County Council of Howard County, Maryland

2017 Legislative Session

Legislative Day No. 9

Resolution No. 94 -2017

Introduced by: The Chairperson at the request of the County Executive

A RESOLUTION revising Volume I (Storm Drainage) of the Design Manual to mandate a specified amount of rainfall for 100-year storms; to clarify provisions related to open channels; to amend provisions related to stormwater management facilities in Howard County; to make technical changes; and generally related to Volume I, Storm Drainage, of the Design Manual.

Introduced and read first time June 5, 2017.

By order Jessica Feldmark
Jessica Feldmark, Administrator

Read for a second time at a public hearing on June 19, 2017.

By order Jessica Feldmark
Jessica Feldmark, Administrator

This Resolution was read the third time and was Adopted___, Adopted with amendments ✓, Failed___, Withdrawn___, by the County Council on July 3, 2017.

Certified By Jessica Feldmark
Jessica Feldmark, Administrator

NOTE: [[text in brackets]] indicates deletions from existing law; TEXT IN SMALL CAPITALS indicates additions to existing law; Strike-out indicates material deleted by amendment; Underlining indicates material added by amendment.

WHEREAS, by passage of Council Resolution No. 38-2010, the County Council approved a revision to Chapter 5 of Volume I (Storm Drainage) of the Design Manual submitted by the County Executive; and

WHEREAS, on December 5, 2016, the Council passed Council Bill No. 79-2016 (CB 79) which became effective on December 9, 2016; and

WHEREAS, CB 79 requires that for all purposes of calculating a 100 year storm event, 8.51 inches of rainfall be used; and

WHEREAS, in accordance with CB 79, Volume I has been updated at Section 3.2.3 to include the changes reflected in CB 79 regarding the 100-year storm event and rainfall amounts for other storm events need to be amended accordingly as required by Section 18.913(c) of the County Code; and

WHEREAS, there are additional changes proposed to Volume I of the Design manual including the following:

1. Section 4.2, Open Channel, is amended to require that the profile and velocity of an improved channel be examined and addressed within the limits of the noted distances and not just at the specifically noted distances;
2. Section 5.2, Stormwater Management Criteria, is amended to no longer allow certain storage volume and Runoff Curve Number (RCN) reductions for in-fill developments; and
3. Minor technical changes, mostly to refer to the most recent versions of publications; and

WHEREAS, changes are shown on pages 3-4, 4-10, 4-19, 5-2, 5-3, 6-7, 6-8, 6-15, 7-1, and 7-5 of the attached Design Manual; and

NOW, THEREFORE, BE IT RESOLVED by the County Council of Howard County, Maryland this 3rd day of July, 2017 that it approves the revised Volume I (Storm Drainage) of the Design Manual.

AND BE IT FURTHER RESOLVED, by the County Council of Howard County, Maryland that the Director of the Department of Public Works is authorized to publish Volume I (Storm Drainage), to correct obvious errors in section references, section numbers and references to existing law, capitalization, spelling, grammar, headings and similar matters, and to make any modifications necessary to the Table of Contents.

EXHIBIT A

INDEX

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CHAPTER 1

INTRODUCTION

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE OF STORM DRAIN DESIGN MANUAL

1.1.1 Introduction

The purpose of this Design Manual is to provide criteria and standards for the design of safe, efficient and coordinated storm drainage systems. The requirements set forth herein represent an acceptable standard to Howard County. The criteria and standards outlined in this Manual are generally compatible with those of the Howard Soil Conservation District, and the Maryland Department of the Environment, the Maryland State Highway Administration, and other governmental agencies.

1.1.2. Applicability

This Design Manual shall apply to all storm drainage, floodplains, and stormwater management systems. Where a new project abuts or is affected by an existing project, the new project shall be designed according to this Manual and shall be able to accept the effects of the existing project.

The design criteria are intended to serve as a guideline for the design professional and developer during the development process. These criteria are not intended to be restrictive, except where the best interests of Howard County are in question.

1.2. LAWS, ORDINANCES AND POLICIES

It shall be the responsibility of the developer and the design professional to be aware of all applicable laws, ordinances, and policies associated with the stormwater systems for projects under design and construction.

1.2.1. Storm Drainage Fee

A storm drainage fee for the improvement of necessary off- site storm drainage facilities due to any increase in run-off (up to and including the 100-year storm event) from the subdivision, within the watershed in which the subdivision is located, shall be paid by the developer prior to the recordation of the subdivision plat unless the fee was previously paid for the specific parcel.

The fees, established by County Council resolution, shall be paid for on a per lot basis for residential subdivision and per acre of land for apartment, commercial, and industrial subdivisions. Payment shall be made for additional lots only and for additional acreage only in the case of apartment, commercial, industrial, golf course, resubdivisions, etc.

1.3. EASEMENTS, OWNERSHIP AND MAINTENANCE

It is the County's policy to require that all public storm drainage facilities, whether natural or improved, surface or subsurface, including stormwater management facilities, be within an easement, right-of-way or fee simple lands.

1. Subsurface drainage facilities which convey drainage flow from a public right-of-way shall be enclosed within a public drainage easement or fee simple lands unless the County stipulates other limits to their maintenance responsibility.

2. Surface drainage facilities which convey drainage flow from a public right-of-way shall be enclosed within a public drainage easement or fee simple lands unless the County stipulates other limits to their maintenance responsibility.

3. Surface drainage facilities conveying stormwater from upstream lots shall have easements as specified in Chapter 4 unless the County stipulates other limits to their maintenance responsibility.

4. For natural drainage systems, the 100- year floodplain shall be enclosed by a Public 100-Year Floodplain, Drainage & Utility Easement or, if the County so desires, conveyed to the County for its fee simple ownership. This area shall be defined by bearings, distances and coordinate values; be tied to property lines; and show the floodplain elevations at all bearing changes and at intervals not exceeding 200 feet between bearing changes.

5. Stormwater management facilities which are to be maintained by the County shall be enclosed within a Public Stormwater Management, Drainage & Utility Easement or fee simple lands, which shall include an access strip surrounding the facility unless the County stipulates other limits to their maintenance responsibility.

