Appendix I: General Design Criteria and Guidelines

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I.1 Hydrology and Runoff Determination

I.1.1 Acceptable Hydrologic Methods and Models

The following are the acceptable methodologies and computer models for estimating runoff hydrographs before and after development. These methods are used to predict the runoff response from given rainfall information and site surface characteristic conditions. The design storm frequencies used in all of the hydrologic engineering calculations will be based on design storms required in this guidebook unless circumstances make consideration of another storm intensity criterion appropriate:

- Urban Hydrology for Small Watersheds TR-55 (TR-55)
- Storage-Indication Routing
- HEC-1, WinTR-55, TR-20, and SWMM Computer Models

These methods are given as valid in principle and are applicable to most stormwater management design situations in the Southern Lowcountry. Other methods may be used when the Southern Lowcountry reviewing authority approves their application.

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Note: Of the above methods, TR-55 and SWMM allow for the easiest correlation of the benefits of retention BMPs used to meet the stormwater retention volume (SWRv) with peak flow detention requirements and are therefore strongly recommended. The Rational Method is not accepted, as it cannot account for the detention benefits of smaller retention BMPs applied on a site.

The following conditions shall be assumed when developing predevelopment, pre-project, and post-development hydrology, as applicable:

- For new development sites the runoff conditions shall be computed independent of existing developed land uses and conditions and shall be based on “Meadow in good condition” or better, assuming good hydrologic conditions and land with grass cover. (NEH, 2004)
- For infill and redevelopment sites the predeveloped condition is the condition at the time of project submittal.
- Post-development conditions shall be computed for future land use assuming good hydrologic and appropriate land use conditions. If an NRCS CN Method-based approach, such as TR-55, is used, this curve number (CN) may be reduced based upon the application of retention BMPs, as indicated in the General Retention Compliance Calculator (Appendix H). This CN reduction will reduce the required detention volume for a site, but it should not be used to reduce the size of conveyance infrastructure.
- The rainfall intensity - duration - frequency curve should be determined from the most recent version of the Hydrometeorological Design Studies Center’s Precipitation Frequency Data Server (NOAA Atlas 14, Volume 2).

- Predevelopment Time of Concentration (Tc) shall be based on the sum total of computed or estimated overland flow time and travel in natural swales, streams, creeks and rivers, but never less than 6 minutes.
- Post-development time of concentration shall be based on the sum total of the inlet time and travel time in improved channels or storm drains but shall not be less than 6 minutes.
- Site drainage areas exceeding 25 acres that are heterogeneous with respect to land use, soils, RCN or Time of Concentration (Tc) shall require a separate hydrologic analysis for each sub-area.
- Hydrologic soil groups (HSGs) approved for use in the <local jurisdiction> are contained in the US Department of Agriculture Web Soil Survey. Where the HSG is not available through the Soil Survey due to the listed soil type being “Urban Soils” or similar, an HSG of C shall be used.

I.1.1.1 Urban Hydrology for Small Watersheds TR-55

Chapter 6 of Urban Hydrology for Small Watersheds TR-55, Storage Volume for Detention Basins, or TR-55 shortcut procedure, is based on average storage and routing effects for many structures and can be used for multistage outflow devices. Refer to TR-55 for more detailed discussions and limitations.

Information Needed

To calculate the required storage volume using TR-55, the predevelopment hydrology, along with the post-development hydrology for the 2, 10, 25, 50 and the 100-year 24-hour storm events are needed. The predevelopment hydrology is based on natural conditions (meadow), and will determine the site’s predevelopment peak rate of discharge, or allowable release rate, qo_2.

The post-development hydrology may be determined using the reduced CNs calculated in the General Retention Compliance Calculator or more detailed routing calculations. This will determine the site’s post-development peak rate of discharge, or inflow for the 2, 10, 25, 50 and the 100-year 24-hour storm events, and the site’s post-developed runoff in inches. Note that this method does not require a hydrograph. Once the above parameters are known, the TR-55 Manual can be used to approximate the storage volume required for each design storm.

Procedure

1) Determine the peak development inflows, q_i, and the allowable release rates, q_O, from the hydrology for the appropriate design storm.

   Using the ratio of the allowable release rate (q_O) to the peak developed inflow (q_i)—or q_O/q_i—for the design storms, use Figure 1 to obtain the ratio of storage volume (V_S) to runoff volume (V_R)—for Type III storms.

