STORMWATER MANAGEMENT DESIGN

STORMWATER MANAGEMENT DESIGN MANUAL

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STORMWATER MANAGEMENT DESIGN MANUAL

1.0 STORMWATER MANAGEMENT CRITERIA

1.1 Definitions

a. APPLICANT

Any person, firm or governmental agency who executes the necessary forms to procure official approval of a proposed plan for a project or a permit to carry out construction of a project.

b. CAPITAL IMPROVEMENT PROJECT

A project under consideration and, in fact, planned for implementation by the Town of Middletown and included in the Town's short- (1 year) or long-term (5-6 years) budget.

c. CHANNELIZATION

The purposeful alteration by a man of a natural stream cross-section, slope or location.

d. DEVELOPER

A person, firm or governmental agency undertaking or proposing the construction of a structure, a project consisting of interrelated structures or other construction, and who primary financial responsibility for the proposal.

e. DITCH

A man-made channel with a well defined cross-section and side slopes of 6:1 or steeper.

f. DRAINAGE AREA

The area of land that contributes storm runoff by virtue of its topography to a specific point under consideration.

g. ENGINEER

Any professional engineer duly registered by the State of Maryland to practice Professional Engineering.

h. EROSION

The process by which the ground surface is worn away by the action of wind and/or water.

i. FLOOD CONTROL

A system of structural measures to protect flood hazard areas from flooding, and in the case of dams, significantly reduce the magnitude and frequency of "natural" flood flows.

j. FLOOD PLAIN

That area which, after total development in its watershed, would be inundated by water runoff from a storm equivalent to the heaviest rainfall in a 100-year period.

k. FLOOD PLAIN MANAGEMENT

A program of identifying areas prone to flooding and providing regulation for the use of those areas by a number of possible alternatives, including building codes, land use regulations, public acquisition and design practices.

l. FLOODWAY

That portion of the natural floodplain that must remain free of fill and other obstructions to safely pass a 100-year flood.

m. FREEBOARD

A vertical tolerance above the estimated water level to allow for wave and variance in the estimate.

n. NRCS

Natural Resouces Conservation Service (Formerly Soil Conservation Service).

o. RETENTION

The storage of runoff water for 24 hours or longer.

p. RUNOFF

That portion of rainfall which immediately flows from point of impact to a stream via the ground surface.

q. SEDIMENT

Soils or surface materials transported by wind or surface water as a product or result of erosion.

r. SWALE

A broad and flat channel---6:1 side slopes or flatter---that normally carry small amounts of runoff.

1.2 Control Requirements

1.2.1 Minimum Requirements: When stormwater management for quantity control is required, the applicant shall provide the management measures necessary to maintain the post-development peak discharges for the 24-hour, 1, 2, 10, and 25 year frequency storm event at a level equal to or less than the respective 24-hour, 1, 2, 10, and 25 year pre-development peak discharge rates, through stormwater management practices which control the volume, timing and rate of flow. As a result of the past experience with sinkholes in the area, the developer shall perform a geotechnical analysis of the site in order to locate any SWM facility in a location and incorporate such measures, so as to minimize the possibility of creating or excaberating sinkhole activity. In all cases, best management practice for stormwater quality control shall be required.

1.2.2 Flood Hazard Management Act: Where applicable, stormwater management and development plans must be consistent with adopted and approved watershed management plans or flood management plans as approved by the Maryland Department of the Environment, in accordance with the Flood Hazard Management Act of 1976 (Section 8-9-01 et seq, Natural Resources Article), the Town Code of Middletown, and the Maryland Floodplain Management Ordinance (adopted May 1989).

1.2.3 Protection of Citizens: When the Town finds it necessary to protect the citizens of Middletown and their real property, the developer may be required to provide stormwater controls beyond those outlined in this section.

1.3 Stormwater Management Measures

1.3.1 Stormwater management measures are required to satisfy the minimum quantity and quality control requirements. The stormwater management practices to be used in developing a stormwater management plan must consist of one or more of the following with the Director of Public Works making the final determination as to which method(s) will be permitted:

a. Flow attenuation by use of open vegetated swales and natural depressions;

b. Stormwater retention structures; and

c. Stormwater detention structures.*

*Extended detention of the first one inch of rainfall will be considered where appropriate site conditions exist.

1.3.2 For stormwater quality control management only and for drainage areas of less than five (5) acres, the following filtering systems may be used with the Director of Public Works making the final determination as to which method(s) will be permitted:

a. Sand Filters

b. Open Vegetated Swales

c. Bioretention Areas with underdrain(s) to storm drain or other outfall acceptable to the Director of Public Works

d. Filter Strips

e. Submerged Gravel Filters

f. Stormceptors

See Section 3.0 for design guidelines.

1.4 Specific Design Criteria

1.4.1 Retention and Detention Ponds: Design and construct according to the criteria of the Natural Resources Conservation Service and meeting the requirements detailed in this manual.

1.4.2 Pre-development Peak Discharge Rate: In computing this rate, all land uses in the site to be developed are in good hydrologic condition.