6. All existing or proposed surface drainage facilities such as swales, streams, unpaved and paved channels, etc., located within privately owned easements will be the legal responsibility of the property owner for operation and maintenance.

   When a privately owned storm drainage system is within a public right-of-way or a public easement, the private system shall terminate at a public storm drainage structure.

7. For improved channels, the 100-year floodplain shall be enclosed by a 100-Year Floodplain, Drainage & Utility Easement extending beyond the floodplain on both sides of the channel for the purpose of access and maintenance. See Chapter 6 for easement requirements.

8. Discharge and Flowage Easements: Discharge easements obtained by the developer for the major drainage system will normally not be required from the downstream property owners unless the point of discharge has been concentrated or altered in location, or the size of the drainage basin has been significantly increased in area. Flowage easements for the drainage system will normally not be required from upstream property owners unless one or more of the following conditions occur:

   A. The point at which the flow crosses the property line is altered in location or concentration. The developer shall be required to construct all facilities to direct stormwater runoff to the new point of entry.

   B. There is an existing development upstream with a closed-conduit system and the hydraulic grade line at the next upstream structure is raised above its computed value prior to development of the site.

   C. There is existing development upstream with an open-channel system and the hydraulic grade line in the open channel at the property line is raised above its computed value prior to development of the site.

   D. There is undeveloped land upstream and a proposed project improvement, other than a bridge or culvert, would raise the hydraulic grade line at the property line above the 100-year floodplain based on the existing natural upstream channel and the ultimate runoff of the fully developed watershed. A flowage easement shall be required only if the backwater or headwater at the property line exceeds the previously defined 100-year floodplain by one foot for a bridge or for a culvert. In no case shall an increase be allowed at the property line, with or without a flowage easement, if it causes flooding or increased flooding of existing structures.

9. All existing or proposed surface drainage facilities such as swales, streams, stormwater management facilities, unpaved or paved channels, etc., located within privately owned easements or on privately owned land with no public easement shall be the legal responsibility of the property owner, easement holder and/or Home Owners Association for operation and maintenance in accordance with County regulations.

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CHAPTER 2

REVIEW AND APPROVAL PROCEDURES

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CHAPTER 2

REVIEW AND APPROVAL PROCEDURES

2.1 GENERAL SUBMISSION REQUIREMENTS

2.1.1 Introduction

The Department of Planning and Zoning administers the review and approval process for all subdivision and land development projects. For Capital Improvement Projects, the administrative responsibility will be with the Department of Public Works. Current information concerning applications, review fees, number of copies, etc., should be obtained from the appropriate agency.

In many cases, storm drainage facilities will be presented on the roadway, site development, and other plans which include other improvements. If this occurs, the requirements for the storm drainage facilities shall be coordinated with the requirements for other improvements.

2.1.2. Design Reports

All design reports shall be submitted in conformance with the requirements established by the current checklists for each project. All design reports shall be signed and sealed by the appropriate design professional, registered in the State of Maryland, clearly stating the individual and company responsible for the work.

2.1.3. Design Computations

Appropriate hydrologic, hydraulic, geometric, structural, and other design computations, together with the environmental inventory and assessment, shall accompany all submissions for the storm drainage improvements. Hand computations shall be completed on the forms and tables presented in the Design Manual.

For the computations accomplished by computers, the following requirements shall be met:

A. The program shall be approved by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division, which shall evaluate the program based on normal program documentation and a user's manual. It is the responsibility of the submitting design professional to provide the County, at no charge, a complete copy of the computer program including the appropriate documentation. This evaluation must indicate that input variables, computational methods and output data are essentially comparable to those presented in the Design Manual. For information regarding approved computer programs check with the appropriate approval authority.

B. A complete listing of all input as well as output data shall be given.

C. Complete sets of hydrologic and hydraulic design computations and the environmental inventory and assessment shall be included with all submissions, review and record copies of plans involving storm drainage facilities. The materials may be included at the

original size of the various computation tables and forms or they may be combined in sequence and reproduced on 24-inch by 36- inch sheets to match the size of the plan sheets. These items need not be included in the sets of plans for bidding or construction purposes. In addition to those bound into the plans, two (2) copies or more, if required, of all storm drainage design computations and the environmental inventory and assessment shall be submitted in separate binders which will fit in a standard letter or legal sized file.

2.1.4. Specifications

All storm drainage construction shall meet or exceed the following specifications as appropriate:

A. Howard County Design Manual, Volume IV, "Standard Specifications and Details for Construction".

B. State Highway Administration Specifications for Materials, Highways, Bridges, and Incidental Structures.

C. 1994 Standards and Specifications for Soil Erosion and Sediment Control or most current edition.

D. Howard County Building and Plumbing Codes.

E. Specifications for items not covered in these specifications shall be submitted to the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division for review and approval.

2.1.5. Quantities and Cost Estimates

In conjunction with other required public improvements, the appropriate design professional shall submit a tabulated estimate of all quantities and costs, including contingent items, for all storm drainage facilities, site work, private water and sewer connections, street lights and stormwater management facilities. The Department of Planning & Zoning/Development Engineering Division and the Department of Public Works should be consulted for information relating to the latest format and unit costs for both development and Capital Improvement Projects respectively.

2.1.6. Easement Plats and Transmittal Sheets

Where storm drainage facilities will occur in areas outside of public roads and highways, easements shall be shown on the project final subdivision plat. Supplementary easement plats shall be required for any off-site easements that are required.

The necessary procedures established as guidelines in the preparation and submission of the storm drainage easement and land acquisition documentation are stated in detail in Department of Public Works Procedure 501.4.

Failure to furnish the required information or essential supporting data will necessitate returning the plans until such information is supplied.

2.1.7. Waivers or Alternative Compliance

A. Capital Projects – In unusual circumstances deviations from the criteria contained in this Manual may be warranted. In such cases, a formal application, by letter, for a waiver from or demonstration of alternative compliance for specific design criteria shall be submitted to the Director, Department of Public Works. No deviation from the criteria and standards contained herein may be permitted unless approved in writing first by the Director, Department of Public Works.

