

SECTION 3 – DRAINAGE

3-1 General

All Drainage plans for proposed development shall be prepared by a Professional Engineer registered in Virginia, except as noted below. Further, their seal and signature shall be placed on the plans.

A Land Surveyor, registered under Section 54.1-408 (formally 54-17-(3b)) of the Code of Virginia, may prepare construction plans for surface drainage, sanitary sewer, water lines and detailed site grading, for subdivisions only, provided such work does not involve design of closed storm drainage systems, bridges or other structures requiring detailed stress analysis, or design of sewage or water treatment plants, pump stations or other work requiring mechanical or electrical equipment.

3-2 Drainage Ordinances and Legal Requirements

All design and construction of site grading and drainage, both surface and subsurface systems, shall comply with all applicable drainage laws, ordinances and standards.

Storm sewers carrying drainage from adjacent properties through the property to be developed shall be installed in easements. Storm sewers carrying drainage from public facilities or right-of-ways through the property to be developed shall be installed in an easement dedicated to the County of Henrico. A Maintenance Agreement (see sample in the Appendix of the Henrico County Environmental Program Manual) is required for stormwater management facilities for water quality and or quantity, which accommodate drainage from public rights-of-way. A drainage easement shall be recorded through all stormwater management facilities and shown on the plan of development.

Offsite drainage easements must be recorded prior to plan approval. Easement plats must be prepared by the developer and submitted to the Department of Public Works for approval. The approved plat shall be forwarded to the Real Property Agent for preparation of the Deed of Easement, and processing of the documentation to the Clerk of the Circuit Court.

3-3 Offsite Drainage

The Department of Public Works shall review all subdivision plans, PODs and building permits to insure there are provisions by the developer for adequate drainage off the site. Such drainage improvements shall be adequate for a minimum 10-year design frequency, unless a 100-year flood study is required of the developer. A 100-year flood plain study shall be required when the offsite drainage area onto the site is greater than 100 acres in accordance with County Code. In the event that a FEMA flood plain is shown to exist on the FEMA panel for the area being developed, or the drainage area is sufficient to justify a FEMA flood plain, the study shall meet the requirements for development within a FEMA flood plain in addition to any County requirements. Required flood studies and flood plain amendments shall be approved prior to approval of site development plans.

Offsite drainage easements necessary for the project completion must be recorded and the corresponding deed book and page number shown on the construction plans prior to approval. Flood plains for the 100-year flood event shall be shown on recorded plats for all land development in accordance with Section 3.8 of this Manual.

Drainage easements for flood plains shall be dedicated to the County of Henrico and recorded in the Office of the Clerk of the Circuit Court by the developer with a copy of the recorded plat sent to the Real Property Agent.

3-4 Flooding and Storm Water Detention

Storm water detention facility needs were initially identified during the late 1970's as a part of a comprehensive countywide stormwater drainage study. Stormwater detention facilities are required to be provided as a part of commercial development in those watersheds where downstream flooding problems are known to occur or if existing homes are located within the 50-year flood plain. The design of these detention facilities shall be such that the post-developed peak flow from the site for a 50-year storm event does not exceed the pre-developed peak flow rate for a 10-year storm event. A summary of the pre and post developed peak flow rates shall be shown on the construction plan.

Storm water detention facilities intended to alleviate downstream channels or system adequacy issues are not permitted in subdivisions unless specifically approved by the Director of Public Works. This restriction also applies to areas designated by the County Comprehensive Drainage Study as 50/10 detention areas.

Public road projects that are constructed by the Virginia Department of Transportation, the Henrico County Department of Public Works, or their subcontractors are not required to control post-developed stormwater runoff for flooding. A map which identifies those watersheds where storm water detention is required is included in Appendix A.

Storm water detention basins should be designed for future ease of maintenance. The developer shall be responsible for all required maintenance of the storm water detention facility.

All storm water maintenance facilities must have a maintenance agreement on file with the Department of Public Works.

3-5 Adequate Outfall

“Adequate channel” means a watercourse that will convey the designated frequency storm event without overtopping its banks or causing erosive damage to the bed, banks and overbank sections of the same.

Adequacy of all channels and pipes shall be verified in the following manner with supporting calculations and cross-sections shown on the construction plans:

1. The applicant shall demonstrate that the total drainage area to the point of analysis within the channel is one hundred times greater than the contributing drainage area of the project in question; or
2. The channels and pipes will be analyzed as follows;
 - a. Natural channels shall be analyzed by the use of a two-year storm to verify that stormwater will not overtop channel banks nor cause erosion of channel bed or banks; and
 - b. All previously constructed man-made channels shall be analyzed by the use of a ten-year storm to verify that stormwater will not overtop its banks or cause roadway flooding and by the use of a two-year storm to demonstrate that stormwater will not cause erosion of channel bed or banks; and
 - c. Pipes and storm sewer systems shall be analyzed by the use of a ten-year storm to verify that stormwater will be contained within the pipe or system.