1.4.3 Natural Topography and Land Cover: The developer must consider incorporating the use of natural topography and land cover, such as wetlands, ponds, natural swales and depressions as they exist before development, to the degree that they can accommodate the additional flow of water.

1.4.4 Natural Resources Conservation Service: The basic criteria, methodologies and construction specifications are those of the Natural Resources Conservation Service, subject to the approval of the Town of Middletown and the Maryland Department of the Environment.

2.0 GENERAL ENGINEERING STANDARDS

2.1 Natural Resources Conservation Service

Because many of the control structures may require Natural Resources Conservation Service (NRCS) approval, and to be consistent in the design and review of all projects, the design methods and criteria of the NRCS outlined below are required for all types of stormwater management facilities. Any additions, deletions and/or changes to the Design Standards will be detailed in the NRCS Newsletter, which is issued periodically.

2.2 Hydrology

2.2.1 Runoff Curve Number

a. Use the NRCS runoff curve number (RCN) method.

b. Use tabular forms for all hydrology computations.

c. Do not use TR-55 Figures 2-1, 2-3 and Exhibits 4-1, 4-1A, 4-111 to determine discharge or its related parameters.

d. RCN's must be based on good hydrologic condition.

Pasture is grazed area. Meadow is the ungrazed equivalent. A hay field is considered to be meadow.

2.2.2 Use of TR-20 for Hydrology

The use of TR-20 for hydrology is permitted with the following restrictions:

a. Round RCN values to the nearest whole number. Round T_c values to two decimal places.

b. Rainfall table must be 0.1 hour table or 0.25 hour table.

c. Submit input and output with full hydrographs.

2.3 Storm Routings

2.3.1 Inflow and Outflow Rates: For stormwater management facilities accepting drainage from off-site areas, use the following criteria to determine inflow and outflow rates:

a. For the 1, 2, 10, and 25 year storms (or any other storm to be managed), base the pond inflows for each routing on existing conditions for the off-site area and proposed conditions for the site.

b. For meeting spillway and freeboard requirements, base inflows for the 25-year and 100-year storms on ultimate conditions of current zoning for the off-site area and proposed conditions for the site.

2.3.2 Design Procedures

a. Short-cut routing procedures may be used in designing underground storage facilities.

b. Use the storage-indication method in designing ponds.

2.4. Time of Concentration

Use the NRCS "Overland Flow" method. Round off the times of concentration (except in TR-20 routings), using the conventional method of routing, to the nearest T_c hour for which hydrographs are provided in TR-55.

2.5 Soils

2.5.1 Soil Types: Soil maps detailing soil types are available at the Natural Resource Conservation Service. Use hydrologic soil groups approved for use in Frederick County by the Natural Resource Conservation Service, as contained in the Storm Drainage Design Manual.

2.5.2 Adjustments for Grading: Soil permeability is very sensitive to disturbance and compaction. Therefore, on sites where substantial grading will occur, the soils classification will be adjusted as follows:

Existing Soil Type	Post-grading Soil Type
A	B
B	C
C	C
D	D

2.6 Rainfall Depths

Frequency	Inches per 24 Hours
1-Year	2.5
2-Year	3.1
5-Year	4.0
10-Year	5.0
25-Year	5.4
100-Year	7.0

2.7 Borings and Test Pits

2.7.1 Minimum Number of Borings and/or Test Pits: A minimum of two borings or test pits are required at the location of each stormwater management facility. In the case of sites using ponds, enough borings shall be obtained to provide a clear picture of subsurface soils in the pond and embankment area. In any case, the Town reserves the right to require additional borings.

2.7.2 Minimum Boring or Test Pit Depth: The minimum boring or test pit depth shall be to groundwater or five feet below the bottom of the storage device, whichever is greater, or to refusal. In any case, the Town reserves the right to require additional borings or test pits.

2.7.3 Boring or Test Pit Data Required

a. Bearing strength (number of blows) - required for ponds only;

b. Unified soil classification for each strata;

c. Groundwater at completion and at 24 hours minimum; and

d. U.S.C.S. soil textural classification for each strata.

2.7.4 Boring or Test Pit Logs: Show boring or test pit logs on the plans for stormwater management facilities.

3.0 STORMWATER MANAGEMENT PRACTICE FOR QUALITY CONTROL (POLLUTANT REMOVAL) IN SMALL DRAINAGE AREAS

3.1 Small Filtering Systems

For stormwater quality control only and for drainage areas less than five (5) acres, stormwater filtering systems may be used. Five broad groups of filtering systems that may be used are as follows:

a. Sand Filters

b. Open Vegetative Swales

c. Bioretention Areas with underdrains

d. Filter Strips

e. Submerged Gravity Filters

f. Stormceptors

In no case, shall infiltration be considered, however.

3.2 Design Guidelines

The design of such systems shall be as described in the manual Design of Stormwater Filtering Systems, December 1996, by the Center for Watershed Protection or manual approved by the Town of Middletown.

3.3 Runoff Volume

A 1.0 inch runoff event shall be used for sizing stormwater filtering practices and for determining storm runoff peak discharge rates.

3.4 Water Quality Volume

To estimate the Water Quality Volume (WQV), use the "Small Storm Hydrology Method" as outlined in the manual described in 3.2.

