### 3.2.3 General Storage Design Procedures

This section discusses the general design procedures for designing storage to provide standard detention of stormwater runoff for the $Qp_2$, $Qp_{10}$, $Qp_{25}$ and $Qp_{100}$. The design procedures for all storage facilities are the same whether or not they include a permanent pool of water. In the latter case, the permanent pool elevation is taken as the “bottom” of storage and is treated as if it were a solid basin bottom for routing purposes.

The location of a storage facility can have a sizeable impact on the effectiveness of such facilities to control downstream impacts. In addition, multiple storage facilities located in the same drainage basin will affect the timing of the runoff through the downstream conveyance system, which could decrease or increase flood peaks in different downstream locations. Therefore, a downstream peak flow analysis (i.e., the 10% rule) should be performed as part of the storage facility design process. In multi-purpose multi-stage facilities such as stormwater ponds, the storage design must be integrated with the overall design for water quality treatment objectives. See Volume 2, Chapter 4 for further guidance and criteria for the design of structural best management practices (BMPs) for water quality control.

#### 3.2.3.1 Design Procedure

The following data are needed for storage design and routing calculations:

- inflow hydrograph for all selected design storms;
- stage-storage curve for proposed storage facility; and
- stage-discharge curve(s) for all outlet control structures.

A general procedure for using the above data in the design of storage facilities is presented below.

1. Compute inflow hydrographs for the 2, 10, 25 and 100-year, 24-hour design storms using the hydrologic methods outlined in Section 3.1. Both existing conditions and post-development hydrographs are required.
2. Perform preliminary calculations to evaluate detention storage requirements for the hydrographs from Step 1.
3. Determine the physical basin dimensions necessary to hold the volumes determined in Step 2, including freeboard, which is defined as 1.0 foot above the $Qp_{100}$ water surface elevation to the lowest point in the detention embankment, excluding the emergency spillway. The maximum storage requirement calculated from Step 2 should be used. From the selected basin shape, determine the maximum depth in the pond.
4. Select the type of outlet(s) and size each outlet structure. The outlet type and size will depend on the type of basin (detention, extended detention or retention) as well as the allowable discharge. The estimated peak stage will occur for the estimated volume from Step 2. The outlet structure(s) should be sized to convey the allowable discharge at this stage.
5. Perform routing calculations using inflow hydrographs from Step 1 to check the preliminary design using a storage routing computer model. If the routed post-development peak discharges ($Qp_2$, $Qp_{10}$, $Qp_{25}$ and the $Qp_{100}$) exceed the existing conditions peak discharges, then revise the available storage volume, outlet device(s), etc., and return to Step 3 until the basin size, basin depth, outlet type and outlet size meet the allowable discharge requirements.
6. Apply the 10% rule (i.e., downstream effects of detention outflows) for the 2-year, 10-year, 25-year and 100-year storms to ensure that the routed hydrograph does not cause downstream flooding problems.
7. Evaluate the control structure outlet velocity and provide channel and bank stabilization if the velocity will cause erosion problems downstream.

Routing hydrographs through storage facilities is critical to the proper facility design and is required in Knox County. Although storage design procedures have been developed that use inflow/outflow analysis without routing, these design procedures have not produced acceptable results in designing detention facilities for many areas of the country, including Knox County.

Although hand calculation procedures are available for routing hydrographs through storage facilities, these procedures are very time consuming, especially when several different designs are evaluated. Many standard hydrology and hydraulics textbooks give examples of hand-routing techniques. For this manual, it is assumed that designers will be using one of the many computer programs available for storage routing and thus other procedures and example applications will not be given here.