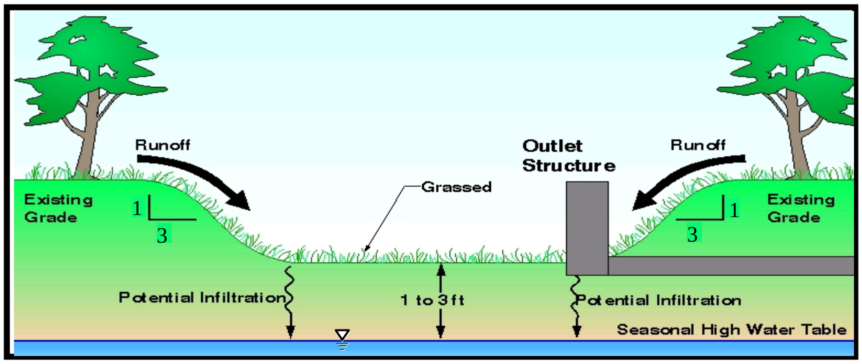
ACTIVITY: Detention (Dry) Basin

P – 01



Targeted Constituents			
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit	
● Sediment	◗ Heavy Metals	◗ Floatable Materials	◗ Oxygen Demanding Substances
◗ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses
○ Construction Wastes			

Implementation Requirements			
● High	◗ Medium	○ Low	
◗ Capital Costs	◗ O & M Costs	◗ Maintenance	○ Training

Description

A detention basin (also known as a detention pond) is the most common method to satisfy both stormwater detention and stormwater quality requirements. It is applicable to small and large developments, can be easily designed and constructed, and is long-lasting and durable while reducing peak flows (with adequate inspection and maintenance). This practice will also provide a significant reduction in sediment, as well as a partial reduction in nutrients, toxic materials, heavy metals, floatable materials, oxygen demanding substances, and oil and grease.

A dry detention basin is intended to drain dry between storm events, but sometimes may not have a chance to drain completely between closely occurring storm events. The detention basin begins to fill as stormwater runoff enters the facility. The first flush volume is captured in order to ensure water quality. One or more outlet structures then release the stormwater runoff slowly to reduce peak discharge rates and to provide time for sediments to settle. Litter and debris should be prevented from leaving the detention basin (thus protecting Tennessee's streams and lakes). Some soluble pollutants are captured by a combination of vegetation and soils.

Selection Criteria

- The primary objective is to reduce the incoming peak flow discharge and slow the stormwater runoff response from a particular property or development, thus reducing flooding downstream. In Tennessee, peak flow runoff after development should not be greater than it was prior to development.
- The secondary objective is to remove suspended sediments, trash and debris, oil, grease and other pollutants to protect the water quality of Tennessee streams and channels. Although dry detention basins are usually not as effective at removing soluble pollutants as wet detention basins and wetlands, dry detention basins are usually easier and less expensive to construct, inspect and maintain. Dry detention basins can be used wherever a lack of sufficient supply water would prevent the use of wet detention basins or wetlands.
- Dry detention basins can also supply multiple benefits for passive recreation during dry periods (recreational trails, ball fields, picnicking). Portions of a dry

detention basin that are not wetted frequently can be attractively landscaped or used for other purposes. See NS-02, Landscaping and Vegetative Control Practices, for the use of buffer zones and typical placement of various stormwater treatment BMPs.

- Dry detention basins may be appropriate to areas where dry weather base flow cannot be used to maintain water levels, as is required for wet ponds and constructed wetlands.

Design and Sizing Considerations

- A permanent detention basin design must be stamped by a professional engineer licensed in the state of Tennessee. The professional engineer must be qualified by education and experience to perform the necessary hydrologic and hydraulic calculations. A wet detention basin must be located and designed so that failure of the structure will not result in danger to human life, damage to personal property, inundation of public streets or highways, interruption of public services or utilities, or inconvenience to the general public.

- As the primary objective, dry detention basins must be designed to have adequate detention storage and outlet structures. Multi-stage detention is required for the 1-year, 2-year, 5-year and 10-year design storm events in all watersheds. Additional stages (i.e. 25-year, 50-year, and 100-year) may be required for special watersheds.

- As the secondary objective, water quality is obtained through the use of the first flush treatment volume. The initial wave of stormwater runoff is more likely to contain aerially-deposited sediments, particulates from vehicles (such as incomplete combustion, dust from brake linings, tire particles), leaves, trash, cigarette butts, etc. The first flush volume must be captured and then slowly released. The overall goal for stormwater treatment is based on 75% removal of total suspended sediments for first flush volume.

- Additional measures may be required to improve stormwater quality, depending upon the nature of the land use and expected pollutants. Pretreatment of stormwater runoff with a media filtration inlet or oil/water separator may be necessary. A trash rack for capturing floating debris is generally considered to be standard equipment for a stormwater treatment BMP.

- Stormwater runoff that falls onto pavement and rooftops should be detained and treated in a manner that will reduce thermal impacts to streams. This may include locating a detention basin away from sunlight by using trees or buildings as shade.

Location and Layout

Basic elements of a dry detention basin are illustrated in Figure P-01-1. The recommended design includes the use of a sediment forebay to reduce sediment loading, particularly if the post-construction detention basin is a modification from a temporary sediment basin during the construction phase. The use of an upper stage (for storage of infrequent storms) is optional; there are both benefits and drawbacks. A shallow detention basin with a large surface area will usually perform better than a deeper detention basin with the same volume. However, shallow storage areas increase the overall surface area needed for detention.

Design flow paths to minimize potential short-circuiting by locating the inlets as far away from the outlet structure as possible. The length-to-width ratio of a basin should be at least 2:1 (and preferably 3:1). Baffles or backslope drains may be used to prevent short-circuiting. If topography or aesthetics require the pond to have an irregular shape, increase pond area and volume to compensate for dead spaces. It is important to reduce the velocity of incoming stormwater using riprap or other energy dissipaters.

Although dry detention basins are generally less expensive to construct and maintain than wet detention basins, they provide lower water quality benefits. The primary disadvantage of a dry detention basin is the amount of surface area required, which can be reduced somewhat by using concrete retaining walls on one or more sides. In general, concrete retaining walls should not face southward in order to reduce the potential for heating on hot summer days.

