

# Analysis of Baseflow through Application of SWAT-BFlow $\beta$ Parameter by Flow-Conditions

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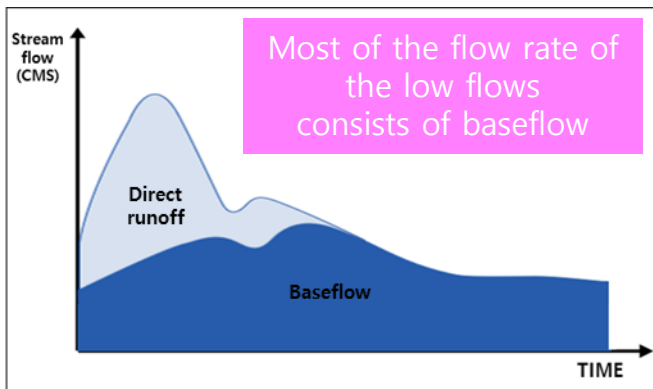
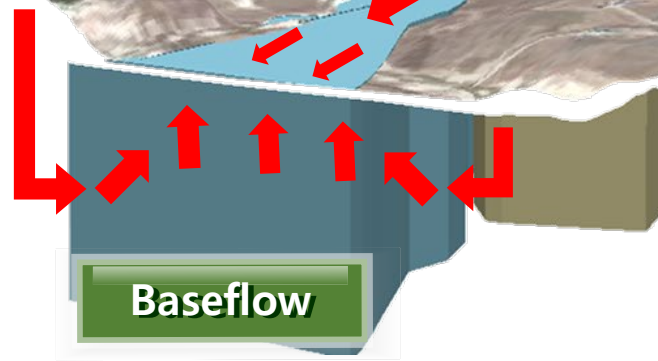
A large, dark blue circular graphic containing the word "PART" in white, uppercase letters at the top left. Below it is a large, white, stylized number "1" that is partially cut off by the right edge of the circle.

# Introduction

# 01 Introduction

## ❖ What are direct runoff and baseflow?

- Streamflow can be divided into direct runoff and baseflow.
- Direct runoff is the precipitation into a river in a relatively short period of time.
- Baseflow is flows into rivers after rainfall infiltrate to groundwater.



# 01 Introduction

## ❖ Definition of baseflow and Necessity to manage it

- In the past, many studies direct runoff from rivers were conducted and relatively few studies on baseflow.
- According to studies on baseflow, the proportion of baseflow in streamflow accounts for more than 50% of each of the four major rivers in South Korea.
- In other words, the proportion of baseflow in streamflow is higher than that of direct runoff.

Journal of Korean Society of Agricultural Engineers, Vol. 49, No. 1, pp. 20-25 (2014)

Journal of Korean Society on Water Environment, Vol. 18, No. 4, pp.437-451 (2014)

Journal of Korean Society on Water Quality, Vol. 22, No. 2, pp.249-259 (2006)

수계별 주요 유역 지형에 대한 관수량과 기저유출 기여도 분석  
수계별 기저유출 기여도 분석

농업소외지역의 기저유출에 의한 오염부하 특성

다량한 기저유출 분리 방법을 이용한 4FDR 소배하 시간대별 (안·개살·물) 기저유출 기여도 분석  
Analysis of Baseflow Contribution Rate Using Various Baseflow Separation Methods in a Watershed

이승환\*, 김희연\*, 김현경\*, 김성민\*  
Lee, Seung-Hwan, Kim, Hee-Yeon, Kim, Hyun-Kyung, Kim, Seung-Min

한강수계의 하천에 대한 직접유출과 기저유출의 기여도  
Quantifying Contribution of Direct Runoff and Baseflow in Han River System, South Korea

홍지영\*, 김경재\*, 신용철\*, 정영훈\*  
Hong, Jiyoung, Kim, Kyungjae, Shin, Yongcheol, Jung, Younghun

Therefore, it is important to accurately estimation the amount of baseflow by separating the baseflow from the streamflow.

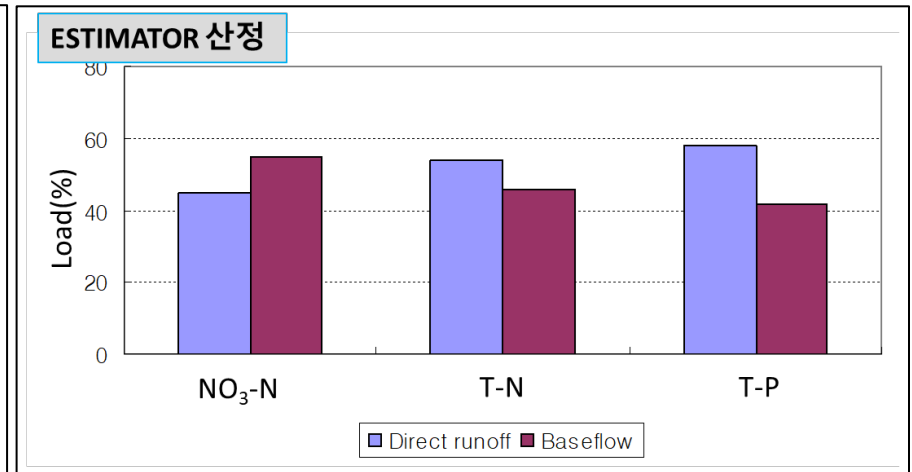
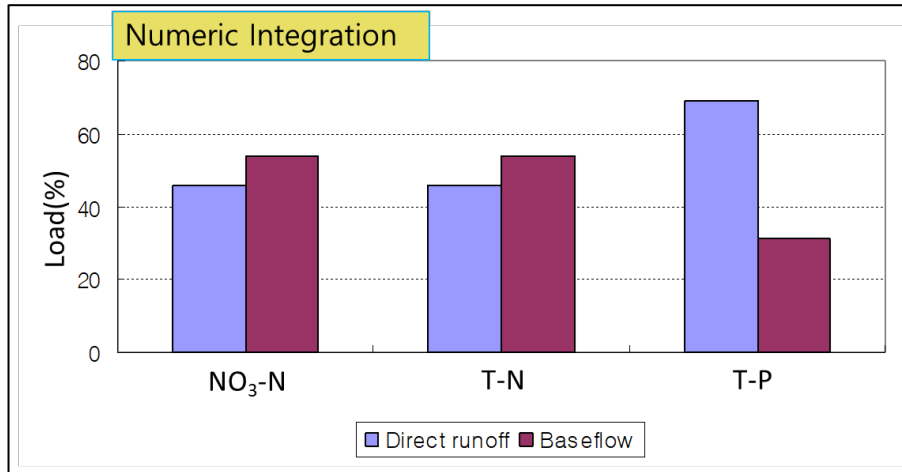
WHAT 시스템 활용  
전국 91개 WAMIS 유량 관측소 유량자료 (2009년 - 2013년 (5년))