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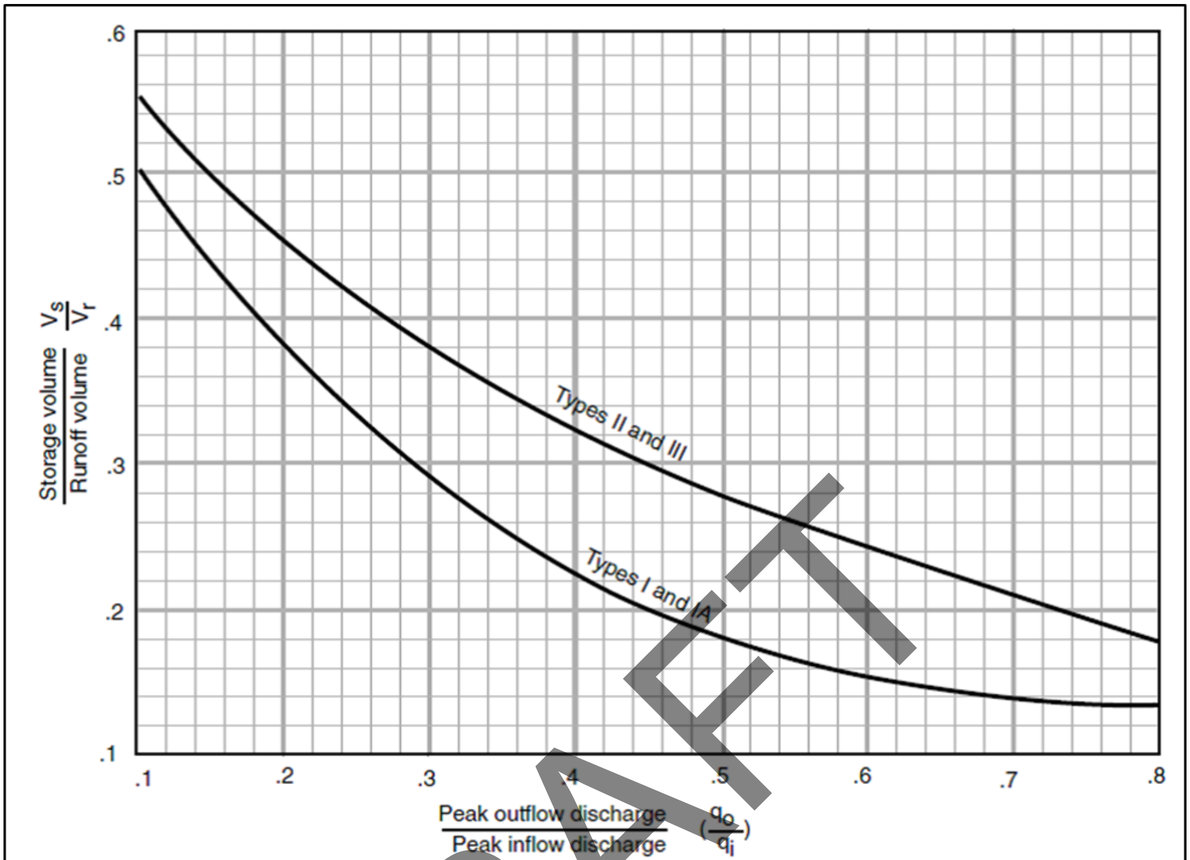

Figure 1. Approximate detention basin routing for rainfall Types I, IA, II, and III.

2) Determine the runoff volume V_R.

$$V_{\mathrm{R}} = \frac{Q}{12} \times SDA$$

where:

V_R = post-development runoff for the design storm (ft^3)

Q = post-development runoff for the design storm (in)

12 = conversion factor (inches to feet)

SDA = site drainage area (ft^2)

3) Multiply the V_S/V_R ratios from Step 1 by the runoff volume (V_R) from Step 2 to determine the required storage volumes (V_S) in acre-feet.

$$\left(\frac{V_S}{V_R}\right) V_R = V_S$$

The design procedure presented above may be used with Urban Hydrology for Small Watersheds TR-55 Worksheet 6a. The worksheet includes an area to plot the stage-storage curve, from which actual elevations corresponding to the required storage volumes can be derived. The characteristics of the stage-storage curve are dependent upon the topography of the proposed storage practice and the outlet structure, and it may be best developed using a spreadsheet or appropriate hydraulics software.

