

**First Session of WMO RA II
Working Group on Hydrological
Services, Seoul, Republic of
Korea, 17-Oct. ~ 19-Oct., 2017.**



Development of Dynamic Water Resources Assessment System for WMO RA II

***Organizer: Ministry of Land, Infrastructure and Transport,
Republic of Korea***

Dr. Hwirin KIM

This Meeting proposed for:

1. Dissemination and testing of new methods for
Dynamic Water Resources Assessment System;
2. Establishment of RA II wide Dynamic Water Resources
Assessment System;
and
3. Discussion for application of the Dynamic Water
Resources Assessment System and future improvements

“WRA is”

- A tool to evaluate water resources in relation to a reference frame, or evaluate the dynamics of the water resource in relation to human impacts or demand
- Part of the IWRM approach, linking social and economic factors to the sustainability of water resources
- Depending on the objective of the assessment, WRA may look at a range of physical features in assessing the dynamics of the water resource
- Assessments for large or long-term projects need to include examination of changes in land use and possible soil degradation as well as climate variability and change

“Purpose of WRA”

- Conducting a WRA help us to establish a common, agreed and trusted information base that can be used by stakeholders as a basis for informed and effective decision making
- In general WRA helps us for clarifying and quantifying different issues like:
 - Current status of water resources at different scales, including inter- and intra-annual variability
 - Current water use (including variability), and the resulting social and environmental trade-offs
 - Scale related externalities, especially when patterns of water use are considered over a range of temporal and spatial scales
 - Social and institutional factors affecting access to water and their reliability
 - Opportunities for saving or making water distribution and use more productive, efficient and/or equitable
 - Efficiency and transparency of existing water-related policies and decision making processes
 - Conflicts between existing information sets, and the overall accuracy of government statistics

“Development of DWAT System”

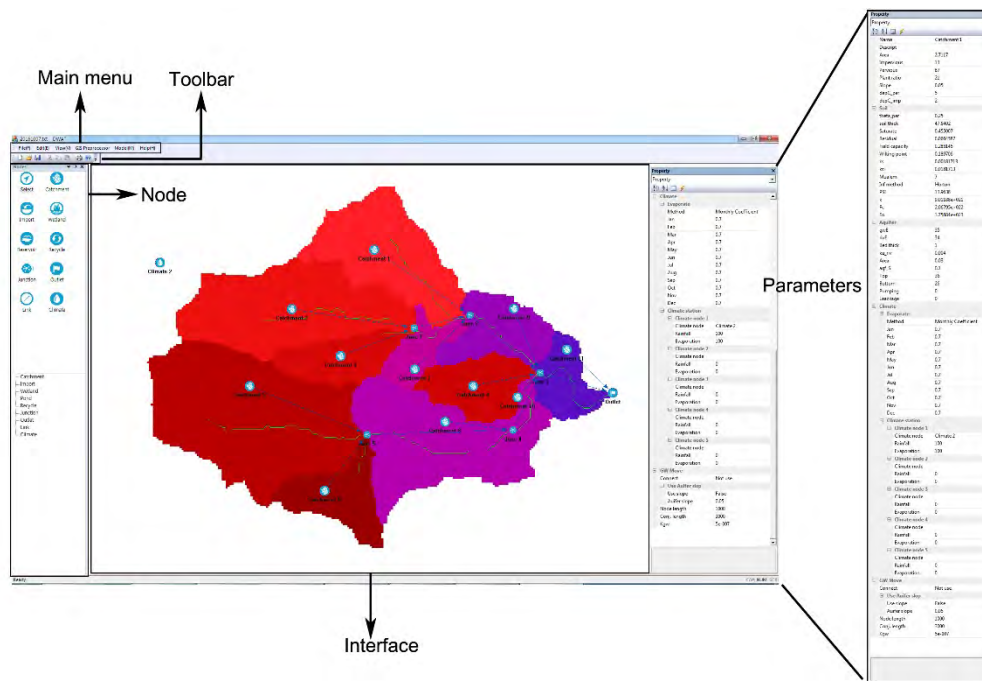
- Effective water resource policy and planning requires comprehensive, consistent and robust information on water generation, distribution, storage, availability and use
- To meet this need, providing crucial information for managers, planners and policy makers, Dynamic Water resources Assessment Tool (DWAT) was developed
- This continental-to-regional scale water balance modelling system supports reporting and assessment of water flows and stores on a daily time scale
- In addition, the system was designed to meet present and future water demands, while maintaining a range of hydrologic variation necessary to preserve the ecological and environmental integrity of the basin

“DWAT System”

- Has a **landscape model** component and a **river model** component that were developed and validated against a range of data sources
- Has basic hydrological functions and is consisted of **pre-process** (based on GIS process) and **water balance process**
- Is a continuous, long-term, and **physical parameter** model designed to simulate the runoff of **pervious and impervious zones** separately
- Has hydrologic components such as **infiltration**, **groundwater flow**, **evapotranspiration**, **channel routing**, etc.
- Has **snowmelt** and diverse weather environment

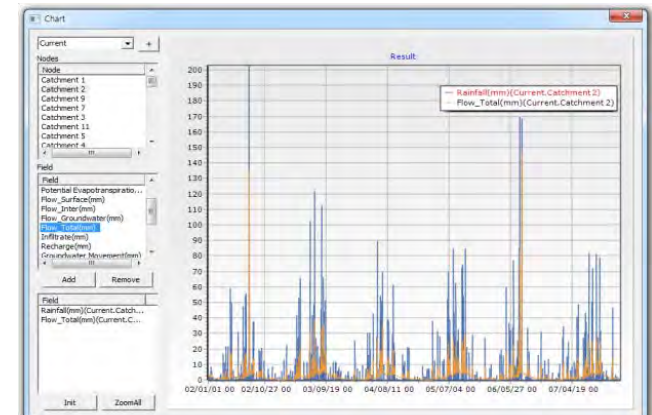
“Characteristics of DWAT System”

- Physical parameter-based link-node type model
- Quantitative assessment of the characteristics of the short/long-term changes in water cycles
- Simple, practical and easily accessible
- Guaranteed satisfactory results with minimal data and efforts
- Easy user convenience system (GUI)
- Provision of results through diverse tables and figures



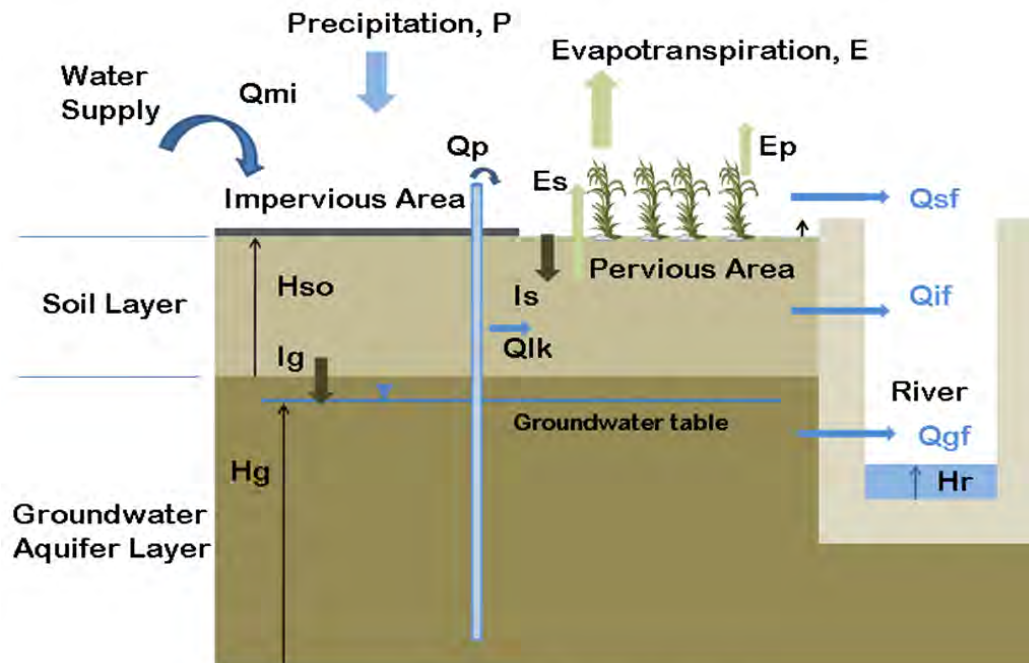
The screenshot shows a table of results for Catchment 1. The table has columns for Date, Interval, Inflow, Outflow, Flow, and various other parameters. The data is organized in a grid format.