Bedrock and topography must be considered when grading in some areas of the state. Karst topography may indicate fractured bedrock, dissolved limestone passages, or sinkholes, for which a detention basin would be highly detrimental. The additional water volume that is introduced to the underground limestone passages, or even the additional weight of ponded water, could intensify karst activity and eventually collapse the bed of the detention pond.

Interaction with site utilities must be considered during preliminary design. Typical utilities include electrical, telephone, cable TV, water, sewer, natural gas, petroleum, etc. These utilities may or may not be in a dedicated utility easement, so it is always necessary to conduct a careful site survey. Detention basins (including embankments) should not be allowed over utility lines. Conversely, utility trenches should not be constructed on existing detention basin structures.

Detention basin easements and access must be considered during preliminary design, in order to allow for the construction easement and maintenance. Detention basins that are not frequently inspected and maintained often become more of a nuisance than a beneficial part of a stormwater management program. In particular, provide access for inspection and maintenance to the sediment forebay and to the outlet control structure. It may also be desirable to encourage or discourage public access to the detention basin (by using site grading, signs, fences or gates). Additional safety elements include trash racks, grating over pipes and culverts, gentle side slopes whenever possible, increased visibility and/or lighting in residential areas, etc.

Small detention basins serving individual properties do not offer as much recreational benefits as community or regional detention basins would. Regional facilities can often be landscaped to offer recreational and aesthetic benefits. Jogging and walking trails, picnic areas, and ball fields are some of the typical uses. For example, portions of the facility for flood control of major design storms can be used for exercise areas, soccer fields, or football fields. Wildlife benefits can also be provided in the form of islands, buffer areas, or preservation zones. It is important to maintain such areas, however as their primary purpose is for stormwater management. Under no circumstances should debris be allowed to accumulate near the outlet.

Volume and Size

The volume of a dry detention basin consists of two elements: the live pool (the upper portion of the basin representing detention capability) and the first flush volume (the lower portion of the basin representing stormwater quality treatment).

Since the post-development peak runoff may not exceed the pre-development peak flow rate, the upper section's volume should be greater than or equal to this difference in volume.

The first flush volume should be sized to capture and slowly release the "first flush" of stormwater runoff, or the volume most likely to contain contaminants and particulate matter. Common practices include slow release of the first one-inch of runoff over a 24 to 72 hour period, or the detention of a 1-year storm.

As a warning to those who design detention basins, it should be realized that future stormwater regulations are likely to be more stringent than the current regulations. This is mostly driven by national and state laws and regulations, which will require municipalities and county governments to accomplish additional pollution reduction with a proportional effort for water quality monitoring and enforcement. Figure P-01-6 shows the measured pollution removal values during the 1980's for dry detention basins near metropolitan Washington, D.C.

Grading

Side slopes of detention basins and embankment dams shall generally be 3H:1V or flatter. This encourages a strong growth of vegetation on the side slopes, helps to prevent soil erosion, and allows for safer mowing. Steep slopes, particularly on embankments or other fill soils, will contribute to soil erosion if not properly vegetated or stabilized, and thereby reduce or negate the effectiveness of a dry detention basin with respect to water quality. Vegetate the side slopes and basin bottom to the maximum extent practical. If significant side erosion is expected, consider the use of soil stabilization or armoring techniques. Detention basins should not be located immediately above or below a steep slope or grade, because impounded water may create slope stability problems.

Minimum width for top of embankment is 5 feet. The embankment height should allow for up to 10% settlement of embankment, unless the embankment is thoroughly compacted with vibratory equipment or sheepsfoot rollers. The top of embankment (after expected settlement) shall generally be at least 2 feet above the top of outlet structure and at least 1 foot above the peak 100-year water surface elevation. Compaction in the immediate area of the emergency spillway can be difficult, but is necessary.

In instances where stormwater runoff does not flow directly down a slope, the side slope of a detention basin can be as steep as 2:1 (H:V) with proper erosion controls, geotextiles, and quick establishment of vegetation. Retaining walls may be used on one or more sides of a detention basin if properly designed. Analysis of a retaining wall should include effects of saturated soil behind the retaining wall, in addition to the usual design considerations of vehicle and structural loadings above the retaining wall.

The use of a backslope drain can be very beneficial in preventing erosion at detention basins. See Figure P-01-5 for a typical detail. The backslope drain is also useful for increasing lengths of flow paths to prevent short circuiting of the detention basin. Intercepted stormwater can be routed around the detention basin to enter at the most hydraulically distant point from the outlet structure.

Outlet Structure

Detention basin outlet structures should be constructed of durable materials, such as concrete or masonry block. Corrugated metal pipe (CMP) and plastic (HDPE) risers and drain pipes are popular in engineering design, but are susceptible to crushing and flotation in detention basins. A concrete outlet structure is generally preferable to a masonry block structure because it is sturdier and more durable. Provisions should be made for sufficient reinforcement and anchoring.

The specific flow-controlling elements of an outlet structure may include one or more of the following: a circular orifice, a noncircular orifice, a rectangular weir, a trapezoidal weir, a triangular weir, a V-notch weir, culvert entrance control or a riser overflow opening.

Figures P-01-2 and P-01-3 illustrate possible designs for the outlet structure. These details are only two possible ways to accomplish stormwater detention and stormwater quality control. The first flush volume is typically drained during a minimum time of 24 hours by using an orifice with a designed size. Maximum drain time should be less than 72 hours to allow for sufficient volume recovery prior to the next period of rainfall. The first flush volume can be filtered through sand by using an underdrain system (shown in Figure P-01-2) or by an aboveground filter box with sand or aggregate (shown in Figure P-01-3). Figure P-01-4 shows an alternative outlet structure with a water quality manhole. Provide an emergency spillway in order to route large storms through the facility without overtopping.