낙동강		
유량	최대값	평균
9	76	58

영산·섬진강						
기저유출 기여도(%)	최소값	최대값	평균	최소값	최대값	평균
0.2-0.4	40	70	55	39	61	50

## ❖ Definition of baseflow pollutant load and Necessity to manage it

- There is a study comparing the NI method and the Estimer method, which are methods of calculating the amount of pollutant load in South Korea (Shin, 2006).
- According to the study, the amount of pollutant load caused by the baseflow is also not small.



**In the management of stream water quality, you need to calculate and manage the amount of pollutant load caused by baseflow.**

## ❖ The purpose of this study

### Baseflow separation

- Use Pass 1 where the baseflow peak stick to falling lomb of the recession curve among the three result values for BFlow
- Filter parameters that are sensitive to the falling lomb when separating baseflow are applied by flow-conditions

### Calculation pollutant load

- Calculation of pollutant load using base water quality values

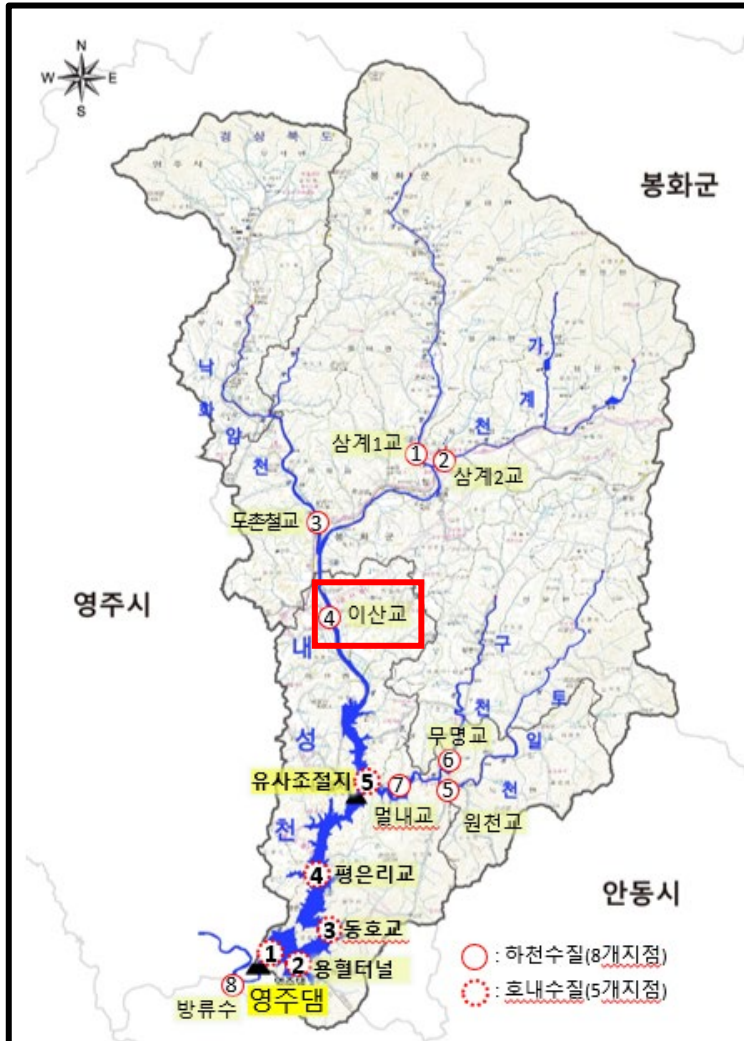
**Calculation of Total/Base Pollutant Load  
Considering the Characteristics of the falling lomb  
Program WAPLE4 Development**