Concentrated stormwater runoff leaving a development site must be discharged directly into a well-defined, natural or man-made offsite receiving channel or pipe. If an adequate outfall does not exist, one must be constructed to convey stormwater to the

nearest adequate channel and all necessary easements for the outfall must be obtained/acquired by the developer.

Where an increase in runoff due to development is likely to cause damage to existing private and/or public facilities downstream, the developer shall be required to make the necessary improvements to obtain an adequate outfall. The improvements shall be to a point where the drainageway can adequately handle the runoff. Improvements may include one or more of the following:

- The developer shall provide facilities within the limits of his property to drain onsite runoff and estimated future upstream runoff based on the current County Land Use Plan.
- Where it becomes necessary to alter the outfall condition from the development to an offsite point by lowering the existing grade or improving the existing drainageway, the offsite improvement required shall be considered “necessary” for onsite development. Offsite drainage outfall improvements must be provided to a point where an adequate outfall can be obtained and all necessary easements for the outfall must be obtained/acquired.

3-6 Open Channels

Open channels, except for roadside ditches are not permitted with development unless this requirement is otherwise superceded by State and/or Federal requirements.

3-7 Paved Invert

Where open ditches or channels are permitted, the minimum design shall be based on a 10-year design storm. Where open ditches or channels are to be paved, paving shall be concrete reinforced with welded wire fabric when required in accordance with VDOT specifications unless otherwise approved by the Department of Public Works.

3-8 Flood Plain

The 100-year flood plain is used to delineate areas subject to inundation and to restrict construction of buildings within an area subject to flooding as a result of major storms. Flood plain requirements for land development shall be in accordance with Chapter 24

of the County Code. The flood plain shall be determined by a qualified professional engineer whenever there is a possibility of buildings or roadways being flooded, without regard to drainage area. Evidence of FEMA approval must be obtained for all regulated development within FEMA flood plains.

Flood plains shall be determined for all major drainage areas, which have a contributing watershed in excess of 100 acres. However, where conditions so dictate, smaller drainage areas may require flood plain calculations. All flood plains shall be calculated based on a 100-year design flood unless a higher flood frequency is advisable or if required by the Director of Public Works. Whenever a FEMA flood plain exists on a site proposed for development, the required amendments and revisions to the FEMA flood plain must be approved prior to approval of the site development construction plans.

The developer's engineer shall use the backwater analysis for flood plain engineering design to determine flood flows and calculate cross sections for determining flood plain limits. Cross sections, stream bed profiles, water surface profiles, topographic maps and any other related data shall be prepared by the developer's engineer and be submitted to the Department of Public Works, in order to verify and record flood plains for future reference. If a revision to a FEMA flood plain is proposed, the flood study and the amendment to the flood plain must be approved by FEMA.

Finished floors of all structures adjacent to a flood plain shall be a minimum of 1 foot above the 100-year flood plain elevation.

Flood Plain Improvements

The engineer or developer shall consult the Department of Public Works prior to planning any project adjacent to rivers, streams, watercourses, lakes and drainageways to verify general requirements, restrictions and improvements that may apply to a particular property.

In no way shall the 100-year flood flow be restricted or impeded.

Filling operations shall not take place within the 100-year flood plain unless a compensating channel is provided. Although compensation is permitted by the County in the 100-year flood plain, FEMA and the Corps of Engineers may also have jurisdiction over filling operations and impacts to wetlands.

The flood plain may be cleared of all debris, scrub growth and improved to be consistent with the type of development using accepted design principles to minimize maintenance problems. The Henrico County Landscape Ordinance, Erosion and Sediment Control Ordinance, and Controlled Density Ordinance will take precedence over this standard.

3-9 Water Quality

Water quality requirements (Chesapeake Bay Act and NPDES) are as stated in the Henrico County Environmental Program Manual, chapters 2 and 3, latest revision and as mandated by Chapter 10 of the County Code.

3-10 Wetlands

Wetlands requirements are as stated in the Henrico County Environmental Program Manual, chapter 7, latest revision.

3-11 Site Grading

Site grading shall constitute any construction causing changes in elevation of existing ground surfaces or alteration of existing surfaces in any way that would affect surface or subsurface drainage flow.

No change in elevation of a site shall be permitted if it will restrict the normal surface flow onto the property unless appropriate drainage is provided.

All grading shall be performed in such a manner as not to cause erosion and shall be in keeping with the Erosion and Sedimentation Control Ordinance.

3-12 Underdrains

As a minimum requirement, VDOT Standard UD-1 underdrains shall be installed at all drop inlet locations in curb and gutter sections to intercept subsurface drainage; 25 feet in each direction of sag inlets and 25 feet on the upside of on-grade inlets. These requirements may be waived on Road Classifications V through IX, since Standard UD-4 underdrains are required for positive lateral drainage on all roadways with a design ADT of more than 1,000 vehicles per day.