Date	Interval	Inflow	Outflow	Flow	...
01/01/01	0.00	0.00	1.12	2.90	0.00
01/01/02	0.00	0.00	1.12	2.90	0.00
01/01/03	0.00	0.00	1.12	2.90	0.00
01/01/04	0.00	0.00	1.12	2.90	0.00
01/01/05	0.00	0.00	1.12	2.90	0.00
01/01/06	0.00	0.00	1.12	2.90	0.00
01/01/07	0.00	0.00	1.12	2.90	0.00
01/01/08	0.00	0.00	1.12	2.90	0.00
01/01/09	0.00	0.00	1.12	2.90	0.00
01/01/10	0.00	0.00	1.12	2.90	0.00
01/01/11	0.00	0.00	1.12	2.90	0.00
01/01/12	0.00	0.00	1.12	2.90	0.00
01/01/13	0.00	0.00	1.12	2.90	0.00
01/01/14	0.00	0.00	1.12	2.90	0.00
01/01/15	0.00	0.00	1.12	2.90	0.00



“DWAT System Structure”

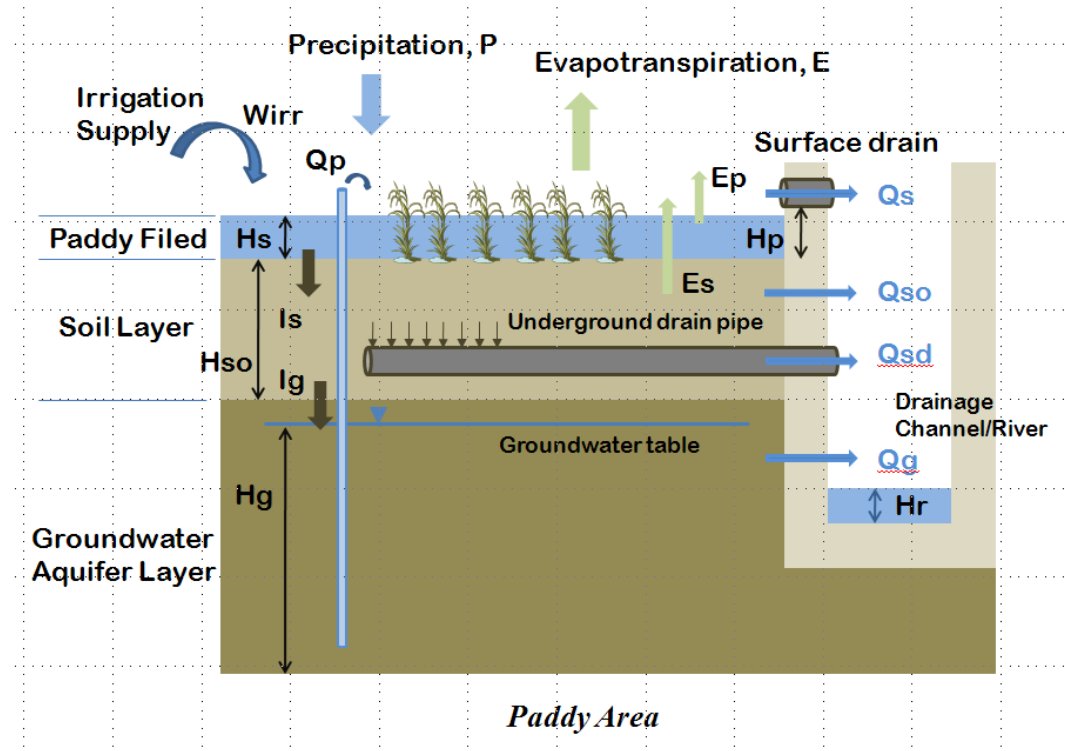
- Pervious and impervious area for rainfall-runoff process
- One soil layer and one aquifer
- Groundwater pumping



Pervious/Impervious Area

“DWAT System Structure”

- Daily ponding depth management in paddy field
- Underground drainage culvert

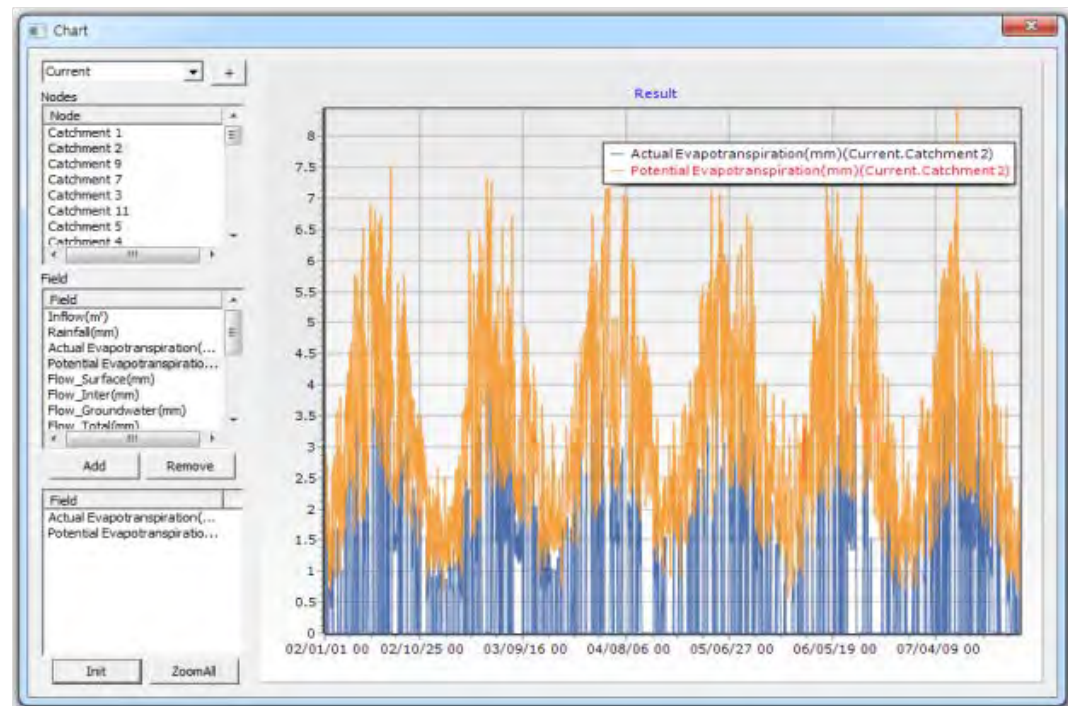


“DWAT System Structure”

- Evapotranspiration

- Potential evapotranspiration by the Penman-Monteith equation
- Actual evapotranspiration by the leaf area index and soil moisture accounting

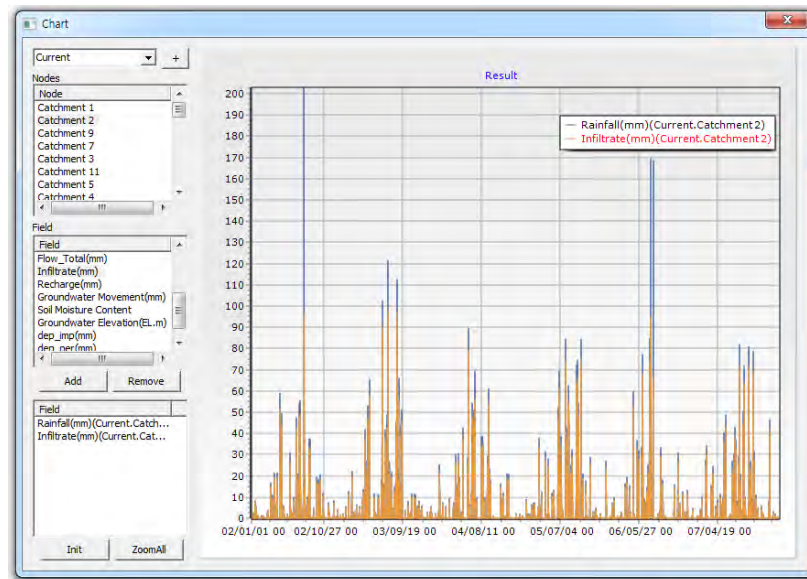
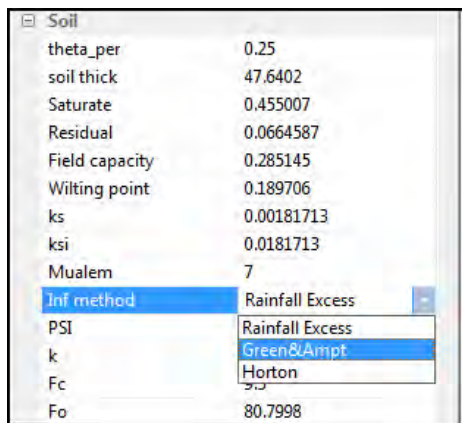
Climate	
Evapotranspiration	
Method	Monthly Coefficient
Jan	Monthly Coefficient
Feb	Leaf Area Index
Mar	FAO56
Apr	0.7
May	0.7
Jun	0.7
Jul	0.7
Aug	0.7
Sep	0.7
Oct	0.7
Nov	0.7
Dec	0.7