**PART**  
**2**  
**Methods**

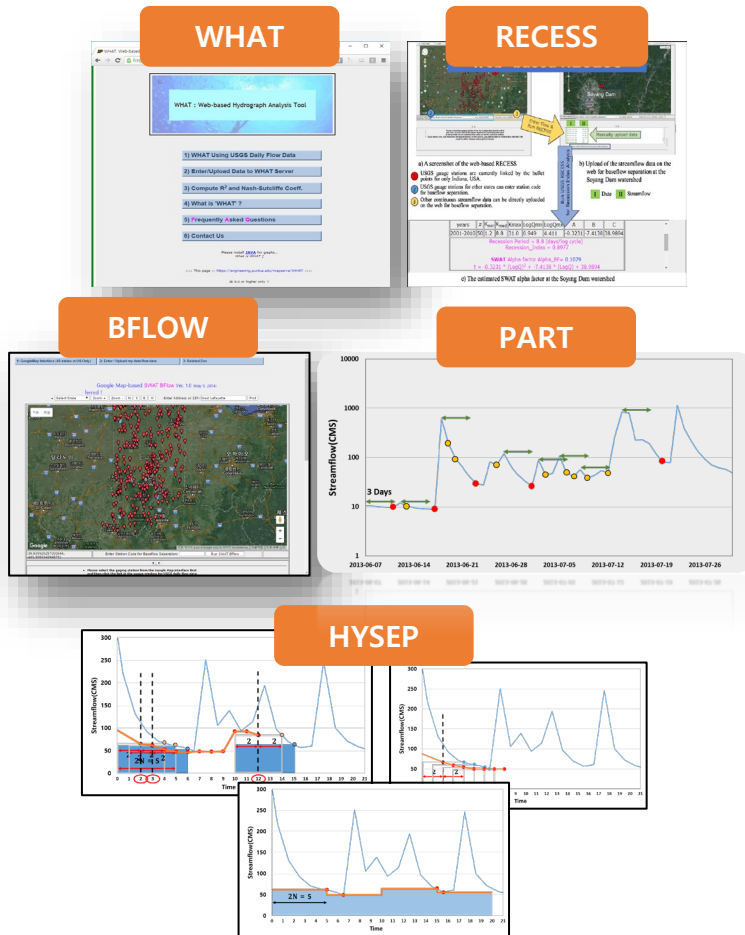


## ❖ Research target area



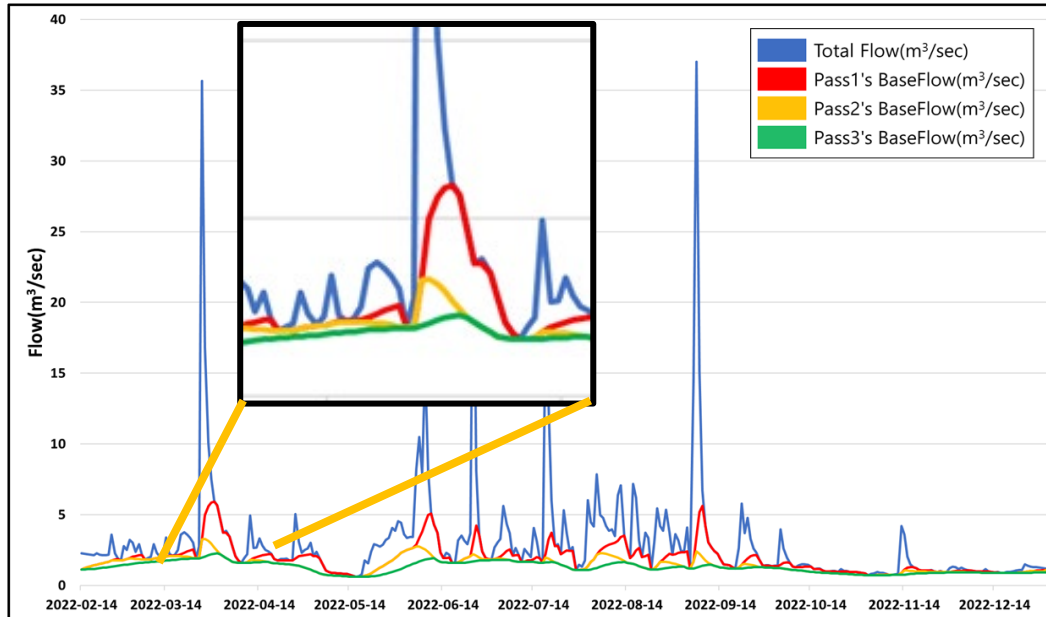
- **Research target area : Isan Bridge, Andong City, South Korea**  
**Area : 648.97 km<sup>2</sup>**  
 Maximum elevation : 860 m  
 Minimum elevation : 40 m  
 Average elevation : about 176 m
- **Gapcheon land use status**  
**Forest : about 67.39%**  
**Urbanization/ Dry area: about 18.36%**  
**Agricultural land : about 7.68%**
- **The simulation period 2019 to 2021**
- **Flow gauge station: Mulgyo Bridge in Munpyeong-dong, Daedeok-gu, Daejeon / Shingu Bridge, Bonsan-dong, Yuseong-gu, Daejeon**
- **Weather gauge station: Daejeon Regional Office of Meteorology**

## ❖ Baseflow separation methods



- There are various algorithms such as Recursive Digital Filter(WHAT), Master recession curve(RECESS), Local Minimum(HYSEP) for separate the baseflow from the streamflow.
- In this study, BFlow, which can be intergrated with the SWAT model used in various ways for watershed management, is used.
- BFlow separates the baseflow from the streamflow by applying a filter method (One parameter filter) that separates the low frequency from the high frequency.

## ❖ BFlow Characteristic and Problem 1



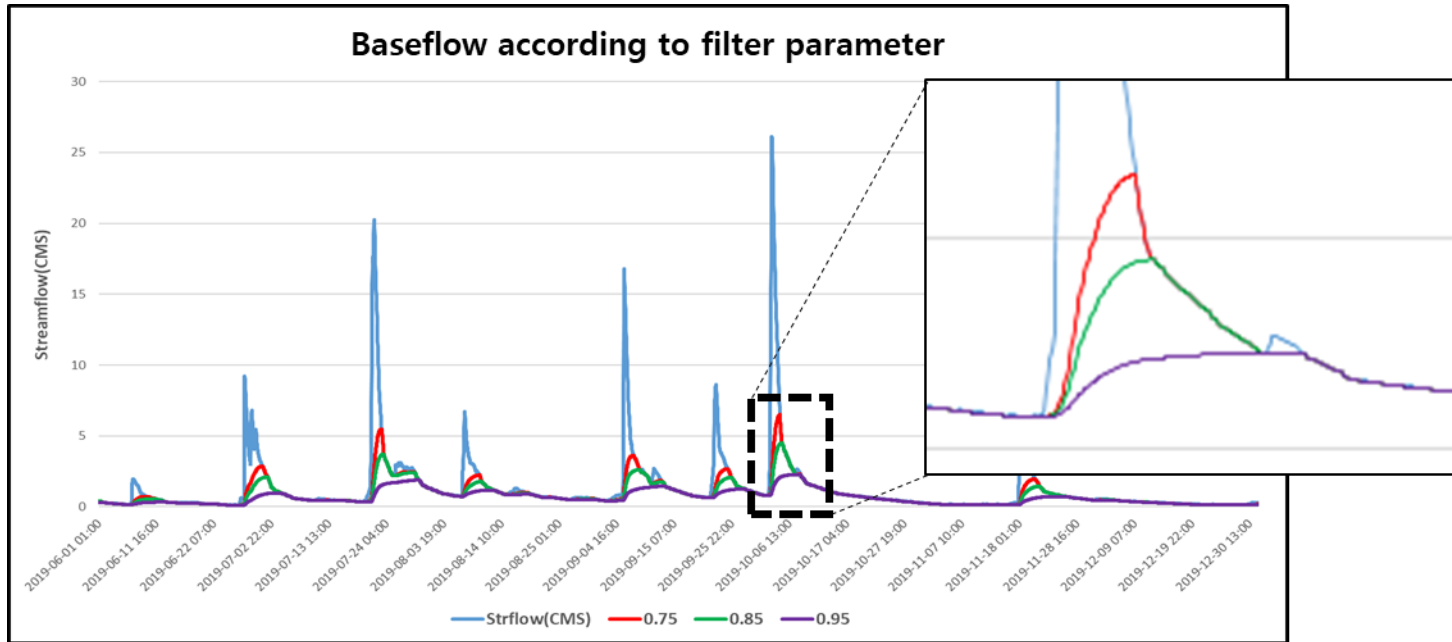
The filter can be passed over the streamflow data three times (forward, backward, and forward), depending on the user's selected estimates of baseflow from pilot studies of streamflow data. In general, each pass will result in less baseflow as a percentage of total flow. Arnold et al. (1995) compared the digital filter results with results from manual separation techniques and with the PART model (Rutledge, 1993; Rutledge and Daniel, 1994) for 11 watersheds in Pennsylvania, Maryland, Georgia, and Virginia (White and Slot, 1990).

