

- NOTES:
1. When calculating flow to a structure if all run-off to the structure is from impervious areas (i.e. pavement & roofs) the C to be used is 0.90.
  2. The lowest range of run-off coefficients may be used for flat areas (areas where the majority of the grades and slopes are 2% and less).
  3. The average range of run-off coefficients should be used for Intermediate areas (areas where the majority of the grades and slopes are from 2% to 5%).
  4. The highest range of run-off coefficients shall be used for steep areas (areas where the majority of the grades are greater than 5%), for cluster areas, and for development in clay soil areas.

#### 504.00 GENERAL REQUIREMENTS FOR STORM SEWERS AND CULVERTS

- 504.01 Deviation from Standards: This Manual shall be followed unless specific deviation therefrom is authorized, in writing, by the Director.
- 504.02 Plan and Profile Sheets: The storm sewer and culvert systems are to be shown in plan and profile on 24" x 36" sheets.
- A. All construction information, including invert elevations (in and out), size, type of pipe, gauge, length and percent of slope shall be shown on plan and/or profile.
  - B. All storm sewer appurtenances shall be identified by type and number (i.e., DI-3B, Y1-1), including number of throats and locations on both plan and profile.
- 504.03 Pipe Materials: All pipe used for the construction of storm drainage systems shall be concrete. Corrugated metal pipe can be used for culverts where permitted.
- A. Concrete pipe whether designated for use within the right of way of a public street or thoroughfare or beyond the limits of a street right-of-way shall meet the three-edge-bearing strength test requirements for ASTM C76 Class III reinforced concrete pipe; latest revision. Culvert pipe classed as "seconds" by the manufacturer of pipe which has been rejected from another project shall not be permitted for use. Class will be increased above these requirements based on height of cover.

- B. Corrugated metal pipe culverts, where permitted by the Director and the Virginia Department of Transportation, shall meet the requirements of current Virginia Department of Transportation Designs and Standards.
- 504.04 Pipe Culvert Sizes: The minimum size for pipe culverts for storm drainage shall be fifteen (15) inches, except when used under driveway entrances without curb and gutter where 12 inch culverts may be permitted. Larger sizes may be required if deemed necessary by the Director and smaller sizes might be allowed if approved by the Director as being of adequate hydraulic design.
- 504.05 Structure Locations: A manhole or inlet shall be constructed at every change in line and grade or change in pipe culvert size. All storm sewers shall be straight between manholes, catch basins, or other appurtenances. At every structure there is required a minimum of 0.10 drop in inverts for pipes having the same diameter. Pipes 18 inches in diameter or larger may be constructed on horizontal curves. Radius and deflections shall not exceed 1/4 of the spigot length or as recommended by the pipe manufacturer. shop drawings shall be submitted to and approved by the Director prior to installation.
- 504.06 Maximum Distance Between Structures: The maximum distance uninterrupted by appurtenances shall be five hundred (500) feet if the pipe diameter is 42" or larger and shall otherwise be three hundred (300) feet.
- 504.07 Reduction of Pipe Size: There may not be a reduction in pipe size along the direction of flow except for stormwater management purposes.
- 504.08 Minimum Cover Requirements: The minimum cover for all drainage culverts within the street right of way shall be 2 feet. When the storm sewer pipe is laid outside the street right-of-way, a minimum of 1' cover shall be required unless subjected to loading conditions, where 2' of cover shall be required. If the minimum cover requirements as set forth in this section, cannot be met, then structural modifications may be submitted for approval by the Director .
- 504.09 Endwalls and Endsections: The ends, entry or exit, of any storm sewer or culvert shall be provided with a standard endwall,

headwall, curb inlet, yard inlet, flared end section or other appurtenance suitable for the intended use of the storm sewer, with the following exception: Twelve (12) and fifteen (15) inch diameter pipe culverts under driveways from streets using open drainage ditches in lieu of an underground system with curb and gutter may not be required to have endwalls. All such structures shall be shown on the plan and profile drawings. The following guidelines will be used to determine whether an end section or endwall will be used:

