Storage Coefficient (Cs) – Hydrological Procedure 16

MSMA · https://mes100.com/docs/storage-coefficient-cs-hydrological-procedure-16/

Introduction

Urban flood estimation is a critical aspect of stormwater management, particularly in rapidly developing regions. In recognition of this, *Hydrological Procedure No. 16 (HP 16) – Flood Estimation for Urban Areas in Peninsular Malaysia* introduces a modified approach to the widely used Rational Method. This modified approach includes an important parameter known as the storage coefficient, Cs, which accounts for the storage effects of urban channels and detention systems.

Function of Storage Coefficient, Cs

In stormwater management systems, **Storage Coefficient (Cs)** is used to model the relationship between **inflow, outflow,** and **storage** within a drainage system or detention facility. It represents the system's ability to **temporarily store runoff and release it more gradually**, thereby reducing the peak discharge.

This storage effect becomes especially significant in urban areas, where large portions of the catchment are impervious and runoff occurs rapidly. When incorporating Cs in the hydrological calculation, the estimation process accounts for the attenuation of peak flows due to storage within natural or man-made channels, drains, and detention systems in both pre-development and post-development phase.

This more realistic modeling approach reduces the peak discharge, which in turn leads to more optimized and cost-effective flood mitigation designs.

Modified Rational Method

The Standard Rational Method is usually expressed in terms of the following equation:

$$Q=C.I.A360Q=\frac{C.I.A}{360}$$

(1)

Where;

Q = Peak discharge (m^3/s)

C = Runoff coefficient

I = Rainfall intensity (mm/hr)

A = Catchment area (ha)

To incorporate channel storage in the hydraulic calculation, Storage Coefficient (Cs) parameter has been added in the Standard Rational Method in Equation (1) to obtain Modified Rational Method as follows:

$$Q=Cs.C.I.A360Q=\frac{C_{s}.C.I.A}{360}$$

(2)

Where:

$$Cs=2tc2tc+tdC_{s}=\frac{2t_{c}}{2t_{c}+t_{d}}$$

(3)

C_{s} = Storage coefficient

t_{c} = Time of concentration (minutes)

t_{d} = Drain flow time (minutes)

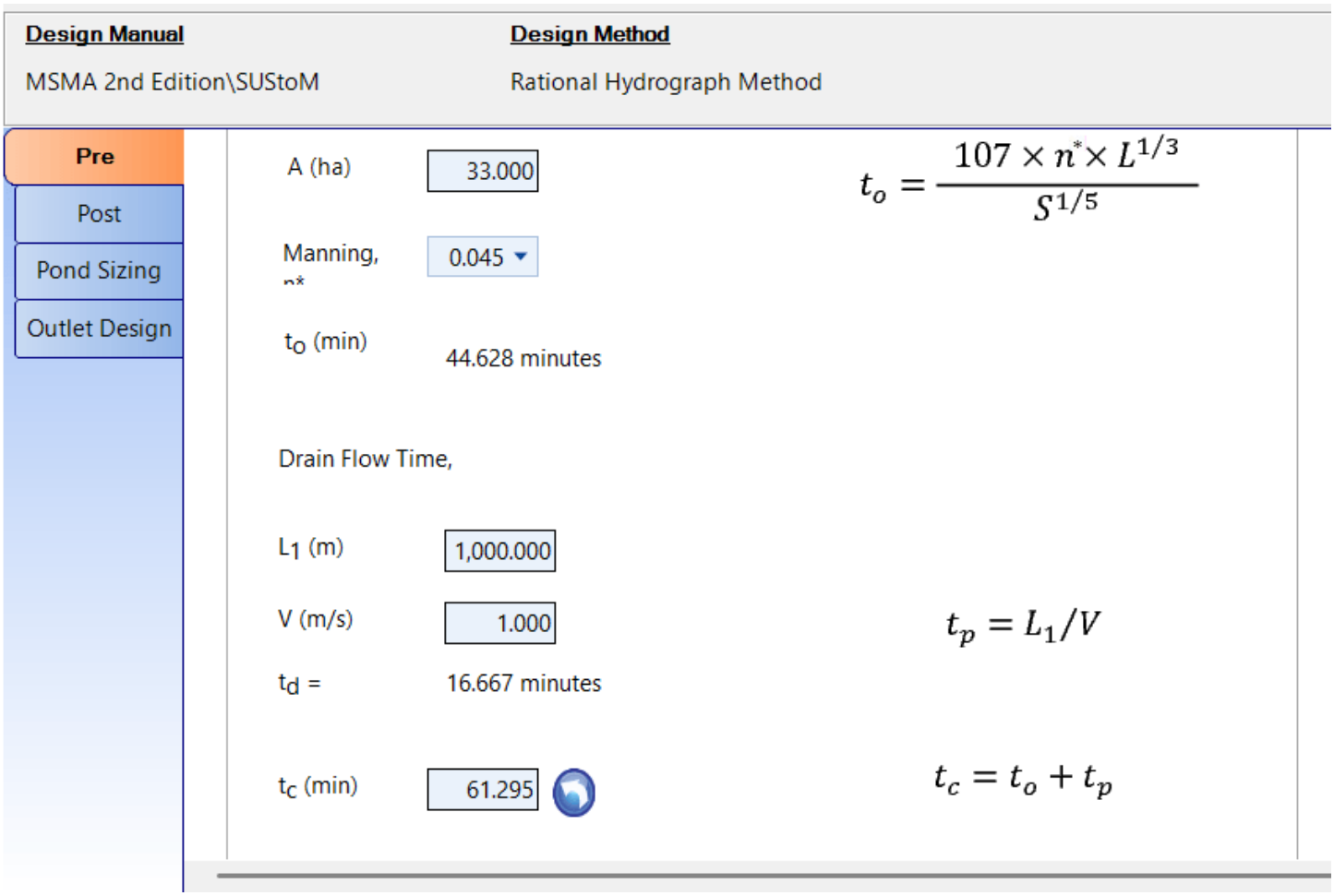
How to Incorporate Storage Coefficient (C_{s}) in MiTS?