TABLE 2. Baseflow as a Fraction of Total Streamflow for Selected One, Two, and Three Passes With the Digital Filter

Watershed	Pass 1	Pass 2	Pass 3
Onyx, Illinois, 1950-1980	0.18	0.19	0.21
Forbes, Illinois, 1915-1985	0.46	0.34	0.27
Madley, Illinois, April 1985-September 1988	0.39	0.37	0.33
Reynolds, Pennsylvania, 1950-1985	0.76	0.74	0.64
Reynolds, Pennsylvania, 1985-1988	0.65	0.70	0.64
Pennington, Queensland, August 1983-December 1986	0.42	0.39	0.35
Reynolds, Maryland, April 1985-March 1990	0.73	0.74	0.64

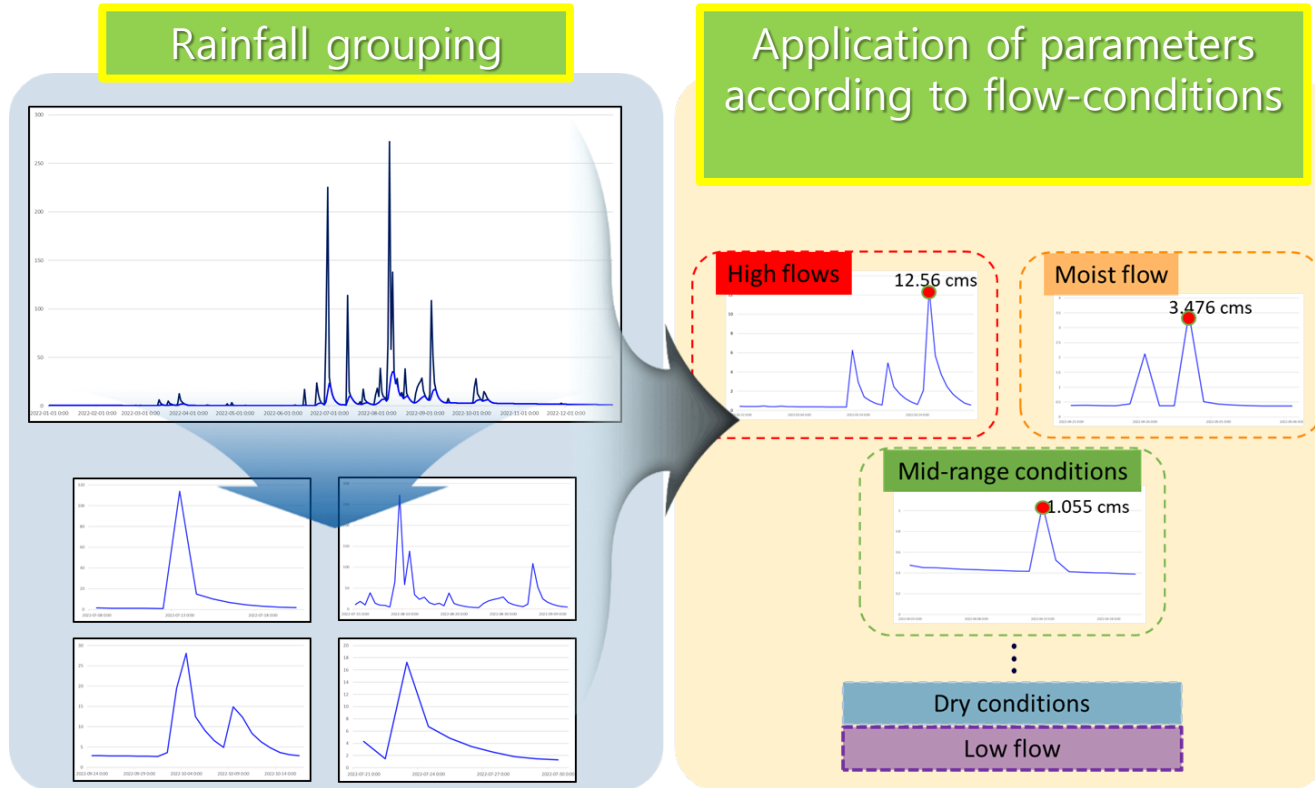
- The result of BFlow comes out as pass 1 ~ 3 depending on how the filter is applied.
  - In the paper of Arnold and Allen (1999), it is recommended to use the pass 2 value among the filter results, and most people use the pass 2 value.
  - However, as a result of the BFlow pass, pass 2 has an inflection point of recession curve in the rising part, which separates the baseflow.
- As the result of pass 1, the peak of baseflow stick to the inflection point of recession curve, and the baseflow is separated.

