COUNTY OF HANOVER, VA.

DRAINAGE DESIGN HANDBOOK

DEPARTMENT OF PUBLIC WORKS

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Approved by the Hanover County Board of Supervisors
November 12, 2014

CONTENTS

I. PURPOSE

The purpose of the Hanover County Drainage Design Handbook ("this Handbook") is to prescribe certain design standards and specifications; construction, acceptance, and maintenance criteria; and associated technical criteria specific to Hanover County which are required for compliance with the *Hanover County Code,* Chapter 10, *Environmental Management,* Article I, *Erosion* and *Sediment Control*, Article II, *Chesapeake Bay Preservation*, and Article V, *Stormwater Management*, and with Chapter 12*, Floodplain and Drainage Control,* Article I and Article II.

II. STANDARDS

Except as stipulated in this Handbook all development, designs, construction materials, conveyance systems, structures and appurtenant facilities and structures requiring design approval constructed in Hanover County shall conform with all applicable federal, state and local laws, regulations, orders, guidelines, with manufacturers' recommendations and with the latest editions of the following:

- *Drainage Manual, Road and Bridge Standards, and the Road and Bridge Specifications* and associated *Instructional & Informational Memorandum* prepared by the Virginia Department of Transportation (VDOT)
- *Virginia Erosion and Sediment Control Handbook*, Third Edition, 1992 (VESCH) Chapters 3, 4, 5, and 6 of the Virginia Department of Conservation and Recreation (DCR)
- Virginia Stormwater Management Program (VSMP) Regulations
- Virginia Stormwater Management Handbook, 2nd Edition 2013, prepared by Virginia Department of Environmental Quality (DEQ)
- Virginia Stormwater BMP Clearinghouse, www. http://vwrrc.vt.edu/swc/
- *Field Office Technical Guide* (FOTG) the United States Department of Agriculture (USDA)

In the event of a conflict, the more stringent or restrictive requirement shall prevail. In no event shall this Handbook be interpreted to waive or alter any of the requirements of federal, state or local laws, regulations, orders or guidance except to impose equivalent or more stringent requirements.

III. FORMS; INFORMATION REQUIRED; INTERPRETATION AND ADMINISTRATION

A. All computations shall be provided in standard VDOT/DCR/DEQ format and included in a legible font on the plans.

B. All deeds and agreements required by this Handbook shall be submitted in a form approved by the County Attorney and with content approved by the Director. All submittals shall be in a form prescribed by the Director and shall include information and

calculations deemed necessary by the Director. The Director shall administer and interpret the provisions of this Handbook.

IV. CONSTRUCTION MATERIALS

A. Bituminous concrete shall not be allowed as a temporary or permanent channel lining.

B. Pipe and culvert materials and associated structures shall be of concrete and/or reinforced concrete construction (poured in place or precast) except as noted below:

1. Bituminous coated or aluminized corrugated metal pipe is approved for use for culverts at single family residential driveway entrances, and for temporary installations.

2. High density polyethylene pipe is approved only for use as culverts for single family residential driveway entrances, for temporary installations, or for piping of an individual residential lot and serving only one single-family residential lot.

3. Solid walled plastic pipe is approved for use for temporary installations, and for privately maintained storm drainage systems for non-residential developments outside of public rights-of-way and public easements.

V. STORM SEWER

A. Design of storm sewer systems shall provide for adequate cover for connection of future storm sewer systems from upstream areas. The storm system design shall accommodate the greater of: (i) the flow from the existing upstream conditions, or (ii) the flow from upstream areas at ultimate development conditions in accordance with the latest version of the County's Land Use Plan.

B. No "necking down" of storm sewer pipe is allowed unless multiple pipes, with an equivalent size at least equal to the upstream pipe, are to be installed. In some instances it may be appropriate to allow storm sewer pipes of new upstream development to tie to existing smaller diameter downstream systems if sufficient capacity in the existing system exists. Inlet shaping is required in connecting structures for a transition in such instances.

C. All sewers shall be a minimum size of 15 inches in diameter. This minimum size requirement does not apply to a private storm sewer

system serving an individual single family lot or to private storm sewer systems which convey drainage from rooftop and unpaved areas, with no off-site drainage entering the system.

D. Storm sewer systems shall be designed to meet the minimum design capacity requirement based on Manning's Equation using non-pressurized flow.