Limitations

This routing method is less accurate as the q_O/q_i ratio approaches the limits shown in Figure 1. The curves in Figure 1 depend on the relationship between available storage, outflow device, inflow volume, and shape of the inflow hydrograph. When storage volume (V_S) required is small, the shape of the outflow hydrograph is sensitive to the rate of the inflow hydrograph. Conversely, when V_S is large, the inflow hydrograph shape has little effect on the outflow hydrograph. In such instances, the outflow hydrograph is controlled by the hydraulics of the outflow device and the procedure therefore yields consistent results. When the peak outflow discharge (q_O) approaches the peak inflow discharge (q_i) parameters that affect the rate of rise of a hydrograph, such as rainfall volume, CN, and Time of Concentration, become especially significant.

The procedure should not be used to perform final design if an error in storage of 25% cannot be tolerated. Figure 1 is biased to prevent under-sizing of outflow devices, but it may significantly overestimate the required storage capacity. More detailed hydrograph development and storage indication routing will often pay for itself through reduced construction costs.

I.1.1.2 Storage-Indication Routing

Storage-Indication Routing may be used to analyze storage detention practices. This approach requires that the inflow hydrograph be developed through one of the methods listed in this appendix (TR-55, WinTR-55, SWMM, etc.), as well as the required maximum outflow, q_o . Using the stage-discharge relationship for a given combination outlet devices, the detention volume necessary to achieve the maximum outflows can be determined.

I.1.1.3 HEC-1, WinTR-55, TR-20, and SWMM Computer Models

If the application of the above computer models is needed, the complete input data file and print-out will be submitted with the Stormwater Management Plans (SWMPs). Submission of SWMPs shall include the following computer model documentation:

- For all computer models, supporting computations prepared for the data input file shall be submitted with the SWMPs.
- Inflow-outflow hydrographs shall be computed for each design storm presented graphically and submitted for all plans.
- Schematic (node) diagrams must be provided for all routings.

I.1.2 Stormwater Volume Peak Discharge

The peak rate of discharge for individual design storms may be required for several different components of water quality BMP design. While the primary design and sizing factor for most stormwater retention BMPs is the design Stormwater Retention Volume (SWRv), several design elements will require a peak rate of discharge for specified design storms. The design and sizing of pretreatment cells, level spreaders, by-pass diversion structures, overflow riser structures, grass swales and water quality swale geometry, etc. all require a peak rate of discharge in order to ensure non-erosive conditions and flow capacity.

The peak rate of discharge from an SDA can be calculated from any one of several calculation methods discussed in this appendix. The two most commonly used methods of computing peak discharges for

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peak runoff calculations and drainage system design are NRCS TR-55 CN methods (NRCS TR-55, 1986) and the Rational Formula. The Rational Formula is highly sensitive to the Time of Concentration and rainfall intensity, and therefore should only be used with reliable Intensity-Duration-Frequency (IDF) curves or tables for the rainfall depth and region of interest (Claytor & Schueler, 1996).

The NRCS CN methods are very useful for characterizing complex sub-watersheds and SDAs and estimating the peak discharge from large storms (greater than 2 inches), but it can significantly under estimate the discharge from small storm events (Claytor and Schueler, 1996). Since the SWRv is based on smaller storm events, this underestimation of peak discharge can lead to undersized diversion and overflow structures, potentially bypassing a significant volume of the design SWRv around the retention practice. Undersized overflow structures and outlet channels can cause erosion of the BMP conveyance features that can lead to costly and frequent maintenance.

In order to maintain consistency and accuracy, the following Modified CN Method is recommended to calculate the peak discharge for the SWRv rain event. The method utilizes the Small Storm Hydrology Method (Pitt, 1994) and NRCS Graphical Peak Discharge Method (USDA, 1986) to provide an adjusted CN that is more reflective of the runoff volume from impervious areas within the SDA. The design rainfall is a NRCS Type II distribution, so the method incorporates the peak rainfall intensities common in the eastern United States, and the time of concentration is computed using the method outlined in TR-55.

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The following steps describe how to calculate the SWRv peak rate of discharge (q_{pSWRv}) for a 1.16-inch rain event.

1) Calculate the adjusted CN for the site or contributing drainage area (CDA).
The following equation is derived from the NRCS CN Method and is described in detail in the National Engineering Handbook Chapter 4: Hydrology (NEH-4), and NRCS TR-55 Chapter 2: Estimating Runoff:

$$CN = \frac{1{,}000}{10 + 5P + 10Q_a - 10(Q_a^2 + 1.25Q_aP)^{0.5}}$$

where:

CN = adjusted curve number

P = rainfall (in, 1.16 in)

Q_a = runoff volume (watershed inches), equal to SWRv/SDA

Note: When using hydraulic/hydrologic model for sizing a retention BMP or calculating the SWRv peak discharge, designers must use this modified CN for the CDA to generate runoff equal to the SWRv for the design rainfall event.