Emergency Spillway

An emergency spillway should be included in addition to the primary outlet structure on a retention pond. The purpose of this spillway is to pass storm events that exceed the design capacity of the pond, in order to prevent overtopping the embankment. The emergency spillway should be located over an undisturbed abutment area and <u>not</u> over the embankment fill for stability reasons. The emergency spillway capacity should be designed to prevent overtopping the embankment structure or dam during a storm event commensurate with the impoundment volume, dam size, and downstream flood hazard potential in event of dam failure. The minimum spillway capacity should be capable of handling a 100-year storm event. The designer is referred to the requirements set forth in the Tennessee Safe Dams Act and Regulations at: www.state.tn.us/environment/permits/safedam.htm

Extended Detention Basins

The extended detention basin is similar to the detention basin, except that the water is detained for a longer period of time—usually between 24-72 hours. This BMP should be used when water quality is of greater concern, since the primary objective of this device is to hold stormwater for a given duration, instead of simply attenuating storm runoff.

Other Design Elements

- Sediment forebay – to facilitate the cleanout of sediment, trash, debris, leaves, etc. The sediment forebay typically contains 5% to 10% of the total volume. It should be located at a point where velocities have dissipated, to allow large sediments and debris to settle out. A forebay can be separated from the remainder of a detention basin by several means: a lateral sill with rooted wetland vegetation, rock-filled gabion, rock retaining wall, or rock check dam placed laterally across the basin. The sediment forebay should be easily accessible so that it can be inspected and maintained.

- Public safety should be considered, particularly in residential areas. Operating detention basins often attract neighborhood children. Avoid steep slopes and dropoffs; consider routes for escaping the detention basin if a person accidentally falls in. Avoid depths over 4 feet when possible; provide fencing and signs in areas where children may potentially play, and where steep slopes are used in the detention area.
- A low-flow channel (or concrete trickle ditch) can assist in completely draining detention basins with flat slopes. It also assists with the observation and removal of accumulated sediment. A typical design may be a triangular ditch, maybe 4' wide and 3" deep with a slope of 0.5 to 1.0 percent.
- Depending on the embankment soil, height of dam, and amount of compaction for the embankment, an anti-seep collar or a cutoff layer of compacted clay may be needed around the outlet pipe to prevent internal piping and erosion. An anti-seep collar should extend at least one pipe diameter from the culvert in all directions, with compacted clay backfill using small mechanical tampers. In areas of abundant clay soils, an anti-seep collar is not required for a dry detention basin.
- To prevent the outlet riser from clogging, include trash racks or other debris barriers with a maximum opening size of 6 inches on all outlet structures, except for any emergency spillway structures that are designed for a 25-year storm or greater return period. Trash racks that are placed at an angle to the direction of flow tend to force debris up and away from the outlet opening and are somewhat less vulnerable to clogging. These racks should be regularly cleaned and maintained.
- Provide means for vehicle access to the detention basin. Detention basins must be located in a maintenance easement so that authorities have the right to inspect the facility. Maintenance easements that are not adjacent to a municipality's right-of-way must also have an access easement, which allows for maintenance vehicle access. This easement should be free of large trees and excessive vehicle grades.
- Include a skimmer, oil/water separator or other type of stormwater runoff pretreatment for detention basins with greater than 50 percent impervious surface or where there may be a potential source of oil and grease contamination. In addition to most large parking lots, oil and grease contamination is also likely for vehicle fueling and maintenance facilities.
- An anti-vortex device for the outlet structure may be potentially needed for very large detention basins in areas where public access is not controlled. The anti-vortex device may be a combination of vanes above the outlet structure or guide walls around the outlet structure, that increases the inlet flow efficiency and might lessen the chance of humans drowning or reduce the potential for erosion and structural undercutting.

Construction/

Inadequate storage is the most frequent problem that occurs in the design review before

Inspection Considerations

construction, and also for the as-built review after construction. This can occur for several reasons:

- The design engineer did not allow enough room to construct the detention basin (most often due to insufficient design detail such as slope transitions, setbacks, parking lot widths, inaccurate contours, utilities not shown).
- The engineer who performs the stormwater computations is not the same person as the design engineer who does site layout and grading. The required detention storage volume and outlet structure details need to be communicated clearly to the design engineer for inclusion on the plans and for construction layout.
- The construction contractor does not correctly follow the design plans, and consequently, does not excavate deep enough or build berms of sufficient height to hold the required detention volume. This may occur due to rock formations encountered or to groundwater. It is important that the elevation-volume configuration shown on the plans be preserved during construction so that the detention basin functions according to intended design.
- The construction contractor changes the basin configuration during the construction without being aware of the required volume. Approval from the engineer was not obtained for a design change.

It is highly recommended that the design engineer is involved in the construction and inspection of the detention basin. Special attention should be given to the detention basin volume, elevations of each outlet, embankment crest and emergency spillway crest; side slopes, size and shape of various weirs or orifices, and installation of cutoff collars in embankments.

Proper hydraulic design of the outlet is critical to achieving good performance for both stormwater detention and stormwater quality of the dry detention basin. The two most common problems for detention basin outlets are:

- The discharge capacity of the outlet system is too great at the detention design depth. This causes excessive basin outflows and results in fast drawdown times and inadequate filling of the detention basin volume. Both stormwater detention and stormwater quality will suffer.
- The outlet structure clogs because it is not adequately protected against trash and debris. The use of innovative trash racks is recommended. Effective trash racks are often created using welded rebar with 6-inch openings. Sloped trash racks are preferable to vertical ones for forcing floating debris upward and away from the opening, rather than being forced against the trash rack, and causing clogging. This is sufficient to stop most beverage cans, fast food containers, tree limbs, etc. Properly designed and installed trash racks also provide a measure of safety to children who may otherwise be pulled toward and held against the opening.

Maintenance

Effective and safe operation of a detention basin depends on continuous maintenance of all system components. This means that the owner should have a regular inspection program in place for checking the condition and integrity of the basin, dam, and outlet control system to prevent minor problems from becoming serious safety and operation problems. Detention basin easements and access must be considered during the planning stage in order to allow for proper inspection and maintenance.