## ❖ BFlow Characteristic and Problem 2



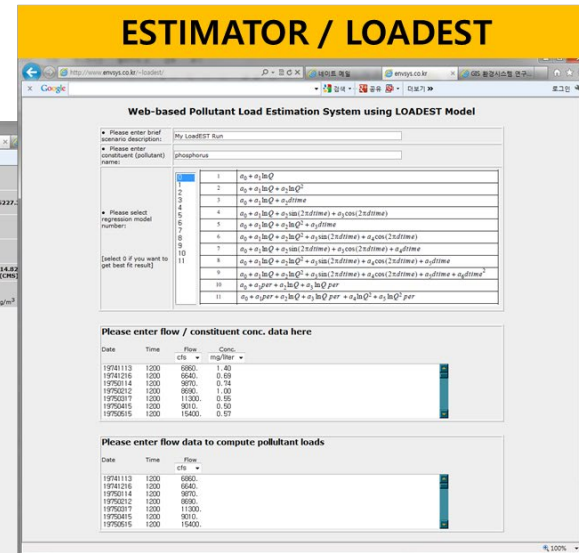
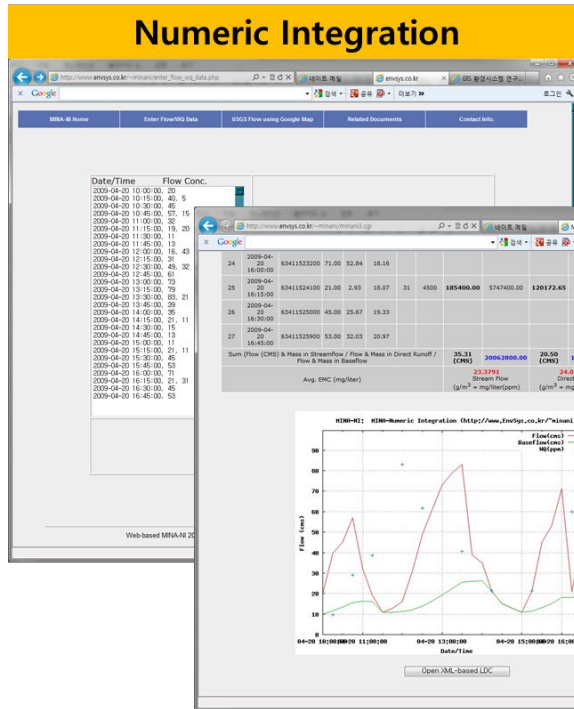
- ✓ Filter parameters utilized for baseflow separation in BFlow use a fixed value of 0.925 and cannot be modified by the user.
- ✓ However, as shown in the graph above, the separated baseflow depends on the Filter parameter.
- ✓ Therefore, Filter parameters should be selected differently for each flow-conditions.

## ❖ Improvements: Apply flow-conditions parameter



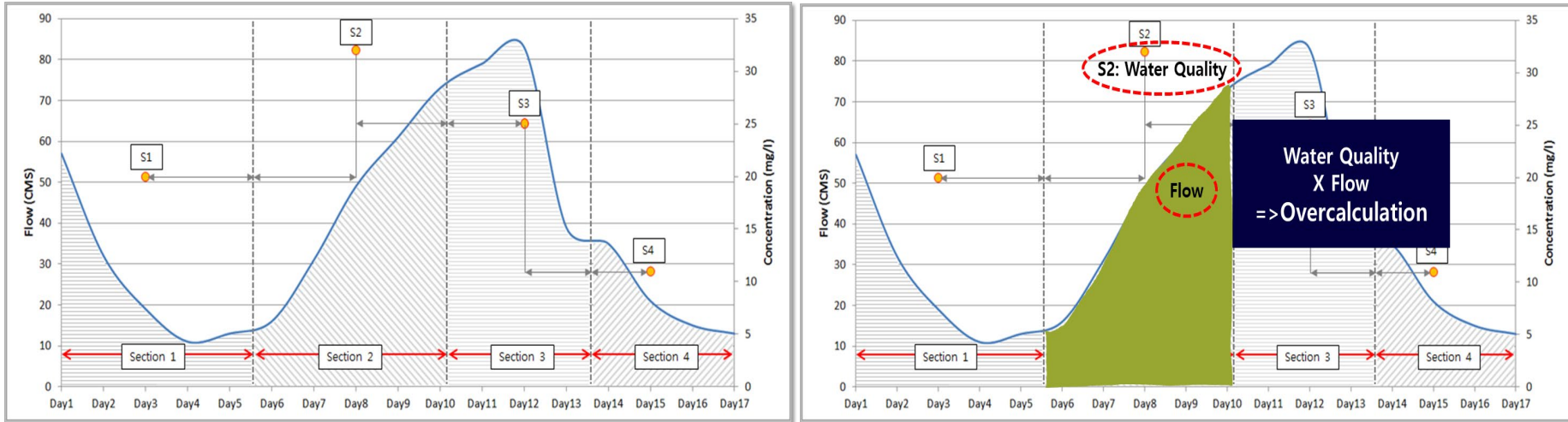
- ✓ First, we had found out the rainfall event throughout the simulated period.
- ✓ Separate the baseflow by applying the filter parameter differently for each flow-conditions.

## ❖ How to pollutant load



❖ Methods for calculating the amount of pollutant load include the Numeric Integration(NI) method, ESTIMATOR, LOADEST, etc.

## ❖ Numeric Integration Characteristic and Problem



- ✓ The NI method can simply calculate the amount of pollutant load by the following equation.