4.0 WET (RETENTION) PONDS, EXTENDED DETENTION PONDS, AND DRY (DETENTION) PONDS

4.1 Off-Site Design Criteria

When off-site detention or retention structures are used, the criteria below must be followed:

a. The contributory drainage area for off-site ponds must be less than 400 acres, unless a larger drainage area is approved by the Maryland Department of the Environment.

b. Design off-site ponds to provide a permanent pool of water or, as a minimum, a 24-hour detention period for releasing the volume of runoff from a 1-year frequency storm. (A permanent dewatering device on the low-flow pipe may be used to extend detention.)

c. Design off-site ponds to manage the increases in peak discharges for the 1, 2, 10 and 25 year frequency storm events.

d. Do not locate off-site ponds so as to discharge to Class III Natural Trout Waters identified in COMAR 10.50.01.021, except as authorized by the Administration in permits issued pursuant to Natural Resources Article, Section 8-803.

4.2 Hydraulics

Detailed hydraulic design calculations are required for all facilities. Present the stage-discharge data in tabular and graphical form with all supporting computations, clearly indicating orifice, pipe and weir flows. Also present the elevation-storage data in both tabular and graphical forms.

4.3 Reservoir Routing

4.3.1 Storage-Indication Method: Use in all cases.

4.3.2 TR-20 Computer Program: The use of this program is permitted as noted in Section 2.2. Hydrology.

4.3.3 Plotted Hydrographs: For extended detention facilities and off-site ponds which require control of the 1-year frequency storm, include the following plotted hydrographs with the stormwater management plans:

a. For extended detention facilities, plot the existing 1 inch of rainfall hydrograph and the routed 1 inch of rainfall hydrograph and compute the volumes for the first 24 hours.

b. For off-site ponds, plot the existing 1-year storm hydrograph and the routed 1-year storm hydrograph and compute the volumes for the first 24 hours.

4.4 NRCS Small Pond Design Criteria

All small-pond designs (wet or dry) must meet or exceed the NRCS Design Standards, current version. Excavated ponds have the same freeboard requirements as embankment structures, as outlined in SCS 378.

4.5 Cutoff Trench

4.5.1 Where Required: Cutoff trenches are required in any pond embankment having any storage above existing ground. When a public road fill is used as a pond embankment, a cutoff trench may not be required.

4.5.2 Specification: The cutoff trench must have a 4-foot (minimum) bottom width, a 4-foot (minimum) depth below the barrel pipe and/or existing ground, and 1:1 side slopes. The trench must extend along the embankment between points where the proposed top of embankment intersects existing ground. Material for the cutoff trench fill must be Unified Soil Classification SC or CL and must be compacted to 95% of AASHTO Specifications T-99 or its ASTM equivalent.

4.6 Impervious Core

4.6.1 When Required: An impervious core is required in addition to a cutoff trench on all retention ponds which are designed to retain a permanent pool of water.

4.6.2 Specifications: The top of the core must be at the riser crest elevation, be a minimum of 4 feet wide, and have 1:1 side slopes extending to existing ground. The impervious core must extend along the entire length of proposed embankment to 1 foot past where the core top meets existing ground. Construct the core of the same material as the cutoff trench fill and compact to 95% of AASHTO Specification T-99 or its ASTM equivalent.

4.7 Emergency Spillway

Provide an emergency spillway for all impoundments, unless mutually waived by the Town of Middletown and the Natural Resource Conservation Service. The Town may consider designs which utilize the emergency spillway for storm frequencies greater than the 25-year storm, provided the level section and exit channel are armored and flow is conveyed to an adequate outfall. Emergency spillway gabion lining must begin at the centerline of emergency spillway level section and extend through the outfall channel. Size the capacity for NRCS 378 criteria and design according to the NRCS Engineering Manual. Token emergency spillways (where principal spillway carries 100-yr. discharge) require only 1 foot of freeboard from emergency spillway crest to settled top of dam.

4.8 Anti-Seep Collar and Phreatic Line

4.8.1 Basis for Design: Base anti-seep collar design on the following:

a. If a pond will have an emergency spillway and will use a metal riser with a concentric trash rack and anti-vortex device for a principal spillway, use either the riser crest or the computed 10-year high water elevation in the pond (whichever is greater) for the start of the phreatic line.

b. If a pond will not have an emergency spillway, use the 100-year computer high water elevation.

c. If a pond will have any other principal spillway (such as a standard or modified headwall or a concrete box drop inlet, etc.) and will have an emergency spillway, use the crest of the emergency spillway elevation for the start of the phreatic line.

4.8.2 Placement of Collars: Place anti-seep collars along the barrel a minimum of two feet from pipe joints. This shall be included as a note with the anti-seep collar detail. Contain the anti-seep collars as much as practical within the saturated zone under the phreatic line, which extends downward at a 4:1 slope from the elevation specified above on the backslope of the embankment. Anti-seep collars may not be required where a public road is used as the pond embankment if mutually waived by the Town of Middletown and the NRCS.

