Evaluation of Watershed Management Practices on receiving water quality using SWAT model

2010.08.04

Jang, Jae Ho

Korea Environment Institute

Outline of Presentation

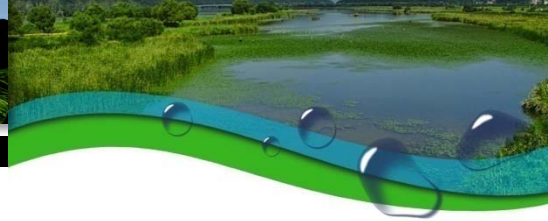
1 Research Background and Objectives

2 Model Preparation and Application

3 Watershed Management Measures

4 Conclusion and Future Study





Research Background and Objectives

Research Background

Nature Problem

Environmental groups

Government plan

Porum and symposium

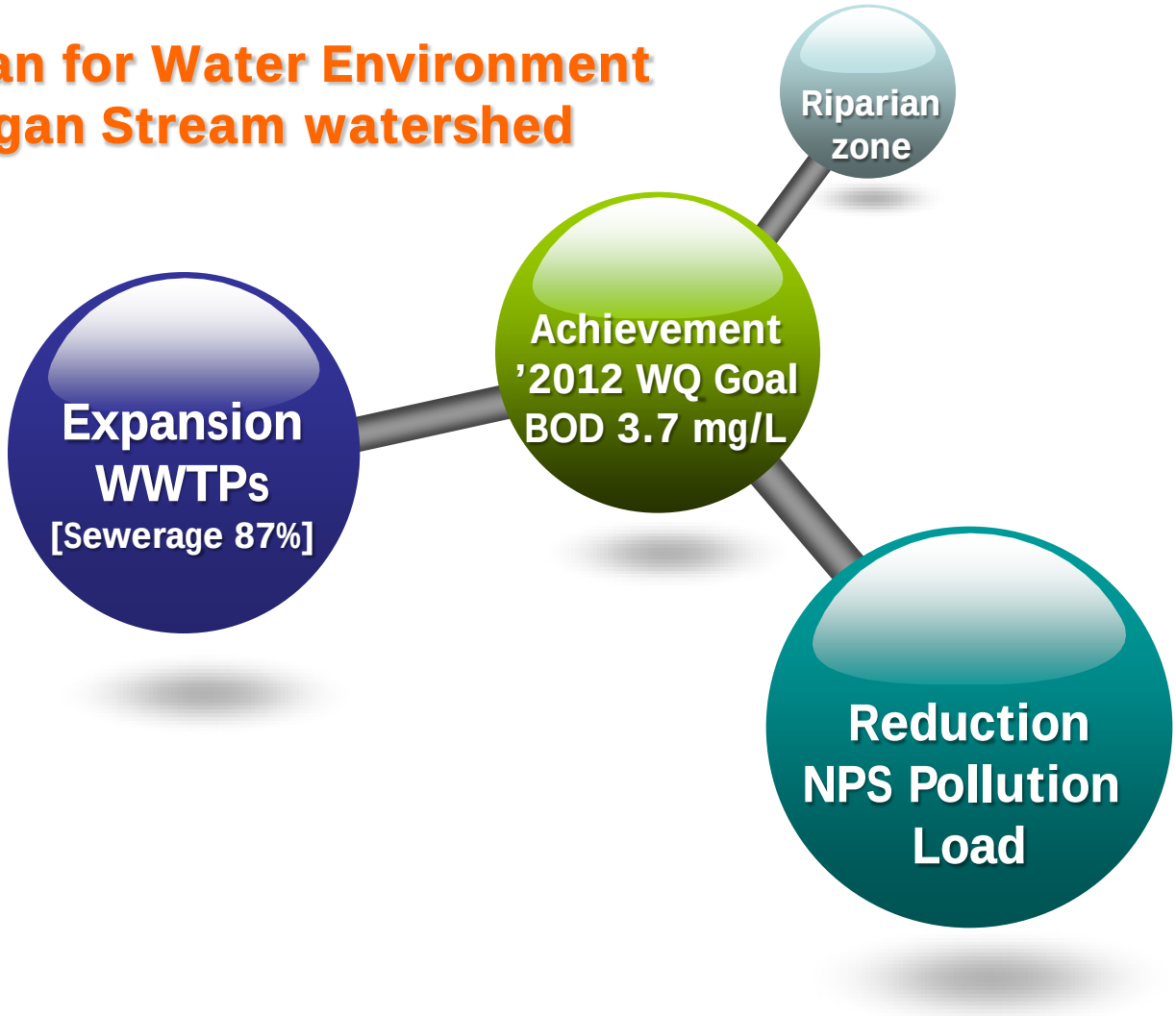
Significantly improved by restoration efforts

Advertisement

Cleaning

Nature Problem

Master Plan for Water Environment for Kyeongan Stream watershed by KMOE



Research Background

Nature Problem

Field monitor to assess watershed
: time consuming, uncertainty

Alternative measure
: Computer modeling

Research Objectives

Model selection & application

Model selection

- Continuous, long-term simulation
- Complicated watershed-scale
- Point and nonpoint source
- Flow and pollutant transportation
- Widely used in home and abroad

SWAT model

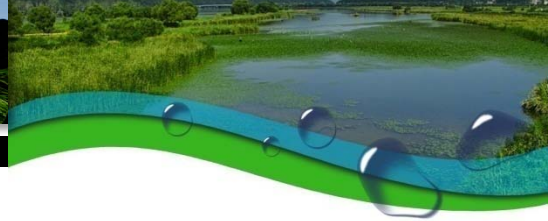
- Model input data and setting

Objections

- Modification of BASINS view for South Korea
- Verification of SWAT applicability
- Evaluation of pollution loads
- Evaluation of BMPs for prevention of water pollution

