Savvy Subsurface Design

The 'how-tos' of underground storage modeling

By Peter Smart

Detention ponds are a frequently used tool for managing storm water runoff. By detaining runoff in a storage area, peak flows can be reduced in order to approximate the predevelopment characteristics of a site. However, traditional above-grade ponds require valuable open space and may create safety hazards or health risks. To maximize land utilization, designers increasingly are turning to underground storage alternatives that can be placed beneath open spaces such as parking lots and playing fields.

On appropriate sites, underground storage also provides a cost-effective means of restoring the infiltration capability that is usually reduced by development activities. In addition to providing groundwater recharge, this helps to offset the increase in runoff volume that accompanies most site development and enables the design of storm water management systems that more closely approximate predevelopment site behavior in terms of peak flow and volume.

Underground storage options include "box of rocks;" rectangular tanks and chambers; and stone with embedded chambers.

Box of Rocks

One of the simplest means of providing underground storage is an excavation filled with clean stone, sometimes referred to as a "box of rocks." The storage is provided by the void space between the stone, which can be as much as 40 percent of the overall volume. Typically, the stone is wrapped in filter fabric to prevent the migration of soil into the stone voids—or even a waterproof membrane for sites on which infiltration is undesirable.

The introduction of water into the stone is typically accomplished with an embedded drywell or perforated pipe. In most cases, the system also includes outlet provisions to handle overflow conditions or achieve a desired discharge into a storm sewer or other design point.

While a box of rocks can be a viable solution on certain sites, the high cost of stone and open space often calls for a more sophisticated storage solution.

Rectangular Chambers

The most space-efficient means of underground storage is often a rectangular tank or chamber. These products range from small injection-molded cells to large concrete tanks or vaults.

Chambers are typically installed in a rectangular grid, using whatever number of rows and chambers is needed to achieve the required storage. Because there is little or no gap between these chambers, storage efficiency can be as high as 95 percent, depending on the thickness of the chamber material. For open-sided chambers, the system is typically wrapped in filter fabric to prevent soil infiltration, while other chambers systems are self-sealing and do not require a fabric barrier.

Embedded Chambers & Pipe

The third category of underground storage involves a combination of stone and embedded chambers. By using perforated chambers, water is also stored in the voids of the surrounding stone, producing an overall storage efficiency of 60 percent to 74 percent. The designer

has many options for embedded storage; these range from perforated pipe to arched storm water chambers.

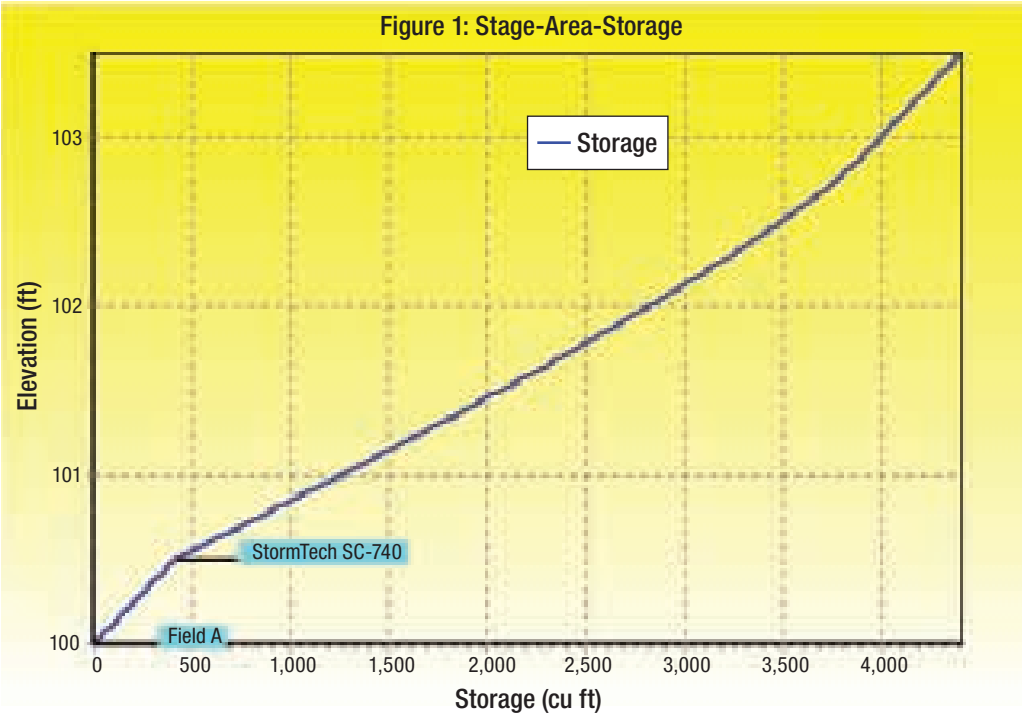
For situations requiring a sealed storage solution—for instance, detention, only without infiltration—the entire chamber-and-stone system can be wrapped in a waterproof membrane. An alternative is to use a closed-chamber solution such as nonperforated pipe, with a typical space efficiency of 35 percent to 55 percent, depending on the type and size of pipe.

Modeling Methods

Regardless of how the storage volume is created, most underground detention or retention systems are modeled like a traditional above-grade pond. This is based on the assumption that water can flow freely within the storage system, creating a level pool that can be modeled with conventional pond routing procedures, for example the storage-indication method.

For tanks or rectangular chambers, storage calculation is based on the overall dimensions, with possible adjustments for reinforcing webs or other intrusions into the storage space. For the basic box of rocks, the storage at any depth is calculated by multiplying

Figure 1: Stage-Area-Storage



the volume of the box by the stone voids. In both cases, the result is a linear stage-storage curve, which can be readily calculated and entered into any pond routing model.

When using a curved storage chamber or a chamber-plus-stone storage combination, the situation becomes considerably more complex. These situations require a detailed analysis of the chamber volume at any given depth, plus the inclusion of stone storage at each water surface elevation.

The result of these calculations is a stage-storage curve, as illustrated in Figure 1 (see page 25). Note the linear storage relationship over the first 0.5 ft, provided by the uniform stone bed on which the chambers are placed. Above the stone bed there is a sudden increase in storage per foot caused by the open chamber, gradually returning to a linear relationship for the stone cover over the top of the chamber.

Stage-Storage Calculations

Stage-storage calculations are often performed with a spreadsheet provided by the chamber maker. After specifying the basic layout parameters, a typical spreadsheet will provide a stage-storage table that can be transferred to the modeling software.

A better approach is to use a modeling program with native support for chamber calculations. This avoids the need to use a different spreadsheet for each storage product and eliminates the time-consuming and error-prone process of transferring spreadsheet data into the modeling program. Native chamber support also allows for immediate changes to the layout and design parameters, without having to manually update the stage-storage data or rerun a separate "chamber tool."

Additional Software Features

Finally, look for a program that provides automated layout of the drainage field, including the ability to automatically apply recommended chamber spacing, bedding and cover. Make sure the software includes a large selection of chambers, including a full range of pipe storage options. The ability to provide cost estimates based on the cost of chambers, stone and excavation is another worthwhile, time-saving feature. SWS

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