In addition, Standard CD-1 underdrains shall be installed under all vertical sags including roads without curb and gutter. Standard UD-2 underdrains shall be installed in

all raised grass medians and/or islands to prevent water infiltration through or under the pavement structure.

If approval is obtained to install an irrigation system in or adjacent to the right-of-way, a condition of approval shall be the installation of an approved underdrain system.

All underdrains shall be installed in accordance with VDOT requirements. The outlet end of all underdrains shall terminate in drainage structures or daylight out of fill slopes with a Standard EW-12 endwall placed at the outlet end of the underdrain.

3-13 Bridge and Culvert Design Criteria

All bridges and culverts shall be of concrete construction and shall be HS 20-44 loading or alternate military loading, or both, in accordance with the VDOT requirements and with the current AASHTO bridge design specifications. All supporting design calculations for the structure shall be submitted with the bridge plan for approval. The construction plans, design calculations and specifications shall be signed and sealed by a professional engineer responsible for the structural design. The engineer shall be responsible for geotechnical and associated engineering during construction and shall perform independent inspections to insure compliance of the plans and specifications. Prior to acceptance, the engineer shall submit a signed and sealed certification that the structure was built in accordance with the plans and specifications.

Travel lanes, clear of all obstructions, shall be in accordance with the road cross-section details for the road classification. All drainage facilities for bridges shall be in accordance with current VDOT requirements and this Manual.

3-14 Dams

Any newly constructed or existing dam which is regulated under the Virginia Dam Safety Act shall obtain approval under the Virginia Dam Safety Regulations and the Department of Conservation And Recreation, as well as the Department of Public Works. Dams which are not regulated under the Virginia Dam Safety Regulations shall comply with the latest edition of the Virginia Storm Water Management Program Manual. The project engineer shall be responsible for associated geotechnical and civil engineering during construction and shall perform independent inspections to ensure compliance of the design. A signed and sealed certification of compliance shall be submitted to the Department of Public Works upon completion and prior to acceptance.

Analysis

A professional engineer shall certify that the dam's hydraulic and structural design is in accordance with current national, state and local practice. All required permits shall be secured prior to plan approval. When requested by the Department of Public Works, a dam break analysis will be required for any impoundment structure.

Stormwater Management Facilities

When Stormwater Management Facilities (water quality and water quantity) are proposed utilizing an earthen embankment height in excess of 3 feet, the design and construction shall be in compliance with the general requirements for dams in the Virginia Storm Water Management Program Manual. A geotechnical engineer shall certify that construction compaction requirements have been achieved. Facilities for subdivisions will not be accepted for County maintenance until the geotechnical certificate is provided and accepted by the Department of Public Works.

Roadways on Dams

If a roadway is proposed on a dam, an agreement acceptable to the Director of Public Works, the County Attorney's Office and the Real Property Office shall be provided prior to plan approval. Other requirements and conditions particular to the proposed dam may apply in addition to the requirements of this Manual. The use of the roadway, as an emergency spillway shall not be allowed.

3-15 Roadway Drainage

Inlets shall be located at the low point of all sag vertical curves and on continuous grades where the spread exceeds the following (maximum gutter flow spread, 2 year design storm):

- Major and Minor Arterial Roads 8 feet
- Collector Roads 10 feet
- Local Roads 12 feet

Vertical Street Grades (sag condition)

Where the actual curb and gutter grade is less than 0.3 percent, flanking inlets shall be provided.

3-16 Drop Inlets

All inlets, junction boxes and manholes for storm sewer shall be constructed in accordance with the VDOT Bridge Standards and Specifications unless otherwise specified in this Manual.

Inlets shall not be permitted in the curb radius of an intersection.

Inlet throat lengths in excess of 6 feet shall not be allowed in any cul-de-sac.

Yard Drainage

Drainage inlets are required to intercept yard drainage in lieu of open pipe. Front yard drainage structures shall be limited to VDOT Standard DI-1, DI-5, DI-7, and DI-12 structures. All yard inlets and grate inlets must be located at an elevation to drain, with appropriate grading limits shown on the construction plan. When DI-5 and DI-7 structures are utilized, Grate Type III shall be installed in pedestrian areas and Grate Type I shall be installed in wooded areas. Load carrying grates (Grate B) shall be used in areas subject to vehicular traffic. All grates and angle iron shall be hot-dipped galvanized.

Structural Design

All drainage structures shall be of concrete and/or reinforced concrete construction (poured in place or precast) and shall be designed in accordance with the VDOT standards and requirements. Smooth dowels (#4 x 8 inches) shall be provided at approximately 12 inches, on center, in all areas adjacent to abutting concrete to prevent settlement. Precast drop inlets shall not be permitted at locations where the grade on the adjacent curb and gutter is less than 1.5 percent. Precast drop inlets having throats with flat inverts shall not be permitted in sag locations when the total length of the required throat opening exceeds 6 feet.