Assistance of Watershed Management Plan and Policy



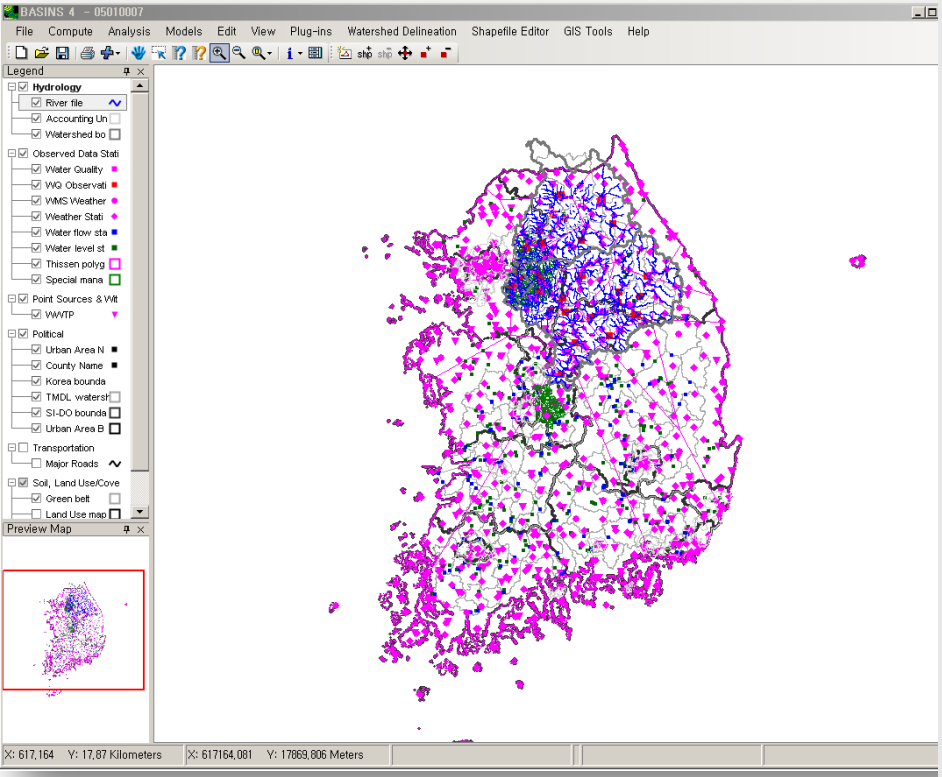


Model Preparation and Application

Model Preparation

BASINS modification

Modification for application of Korea



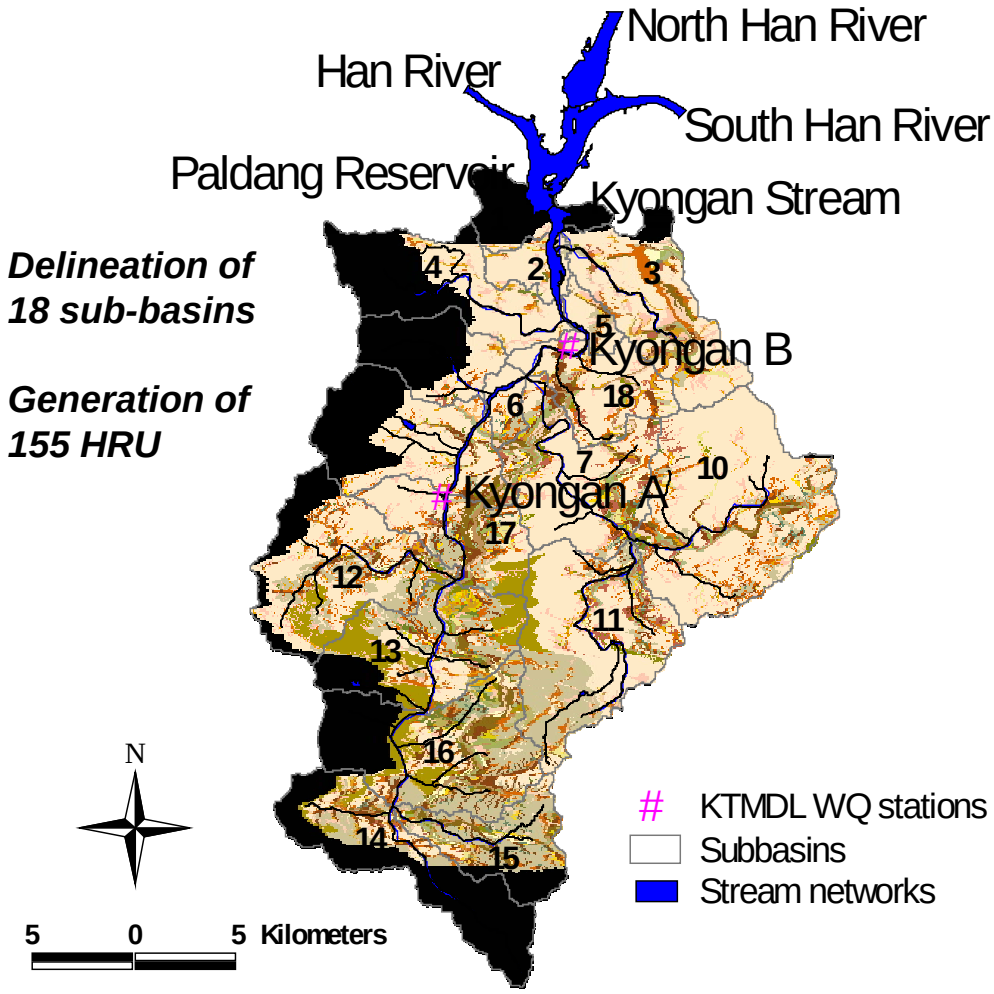
Original initial datasets	Modified initial datasets
Hydrology	**Hydrology**
Reach File, V1	River file
Cataloging Unit Code	Drainage area
Accounting Unit Boundaries	Multi-Purpose Dam
Cataloging Unit Boundaries	Watershed boundaries
Observed Data Stations	**Observed Data Stations**
Water Quality	Water quality (KMOE)
Water Quality Observation	Weather Station Site
WDM Weather Data	Water Level Station
USGS Gage	Water Flow Station (TMDL)
Bacteria	WQ Observation (TMDL)
Weather Station Area	Thissen Polygons
NAWQA Study Area Unit Boundaries	Special manage Region
Point Sources & Withdrawals	**Point Sources & Withdrawals**
Permit Compliance System	WWTP
Political	**Political**
Urban Area Name	Urban Area Name
EPA Region Boundaries	boundary
State Boundaries	TMDL watershed
Urban Area Boundaries	SI-DO boundaries
	Urban area Boundaries
Transportation	**Transportation**
Major Roads	Major Roads
Soil, Land use/Cover	**Soil, Land Use/Cover**
Land Use Index	Land Use map
Managed Area Database	Managed Area Database
Soil index	Soil Map

Model input data availability

Input data	Source of data and Information
Hydrology boundary conditions	
River file	National Geographic Information Institute
Watershed boundaries	(Hydrologic unit map)
GIS data	
Land Use map	Environmental Geographic Information System (1:25,000 scale in shape-polygon format)
Soil Map	National Institute of Agricultural Science and Technology (1:25,000 digital detailed soil map)
Digital Elevation Model	Ministry of Environment (MOE) (Resolution 30m × 30m)
Observed data	
Flow and Water quality data	MOE (8-day intervals data at two monitoring stations during 2004 - 2008)
Weather data	Korea Meteorological Administration (3 stations)
Point Sources	MOE (Daily discharge flow from WWTPs)

Model Preparation

BASINS application and water quality data



Delineation of 18 sub-basins

Generation of 155 HRU

Station No.

Kyeongan A, Kyeongan B

Data collection

Streamflow
DO
BOD
SS
TN forms
TP forms

Simulation period

2004.8~2008.12

Model Application

Modeling process

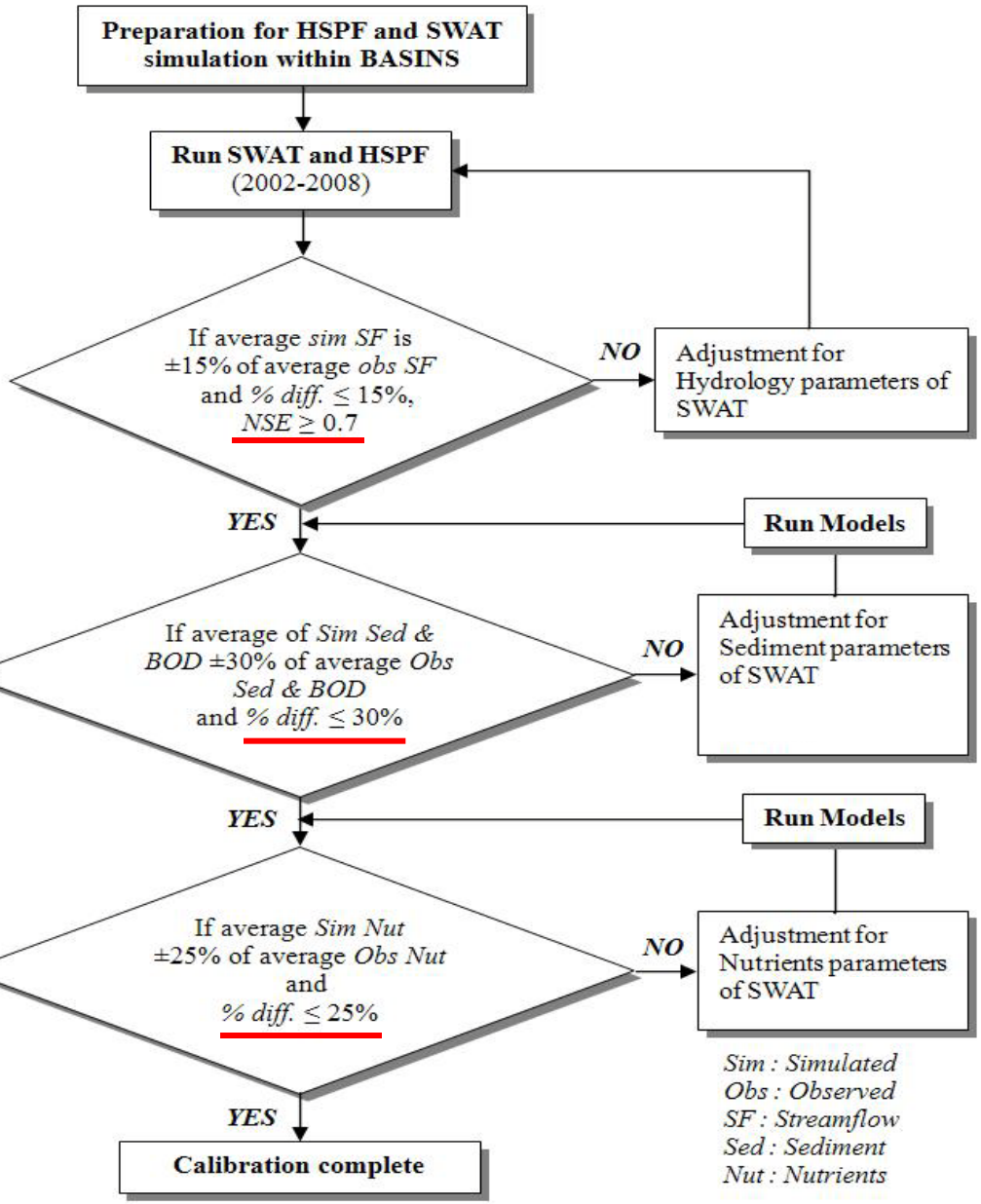
Graphical comparisons and statistical tests