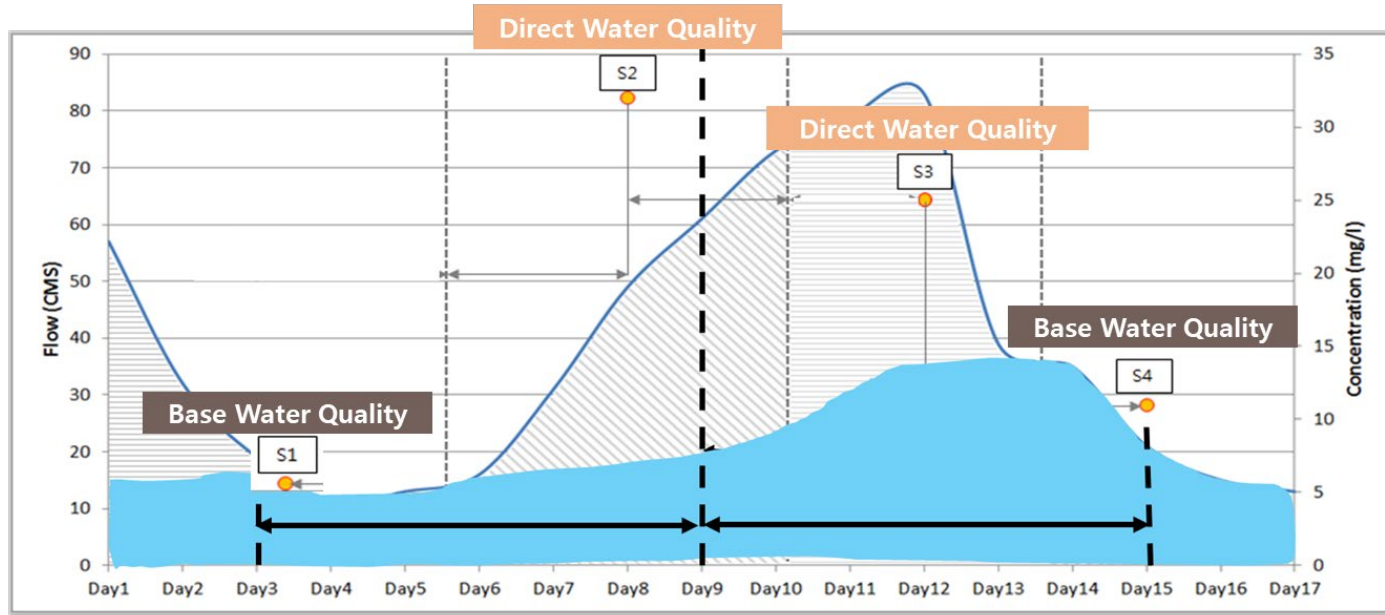
$$Load = \sum_{i=1}^n c_i q_i t_i$$

- ✓  $C_i$  : Concentration of the i-th sample,  $q_i$  : flow of the i-th sample,  
 $t_i$  : i-th time interval  $(t_{i+1} - t_{i-1})/2$

If the pollutant load is calculated with a **value** in the baseflow, there is a problem



## ❖ Total/Baseflow Pollutant Load



- ✓ In this study, water quality was classified according to the amount of baseflow separated by BFlow.
- ✓ In addition, the total pollutant load and the baseflow pollutant load were calculated, respectively.



## ❖ Flow chart of the study

Use **Pass 2** among BFlow result values

Use a **single parameter** throughout the simulated period

When calculating the baseflow pollutant load, Calculation using **water quality value**

Use **Pass 1** among BFlow result values

Apply **flow-conditions parameters**

When calculating the baseflow pollutant load, Calculation using **base water quality value**



**WAPLE4**



WAPLE(WHAT-Pollutant Load Estimation)

## ❖ WAPLE4 usage developed in this study by Web

**Data Upload**

Example Data: 상계1교 (\*.csv)

**WAPLE4**

Please upload input data file (\*.csv)

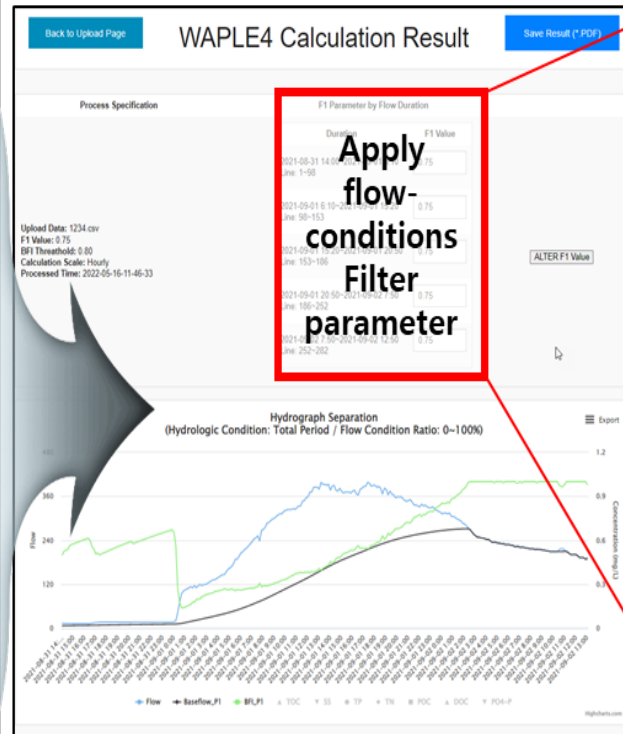
Input csv drag & drop

Filter parameter

Enter the representative BFI value by water quality

**RUN**

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**F1 Parameter by Flow Duration**

Duration	F1 Value
High flows	0.23
Moist conditions	0.4
Mid-range conditions	0.45
Dry conditions	0.4
Low flows	0.35

The graphic consists of a large blue circle on the left. Inside the circle, the word "PART" is written in white, uppercase letters at the top. A large, white, stylized number "3" is positioned in the center of the circle, overlapping the word "PART". To the right of the circle, the word "Result" is written in a bold, blue, sans-serif font.

