

Effectiveness of Time of Concentration Elongation on Peak Flow Reduction

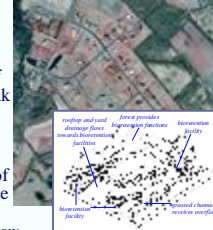
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Introduction

One of the general benefits of LID often advocated in LID literature is that some LID practices could elongate the flow path of the runoff and thereby decrease the runoff peak flow rate (Q_p).



- In practice, a longer flow path does not necessarily mean longer Time of Concentration (T_c). An LID practice could elongate the T_c only if:
1. It alters the travel time of the critical flow path or generates a new critical path draining a large portion of the area.
 2. Its effect lasts through the duration of peak flow generation.

Ineffective T_c Elongation

if you block the stormwater inlet with a short barrier, this is not T_c elongation. If the barrier overtops before arrival of peak flow to that point, it will be ineffective during arrival of peak flow. If it controls your design peak flow, you are defeating the purpose of stormwater control (by letting the peak flow to pond and spread on the ground).



Note: This study relates to the cases where T_c elongation is achieved effectively in field.

Study Objective

The objective of this study was to theoretically evaluate the relative impact of T_c elongation on peak flow reduction under typical conditions of LID use.

Note: This issue has been neither experimentally nor theoretically adequately addressed before.

Computational Method

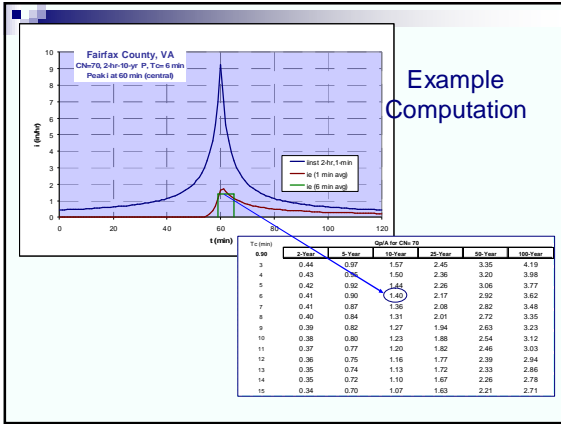
- A special runoff computation routine was developed to carry out the required calculations. This routine is simple enough to allow convenient repetitive calculations while sophisticated enough to simulate non-linear runoff generation and identify the critical excess rainfall intensity.

Note: In this study the relative changes in peak flows are important and not their absolute values. The method employed here produces the same relative changes of peak flows as would be obtained by using WinTR-55 using a 24-hr Type II rainfall distribution (albeit the Q_p s are smaller).

Computational Steps in Spreadsheet

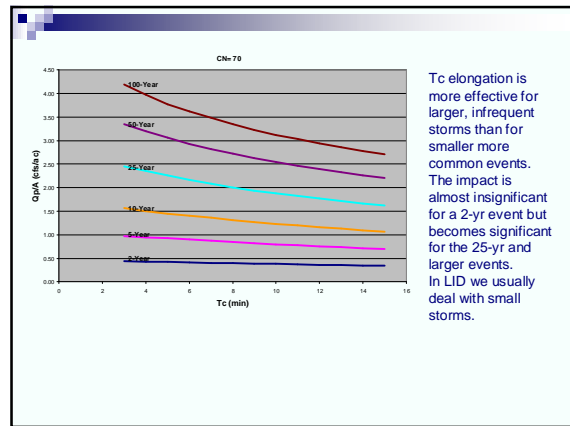
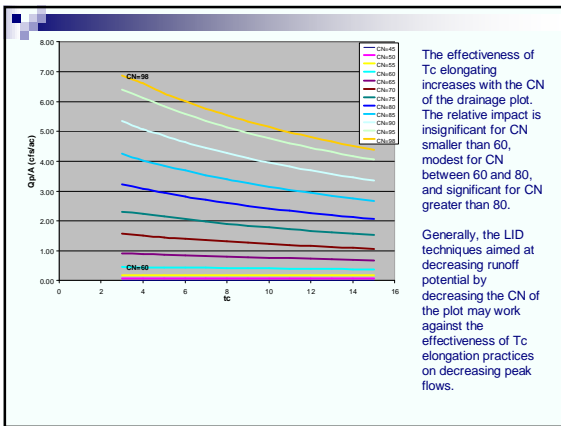