2) Compute the site drainage area's time of concentration (*Tc*).
TR-55 Chapter 3: Time of Concentration and Travel Time provides a detailed procedure for computing the Tc.

3) Calculate the stormwater retention volume peak discharge (q_{pSWRv}).
The q_{pSWRv} is computed using the following equation and the procedures outlined in TR-55, Chapter 4: Graphical Peak Discharge Method. Designers can also use WinTR-55 or an equivalent TR-55 spreadsheet to compute q_{pSWRv}:

- Read initial abstraction (I_a) from TR-55 Table 4.1 or calculate using I_a = 200/CN – 2
- Compute I_a/P (P = 1.2)
- Read the Unit Peak Discharge (q_u) from Exhibit 4-II using Tc and I_a/P
- Compute the q_{pSWRv} peak discharge:

$$qp_{SWRv} = q_u \times A \times Q_a$$

where:

q_{pSWRv} = stormwater retention volume peak discharge (ft^3/sec)

q_u = unit peak discharge (ft^3/sec/mi^2/in)

A = site drainage area (mi^2)

Q_a = runoff volume (watershed inches), equal to SWRv/SDA

This procedure is for computing the peak flow rate for smaller rainfall events. Calculations of peak discharge from larger storm events for the design of drainage systems, culverts, etc., should use published CNs and computational procedures.

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I.1.3 Land Cover Designations

I.1.3.1 General Notes

The retention standard approach taken in this guidance manual for on-site stormwater management and the run-off reduction methodology recognizes the ability of pervious land covers to manage some, or most, of the rainwater that falls on it. This is termed "land abstraction" in this appendix and is assumed to be based on SCS Hydrologic soil group or soil type and whether the land cover is best represented as Forest/Open Space (RVN), Managed Turf (RvC) or Impervious Cover (RvI). As noted in Section 2.5, equation 2.1 Stormwater Retention Volume, the designation of Forest/Open Space with these lands will generate between 2-5% stormwater runoff for a design rain event. The designation of compacted cover assumes these lands will generate 15-25% stormwater runoff for a design rain event. Impervious cover will generate 95% stormwater runoff for the design rain event. The minimum area threshold for the natural cover designation is 1,500 square feet, with a minimum length of 30 feet. Areas not meeting the natural cover threshold will be considered compacted cover RvC. To insure no loss of land abstraction, all land cover designations must be recorded in the declaration of covenants.

I.1.3.2 Existing Natural Cover Requirements

A site claiming natural cover based on the preservation of existing conditions must ensure conditions remain undisturbed to preserve hydrologic properties equal to or better than meadow in good condition. Preservation areas for natural cover may include the following:

- Portions of residential yards in forest cover that will not be disturbed during construction
- Community open space areas that will not be mowed routinely, but left in a natural vegetated state, as defined below, (can include areas that will be rotary mowed no more than two times per year)
- Utility rights-of-way that will be left in a natural vegetated state (can include areas that will be rotary mowed no more than two times per year)
- Other areas of existing forest and/or open space that will be protected during construction and that will remain undisturbed

I.1.3.3 Planting Requirements for the Creation of Natural Cover

- Every 1,500 square feet of created natural area shall be vegetated according to the following options of plant material quantity:
  - 1 native shade tree: 1.5-inch caliper (minimum), or
  - 2 native ornamental trees: 6-foot height (minimum), or
  - 6 native shrubs: 5-gallon container size (minimum), or
  - 50 native perennial herbaceous plants: 1-gallon container size (minimum), or
  - 1 native ornamental tree: 6- to 10-foot height (minimum), and 25 native perennial herbaceous plants: 1-gallon container size (minimum), or
  - 3 native shrubs: 5-gallon container size (minimum), and 25 native perennial herbaceous plants: 1-gallon container size (minimum), or
  - Steep slope greater than 6% grade will require additional plantings, soil stabilization, or a terracing system.