E. Hydraulic grade line (HGL) computations are required for all storm sewer systems. Storm sewer profiles shall include the HGL plotted on the construction plan profile sheets. When computing the HGL, flow under pressurized conditions can be considered in order to show the design storm is contained within the system.

VI. OPEN MANMADE and NATURAL CHANNELS

A. Permissible Velocity

1. Open manmade channels shall be designed and constructed to preclude erosion during the 2-year storm and to contain the 10-year storm. Open natural channels shall be evaluated and determined to be safe from erosion during the 2-year storm. Flooding shall be evaluated in accordance with floodplain management requirements in section X of this Handbook.

2. Design calculations for new manmade open channels shall use Manning's "n" values listed in Appendix A, "**Values of Roughness Coefficient "n" (Uniform Flow)**."

3. Analysis of existing open or natural channels shall use the Manning's "n" values listed in Appendix A, "**Values of Roughness Coefficient "n" (Uniform Flow)**."

4. The 2 year storm velocity for new or existing manmade or natural channels shall not exceed the permissible velocity for the soil type and treatment based on the chart found in Appendix B, titled "**Maximum Permissible Water Velocities as a Function of Soil Type."** Newly established grassed lined channels must be lined with a minimum Soil Stabilization Treatment "1" or VDOT EC-2 when velocities exceed 2.5 ft/s.

B. Minimum longitudinal slope for new manmade channels with grass linings = 0.5%.

C. The minimum longitudinal slope for concrete lined channels = 0.5%.

D. When used, concrete lining shall be installed to a depth of at least 110% of the 10 year storm depth.

E. Rip-Rap Lined Channels shall meet the following criteria:

1. Minimum rip-rap size of Class I to be used in all applications.

2. Maximum side slope of 2:1.

3. Minimum rip-rap thickness =18 inches.

4. Minimum channel depth = 18 inches.

5. Rip-rap shall be placed over a layer of filter fabric.

6. Rip-rap shall not be allowed for energy dissipation or channel lining on slopes over 15%.

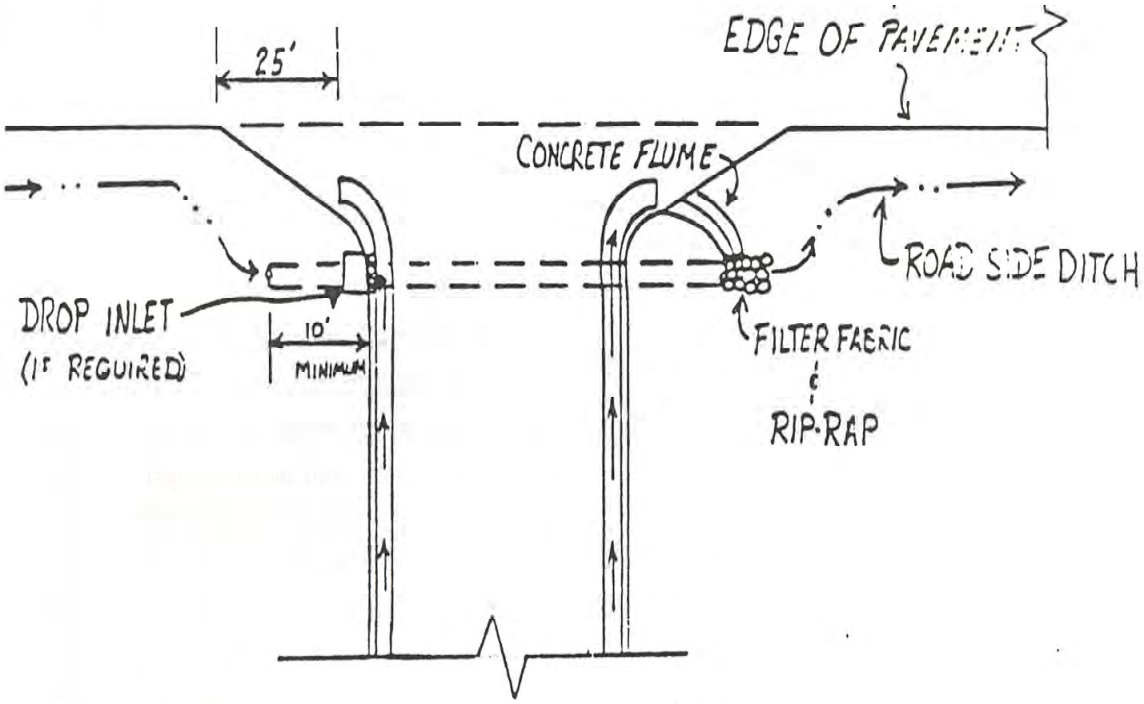
7. Rip-rap channel lining shall not be allowed within 200 hundred feet of residences. The two hundred feet distance will be measured from the front yard set-back line.

