Storm Water Control Facilities

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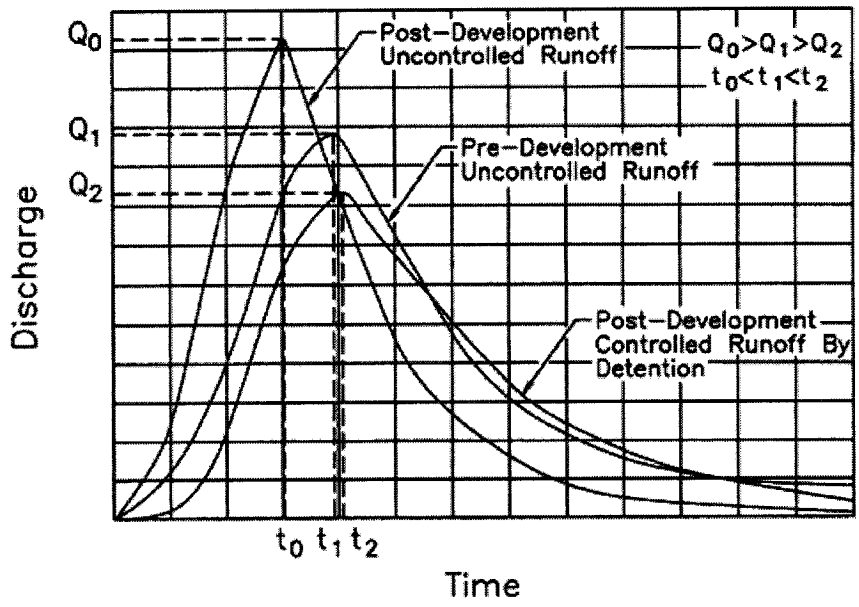
CHAPTER 8

STORM WATER CONTROL FACILITIES

8-1 **GENERAL.** Many land development activities, including the construction of roads and airports, convert natural pervious areas to impervious areas. These activities cause increased runoff because infiltration is reduced, the surface is usually smoother, allowing more rapid drainage, and depression storage is usually reduced. In addition, natural drainage systems are often replaced by lined channels, storm drains, and curb-and-gutter systems. These man-made systems produce an increase in runoff volume and peak discharge as well as a reduction in the time to peak of the runoff hydrograph. This concept is illustrated by the hydrograph in Figure 8-1.

Figure 8-1. Hydrograph Schematic



8-1.1 **Storage and Detention/Retention Benefits**. The temporary storage or detention/retention of excess storm water runoff as a means of controlling the quantity and quality of storm water releases is a fundamental principle in storm water management and a necessary element of many storm drainage systems. Previous concepts that called for the rapid removal of storm water runoff from developed areas, usually by downstream channelization, are now being combined with methods for storing storm water runoff to prevent overloading of existing downstream drainage systems. The storage of storm water can reduce the frequency and extent of downstream flooding, soil erosion, sedimentation, and water pollution. Detention/retention facilities also have been used to reduce the costs of large storm drainage systems by reducing the required size for downstream storm drain conveyance systems. The use of detention/retention facilities can reduce the peak

discharge from a given watershed, as shown in Figure 8-1. The reduced post-development runoff hydrograph is typically designed so that the peak flow is equal to or less than the pre-developed runoff peak flow rate. Additionally, the volume of the post-development hydrograph is the same as the volume of the reduced post-development runoff hydrograph. Specific design criteria, detailed design guidance, and example problems that address storm water management are provided in Chapter 8 of HEC-22.

8-1.2 Design Objectives

8-1.2.1 One of the fundamental objectives of storm water management is to maintain the peak runoff rate from a developing area at or below the pre-development rate to control flooding, soil erosion, sedimentation, and pollution. Design criteria related to pollution control are presented in Chapter 11.

