Hydrologic Modeling System (HEC-HMS) Adaptions for Ontario

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Floodplain Mapping Knowledge Transfer Workshop
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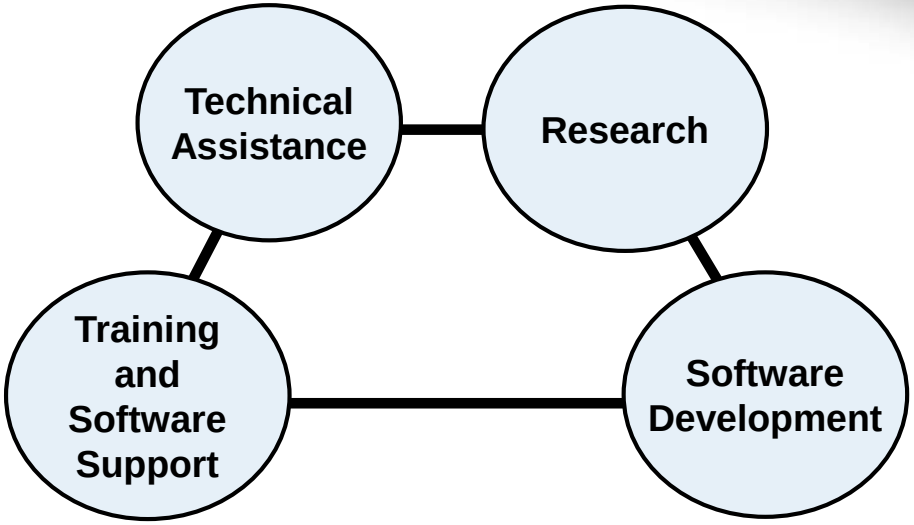
US Army Corps of Engineers®

Hydrologic Engineering Center

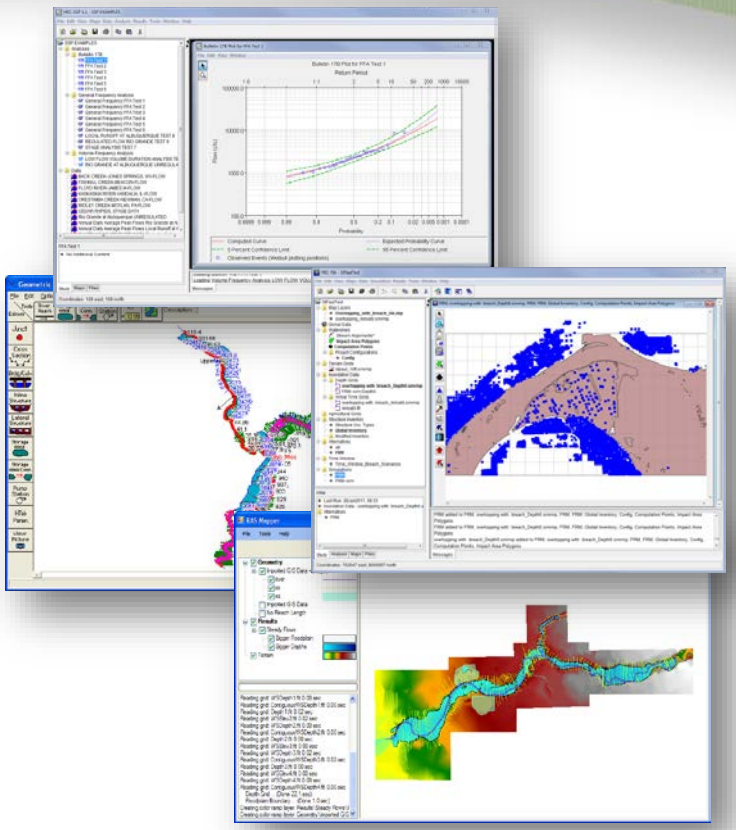
How We View Our Role In The World

- HEC exists to help the Corps of Engineers perform its civil works mission in a world-class manner:
  - The work of the Corps is performed at the field office level.
  - HEC products and services are for field use and application.
  - Generic software can be used anywhere, worldwide.
  - Software is used worldwide for five major reasons.
- The primary goal is to take "State-of-the-Art" and turn it into "State-of-the-Practice."