“DWAT System Structure”

● Infiltration

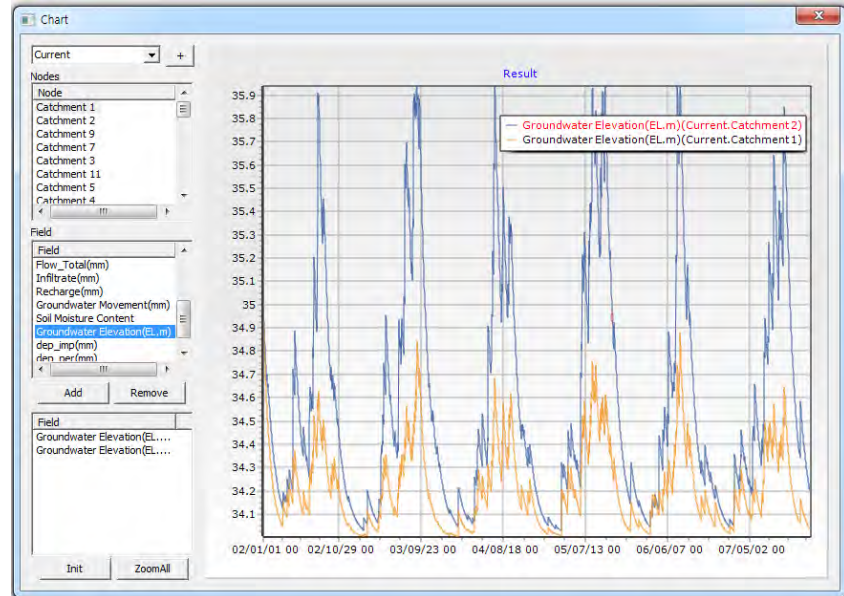
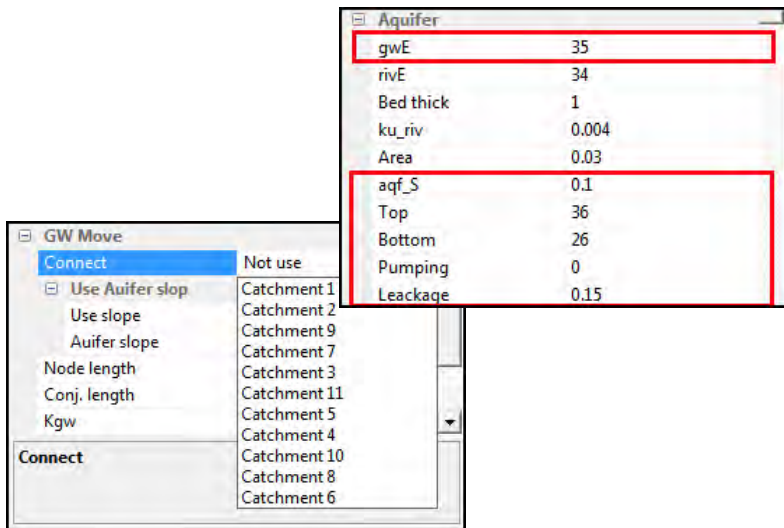
- Infiltration and deep percolation to the aquifer are analyzed based on the physical parameters of soil layer; soil depth, saturated hydraulic conductivity, horizontal hydraulic conductivity, saturated moisture contents, residual moisture contents and Mualem's n
- Soil moisture increasing by the rainfall and depression storage
- Infiltration methods; Rainfall excess, Green & Ampt and Horton



“DWAT System Structure”

● Groundwater

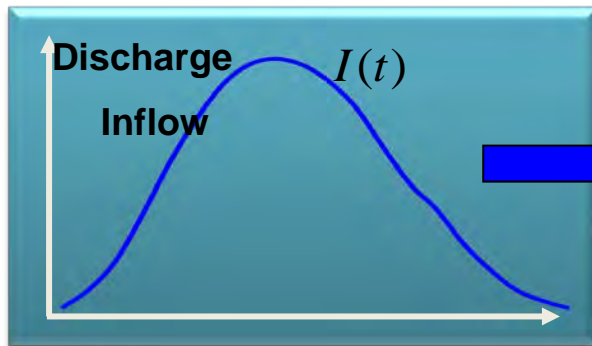
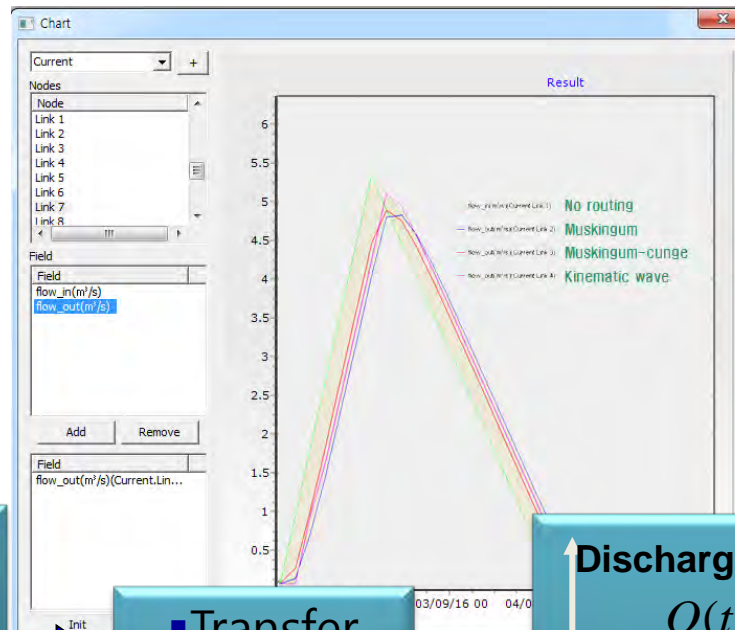
- Groundwater runoff are simulated using the relationship between groundwater level and river stage
- Designed to consider groundwater pumping and leakage from water supply networks
- Groundwater movement from an aquifer to adjacent aquifer (based on groundwater hydraulic gradient)



“DWAT System Structure”

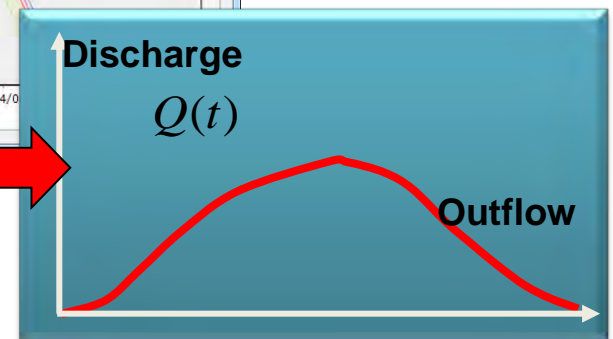
- Channel Routing

- Outflow hydrograph in the channel using several flow routing methods
- Muskingum
- Muskingum-Cunge
- Kinematic wave



$I(t) = \text{Inflow}$

■ Transfer
■ Function

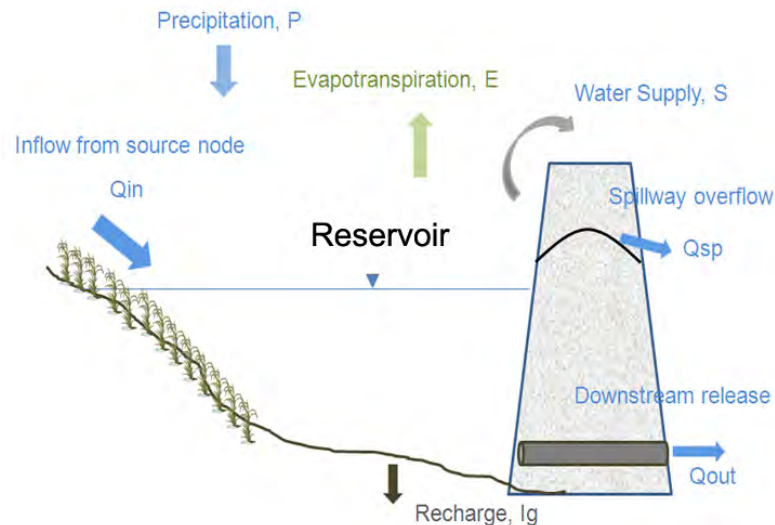







$Q(t) = \text{Outflow}$

“DWAT System Structure”

