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

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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"

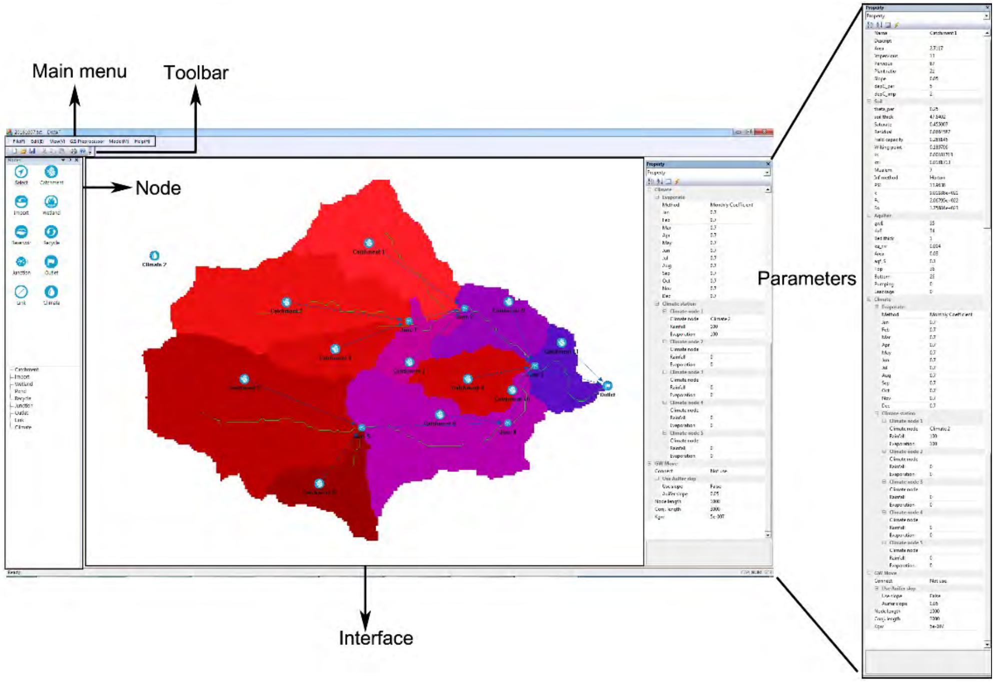
- Effective water resource policy and planning requires comprehensive, consistent and robust information on water generation, distribution, storage, availability and use
- To meet this need, providing crucial information for managers, planners and policy makers, Dynamic Water resources Assessment Tool (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

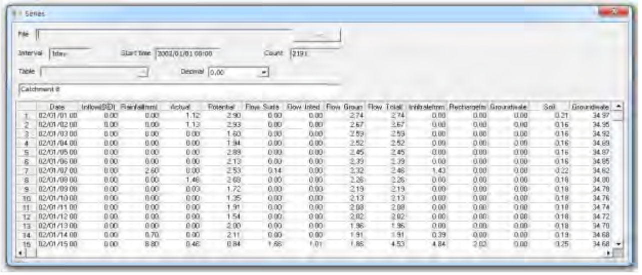
"DWAT System"

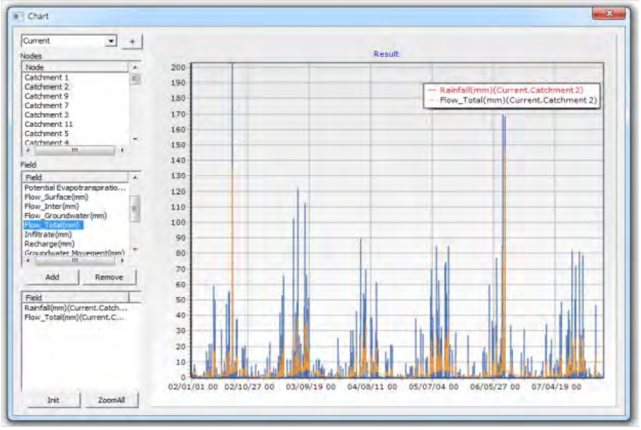
- Has a landscape model component and a river model component that were developed and validated against a range of data sources
- Has basic hydrological functions and is consisted of pre-process (based on GIS process) and water balance process
- Is a continuous, long-term, and physical parameter model 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

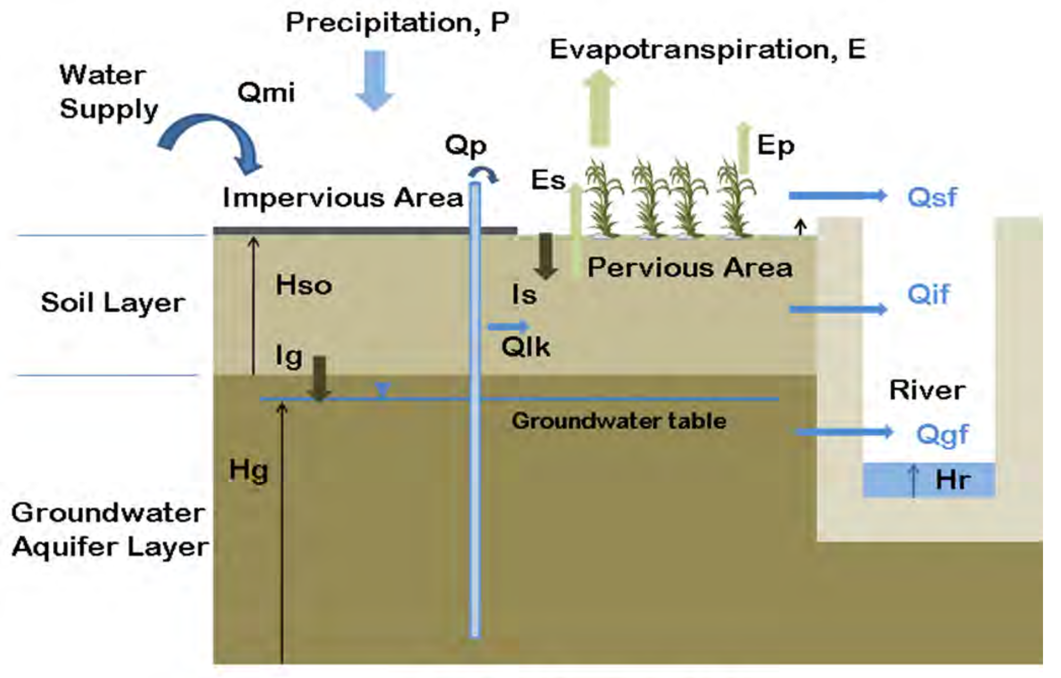






"DWAT System Structure"