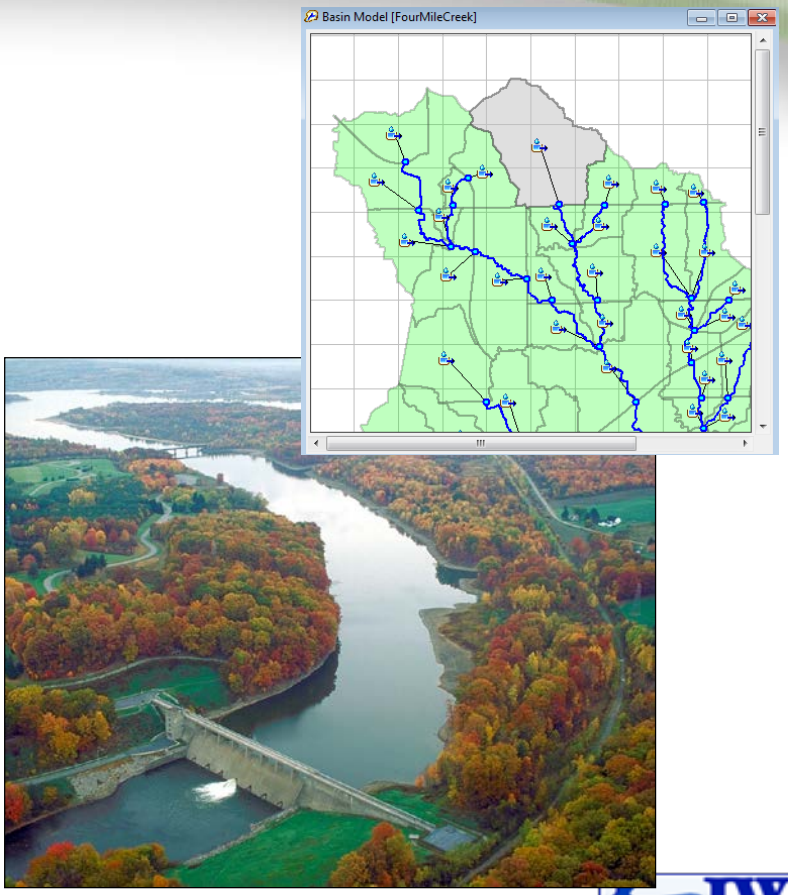
HEC Software Activities

- Solve problems in a general manner to support multiple end uses.
- Complete product line for hydrologic engineering and planning analysis:
  - Hydrologic statistics and simulation.
  - Reservoir systems.
  - Riverine hydraulics.
  - Consequences and life loss.
  - Flood risk management.
  - Real-time forecasting.
- Continually drive the software forward with new features to meet emerging needs:
  - Corps of Engineers R&D programs.
  - Special application projects.



Hydrologic Modeling System

- A fully-featured riverine hydrologic modeling system for a wide range of water resource study goals.
- Integrated work environment with tools for data entry, mapping, simulation, parameter estimation, and results visualization.
- The full scope of the hydrologic cycle is encompassed with meteorology, land surface, river channel, and structures.
- Over 48,000 software downloads during 2017.
- Canada is the #2 leading country accessing our website.