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- Whip and seedling stock may be used (when approved by *<local jurisdiction>*) as a site's natural cover creation if a stream bank stabilization opportunity falls within the site's footprint. In this instance, whips or seedlings must be planted at a minimum density of 700 plants per acre, and at least 55% of these plants must remain at the end of the 2-year management period.
- Natural regeneration (i.e., allowing volunteer plants to propagate from surrounding natural cover as a cover creation technique) may be allowed by *<local jurisdiction>*, when 75% of the proposed planting area is located within 25 feet of adjoining forest, and the adjoining forest contains less than 20% cover of invasive exotic species (as documented by the South Carolina Exotic Pest Plant Council 2014 list here: https://www.se-eppc.org/southcarolina/SCEPPC_LIST2014finalOct.pdf). In this case, supplemental planting must ensure a density of 400 seedlings per acre.
- All plant materials used must be native to the southeastern region and must be installed in areas suitable for their growth. There are several websites that may be consulted to select the most appropriate plantings for the Southern Lowcountry;
    - Low Impact Development in Coastal South Carolina: A Planning and Design Guide; see suggested plant lists for bioretention (4.2), open channels (4.8) and stormwater wetlands (4.12) http://www.northinlet.sc.edu/lid/
    - South Carolina Wildlife Federation: http://www.scwf.org/native-plant-list
    - South Carolina Native Plant Society: https://scnps.org/wp-content/uploads/2012/04/CoastalNativePlantList.pdf
    - Carolina Yards Plant Database: https://www.clemson.edu/extension/carolinayards/plant-database/index.html
    - Clemson University Cooperative Extension Services Home & Garden Information Center factsheet for freshwater shoreline landscaping: https://hgic.clemson.edu/factsheet/shorescaping-freshwater-shorelines/
- Plant irrigation is recommended until established.

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I.1.3.4 Stormwater Management Plans and Natural Cover

Sites using preservation of existing areas for the natural cover designation shall include on their Stormwater Management Plan (SWMP) a tree and vegetation survey, identification of location, and extent of preservation areas. Depending on the extent of the preservation area, *<local jurisdiction>* may require the SWMP to include a more detailed schedule for retained trees, noting the tree species, size, canopy, condition, and location.

The SWMP will include the identification of material and equipment staging areas and parking areas. Material and equipment staging areas and parking areas must be sufficiently offset for preservation areas to ensure no adverse impacts.

For areas maintained as meadow in good condition, the SWMP shall document either the preservation of existing conditions or the creation of meadow conditions. A plan submission claiming meadow preservation will note the existing meadow boundaries and include a field survey of the richness and diversity of existing plant species and the existing soil conditions. A plan submission claiming meadow creation will note the proposed meadow boundaries, the planting and/or seeding species methods, and provide a soil amendment plan as specified in Appendix C Soil Compost Amendment Requirements.

I.1.3.5 Construction Requirements for Natural Cover Designation

The preservation of lands designated as natural cover—such as undisturbed portions of yards, community open space, and any other areas designated on a site's SWMP as preserved natural cover—must be shown outside the limits of disturbance on the site's Soil Erosion and Sediment Control Plan. These areas must be clearly demarcated with signage prior to commencement of construction on the site on the site and with fencing during construction.

The creation of lands designated as natural cover as part of a public right-of-way (PROW) project and on sites where soils were not protected from compaction during construction the soils must be conditioned prior to planting with soil compost amendments as prescribed in Appendix C Soil Compost Amendment Requirements.

For maximum survivability, planting of trees, shrubs, and herbaceous vegetation for the creation of natural cover should occur only during the fall and early spring (i.e., September through November and March through May). The work should be done only under the supervision of someone qualified and skilled in landscape installation (see Section 4.12 Tree Planting and Preservation for details on qualifications). Proper maintenance of the materials after installation will be key in ensuring plants survival. Prior to inspection, all trees and shrubs planted must be alive and in good health, and native grass and wildflower seeds must have been sown at adequate densities and at the right time of year for each species.

Once a natural cover designation has been assigned to a portion of regulated development site, that area will need to be recorded in the declaration of covenants, documented at the site prior to construction activities, protected during construction activities, and permanently protected/maintained for the life of the regulated site.

Root pruning and fertilizing are examples of preconstruction activities. These measures aim to increase the wellbeing of trees and prepare them for higher stress. Prior to beginning construction, temporary devices such as fences or sediment controls are installed and remain throughout the construction phase. Some devices, like retaining walls and root aeration systems may remain permanently. For example, if part of a root system is collapsed by a built road, permanent aeration may be necessary for the tree to remain healthy.

I.1.3.6 Maintenance Requirements for Natural Cover Designation

All areas that will be considered natural cover for stormwater purposes must have documentation that prescribes that the area will remain in a natural, vegetated state. Appropriate documentation includes subdivision covenants and restrictions; deeded operation and maintenance agreements and plans; parcels of common ownership with maintenance plans; third-party protective easements within the PROW; or other documentation approved by *<local jurisdiction>*.