- As a minimum, an owner should inspect the dry detention basin regularly (several times a year) and particularly after heavy rainfall events. Record all observations and measurements taken. Perform any maintenance and repair erosion promptly. Remove debris and trash after storm events. Check outlet structures regularly for clogging.
- Remove sediment when accumulation becomes noticeable (1" to 2" over a wide area) or if resuspension is observed or probable. Sediment may be permitted to accumulate if the detention basin volume has been overdesigned with adequate controls to prevent further sediment movement. If a sand underdrain is used, look for reduced infiltration or ponded water; sand layer replacement may be needed.
- Maintain a thick and healthy stand of vegetation (usually grass). Mow or trim at regular intervals to encourage thick growth. Remove leaves, grass clippings, or sticks from detention basin regularly to prevent stormwater pollution. Remove trees or nuisance vegetation as necessary to ensure structural integrity of the basin. This is especially true in embankments. Signs should be posted at detention ponds to discourage local homeowners from depositing yard trimmings, waste, and fill materials inside the basin. Appropriate signs and barriers such as fences should also be considered at detention basins where children have easy access to the site.
- If both the operational and aesthetic characteristics of a dry detention basin are not properly maintained, recognize that it becomes an eyesore and has a negative environmental impact. Vegetation needs to be trimmed or harvested. Signs should be posted and maintained at detention ponds to warn of hazardous water conditions and to prohibit local homeowners from depositing yard trimmings, waste, and other fill materials inside the basin.

Sediment Removal

A primary function of stormwater treatment BMPs is to collect and remove sediments. The sediment accumulation rate is dependent on a number of factors including watershed size, facility sizing, construction upstream, nearby industrial or commercial activities, etc. Sediments should be identified before sediment removal and disposal is performed. Special attention or sampling should be given to sediments accumulated from industrial or manufacturing facilities, heavy commercial sites, fueling centers or automotive maintenance areas, parking areas, or other areas where pollutants are suspected. Sediment should be treated as potentially hazardous until proven otherwise.

Some sediment may contain contaminants for which TDEC requires special disposal procedures. Consult TDEC – Division of Water Pollution Control if there is any uncertainty about what the sediment contains or if it is known to contain contaminants. Clean sediment may be used as fill material, hole filling, or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in stormwater runoff. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.

Cost Generally less expensive than wet ponds and wetlands, but more expensive than

Considerations

biofilters.

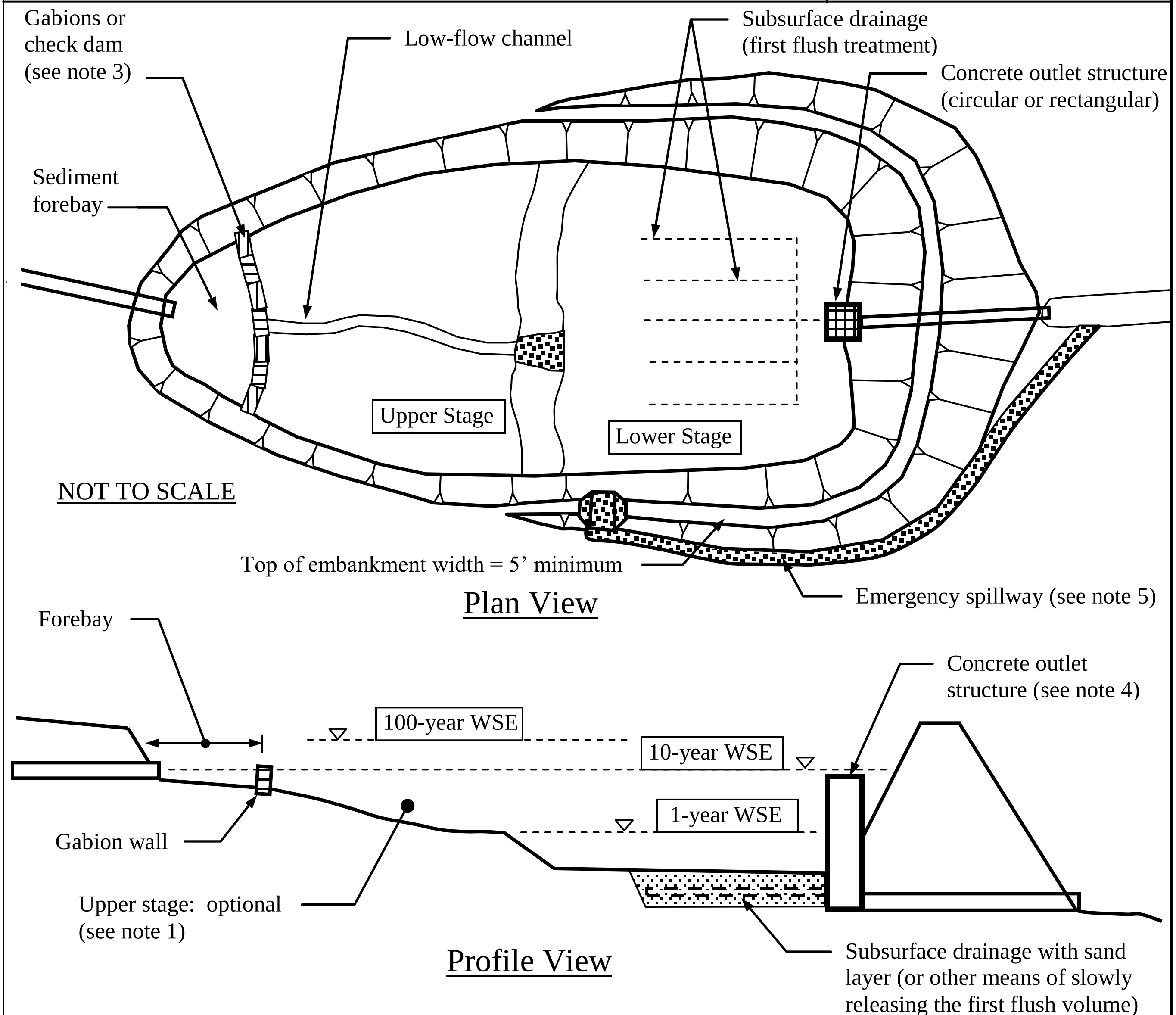
Limitations

- A dry detention basin will require frequent inspection and maintenance. Trash, debris, leaves and other large items should be removed from the detention basin following each rainfall event. If upstream erosion is not properly controlled, dry detention basins can be maintenance-intensive with respect to sediment removal, nuisance odors, insects and mosquitoes, etc. Municipalities should develop clear policies on who is responsible for maintaining detention basins.
- A dry detention basin may not have sufficient vegetation on the slopes and bottom to prevent erosion. Vegetation must be maintained and cut at adequate intervals. Remove grass clippings from detention basin immediately after cutting, using rakes or other hand equipment.
- A dry detention basin that impounds more than 30 acre-feet of volume (and minimum 6 feet high) or which is higher than 20 feet (and minimum 15 acre-feet of volume) is subject to the Tennessee Safe Dams Act of 1973 and as amended by law. The Safe Dams Act is administered by the TDEC Division of Water Supply; further information on design standards, regulations and permit applications is available at the TDEC website:

  http://www.state.tn.us/environment/permits/safedam.htm
- Dry detention basins require a relatively large surface area (typically 1% to 3% of the contributing drainage area) in order to provide sufficient pond volume for detention and water quality. Dry detention basins require a differential elevation between inlets and outlets, for which extremely flat areas may not be suitable.

Additional Information

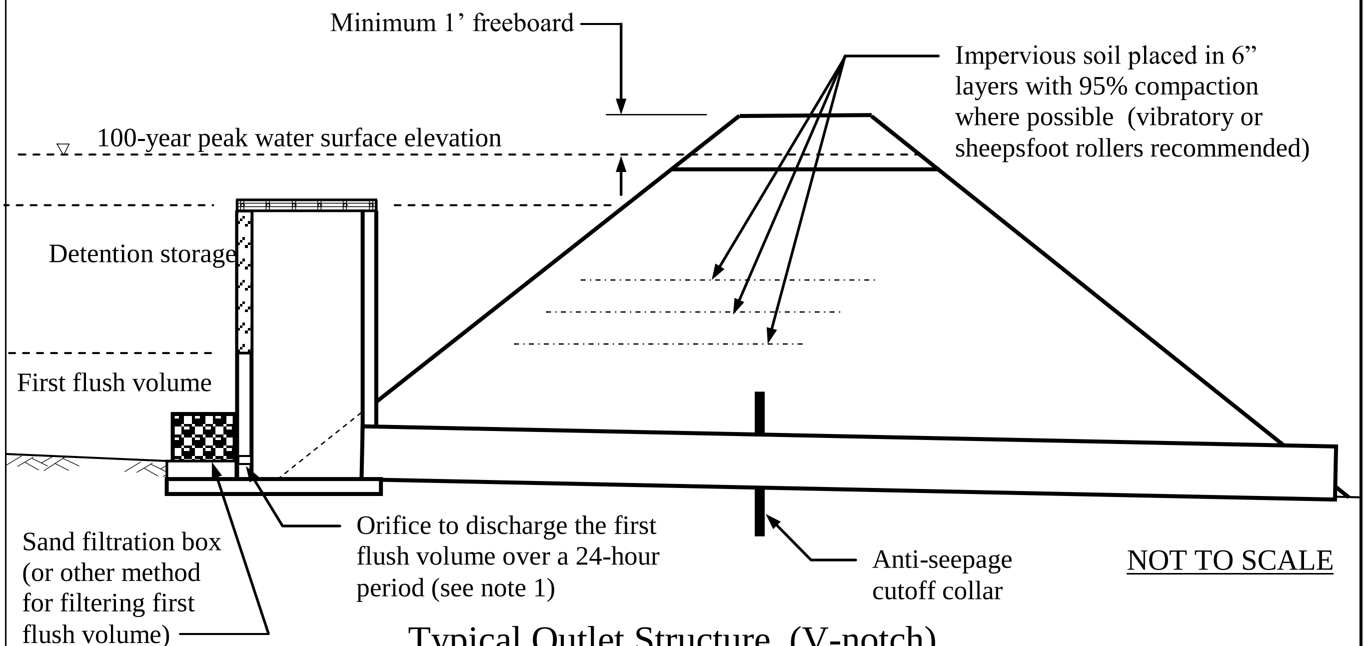
See attached figures.



Notes:

1. This example of a typical dry detention basin layout shows an upper stage which is used for stormwater detention on infrequent storms. An upper stage can also be located on the side of a dry detention basin, eliminating the need for a low-flow channel.
2. The lower stage is typically sized to handle the first flush volume or the 1-year design storm, whichever is greater.
3. A forebay can be constructed from gabions, rock check dams, or a separate berm with culvert. A forebay can facilitate the capture and cleanup of coarse sediments, debris and trash.
4. The outlet structure typically has orifices or weirs at computed elevations that will release the 1-year, 2-year, 5-year and 10-year storms at the specified predevelopment peak flow rates. Certain watersheds are also required to detain the 100-year design storm.
5. The emergency spillway is generally constructed on natural ground or excavated areas (rather than fill soils) to reduce the potential for erosion and washout.

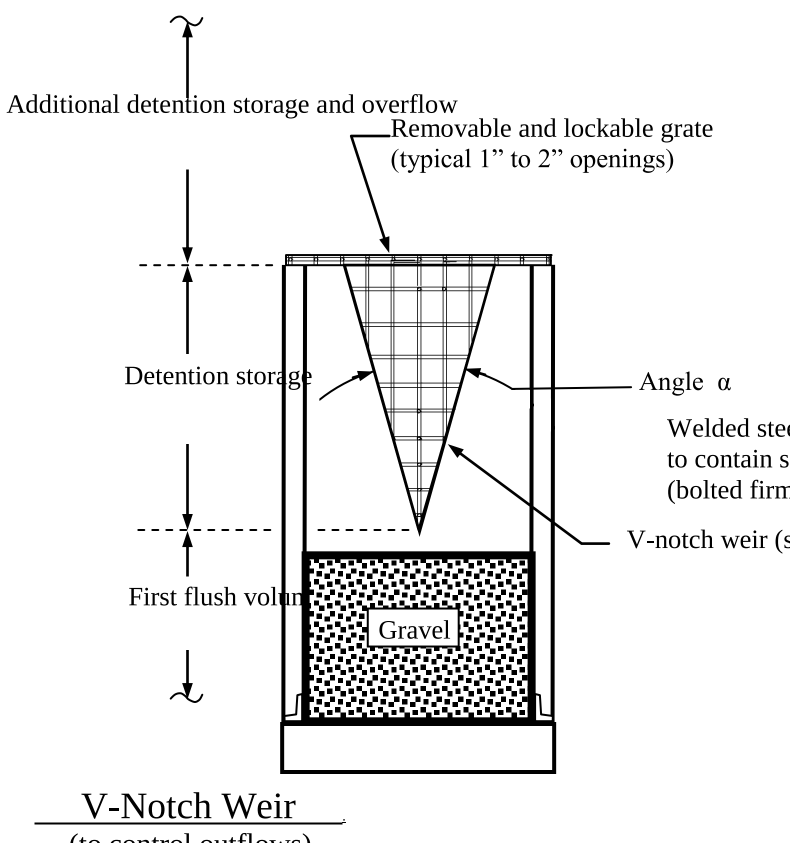
Figure P-01-1
Typical Dry Detention Basin Layout