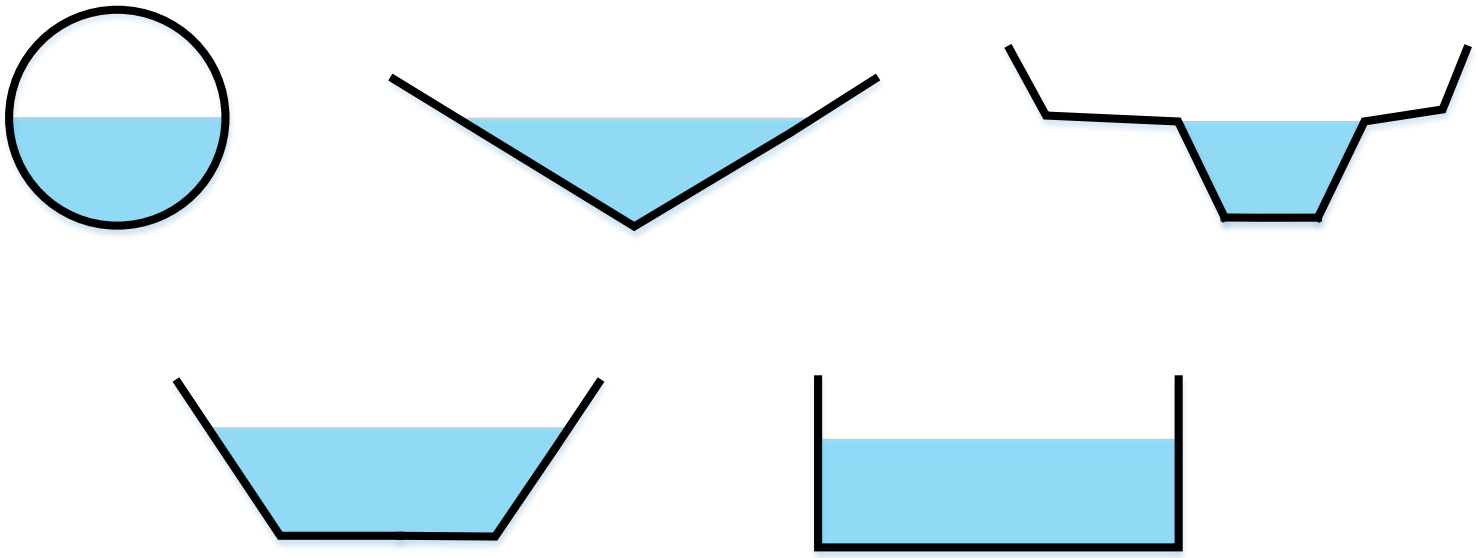
Important Topics

1. Muskingum Cunge channel routing with complex cross sections.

2. Green Ampt infiltration with a layered soil profile.

3. Baseflow and snowmelt.

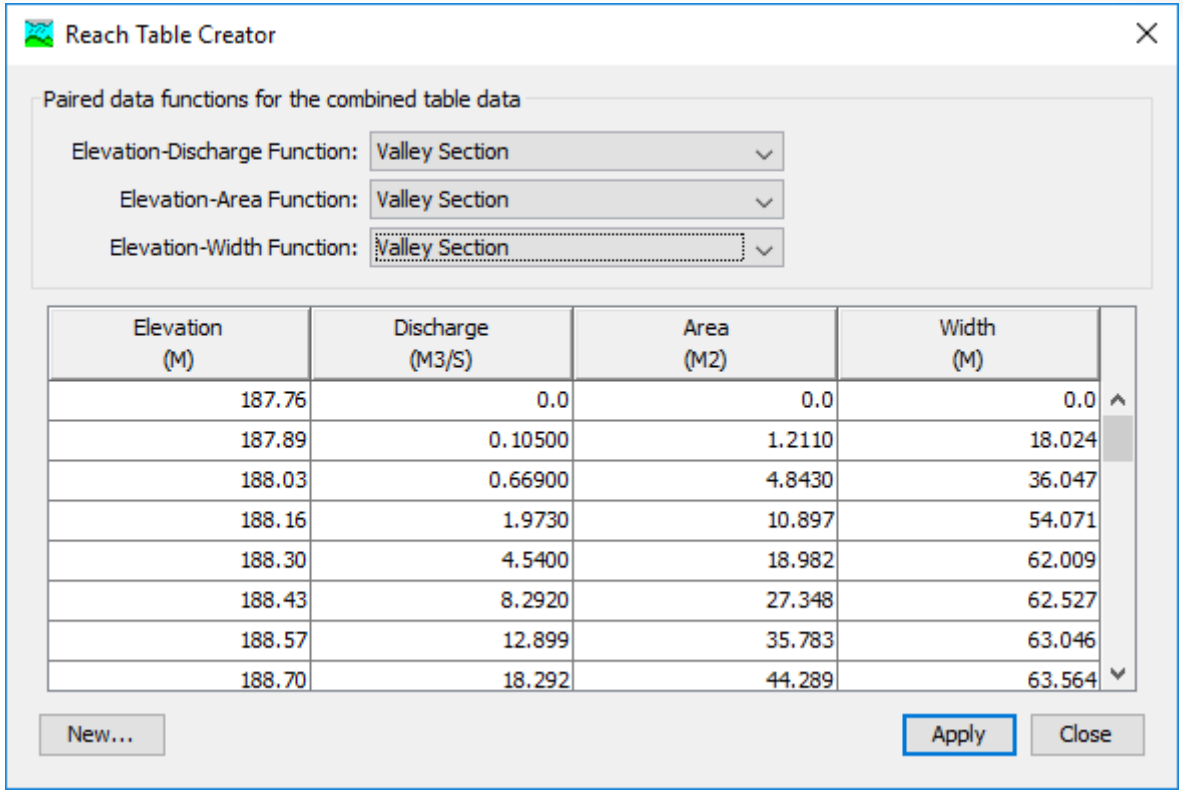
Muskingum Cunge Routing



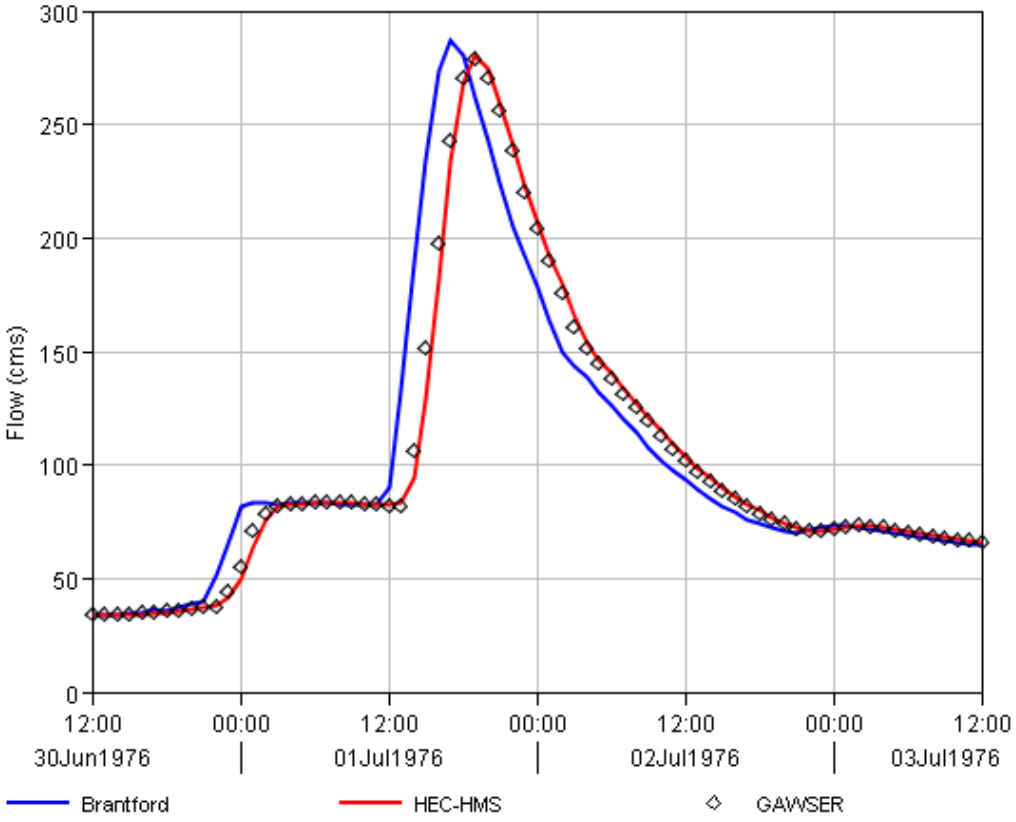
Muskingum Cunge Routing

- Routing coefficients:
  - Moving from using fixed coefficients C_1, C_2, and C_3 recalculated every 24 days…
  - To using variable coefficients recalculated every temporal step.
- Selecting the spatial step *dx*:
  - Moving from the user manually specifying the number of *dx* in the reach…
  - To automatically calculating the steps using the index wave celerity, multiplied by the simulation time interval.
- Selection the temporal step *dt*:
  - Moving from *dt* always set equal to the simulation time interval…
  - To automatically calculating *dt* as less than or equal the simulation time interval such that the travel distance per *dt* is less than the reach length.
- Implementation is fully complete.
- GAWSER team and others will be Beta testing for the Version 4.3 release.