B. Land Development Projects – In unusual circumstances deviations from the criteria contained in this Manual may be warranted. In such cases, a formal application, by letter, for a waiver from or demonstration of alternative compliance for specific design criteria shall be submitted, along with the required application fee, to the Division Chief, Department of Planning & Zoning/Development Engineering Division. No deviation from the criteria and standards contained herein may be permitted unless approved in writing ~~first~~ by the Division Chief, Department of Planning & Zoning/Development Engineering Division.

C. Fee-in-Lieu of Construction – The waiver process outlined in Section 2.1.7(A) and (B) also applies to all related projects requesting a fee- in-lieu of construction. All other design deviations are to be processed in tandem with project submittals.

These items are to be identified on the submitted checklists with accompanying satisfactory written justification.

2.2. LAND DEVELOPMENT PROJECTS

2.2.1. Introduction

The purpose of this section is to indicate the specific requirements for storm drainage facilities, soil erosion and sediment control measures, and stormwater management facilities as shown on the various plan submissions, which are not covered in detail by the Howard County Subdivision and Land Development Regulations, as amended to date. Several of the required plans pertain only to storm drainage, whereas others include storm drainage along with other features. In the latter case, the requirements listed herein relate only to storm drainage facilities. The requirements apply to all types of land development projects unless indicated otherwise.

2.2.2. Sketch Plans

The latest copy of the Sketch Plan Checklist contains all requirements pertaining to storm drainage and stormwater management facilities for the sketch plan submission.

2.2.3. Preliminary Plans

The latest copy of the Preliminary Plan Checklist contains all requirements pertaining to storm drainage and stormwater management facilities for the preliminary plan submission except that ~~a~~ preliminary drainage area maps are also required. The appropriate design professional should

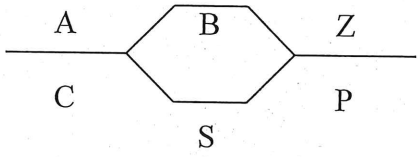
note that the preliminary plan shall indicate stormwater management facilities, with indications of locations and drainage areas controlled.

2.2.4. Drainage Area Map

Off-site drainage area maps shall be prepared from the largest practical and available scale topographic maps. On-site drainage area maps shall be prepared at the scale of the project preliminary or site development plan. Preliminary drainage area maps shall be revised to reflect final design conditions if they are to be utilized for the final drainage area map.

The entire area under consideration shall be subdivided into areas tributary to each entry or design point. Each tributary area shall be delineated by bold, dashed lines along its ridges. Sufficient flow arrows shall be shown to clearly indicate high points, direction of surface runoff, direction of gutter or channel flow and points of concentration. For the Sketch Plan submission, the tributary areas can be based on County aerial topography with 5- foot contour intervals. For the Preliminary Equivalent Sketch Plan, Preliminary Plan, Final Plan and Site Development Plan submission, onsite tributary areas and direction of flow shall be based on field run or field run aerial topography at 2- foot contour intervals. Offsite areas shall be based on reliable topography, suitable for the design effort. At a minimum, County aerial shall be used. Final drainage area maps shall show all paths of drainage at street intersections, gutters and side road ditches. A drainage area map shall be prepared for the analysis of WQv management, Cpv management and Floodplain studies.

Each tributary shall be identified as follows:



In which:

- A is the area (acre, square mile).
- B is the area identification
- C is the composite rational method coefficient or the SCS runoff method curve number
- Z is the type of zoning; if more than one type, indicate percentages of each type of zoning
- P is the weighted percentage of impervious area
- S is the percentage of each of the four SCS hydrologic soil types.

As an alternative the required information can be tabulated and shall be provided on the drainage area map (See Figure 2.01).

The Drainage Area Map shall show all existing site features, structures, property lines and ownership information for all areas within 200' of the site.

2.2.5. Final Construction and Site Development Plans

The latest copy of the Final Plan and Site Development Plan Checklists contain all the requirements pertaining to storm drainage and stormwater management facilities for the pertinent plan submission.

A. Construction Plan Set

1. Construction Plan Sets involving storm drainage and stormwater management may include the following plans:

Grading Plans

Road Plans & Profiles

Site Development Plans

Soil Erosion and Sediment Control Plans

Stormwater Management Plans

Storm Drainage Profiles

Detail Sheets

Drainage Area Maps

Landscape & Forest Conservation Plans

Private Water & Sewer Plans and Profiles

2. Grading Plans: Generally all pertinent grading is shown on the Road Construction Plans or the Site Development Plans. In some cases this may be a separate plan. These plans are normally prepared at the same scale as the Final Plan or the Site Development Plan. These plans shall show existing and proposed grade contours, temporary or permanent drainage and stormwater management facilities, existing features and shall be coordinated with the Sediment and Erosion Control Plan.

2.2.6. Final Subdivision Plat

For storm drainage and stormwater management, the plat shall show drainage easements, public and private stormwater management easements, stormwater credit easements, 100- year floodplain limits and elevations, maintenance responsibilities and dedication statements.

2.2.7. Wetlands

Wetlands shall be identified and reported in accordance with all County Code and Land Development Regulations. A certified wetland report shall be submitted for review by the Department of Planning & Zoning. The Department of Planning & Zoning will review any proposal to impact wetlands. Copies of applications for wetland permits to State and Federal agencies and copies of the issued permits from these agencies shall be provided to the Department of Planning & Zoning.

2.3. CAPITAL IMPROVEMENT PROJECTS

Capital improvement projects shall meet the same general criteria as the developer projects and shall meet the site specific project scope of services.