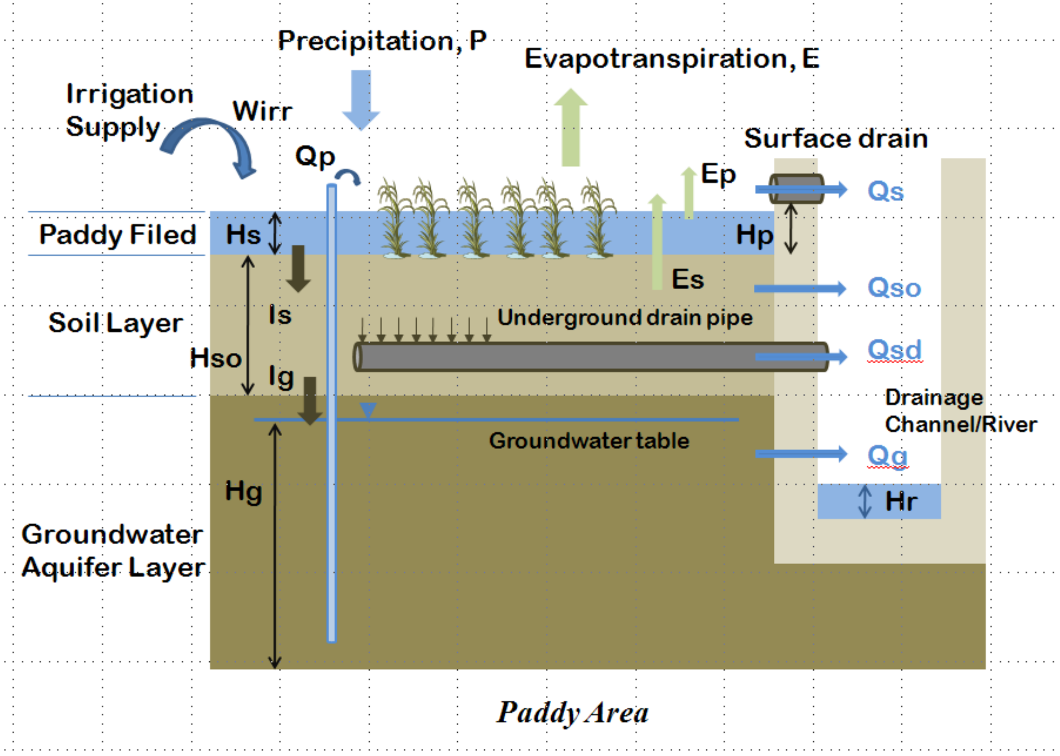
- Pervious and impervious area for rainfall-runoff process
- One soil layer and one aquifer
- Groundwater pumping



Pervious/Impervious Area

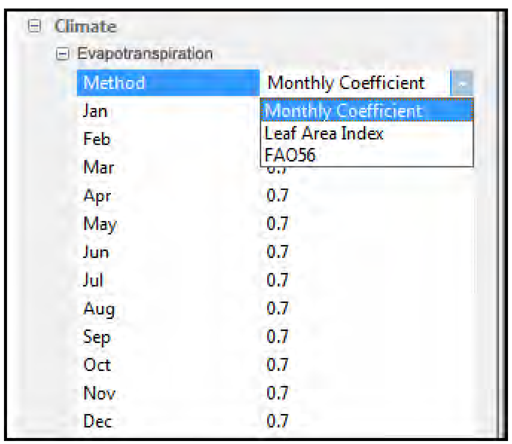
“DWAT System Structure”

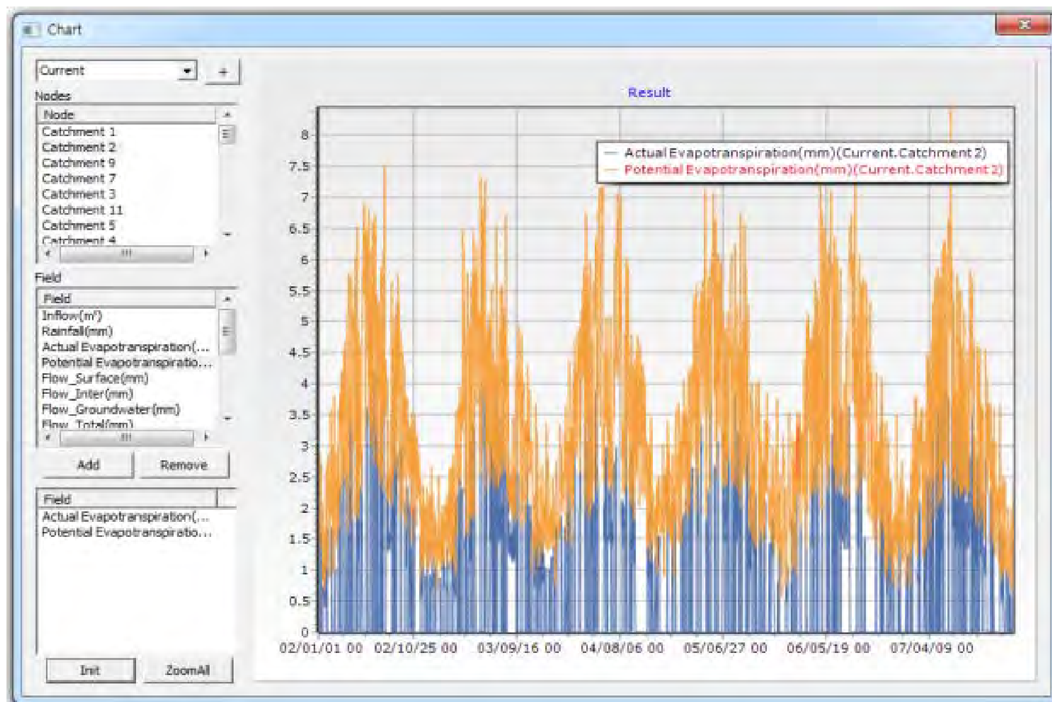
- Daily ponding depth management in paddy field
- Underground drainage culvert



“DWAT System Structure”

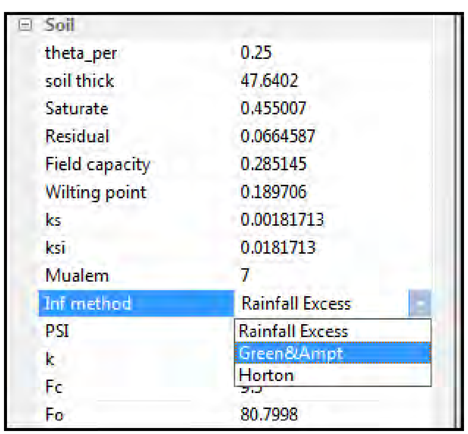
- Evapotranspiration
  - Potential evapotranspiration by the Penman-Monteith equation
  - Actual evapotranspiration by the leaf area index and soil moisture accounting

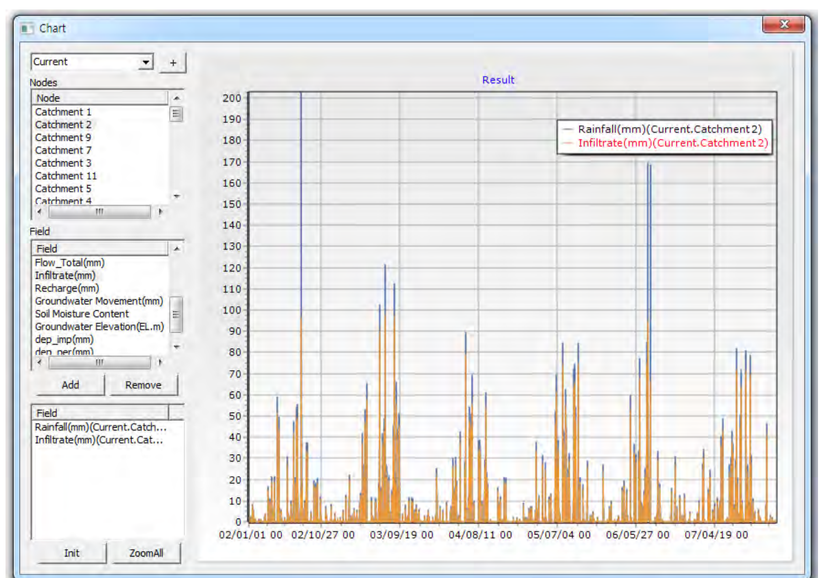




"DWAT System Structure"

