A. Introduction

The purpose of the overbank flood protection and extreme flood protection criteria is to protect downstream properties from flood increases due to upstream development. The standard practice has been to control peak flow at the outlet of a site such that post-development peak discharge equals predevelopment peak discharge (usually the Q_p for the 5-year storm) Stormwater detention is quite effective in preventing nuisance flooding immediately downstream of intense changes in land use. The effect of temporary storage of surface runoff on the shape of the hydrograph is pronounced and highly significant. The location and magnitude of storage in relation to the size of the watershed is important in determining the degree of peak-flow attenuation. In general, large facilities on the main- stem of the watershed and its major tributaries have a greater effect on the peak than many small facilities distributed widely through the watershed.

In some cases, this does not always provide effective water quantity control downstream from the site, and may actually increase the flooding problems downstream. The benefits of detention in the headwaters of a watershed are minimal in the downstream end of the watershed. Beneficial results in the downstream end can often be best achieved by providing detention storage in the middle portions of the watershed. The tributary detention storage in the downstream portion of the watershed can increase peak flows in the mainstem, due to the interaction between the mainstem peak flows and the delayed release of stormwater from the upstream basins.

The basic reasons for this have to do with the timing of the flow peaks and the total increase in volume of runoff. In addition, due to a site's location within a watershed, there may be very little reason for requiring overbank flood control from a particular site. This discussion outlines a suggested procedure for determining the impacts of post-development stormwater peak flows and volumes on downstream flows. The procedure is recommended as part of the drainage assessment and final stormwater management plan required by the jurisdiction during project development and review.

B. Reasons for downstream problems

1. **Flow timing.** If water quantity control (detention) structures are indiscriminately placed in a watershed and changes to the flow timing are not considered, the structural control may actually increase the peak discharge downstream. The reason for this may be seen in Figure C3-S14-1. The peak flow from the site is reduced appropriately, but the timing of the flow is such that the combined detained peak flow (the larger dashed triangle) is actually higher than if no detention were required. In this case, the shifting of flows to a later time brought about by the detention pond actually makes the downstream flooding worse than if the post-development flows were not detained.

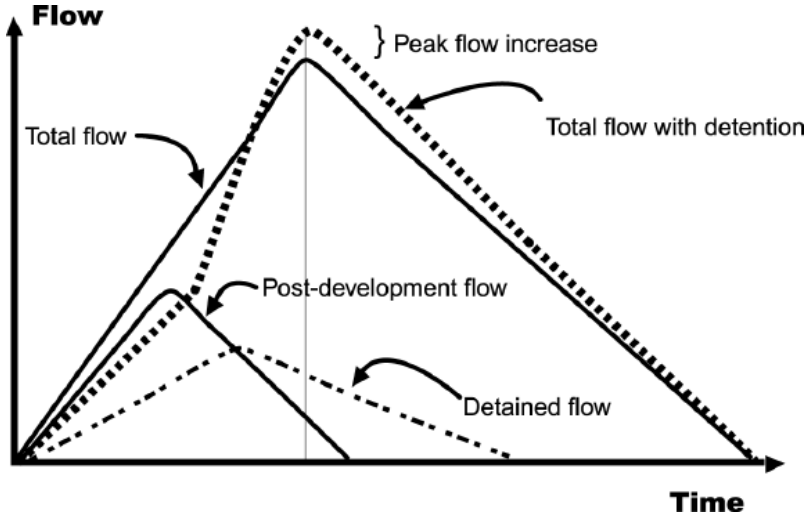

Figure C3-S14-1: Example of detention timing
Source: Georgia Stormwater Manual, 2000

2. **Increased volume.** The typical impact of new development is an increase in the total runoff volume of flow. Even if the if the peak flow is effectively attenuated, the longer duration of higher flows due to the increased volume may combine with downstream tributaries to increase the downstream peak flows. Figure C3-S14-2 illustrates this concept. The figure shows the pre- and post-development hydrographs from a development site (Tributary 1). The post-development runoff hydrograph meets the flood protection criteria (i.e., the post-development peak flow is equal to the predevelopment peak flow at the outlet from the site). However, the post-development combined flow at the first downstream tributary (Tributary 2) is higher than predevelopment combined flow. The increased volume and timing of runoff from the developed site increases the combined flow and flooding downstream. In this case, the detention volume would have to have been increased to account for the downstream timing of the combined hydrographs to mitigate the impact of the increased runoff volume.

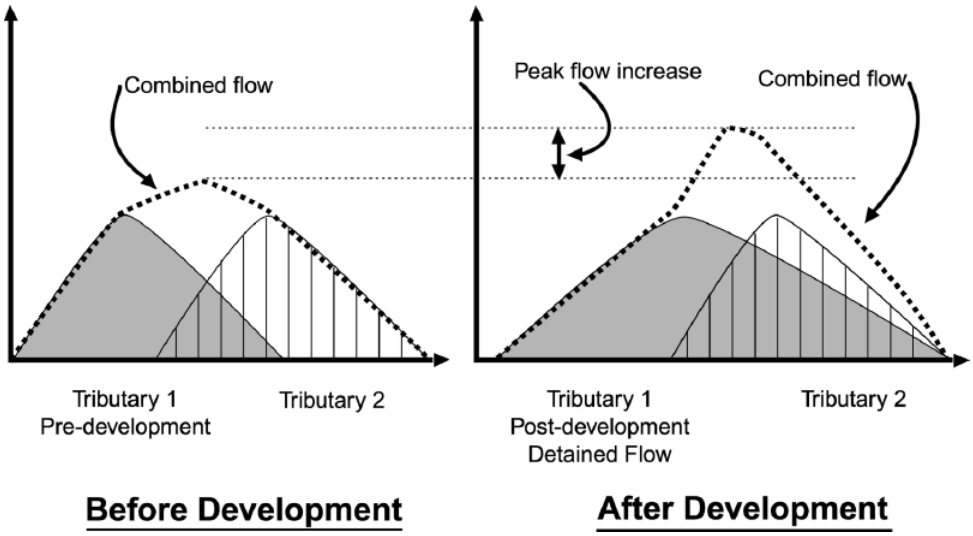

Figure C3-S14-2: Impact of increased post-development volume with detention on a downstream hydrograph
Source: Georgia Stormwater Manual, 2001