While the goal is to have natural cover areas remain undisturbed, some activities may be prescribed in the appropriate documentation, as approved by *<local jurisdiction>*, such as forest management, control of invasive species, replanting and revegetation, passive recreation (e.g., trails), limited bush hogging to maintain desired vegetative community, etc.

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I.1.3.7 Compacted Cover Designation

The compacted cover designation can apply to all site areas that are disturbed and/or graded for eventual use as managed turf or landscaping. Examples of compacted cover include lawns, portions of residential yards that are graded or disturbed and maintained as turf (including yard areas), residential utility connections, and PROW. Landscaping areas intended to be maintained as vegetation other than turf within residential, commercial, industrial, and institutional settings are also considered compacted cover if regular maintenance practices are employed.

I.2 Storm Sewer Collection System

I.2.1 Introduction

The focus of this guidebook is to define standards and specifications for design, construction and maintenance of BMPs required to meet stormwater performance objectives. The components and considerations of the accompanying stormwater conveyance system are outlined in this appendix.

I.2.2 Clearance with Other Utilities

- All proposed and existing utilities crossing or parallel to designed storm sewer systems must be shown on the plan and profile.
- Storm drain and utility crossings must not have less than a 45-degree angle between them.
- Minimum vertical and horizontal clearances, wall to wall, must be provided between storm drainage lines and other utilities as defined by the Beaufort-Jasper Water & Sewer Authority.

I.2.3 Design of Stormwater Conveyance Systems

The Chezy-Manning formula is to be used to compute the system's transport capacities:

$$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$$

where:

Q	= channel flow (ft^3/sec)
n	= Manning's roughness coefficient (Table)
A	= cross-sectional area of flow (ft^2)
R	= hydraulic radius (ft)
S	= channel slope (ft/ft)
Wp	= wetted perimeter (ft)

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Table 1. Manning's Roughness Coefficient (n) values for various channel materials.

Channel Materials	Roughness Coefficient
Concrete pipe and precast culverts	
≤ 24 inches in diameter	0.015
≥ 27 inches in diameter	0.013
Monolithic concrete in boxes, channels	0.015
Corrugated metal	0.022
PVC pipes	0.011
Sodded channel with water depth < 1.5 feet	0.050
Sodded channel with water depth >1.5 feet	0.035
Smooth earth channel or bottom of wide channels with sodded slopes	0.025
Riprap channels	0.035

Note: Where drainage systems are composed of more than one of the above channel materials, a composite roughness coefficient must be computed in proportion to the wetted perimeter of the different materials.

See SCDOT, 2009 Section 1.6.3.2 and Table 3 for additional Manning n roughness coefficients

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Also, the computation for the flow velocity of the channel must use the continuity equation as follows:

$$Q = A \times V$$

where:

V = velocity (ft/s)

A = cross-sectional area of flow (ft^2)

I.2.4 Gutters

With uniform cross slope and composite gutter section use the following equation:

$$Q = \frac{0.50}{n} \times S_x^{1.67} \times S^{0.5} \times T^{2.67}$$

where:

Q = flow rate (ft^3/sec)

n = Manning's roughness coefficient (Table)

S_X = cross slope (ft/ft)

S = longitudinal slope (ft/ft)

T = width of flow (spread, ft)

I.2.5 Inlets

In accordance with the current requirements of the SCDOT, all inlets on private or public parcels, but outside the public right-of-way (PROW), must be sized to ensure safe conveyance of stormwater flows exceeding the capacity of the approved on-site stormwater management practices and the designated pervious land cover areas. These stormwater flows must not flow over property lines onto adjacent lots unless these flows run into an existing natural water course. Stormwater inlets in the PROW must be designed in accordance with the current requirements in SCDOT's Requirements for Hydraulic Studies, Part 2 Requirements for Roadway Drainage (SCDOT, 2009).

I.2.6 Street Capacity (Spread)

Design of the conveyance of stormwater runoff within the PROW must follow the current requirements in SCDOT's Requirements for Hydraulic Studies, Part 2 Requirements for Roadway Drainage (SCDOT, 2009).

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Manhole and Inlet Energy Losses

The following formulas must be used to calculate headloss:

$$HL = \frac{V_{outlet}^2 - V_r^2}{2g} + SL$$

$$V_r = \frac{Q(V \cos\frac{a}{2})(inlet1) + Q(V \cos\frac{a}{2})(inlet2) + \ ...}{Q(outlet)}$$

where:

HL = headloss in the structure

V_r = resultant velocity

g = gravitational acceleration (32.2 ft/sec^2)

SL = minimum structure loss

a = angle between the inlet and outlet pipes (180°)

Table 2 provides the minimum structure loss for inlets, manholes, and other inlet structures for use in the headloss calculation.