8-1.2.2 Specific design criteria for peak flow attenuation are typically established by local government bodies. Some jurisdictions also require that flow volume be controlled to pre-development levels as well. Controlling flow volume is only practical when site conditions permit infiltration. To compensate for the increase in flow volume, some jurisdictions require that the peak post-development flow be reduced to below pre-development levels.

8-1.2.3 When storm water management first became common, most detention/ retention facilities were designed for control of runoff from only a single storm frequency. Typically, 2-year, 10-year, or 100-year storms were selected as the controlling criteria. However, single storm criteria have been found rather ineffective since such a design may provide little control of other storms. For example, design for the control of frequent storms (low return periods) provides little attenuation of less frequent but much larger storm events. Similarly, design for less frequent large storms provides little attenuation for the more frequent smaller storms. Some jurisdictions now enforce multiple-storm regulatory criteria that dictate that multiple storm frequencies be attenuated in a single design. A common criteria would be to regulate the 2-year, 10-year, and 100-year events.

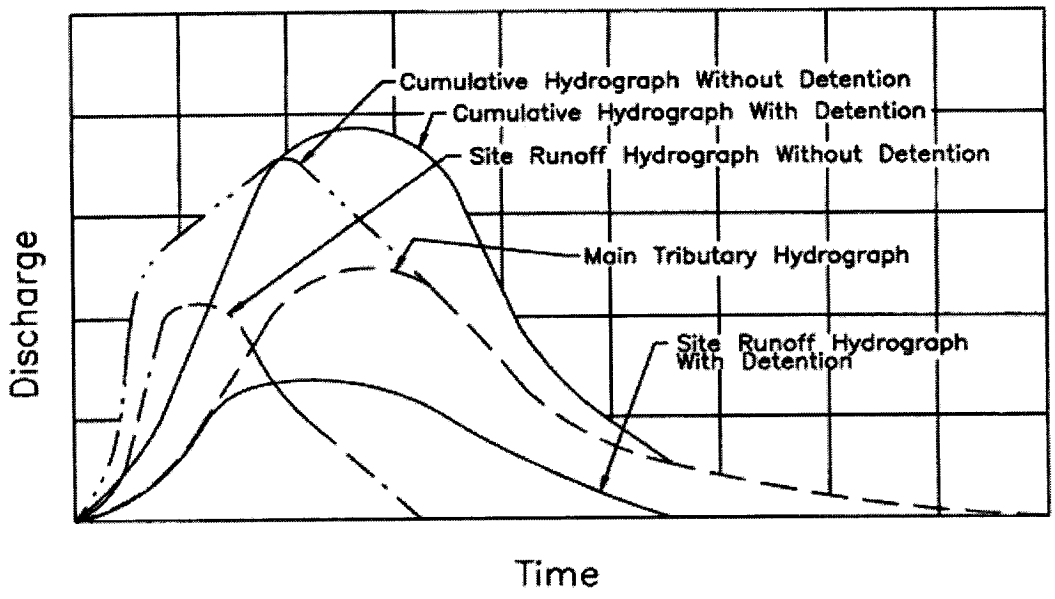
8-2 ISSUES RELATED TO STORM WATER QUANTITY CONTROL FACILITIES.

Three potential problem areas are associated with the design of storm water quantity control facilities, and these problem areas must be considered during design. They are release timing, safety, and maintenance.

8-2.1 **Release Timing**. The timing of releases from storm water control facilities can be critical to the proper functioning of overall storm water systems. As illustrated in Figure 8-1, storm water quantity control structures reduce the peak discharge and increase the duration of flow events. Though this is the desired result for flow tributary to an individual storm water control facility, this shifting of flow peak times and durations in some instances can cause adverse effects downstream.

For example, where the drainage area being controlled is in a downstream portion of a larger watershed, delaying the peak and extending the recession limb of the hydrograph may result in a higher peak on the main channel. As illustrated in Figure 8-2, this can occur if the reduced peak on the controlled tributary watershed is delayed in such a way that it reaches the main stream at or near the time of its peak. On occasions, it has also been observed that in locations where multiple detention facilities have been installed within developing watersheds, downstream storm flooding problems continue to be noticed. In both of these cases, the natural timing characteristics of the watershed are not being considered, and are not being duplicated by the uncoordinated use of randomly located detention facilities. It is critical that release timing be considered in the analysis of storm water control facilities to ensure the desired result.