Muskingum Cunge Routing



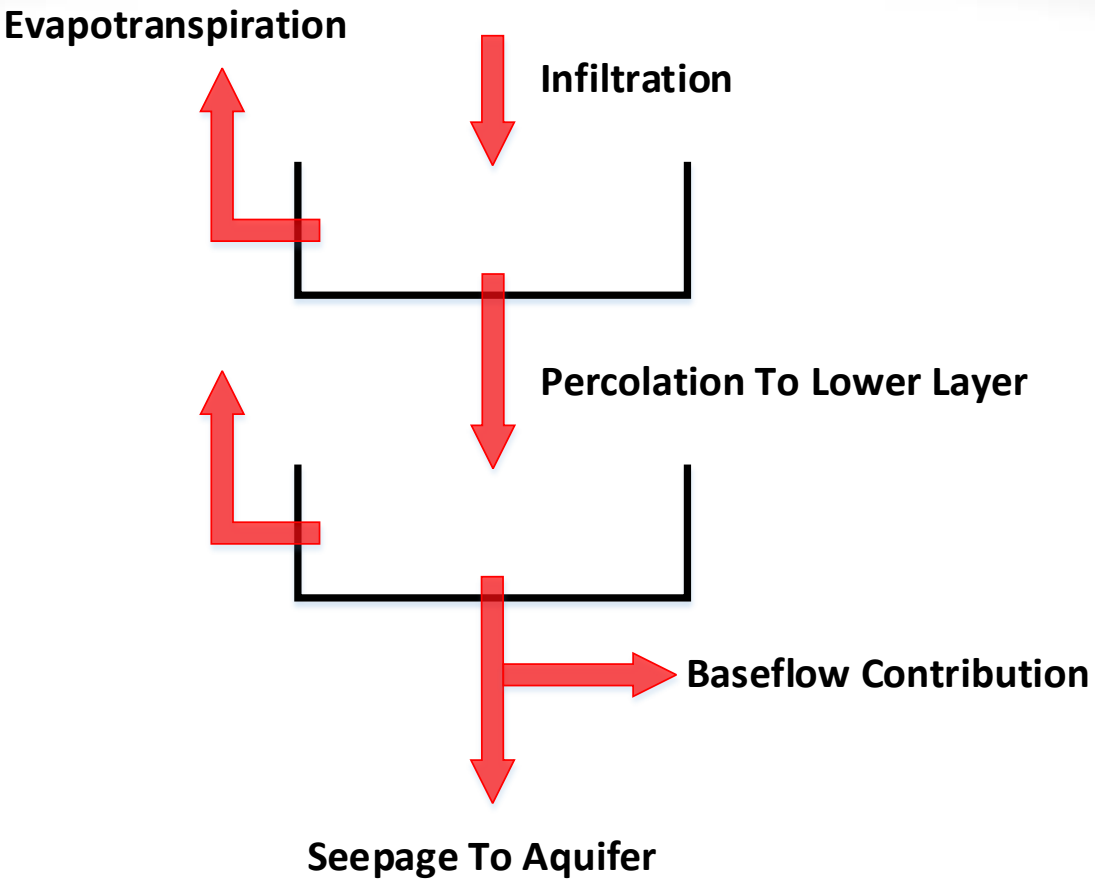
Muskingum Cunge Routing



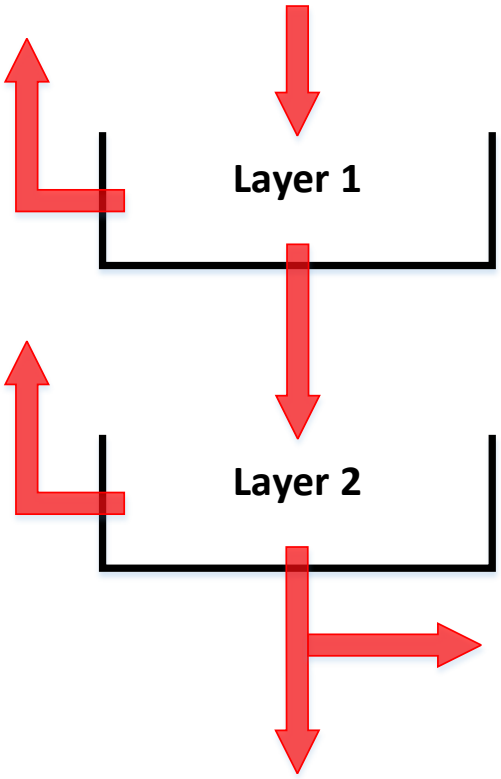
Green Ampt Infiltration

- HEC-HMS implements Green Ampt infiltration with an old algorithm designed for individual storm events.
- GAWSER implements a different approach to Green Ampt infiltration that includes two layers and soil moisture drying.
- GAWSER team will contribute expert advice:
  - Documentation of the GAWSER algorithm.
  - Applications experience, especially parameter estimation.
- HEC-HMS team will implement a new infiltration method based on the work of the GAWSER team:
  - Old "Green Ampt" method for event simulation.
  - New "Layered Green Ampt" method for multi-event and continuous.
- GAWSER team and others will be Beta testing for the Version 4.4 release.

Green Ampt Infiltration



Green Ampt Infiltration



Subbasin | Loss | Transform | Options

Basin Name: metric layerGA
Element Name: Subbasin-1

*Layer 1 Initial Content	0.1
*Layer 1 Field Capacity	0.4
*Layer 1 Saturated Content	0.48
*Layer 1 Thickness (MM)	100
*Layer 2 Initial Content	0.2
*Layer 2 Field Capacity	0.4
*Layer 2 Saturated Content	0.48
*Layer 2 Thickness (MM)	250
*Suction (MM)	142
*Conductivity (MM/HR)	26
*Max Percolation (MM/HR)	12
*Max Seepage (MM/HR)	4
*Impervious (%)	0.0
*Dry Duration (HR)	12.000