2.4. REVIEW AND APPROVAL

Storm drainage submissions may be reviewed by the following agencies for compliance with the given requirements:

1. Department of Planning & Zoning for compliance with the following:
   - A. Subdivision and Land Development Regulations,
   - B. Design Manuals,
   - C. stormwater management inspection schedule, reports and requirements during construction in accordance with the County Code Section 18.904,
   - D. stormwater management maintenance and maintenance agreement in accordance with the County Code Section 18.905 and the Development Process Procedures.
2. Department of Public Works for compliance with the following:
   - A. Design Manuals,
   - B. stormwater management inspection schedule, reports and requirements during construction in accordance with the County Code Section 18.904,
   - C. stormwater management maintenance and maintenance agreement in accordance with the County Code Section 18.905 and the Development Process Procedures.
3. Department of Inspections, Licenses and Permits
   - A. building and plumbing codes,
   - B. grading permit.
4. Department of Recreation and Parks

5. Other County departments/agencies for compliance with the Subdivision and Land Development Regulations.

6. Howard Soil Conservation District and Maryland Department of the Environment, as appropriate, for compliance with the Maryland Standards and Specifications for Soil Erosion and Sediment Control and current criteria for the design of dams and ponds for stormwater management.

7. Department of Transportation, State Highway Administration for compliance with its design practices, criteria and specifications for construction within its rights-of-way for an access permit.

8. Maryland Department of the Environment for issuance of a permit involving construction in a major floodplain or a major dam and reservoir where the drainage area is 400 acres or greater for Class I and Class II waterways and 100 acres for Class III and Class IV waterways and for impacts to non-tidal wetlands.

9. Maryland Department of the Environment for sedimentation/erosion control, stormwater management and water quality certification.

10. U.S. Army Corps of Engineers for 404 or Section 10 permits.

11. U.S. Department of Housing and Urban Development, Federal Insurance Administration for compliance with its criteria and regulations for floodplain delineation for Federal Flood Insurance.

2.5 CHECKLISTS

A completed checklist shall be submitted with each initial plan submission, signed, sealed and dated by the appropriate design professional. For copies of the latest lists, the design professional should contact the agencies directly. In the Department of Public Works, contact the Bureau of Engineering. In the Department of Planning & Zoning, contact the Development Engineering Division.

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FIGURES

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Figure 2.01

AREA AND “C” FACTOR TABULATION

JOB NAME:____ DATE:_________________

DPZ NO.: ____________________________

PHASE	INLET #	ZONING (Z)	SUBAREA (B)	AREA (ac) (A)	“C” FACTOR (C)	% IMPERVIOUS (P)

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CHAPTER 3

HYDROLOGY

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CHAPTER 3

HYDROLOGY

3.1 INTRODUCTION

It is necessary to compute stormwater runoff indirectly from rainfall. The Rational Method relates peak runoff to rainfall by a proportionality factor. The USDA-NRCS hydrograph methods are based on the residue of rainfall after allowances have been made for various abstractions. Both of these methods may be used in Howard County for the design of stormwater conveyance systems.

3.2 RAINFALL-RUNOFF METHODS

3.2.1 Introduction

A. It is recommended that the following methods be used as described below:

1. The Rational Method may be used for homogeneous drainage basins of 50 acres or less for closed storm drainage systems. For drainage basins greater than 50 acres but less than 400 acres, it may be used for the determination of peak runoff only. The Rational Method is not to be used for stormwater management design, culverts larger than 48" diameter or bridge crossings.

2. The latest edition of the USDA-NRCS TR-55 "Urban Hydrology for Small Watersheds" may be used for small watersheds.

3. The latest version of the USDA-NRCS TR-20 "Computer Program for Project Formulation – Hydrology" may be used for watersheds, which have:

   - drainage areas requiring a culvert larger than 48" diameter
   - 50 acres or more
   - subareas with different runoff characteristics
   - reservoirs, dams and/or ponds which are either existing or proposed.

B. Existing site topography and existing development conditions of the watershed shall be determined based on the County's 1"=200' scale topography at 5- foot contour intervals for Sketch Plan submissions only and field run or field run aerial topography at 2- foot contour intervals for all subsequent submissions in accordance with Section 2.2.4 of this design manual.

C. Proposed site topography shall be the developer's proposed plan and shall be shown with 2' contour intervals.

D. Ultimate development conditions of the site and watershed shall be determined based on the current zoning or the General Plan, whichever will result in the greatest amount of runoff.

3.2.2 Rational Method

In the rational method, the peak discharge at any point may be determined by the formula,

$$Q=CiA$$

where:

Q = peak runoff rate in cubic feet per second
C = runoff coefficient
i = average rainfall intensity in inches/hour
A = drainage area in acres

A. Area (A)

The size of the drainage area shall be a maximum of 400 acres and the land use shall be homogeneous to as much of an extent as possible. In the case of perimeter developed areas to be analyzed, non-homogeneous areas may be allowed at the direction of the Department of Public Works or the Department of Planning &Zoning/Development Engineering Division.

B. Runoff Coefficient (C)

The runoff coefficient is a factor dependent on the characteristics of the drainage area. It is dependent upon many variables including ground cover, infiltration, slopes, surface-depression storage, antecedent precipitation and soil moisture.

A composite C value for the entire watershed under consideration is computed based on an area-weighted average if the individual runoff coefficients of the various subareas of the watershed. See Table 3.01, a b, c and d for runoff coefficients for various land uses, soil groups and slopes.

The design professional shall verify "C" factors from field inspection and development plans and are to consider the type of soil and average slopes of each subarea.

For computing the composite "C" for each subarea, the design professional should use Figure 3.04, "Howard County "C" Factor Computations".

C. Rainfall Intensity (i)

Rainfall intensities for the required design frequency and the appropriate time of concentration can be obtained from table 3.02, Figures 3.01 or 3.02.

D. Time of Concentration (t_c)

The time of concentration (t_c) is the period of time required for water to flow from the most distant hydrological point within the watershed to the point under consideration. The time of concentration for the storm drainage system is the sum of the inlet time and the travel time of the flow in the system

Inlet time includes overland flow time and travel time through swales, ditches and gutters. The minimum inlet time shall be 5 minutes for commercial developments and 10 minutes for residential developments.