● Reservoir

- Reservoir storage, water level and discharge are calculated using the initial storage, effective storage, intake, the specifications of spillways and discharge outlet in the reservoir
- Storage and water levels are renewed by inflows based on the relationships of stage-storage-area
- Evaporation from water surface and water supply from the reservoir
- Discharge into downstream through the drainage outlet pipe

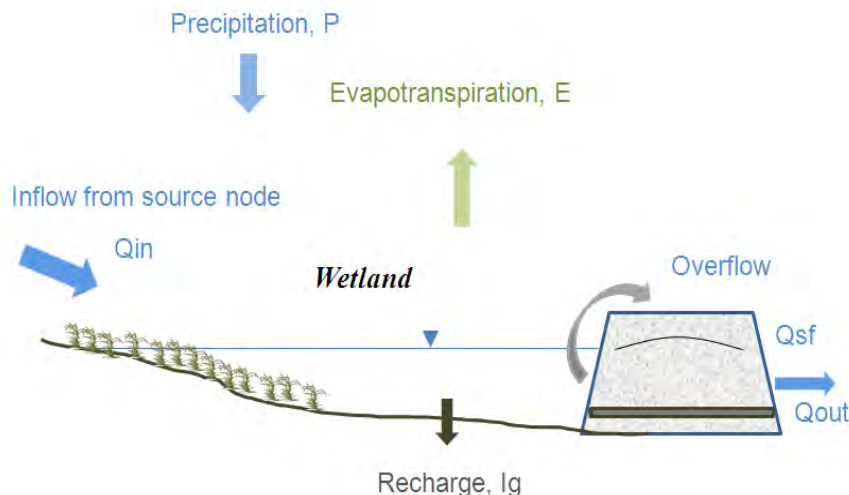


Property		X			
Property					
    					
Pond node					
Name	Reservoir 1				
Descript					
Climate					
Rainfall					
Climate					
Base					
Type	Online				
vol_init	1e+006				
vol_eff	1e+006				
Kgw	0.0005				
Recharge to					
Pipe					
pipe_ht	5				
pipe_area	1				
pipe_coef	0.5				
Spillway					
spill_ht	15				
spill_length	30				
spill_coef	0.8				
Offline					
offline_max	0.5				
offline_ratio	0.5				
offline_out	1				
Intake					
Type	Constant				
Supply to	None				
Intake	10000				
Series file					
Table					
Field					
WL-Volume-Area Relationship					
	1	2	3	4	5
WL(m)					
VDL(m3)					
AREA(m2)					

“DWAT System Structure”

Wetland

- This module was designed to have any amount of water exceeding the storage capacity of wetlands overflow and discharge to the downstream
- Wetlands reflect vegetation and evaporation from water surface
- Storage and water levels are renewed by inflows based on the relationships of stage-storage-area
- Discharge into downstream through the drainage outlet pipe

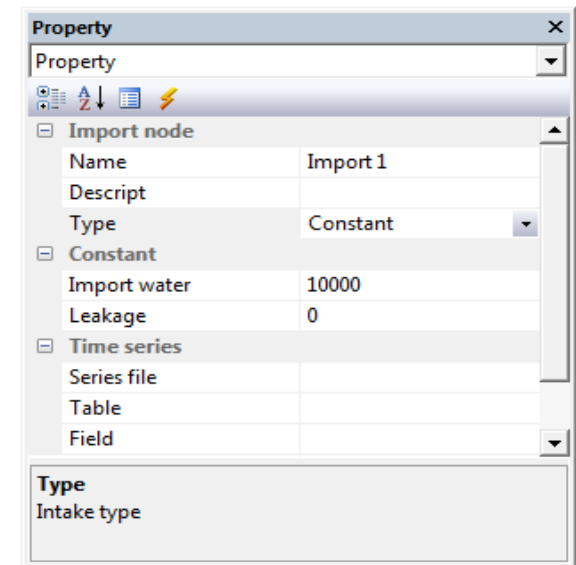
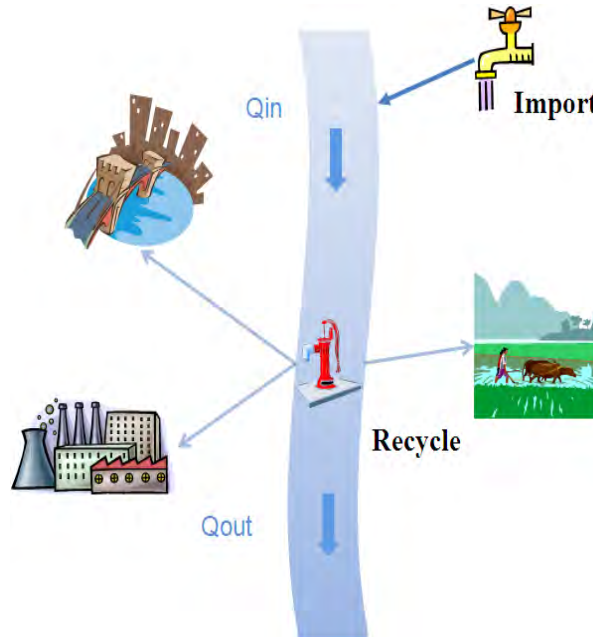
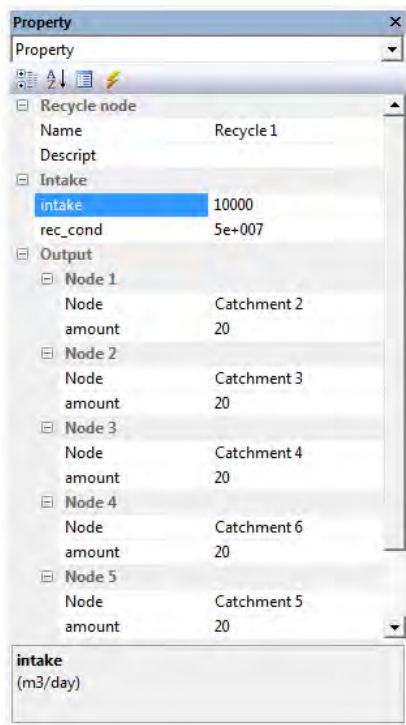


Property					
Property					
<div> </div>					
WetLand node					
Name	WetLand 1				
Descript					
Climate					
Rainfall	Climate 1				
Evaporation	Climate 1				
Base					
Init volume	10000				
Maximum storage	100000				
Flood bypass	1				
Kgw	0.0005				
Recharge to					
Pipe					
Pipe height	1				
Pipe area	0.5				
Pipe coefficient	0.5				
WL-Volume-Area Relationship					
	1	2	3	4	5
WL(m)					
VOL(m3)					
AREA(m2)					

“DWAT System Structure”

● Recycle & Import

- A recycle was planned so that water can be taken from rivers and supplied to other catchment
- the system was designed to reflect water supply from outside of the catchment