## ❖ Parameters and duration of simulation of WAPLE4

- Representative Filter parameter: 0.925
- BFI: 0.9
- Simulated period: Jan 01, 2022 ~ Dec 31, 2022

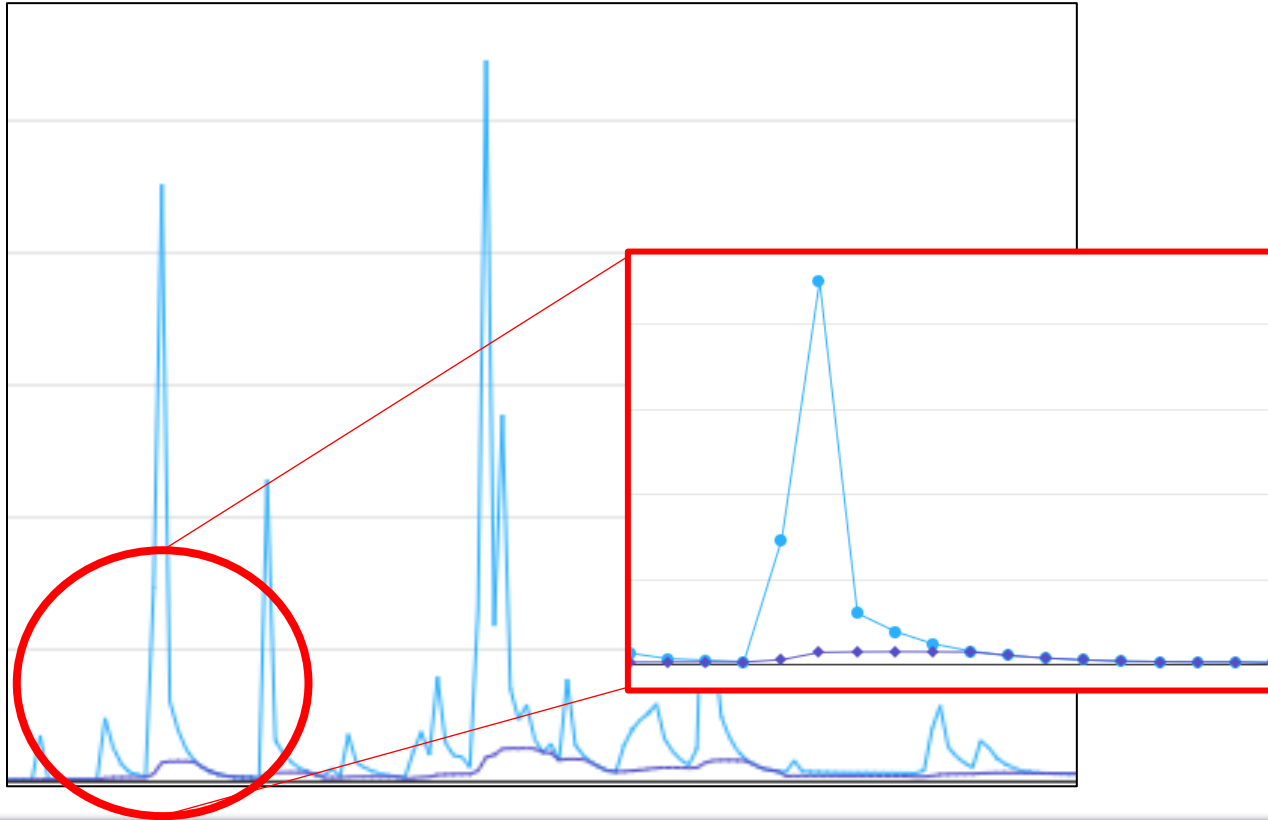
### Filter parameter by Flow-conditions

Duration	F1 Value
High flows	0.9
Moist conditions	0.8
Mid-range conditions	0.8
Dry conditions	0.7
Low flows	0.925

## ❖ Comparison of WAPLE4 and WAPLE2 Baseflow Separation

WAPLE2

Baseflow separation using WHAT

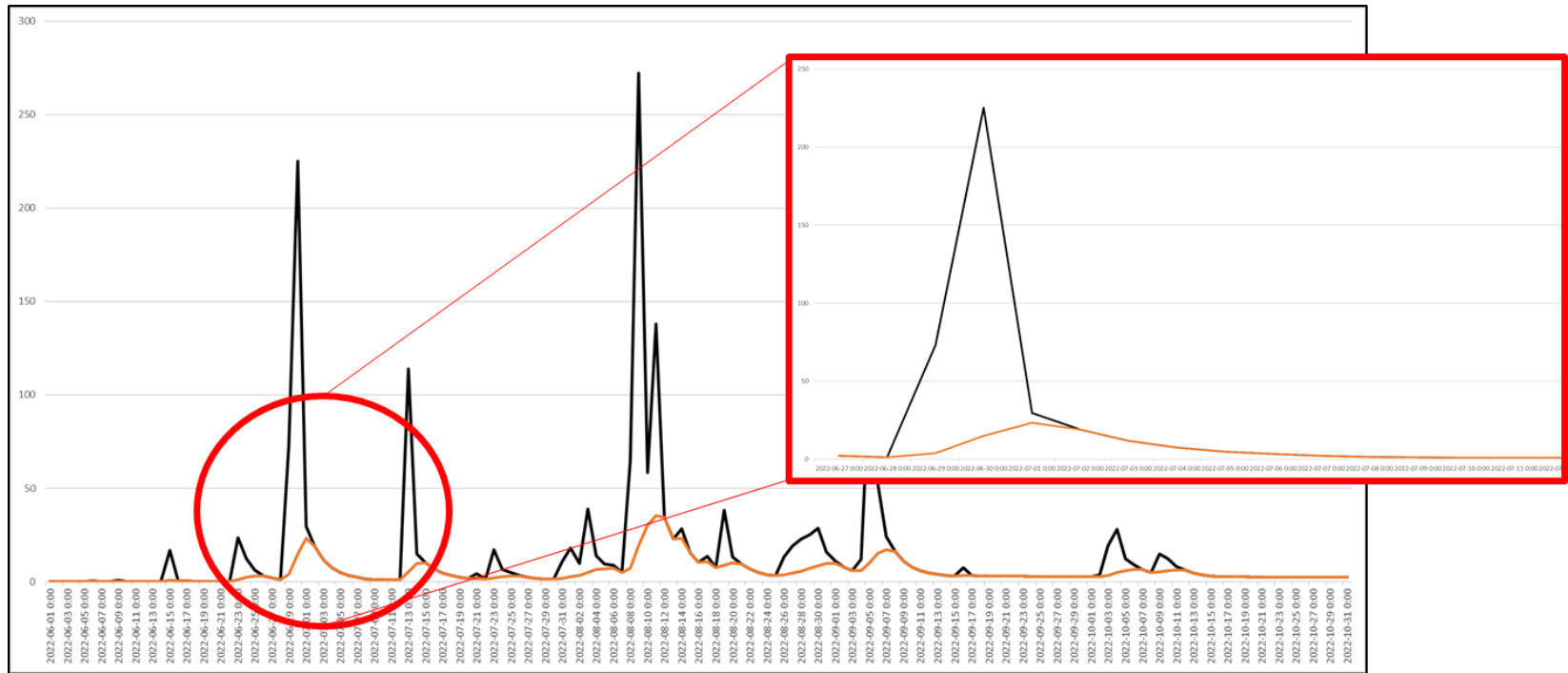


- ✓ In WAPLE2, the peak of the baseflow graph does **not stick to the inflection point**