Currently MiTS does not pre compute the Storage Coefficient using the formula given in HP16. As a makeshift solution, you can manually calculate the storage coefficient using Equation (3) and key in the value inside the Peak Flow Modification Factor box (under Pre Tab and Post Tab). tc and td will be calculated automatically in MiTS.

Project file here

Pre-Development Phase

Calculate the time of concentration, then use Equation (3) to obtain the pre-development storage coefficient:



tc,pre=to+td=44.628+16.667=61.295 min\begin{aligned} t_{c,pre}&=t_{o}+t_{d} \\ &= 44.628+16.667 \\ &= 61.295\;\mathrm{min} \end{aligned}

(4)

$$C_{s,pre}=\frac{2t_c}{2t_c+t_d}=\frac{2(61.295)}{2(61.295)+16.667}=0.88$$

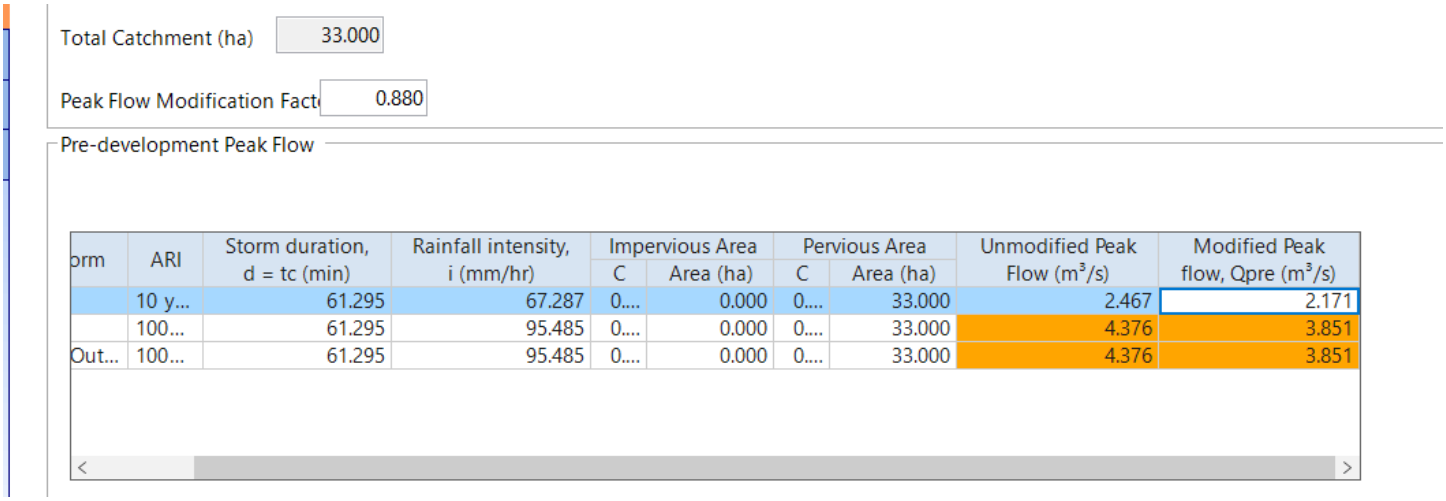
(5)