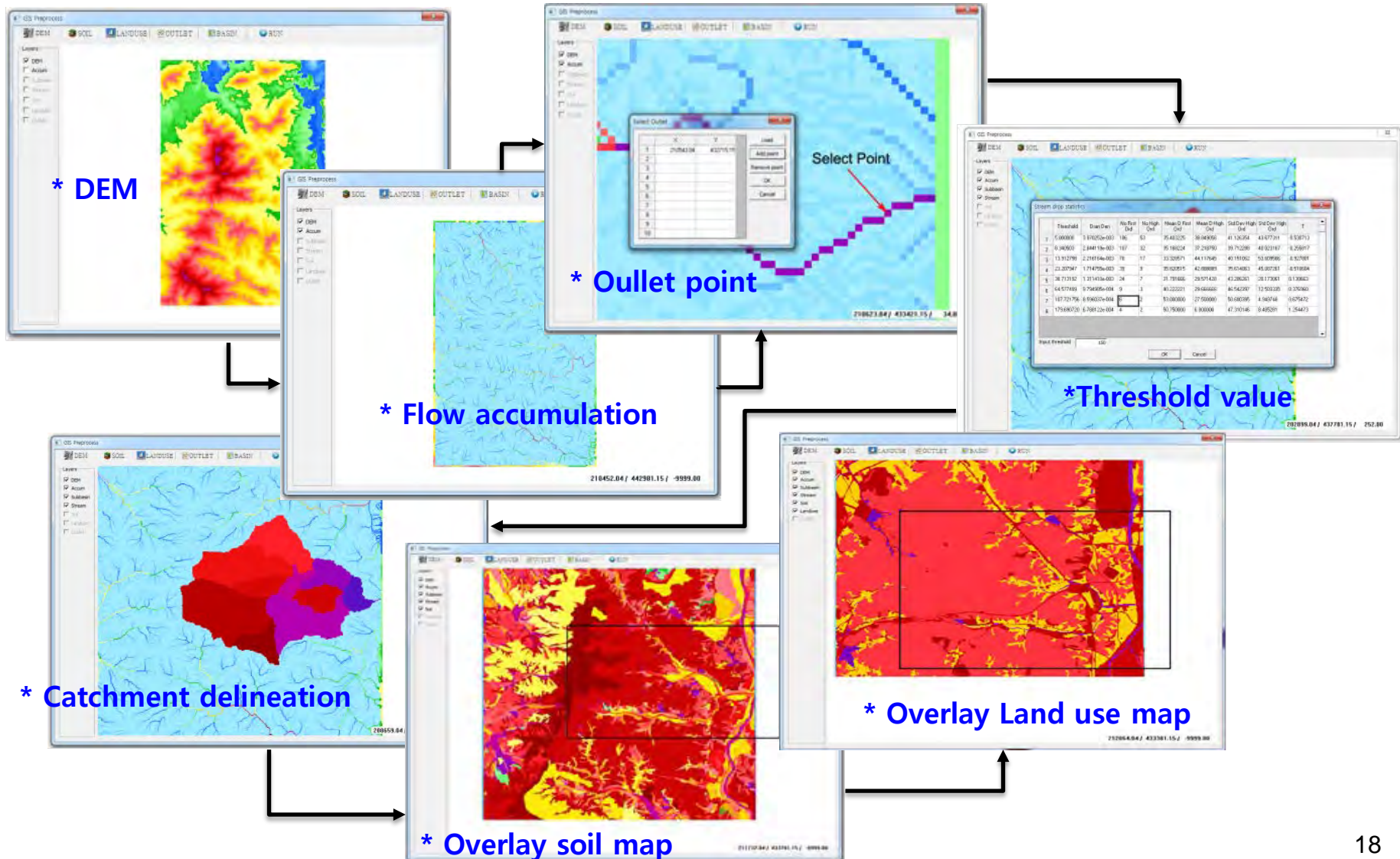
“DWAT System Structure”

- GIS Pre-processor

- Hydrologic models like DWAT require land use and soil data to determine the area and the hydrologic parameters of each land-soil category simulated within each sub-catchment
- The physical parameters of the system can be searched and optimized conveniently using **GIS Pre-processor menu**
- This tool allows users to load land use and soil themes into the current project and determine the land use/soil class combinations and distributions for the delineated catchment
- The complete process of watershed delineation and input parameters using GIS Pre-processor involves a sequence of steps

- ✓ *Importing DEM*
- ✓ *Determining the slope direction at each pixel*
- ✓ *Determining the “flow accumulation”*
- ✓ *Calculation of preliminary stream network raster using a flow accumulation*
- ✓ *Determining catchment area using channel threshold value*
- ✓ *Overlay Soil map*
- ✓ *Overlay Land use map*

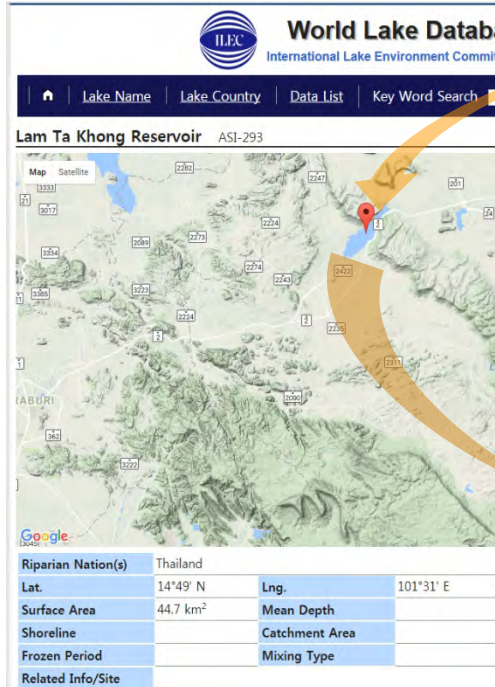
“DWAT System Structure”



“DWAT Application”

- Study Area:

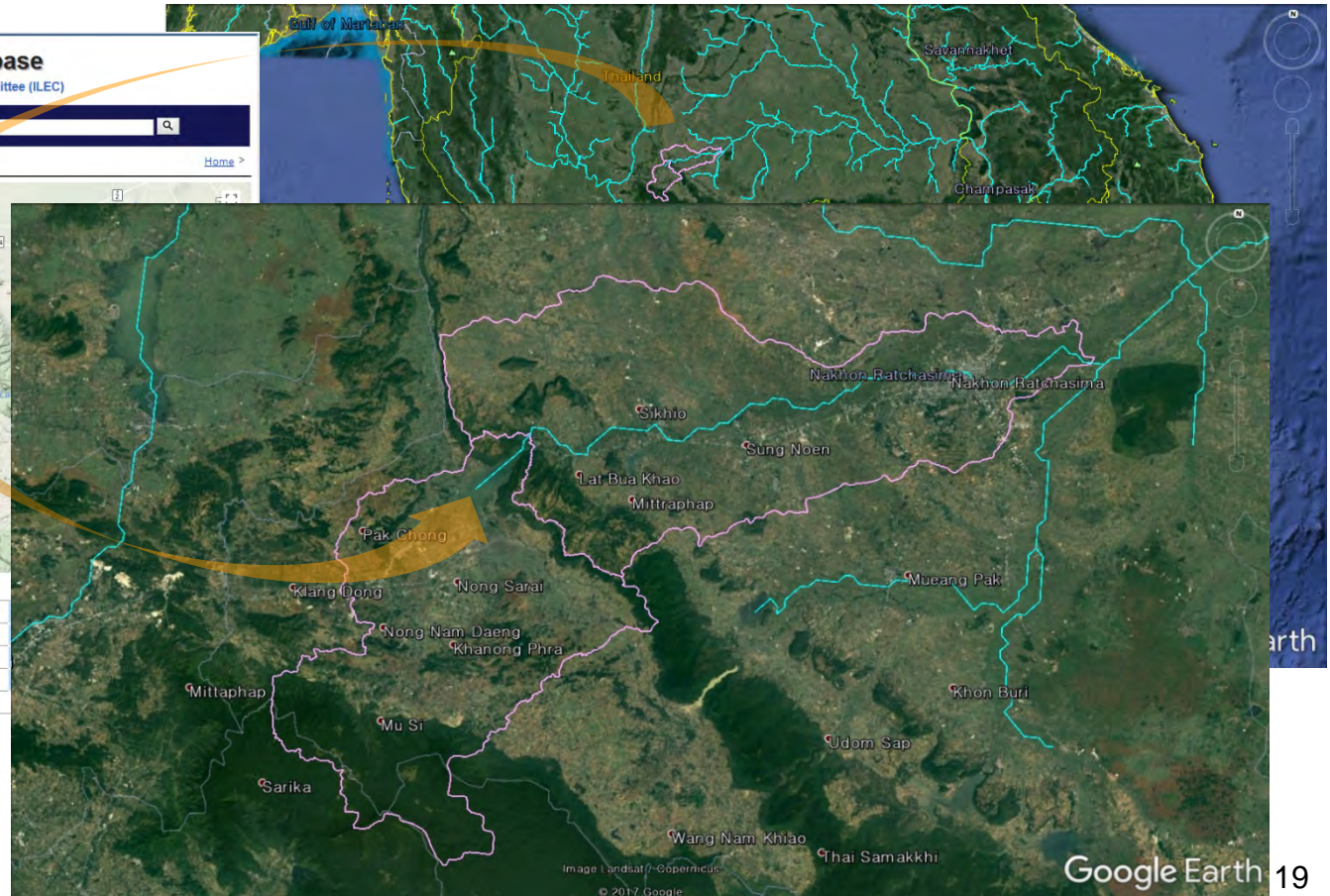
- Lam Takhong Reservoir (<http://wldb.ilec.or.jp/Details/Lake/ASI-293>)
- Watershed Area : 1,423 km², Volume : 440 x 10⁶ m³