- A. On culverts or storm sewer inlets and outlets from 12" in diameter to 24" in diameter flared end sections will be used unless the height of fill and side slopes exceeds 20 feet or 2:1 respectively in which case a standard headwall should be used. If the headwater exceeds HW/D ratio greater than 1.5, then a headwall or approved end treatment will generally be required provided it can be installed safely and won't create a potential traffic hazard in the opinion of VDOT or the Director.
- B. On culverts or storm sewer inlets and outlets between 24" and 36" in diameter either standard flared end-sections or headwalls will be required depending upon the height of the fill, the quantity of water, and its velocity for the designed year storm. Generally speaking, a flared end-section can be used if the fills are 20' or less, HW/D is less than 1.5, there is less than 50 cfs inflow, or if the installation of a headwall would constitute a safety hazard in the opinion of the Virginia Department of Transportation and the Director.
- C. If the culvert or storm sewer inlet and outlet exceeds 36" in diameter a standard headwall will be provided unless this headwall would constitute a safety hazard to the traveling public in the opinion of VDOT and the Director, in which case a flared end-section should be considered. It should also be noted that for oval or elliptical shaped pipes the comparative size for round pipes will be used in determining what type of end treatment will be provided.

504.10 Erosion Control at Outlets: Provide erosion protection at the outlets of storm sewer lines and culverts based on outlet velocity in accordance with the following:

- A. 2 fps to 5 fps velocity: sod protection at the outlet (Kentucky Blue Grass or equally erosion resistant sod or other material).
- B. 5 fps to 8 fps velocity: VDOT Class I, dry rip-rap ( VDOT Spec 414.03) or current equivalent.

- C. 8 fps to 11 fps velocity: VDOT Class II, dry rip-rap (VDH&T VDOT Spec 414.03) or current equivalent.
- D. 11 fps to 18 fps velocity: VDOT grouted rip-rap ( VDOT Spec 414.03) or current equivalent.
- E. Velocities in excess of 18 fps shall require special design energy dissipators or impact basins. These structures may be designed in accordance with the following publications: Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Nomograph #25, U.S.Department of the Interior, Bureau of Reclamation; Design of Small Dams, U. S. Department of the Interior, Bureau of Reclamation, or similar text. Appropriate rip-rap protection should be provided in conjunction with these devices to prevent erosion and scour below the structure.

504.11 Placement of Erosion Control Measures: Placement of the above erosion control measures shall be performed in accordance with VDOT Standard 114.01, EC-1 with the following exceptions:

- A. The length of the apron of erosion control shall be calculated by the following formula:  

$$L_a = 0.37V_o D$$
 Where  $L_a$  = apron length required, in feet  $V_o$  = outlet velocity, feet per second  
 $D$  = diameter of pipe, in feet
- B. The minimum depth of Class II rip-rap (414.03) shall be 24" (2 feet). If necessary, appropriate notes and/or details for construction of these erosion control measures shall be included on the plans.

504.12 Erosion Control Guidelines: In an effort to eliminate the numerous erosion problems and subsequent construction failures which have occurred at the outlets of storm sewer systems, the Director recommends the following guidance for laying out and designing storm sewer systems:

- A. The outlet end of the storm sewer system should, without exception, discharge directly into a stabilized existing drainageway.
- B. The outlet end of the storm sewer system should be as

compatible as possible with the grade, horizontal and vertical alignment and location of the existing drainageway into which it will discharge.

- C. Placing outlet structures or storm sewer systems on fill material should be avoided. If the outlet is on fill extra erosion protection is required.
- D. Placing erosion protection at outlets on fill material should be avoided. Should it be necessary for some reason to deviate from items (a) and (b) above, the preferred alternative would be a stabilized ditch of adequate capacity to convey the design storm flow from the outlet structure to the existing drainageway. However, any such deviation from the above stated policy will be subject to the review and approval of the Director.

