



2.4 Stormwater Quantity Management

This section addresses the design criteria and policies associated with Knox County's requirements for overbank protection and extreme flood protection. This section also presents justification, policies and requirements for the downstream impact analysis.

2.4.1 Overbank Flood Protection Criteria (Q_{p25})

Minimum Stormwater Management Standard #4 establishes overbank flood protection design criteria (Q_{p25}). The purpose of Q_{p25} is to prevent an increase in the frequency and magnitude of damaging out-of-bank flooding (i.e., flow events that exceed the capacity of the channel and enter the floodplain). It is intended to protect downstream properties from flooding during and after middle-frequency storm events.

The Q_{p25} criteria requires that the calculated peak discharge of stormwater runoff resulting from the 2-year, 10-year, and 25-year return frequency, 24-hour duration storm events be no greater after development or redevelopment of the site than that which would result from the same 2-year, 10-year, and 25-year return frequency, 24-hour duration storms on the same site prior to development or redevelopment. Hydrologic calculation methods for Q_{p25} are provided in Volume 2, Chapter 3.

Typically, peak discharge control is achieved through detention of runoff for the design events; however, Knox County does not mandate the use of detention facilities. It should be noted that the smaller design events (e.g., 2-year and 10-year) are often effectively controlled through the combination of the required channel protection (CPv) control (i.e., extended detention of the 1-year event) and the control of the 25-year frequency event.

2.4.2 Extreme Flood Protection (Q_{p100})

The intents of Minimum Standard #5, also called the extreme flood protection design criteria (Q_{p100}), are to:

- prevent flood damage from infrequent, but large, storm events;
- maintain the boundaries of the mapped 100-year floodplain; and,
- protect the physical integrity of the structural stormwater BMPs as well as downstream stormwater and flood control facilities.

The Q_{p100} criteria requires that the calculated peak discharge of stormwater runoff resulting from a 100-year frequency, 24-hour duration storm be no greater after development or redevelopment of the site than that which would result from a 100-year frequency, 24-hour duration storm on the same site prior to development or redevelopment. In addition, all drainage systems shall be designed to insure that no habitable finished floor elevations are flooded for the 100-year frequency storm. Pipes and culverts designed for a 100-year storm shall be constructed of reinforced concrete if such pipes or culverts lie in public lands or easements.

Design of stormwater systems that will include extreme flood protection controls must route the Q_{p100} through the drainage system and stormwater management facilities to determine the effects on the facilities, adjacent property, and downstream areas. Emergency spillways of structural BMPs must be designed appropriately to safely pass the Q_{p100} .

Further guidance on hydrologic analysis and design for the Q_{p100} criteria is provided in Volume 2, Chapter 3.



2.4.3 Downstream Impact Analysis

2.4.3.1 Background

The $Q_{p_{25}}$ and $Q_{p_{100}}$ flood protection criteria require the design to control peak discharges at the outlet of a site, such that the post-development peak discharge does not exceed the pre-development peak discharge. Typically, this peak discharge control is achieved through construction of one or more on-site detention facilities. However, stormwater master plans developed for a number of Knox County watersheds indicate that peak discharge control does not always provide effective water quantity control from the site, and may actually exacerbate flooding problems downstream of the site. Moreover, master plans have shown that a development site's location within a watershed may preclude the requirement for overbank flood control from a particular site.

A major reason for negative impacts due to detention involves the timing of the peak discharge from the site in relation to the peak discharges in the receiving stream and/or its tributaries. If detention structures are indiscriminately placed in a watershed without consideration of the relative timing of downstream peak discharges, the structural control may actually increase the peak discharge downstream. An example of this situation is presented in Figure 2-3, which shows a comparison of the total downstream flow on a receiving stream (after development) with and without detention controls. In Figure 2-3, the smaller dashed-dot and solid lines denote the runoff hydrograph for a development site with and without detention, respectively. These runoff hydrographs will combine with a larger runoff hydrograph of the receiving stream (not shown). The combined discharges from the site and receiving stream are shown in the larger solid and dashed lines.