World Lake Database
International Lake Environment Committee (ILEC)

Lam Ta Khong Reservoir ASI-293

Riparian Nation(s)	Thailand		
Lat.	14°49' N	Lng.	101°31' E
Surface Area	44.7 km ²	Mean Depth	
Shoreline		Catchment Area	
Frozen Period		Mixing Type	
Related Info/Site			



“DWAT Application”

● Data Collection:

- USGS Hydro1K (<https://earthexplorer.usgs.gov/>) : DEM, Land Cover (Asia region)
- APCC (LT Reservoir): Soil Type, Weather Station, Sub-catchments, Reservoir data(inflow, outflow, storage, Elev.-Vol. Curve), Paddy Area
- USGS HydroSHEDS (<https://hydrosheds.cr.usgs.gov/dataavail.php>) : River, Drainage Basins (Asia region)

USGS Hydro1K

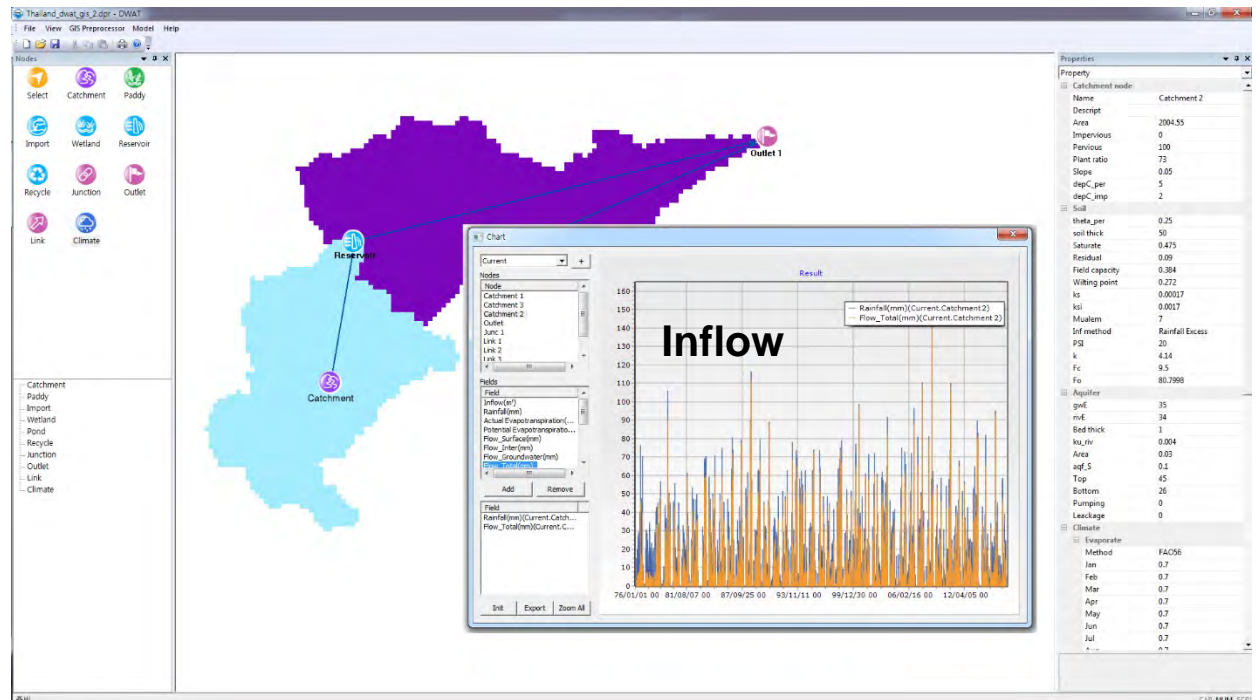
The screenshot shows the USGS Earth Explorer interface. The top navigation bar includes 'Home', 'Search Criteria', 'Data Sets', 'Additional Criteria', and 'Results'. The main content area displays '4. Search Results' with a note about logging in to download. Below this, a 'Data Set' section lists five results for 'GTOP30 HYDRO 1K'. Each result includes a thumbnail map, a title, and metadata such as 'Entity ID', 'Publication Date', 'Coordinates', and 'Continent'. The results are: 1. GTOP30 HYDRO 1K (Entity ID: GT30H1KAS, Asia), 2. GTOP30 HYDRO 1K (Entity ID: GT30H1KAU, Australia), 3. GTOP30 HYDRO 1K (Entity ID: GT30H1KEU, Europe), 4. GTOP30 HYDRO 1K (Entity ID: GT30H1KNA, North America), and 5. GTOP30 HYDRO 1K (Entity ID: GT30H1KSA, South America). The bottom of the page contains links for 'Accessibility', 'FOIA', 'Privacy', 'Policies and Notices', and 'Google Maps API Disclaimer'.

The screenshot shows the USGS HydroSHEDS website. The top navigation bar includes 'Home', 'Overview', 'Data Sources', 'Data Set Development', 'Quality Assessment', 'Data Availability', 'Data Formats', 'Notes for Users', 'References', and 'Disclaimer'. The main content area is titled 'Data Downloads' and lists 'Available Datasets' with links to download various data products. The datasets include: 1. 30sec GRID: Void-filled DEM, 2. 30sec GRID: Conditioned DEM, 3. 30sec GRID: Flow Direction, 4. 30sec BIL: Void-filled DEM, 5. 30sec BIL: Conditioned DEM, 6. 30sec BIL: Flow Direction, 7. 15sec GRID: Conditioned DEM, 8. 15sec GRID: Flow Accumulation, 9. 15sec GRID: Flow Direction, 10. 15sec BIL: Conditioned DEM, 11. 15sec BIL: Flow Accumulation, 12. 15sec BIL: Flow Direction, 13. 30sec SHAPC: River Network, 14. 30sec SHAPC: Drainage Basins (Beta), 15. 30sec GRID: Conditioned DEM, 16. 30sec GRID: Flow Accumulation, 17. 30sec GRID: Flow Direction, 18. 30sec BIL: Conditioned DEM, 19. 30sec BIL: Flow Accumulation, 20. 30sec BIL: Flow Direction, 21. 30sec SHAPC: River Network, and 22. 30sec SHAPC: Drainage Basins (Beta). The bottom of the page contains links for 'Accessibility', 'FOIA', 'Privacy', 'Policies and Notices', and 'Google Maps API Disclaimer'.

“DWAT Application”

● DWAT results (Before Calibration):