For Minor Design Storm ARI 10 years;

Peak Flow (Using Modified Rational Method, Equation (2))

$$Q_{pre,mod}=C_s.C.I.\frac{A}{360}=(0.88)(0.40)(67.287)\frac{(33)}{360}=2.171\ m^3/s$$

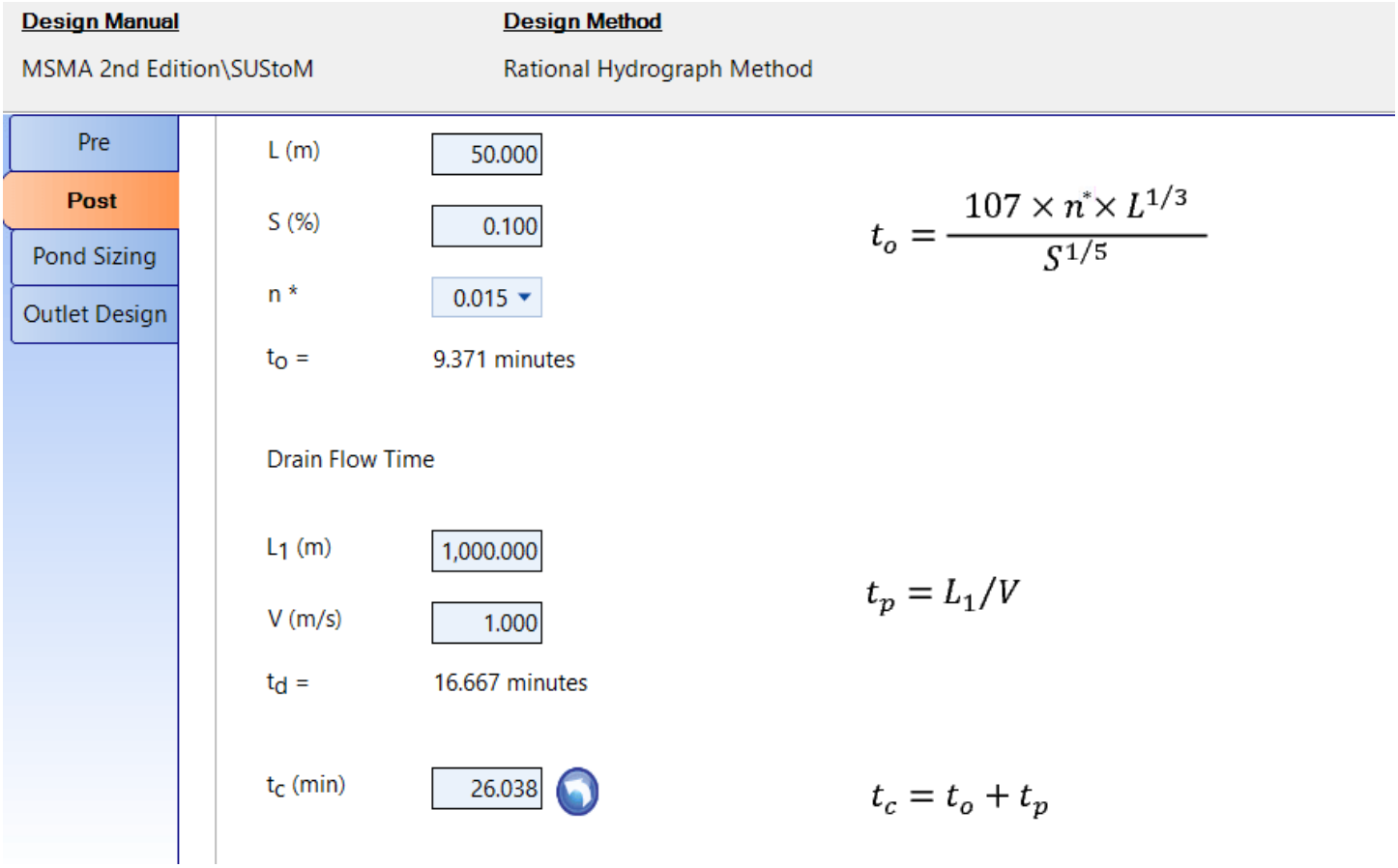
(6)