Figure 8-2. Example of a Cumulative Hydrograph with and without Detention



8-2.2 **Safety**

8-2.2.1 In the design of water quantity control facilities, it is important to consider the possibility that people may be attracted to the site, regardless of whether or not the site or structure is intended for their use. It is important to design and construct inflow and outflow structures with safety in mind. Considerations for promoting safety include preventing public trespass, providing emergency escape aids, and eliminating other hazards.

8-2.2.2 Removable, hydraulically-efficient grates and bars may be considered for all inlet and outlet pipes, particularly if they connect with an underground storm drain system and/or they present a safety hazard. Fences may be needed to enclose ponds.

8-2.2.3 Where active recreation areas are incorporated into a detention basin, very mild bottom slopes should be used along the periphery of the storage pond. Ideally, detention basins should be located away from busy streets and intersections. Outflow structures should be designed to limit flow velocities at points where people could be drawn into the discharge stream. Persons who enter a detention pond or basin during periods when storm water is being discharged may be at risk. The force of the currents may push a person into an outflow structure or may hold a victim under the water where a bottom discharge is used. Several design precautions intended to improve safety are addressed in other storm water publications.

8-2.2.4 In the case of airfields, give special consideration to the attraction of wildlife to the facility. Waterfowl, in particular, create a significant safety hazard to aircraft and therefore must be considered during the design phase. For more information on waterfowl hazards, refer to AFPAM 91-212 or AC 150/5200-33.

8-2.3 **Maintenance.** Storm water management facilities must be properly maintained if they are to function as intended over a long period of time. Certain types of maintenance tasks should be performed periodically to ensure that storm water management facilities function properly:

- Inspections: Storm water storage facilities should be inspected periodically for the first few months after construction and on an annual basis thereafter. In addition, these facilities should be inspected during and after major storm events to ensure that the inlet and outlet structures are still functioning as designed, and that no damage or clogging has occurred.

- Mowing: Impoundments should be mowed at least twice a year to discourage woody growth and control weeds.

- Sediment, Debris and Litter Control: Accumulated sediment, debris, and litter should be removed from detention facilities at least twice a year. Particular attention should be given to removing sediment, debris, and trash around outlet structures to prevent clogging of the control device.

- Nuisance Control: Standing water or soggy conditions within the lower stage of a storage facility can create nuisance conditions such as odors, insects, and weeds. Allowance for positive drainage during design will minimize these problems. Additional control can be provided by periodic inspection and debris removal, and by ensuring that outlet structures are kept free of debris and trash.

- Structural Repairs and Replacement: Inlet and outlet devices and standpipe or riser structures have been known to deteriorate with time, and may have to be replaced. The actual life of a structural component will depend on individual, site-specific criteria, such as soil conditions.

8-3 **STORAGE FACILITY TYPES.** Storm water quantity control facilities can be classified by function as either detention or retention facilities. The primary function of detention is to store and gradually release or attenuate storm water runoff by way of a control structure or other release mechanism. True retention facilities provide for storage of storm water runoff, and release via evaporation and infiltration only. Retention facilities that provide for slow release of storm water over an extended period of several days or more are referred to as extended detention facilities.

8-3.1 **Detention Facilities**

8-3.1.1 The detention concept is most often employed in highway and municipal storm water management plans to limit the peak outflow rate to that which existed from the same watershed before development for a specific range of flood frequencies. Detention storage may be provided at one or more locations and may be both above or below ground. These locations may exist as impoundments, collection and conveyance facilities, underground tanks, and on-site facilities such as parking lots, pavements, and basins. The facility may have a permanent pool, known as a wet pond. Wet ponds are typically used where pollutant control is important. Detention ponds are the most common type of storage facility used for controlling storm water runoff peak discharges. The majority of these are dry ponds that release all the runoff temporarily detained during a storm.