Table 2. Minimum structure loss to use in hydraulic grade line calculation.

Velocity, V_{outlet} (ft/s)*	Structure Loss, *SL*
2	0.00
3	0.05
4	0.10
5	0.15
6	0.20
6	0.25

* Velocities leaving the structure.

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Headloss at the field connection is to be calculated like those structures, eliminating the structure loss. For the angular loss coefficient, cos(*a*/2) is assumed to be 1.

I.2.7 Pipe Systems

- The pipe sizes used for any part of the storm drainage system within the PROW must be designed in accordance with the current requirements in SCDOT's Requirements for Hydraulic Studies, Part 2 Requirements for Roadway Drainage. (SCDOT, 2009)
- The material and installation of the storm drain for any part of public storm sewer must be designed in accordance with the current requirements in SCDOT's Requirements for Hydraulic Studies, Part 2 Requirements for Roadway Drainage. (SCDOT, 2009)

- An alternative overflow path for the 100-year storm is to be shown on the plan view if the path is not directly over the pipe. Where applicable, proposed grading must ensure that overflow will be into attenuation facilities designed to control the 100-year storm.
- A pipe schedule tabulating pipe length by diameter and class is to be included on the drawings. Public and private systems must be shown separately.
- Profiles of the proposed storm drains must be shown on the drawings and indicate size, type, and class of pipe, percent grade, existing ground and proposed ground over the proposed system, and invert elevations at both ends of each pipe run. Pipe elevations and grades must be set to avoid hydrostatic surcharge during design conditions. Where hydrostatic surcharge greater than 1-foot of head cannot be avoided, a rubber gasket pipe is to be specified.

I.2.8 Hydraulic Grade Line

A hydraulic grade line (HGL) must be clearly indicated on the system profiles and identified with the initials HGL on the line and identified in the legend key. This grade line must take into consideration pipe and channel friction losses, computing structures losses, tailwater conditions and entrance losses. All pipe systems must be designed so that they will operate without building up a surcharged hydrostatic head under design flow conditions. It is recommended that the HGL be no more than 1 foot above the pipe crown. If pipes have a HGL more than 1 foot above the pipe crown, rubber gaskets are required.

If the structural stormwater BMP discharges into a storm sewer, a detailed HGL analysis of the system including the receiving system must be submitted with the final Stormwater Management Plans (SWMPs) for 100-year storm event. Provide documentation supporting safe passage of the 100-yr post development flow downstream and an analysis of the surrounding neighborhood area to identify any existing capacity shortfalls or drainage blockages based on the 10% rule in Section 2.7.

I.2.9 Manholes and Inlets

- The current requirements in SCDOT's Requirements for Hydraulic Studies, Part 2 Requirements for Roadway Drainage (SCDOT, 2009). must be used to design and specify all structures in the PROW. All structures are to be numbered and listed in the structure schedule and must include type, standard detail number, size, top elevation, slot elevation and locations, and modification notes.
- Access structures must be spaced according to the current requirements in SCDOT's Requirements for Hydraulic Studies, Part 2 Requirements for Roadway Drainage (SCDOT, 2009).
- A minimum drop of 0.1 foot must be provided through the structure invert.
- Drainage boundary and contours must be shown around each inlet to ensure that positive drainage to the proposed inlet is provided.
- Invert elevations of the pipes entering and leaving the structures must be shown in the profile view.
- Curb inlets located on private cul-de-sacs must have a maximum 10 linear feet opening.
- For commercial/industrial areas, inlets must be kept at least 5 feet away from the driveway aprons.