Figure 2-3 conveys a possible consequence of detention. The post-development flow from the site is reduced as required by flood protection design criteria to result in the detained flow (the smaller dashed-dot hydrograph). However, the timing of the peak discharge for the detained post-development flow, while reduced in magnitude, corresponds more closely with the timing of the peak discharge of the receiving stream (not shown) than the peak discharge of the post-development flow that was not detained. Therefore, the combination of the detained flow with the flow in the receiving stream is actually higher than would occur if no detention were required, as shown in the larger dashed hydrograph. Hence, there is a peak flow increase that is caused by detention.

Poor peak discharge timing can have an even greater impact when one considers all the developments located in a watershed and the cumulative effects of increases in runoff volume and the duration of high volume runoff in the channel, as well as peak discharge timing. Even if peak discharges are handled effectively at the site level and immediately downstream, the longer duration of higher flows due to the increased volume from many developments located on or near a stream may combine with downstream tributaries and receiving streams to dramatically increase the downstream peak flows.

Figure 2-4 illustrates this concept. The figure shows the pre- and post-development hydrographs at the confluence of two tributaries. Development occurs, meets the local flood protection criteria (i.e., the post-development peak flow is equal to the pre-development peak flow at the outlet from the site), and discharges to Tributary 1. When the post-development detained flow from Tributary 1 combines with the first downstream tributary (Tributary 2), it causes a peak flow increase when compared to the pre-development combined flow. This is due to the increased volume and timing of runoff from Tributary 1, relative to the peak flow and timing in Tributary 2. In this case, the detention volumes on Tributary 1 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 2-3. Potential Effect of On-Site Detention on Receiving Streams

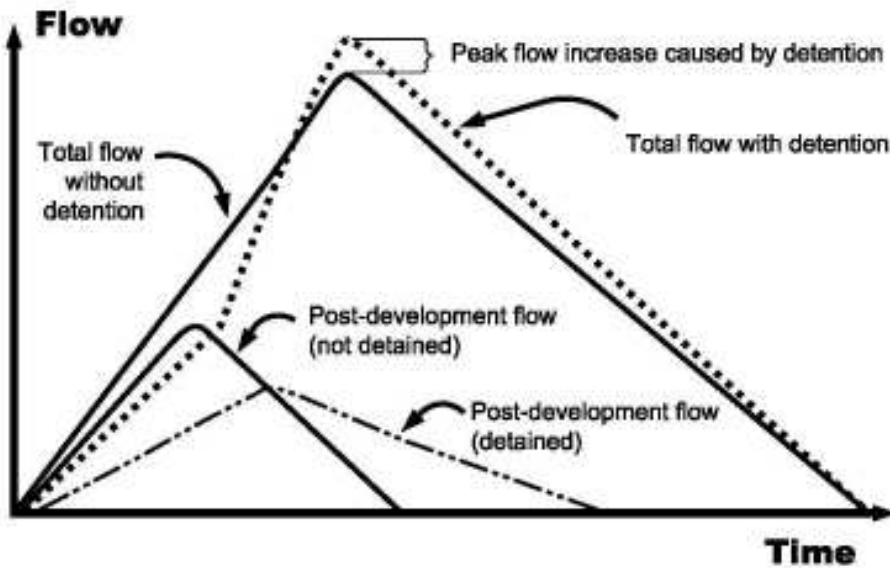
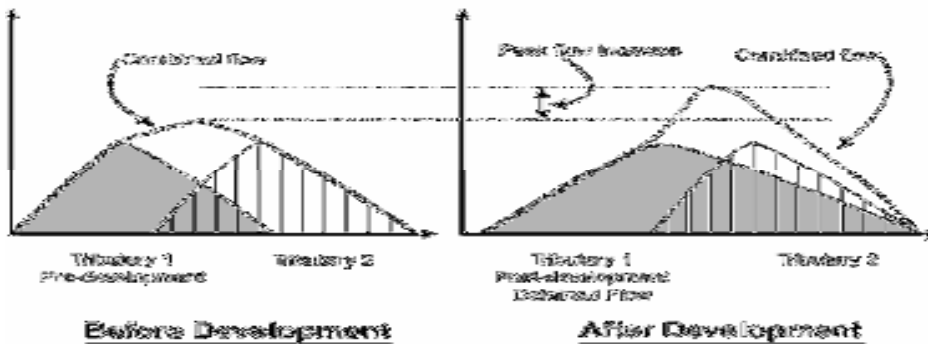