orm	ARI	Storm duration, d = tc (min)	Rainfall intensity, i (mm/hr)	Impervious Area C	Impervious Area Area (ha)	Pervious Area C	Pervious Area Area (ha)	Unmodified Peak Flow (m^3/s)	Modified Peak flow, Qpre (m^3/s)
	10 y...	61.295	67.287	0....	0.000	0....	33.000	2.467	2.171
	100...	61.295	95.485	0....	0.000	0....	33.000	4.376	3.851
Out...	100...	61.295	95.485	0....	0.000	0....	33.000	4.376	3.851

Post-Development Phase

Repeat the calculation with the post-development time of concentration, using Equation (3):



tc,post=to+td=9.371+16.667=26.04 min\begin{aligned} t_{c,post}&=t_{o}+t_{d} \\ &= 9.371+16.667 \\ &= 26.04\;\mathrm{min} \end{aligned}

(7)

Cs,post=2tc2tc+td=2(26.04)2(26.04)+16.667=0.76\begin{aligned} C_{s,post}&=\frac{2t_{c}}{2t_{c}+t_{d}} \\ &=\frac{2(26.04)}{2(26.04)+16.667} \\ &= 0.76 \end{aligned}

(8)

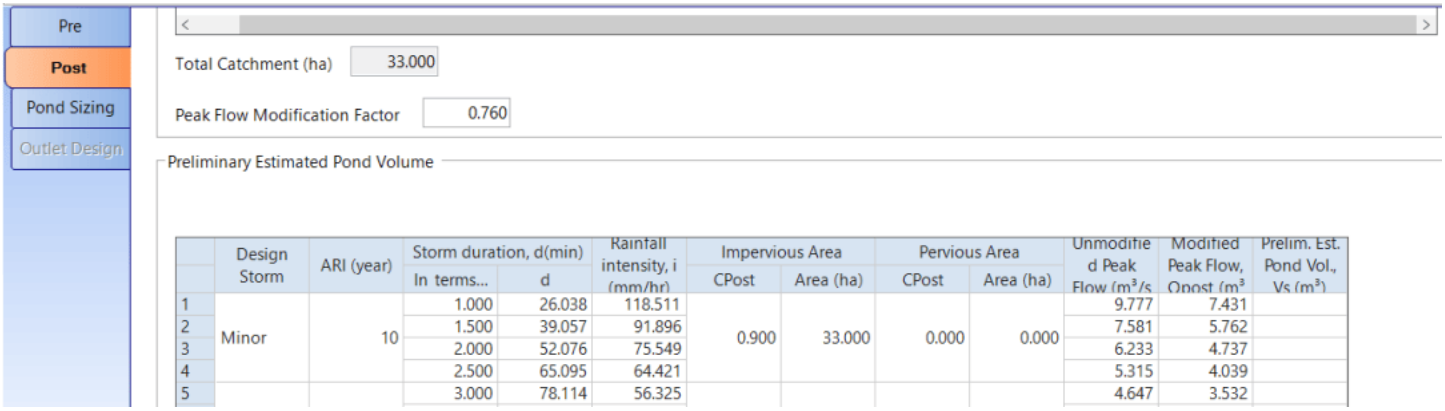
For Minor Design Storm ARI 10 years;

Peak Flow (Using Modified Rational Method, Equation (2))

Qpost,mod=Cs.C.I.A360=(0.76)(0.90)(118.51)(33)360=7.43 m3/s\begin{aligned} Q_{post,mod}&=\frac{C_{s}.C.I.A}{360} \\ &=\frac{(0.76)\ (0.90)(118.51)(33)}{360} \\