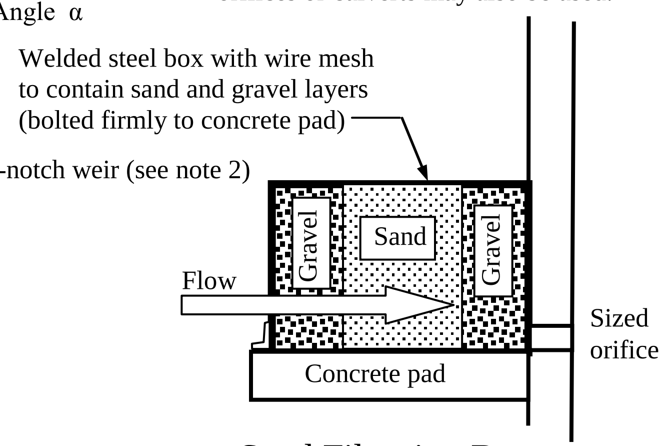
Typical Outlet Structure (V-notch)

Notes:

1. The orifice is sized to release the first flush volume over a period of 24 hours. Protect the orifice from clogging by a sand filtration box, gravel filtration box or with a trash rack.
2. This example of a typical outlet structure shows a V-notch weir which should be sized to release the 1-year, 2-year, 5-year and 10-year storm peak flows at the predevelopment rates. Other control geometries such as orifices or culverts may also be used.

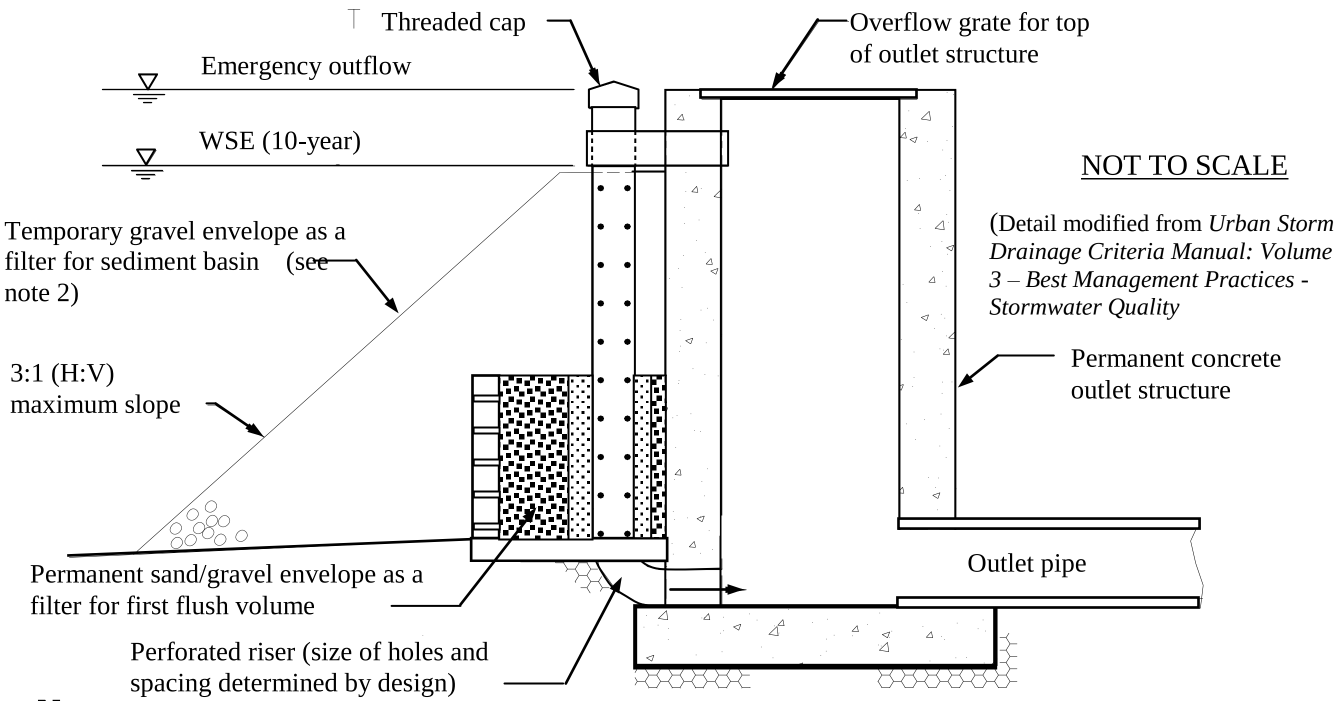


V-Notch Weir
(to control outflows)



Sand Filtration Box
(first flush release)

Figure P-01-2
Typical Outlet Structure
(shown with a V-notch weir & sand filtration box)



Notes:

1. This type of outlet structure may be used as a permanent outlet structure for a dry detention basin. Maintain clean sand/gravel envelope in unclogged condition within an enclosure in front of outlet structure to protect the perforated riser.

OR

2. This type of outlet structure may be used as a temporary modification to a dry detention basin (so that it may also be function as a sediment basin). A temporary plastic riser is securely fastened using bolts, screws or threaded connectors.