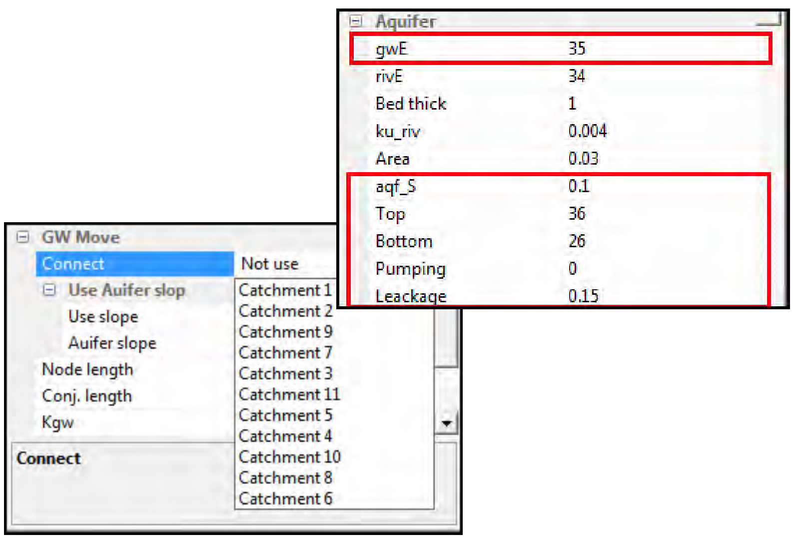
- Infiltration
  - Infiltration and deep percolation to the aquifer are analyzed based on the physical parameters of soil layer; soil depth, saturated hydraulic conductivity, horizontal hydraulic conductivity, saturated moisture contents, residual moisture contents and Mualem's n
  - Soil moisture increasing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

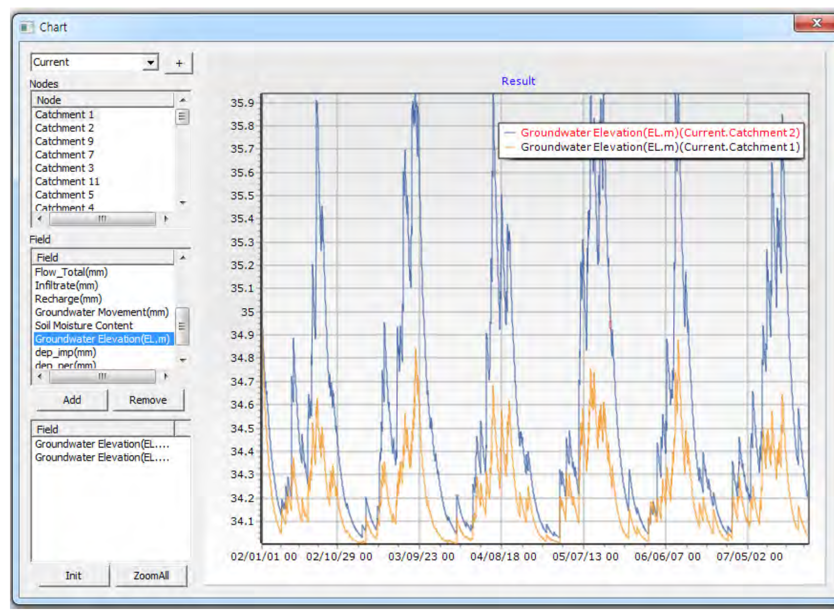




“DWAT System Structure”

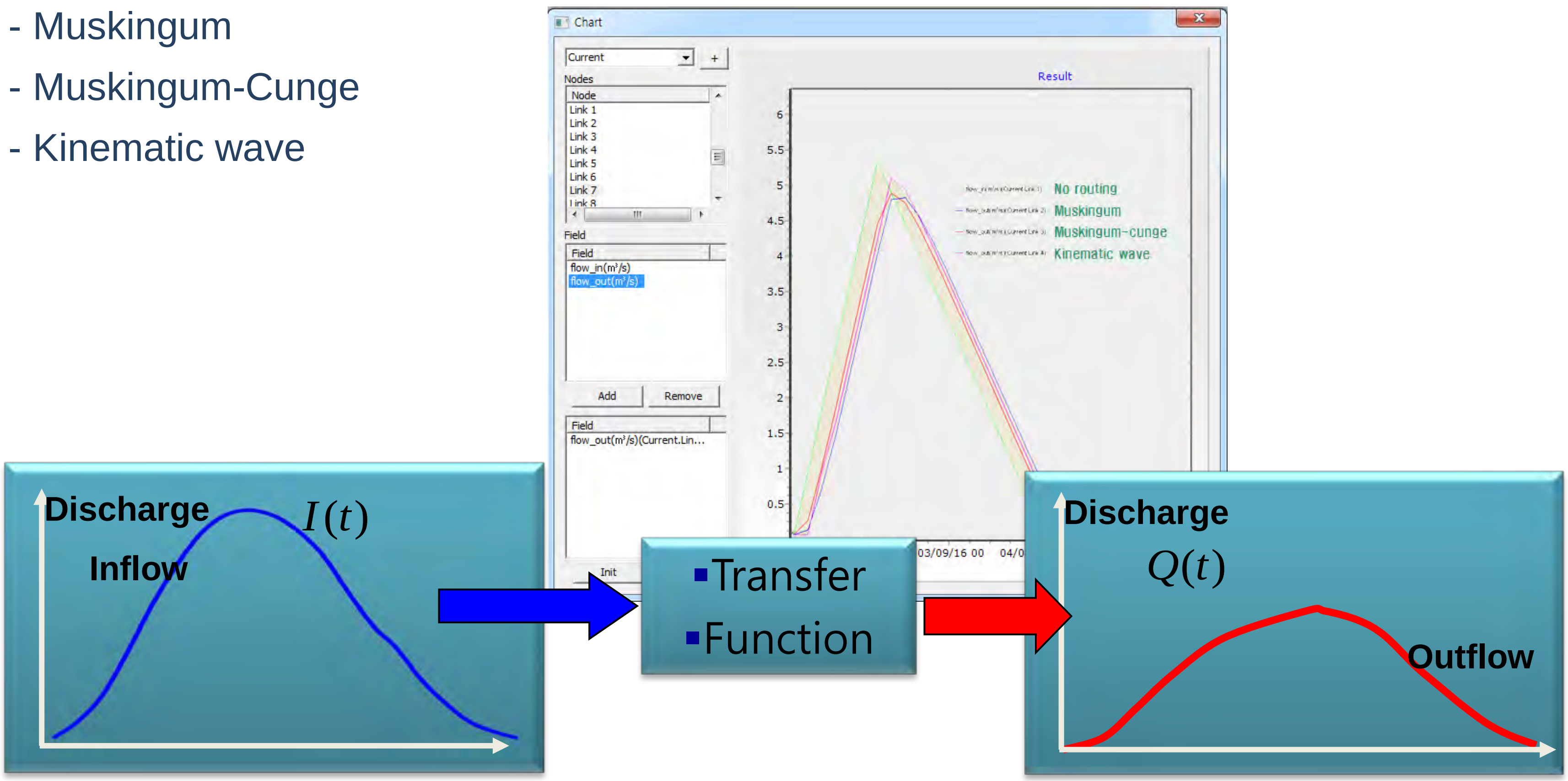
- Groundwater
  - Groundwater runoff are simulated using the relationship between groundwater level and river stage
  - Designed to consider groundwater pumping and leakage from water supply networks
  - Groundwater movement from an aquifer to adjacent aquifer (based on groundwater hydraulic gradient)





“DWAT System Structure”