1. User selects any Virginia County (or City) and chooses the Rainfall Return Period, and inputs T_c and Curve Number (CN).
2. Spreadsheet distribute the n-yr 2-hr storm IDF in time using Chicago Distribution while preserving the local IDF relationship with a user-selectable location parameter.
3. Spreadsheet determines I_{max} (max. average excess rainfall intensity for the duration of T_c). This gives peak runoff per unit area or Q_p/A .
4. Spreadsheet repeat calculations for different combinations of T_c and CN and Return Period.
5. Results could be analyzed for relative impact of changing T_c on Q_p/A .



Example Computation

Analysis of Results



So, Tc elongation varies with CN and the frequency of the storm event.

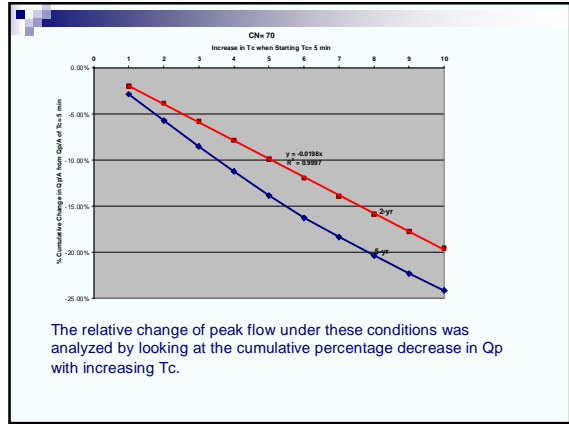
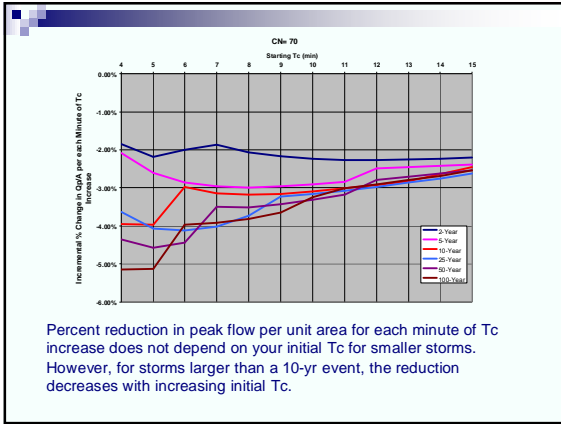
Consider the conditions of a typical LID application: An urban open space covered with grass with a **CN of 70**.

Also, a typical Tc elongation technique would not work under large storms due to its inadequate capacity. Therefore, the analysis of the typical case should focus on the **2-yr storm**.

The results for the typical application for Fairfax County, VA showed that the peak discharge per unit area linearly but mildly decreases with increasing Tc. The relationship becomes non-linear for storms larger than a 10-yr event. The best-fit linear equation describing this relationship for the 2-yr event is:

$$(Q_p / A) = 0.464 - 0.0084 T_c$$

where Qp/A is the peak flow rate per unit area in cfs/ac (for Fairfax County, VA based on the 2-yr, 2-hr rainfall and CN= 70) and Tc is the time of concentration in minutes. The very small slope of this line indicates the potential of decreasing peak flow rate by increasing Tc is insignificant.



This relationship was found to be linear for the 2-yr event. Assuming an initial Tc of 5 minutes, the best-fit linear equation would be:

$$\% \Delta(Q_p / A) = -0.02(T_{cf} - 5)$$

The slope of -0.02 shows that for each minute that the Tc is extended from 5 minutes, Qp decreases only by 2%.

Note: This percentage would only slightly increase if the Tc elongation design has larger capacity than the 2-yr storm. The corresponding percentages of decrease of Qp for the 5- and 10-yr storms are 2.3% and 2.5% respectively.

Note: Calculations repeated by WinTR-55 with 24-hr storm with Type II distribution produced the same conclusions.

Conclusions

- n The results of this study theoretically demonstrate that under typical conditions, increasing Tc by a few minutes is not an efficient way of reducing Qp, especially for small storms for which LID is designed.
- n Therefore, to achieve the objective of maintaining the peak flows of natural conditions, it may be more productive to focus on LID management techniques other than increasing Tc.

Questions ?

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