



# MATS-TC: Automating Time of Concentration Through Multidisciplinary Collaboration

2018 ASFPM Annual Conference

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June 20, 2018



**CDM  
Smith.**

**WATER** + ENVIRONMENT + TRANSPORTATION + ENERGY + FACILITIES

# MATS-TC: Automating Time of Concentration Through Multidisciplinary Collaboration



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  - FEMA H&H Studies



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  - GIS Specialist
  - Process Development & Scripting

# Overview

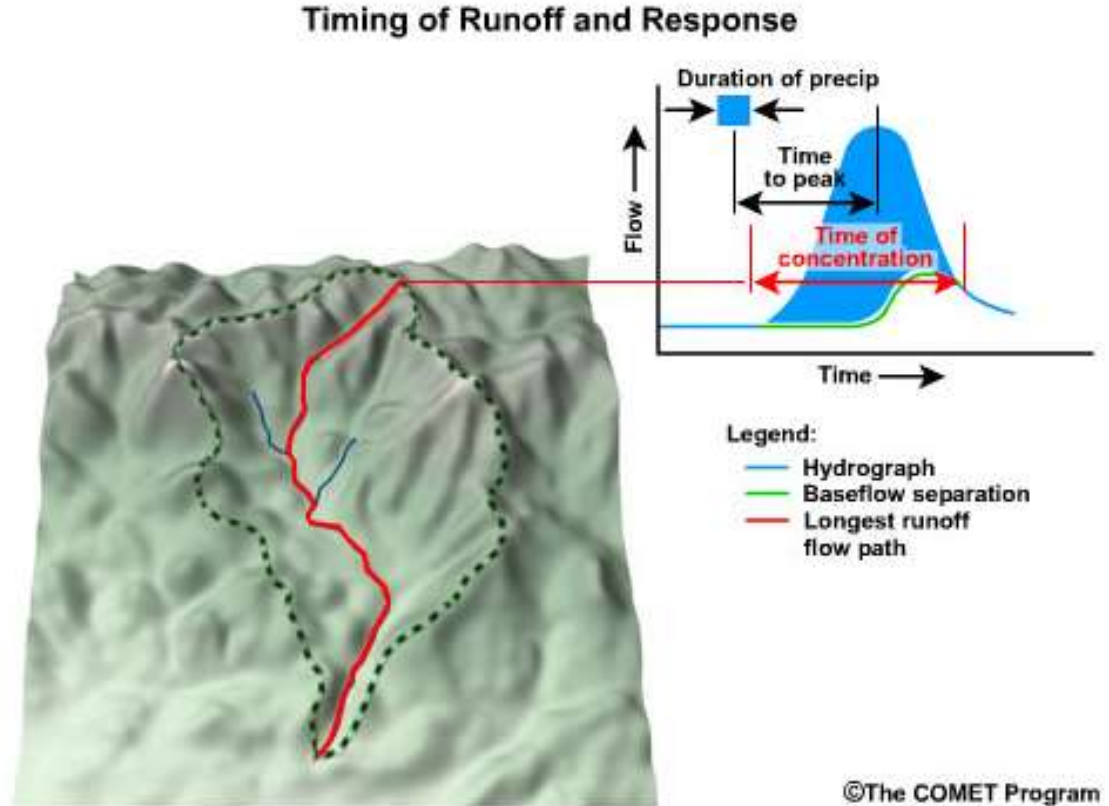
- Time of Concentration
- Previous process
- Full Automation
- Outcome
- Moving Toward the Future

# Time of Concentration



# Time of Concentration

- Time of concentration ( $T_c$ ) is the time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet.



©The COMET Program

# Velocity Method

- Adds the travel time of various flow types, the sum is the watershed's TC
- Three main flow types
  - Sheet
  - Shallow Concentrated
  - Channel
- Each flow has its own formula for travel time

# Travel Time Formulas

- Sheet

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5} S^{0.4}} \quad (\text{eq. 15-8})$$

where:

$T_t$  = travel time, h

$n$  = Manning's roughness coefficient (table 15-1)

$\ell$  = sheet flow length, ft

$P_2$  = 2-year, 24-hour rainfall, in

$S$  = slope of land surface, ft/ft

- Shallow Concentration

- Channel

$$V = \frac{1.49r^{\frac{2}{3}}s^{\frac{1}{2}}}{n} \quad (\text{eq. 15-10})$$

where:

$V$  = average velocity, ft/s

$r$  = hydraulic radius, ft

$$= \frac{a}{P_w}$$

$a$  = cross-sectional flow area, ft<sup>2</sup>

$P_w$  = wetted perimeter, ft

$s$  = slope of the hydraulic grade line (channel slope), ft/ft

$n$  = Manning's  $n$  value for open channel flow

Travel time ( $T_t$ ) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \quad [\text{eq. 3-1}]$$