4.9 Outlet Protection

Place velocity dissipation devices at the outfall of all detention or retention structures and along the length of any outfall channel as necessary to provide a non-erosive velocity of flow from the structure to a water course. Construct outfall channels of riprap or Class IV gabions.

4.10 Downstream Analysis

4.10.1 Submission: If required by the Town of Middletown, the developer must submit to the Town an analysis of the impacts of stormwater flows downstream in the watershed.

4.10.2 Hydrologic and Hydraulic Calculations: Include in the analysis hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing modifications of the proposed development on a dam, highway, structure or other point established by the Town, but at a minimum downstream of a tributary of the following size:

a. The first downstream tributary whose drainage area equals or exceeds the contributing area to the pond; or

b. The first downstream tributary whose peak discharge exceeds the largest designed release rate of the pond.

4.10.3 Modifying Designed Release Rate: Modify the designed release rate of the structure when any increase in flooding or stream channel erosion would result at the downstream dam, highway, structure, or other point selected by the Town. The release rate of the structure must:

a. Be reduced to a level which will prevent any increase in flooding or stream channel erosion at the downstream control point;

b. Be not less than the 1-year pre-development peak discharge rate;

c. Meet the requirements of Section 1.1.

4.10.4 Waiving Use of Detention or Retention Structures: The Burgess and Commissioners may waive the use of detention or retention structures when the characteristics of the receiving stream or the site are such that detention of flows are contrary to accepted engineering practice or detrimental to the environment.

4.10.5 Dambreach Analysis: When directed by the Town of Middletown or the NRCS, the Engineer must provide a dambreach analysis based on NRCS publications TR-66 and National Engineering Manual 210-V Circular No. 1, dated July 14, 1980. The County permits use of the maximum breach discharge at each of the downstream sections if the Engineer desires. However, in critical situations, the attenuation modeled by the normal TR-66 procedure may provide more accurate results. Continue analysis to the point at which:

a. Breach discharge is less than the 100-year discharge; or

b. Where a stream crossing causes significant ponding; or

c. When the County or NRCS permits ending the study.

4.10.6 100-Year Floodplain Study: Is required if so directed by the Town of Middletown.

4.11 Fencing of Facilities

All stormwater management facilities shall be fenced. The fence shall consist of wood rail with wire mesh fencing attached to the inside. The minimum height of the fence shall be 42 inches.

4.12 Access and Swing Gates

Provide an 18-foot minimum access gate when access is perpendicular to the gate. Provide a 24-foot gate when access is skewed. For all ponds, provide a swing gate at the public road right-of-way to prevent unauthorized vehicles from using the access road.

4.13 Embankment Slopes

Slopes must never be steeper than 4:1 inside the facility without fencing and no steeper than 2:1 outside the facility. Interior slopes may be steepened to 2:1 if the facility is fenced in accordance with Section 4.11. The interior and exterior embankment slopes must total at least 5:1.

4.14 Filter Cloth

Use filter cloth under riprap and under gabions. The type of filter fabric must be specified on the plans and must be approved by the Town of Middletown.

4.15 Gabion Baskets and Mattress

Construct gabion baskets and mattress in accordance with Maryland Department of the Environment standards. Plans must specify use of Class IV, PVC-coated wire baskets for gabions. A preferred option to gabions is the use of imbricated riprap.

4.16 Riser

If a circular riser is used, situate so as to provide a minimum of 1 foot and a maximum of 2 feet clearance between the bottom of the anti-vortex device and the proposed ground. If the rise type does not require an anti-vortex device, the top of the riser must be a maximum of 2 feet above the proposed ground. Provide trash racks for low-flow pipes and for risers not having an anti-vortex device. Refer to SCS 378 Standards for design criteria.

4.17 Construction Specifications

4.17.1 Authority: Construct all stormwater management facilities in accordance with the NRCS Maryland Construction Specifications for Ponds, contained in the November 1992 SCS 378 Standards, with modifications and additions.

4.18 Construction Drawings

Show the following information on the final construction drawings submitted to the Town of Middletown and the NRCS for review and approval. (Scales may be changed after approval by the Department of Public Works. Use larger scales when necessary to show detail clearly.)

a. Facilities shall be presented on standard 24" x 36" mylar film (reproducible stick-ons are permitted);

b. Location and drainage area map (Scale 1" = 200' min.) showing the contributing drainage area, soil types, and the time of concentration paths.

c. Plan view of the pond and dam (Scale 1" =50' min.) with 2-foot contours, showing incoming drains and channels, pilot channel, riser, barrel, outlet protection, emergency spillway, property lines and owners, embankment stations, fence, access road and ramp, flood easements, and utility easements.

d. Profile along the centerline of the dam (Scale 1" = 50' horizontal, 1" = 5' vertical min.) showing top of dam as constructed and after settlement, emergency and principal spillway, cutoff trench, existing ground, proposed ground line within pond, and stationing.

e. Profile through the principal spillway (Scale 1" = 20' horizontal, 1" = 5' vertical min.) showing existing and proposed ground, cutoff trench, riser, low-flow pipe, barrel, outlet protection, phreatic line, anti-seep collars, constructed and settled top of dam, pipe inverts, design stormwater surface elevations and emergency spillway crest elevation. Indicate sizes, types, length, gages, slopes, flows and velocities.