8-3.1.2 Detention facilities should be provided only where they are shown to be beneficial by hydrologic, hydraulic, and cost analysis. Additionally, some detention facilities may be required by ordinances and should be constructed as deemed appropriate by the governing agency. Specific design guidance and criteria for detention storage apply:

- Design rainfall frequency, intensity, and duration must be consistent with applicable standards and local requirements.
- The facility's outlet structure must limit the maximum outflow to allowable release rates. The maximum release rate may be a function of existing or developed runoff rates, downstream channel capacity, potential flooding conditions, and/or local ordinances.
- The size, shape, and depth of a detention facility must provide sufficient volume to satisfy the project's storage requirements. This is best determined by routing the inflow hydrograph through the facility. HEC-22, Chapter 8, outlines techniques that can be used to estimate an initial storage volume, and provides an explanation of storage routing techniques.
- An auxiliary outlet must be provided to allow overflow that may result from excessive inflow or clogging of the main outlet. This outlet should be positioned such that overflows will follow a predetermined route. Preferably, such outflows should discharge into open channels, swales, or other approved storage or conveyance features.

- The system must be designed to release excess storm water expeditiously to ensure that the entire storage volume is available for subsequent storms and to minimize hazards. A dry pond, which is a facility with no permanent pool, may need a paved low flow channel to ensure complete removal of water and to aid in nuisance control.

- The facility must satisfy Federal and state statutes and recognize local ordinances. Some of these statutes are the Federal Water Pollution Control Act, the Water Quality Act, and other Federal, state, and local regulations.

- Access must be provided for maintenance.

- If the facility will be an "attractive nuisance" or is not considered reasonably safe, it may have to be fenced and/or signed.

8-3.2 Retention Facilities

8-3.2.1 Retention facilities as defined here include extended detention facilities, infiltration basins, and swales. In addition to storm water storage, retention may be used for water supply, recreation, pollutant removal, aesthetics, and/or groundwater recharge. As explained in Chapter 11, infiltration facilities provide significant water quality benefits, and although groundwater recharge is not a primary goal of highway storm water management, the use of infiltration basins and/or swales can provide this secondary benefit.

8-3.2.2 Retention facilities are typically designed to provide the dual functions of storm water quantity and quality control. These facilities may be provided at one or more locations and may be either above or below ground. These locations may exist as impoundments, collection and conveyance facilities (swales or perforated conduits), and on-site facilities such as parking lots and roadways using pervious pavements.

8-3.2.3 Design criteria for retention facilities are the same as those for detention facilities except that it may not be necessary to remove all runoff after each storm. Additional criteria should be applied, however. See paragraphs 8-3.3 and 8-3.4 for this criteria.

8-3.3 Wet Pond Facilities

- Wet pond facilities must provide sufficient depth and volume below the normal pool level for any desired multiple use activity.

- Shoreline protection should be provided where erosion from wave action is expected.

- The design should include a provision for lowering the pool elevation or draining the basin for cleaning purposes, shoreline maintenance, and emergency operations.

- Any dike or dam must be designed with a safety factor commensurate with an earth dam and/or as set forth in state statutes.

- Safety benching should be considered below the permanent water line at the toe of steep slopes to guard against accidental drowning.

8-3.4 Infiltration Facilities

- A pervious bottom is necessary to ensure sufficient infiltration capability to drain the basin in a reasonable amount of time so that it will have the capacity needed for another event.

- Because of the potential delay in draining the facility between events, it may be necessary to increase the emergency spillway capacity and/or the volume of impoundment.

- Detailed engineering geological studies are necessary to ensure that the infiltration facility will function as planned.

- Particulates from the inflow should be removed so they do not settle and preclude infiltration.

The FHWA's TS-80-218 is recommended for additional information on underground detention and retention facilities.