- 2002 - 2003 : stabilization
- 2004 - 2006 : calibration
- 2007 - 2008 : validation

Good simulation

O.K.

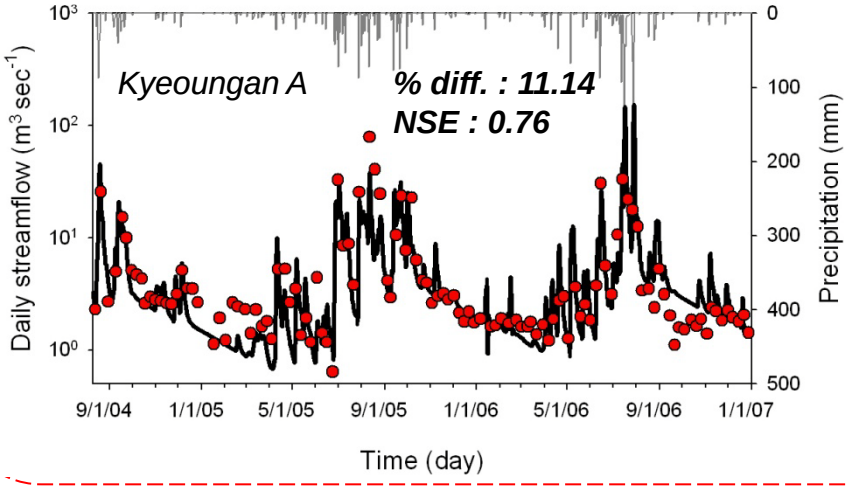
Model simulation tolerance (Donigian, 2000)
: *O/S* ratio, *NSE*, *% difference*

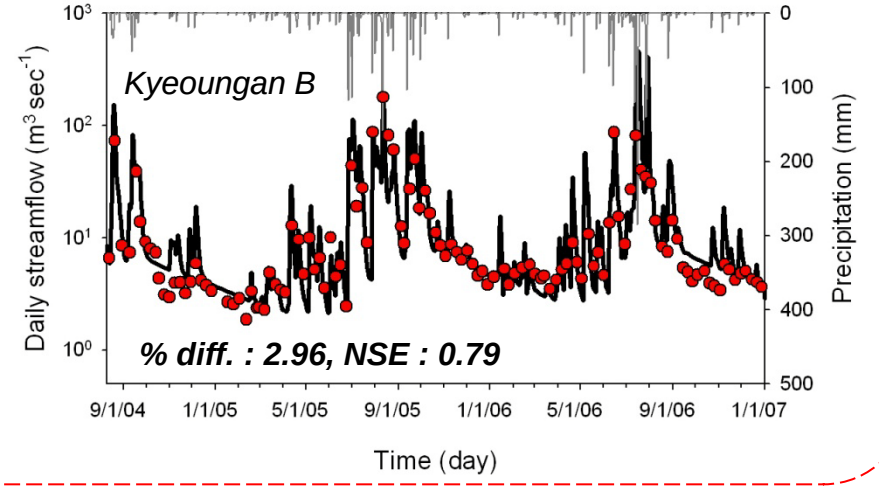


Model Application

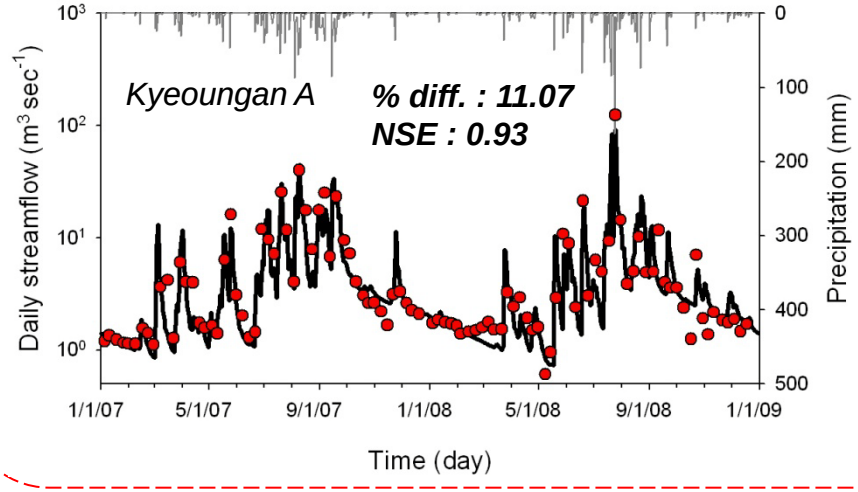
Hydrology simulation results

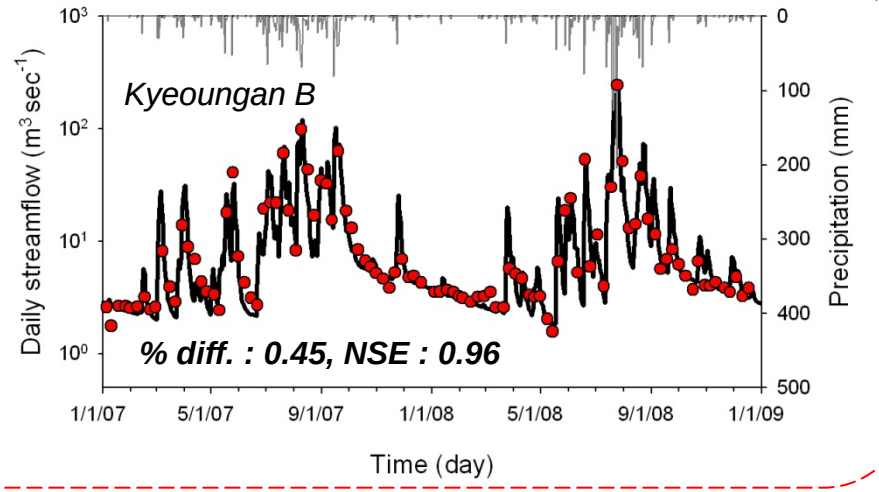
Calibration (2004~2006)





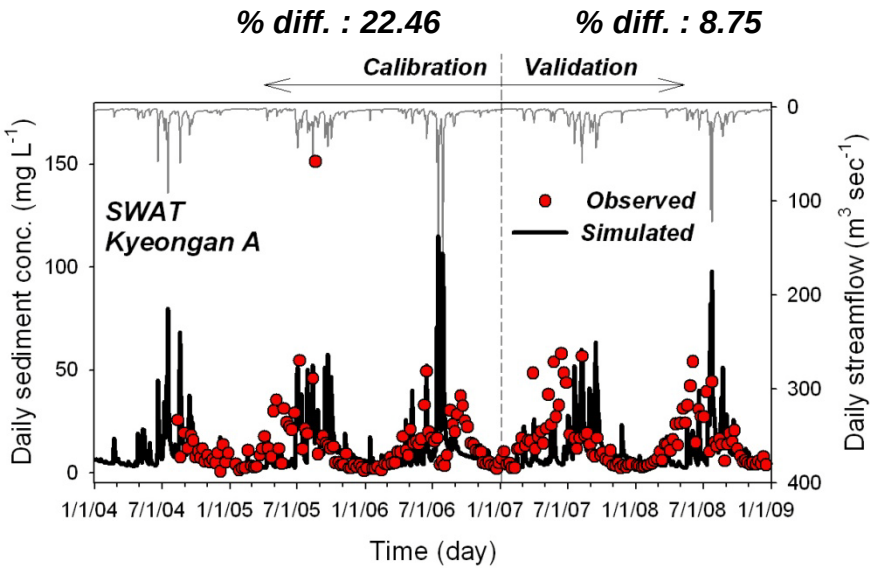
Validation (2007~2008)