Hydraulic Design

All inlets shall be designed to intercept drainage based on a 10-year storm.

3-17 Storm Sewers

All storm sewers shall be installed and constructed in accordance with VDOT Road and Bridge Specifications and Standards unless otherwise specified in this Manual.

All storm sewers shall discharge into an adequate outfall channel, or pipe system, which has positive gravity flow to a natural outfall. If such an outfall is not available, it shall be the responsibility of the developer to obtain the outfall easements to construct the outfall system.

Minimum Class of Concrete Pipe

The minimum class of concrete pipe used in the right-of-way shall be ASTM, C-76 Class III pipe. This pipe shall be used in road right-of-way, parking areas, driveways, and all other areas subject to vehicular traffic.

Concrete pipe ASTM, C-76 Class II for sizes up to 24" diameter may be used in easements and areas outside the right-of-way not subject to vehicular traffic.

Abandoned Storm Sewer

Abandoned storm sewers and drainage pipe shall be removed when no longer needed. If removal is not practical, as deemed by the Department of Public Works, the pipes are to be plugged and filled with flowable fill in accordance with VDOT requirements.

Design Requirements for Storm Sewers

The minimum design frequency for storm sewer shall be a 10-year storm.

The minimum pipe size within road right-of-way and public easements will be 15 inches in diameter.

The minimum design velocity in storm sewers shall be two feet per second based on a two-year storm. In no instance, shall the storm sewer design be less than a 0.3% slope.

When velocity exceeds five feet per second, based on a 10-year storm, at the storm sewer discharge, energy dissipation methods are required.

Radial pipe and/or special bends may be used where the design permits or dictates and on approval of the Director of Public Works.

Hydraulic grade lines are required with all proposed storm sewer.

Installation

All drainage pipes and structures shall be installed on a firm foundation as required by the VDOT Road and Bridge Specifications and Standards. A minimum of 4 inches of pipe bedding shall be required under all storm sewer pipes, paved ditches and drainage structures.

Excavation & Backfill

Trench width shall not be less than the outside diameter of the pipe plus 18 inches on each side unless, otherwise approved.

The minimum cover for Class III concrete pipe in roadside ditch sections shall be 9 inches from the top of pipe to finished grade. Storm sewer pipe must be installed at depths that will accommodate minimum height requirements for drop inlets.

Unless otherwise approved, all pipe under public travel ways shall be backfilled with an approved crushed aggregate to a minimum elevation of 12 inches over top of the pipe or to finished subgrade where there is an overlap in elevations for the subsequent layer of pavement structure (provided that the total cover over the pipe is at least 12 inches when the subgrade depth is considered).

Pipes in easements or right-of-way not subject to vehicular traffic must be backfilled with an approved crushed aggregate to the top of the pipe. The remainder of backfill shall be placed and compacted in accordance with the latest edition of the VDOT Road and Bridge Specifications to prevent settlement.

All pipes must be installed to grade as specified on an approved plan. When required by the Department of Public Works, as-built profiles shall be submitted for review.

Roof Drains

Design and inspection of storm sewer relative to connecting roof drains shall be under the jurisdiction of the County Building Official. All connections to the public storm sewer must be submitted to the Department of Public Works for approval and inspection.

Cross Gutter, Valley Gutters

Cross gutters, valley gutters are not permitted.

3-18 Erosion and Sediment Control

Erosion and sediment controls shall be designed and installed in accordance with the Henrico County Environmental Program Manual, chapter 5, latest revision

3-19 Lot Grading and Drainage

1. **Construction Plan Requirements** - An overall lot drainage map shall be included in all subdivision construction plans at a minimum scale of 1"=200', and include the following:
 - a. Flow direction arrows
 - b. Minimum finished floor (MFF) elevation for each lot based on required grading to ensure proper drainage. House locations to be shown as determined necessary by the project engineer.
 - c. Necessary grading and drainage improvements serving multiple lots including fill for low-lying areas and wetlands, and drainage swales.

2. **Building Permit Special Requirements** – Lots which have special building permit requirements shall be identified on the construction plans as follows: **NBP1, NBP2, NBP3.**
 - a. **NBP1 – All lots requiring grading and drainage improvements as defined above.** Submittal of a certification of construction compliance is required by the engineer of record prior to issuance of permit.
 - b. **NBP2 – All lots that include storm sewer outfalls.** Submittal of a certified plat identifying the location of the storm sewer easement and installed drainage improvements is required by the engineer of record prior to issuance of permit.
 - c. **NBP3 –All lots identified as having permit restrictions related to sediment basin/trap locations.**