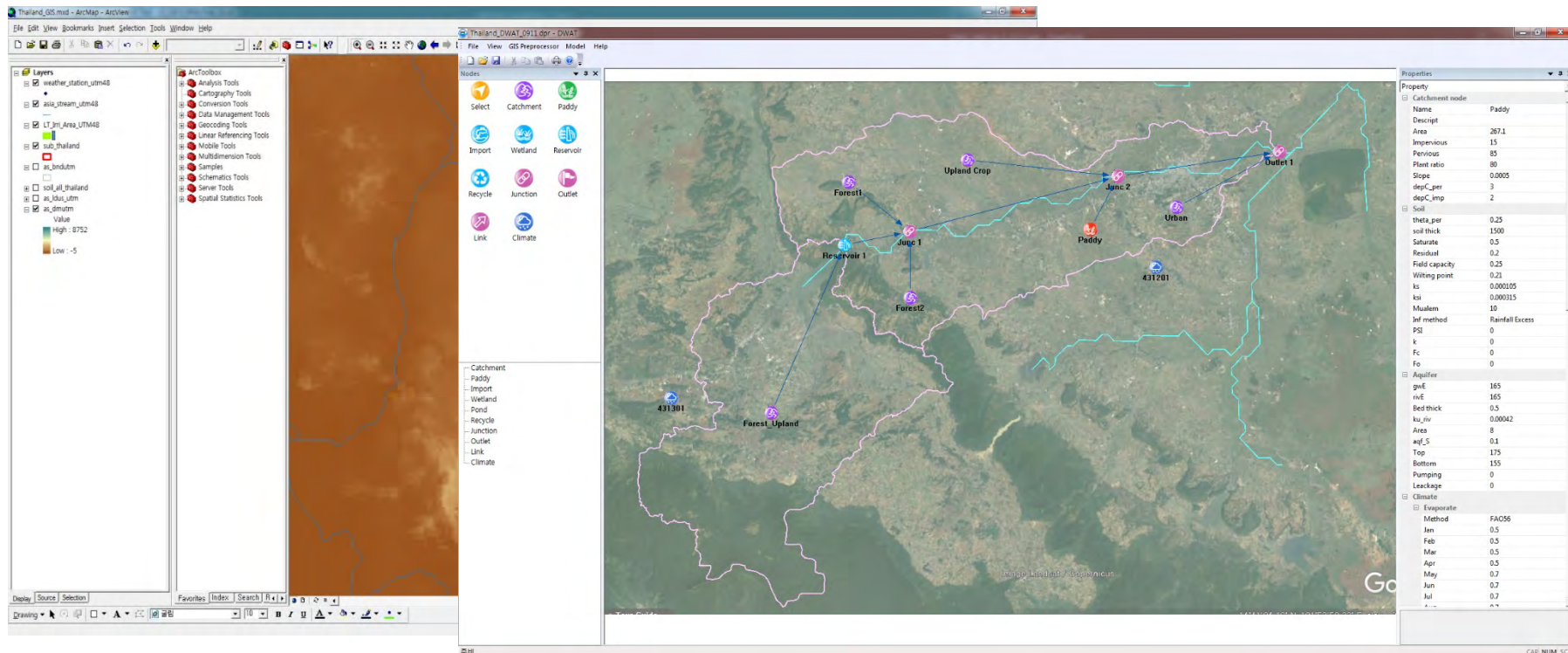
- Parameters from GIS pre-process
- Condition of simulation
 - weather and rainfall : 1976 ~ 2016 daily (APCC, RID)
 - reservoir level/storage : 1976 ~ 2016 monthly, inflow, outflow, storage (APCC, RID)
 - upstream/downstream of reservoir
- Results
 - monthly inflow (1976 ~ 2016)



“DWAT Application”

● DWAT results (After Calibration):

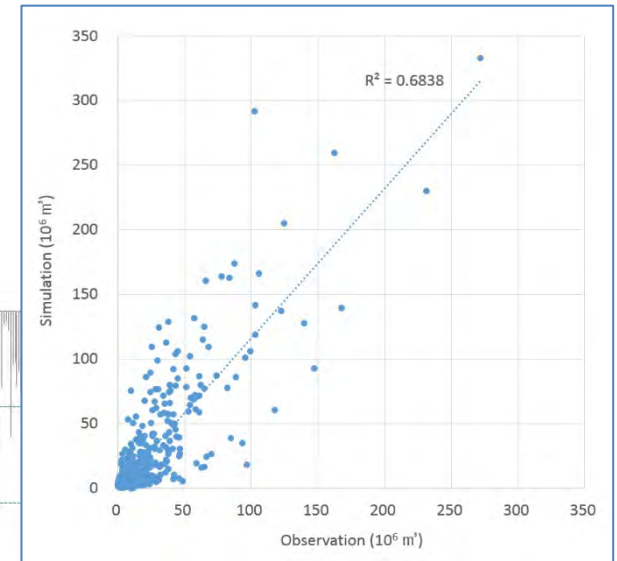
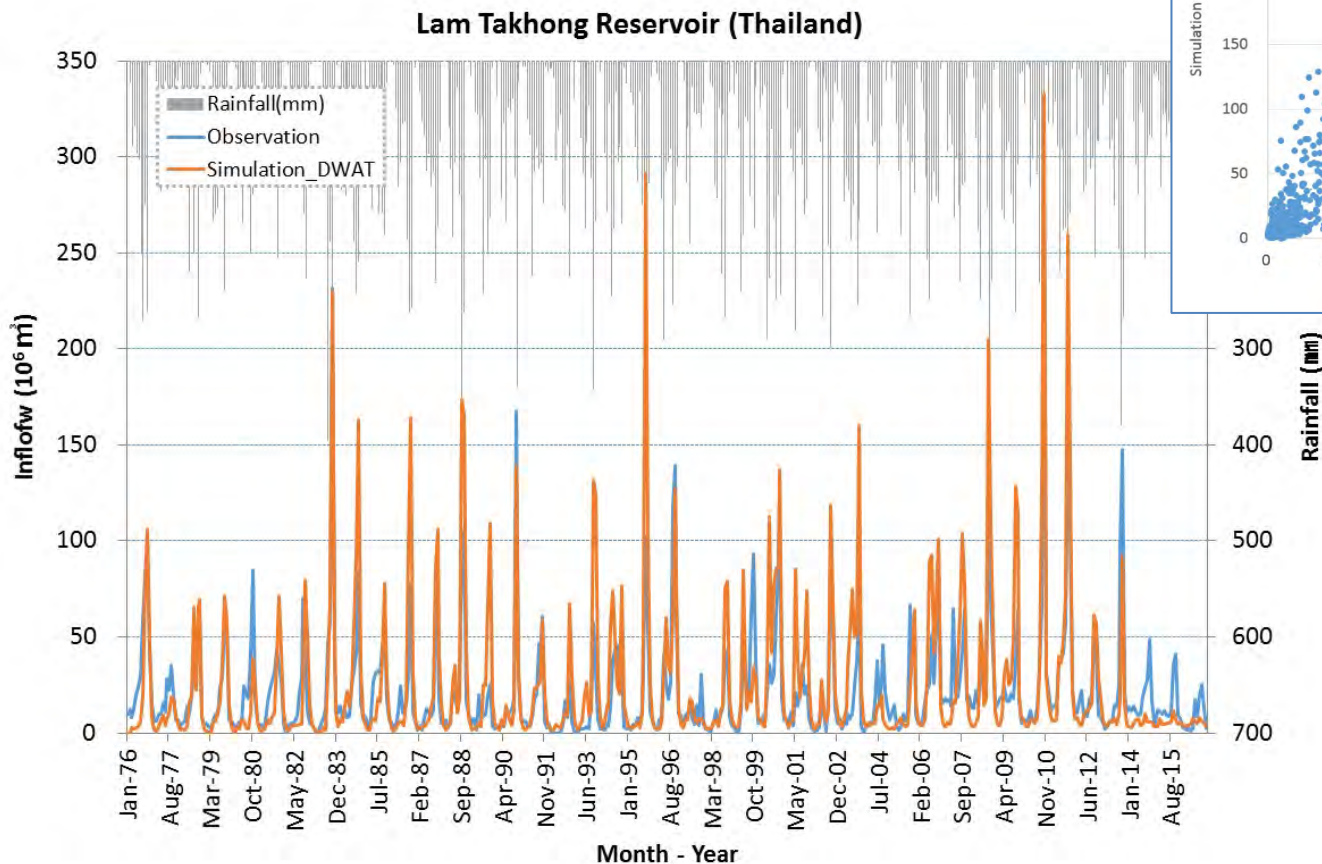
- Land Cover based on Goggle Map
 - Upstream of reservoir: upland and forest (1,423 km²)
 - Downstream of reservoir: paddy (267 km²), upland (1,353 km²), urban (89 km²), forest (182 km²)
- Lam Takhong Irrigation Area: paddy field area (APCC)
 - water depth management in paddy field (assumption)



“DWAT Application”

- DWAT results (After Calibration):

- Lam Takhong Reservoir inflow (measured)
 - runoff ratio: 20%, evapotranspiration: 80%