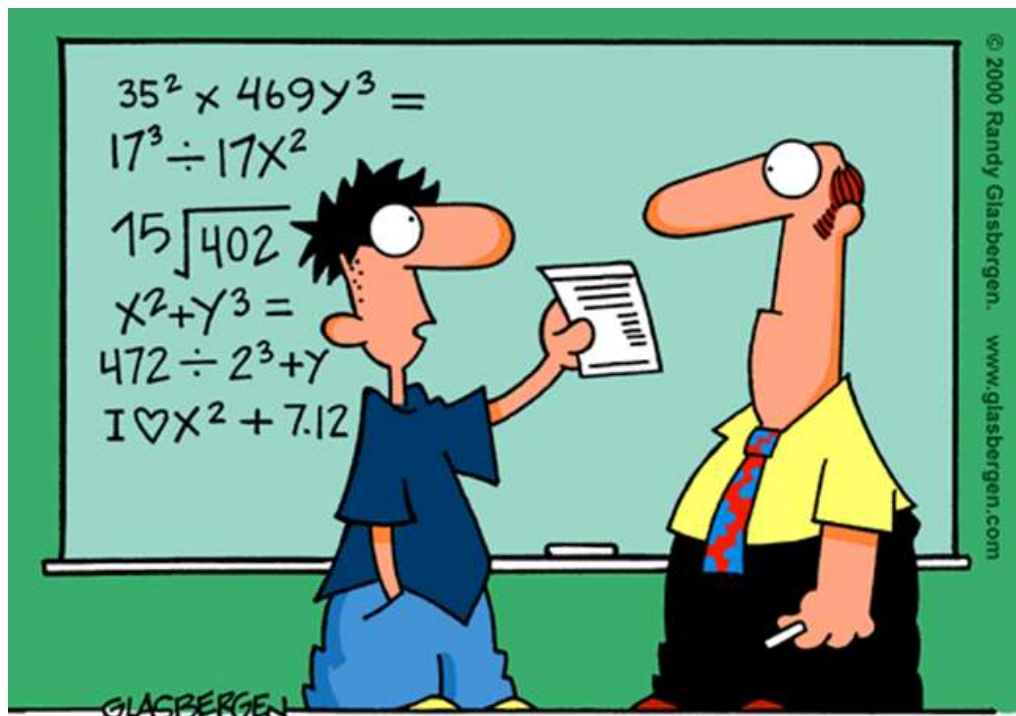
where:

$T_t$  = travel time (hr)

$L$  = flow length (ft)

$V$  = average velocity (ft/s)

3600 = conversion factor from seconds to hours.



"I HAD MY DOCTOR DO A D.N.A. BLOOD ANALYSIS.  
AS I SUSPECTED, I'M MISSING THE MATH GENE."



# Previous Process



# Types of Inputs

- Engineering Judgement
  - Depth/width/etc.
  - Channel Segmentation
  - Surface Description
  - Manning's N
- Manual Editing
  - Rainfall (2yr, 24hr)
  - Channel Segmentation
- Arc Calculations
  - Slope
  - Length
- To still be automated
  - Landcover/Surface Description
  - Manning's N

# Example

The screenshot shows a spreadsheet with columns A through F. It is organized into sections for different flow types:

- SHEET FLOW:** Includes parameters like Surface Description, Flow Length (L), Manning's 'n', High point elevation, Low point elevation, Watercourse slope (S), Average Velocity (V), and Travel Time (T). A formula for Travel Time is shown:  $T_t = 0.002 \sqrt{L} / S$ .
- SHALLOW CONCENTRATED FLOW - Path 1:** Includes parameters like Surface Description, Flow Length (L), High point elevation, Low point elevation, Watercourse slope (S), Average Velocity (V), and Travel Time (T).
- SHALLOW CONCENTRATED FLOW - Path 2:** Includes parameters like Surface Description, Flow Length (L), High point elevation, Low point elevation, Watercourse slope (S), Average Velocity (V), and Travel Time (T).
- CHANNEL FLOW - Path 1:** Includes parameters like Channel length (L), High point elevation, Low point elevation, Manning's 'n', Channel bottom width, Channel top width, Channel depth, Cross-sectional flow area (A), Water perimeter (P), Hydraulic radius (R), Channel slope (S), Average Velocity (V), and Travel Time (T).

At the bottom, it references 'Source: Urban Hydrology for Small Watersheds (TR-55), Hydrology National Engineering Handbook (Part 63), Chapter 10'.