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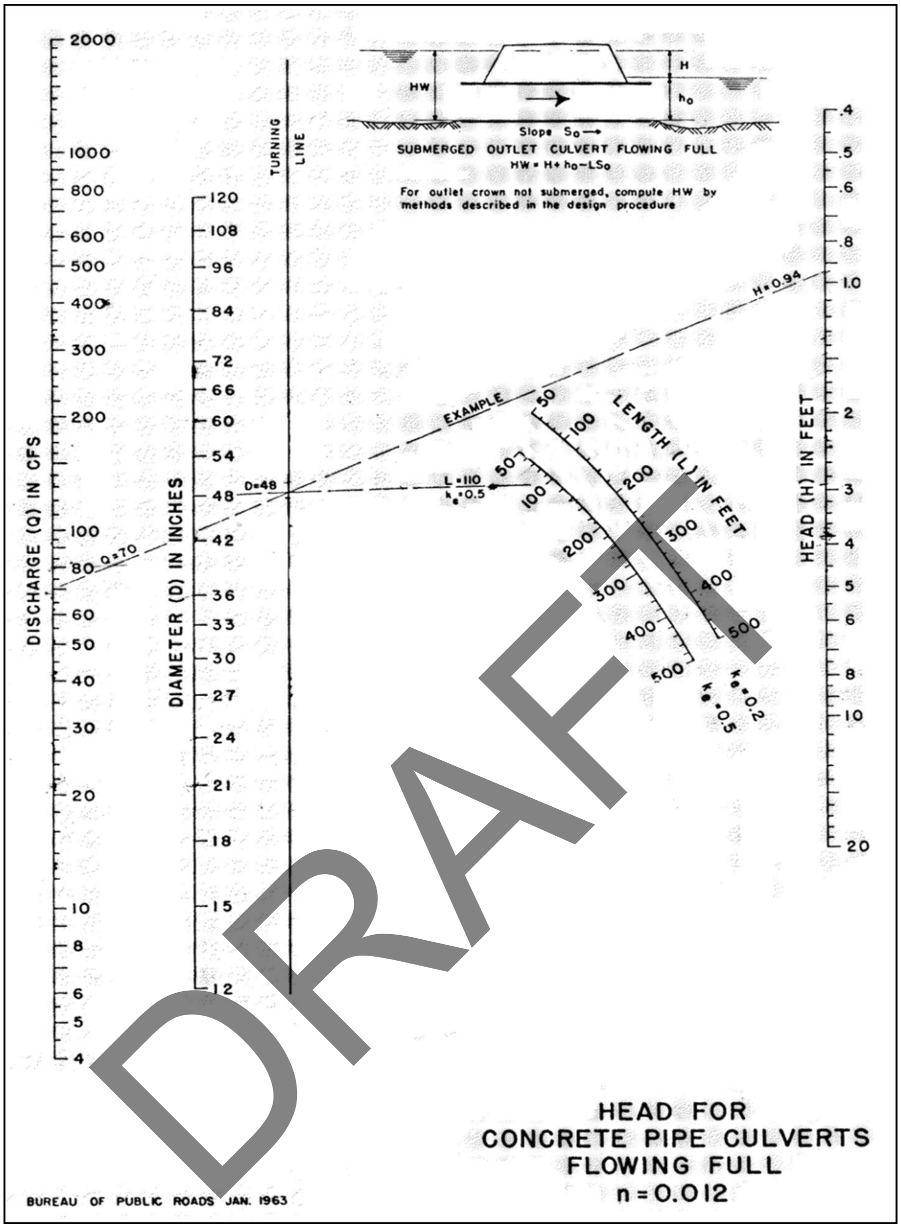

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Figure 2. Typical nomograph for culverts under outlet control.

The determination of the minimum width of a structure based on incoming pipes is based on the following formula:

$$W = \frac{D}{\sin\theta} + \frac{T}{\tan\theta}$$

where:

- W = minimum structure width (inside)
- D = pipe diameter (outside)
- T = inlet wall thickness
- θ = angle of pipe entering structure (°)

I.3 Open Channels

- Calculations must be provided for all channels, streams, ditches, swales, etc., including a typical section of each reach and a plan view with reach locations. In the case of existing natural streams/swales, a field survey of the stream (swale) cross sections may be required prior to the final approval.
- The final designed channel must provide a 6-inch minimum freeboard above the 100-yr storm event water surface profile of the channel.
- If the base flow exists for a long period of time or velocities are more than 5 feet per second in earth and sodded channel linings, gabion or riprap protection must be provided at the intersection of the inverts and side slopes of the channels unless it can be demonstrated that the final bank and vegetation are sufficiently erosion-resistant to withstand the designed flows, and the channel will stay within the floodplain easement throughout the project life.
- Channel inverts and tops of bank are to be shown in plan and profile views.
- For a designed channel, a cross section view of each configuration must be shown.
- For proposed channels, a final grading plan must be provided.
- The limits of a recorded 100-year floodplain easement or surface water easement sufficient to convey the 100-year flow must be shown.
- The minimum 25-foot horizontal clearance between a residential structure and 100-year floodplain must be indicated in the plan.
- For designed channels, transition at the entrance and outfall is to be clearly shown on the site plan and profile views.

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I.4 References

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