504.13 Flow Velocities Exceeding 20 Ft/Second: For velocities in storm pipes greater than 20 fps based on 10 year frequency storms, pipe manufactured with 6000 psi concrete and meeting the strength requirements of ASTM C76 Class III and Class IV latest revision, as required for the intended use and location shall be required. Where velocities exceed 20 fps special designs will be required for consideration by the Director.

504.14 Manning's Formula: Storm sewer pipe sizes are to be determined by using Manning's Formula:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

with a minimum coefficient of roughness for the following types of pipes:

concrete pipe	0.013
corrugated metal pipe culverts with paved invert	0.021
plain corrugated metal pipe	0.024
field bolted arch pipe	0.030

- 504.15 Spread on Streets: Storm sewer systems must be designed and constructed in accordance with the VDOT Drainage Manual.
- 504.16 Drainage Across Intersections of Streets with Curb and Gutter: Whenever curb and gutter construction is proposed, storm water shall not be allowed to cross the surface of street intersections except in unusual circumstances where subsurface conveyance of storm water is deemed impractical (due to the distance to the nearest structure) by the Director and provided that the surface storm water flow does not exceed 2 cubic feet per second. In such cases the means of surface conveyance shall be approved by the Director and the Resident Engineer of the Virginia Department of Transportation.
- 504.17 Drainage Across Intersections of Streets without Curb and Gutter: Whenever streets without curb and gutter are proposed, no water shall be allowed to cross a street intersection. The water must be handled by a storm sewer pipe or system.
- 504.18 Headwater and Tailwater Computations: Headwater and tailwater computations must be submitted on standard forms approved by the Director (See Plate V-G). The maximum allowable headwater depth is that depth where the water does not exceed a height greater than 18 inches below the edge of the roadway shoulder, or where the depth of the ponded area exceeds 15 feet.
- 504.19 Easement Widths for Storm Sewer Systems: The widths of drainage easements shall not be less than as prescribed in the following table and shall be shown on plan and profile sheets and record plats:

15" to 18" pipe	15' easement
21" to 33" pipe	20' easement
36" to 48" pipe	25' easement
54" to 72" pipe	30' easement

For trench depths greater than six feet (6'), five feet of additional easement width shall be required for each five feet increment of additional depth.

All storm sewers shall be placed within the middle third of the easement.

- 504.20 Easement Widths for Open Drainageways: All open drainageways (areas of concentrated flow) will be in a minimum drainage easement of fifteen (15) feet. For open drainageways (areas of

concentrated flow) an easement is required of sufficient width for proper construction and maintenance based on the drainageways slope and typical cross-section. Drainage ditches shall be designed and constructed in accordance with the current Virginia Department of Highways Transportation Drainage Manual. The computations shall be submitted to the Director and the ditch shall be shown on the plan and profile with a typical section. Stabilization will be required based on velocity. Easements shall be shown on the record plat.

- 504.21 Flood Plain Studies: Flood plain studies, when requested by the Director shall be based upon the 100 year frequency rainfall curve. Two copies of the study shall be submitted which shall include plan and profile, topography contour intervals, flood level line, freeboard line and all lots adjacent to flood plain limits. Flood plain studies will be required whenever the drainage area is greater than 100 acres.

Flood plain studies may be required with a drainage area greater than 40 acres if there are lots proposed adjacent to the stream, it is a high density area and if the upstream development (actual or proposed) is not controlled, or planned to be controlled, by storm water management devices. In addition to determining the 100 year flood plain, the Director may require calculation of a floodway.

Flood plain studies may be required for drainage areas less than 40 acres. If there are lots proposed adjacent to the stream on which the proposed building site is less than 10 feet above the flow line of the stream. In such cases where the flood plain study is not required, a building restriction line shall be shown on the plat which conforms, as a minimum, to the contour which is 10 feet above the flow line of the stream. An easement shall be required for the flood area as established above.