F. Where intersecting a street that does not have curb and gutter, the design shall accommodate the conveyance of run-off from the curb and gutter section to the roadside ditch via paved ditch transitions or drop structures. See Figure C-1 for illustration.

G. In residential developments, open channels shall be designed in a manner to permit maintenance by residents. This requires:

1. Maximum side slopes for grassed channels to facilitate maintenance is 3H: 1V, rounded at the top.

2. Longitudinal slope sufficient to allow stormwater to drain unless specifically designed and approved as a Best Management Practice (BMP).



ENDING CURB & GUTTER AT AN INTERSECTION

FIGURE C-1

VII. LOT GRADING

A. General

In all developments, plans shall provide for drainage by gravity of all lands within the boundaries of the project to a natural watercourse, wetland, man-made system, or natural receiving area so as not to create a public nuisance due to increase in standing water not specifically intended for Best Management Practice, Low Impact Development (LID) or Environmental Site Design (ESD) purposes. Measures to allow for efficient dissipation of stormwater shall be provided on all plans.

B. Non-residential (Business, Commercial, Industrial)

In non-residential developments, provide a minimum 0.5% slope to provide positive drainage for all unpaved areas. All unpaved areas shall slope continuously at a minimum 0.5% to lower elevations off

the lot in accordance with the general requirements for lot grading, or to drainage structures on the lot.

C. Residential (Single Family, Multi-Family, Townhouse)
Lot grading plans shall be submitted to and approved by the County in order to obtain building permits for construction. Lot grading plans shall be in substantial conformance to the grading shown on approved construction plans. The owner is responsible for the implementation of the lot grading plan. Should an on-site inspection reveal areas of standing water or areas not in accordance with approved plans, improvements or re-grading to provide adequate drainage shall be required. A Certificate of Occupancy may not be issued if an inspection reveals that work has not been completed in accordance with the approved plan.

D. Lot grading plans shall include the items listed under the "Required attachments" list found on the Erosion and Sediment Control and Chesapeake Bay Permit Application, Form 201, found in the Building Permit Application Package and shall comply with the following criteria:

1. Provide minimum fall of 6 inches from structure in no more than 10 feet, except as restricted by side lot lines or other major considerations, without regard to soil type. Paved areas adjacent to or within 10 feet of the structure need be constructed at an elevation that allows for gravity drainage away from the foundation. The horizontal length of such slopes may be reduced as necessary at building corners and side yards; the 6-inch fall may not be reduced.

2. Provide a minimum 1% slope to provide drainage by gravity for all disturbed areas. All disturbed areas shall slope continuously at a minimum 1% to lower elevations off the lot, or to drainage structures on the lot.

3. Slabs on grade shall be higher than exterior grades.

VIII. IMPOUNDMENTS AND EMBANKMENTS

A. When a permanent dam is proposed within any development, or when an existing dam is affected by development, the County regulates the design and construction of the dam for safety purposes and to prevent wash-outs that may cause downstream siltation or flooding. An existing impoundment is considered "affected" by development when there is any increase in run-off to the impoundment. Ponds located downstream of development will not

be considered “affected” if the peak post-development discharge rate to the impoundment is attenuated to pre-development 2, 10, and 100-year flows.

B. All impoundments shall be designed and inspected by a qualified professional and shall meet the following criteria:

1. All impoundments shall be capable of passing the 10-year storm event through a hardened principal and / or auxiliary spillway. A 100-year storm event shall be conveyed through the combined principal and emergency spillways while maintaining 1-foot of freeboard at the dam embankment. Basins without embankments (completely dug ponds) and impoundments with spillway design floods in excess of the .25 Probable Maximum Flood (PMF) are not required to meet the 1 foot freeboard requirement.

2. The embankment shall be structurally able to withstand the intended depth of the impoundment.

3. Impoundment side slopes shall not exceed 2 horizontal to 1 vertical.

4. In dry impoundments, the basin bottom shall be graded to drain at a minimum 1% slope, from all directions to the outlet structure for vegetated surfaces or 0.25% for facilities with concrete low flow channels.