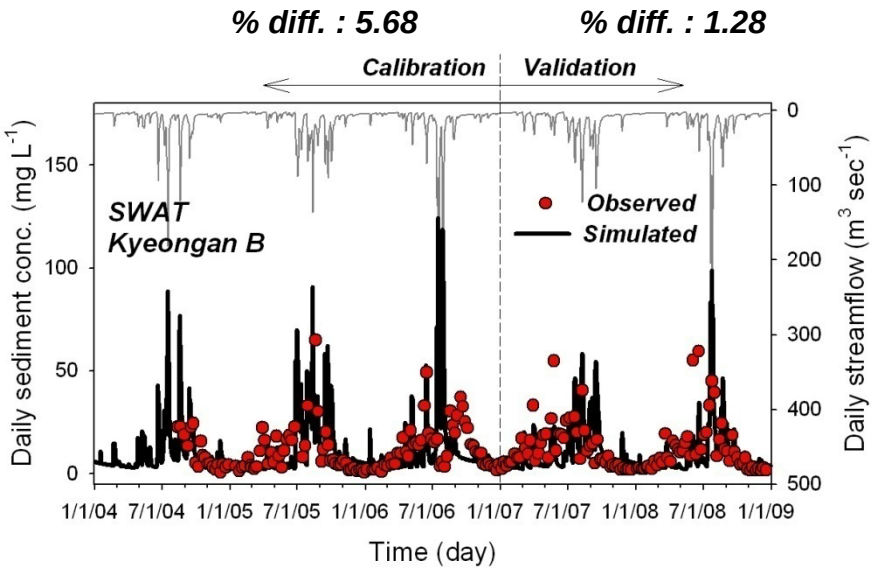




SS simulation results

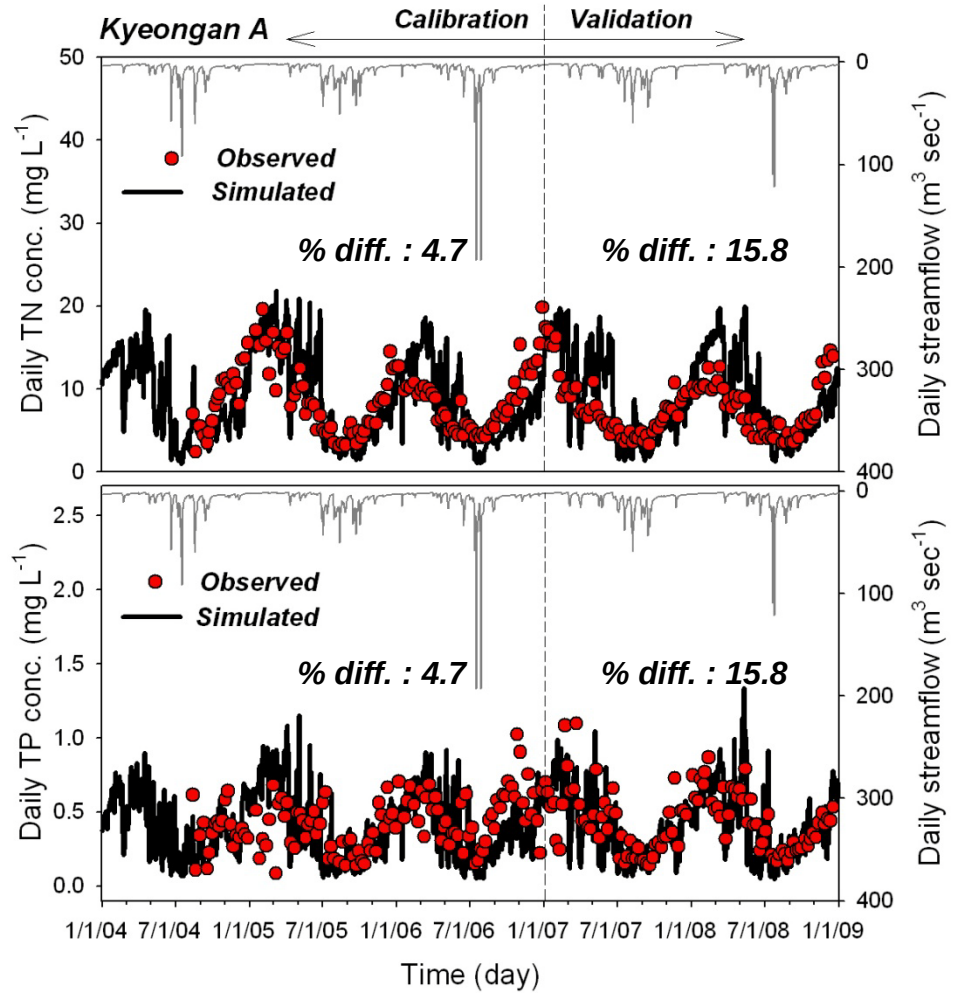
Calibration & Validation (2004~2008)