- 504.22 Drainage Computation Sheets: Drainage computations sheets shall be submitted on forms approved by the Director. This shall include consideration of on-site and off-site drainage.
- 504.23 Overland Relief: All storm drainage systems must be designed to, as a minimum, provide overland relief for the 100 year storm without damaging or endangering nearby buildings.
- 504.24 Drainage/Flow Arrows: Drainage arrows are to be shown on curb and gutter, storm sewers, ditches, on-site pavement and drainage

areas.

- 504.25 Minimum Allowable Clearance: Minimum allowable clearance between storm sewer and any other underground piping shall be 18 inches.
- 504.26 Erosion Protection at End of Curb and Gutter: Erosion protection shall be placed where curb and gutter ends on fill sections or any soil which has eroding characteristics as determined by the Director.
- 504.27 Paved Ditches: In addition to other situations that require paved ditches, paved ditches shall be required in accordance with VDOT specifications. All paved ditches shall be shown in plan and profile by stationing and grade. A typical section of proposed ditch shall be shown on plans. Transitioning of paved ditches to other appurtenances shall be shown.
- 504.28 Construction to Property Line: All storm sewer pipes or systems including energy dissipating devices shall be constructed to the back of property line to protect adjacent properties. Where a storm sewer system terminates at a rear property line above the toe of a fill slope, the storm sewer system shall be continued to the toe of the slope either by means of additional sewer pipe or paved ditch.
- 504.29 Curb Inlets in Sag Points: For curb inlets occurring in sag points of the roadway, a minimum length of throat of six feet (6') shall be required and shall be calculated based on a 0.1% grade.
- 504.30 Major Culvert Design: All major culvert designs will be in accordance with the Virginia Department of Transportation drainage policy.
- 504.31 Ditch Linings: In storm drainage systems, permanent ditch liners of part-circle sections of bituminous or asbestos fiber pipe, or plastic or similar materials of light weight with non-rigid properties, are not acceptable. Ditch liners of part-circle sections of heavy weight, rigid pipe, such as cement concrete may or may not be acceptable depending on conditions, means of jointing and anchoring provided, bedding indicated, etc. Ditch linings of poured concrete are generally acceptable for most situations.
- 504.32 Storm Sewer Construction on Steep Grades: The need for anchors must be investigated when concrete storm sewers are laid on steep grades. Give careful attention to providing effectual anchors to



prevent sliding when the slope exceeds 16%, and erosion control at the outlet to prevent undermining of the endwall. Generally, slopes over 20% are not acceptable unless specifically approved by the Director.

504.33 Standard Details - Drainage Structures: Structures and appurtenances for inlets, curb and gutter, endwalls, junctions, etc., shall conform to the current edition of the Road Designs and Standards of the Virginia Department of Highways and Transportation unless approved otherwise in writing and on the plans by the Director. The use of precast structures from an approved manufacturer as per VDOT will be allowed.

505.00 GENERAL REQUIREMENTS FOR INSTALLATION OF DRAINAGE APPURTENANCES

505.01 Construction Stakeout: Prior to the construction of any storm drainage system, the owners' or developers' engineer or surveyor shall place adequate line and grade stakes and shall also set stakes and furnish grades so that all manhole tops can be set to finish grade, all in accordance with approved plans.

505.02 Trenches: The provisions of Section 204.02 of this manual shall apply to the construction of trenches to contain storm drainage systems.

505.03 Bedding: The provisions of the current sections of the VDH&T VDOT Specifications shall apply for the bedding requirements of storm drainage systems.

505.04 Backfilling: In addition to the provisions of Section 204.02 of this manual, all storm drainage pipe culverts shall be backfilled to a minimum depth of cover of two (2) feet above the top of the pipe.

If necessary when the storm drain occurs under curb and gutter, a minimum of nine inches (9") clearance from the bottom of the gutter may be permitted by the Director.

505.05 Pipe Materials: Unless otherwise approved in writing by the Director, or unless specifically indicated on plans having his approval, all pipe used for construction of storm drainage systems shall be concrete culvert pipe, meeting the current and appropriate specifications of the American Society for Testing Materials. The laying length shall not be less than three (3) feet.