## ❖ Comparison of WAPLE4 and WAPLE2 Baseflow Separation

WAPLE4

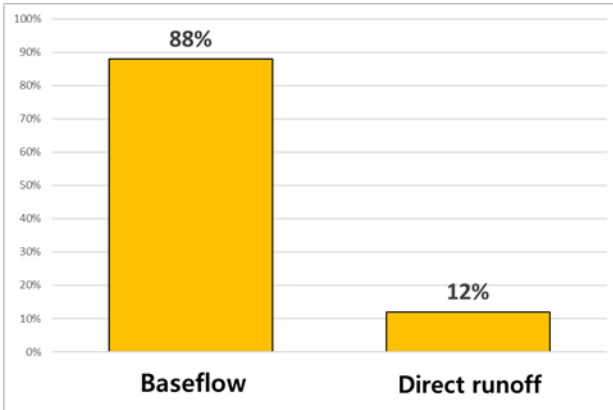
Baseflow separation using BFlow



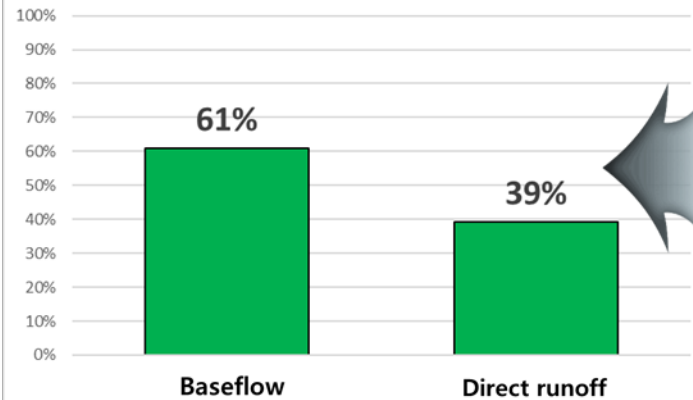
✓ In WAPLE4, the peak of the base flow graph stick to the inflection point

## ❖ Baseflow separation with single/flow-conditions parameters

Single filter parameter : 0.925



Flow-conditions filter parameter



F1 Parameter by Flow Duration

Duration	F1 Value
High flows	0.9
Moist conditions	0.8
Mid-range conditions	0.8
Dry conditions	0.7
Low flows	0.925

## ❖ Comparison of WAPLE4 and WAPLE2 calculation results

	BFI			
	Baseflow		Direct runoff	
WAPLE2	1,838 m <sup>3</sup> /s	<b>76%</b>	577 m <sup>3</sup> /s	24%
WAPLE4	1,447 m <sup>3</sup> /s	<b>61%</b>	931 m <sup>3</sup> /s	39%

	T-N Pollutant Load			
	Baseflow		Direct runoff	
WAPLE2	472,012 kg	<b>81%</b>	107,599kg	19%
WAPLE4	319,688 kg	<b>56%</b>	246,549 kg	44%

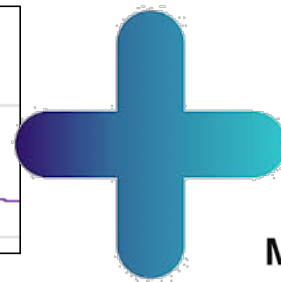
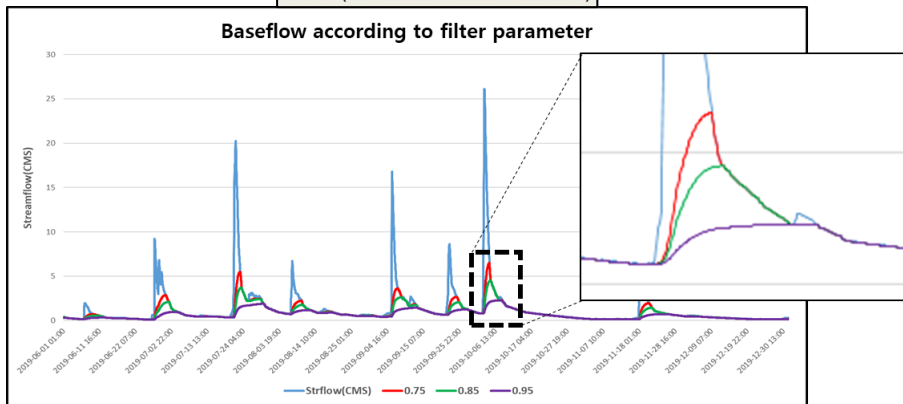


A graphic consisting of a dark blue circle containing the word 'PART' in white, a large white number '4' that overlaps the circle's edge, and the word 'Conclusion' in a dark blue sans-serif font to the right of the circle.

**PART**  
**4** **Conclusion**

## ❖ Conclusion and Research limitation

- In this study, we developed WAPLE4, which can separate baseflow from streamflow, and estimates the baseflow pollutant load and streamflow pollutant load, more accurately.
- In addition, the baseflow was separated from the streamflow by applying the filter parameter for each flow-conditions.
- In the future research, we plan to find out to inflection point in the recession curve using machine learning.



**MACHINE LEARNING**





**SWAT** Soil & Water  
Assessment Tool

# Thank you

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