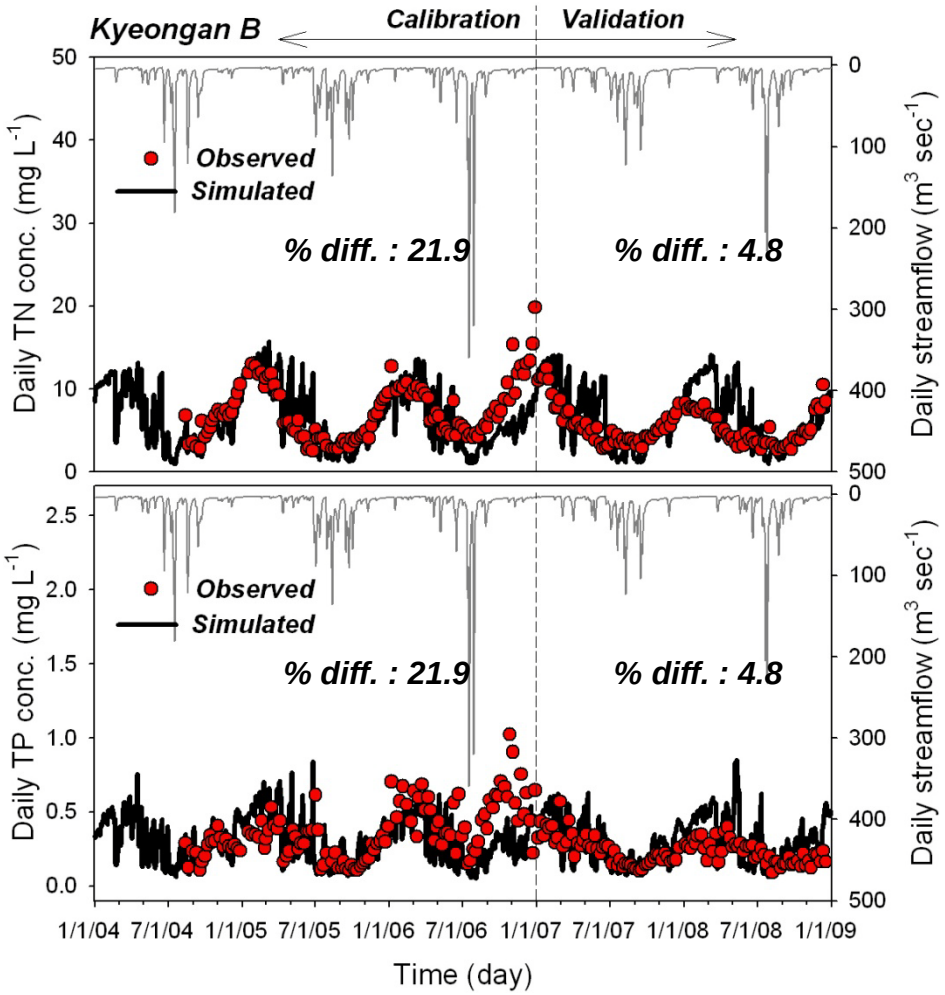




TN and TP simulation results

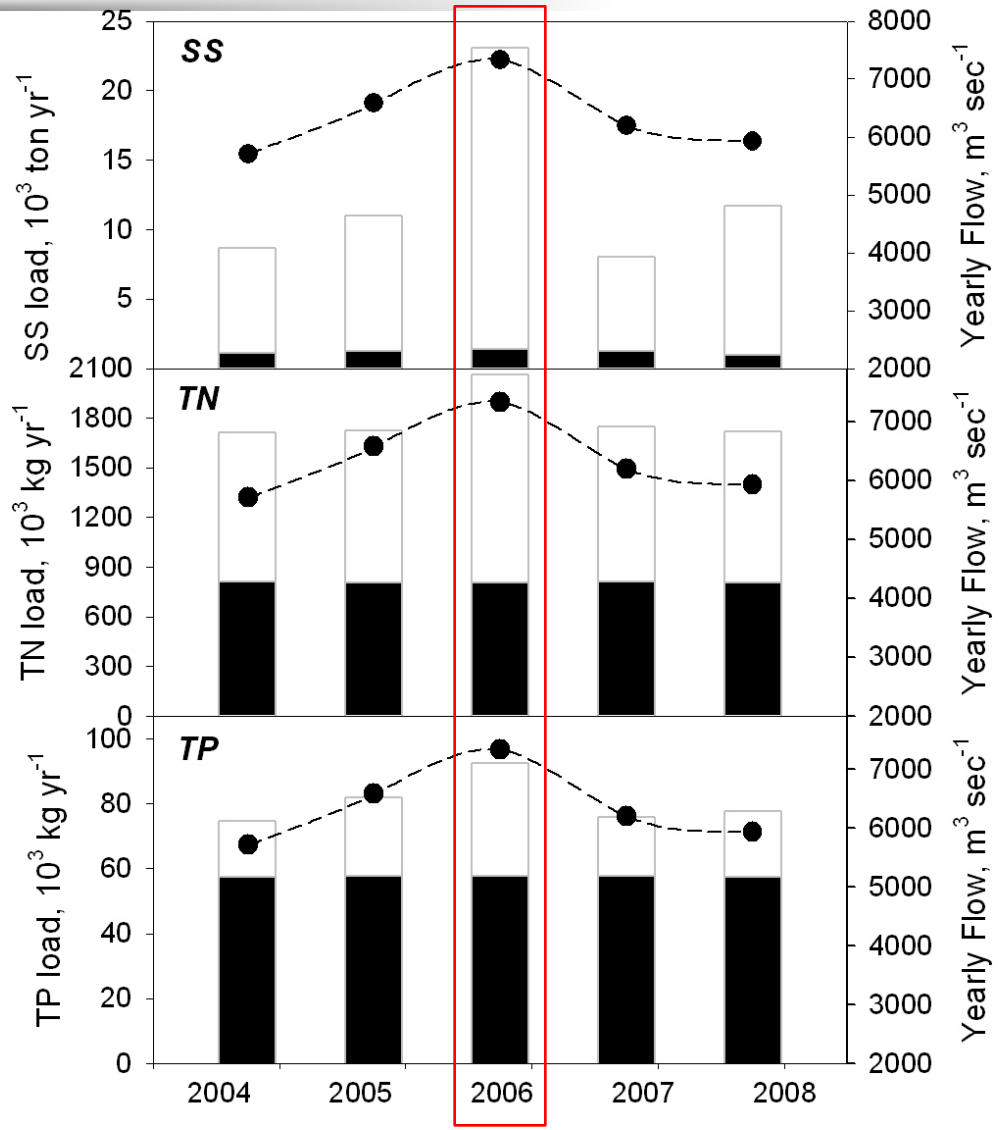
Calibration & Validation (2004~2008)





Model Application

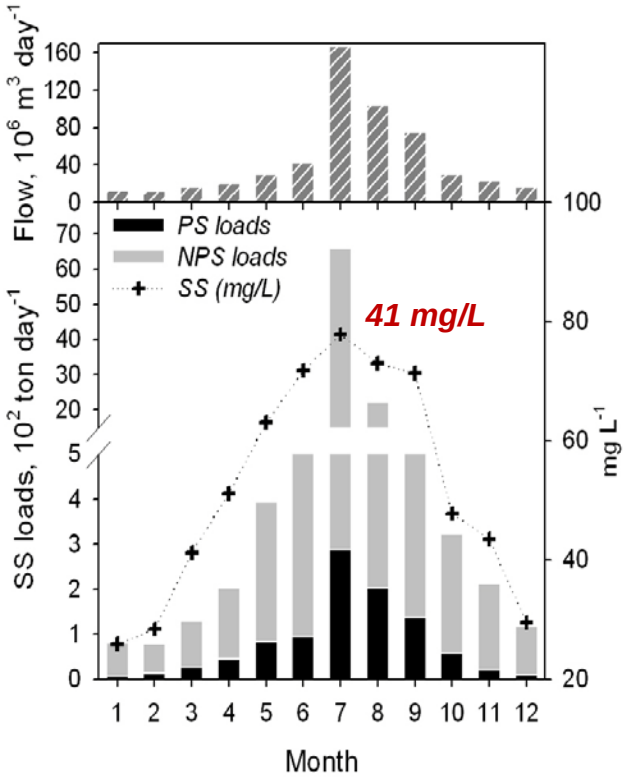
Assessment of Pollutant load

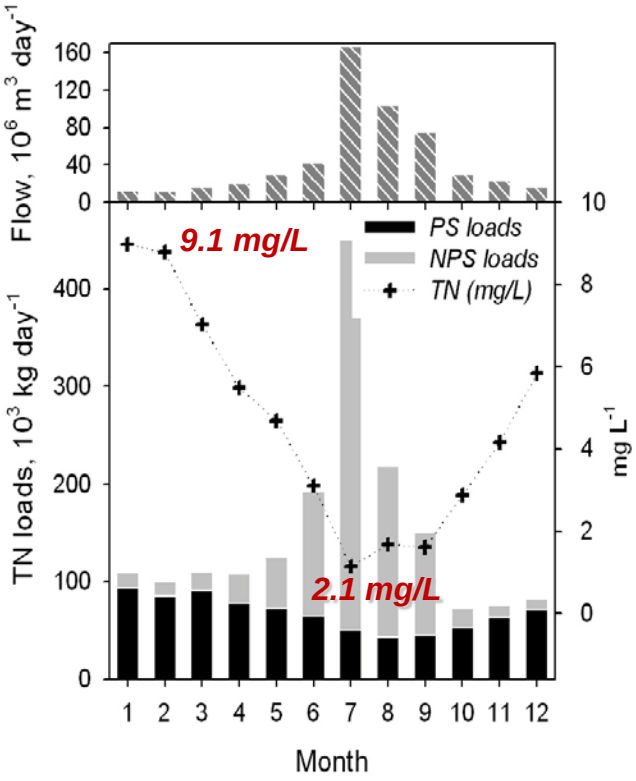


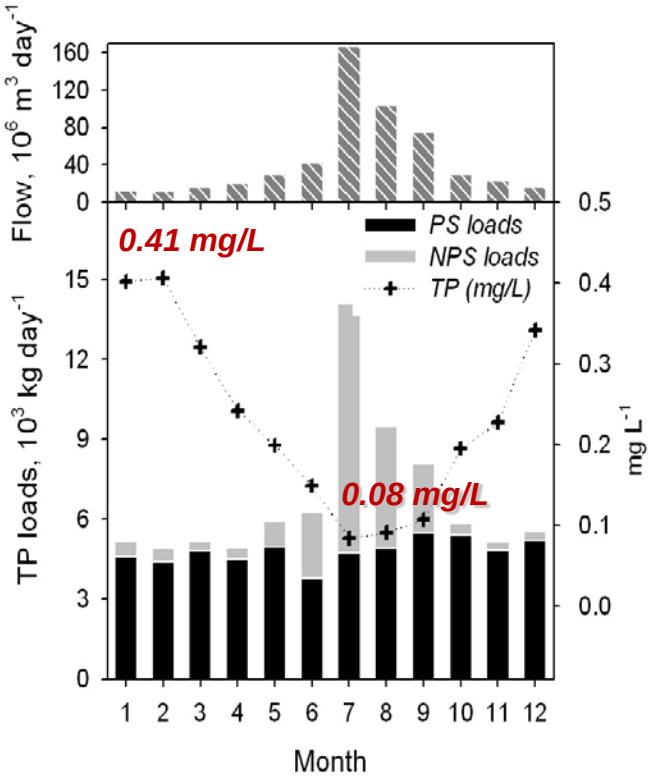
	NPS pollution ratio
SS	Average 90.6 %
TN	Average 55.0 %
TP	Average 28.5 %