5. The professional shall address seepage around the barrel pipe. At a minimum, this requirement shall be addressed by the use of gasketed concrete pipe bedded and backfilled with flowable fill or alternate equivalent approved by the Director.

6. The qualified professional shall address how the outlet structure is protected from debris and clogging.

7. The limits of the “Maintenance Agreement” for impoundments and embankments shall be recorded to a point 10 feet past the toe of slope of the embankment and to either the elevation of the maximum design storm or 20 feet landward of the normal pool elevation, whichever is greater. In addition, maintenance agreements must conform to the general requirements of this Handbook.

8. Following completion, a qualified professional shall prepare a certification stating the embankment and impoundment have been constructed in accordance with the approved plans.

9. All existing impoundments shall be inspected by a qualified professional to assess the structural stability of the embankment and make any recommendations for repairs, if necessary, when affected by development. A report shall be prepared and submitted by the qualified professional detailing the dam condition and including information required by the Director.

IX. STORMWATER MANAGEMENT

A. All impoundments, embankments or other structures serving as water quality or water quantity control measures additionally shall be designed in accordance with the applicable standards set forth in this Handbook and in the regulations and documents listed in section II of this Handbook.

B. The adequacy of receiving channels shall be analyzed in accordance with the requirements of the Hanover County Stormwater Ordinance, the Hanover County Drainage Design Handbook, the Hanover County Drainage Ordinance, and applicable state regulations.

Discharges from development must first meet the requirements set forth in 9VAC25-870-66. Discharges must then be evaluated using the permissible velocity requirements set forth in this Handbook to determine which is most restrictive, energy balance or permissible velocity. The “energy balance formula” set forth in 9VAC25-870-66(B)(3)(a) shall only be used if it is demonstrated to be at least as protective as the permissible velocity requirements of this Handbook. Channel cross-sections and calculations for the downstream receiving channel shall be provided on the plans. Cross sections shall be representative and conservatively selected to represent the worst case erosion condition along the channel, as required by the Director, to a point of analysis within the channel that is one hundred times greater than the contributing drainage area of the project in question or to a point where the flow from the project is one percent or less of the total flow. If permissible velocity is found to be more restrictive than energy balance, then, as a default, an applicant will be deemed to be in compliance with receiving channel adequacy requirements when the applicant has demonstrated compliance with 9VAC25-870-66, and post-developed peak release rate from the 2-year storm is attenuated to the peak release rate associated with

forest in good condition for the contributing project pre-development drainage area, provided the discharge is to a receiving channel.

X. FLOODPLAIN MANAGEMENT

Downstream properties and drainage ways shall be protected from damage from localized flooding due to changes in runoff rate of flow and hydrologic characteristics, including but not limited to, changes in volume, velocity, frequency, duration, and peak flow rate of stormwater runoff in accordance with the Code of Federal Regulations CFR 44, applicable building codes, and the minimum design standards set out in this section.

In addition:

1. The 100-year storm elevation shall be calculated for all culverts and drop inlets located in road sags and other depressed areas. The 100-year elevation shall be shown on plans.

2. Structures within any floodplain or computed 100-year storm elevation area shall clearly demonstrate compliance with floodplain requirements.

3. Residential structures shall be designed and built with a minimum finished floor (habitable) elevation above the 100 year elevation or designed to be outside of these areas. In addition all subfloor insulation materials, electrical and mechanical equipment and appurtenances shall be above or outside this elevation.