Overland flow time can be computed using Figure 3.03 or the method found in the USDA-NRCS TR-55. The maximum flow length shall be limited to 100 feet.

The design professional should use the forms available in the TR-55 Manual or may use the Howard County standard from Figure 3.05, "Runoff Curve Number and Time of Concentration".

E. Special Considerations

If the rational method is used for design, the following peculiarity should not be overlooked:

Apparent Reduction in Peak Discharge: In many watersheds, particularly where the mainstream channel is in a natural condition and there are not significant tributaries, the intensity values associated with the time of concentration based on travel time in the mainstream will decrease faster than the total area of the watershed increases. This results in a decrease in the product of i times A and hence the peak runoff as the design proceeds downstream. For such a condition, the runoff shall not be decreased, but the greatest upstream value of peak runoff shall be used until a point is reached for which the peak runoff again increases.

3.2.3 USDA-NRCS TR-20 and TR-55 Hydrograph Methods

The USDA-NRCS method is described in the Urban Hydrology for Small Watersheds, Technical Release No. 55. A similar computerized version of this method is the USDA-NRCS TR-20.

This method uses three variables to estimate runoff: rainfall, antecedent moisture conditions and hydrologic soil-cover complex.

The design professional should consult the TR-20 user's manual for an explanation of methodologies and equation parameters.

A. The following criteria shall be observed when using the TR-55 or TR-20 models:

1. Runoff curve number, RCN, computations shall be provided along with a soil survey map and a zoning map of the area to be developed.

2. In computing the existing conditions runoff curve numbers, the existing ground cover shall be assumed to be Meadow in Good Condition, Woods or Impervious Area. In computing the proposed conditions runoff curve numbers, Zoning shall be used for the developed areas, Paving shall be assumed for all rights-of-way, use-in-common driveways (over 200') within the access easement, gravel roads and dirt roads and grass and woods in good condition shall be used if areas are to be left in their natural state.

The design professional should use the forms available in the TR-55 Manual or may use the Howard County standard form Figure 3.05, "Runoff Curve Number and Time of Concentration"

3. Sheet flow length of 100' or less shall be used.

4. When computing the travel time for sheet flow, use the 24-hour rainfall for the 2-year design storm.

5. Schematic diagrams shall be provided for all TR-20 routings. Also, indicate on the TR-20 input and output the hydrographs and routings for all design storms under consideration.

6. The antecedent moisture condition II shall be used.

7. In the TR-20 computer analysis provide the "FULL PRINT" and "SUMMARY" options.

8. Provide verification for all rating curves used in the TR-20 reach routing analysis.

9. Provide the hydrograph at the point of discharge from the site and/or stormwater management facilities for the site.

B. Current rainfall depths for Howard County shall be used for all TR-55 and TR-20 analysis and are listed as follows:

Rainfall for 24- hour Storm Duration

1 yr.	=	~~2.6~~ 2.64 inches
2 yr.	=	~~3.2~~ 3.19 inches
5 yr.	=	~~4.2~~ 4.10 inches
10 yr.	=	~~5.1~~ 4.91 inches
25 yr.	=	~~5.6~~ 6.14 inches
50 yr.	=	~~6.3~~ 7.23 inches
100 yr.	=	**8.51**[[7.2]] inches

The type II synthetic storm distribution must be used. When using the TR-20 computer program the County recommends the use of the recently developed 0.1 hour rainfall table (Table 3.03). The standard 0.25 hour table available with the latest version of the TR-20 program is acceptable.

C. Additional requirements:

1. The Department of Public Works or the Department of Planning & Zoning/Development Engineering Division has the option of requesting a run of the TR-20 edit program.

2. For large watersheds, the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division may request a copy of a computer disk compatible with the County computer system.

3.2.4 Other Runoff Methods

Other hydrologic methods may be used with prior approval of the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division. Complete documentation, including the users manual, complete input data, printout, etc, shall be submitted for each project.

Any computer program use by design professionals that is not approved by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division for use in hydrologic design or analysis, shall be purchased with full documentation and given to the County for review as to its' acceptability. It shall be shown that the same information, results, etc, will be obtained as would be generated with current approved programs.

It should be noted that the burden of proof to the computer programs adequacy is upon the design professional not the County. The County reserves the sole right to accept or reject any computer program that it deems inadequate.

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REFERENCES

1. U.S. Department of Agronomy, National Oceanic and Atmospheric Administration, Maryland Experimental Station, Climatography of the United States No. 20-18, Climatological Summary, May 1974.

2. Hershfield, David M., Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 hours and Return Periods from 1 to 100 Years, U.S. Department of Commerce, Technical Paper No. 40, May 1961.

3. U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, Supplements to August 1972.

4. U.S. Department of Agriculture, Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release No. 55, June 1986.

5. U.S. Department of Agriculture, Soil Conservation Service, Engineering Field Manual, Chapter 2, with Maryland Supplements, June 1974.

6. U.S. Department of Agriculture, Soil Conservation Service, National Engineering Memorandum 27, Revised March 19, 1965, with supplements 1 - 7.

7. U.S. Department of Agriculture, Soil Conservation Service, TR-20 Project Formulation Program - Hydrology, June 8, 1965 and 1983.

8. U.S. Department of Agriculture, TSC Technical Note, Engineering, UD-20, Tabular Method of Flood Routing – 24 Hour Type II Storm Distribution, Regional Technical Service Center, Upper Darby, Pennsylvania, January 20, 1972.