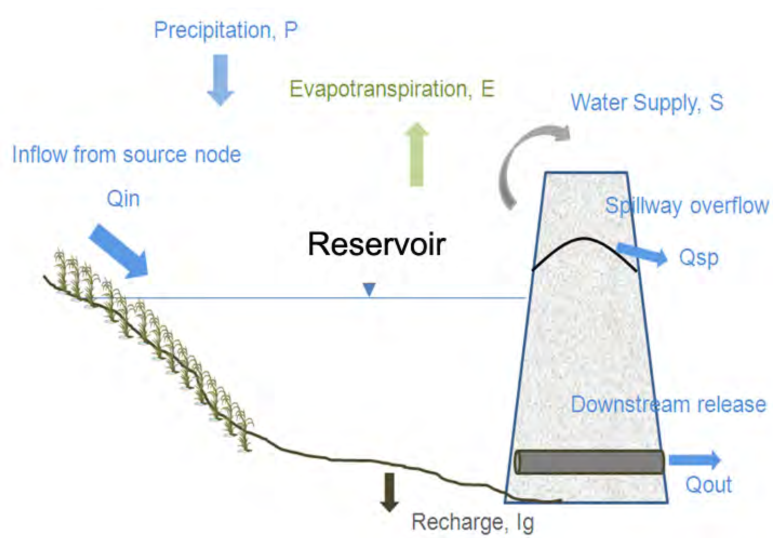
- Channel Routing
  - Outflow hydrograph in the channel using several flow routing methods
  - Muskingum
  - Muskingum-Cunge
  - Kinematic wave

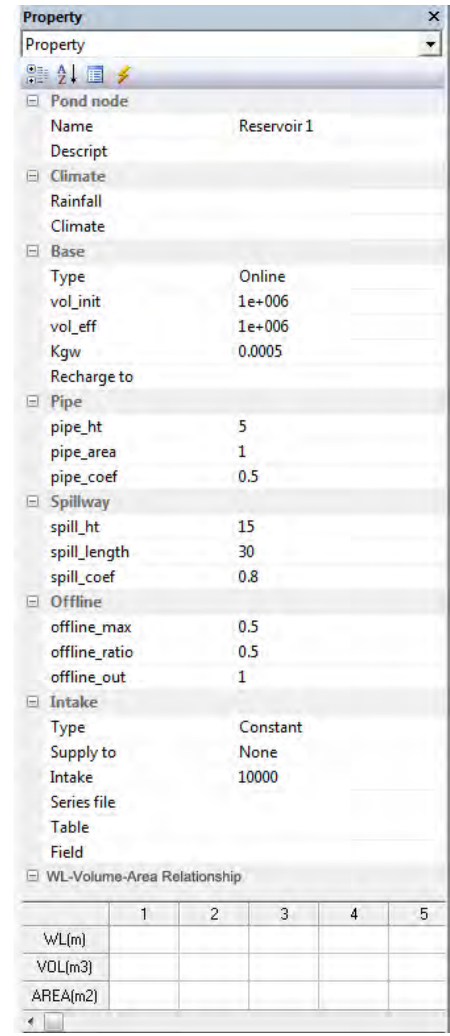


$I(t) = \text{Inflow}$ $Q(t) = \text{Outflow}$

“DWAT System Structure”

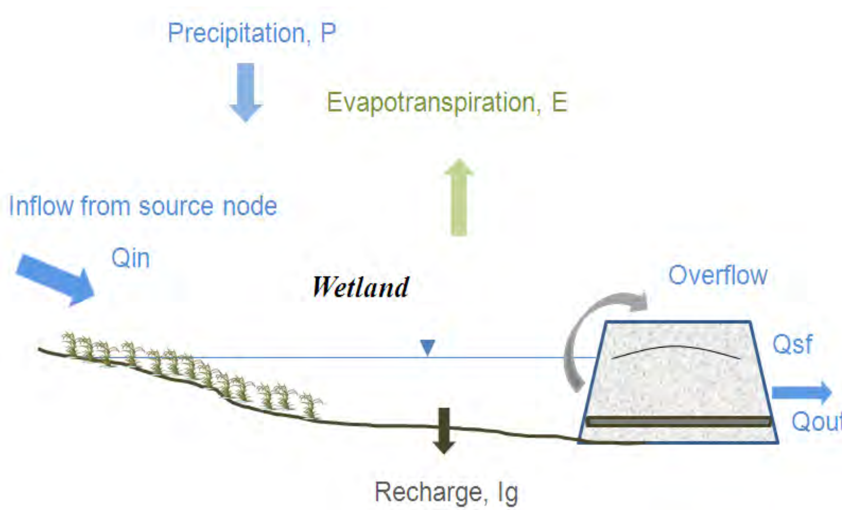
- Reservoir
  - Reservoir storage, water level and discharge are calculated using the initial storage, effective storage, intake, the specifications of spillways and discharge outlet in the reservoir
  - Storage and water levels are renewed by inflows based on the relationships of stage-storage-area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

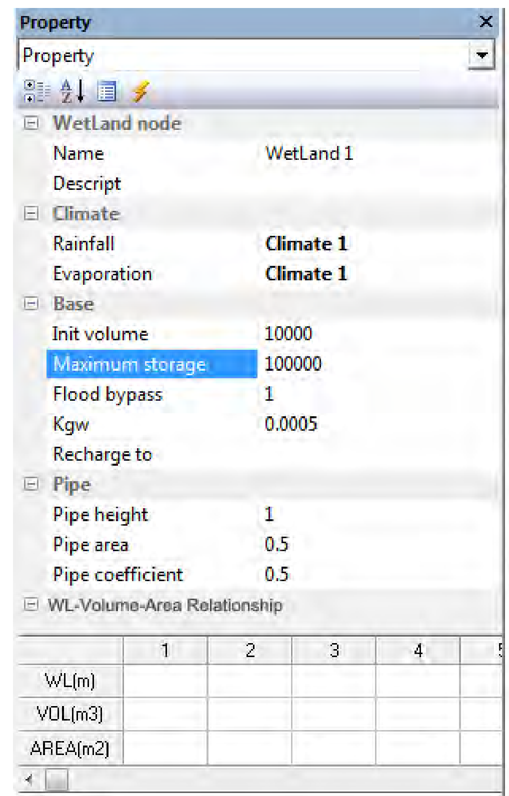




"DWAT System Structure"

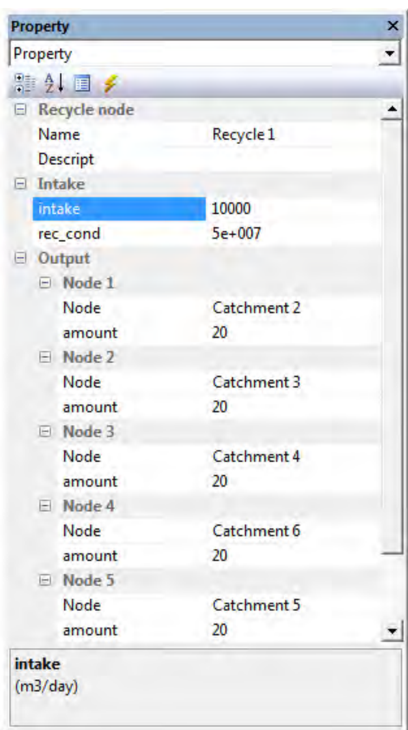
- Wetland
  - This module was designed to have any amount of water exceeding the storage capacity of wetlands overflow and discharge to the downstream
  - Wetlands reflect vegetation and evaporation from water surface
  - Storage and water levels are renewed by inflows based on the relationships of stage-storage-area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