C. The ten-percent rule

The ten percent criterion is recommended as a flexible and effective approach for ensuring that stormwater quantity detention ponds actually attempt to maintain predevelopment peak flows throughout the system downstream. The ten-percent rule recognizes the fact that a structural control providing detention has a zone of influence downstream where its effectiveness can be felt. Beyond this zone of influence, the structural control becomes relatively small and insignificant compared to the runoff from the total drainage area at that point. Based on studies and master planning results for a large number of sites, that zone of influence is considered to be the point where the drainage area controlled by the detention or storage facility comprises 10% of the total drainage area. For example, if the structural control drains 10 acres, the zone of influence ends at the point where the total drainage area is 100 acres or greater. Typical steps in the application of the ten-percent rule are:

1. Determine the target peak flow for the site for predevelopment conditions.
2. Using a topographic map determine the lower limit of the zone of influence (10% point).
3. Using a hydrologic model determine the predevelopment peak flows and timing of those peaks at each tributary junction, beginning at the pond outlet and ending at the next tributary junction beyond the 10% point.
4. Change the land use on the site to post-development and re-run the model.
5. Design the structural control facility such that the overbank flood protection (25-year) post-development flow does not increase the peak flows at the outlet and the determined tributary junctions.
6. If it does increase the peak flow, the structural control facility must be redesigned or one of the following options considered:
   a. Control of the overbank flood volume (Q_{p5}, Q_{p10}, etc.) may be waived by the local authority, saving the developer the cost of sizing a detention basin for overbank flood control. In this case, the ten-percent rule saved the construction of an unnecessary structural control facility that would have been detrimental to the watershed flooding problems. An alternative may be a development fee paid to the local jurisdiction in lieu of detention. The fee would go toward alleviating downstream flooding, contribute to the cost for larger

regional detention facilities, or making channel or other conveyance improvements.

b. Work with the local government to reduce the flow elevation through channel or flow conveyance structure improvements downstream.
c. Obtain a flow easement from downstream property owners to the 10% point.

Even if the overbank flood protection requirement is eliminated, the water quality treatment (WQv), channel protection (Cpv), and extreme flood protection (Qf) criteria will still need to be addressed.

D. Design example

From Georgia Stormwater Manual, 2001, Figure C3-S14-3 illustrates the concept of the ten-percent rule for two sites in a watershed.

Site A is a development of 10 acres, all draining to a wet ED stormwater pond. The overbank flooding and extreme flood portions of the design are going to incorporate the ten-percent rule. Looking downstream at each tributary in turn, it is determined that the analysis should end at the tributary marked “80 acres.” The 100-acre (10%) point is in between the 80-acre and 120-acre tributary junction points.

The assumption is that if there is no peak flow increase at the 80-acre point, then there will be no increase through the next stream reach downstream through the 10% point (100 acres) to the 120-acre point. The designer constructs a simple HEC-1 model of the 80-acre areas using single existing condition sub-watersheds for each tributary. Key detention structures existing in other tributaries must be modeled. An approximate curve number is used since the actual peak flow is not key for initial analysis; only the increase or decrease is important. The accuracy in curve number determination is not as significant as an accurate estimate of the time of concentration. Since flooding is an issue downstream, the pond is designed (through several iterations) until the peak flow does not increase at junction points downstream to the 80-acre point.

Site B is located downstream at the point where the total drainage area is 190 acres. The site itself is only 6 acres. The first tributary junction downstream from the 10% point is the junction of the site outlet with the stream. The total 190 acres is modeled as one basin, with care taken to estimate the time of concentration for input into the TR-20 model of the watershed. The model shows that a detention facility, in this case, will actually increase the peak flow in the stream.

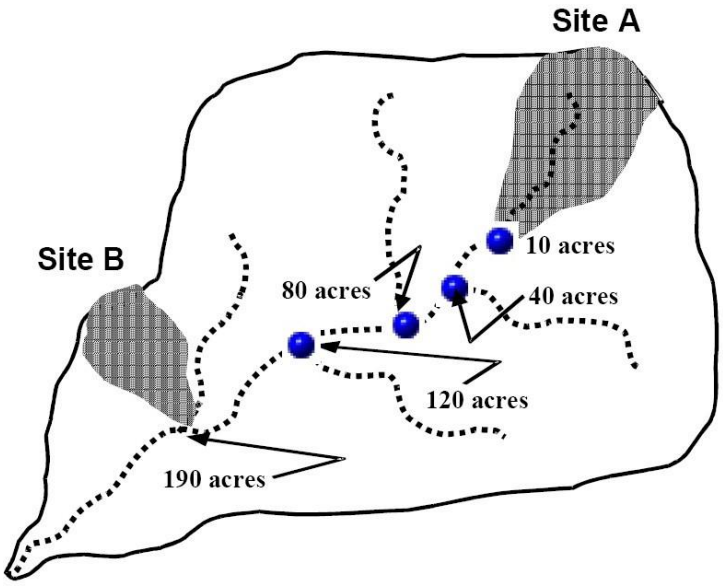

Figure C3-S14-3: Schematic for ten percent rule example