Figure P-01-3
Outlet Structure – Alternative A
(also shown as a temporary sediment basin during construction)

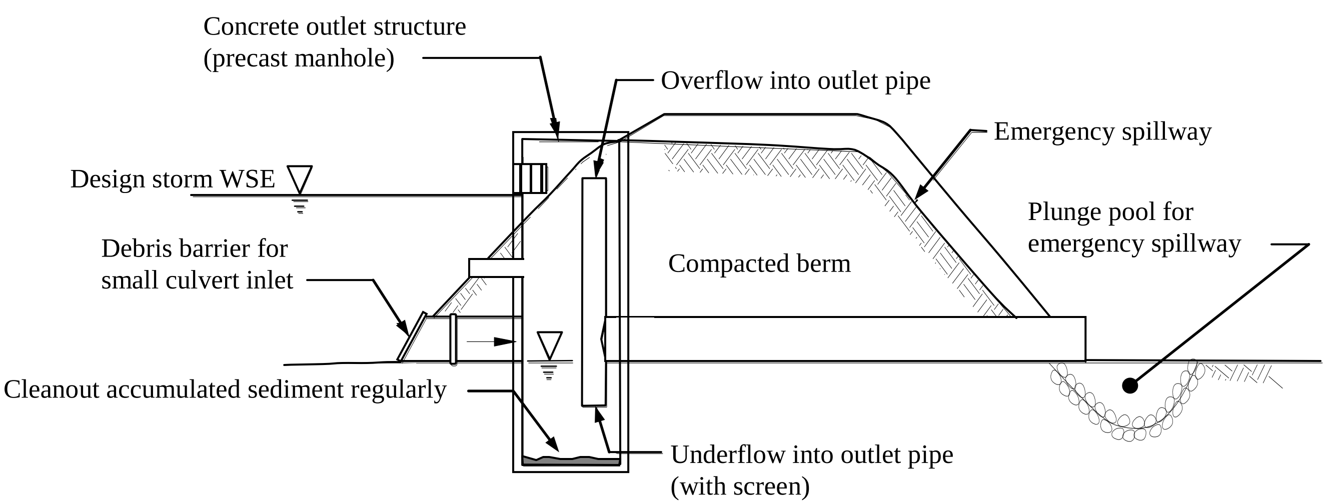


Figure P-01-4
Outlet Structure – Alternative B
(includes water quality manhole with underflow)

A backslope drain has two purposes:

1. Safely convey stormwater to the bottom of a detention basin slope.
2. Increase flow paths by channeling stormwater into the detention basin far from outlet structure.