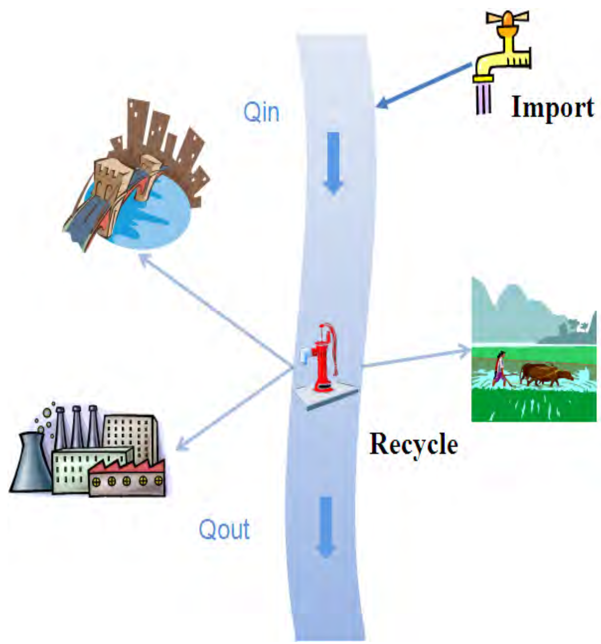


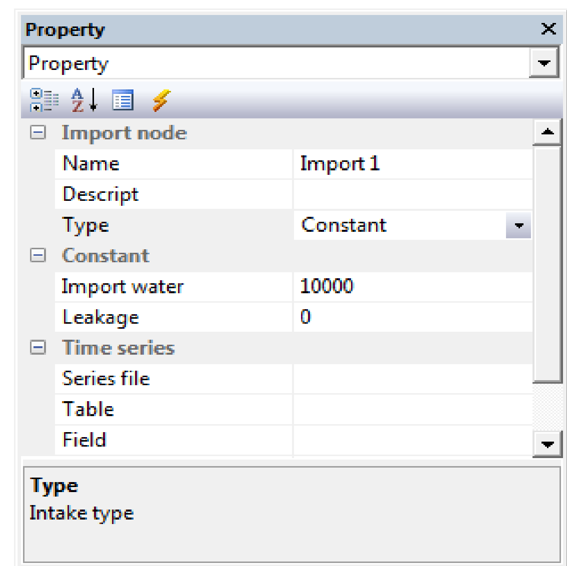


“DWAT System Structure”

- 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







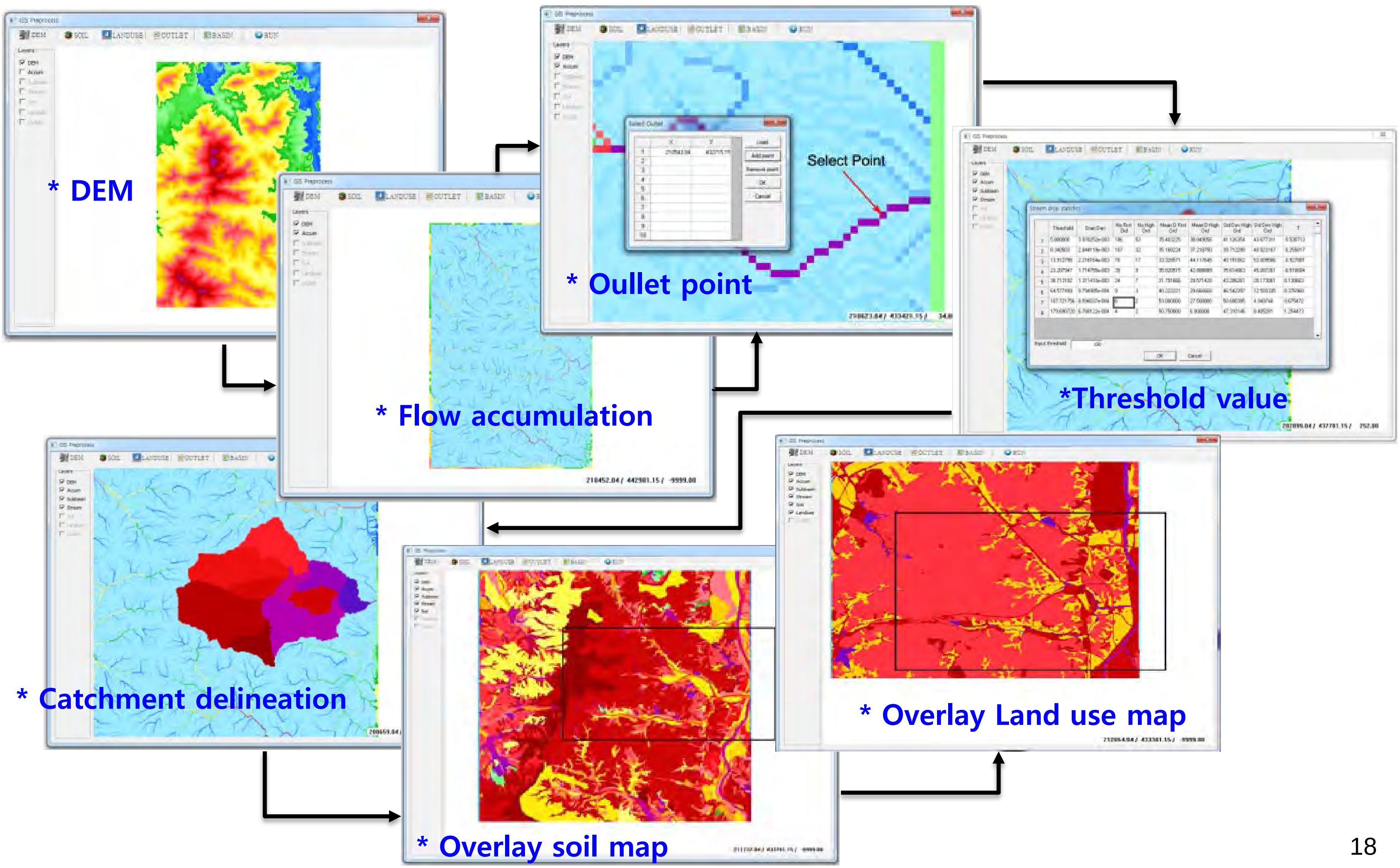
"DWAT System Structure"