f. Cross-section and profile of the emergency spillway (Scale 1" = 20' horizontal, 1" = 5' vertical min.) showing existing and proposed ground, inlet, control and outlet sections labeled with lengths and elevations), slopes, discharge and velocity, limits of stabilization, labeled if token spillway;

g. Elevations, dimensions, and details of earthwork, cutoff trench, riser, barrel, pilot channels, welding detail, anti-seep collars, trash rack and anti-vortex device, outlet treatment, and soil boring locations.

h. The following certifications (place on Sheet 1 of the Construction Drawing): Engineer's, Developer's, and As-Built (Professional Engineers licensed in Maryland must sign and seal all construction drawings and "As-Built" drawings.)

i. Construction specifications from NRCS 378;

j. Structure classification, storage-height product, watershed area to pond, level of management provided by pond (1, 2, 10, 25 and 100 year), height and top width of embankment, allowable release rates for design storms, peak inflow and outflow from pond (1, 2, 10, 25 and 100 year), design high-water elevations (1, 2, 10, 25 and 100-year) and associated storage volumes (Ac.-ft.).

l. One (1) copy of the As-Built Drawings on mylar plan sheets with the statement and the Engineer's signature, as shown in the Appendix, shall be submitted to the Office of Planning and Zoning within thirty (30) days of completion and acceptance of the work by the Town and on computer or GIS diskette in a format approved by the Office of Planning and Zoning.

m. Three (3) copies of the final plans shall be submitted to the Office of Planning and Zoning for use by the Town.

APPENDIX

STORMWATER MANAGEMENT DESIGN MANUAL

RAINFALL – RUNOFF DEPTHS IN INCHES

	DESIGN STORM YEAR AND RAINFALL INCHES						
	1 YR.	2 YR.	5 YR.	10 YR.	25 YR.	50 YR.	100 YR.
RCN	2.5"	3.1"	4.0"	5.0"	5.4"	6.1"	7.0"
60	0.17	0.37	0.76	1.30	1.54	1.99	2.61
61	0.20	0.40	0.81	1.37	1.61	2.07	2.70
62	0.22	0.44	0.86	1.44	1.68	2.16	2.88
63	0.25	0.47	0.92	1.51	1.76	2.25	2.91
64	0.26	0.51	0.97	1.58	1.84	2.33	3.00
65	0.30	0.55	1.03	1.65	1.92	2.42	3.10
66	0.33	0.60	1.09	1.73	2.01	2.51	3.20
67	0.36	0.64	1.15	1.81	2.09	2.61	3.31
68	0.38	0.68	1.20	1.88	2.16	2.70	3.41
69	0.42	0.72	1.27	1.96	2.25	2.79	3.51
70	0.45	0.77	1.33	2.04	2.33	2.88	3.61
71	0.49	0.82	1.39	2.11	2.42	2.98	3.72
72	0.53	0.87	1.46	2.19	2.51	3.08	3.83
73	0.57	0.92	1.53	2.28	2.60	3.17	3.94
74	0.61	0.97	1.60	2.37	2.69	3.28	4.05
75	0.65	1.02	1.67	2.44	2.77	3.36	4.15
76	0.69	1.08	1.74	2.54	2.87	3.47	4.26
77	0.74	1.14	1.81	2.62	2.96	3.56	4.36
78	0.79	1.20	1.89	2.72	3.06	3.67	4.48
79	0.84	1.26	1.96	2.80	3.15	3.77	4.58

Reference: "SCS-TR-55"

RAINFALL – RUNOFF DEPTHS IN INCHES

	DESIGN STORM YEAR AND RAINFALL INCHES						
	1 YR.	2 YR.	5 YR.	10 YR.	25 YR.	50 YR.	100 YR.
RCN	2.5"	3.1"	4.0"	5.0"	5.4"	6.1"	7.0"
80	0.89	1.33	2.04	2.89	3.25	3.87	4.69
81	0.94	1.39	2.12	2.98	3.34	3.97	4.80
82	0.99	1.46	2.20	3.08	3.44	4.07	4.91
83	1.06	1.53	2.29	3.17	3.54	4.18	5.02
84	1.12	1.60	2.37	3.27	3.64	4.29	5.14
85	1.18	1.68	2.46	3.37	3.74	4.40	5.26
86	1.24	1.74	2.54	3.46	3.83	4.50	5.36
87	1.31	1.83	2.64	3.57	3.95	4.61	5.48
88	1.38	1.90	2.72	3.66	4.05	4.72	5.58
89	1.46	1.99	2.82	3.77	4.16	4.95	5.83
90	1.53	2.08	2.92	3.88	4.26	4.95	5.83
91	1.61	2.16	3.02	3.99	4.37	5.05	5.94
92	1.69	2.26	3.12	4.09	4.48	5.17	6.06
93	1.78	2.35	3.22	4.20	4.59	5.28	6.17
94	1.87	2.44	3.32	4.30	4.70	5.39	6.28
95	1.97	2.54	3.42	4.41	4.81	5.50	6.40
96	2.07	2.66	3.55	4.54	4.94	5.64	6.53
97	2.17	2.77	3.66	4.66	5.06	5.75	6.65
98	2.27	2.87	3.77	4.77	5.17	5.87	6.77