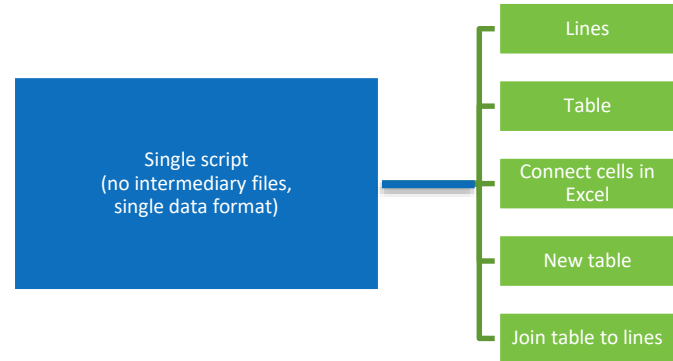
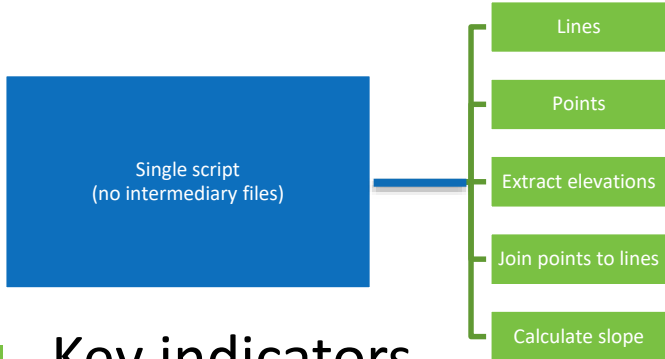
- Base spreadsheet
- One per subbasin
- Heavy on manual manipulations
  - ↓ Summing the total
  - ↓ Hard to adjust/edit
  - ↓ Tedious
  - ↓ Poor Readability
  - ↓ Difficult to QC
  - ↓ Cumbersome to share

# Manual Process

- Inputs created manually
  - Stream widths & depths
  - Stream segment splitting
  - Stream segment attribution
- Data Calculations
  - Data exported, processed, imported back
  - Formula components added manually
  - Large file size

# The Beginning

- Simple question
  - Split line segments 0 – 100 feet | 100 feet – end
- Questions of increasing complexity
  - Add slope to each segment
  - Time of concentration calculations



- Key indicators

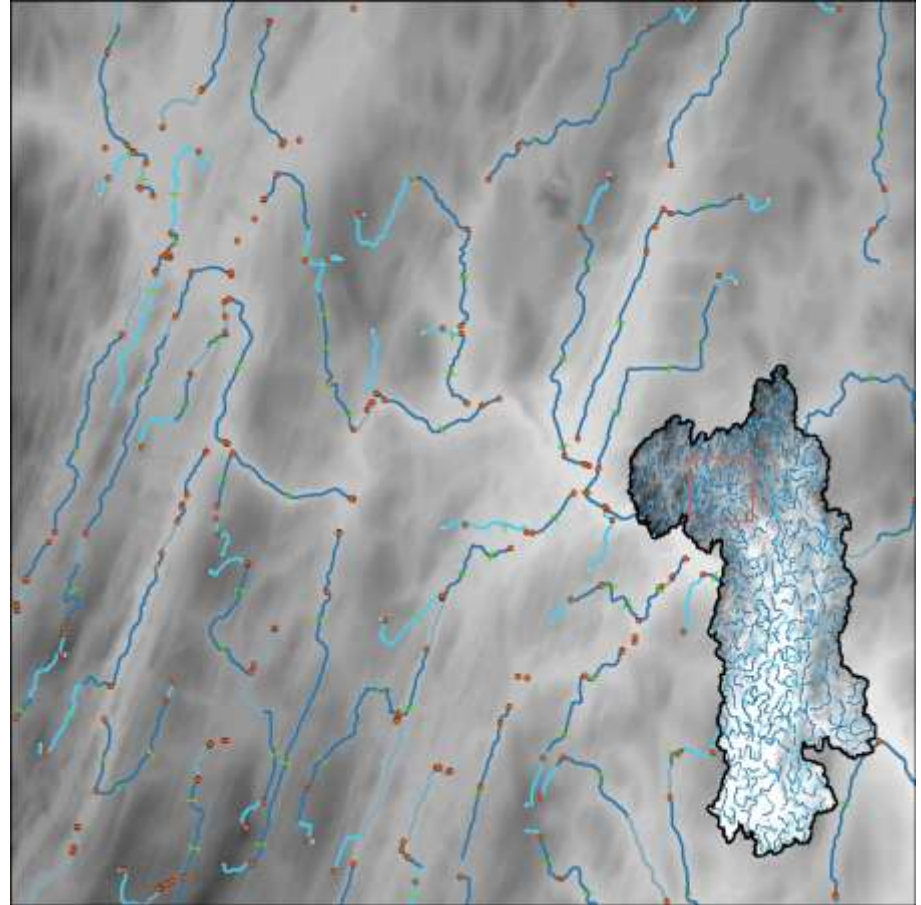
- Repetitive; Multiple steps/outputs; Multiple data formats