- 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

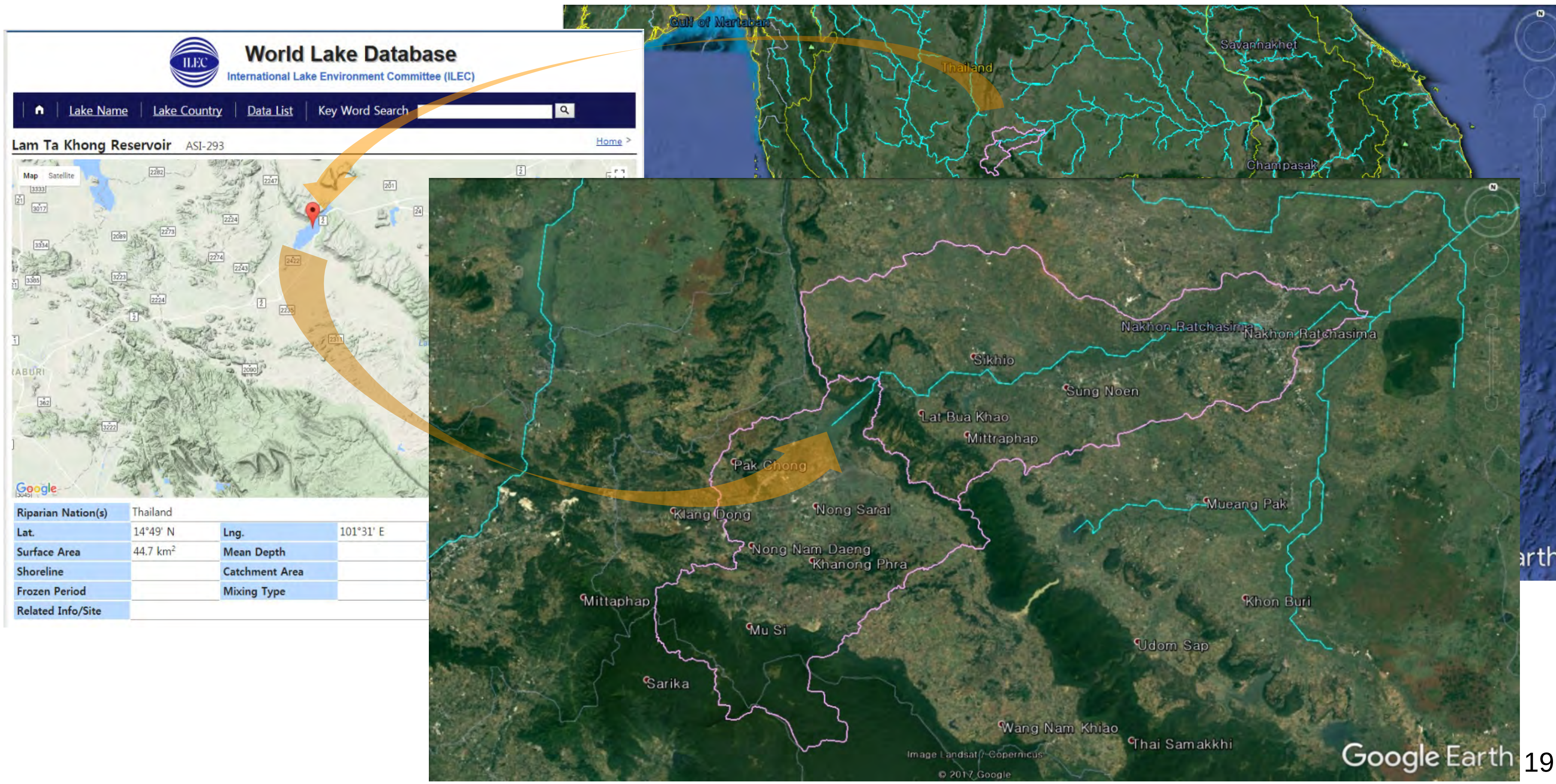
    - ✓ *Importing DEM*
    - ✓ *Determining the slope direction at each pixel*
    - ✓ *Determining the "flow accumulation"*
    - ✓ *Calculation of preliminary stream network raster using a flow accumulation*
    - ✓ *Determining catchment area using channel threshold value*
    - ✓ *Overlay Soil map*
    - ✓ *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 ㎢, Volume : 440 x 10^6 ㎥

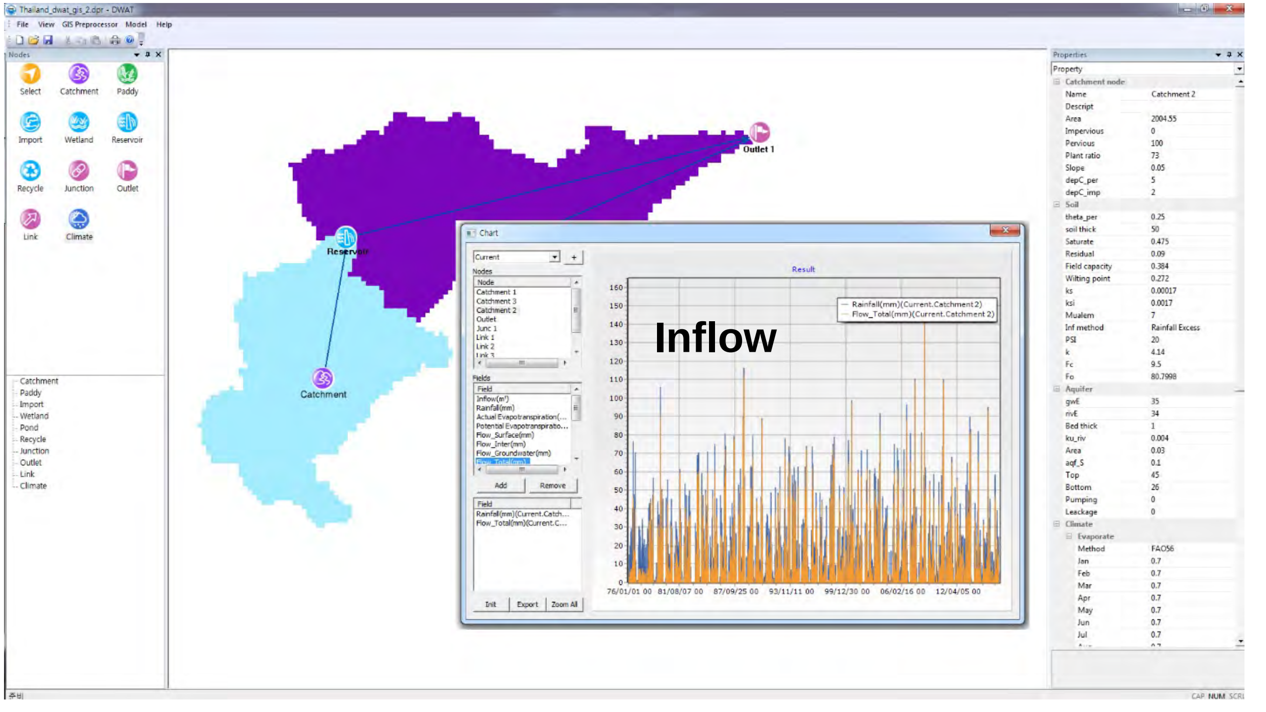


“DWAT Application”

- 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)