&=7.43\;\mathrm{m}^{3}/\mathrm{s} \end{aligned}

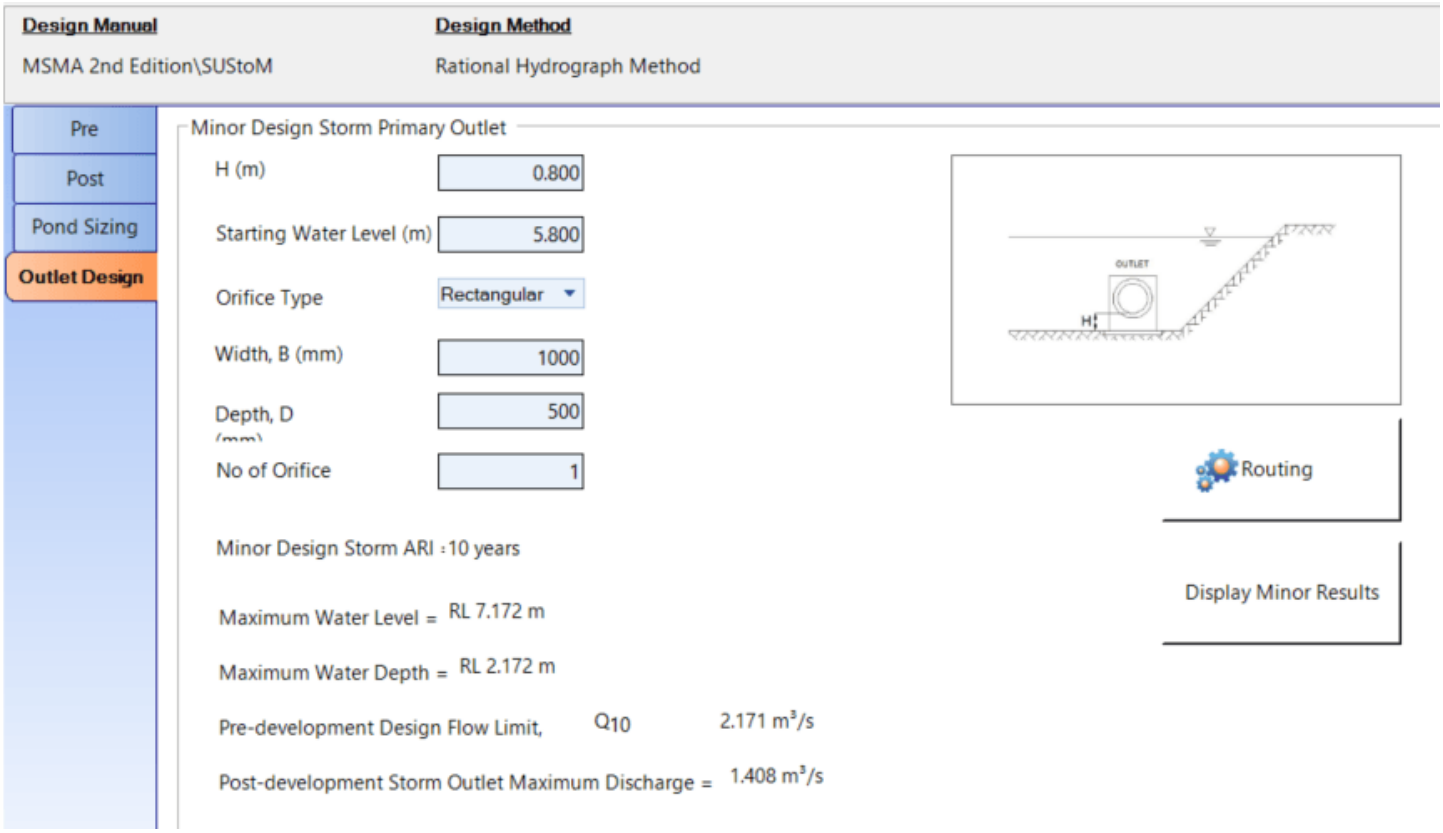
(9)



	Design Storm	ARI (year)	Storm duration, d(min) In terms...	d	Rainfall intensity, i (mm/hr)	Impervious Area CPost	Impervious Area Area (ha)	Pervious Area CPost	Pervious Area Area (ha)	Unmodified Peak Flow (m^3/s	Modified Peak Flow, Qpost (m^3	Prelim. Est. Pond Vol., Vs (m^3)
1	Minor	10	1.000	26.038	118.511	0.900	33.000	0.000	0.000	9.777	7.431	
2			1.500	39.057	91.896					7.581	5.762	
3			2.000	52.076	75.549					6.233	4.737	
4			2.500	65.095	64.421					5.315	4.039	
5			3.000	78.114	56.325					4.647	3.532	

Outlet Design

Outlet design for Minor, Major and Secondary Design Storm will use the Modified Pre-Development Peak Flow (Qpre) of respective ARI as the allowable limit for Post-Development Peak Flow (Qpost) of the same ARI.



Qpost<Qpre,modQ_{post}<Q_{pre,mod}

(10)

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Ngu Soon Hui

I’m the Benevolent Dictator for Life for MiTS Software cum Editor of this website. Read more here.

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