Reference: "SCS-TR-55"

TABULAR DISCHARGES FOR TYPE II STORM DISTRIBUTIONS
CSM/INCH

TIME OF CONCENTRATION = 0.1 hours
Hydrograph Time in Hours

T_s	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	24	51	299	991	746	477	233	152	132	121	111	85	74	70	68	65	52	48	39	33	29	24	18	14
0.25	20	38	66	140	327	626	686	546	364	236	169	137	117	97	83	75	66	52	41	35	30	24	18	14
0.50	15	27	36	43	67	133	288	482	580	543	429	310	222	168	134	110	81	63	47	38	32	26	19	15
0.75	12	20	25	29	34	42	65	125	245	392	496	515	452	360	273	206	127	80	53	42	35	27	19	15
1.00	9	15	19	21	24	28	32	41	63	115	209	328	427	470	451	389	245	121	64	47	38	29	20	16
1.50	6	10	12	13	14	16	17	19	22	25	29	38	56	92	154	236	410	360	133	66	47	33	21	16
2.00	3	6	7	8	9	10	11	12	13	14	16	18	20	23	27	34	74	244	371	142	68	38	23	17
2.50	2	4	4	5	5	6	7	7	8	9	10	11	12	13	15	16	21	41	243	343	150	48	26	19
3.00	1	2	2	3	3	4	4	4	5	5	6	7	7	8	9	10	12	17	50	239	321	74	29	20
3.50	0	1	1	1	1	2	2	2	3	3	4	4	4	5	6	6	7	10	17	59	304	159	33	21
4.00	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	4	5	6	10	18	67	290	39	23

TIME OF CONCENTRATION = 0.2 hours
Hydrograph Time in Hours

T_s	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	23	47	208	509	796	641	424	245	170	138	121	104	85	75	71	68	56	49	40	34	29	24	18	14
0.25	18	34	49	91	196	419	603	627	486	341	235	173	138	114	96	83	70	55	43	36	31	25	18	15
0.50	14	24	32	37	50	87	181	341	490	545	497	397	296	219	167	133	92	67	49	39	33	26	19	15
0.75	11	18	23	26	30	36	49	84	161	284	409	491	481	422	340	263	157	89	56	43	36	27	19	15
1.00	9	14	18	20	22	25	29	35	48	79	143	240	347	426	452	427	299	147	69	49	39	29	20	16
1.50	5	9	11	12	13	14	16	18	20	23	26	32	43	67	110	176	330	399	159	72	50	33	22	17
2.00	3	6	7	7	8	9	10	11	12	13	15	16	18	21	24	29	56	192	363	168	75	40	24	18
2.50	1	3	4	5	5	6	6	7	7	8	9	10	11	12	13	15	19	33	200	337	174	51	26	19
3.00	0	2	2	2	3	3	4	4	5	5	6	6	7	8	8	9	11	15	40	203	316	82	29	20
3.50	0	0	1	1	1	2	2	2	2	3	3	4	4	5	5	6	7	9	16	46	300	180	34	22
4.00	0	0	0	0	0	1	1	1	1	1	2	2	2	3	3	3	4	6	9	16	53	286	41	24

TIME OF CONCENTRATION = 0.3 hours

Hydrograph Time in Hours

T_L	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	21	43	141	324	586	658	535	372	251	184	148	124	102	86	77	71	61	51	41	34	30	24	18	14
0.25	17	31	43	67	134	279	461	559	530	428	318	234	179	143	116	97	76	59	45	37	32	25	18	15
0.50	13	22	29	34	42	65	124	238	378	479	499	447	363	281	216	168	110	74	51	41	34	26	19	15
0.75	10	17	21	24	27	32	41	63	114	203	316	413	457	443	389	319	198	105	60	45	37	28	20	15
1.00	8	13	16	18	20	23	26	31	40	60	103	176	269	358	415	426	344	182	77	51	41	30	20	16
1.50	5	8	10	11	12	13	15	16	18	21	24	28	36	52	82	132	272	382	192	81	52	34	22	17
2.00	3	5	6	7	8	8	9	10	11	12	14	15	17	19	21	25	44	151	351	198	85	41	24	18
2.50	1	3	4	4	5	5	6	6	7	8	8	9	10	11	12	14	17	28	162	328	200	54	27	19
3.00	0	1	2	2	3	3	3	4	4	5	5	6	6	7	8	9	10	14	33	169	309	94	30	20
3.50	0	0	1	1	1	1	2	2	2	3	3	3	4	4	5	5	6	9	14	38	172	294	35	22
4.00	0	0	0	0	0	0	1	1	1	1	1	2	2	2	3	3	4	5	9	15	43	281	42	24