Assessment of Pollutant load

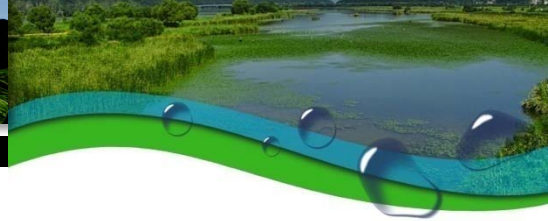
Monthly pollutants load







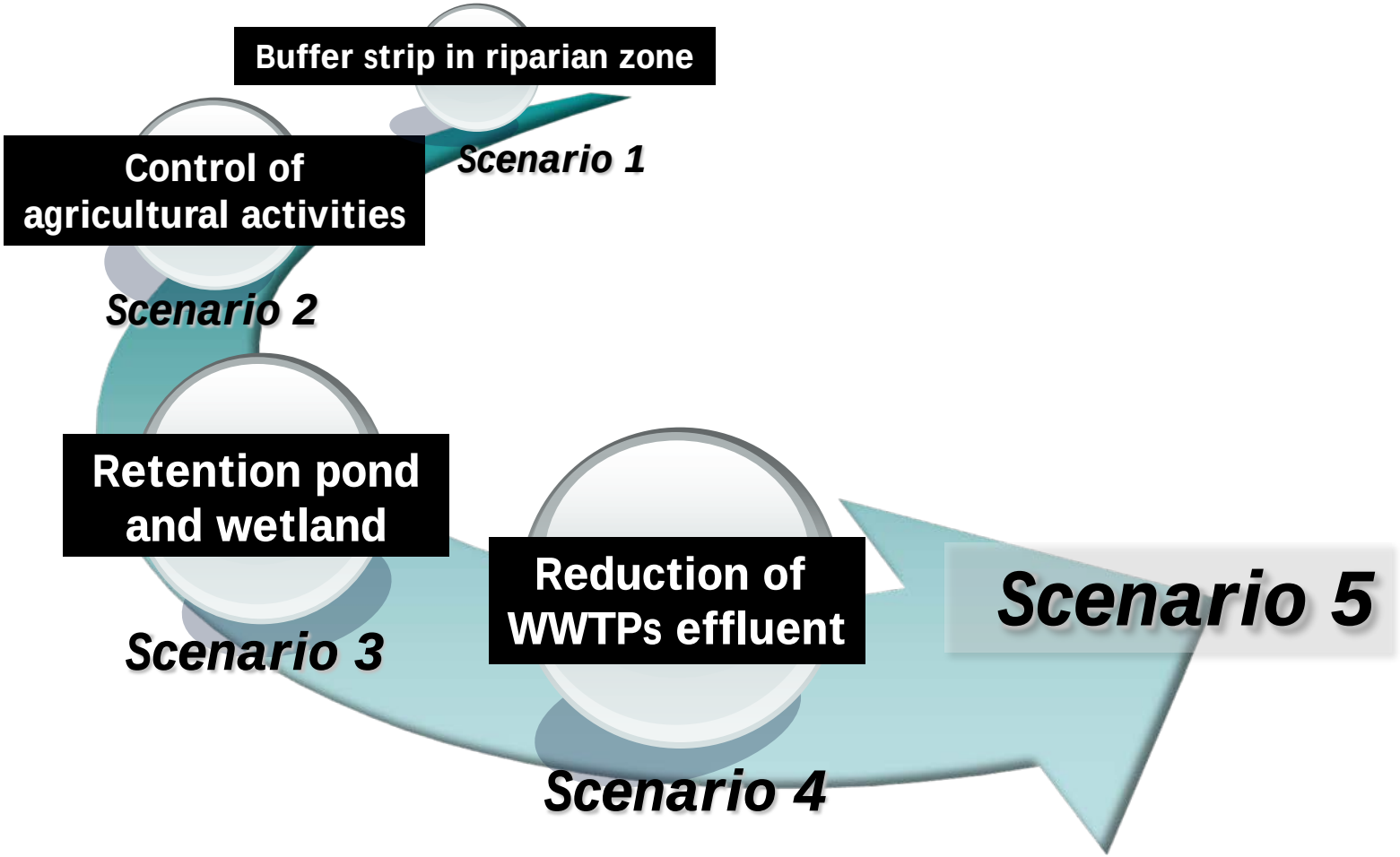




Watershed Management Measures

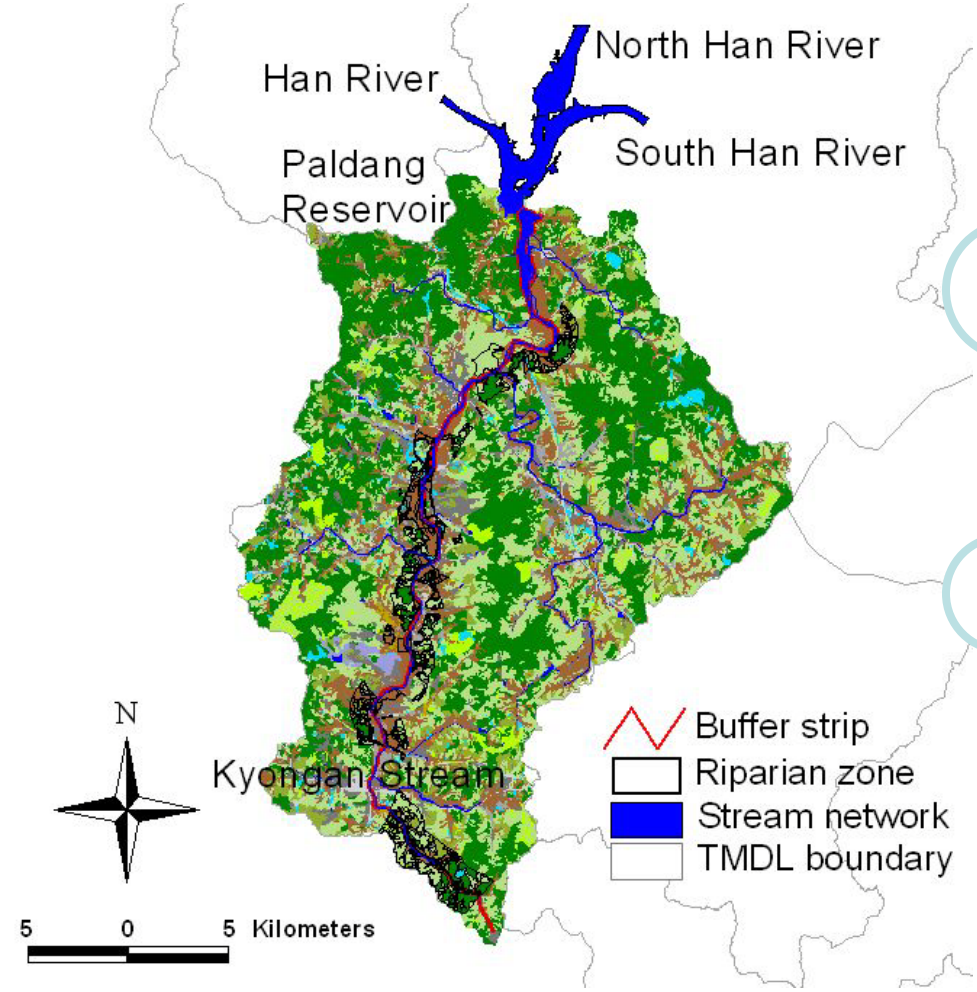
Watershed Management Measures

Reduction Scenarios



S1-Riparian Buffer Strip

Land -use	Residential	Agriculture	Forest	Pasture	Barren	Wetland	Water	Total
Area (km^2)	2.80	9.75	21.04	0.81	1.05	0.04	0.33	35.82 (6.1%)