Figure 2-4. Potential Effect of Cumulative Detention Ponds



Potential problems such as those described above are quite common, but can be avoided through the use of a stormwater master plan and/or downstream analysis of the effects of a planned development. Studies have shown that if a developer is required to assess the impacts of a development downstream to the point where the developed property is 10% of the total drainage area, and there are no adverse impacts (i.e., stream peak discharge increases), then there is assurance that there will not be significant increases in flooding problems further downstream. For example, for a 10-acre site, the assessment would have to take place down to a point where the total accumulated drainage area is 100 acres.

While this assessment does require some additional labor on the part of the design engineer, it allows smart stormwater management within a watershed. The assessment provides the developer, Knox County and downstream property owners with a better understanding (and corresponding documentation) of the potential downstream impacts of development. In turn, this information identifies those developments for which waivers or reductions in the flood protection requirements may prove beneficial.



2.4.3.2 Regulations and Policies

Regulations and policies pertaining to the downstream impact analysis are listed below.

1. In accordance with Minimum Standard #6 (Chapter 1), downstream impact analysis shall be required for all developments and redevelopments for which a stormwater management plan is required. The analysis shall determine if the proposed development or redevelopment causes an increase in peak discharge as compared to pre-development runoff rates for the same site, or has the potential to cause downstream channel and streambank erosion. This analysis must be done for the 2-year, 10-year, 25-year and 100-year return frequency, 24-hour duration storm events, at the outfall(s) of the site, and at each downstream tributary junction and each public or major private downstream stormwater conveyance structure to the point(s) in the stormwater system where the area of the portion of the site draining into the system is less than or equal to 10% of the total drainage area above that point.
 2. If the downstream impact analysis shows that the development or redevelopment causes an increase in peak discharges, downstream flood protection shall be provided such that the calculated peak discharges for the 2-year, 10-year, 25-year and 100-year return frequency, 24-hour duration storm events after development of the site are not greater than that which would result from the same duration storms in the same downstream analysis area prior to development or redevelopment. These criteria must be applied throughout the 10% downstream analysis area
 3. Downstream flood protection can be provided by downstream conveyance improvements and/or purchase of flow easements in lieu of peak discharge controls subject to prior approval by the Director and satisfaction of the following requirements:
 - (1) **Sufficient hydrologic and hydraulic analysis must be presented that shows that the alternative approach will offer adequate protection from downstream flooding for all potentially affected downstream property owners.**
 - (2) **The applicant is responsible for submittal and approval of any necessary CLOMR prior to construction, and a LOMR upon completion of construction.**
 - (3) **The applicant is responsible for all State and Federal permits that may be applicable to the site including TDEC NPDES and ARAP permits, US Army Corps of Engineers Section 404 permits, and TVA Section 26A permits.**
1. Developments and redevelopments that do not cause an increase in peak discharges are not exempt from conformance with the minimum standards for water quality treatment (WQv) and channel protection (CPv), presented earlier in this chapter.
2. The downstream analysis should be performed after any WQv credits for better site design practices have been taken into consideration in the calculation of peak discharges leaving the site. While there are no credits for flood protection criteria, the use of better site design practices will inherently reduce runoff volumes and potentially reduce post-development peak discharges, both on-site and downstream of the site.
3. The data and results of the downstream analysis must be presented to Knox County Engineering as part of the stormwater management plan.

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