TIME OF CONCENTRATION = 0.4 hours

Hydrograph Time in Hours

T_L	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	20	39	103	224	419	558	575	451	331	247	190	155	127	105	90	80	66	53	42	35	30	24	18	14
0.25	15	28	38	54	98	196	343	467	508	464	380	295	228	180	145	119	87	64	47	38	32	26	19	15
0.50	12	20	26	30	37	53	92	172	286	395	462	453	402	332	266	211	137	84	54	42	35	27	19	15
0.75	10	16	19	22	25	29	36	51	85	150	242	338	407	429	406	356	241	128	65	47	38	29	20	16
1.00	8	12	15	17	19	21	24	28	34	49	78	132	208	292	362	403	368	220	88	55	42	30	21	16
1.50	5	8	9	10	11	12	14	15	17	19	22	25	31	43	65	102	220	365	224	93	56	35	22	17
2.00	3	5	6	6	7	8	9	9	10	11	13	14	16	17	20	23	37	119	338	225	99	43	24	18
2.50	1	3	3	4	4	5	5	6	6	7	8	9	10	11	12	13	16	25	132	317	225	58	27	19
3.00	0	1	2	2	2	3	3	3	4	4	5	5	6	7	7	8	10	13	28	140	300	107	31	21
3.50	0	0	1	1	1	1	1	2	2	2	3	3	3	4	4	5	6	8	13	32	146	286	36	22
4.20	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	3	3	5	8	14	36	275	44	24

TIME OF CONCENTRATION = 0.5 hours

Hydrograph Time in Hours

T_i	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	18	36	80	166	301	433	496	474	395	309	242	194	158	130	109	94	75	57	43	36	31	25	18	15
0.25	15	26	37	52	94	172	277	372	425	424	383	326	270	221	182	150	107	73	49	39	33	26	19	15
0.50	12	20	25	30	38	58	101	169	252	327	374	385	366	329	285	241	169	103	59	44	36	27	19	15
0.75	9	15	19	22	25	30	41	63	103	162	229	292	335	354	348	325	255	157	77	50	39	29	20	16
1.00	7	12	15	17	19	21	25	31	43	66	103	153	210	264	304	327	317	231	109	61	44	31	21	16
1.50	5	8	9	10	11	12	14	15	17	20	24	31	43	63	92	129	214	295	224	115	65	36	23	17
2.00	3	5	6	6	7	8	9	10	11	12	13	14	16	19	23	30	58	143	271	216	120	46	25	18
2.50	1	3	3	4	4	5	5	6	7	7	8	9	10	11	12	14	18	39	150	253	209	71	28	19
3.00	0	1	2	2	2	3	3	4	4	4	5	5	6	7	7	8	10	15	48	154	239	126	32	21
3.50	0	0	1	1	1	1	2	2	2	2	3	3	4	4	5	5	6	8	16	56	155	227	38	23
4.00	0	0	0	0	0	1	1	1	1	1	1	2	2	2	3	3	4	5	9	19	63	217	52	25

TIME OF CONCENTRATION = 0.75 hours

Hydrograph Time in Hours

T_i	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	15	29	57	98	163	248	329	375	388	369	325	276	232	195	165	142	107	76	51	39	33	26	19	15
0.25	12	21	29	39	61	100	158	227	291	336	355	348	321	285	247	212	156	103	62	44	36	27	19	15
0.50	10	16	21	24	29	41	63	100	150	208	263	303	327	329	314	288	226	147	79	52	40	29	20	16
0.75	8	13	16	18	20	24	30	43	65	98	142	192	239	278	303	311	286	208	107	63	45	31	21	16
1.00	6	10	13	14	15	17	20	24	31	44	65	95	134	177	220	256	294	264	149	81	53	33	21	16
1.50	4	6	8	9	10	11	12	13	14	16	19	23	31	42	60	83	147	269	248	152	85	40	23	17
2.00	2	4	5	5	6	7	7	8	9	10	11	12	14	16	18	23	39	97	251	235	153	56	26	19
2.50	1	2	3	3	4	4	4	5	5	6	7	7	8	9	10	11	15	28	107	218	236	91	29	20
3.00	0	1	1	2	2	2	2	3	3	4	4	5	5	6	6	7	8	12	33	113	225	153	34	22
3.50	0	0	1	1	1	1	1	1	2	2	2	3	3	3	4	4	5	7	13	39	117	215	44	24
4.00	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	3	4	7	15	45	207	63	26

TIME OF CONCENTRATION = 1.0 hours

Hydrograph Time in Hours

T_t	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	13	24	45	66	107	155	211	258	301	313	316	301	277	247	217	188	146	102	64	46	36	27	19	15
0.25	10	18	24	32	45	68	102	146	193	238	272	293	299	293	275	252	200	139	81	54	41	29	20	16
0.50	8	14	17	20	24	32	46	68	99	136	178	219	251	274	284	283	254	187	105	65	47	31	21	16
0.75	7	11	13	15	17	20	25	33	46	67	94	128	165	202	233	256	273	236	140	82	55	33	21	16
1.00	5	9	11	12	13	15	17	20	25	33	46	65	90	121	154	187	240	262	183	107	66	37	22	17
1.50	3	5	7	7	8	9	10	11	12	14	16	19	24	31	43	58	103	185	244	181	110	48	24	18
2.00	2	3	4	4	5	6	6	7	8	8	9	10	11	13	15	18	29	69	182	230	178	70	27	19
2.50	1	2	2	3	3	3	4	4	5	5	6	6	7	8	9	10	12	21	77	178	219	114	31	21
3.00	0	1	1	1	1	2	2	2	3	3	3	4	4	5	5	6	7	10	25	83	210	172	39	22
3.50	0	0	0	0	1	1	1	1	1	2	2	2	2	3	3	3	4	6	11	29	88	202	52	25
4.00	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	4	6	12	33	195	77	28