# Full Automation



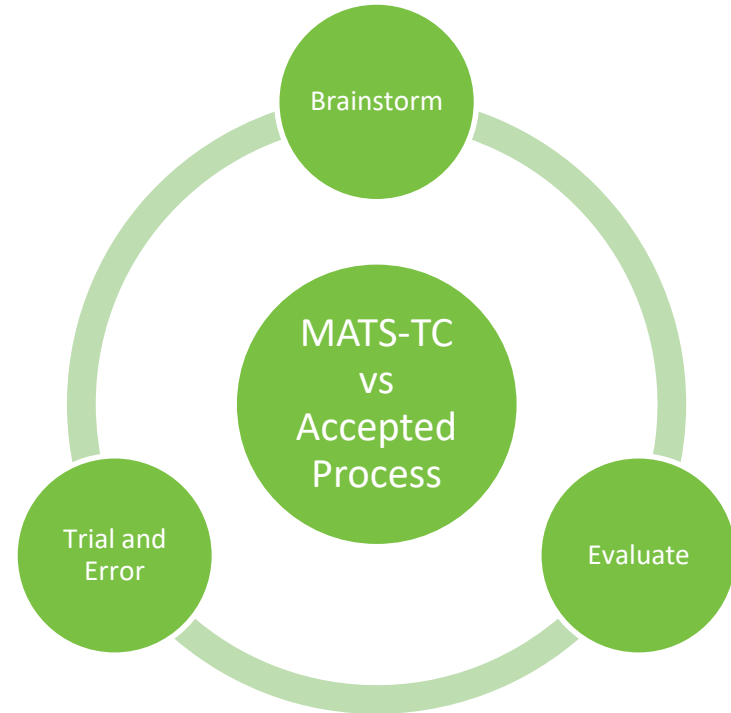
# Jumping Off Point

- Automating engineering decisions
  - Feasibility
  - Time
  - Level of effort
  - Accuracy
  - Quality



# MATS Process

- Multi-disciplinary Automated Technical Solution
  - Collaborative approach
  - Finding commonalities
  - What's needed/what's possible/what's available
  - Identify critical elements

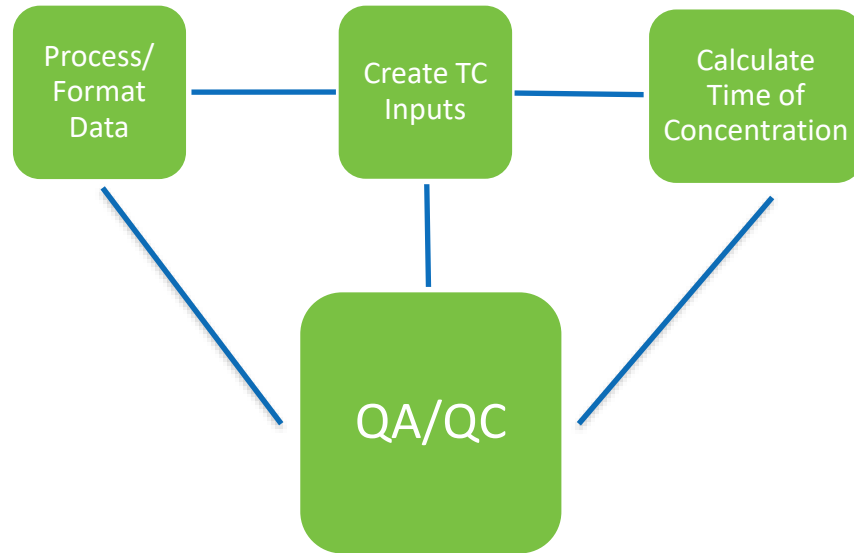




# Outcome



# MATS-TC



# Results and Benefits

## ■ TC

- ↑ Accuracy
- ↑ Speed
- ↑ Repeatability
- ↑ Data Integrity
- ↓ Project Time
- ↓ Manual Processing
- ↓ Subjective Decision Making
- ↓ Human Error

## ■ MATS

- ↑ Collaboration
- ↑ Communication
- ↑ Innovation
- ↑ Interdisciplinary Understanding



# Moving Toward the Future

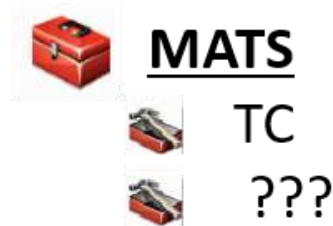
# Next Steps

- TC

- Refine as more areas are studied
- Improve error handling and documentation
- Test and update for a variety of different areas and situations

- MATS

- Make collaboration contagious
- Increase interdisciplinary understanding
- Apply method to other workflows



# Thank you!

- Questions? Please email us:
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