Alteration area
Agriculture + Barren : 10.08 km^2

Change

Pasture : 2 km^2 (20%)

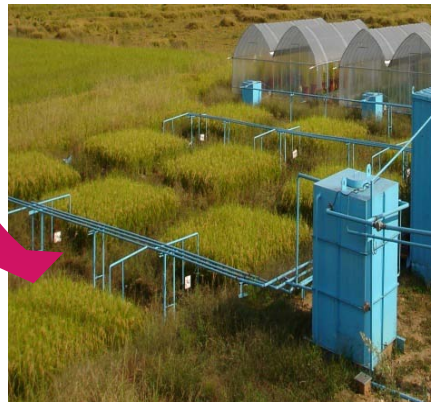
Reducing Fertilization

Plant growth-related factors

-Input major crop data: paddy, cabbage, corn, soybean
(cultivation, planting, fertilization, irrigation, and harvesting)

"Alternative Water Resource Project"

Treated Wastewater Reuse for Agriculture



Same amount of crop
as 40% of Standard fertilization

Reduce the standard amount of fertilizer up to 60%

S2-BMPs for Agricultural Activities

Planting and Structural BMPs

Soil erosion yield in sub-basins

By NAAS report

Sub-basin	2	4	5	7	8	12	13	16	17	18
% Upland	11.4	10.6	19.8	12.8	10.4	13.7	12.7	13.9	15.0	14.4
SYLD[a]	0.50	1.10	3.64	2.29	2.91	2.51	2.85	3.17	3.18	4.61

[a] : SYLD (sediment yield, ton/ha·yr)

BMPs application as Soil erosion yield

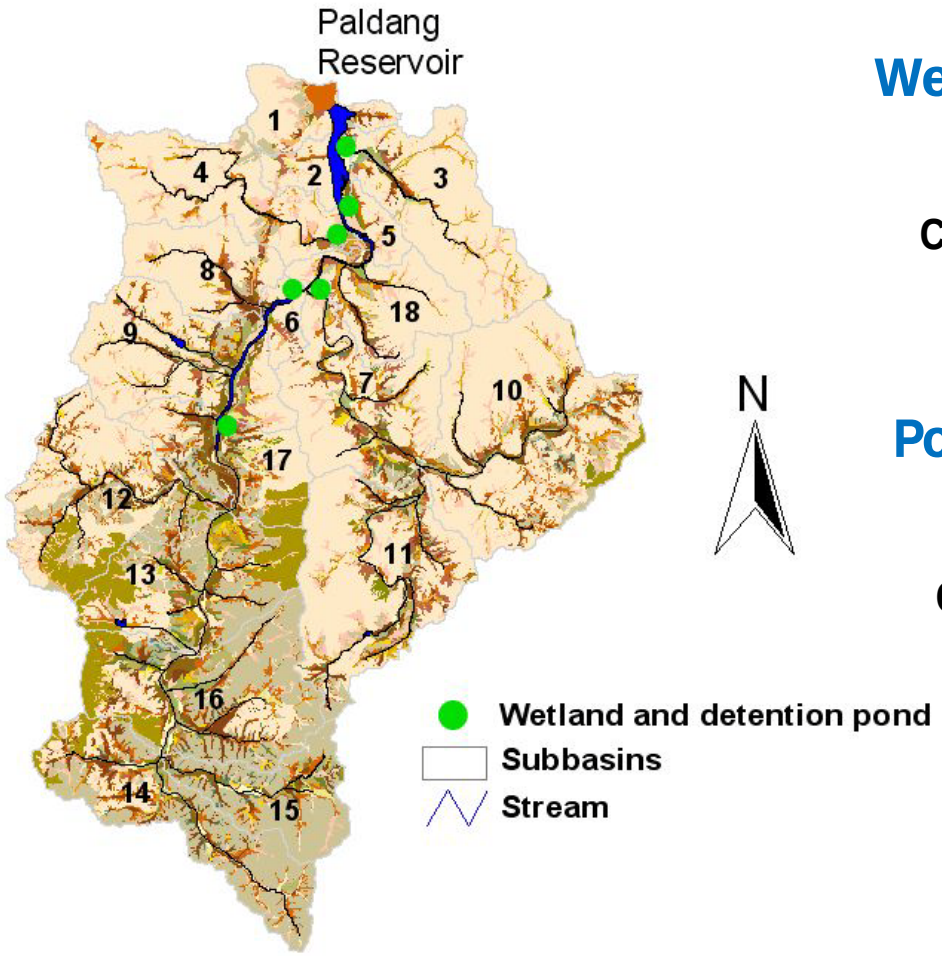
SYLD ranges	BMPs application	Sub-basins
2 >	Grassed swale, Planting	2, 4
2~4	Grassed swale, Contour farming, Parallel terrace, Filter strip	5, 7, 8, 12, 13, 16, 17
4<	Grassed swale, Contour farming, Parallel terrace, Filter strip, Farm pond, Grade stabilization structure	18

Planting and Structural BMPs

Representation BMPs with SWAT

BMP	Function	Representative SWAT parameter		
		Variables (Input file)	Value with no BMP	Value with BMPs in good condition
Grassed swale/ Planting	Increase channel cover	CH_COV	1.0	0.25
	Reduce channel erodibility	CH_EROD	0.6	0.15
	Increasing channel roughness	CH_N2	0.14~0.28	0.24
Contour farming/ Parallel terrace	Reduce overland flow	CN2	83	62
	Reduce sheet erosing	USLE_P	1.0	0.54
Field border	Increase sediment trapping	FILTERW	0	5
Farm retention pond	Present pothole	POT_FR	0	0.3
		POT_TILE	0	0.1
		POT_VOLX	0	0.05
Grade stabilization structure	Reduce gully erosion	CH_EROD	0.6	0.15
	Decrease cover factor	USLE_C	Assigned by SWAT	0.05

Representation of wetland



Wetland : 0.3~0.5 m in depth
50 m X 400 m (2ha)

Capacity : 0.6 X 10^4 m^3 (normal season)
1.25 X 10^4 m^3 (rainy season)

Pond : 1.5~2.0 m in depth
50 m X 100 m (0.5ha)

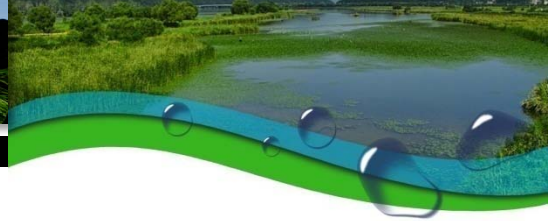
Capacity : 0.75 X 10^4 m^3 (normal season)
1.0 X 10^4 m^3 (rainy season)

S3-Retention Pond and Wetland

Representation of wetland

Variable Name	Definition	Values
IPND1	Beginning month of mid-year nutrient settling "season"	January
IPND2	Ending month of mid-year nutrient settling "season"	December
WET_FR	Fraction of sub-basin area that drains into wetland	0.02
WET_SED	Initial sediment concentration in wetland water	20 mg L^{-1}
WET_NSED	Equilibrium sediment concentration in wetland water	5.00 mg L^{-1}
WET_K	Hydraulic conductivity of bottom of wetlands	0.03 mm hr^{-1}
PSETLW1	Phosphorus settling rate in wetlands for months IPND1 through IPND2	0.7 m yr^{-1}
PSETLW2	Phosphorus settling rate in wetlands for months other than IPND1-PND2	0.7 m yr^{-1}
NSETLW1	Nitrogen settling rate in wetlands for months IPND1 through IPND2	0.3 m yr^{-1}
NSETLW2	Nitrogen settling rate in wetlands for months other than IPND1-IPND2	0.3 m yr^{-1}