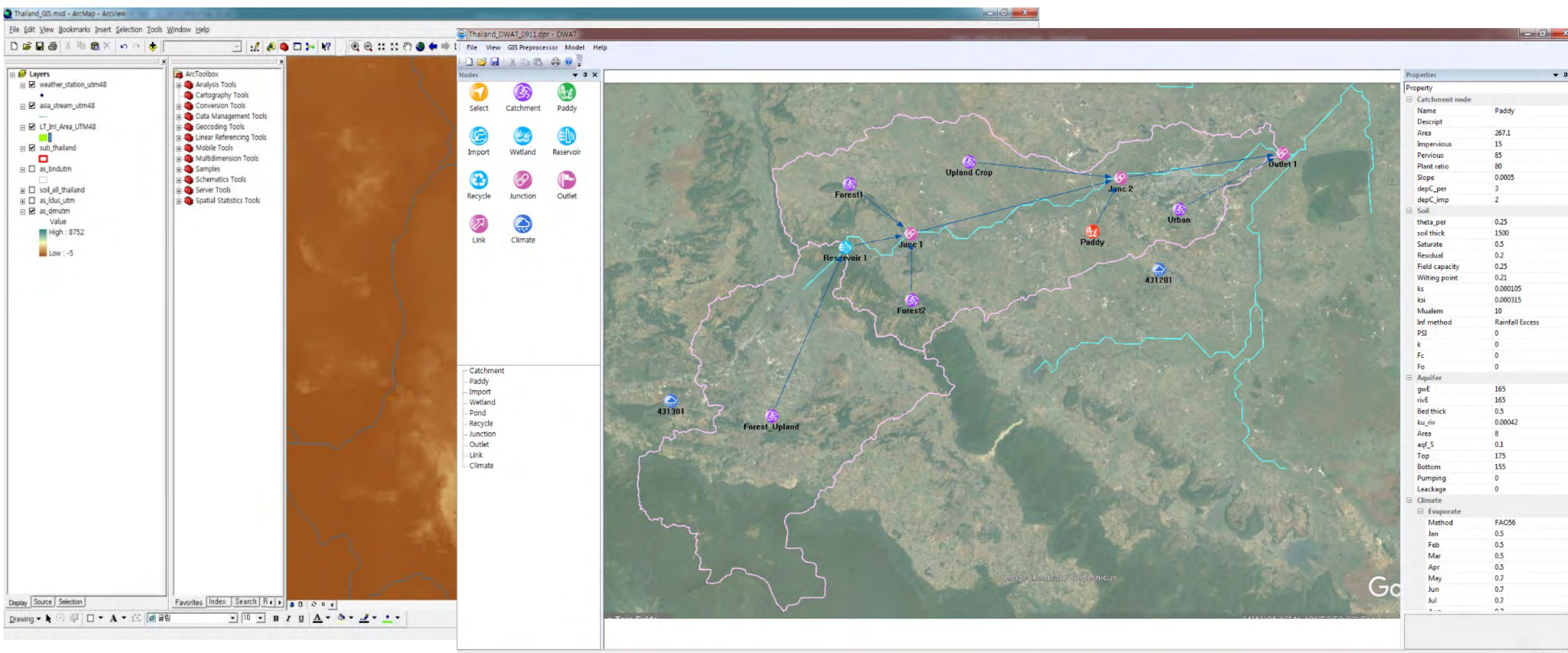
“DWAT Application”

- 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)



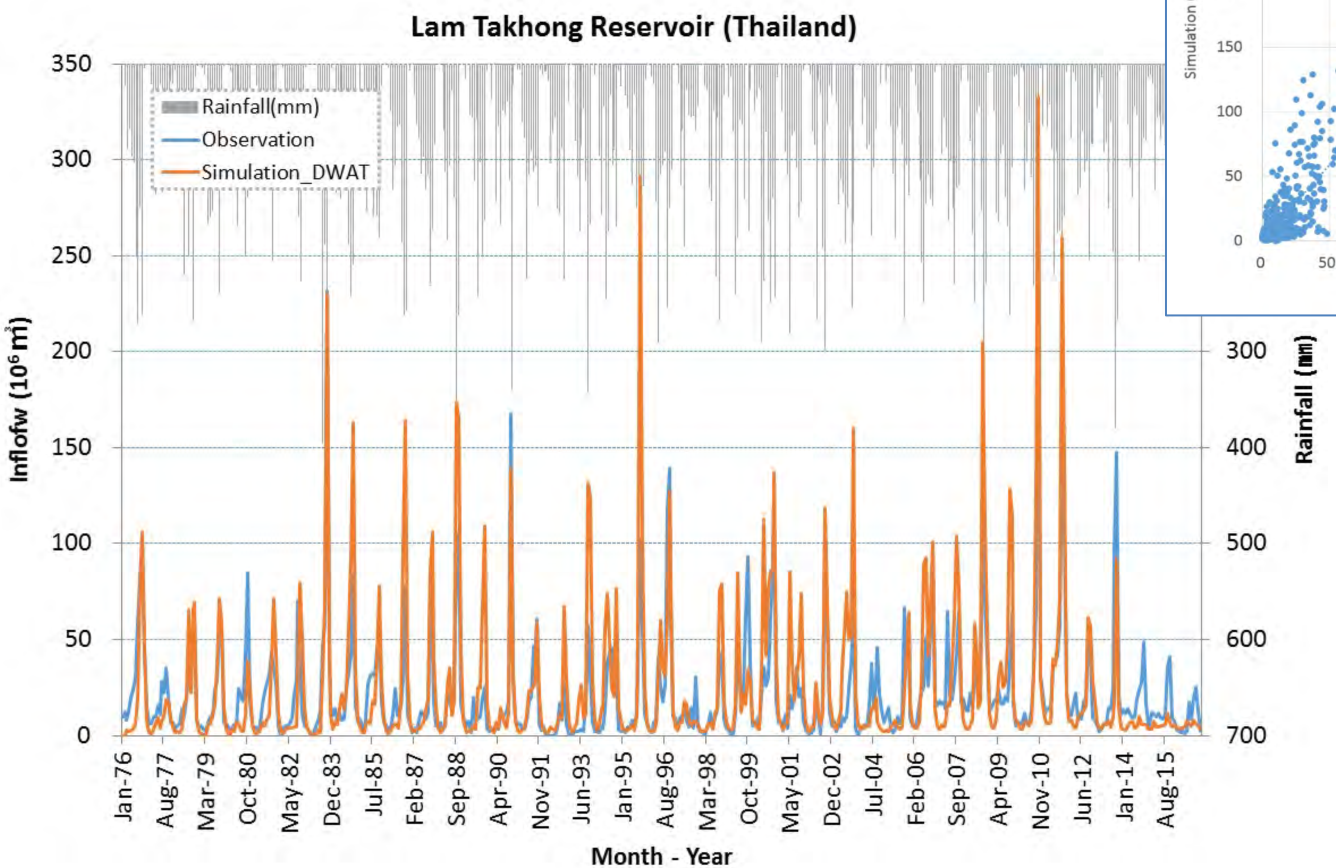
“DWAT Application”

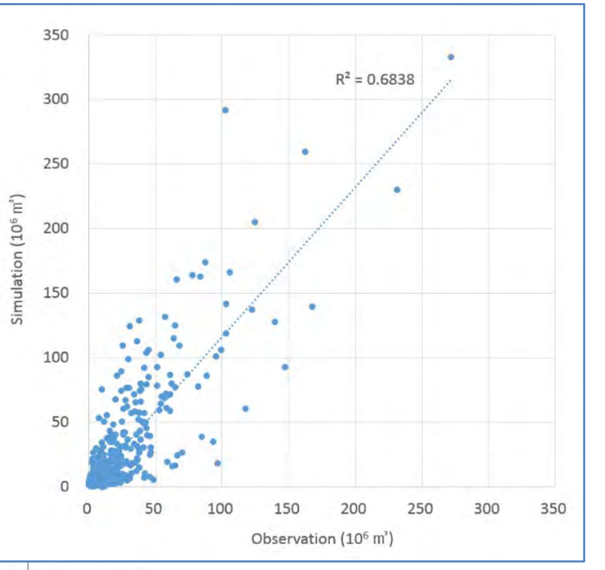
- DWAT results (After Calibration):
  - Land Cover based on Goggle Map
    - Upstream of reservoir: upland and forest (1,423 ㎢)
    - Downstream of reservoir: paddy (267 ㎢), upland (1,353 ㎢), urban (89 ㎢), forest (182 ㎢)
  - Lam Takhong Irrigation Area: paddy field area (APCC)
    - water depth management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



"DWAT Application"