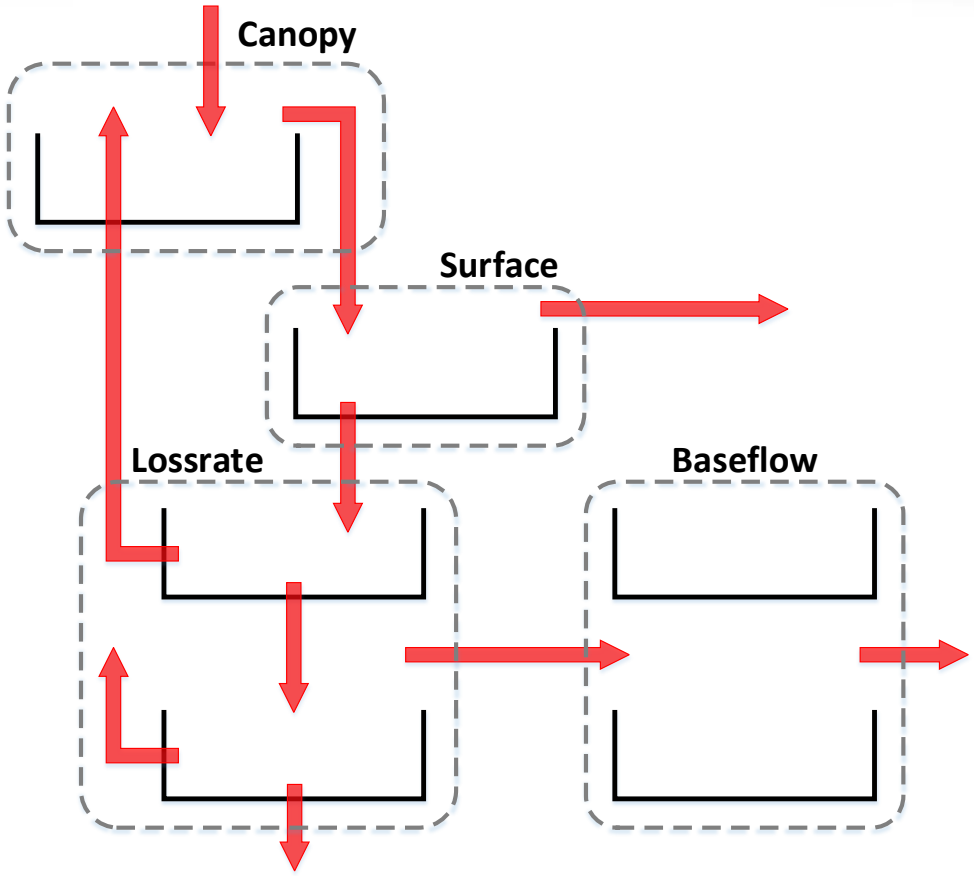
Green Ampt Infiltration

- Infiltration to the upper layer is calculated according to the Green Ampt equation, using hydraulic conductivity (mm/hr) and wetting front suction (mm):

$$f_t = K_{sat}\left[1 + \frac{(\varphi - \theta_{init})}{F_t}\right]$$

- The upper and lower layers are described physically:
  - Total bulk thickness (mm)
  - Field capacity (cm^3/cm^3)
  - Saturated water content (cm^3/cm^3)
- Percolation and seepage happen when water content exceeds the field capacity. Evapotranspiration happens at all water contents.
- The Green Ampt infiltration resets when the ground surface has been dry for a specified duration, usually 12 hours.

Green Ampt Infiltration



Green Ampt Infiltration

- Implementation is partially complete.
- Interface Development – Finish the parameter editor table.
- Finish integrating the layers with the potential evapotranspiration demand from the canopy component.
- Finish integrating the parameters with the simulation framework:
  - Optimization trials – automatic parameter estimation.
  - Forecast alternatives – zone adjustments for real-time operations.
  - Uncertainty analyses – sampling during a Monte Carlo simulation.
- Validation Testing – Demonstrate that the equations have been implemented correctly. Show that results are comparable to GAWSER.
- Application Testing – Pilot testing for applications in flood forecasting, floodplain regulation, and water balance studies.

Linear Reservoir Baseflow

- HEC-HMS includes the linear reservoir baseflow method designed for water balance studies. It allows one or two layers.
- GAWSER also includes a linear reservoir baseflow method, but it includes three layers specifically designed to connect to the Green Ampt infiltration method.

- The existing linear reservoir baseflow method will get a new third layer. The user will have more control over the number of layers to use.
- Connections will be added for working with loss rate methods that use either one or two layers.
- A special connection will be added for working with soil moisture accounting and layered Green Ampt loss rate methods:
  - Better control of the partition between baseflow and aquifer recharge.

Snowmelt

- HEC-HMS includes a temperature index snowmelt method designed mountainous watersheds that accumulate deep snowpacks.
- GAWSER includes a temperature index snowmelt method designed for shallow, transient snowpacks typical of Ontario and surrounding Provinces.

- A new snowmelt method will be implemented in HEC-HMS, following closely the method from GAWSER.
- The new implementation will support an elevation band approach.
- The new implementation will also support a gridded approach.

HEC-HMS on the Internet

www.hec.usace.army.mil/software/hec-hms