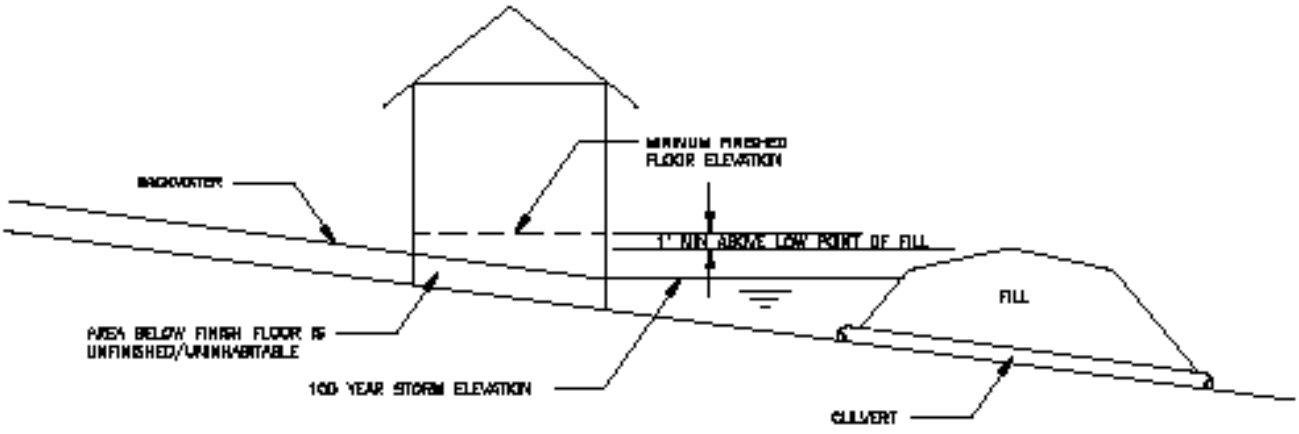
4. In cases as shown in Figures G-1(a) and (b) where a permanent structure is proposed upstream of an embankment, impoundment or other fill section, the structure shall have a minimum finished floor elevation 1 foot or more above the low point of the fill.

5. In cases as shown in Figures G-1(A) and (B) where a new fill section, embankment or impoundment is proposed downstream of an existing permanent structure a minimum finished floor elevation 1 foot or more above the low point of the fill shall be maintained.

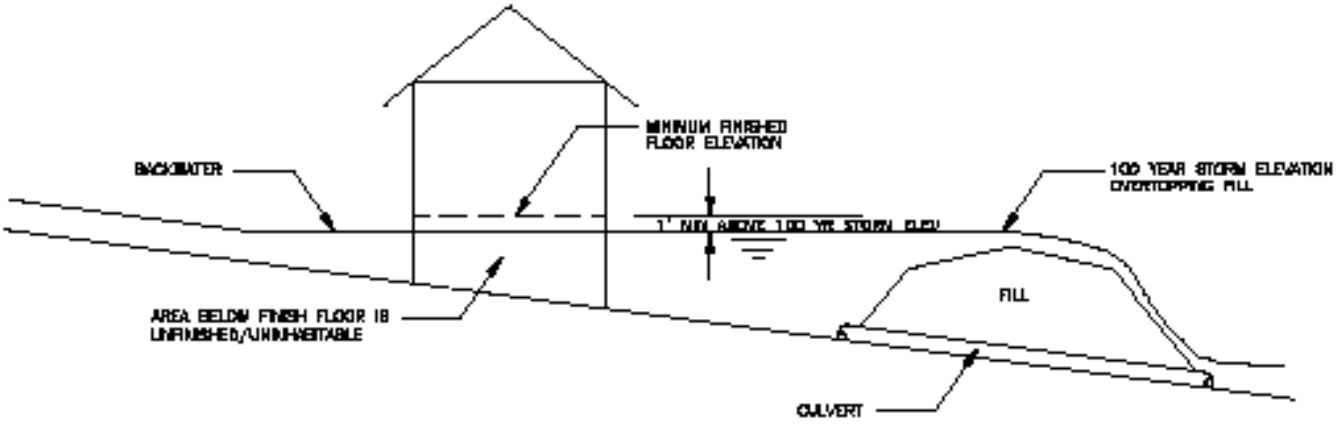
6. Any fills or grading necessary to elevate the structure shall be shown on the site or subdivision construction plans and building permit.

7. Computations and survey data shall be submitted to demonstrate that the 100-year flood level as the result of proposed improvements for the developed watershed will not increase the flooding impact for existing structures on adjacent properties.

8. Computations and survey data shall be submitted to demonstrate that proposed improvements will not increase the 100 year flood level for the developed watershed more than 1 foot on adjacent properties.