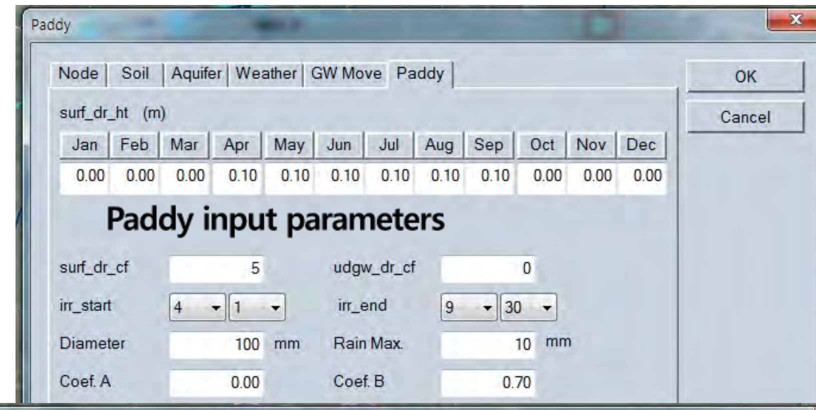
- DWAT results (After Calibration):
  - Lam Takhong Reservoir inflow (measured)
    - runoff ratio: 20%, evapotranspiration: 80%

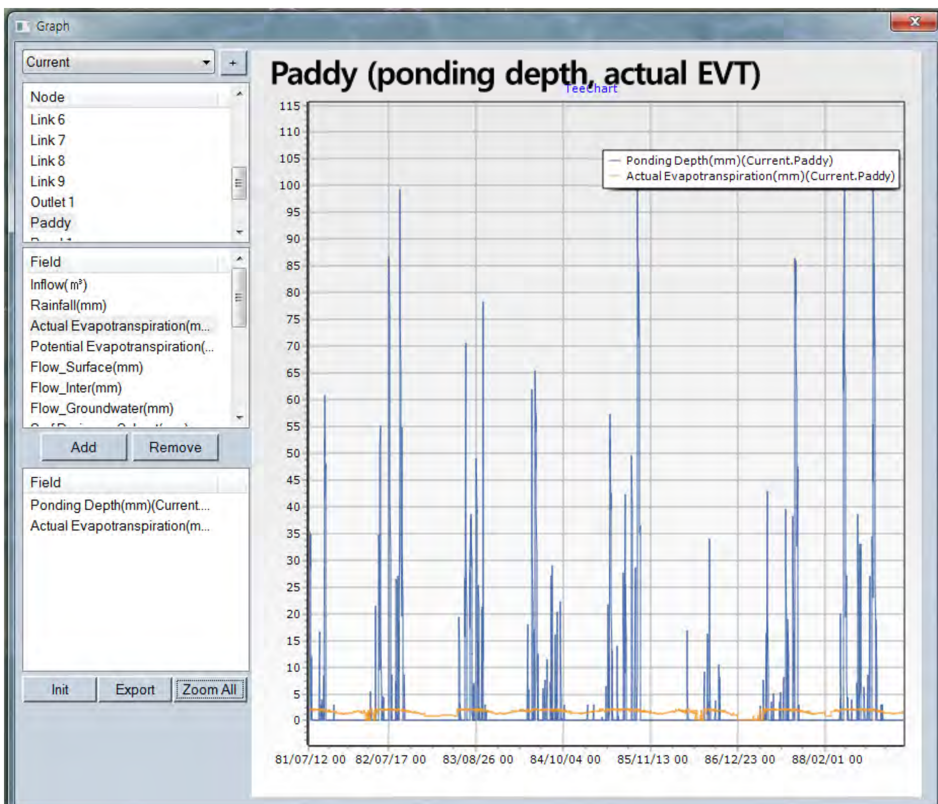


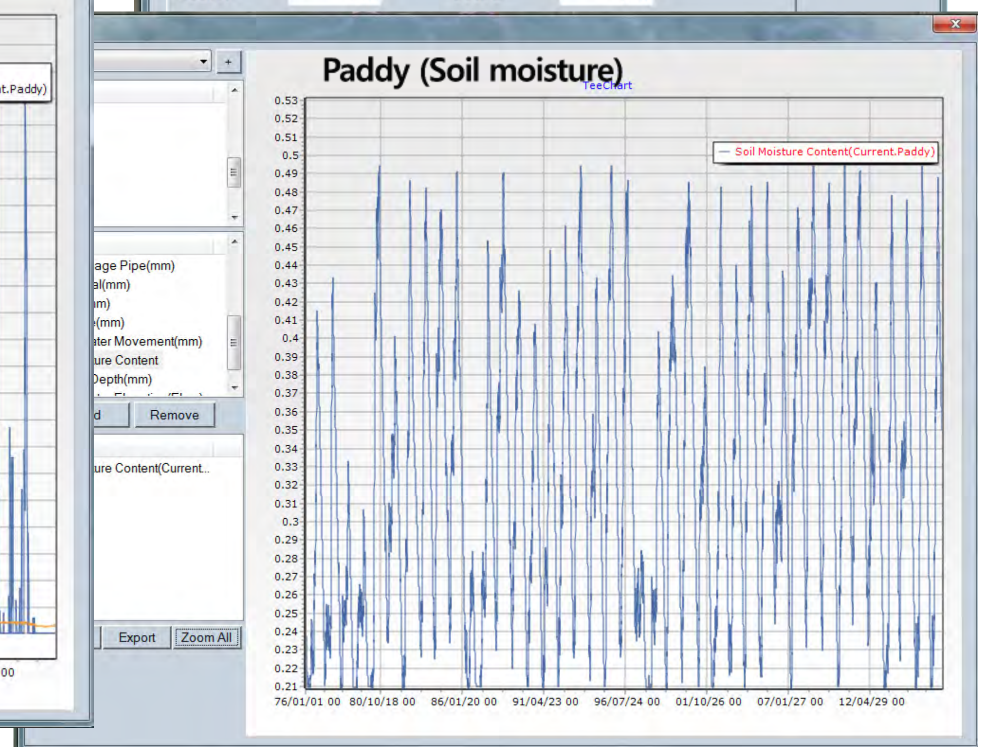


“DWAT Application”

- DWAT results (After Calibration):
  - Paddy Area
    - irrigation period: April ~ September
    - 10 ㎝ of ponding water depth

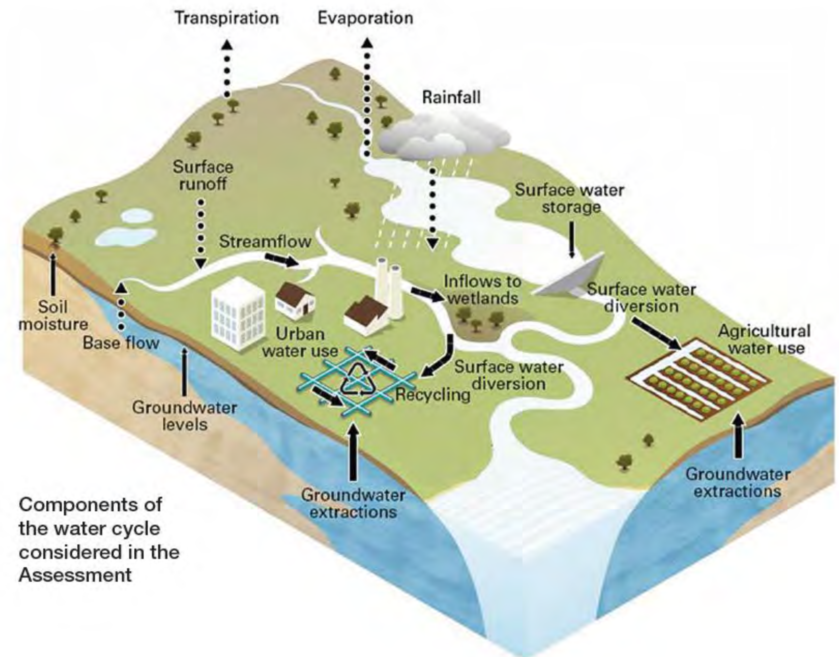






"What do DWAT System do?"

- 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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