9. Maryland Department of the Environment, Maryland Stormwater Design Manual, Latest Edition.

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TABLES

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RATIONAL FORMULA RUNOFF COEFFICIENTS
For SCS HYDOLOGIC SOILS GROUPS (A, B, C, D)

Table 3.01(a)

Rural Land Uses

1. Storm Frequencies of Less Than 25 Years
2. Storm Frequencies of 25 Years of Greater

Land Use	Treatment or Practice	Hydrologic Condition	A			B			C			D		
			0–2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range	Contoured	Poor	0.23	0.25	0.26	0.31	0.33	0.34	0.37	0.38	0.39	0.40	0.41	0.42
			0.27	0.29	0.31	0.36	0.37	0.39	0.42	0.43	0.44	0.45	0.46	0.47
		Fair	0.12	0.13	0.15	0.24	0.25	0.27	0.31	0.33	0.34	0.36	0.37	0.38
			0.15	0.17	0.19	0.28	0.30	0.32	0.36	0.37	0.39	0.40	0.41	0.43
		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
			0.09	0.11	0.13	0.22	0.24	0.26	0.32	0.33	0.35	0.37	0.38	0.40
		Poor	0.11	0.12	0.14	0.22	0.24	0.26	0.33	0.34	0.36	0.39	0.40	0.41
			0.13	0.16	0.18	0.26	0.28	0.30	0.37	0.39	0.40	0.44	0.45	0.46
		Fair	0.06	0.07	0.08	0.17	0.19	0.21	0.28	0.30	0.31	0.35	0.36	0.37
			0.07	0.08	0.10	0.21	0.23	0.25	0.32	0.34	0.36	0.39	0.41	0.42
		Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
			0.05	0.06	0.08	0.13	0.14	0.15	0.28	0.30	0.32	0.36	0.37	0.39
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
			0.08	0.11	0.14	0.13	0.18	0.22	0.16	0.20	0.26	0.21	0.25	0.32
Wooded		Poor	0.10	0.12	0.13	0.13	0.15	0.20	0.16	0.19	0.25	0.18	0.22	0.26
			0.12	0.14	0.16	0.16	0.19	0.23	0.19	0.23	0.28	0.22	0.27	0.33
		Fair	0.06	0.08	0.09	0.10	0.13	0.18	0.11	0.15	0.20	0.13	0.18	0.23
			0.08	0.10	0.12	0.13	0.17	0.21	0.15	0.18	0.24	0.18	0.22	0.29
		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21
			0.06	0.09	0.11	0.11	0.15	0.18	0.13	0.17	0.21	0.15	0.19	0.25

*From MSHA Design Manual 1977

RATIONAL FORMULA RUNOFF COEFFICIENTS
For SCS HYDOLOGIC SOILS GROUPS (A, B, C, D)

Table 3.01(b)

Agricultural Land Uses

1. Storm Frequencies of Less Than 25 Years
2. Storm Frequencies of 25 Years of Greater

Land Use	Treatment or Practice	Hydrologic Condition	A			B			C			D		
			0–2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Fallow	Straight Row		0.41	0.48	0.53	0.60	0.66	0.71	0.72	0.78	0.82	0.84	0.88	0.91
			0.57	0.64	0.69	0.70	0.76	0.80	0.83	0.88	0.91	0.95	0.97	0.98
Row Crops	Straight Row	Poor	0.31	0.36	0.39	0.54	0.58	0.62	0.70	0.74	0.77	0.75	0.78	0.80
			0.45	0.50	0.54	0.65	0.70	0.73	0.82	0.86	0.88	0.86	0.88	0.89
		Good	0.24	0.30	0.35	0.43	0.48	0.52	0.61	0.65	0.68	0.73	0.76	0.78
			0.38	0.44	0.49	0.60	0.64	0.67	0.75	0.77	0.79	0.83	0.85	0.86
	Contoured	Poor	0.28	0.34	0.39	0.51	0.55	0.59	0.61	0.65	0.68	0.70	0.74	0.77
			0.43	0.48	0.52	0.64	0.68	0.71	0.73	0.76	0.78	0.84	0.86	0.88
		Good	0.21	0.26	0.30	0.41	0.45	0.49	0.55	0.59	0.63	0.63	0.66	0.68
			0.33	0.38	0.42	0.56	0.60	0.64	0.69	0.72	0.74	0.74	0.76	0.77
	Contoured & Terraced	Poor	0.26	0.30	0.34	0.38	0.42	0.46	0.50	0.54	0.57	0.56	0.59	0.61
			0.38	0.42	0.46	0.52	0.57	0.62	0.66	0.70	0.74	0.69	0.72	0.74
		Good	0.20	0.24	0.27	0.31	0.35	0.39	0.45	0.48	0.51	0.55	0.58	0.60
			0.34	0.37	0.40	0.45	0.49	0.53	0.61	0.64	0.67	0.68	0.70	0.72
Small Grain	Straight Row	Poor	0.24	0.28	0.32	0.43	0.47	0.51	0.62	0.65	0.68	0.72	0.74	0.76
			0.37	0.40	0.43	0.59	0.63	0.66	0.73	0.76	0.78	0.84	0.86	0.87
		Good	0.23	0.26	0.29	0.42	0.45	0.48	0.57	0.60	0.62	0.71	0.73	0.75
			0.35	0.38	0.41	0.57	0.60	0.63	0.70	0.73	0.75	0.83	0.85	0.86

*From MSHA Design Manual 1977

RATIONAL FORMULA RUNOFF COEFFICIENTS
For SCS HYDOLOGIC SOILS GROUPS (A, B, C, D)

Table 3.01(c)