MINIMUM FINISHED FLOOR ELEVATION
OF STRUCTURE LOCATED UPSTREAM OF FILL SECTION
WHEN 100 YEAR STORM DOES NOT OVERTOP FILL
FIGURE G–1(A)



MINIMUM FINISHED FLOOR ELEVATION
OF STRUCTURE LOCATED UPSTREAM OF FILL
SECTION WHEN 100 YEAR STORM OVERTOPS FILL
FIGURE G–1(B)

HANOVER DPW	MINIMUM FINISHED FLOOR ELEVATIONS TO ADDRESS FLOODING	DRWG. NO. G1

Approved by the Hanover County Board of Supervisors
November 12, 2014

XI. AGRICULTURAL IMPOUNDMENTS, CONSERVATION ASSESSMENT AND AGRICULTURAL BEST MANAGEMENT PRACTICES

Agricultural engineering practices, including designs for impoundments and conservation assessment and best management practices shall conform to the United States Department of Agriculture (USDA) Field Office Technical Guide (FOTG) or applicable Agricultural Best Management Practice Cost Share specifications. The practice of engineering as it pertains to agricultural engineering practices is in accordance with standards of practice for engineering under Code of Virginia 54.1.

XII. DRAINAGE EASEMENTS

A. General

1. Storm sewer may enter the public road right of way in order to allow for connections from yards or properties and may leave the right of way for purpose of out-falling. Generally these connections shall be at 90 degree angles to the right of way. Public drainage easements outside the road right of way shall be a minimum 20 feet in width. Wider easements may be required by the Director based on depth of the system and other factors relating to the long term maintenance of the facility.

2. Required landscaping shall generally not be located within drainage easements. If there is no other alternative, landscaping will be permitted within the easement as long as the landscaping does not interfere with the installed drainage system.

3. Dedications and conveyances shall be free of title or other encumbrances interfering with use for the intended purposes, as evidenced by title documentation required by the Director. Public easements shall extend to the limits of the development to allow for future connection. This requirement applies to property boundaries both upstream and downstream of the drainage system.

4. Public easements may be dedicated by recordation of subdivision plat, if approved by the Director.

B. Residential Development

1. Stormwater conveyance systems providing for drainage of a public road shall be contained within the public right of way or within public easements.

2. If fill sections are necessary for construction of road and drainage infrastructure, then this area shall be included within public right of way and slope easements shall not be permitted. The expansion of right of way for cut slopes will not be required unless required by the Virginia Department of Transportation for maintenance acceptance.

3. Private drainage easements shall be recorded prior to subdivision plat recordation and the recordation information noted on the subdivision plat.

C. Non-residential Development

1. A combined public drainage easement and private maintenance agreement, stipulating maintenance by the property owner, shall be required if private drainage is combined with public drainage from a publically maintained roadway, or if the site accommodates surface drainage from off-site properties. If the system accommodates surface drainage from off-site upstream properties, public easements shall be extended to the limits of the development for future connection. Off-site easements shall be recorded prior to plan approval.

2. Fill slopes may be contained within a slope easement, provided that a Maintenance Agreement is recorded in conjunction with the slope easement and shown on the subdivision construction plans or site plan, prior to plan approval.

3. Easements shall be recorded and recordation information noted on site plans prior to DPW site plan approval. Off-site easements shall be recorded prior to site plan or subdivision plan approval.

XIII. MAINTENANCE AGREEMENTS

A. Maintenance agreements shall be required by the Director for all Best Management Practices (BMPs), Low Impact Development Practice (LID), Environmental Site Design Practice (ESD),

impoundments or embankments or other facility or feature necessitating permanency or long term maintenance when, in the judgment of the Director such agreements are necessary to comply with local, state or federal requirements. These maintenance agreements shall reference a plan or plat that clearly delineates the boundary for the facility and any necessary or anticipated maintenance and access.

B. A suitable access route and, if necessary, easement shall be provided from a public road to the facility requiring long term maintenance. These routes and / or easements shall be shown on the site plan or construction plan and subdivision plat. The Hanover County "Maintenance Agreement" shall be executed and recorded prior to plan approval. Recordation information shall be noted on the site plan or construction plan and subdivision plat, as applicable.