TIME OF CONCENTRATION = 1.25 hours

Hydrograph Time in Hours

T_t	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	11	21	37	51	79	107	147	187	219	249	264	271	267	256	241	219	177	128	81	56	42	29	20	16
0.25	9	15	21	27	36	53	74	103	137	172	205	231	249	259	259	253	223	167	102	67	48	31	21	16
0.50	7	12	15	17	21	27	37	51	72	98	128	160	190	216	235	247	251	209	130	82	56	34	21	16
0.75	6	9	12	13	15	17	21	27	36	50	69	93	120	149	177	202	235	242	165	103	67	38	22	17
1.00	4	7	9	10	11	13	14	17	21	27	36	49	66	88	113	139	190	236	200	130	83	43	23	17
1.50	3	5	6	6	7	8	8	9	10	12	14	16	20	25	33	44	76	142	223	195	131	58	26	18
2.00	1	3	3	4	4	5	5	6	6	7	8	9	10	11	13	15	24	52	143	212	189	86	29	20
2.50	1	1	2	2	2	3	3	3	4	4	5	5	6	7	7	8	10	17	58	143	201	132	35	21
3.00	0	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	6	9	20	64	143	196	45	23
3.50	0	0	0	0	0	1	1	1	1	1	1	2	2	2	2	3	4	5	9	23	68	190	62	26
4.00	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	3	5	10	26	184	91	30

TIME OF CONCENTRATION = 1.5 hours

Hydrograph Time in Hours

T_t	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	10	18	31	42	57	81	105	133	164	192	209	227	235	236	236	225	201	153	99	68	50	32	20	16
0.25	8	13	17	22	30	41	57	76	99	125	153	178	199	215	225	230	224	188	122	82	58	36	21	16
0.50	6	10	13	15	18	22	30	40	54	72	94	118	143	167	188	204	224	214	152	99	68	39	22	17
0.75	5	8	10	11	13	15	18	22	29	39	52	69	89	111	134	157	194	219	182	122	82	44	23	17
1.00	4	6	8	9	10	11	12	14	17	22	29	38	50	66	84	105	148	198	214	150	100	50	24	18
1.50	2	4	5	5	6	7	7	8	9	10	12	14	17	21	26	34	58	109	191	204	149	70	28	19
2.00	1	2	3	3	4	4	4	5	5	6	7	8	8	10	11	13	19	40	112	184	197	102	33	20
2.50	0	1	1	2	2	2	3	3	3	4	4	5	5	6	6	7	9	14	45	114	190	147	40	22
3.00	0	0	1	1	1	1	1	1	2	2	2	3	3	3	4	4	5	7	16	49	115	184	53	25
3.50	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	2	3	4	8	18	53	178	74	28
4.00	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	4	8	21	174	105	34

TIME OF CONCENTRATION = 2.0 hours

Hydrograph Time in Hours

T_t	11.0	11.5	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	18.0	20.0
0	7	14	22	30	38	49	64	80	95	114	133	152	165	175	184	192	190	176	129	93	68	41	23	17
0.25	6	10	13	17	22	28	37	47	61	75	91	108	126	143	157	168	185	189	153	109	79	46	24	17
0.50	5	8	10	11	13	17	21	27	35	45	57	71	86	103	119	135	162	186	172	129	92	52	26	18
0.75	4	6	8	8	10	11	13	16	21	26	34	43	55	67	82	97	129	166	183	149	109	59	27	18
1.00	3	5	6	7	7	8	9	11	13	16	20	26	33	42	52	64	92	136	180	167	127	68	29	19
1.50	1	3	3	4	4	5	5	6	7	8	9	10	12	15	18	23	37	68	135	175	163	93	34	21
2.00	1	1	2	2	3	3	3	4	4	5	5	6	6	7	8	10	14	26	71	133	170	127	42	23
2.50	0	1	1	1	1	1	2	2	2	3	3	3	4	4	5	5	7	11	29	74	132	166	53	26
3.00	0	0	0	0	1	1	1	1	1	1	2	2	2	2	3	3	4	5	12	32	76	162	71	30
3.50	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	3	6	13	35	158	95	35
4.00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	3	6	14	80	155	43

AS-BUILT DRAWING

I HEREBY STATE, TO THE BEST OF MY KNOWLEDGE AND PERSONAL BELIEF, THAT THE WORK SHOWN ON THESE PLANS WAS CONSTRUCTED TO THE LINES AND GRADES SHOWN.

ENGINEER DATE P.E. NO.

	AS-BUILT DRAWING STATEMENT	TOWN OF MIDDLETOWN