Agricultural Land Uses

1. Storm Frequencies of Less Than 25 Years
2. Storm Frequencies of 25 Years of Greater

Land Use	Treatment or Practice	Hydrologic Condition	A			B			C			D		
			0–2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Small Grain	Contoured	Poor	0.21 0.33	0.26 0.38	0.30 0.42	0.38 0.53	0.42 0.57	0.46 0.61	0.55 0.69	0.59 0.72	0.62 0.75	0.63 0.75	0.65 0.77	0.67 0.78
		Good	0.17 0.29	0.22 0.34	0.27 0.38	0.33 0.50	0.38 0.54	0.42 0.58	0.54 0.67	0.58 0.70	0.61 0.73	0.62 0.74	0.65 0.76	0.67 0.77
	Contoured & Terraced	Poor	0.18 0.30	0.22 0.34	0.26 0.37	0.32 0.46	0.36 0.50	0.40 0.53	0.52 0.65	0.55 0.68	0.58 0.71	0.56 0.70	0.59 0.72	0.61 0.73
		Good	0.16 0.28	0.20 0.32	0.24 0.35	0.31 0.44	0.35 0.48	0.38 0.51	0.45 0.62	0.48 0.64	0.50 0.66	0.55 0.68	0.58 0.70	0.60 0.71
Closed-Seeded Legumes or Rotation Meadow	Straight Row	Poor	0.25 0.37	0.30 0.42	0.35 0.46	0.44 0.60	0.48 0.64	0.52 0.67	0.62 0.74	0.65 0.77	0.68 0.80	0.73 0.83	0.76 0.85	0.78 0.86
		Good	0.15 0.20	0.19 0.24	0.23 0.28	0.31 0.47	0.35 0.50	0.38 0.53	0.55 0.67	0.58 0.70	0.60 0.72	0.63 0.75	0.65 0.77	0.66 0.78
	Contoured	Poor	0.23 0.35	0.28 0.40	0.32 0.44	0.41 0.56	0.45 0.60	0.49 0.63	0.57 0.70	0.60 0.73	0.63 0.76	0.62 0.74	0.65 0.77	0.67 0.79
		Good	0.14 0.24	0.18 0.28	0.21 0.31	0.30 0.42	0.34 0.46	0.37 0.49	0.45 0.61	0.48 0.64	0.51 0.66	0.58 0.71	0.60 0.73	0.61 0.74
	Contoured & Terraced	Poor	0.21 0.33	0.26 0.38	0.30 0.42	0.34 0.50	0.38 0.54	0.42 0.57	0.51 0.67	0.54 0.70	057 0.72	0.58 0.71	0.60 0.73	0.61 0.74
		Good	0.07 0.20	0.10 0.24	0.13 0.28	0.28 0.40	0.32 0.44	0.35 0.47	0.44 0.61	0.47 0.63	0.49 0.65	0.52 0.68	0.54 0.70	0.56 0.71

*From MSHA Design Manual 1977

RATIONAL FORMULA RUNOFF COEFFICIENTS
For SCS HYDOLOGIC SOILS GROUPS (A, B, C, D)

Table 3.01(d)

Urban Land Uses

1. Storm Frequencies of Less Than 25 Years
2. Storm Frequencies of 25 Years of Greater

Land Use	Treatment or Practice	Hydrologic Condition	A			B			C			D		
			0–2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Paved Areas & Impervious Surfaces			0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97
Open Space & Lawns			0.08 0.11	0.12 0.15	0.15 0.19	0.11 0.15	0.16 0.20	0.21 0.26	0.14 0.19	0.19 0.24	0.24 0.32	0.20 0.25	0.24 0.29	0.28 0.37
Industrial			0.67 0.85	0.68 0.85	0.68 0.86	0.68 0.85	0.68 0.86	0.69 0.86	0.68 0.86	0.69 0.86	0.69 0.87	0.69 0.86	0.69 0.86	0.70 0.88
Commercial			0.71 0.88	0.71 0.88	0.72 0.89	0.71 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.90	0.72 0.89	0.72 0.89	0.72 0.90
Residential														
Lot Size	1/8 acre		0.25 0.33	0.28 0.37	0.31 0.40	0.27 0.35	0.30 0.39	0.35 0.44	0.30 0.38	0.33 0.42	0.38 0.49	0.33 0.41	0.36 0.45	0.42 0.54
Lot Size	1/4 acre		0.22 0.30	0.26 0.34	0.29 0.37	0.24 0.33	0.29 0.37	0.33 0.42	0.27 0.36	0.31 0.40	0.36 0.47	0.30 0.38	0.34 0.42	0.40 0.52
Lot Size	1/3 acre		0.19 0.28	0.23 0.32	0.26 0.35	0.22 0.30	0.26 0.35	0.30 0.39	0.25 0.33	0.29 0.38	0.34 0.45	0.28 0.36	0.32 0.40	0.39 0.50
Lot Size	1/2 acre		0.16 0.25	0.20 0.29	0.24 0.32	0.19 0.28	0.23 0.32	0.28 0.36	0.22 0.31	0.27 0.35	0.32 0.42	0.26 0.34	0.30 0.38	0.37 0.48
Lot Size	1 acre		0.14 0.22	0.19 0.26	0.22 0.29	0.17 0.24	0.21 0.28	0.26 0.34	0.20 0.28	0.25 0.32	0.31 0.40	0.24 0.31	0.29 0.35	0.35 0.46

*From MSHA Design Manual 1977

RAINFALL INTENSITY DATA (in/hr)