S3-Retention Pond and Wetland



Representation of pond

Variable Name	Definition	Values
PND_FR	Fraction of sub-basin area that drains into ponds	0.01
PND_SED	Initial sediment concentration in pond water	20 mg L
PND_NSED	Equilibrium sediment concentration in pond water	5.00 mg L^{-1}
PND_K	Hydraulic conductivity of bottom of ponds	0.01 mm hr^{-1}
PSETL1	Phosphorus settling rate in pond for months IPND1 through IPND2	0.7 m yr^{-1}
PSETL2	Phosphorus settling rate in pond for months other than IPND1-IPND2	0.7 m yr^{-1}
NSETL1	Nitrogen settling rate in pond for months IPND1 through IPND2	0.3 m yr^{-1}
NSETL2	Nitrogen settling rate in pond for months other than IPND1-IPND2	0.3 m yr^{-1}
CHLA	Chlorophyll a production coefficient for ponds	1.00
SECCI	Water clarity coefficient for ponds	1.00
NDTARG	Number of days need to reach target storage from current pond storage	6 days
WUPND	Average daily water removal from the pond for the month (10^4 m^3 day^{-1})	0.3

S4-Point Source Reduction

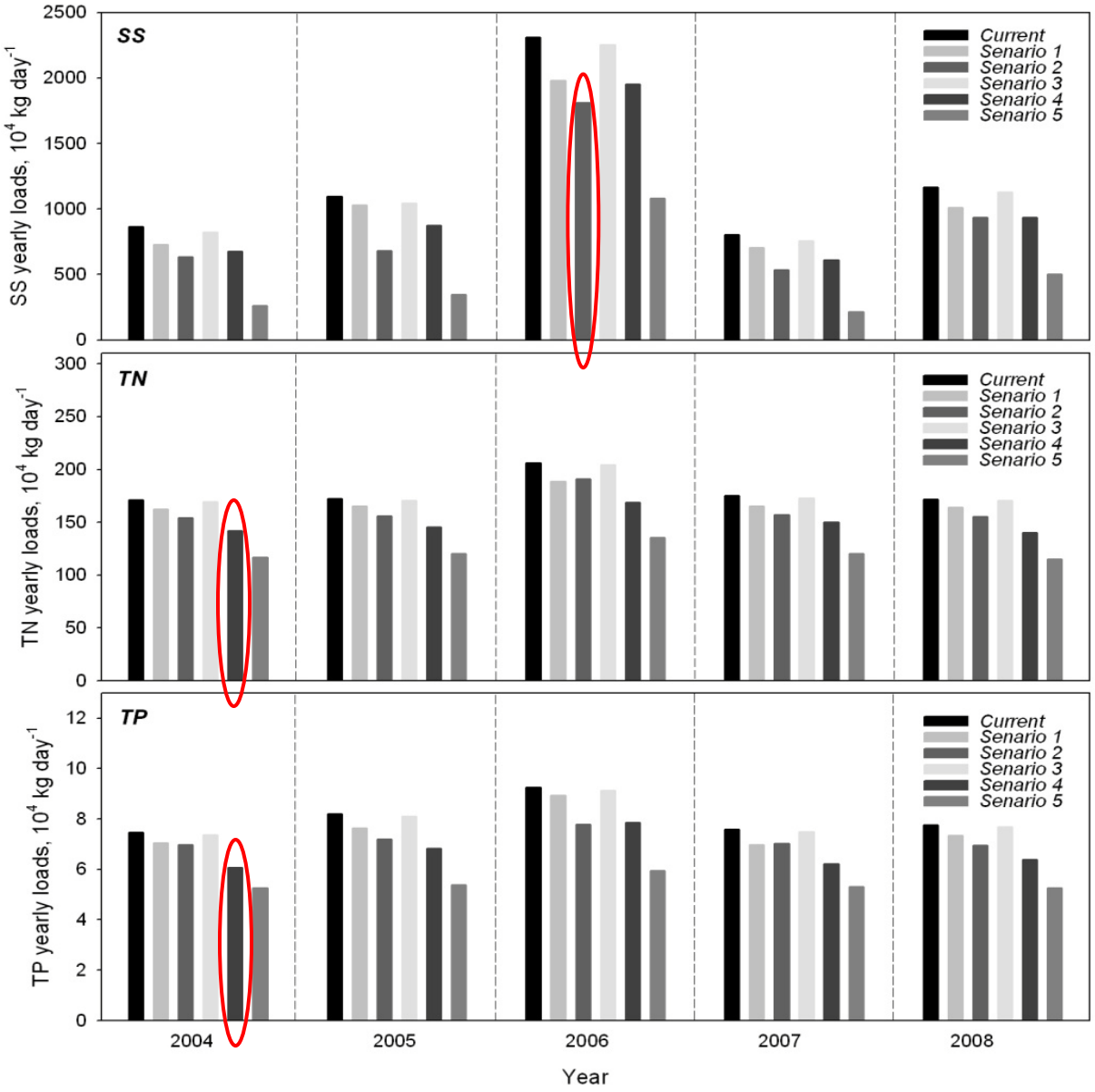
Reduction of WWTPs effluent

Sub-basins	Treatment plants	Capacity (m^3 day^{-1})	Extension capacity	Advanced treatment
13	Yongin[a]	48,000	SS : 50%	TN : 30%, TP : 30%
12	Ohpho[a]	7,000	SS : 50%	TN : 30%, TP : 30%
7	Konjiam[b]	20,000	SS : 50%	-
18	Kwangju[a]	5,000	SS : 50%	TN : 30%, TP : 30%
4	Kyongan[b]	25,000	SS : 50%	-

[a] : High effluent concentration of WWTPs

[b] : WWTPs are above 20,000 m^3/day of wastewater treatment capacity

BMPs Results with SWAT



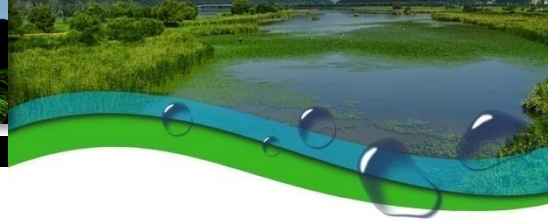
BMPs Results with SWAT

Annual pollutant load reduction

		No BMPs	Scenario1	Scenario2	Scenairo3	Scenario4	Scenario5
SS	Load(kg day^{-1})	12,482,821	10,893,567	9,198,252	12,001,671	10,094,213	4,087,902
	Conc.(mg L^{-1})	12.72	11.45	10.27	12.01	10.00	7.36
	Efficiency (%)	-	12.5	27.9	4.4	20.3	64.3
TN	Load(kg day^{-1})	1,792,960	1,691,642	1,627,892	1,775,987	1,492,383	1,214,915
	Conc.(mg L^{-1})	4.86	4.65	4.50	4.83	4.21	3.61
	Efficiency (%)	-	5.5	9.3	1.0	16.7	32.2
TP	Load(kg day^{-1})	80,501	75,816	68,332	79,489	66,686	49,221
	Conc.(mg L^{-1})	0.245	0.233	0.216	0.242	0.211	0.169
	Efficiency (%)	-	5.9	14.8	1.3	17.3	38.7

Scenario 5 > ***Scenario 2 and Scenario 4*** > ***Scenario 1*** > ***Scenario 3***



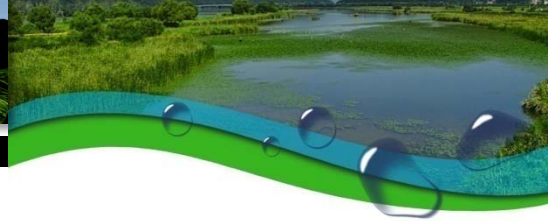


Conclusion and Future study

Conclusion and Future studies

- Modification of the database for BASINS
- Good calibration and validation in the KSW
- Useful to simulate and evaluate pollutant load in the watershed-scale
- Representation of BMPs into appropriate with SWAT
- Useful to propose the integrated watershed management strategy
- Analysis of BMPs cost-benefit effect
- Water quality impacts on Climate Change





Thank you for attention !!