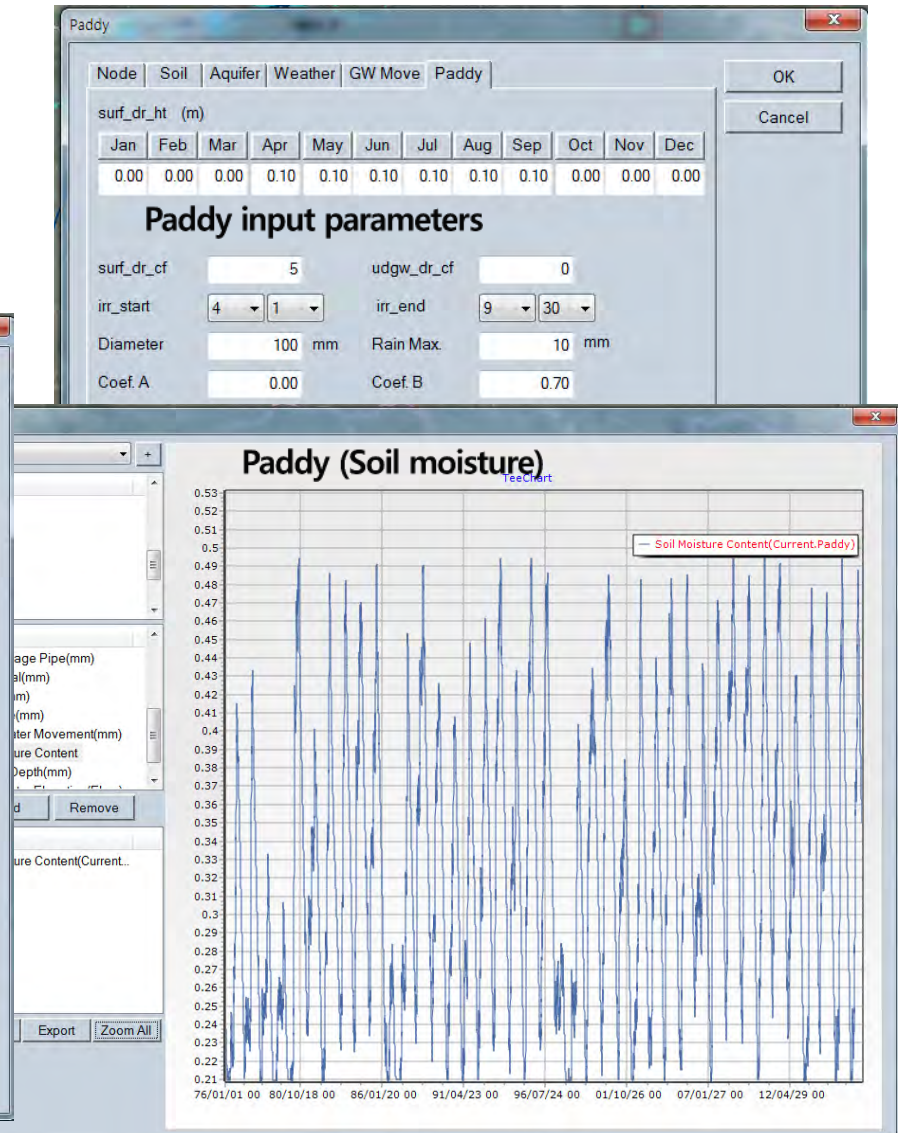
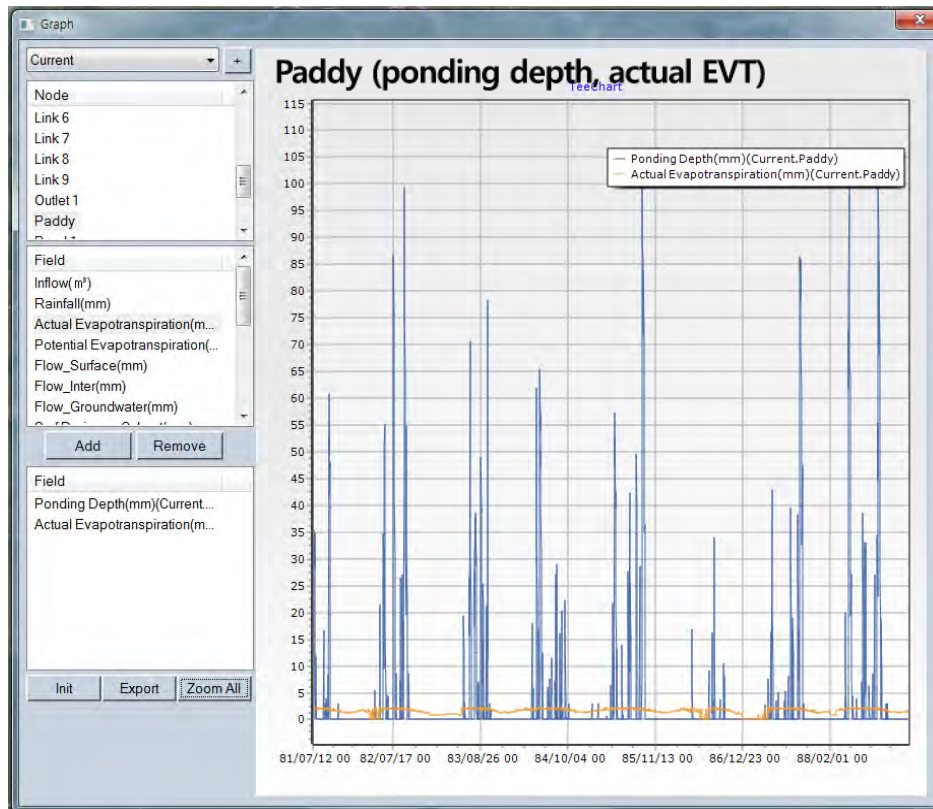


“DWAT Application”

- DWAT results (After Calibration):

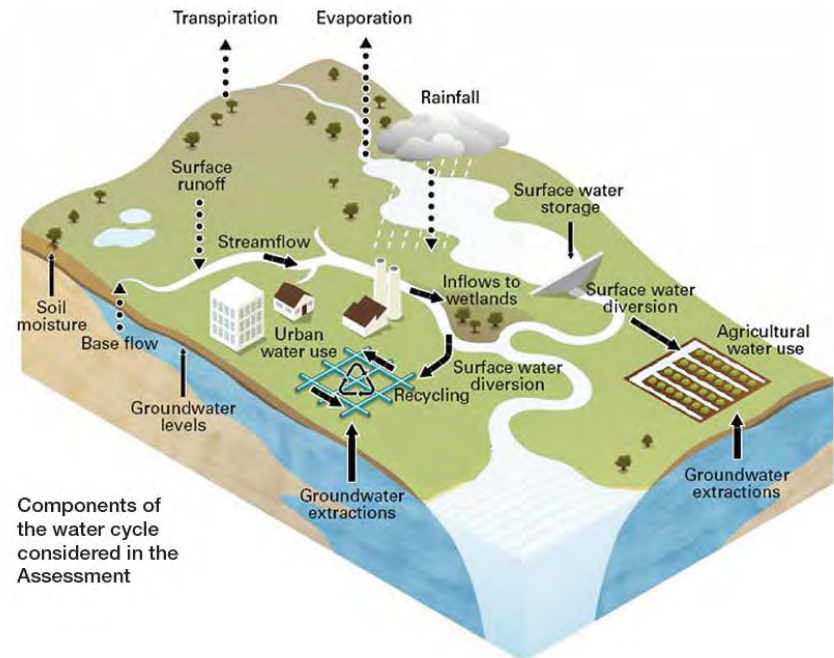
- Paddy Area

- irrigation period: April ~ September
- 10 cm of ponding water depth



“What do DWAT System do?”

- Provide information on urban and rural water use and flow of surface water storage and aquifers
- Use a nationally-consistent landscape water balance model to estimate landscape water flows
- Evaluate trends in water availability and use at local, regional and national scales over daily timescales
- Analysis on the hydrological state of rivers, wetlands, storages and aquifers



✧ Source: Bureau of Meteorology (Australian Government)

“Using the DWAT System”

- This scientifically robust and nationally-consistent Assessment is intended to help users, particularly policy specialists and water resource managers to:
 - identify current and future water management challenges
 - compare the current and past states of water resources
 - improve understanding of the impacts of past and present water management practices on water resources
 - better understand interactions between climate, water and landscape
- Activities for which the National Water Resources Assessment can be used:
 - contributing to research and water reform by providing nationally and regionally consistent water resources information and data, such as, surface water, groundwater, urban and agricultural water supply and use
 - assisting government policy formulation and the development of broad scale strategic plans and decision-making

“Future Plans”

	2016	2017	2018	2019	2020
Development	Beta version	Version 1.0 (Basic functions)		Version 2.0 (Analysis functions)	
Activity	Progress Workshop	System Review(CHy)	Users Workshop		Training Workshop
Support	✓ English Manual (draft)	✓ Website ✓ English Manual	✓ Establish Users Group		

Thank you for your attention!

“All comments and suggestions are welcome”

For more information of the “Dynamic Water resources Assessment Tool” , Please send contact

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