APPENDIX A

Values of Roughness Coefficient "n" (Uniform Flow)

Type of Channel and Description	Minimum	Normal	Maximum
LINED CHANNELS (Selected linings)			
a. Concrete			
1. Trowel finish	0.011	0.013	0.015
2. Float finish	0.013	0.015	0.016
3. Gunite, good section	0.016	0.019	0.023
b. Asphalt			
1. Smooth	0.013	0.013	-
2. Rough	0.016	0.016	-
c. Riprap (standard VDOT sizes)			
1. Class 1A	0.033	0.038	-
2. Class 1	0.035	0.040	-
3. Class 2	0.037	0.042	-
4. Class 3	0.039	0.045	-
5. Type I	0.041	0.047	-
6. Type II	0.044	0.050	-
EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.025	0.030	0.035
5. Stony bottom and weedy sides	0.025	0.035	0.045
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
NATURAL STREAMS			
1. Minor streams (top width at flood stage <100 ft)			
a. Streams on Plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones/weeds	0.030	0.035	0.040
3. Clean, winding, some pools/shoals	0.033	0.040	0.045
4. Same as above, but some weeds/stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070

Values of Roughness Coefficient n (Uniform Flow) continued:

Type of Channel and Description	Minimum	Normal	Maximum
2. Floodplains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated area			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense Willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
3. Major Streams (top width at flood stage > 100 ft)			
The n-value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	-	0.060
b. Irregular and rough section	0.035	-	0.100

* For bare earth linings when the soil classifications in accordance with either AASHTO or USCS designations are known, use the Manning's "n" values recommended in the preceding tables

Source: VDOT Drainage Manual*

APPENDIX B

Maximum Permissible Water Velocities as a Function of Soil Type based on the AASHTO Classification:

ASSHTO Classification	ASSHTO Soil Description	Fortier and Scobey Soil Description	Maximum Water Velocity (ft/s)
	BROKEN ROCK and COBBLES	Cobbles and Shingles	5.5
A-1-a	Stone fragments or **GRAVEL,** with or without well-graded 1 binder2	Coarse gravel, non-colloidal	4.5
A-1-a	Stone fragments or **GRAVEL,** with or without well-graded 1 binder2	Fine gravel	3.5
A-1-b	Coarse **SAND**, with or without well-graded 1 binder2	Graded loam to cobbles when non-colloidal	4.0
A-2 (A-2-4. A-2-5. A-2-6, A-2-7)	Mixture of **GRAVEL** and **SAND**, with silty or clay fines3, or nonplastic silt fines	Graded silts to cobbles when colloidal	4.5
A-2 (A-2-4. A-2-5. A-2-6, A-2-7)	Mixture of **GRAVEL** and **SAND**, with silty or clay fines3, or nonplastic silt fines	Sandy loam, non-colloidal	2.0
A-3	Fine **SAND,** without silty clay fines; e.g. beach sand or stream-deposited fine sand	Fine Sand, non-colloidal	1.5
A-3	Fine **SAND,** without silty clay fines; e.g. beach sand or stream-deposited fine sand	Silt loam, non-colloidal	2.3
A-4	Non- to moderately plastic4 **SILT;** mixtures of silt, sand, and/or gravel, with a minimum silt content of 36%	Alluvial silts, non-colloidal	2.3
A-5	Moderately to highly plastic 4 **SILT**. Soil; mixtures of silt, sand, and/or gravel, with a minimum fines3 content of 36%	Ordinary firm loam	2.5
A-6	Plastic4 **CLAY** soil; mixtures of clay, sand, and/or gravel, with a minimum fines3 content of 36%	Alluvial silts, colloidal	3.5
A-7	Moderately to highly plastic, **CLAY**; mixtures of clay, sand, and/or gravel, with a minimum clay content of 36%	Stiff clay, very colloidal	4.0

Maximum Permissible Water Velocities as a Function of Soil Type based on the Unified Soil Classification System (USCS):

USCS Classification	USCS Soil Description	Fortier and Scobey Soil Description	Maximum Water Velocity (ft/s)
BROKEN ROCK and COBBLES	Cobbles and Shingles		5.5
GP, GW, SW, SP	Poorly graded gravel, well graded gravel, well graded sand, poorly graded sand	Coarse gravel, non-colloidal	4.5
		Fine gravel	3.5
SW	Well graded sand	Graded loam to cobbles when non-colloidal	4.0
GC, SC	Clayey gravel, clayey sand	Graded silts to cobbles when colloidal	4.5
SM	Silty sand	Sandy loam, non-colloidal	2.0
SP, SW	Poorly graded sand, well graded sand	Fine Sand, non-colloidal	1.5
ML	Silt	Silt loam, non-colloidal	2.3
CL	Lean clay	Alluvial silts, non-colloidal	2.3
ML, CL	Silt, lean clay	Ordinary firm loam	2.5
CL	Lean clay	Alluvial silts, colloidal	3.5
CH	Fat clay	Stiff clay, very colloidal	4.0