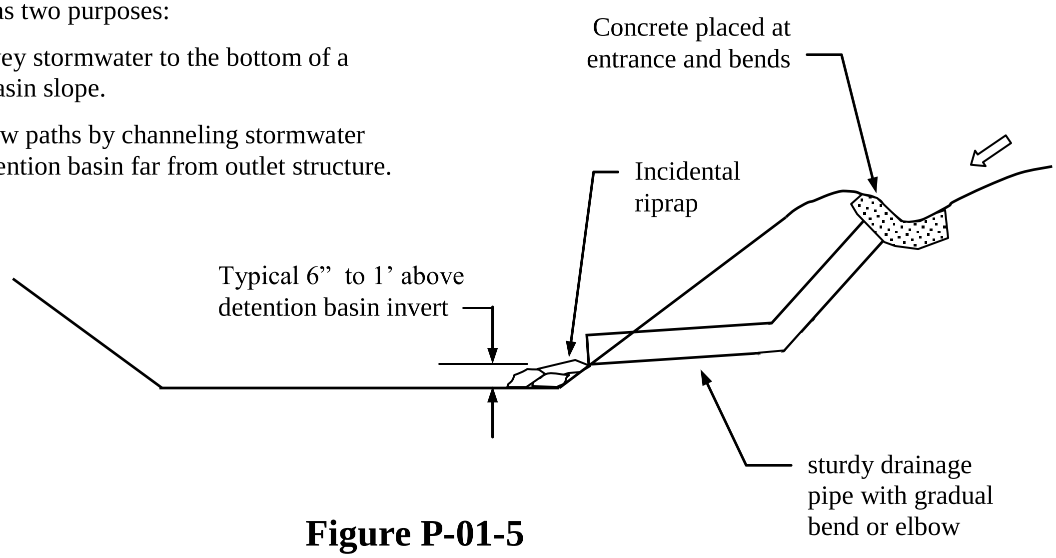


Figure P-01-5
Typical Detail - Backslope Drain

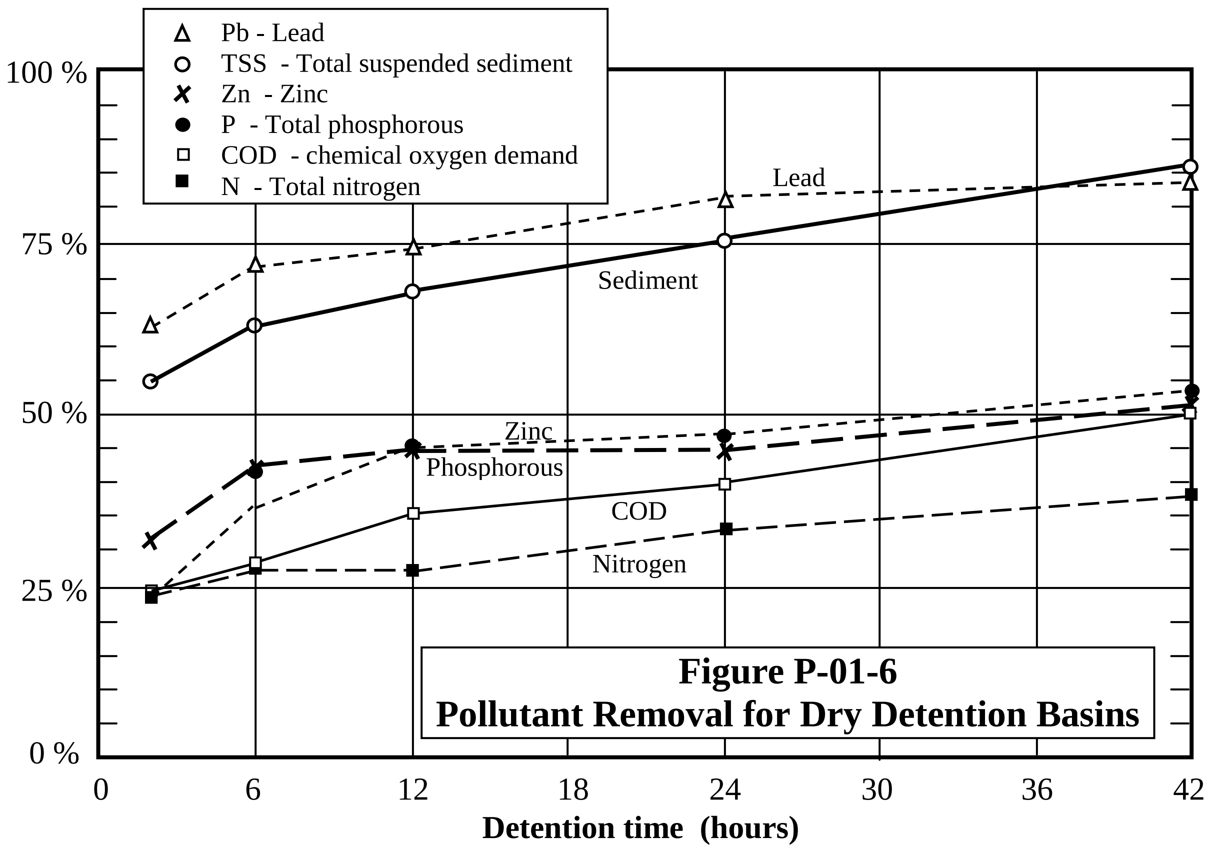


Figure P-01-6
Pollutant Removal for Dry Detention Basins

References

Austin (city of), Texas, *Environmental Criteria Manual*, 1989.

Camp Dresser & McKee, *Sevenmile Creek Basin Pilot Stormwater Quality Master Plan*, Report to Metropolitan Nashville and Davidson County, Tennessee, February 2000.

Camp Dresser & McKee, Larry Walker Associates, Uribe & Associates, Resources Planning Associates, *Industrial/Commercial Handbook, California Storm Water Best Management Practice Handbooks,* for the California Storm Water Quality Task Force (SWQTF), March 1993.

Camp Dresser & McKee, Woodward-Clyde, Aguilar Engineering, Psomas & Associates, MK Centennial, *Construction Contractors Guide and Specifications, Caltrans Storm Water Quality Handbooks*, prepared for the California Department of Transportation, 1997.

Charlotte (city), Mecklenburg County, Debo and Associates, Ogden Environmental and Engineering Services, *Charlotte Mecklenburg Storm Water Design Manual,* July 1993.

Dewberry & Davis, *Land Development Handbook,* Editors S.O. Dewberry and J.S. Matusik, McGraw-Hill Inc, 1996.

Federal Highway Administration, *Debris-Control Structures, Hydraulic Engineering Circular No. 9*, March, 1971.

Galli, John, *personal communication to Camp Dresser & McKee*, Metropolitan Washington Council of Governments (MWCOG).

GKY and Associates, *Outlet Hydraulics of Extended Detention Facilities*, for the Northern Virginia Planning District Commission, 1989.

Hartigan, P., *personal communication to Camp Dresser & McKee*, Washington Department of Ecology (formerly with the City of Austin).

Maine Department of Environmental Protection, *Stormwater Management for Maine: Best Management Practices*, November 1995.

McCormick, C.D., F.M. Schmidt, and C. Hasty, *Retrofitting Existing Dry Ponds to Benefit Stormwater Quality*, Tennessee Society of Professional Engineers (TSPE) Professional Development Seminar, March 1999.

McCuen, Richard H., *Hydrologic Analysis and Design*, Prentice Hall, 1998, 814 pp.

Merritt, F.S., M.K. Loftin, and T.J. Ricketts, *Standard Handbook for Civil Engineers*, Fourth Edition, McGraw-Hill, 1996.

Metropolitan Washington Council of Governments (MWCOG), *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Nonpoint Source Pollution in the Coastal Zone*, Publication #92705, March 1992.

Metropolitan Washington Council of Governments (MWCOG), *Nationwide Urban Runoff Program Pollution Removal Capability of Urban Best Management Practices in the Washington Metropolitan Area*, PB84-245497, 1983.
Northern Virginia Planning District Commission (NVPDC), *BMP Handbook for the Occoquan Watershed*, 1987.

Randall, C.W., K. Ellis, T. Grizzard and W. Knocke, *Urban Runoff Pollutant Removal by Sedimentation*, Proceedings of the Conference on Stormwater Detention Facilities, Henniker NH, ASCE, pages 205-219, August 2-6, 1982.

Roesner, L.A., J. Aldrich, J. Hartigan, et.al., *Urban Runoff Quality Management – WEF Manual of Practice No. 23 / ASCE Manual and Report on Engineering Practice No. 87*, 1998.

Romans, Terry E., *Performance Analysis of Constructed Urban Stormwater Detention Ponds*, M. S. Thesis, University of Tennessee, Civil and Environmental Engineering Department, Knoxville, December 1997, 249 pp.

Tennessee Safe Dams Act of 1973, TCA, Section 69-12-101, as amended. 1991.

United States Department of Agriculture (USDA), Soil Conservation Service (SCS), *Urban Hydrology for Small Watersheds*, Technical Release 55 (TR-55), June 1986.

Urban Drainage & Flood Control District, Denver Colorado, *Urban Storm Drainage Criteria Manual: Volume 3 – Best Management Practices - Stormwater Quality*, September 1999.

Virginia Department of Conservation and Recreation, *Virginia Stormwater Management Handbook*, First Edition, 1999.

Whipple, W., and J. Hunter, *Settleability of Urban Runoff Pollution*, Journal of Water Pollution Control Federation, Volume 53, Number 12, pages 1726-1731, December 1981.