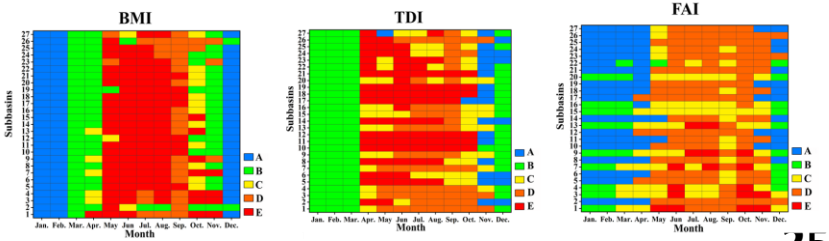
❖ Prediction of Aquatic Ecosystem Health through SWAT and Machine Learning Models

- We plan to display the prediction results of aquatic ecosystem health based on watershed environment, not only water quantity and water quality, in the 3D-based decision support system, by utilizing a machine learning model and the SWAT model for predicting aquatic ecosystem health.

Soil & Water Assessment Tool SWAT

Visualization of prediction data for changes in aquatic ecosystem health according to watershed environment





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Thank you for listening!

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