Table 3.02

Duration (Minutes)	Frequency Interval 2 YR	5 YR	10 YR	25 YR	50 YR	100 YR
5	5.90	7.15	8.50	9.76	11.20	12.75
6	5.62	6.83	8.00	9.31	10.69	12.20
7	5.34	6.51	7.60	8.86	10.18	11.65
8	5.06	6.19	7.20	8.40	9.67	11.10
9	4.78	5.87	6.90	7.95	9.16	10.55
10	4.50	5.55	6.60	7.50	8.65	10.00
11	4.36	5.36	6.30	7.26	8.36	9.68
12	4.22	5.17	6.05	7.03	8.07	9.36
13	4.08	4.98	5.80	6.79	7.78	9.04
14	3.94	4.79	5.60	6.56	7.49	8.72
15	3.80	4.60	5.45	6.32	7.20	8.40
16	3.69	4.46	5.30	6.14	6.98	8.15
17	3.57	4.32	5.15	5.95	6.76	7.90
18	3.46	4.18	5.00	5.77	6.54	7.65
19	3.34	4.04	4.85	5.58	6.32	7.40
20	3.23	3.90	4.70	5.40	6.10	7.15
21	3.16	3.91	4.59	5.28	5.97	6.99
22	3.09	3.73	4.47	5.16	5.84	6.83
23	3.01	3.64	4.36	5.04	5.71	6.67
24	2.94	3.56	4.24	4.92	5.58	6.51
25	2.87	3.47	1.13	4.80	5.45	6.35
26	2.82	3.40	4.05	4.71	5.35	6.23
27	2.76	3.33	3.98	4.62	5.25	6.11
28	2.71	3.26	3.90	4.53	5.15	5.99
29	2.65	3.19	3.93	4.44	5.05	5.87
30	2.60	3.12	3.75	4.35	4.95	5.75
31	2.56	3.08	3.70	4.28	4.86	5.65
32	2.52	3.03	3.64	4.22	4.78	5.54
33	2.48	2.99	3.59	4.15	4.69	5.44
34	2.44	2.94	3.53	4.09	4.61	5.33
35	2.40	2.90	3.48	4.02	4.52	5.23
36	2.36	2.86	3.42	3.96	4.45	5.13
37	2.32	2.82	3.37	3.89	4.38	5.04
38	2.28	2.78	3.31	3.83	4.32	4.94
39	2.24	2.74	3.26	3.76	4.25	4.85
40	2.20	2.70	3.20	3.70	4.18	4.75
41	2.17	2.66	3.16	3.66	4.12	4.68
42	2.13	2.63	3.12	3.61	4.06	4.61
43	2.10	2.59	3.08	3.57	4.00	4.54
44	2.06	2.56	3.04	3.52	3.94	4.47
45	2.03	2.52	3.00	3.48	3.88	4.40
46	2.00	2.49	2.96	3.43	3.83	4.34
47	1.98	2.46	3.92	3.38	3.78	4.28
48	1.95	2.44	2.87	3.33	3.72	4.22
49	1.93	2.41	2.83	3.28	3.67	4.16
50	1.90	2.38	2.79	3.23	3.62	4.10
51	1.88	2.35	2.76	3.19	3.58	4.05
52	1.86	2.33	2.72	3.16	3.53	4.00
53	1.83	2.30	2.69	3.12	3.49	3.95
54	1.81	2.28	2.65	3.09	3.44	3.90
55	1.79	2.25	2.62	3.05	3.40	3.85
56	1.77	2.22	2.60	3.01	3.36	3.81
57	1.75	2.20	2.57	2.98	3.32	3.76
58	1.74	2.17	2.55	2.94	3.29	3.72
59	1.72	2.15	2.52	2.91	3.25	3.67
60	1.70	2.12	2.50	2.87	3.21	3.63

*For rational Method Only

USDA-NRCS TYPE II 24-HOUR RAINFALL DISTRIBUTION TABLE

11/23/88

Table 3.03

	TABLE NO.		TIME INCREMENT				
5	RAINFL	2		0.1000			
8			0.0000	0.0010	0.0020	0.0030	0.0041
8			0.0051	0.0062	0.0072	0.0083	0.0094
8			0.0105	0.0116	0.0127	0.0138	0.0150
8			0.0161	0.0173	0.0184	0.0196	0.0208
8			0.0220	0.0232	0.0244	0.0257	0.0269
8			0.0281	0.0294	0.0306	0.0319	0.0332
8			0.0345	0.0358	0.0371	0.0384	0.0398
8			0.0411	0.0425	0.0439	0.0452	0.0466
8			0.0480	0.0494	0.0508	0.0523	0.0538
8			0.0553	0.0568	0.0583	0.0598	0.0614
8			0.0630	0.0646	0.0662	0.0679	0.0696
8			0.0712	0.0730	0.0747	0.0764	0.0782
8			0.0800	0.0818	0.0836	0.0855	0.0874
8			0.0892	0.0912	0.0931	0.0950	0.0970
8			0.0990	0.1010	0.1030	0.1051	0.1072
8			0.1093	0.1114	0.1135	0.1156	0.1178
8			0.1200	0.1222	0.1246	0.1270	0.1296
8			0.1322	0.1350	0.1379	0.1408	0.1438
8			0.1470	0.1502	0.1534	0.1566	0.1598
8			0.1630	0.1663	0.1697	0.1733	0.1771
8			0.1810	0.1851	0.1895	0.1941	0.1989
8			0.2040	0.2094	0.2152	0.2214	0.2280
8			0.2350	0.2427	0.2513	0.2609	0.2715
8			0.2830	0.3068	0.3544	0.4308	0.5679
8			0.6630	0.6820	0.6986	0.7130	0.7252
8			0.7350	0.7434	0.7514	0.7588	0.7656
8			0.7720	0.7780	0.7836	0.7890	0.7942
8			0.7990	0.8036	0.8080	0.8122	0.8162
8			0.8200	0.8237	0.8273	0.8308	0.8342
8			0.8376	0.8409	0.8442	0.8474	0.8505
8			0.8535	0.8565	0.8594	0.8622	0.8649
8			0.8676	0.8702	0.8728	0.8753	0.8777
8			0.8800	0.8823	0.8845	0.8868	0.8890
8			0.8912	0.8934	0.8955	0.8976	0.8997
8			0.9018	0.9038	0.9058	0.9078	0.9097
8			0.9117	0.9136	0.9155	0.9173	0.9192
8			0.9210	0.9228	0.9245	0.9263	0.9280
8			0.9297	0.9313	0.9330	0.9346	0.9362
8			0.9377	0.9393	0.9408	0.9423	0.9438
8			0.9452	0.9466	0.9480	0.9493	0.9507
8			0.9520	0.9533	0.9546	0.9559	0.9572
8			0.9584	0.9597	0.9610	0.9622	0.9635
8			0.9647	0.9660	0.9672	0.9685	0.9697
8			0.9709	0.9722	0.9734	0.9746	0.9758
8			0.9770	0.9782	0.9794	0.9806	0.9818
8			0.9829	0.9841	0.9853	0.9864	0.9876
8			0.9887	0.9899	0.9910	0.9922	0.9933
8			0.9944	0.9956	0.9967	0.9978	0.9989
8			1.000	1.000	1.0000	1.000	1.0000
9	ENDTBL						

FIGURES

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FIGURE 3.01

RAINFALL INTENSITY-DURATION FREQUENCY CURVES

(For Rational Method Only)

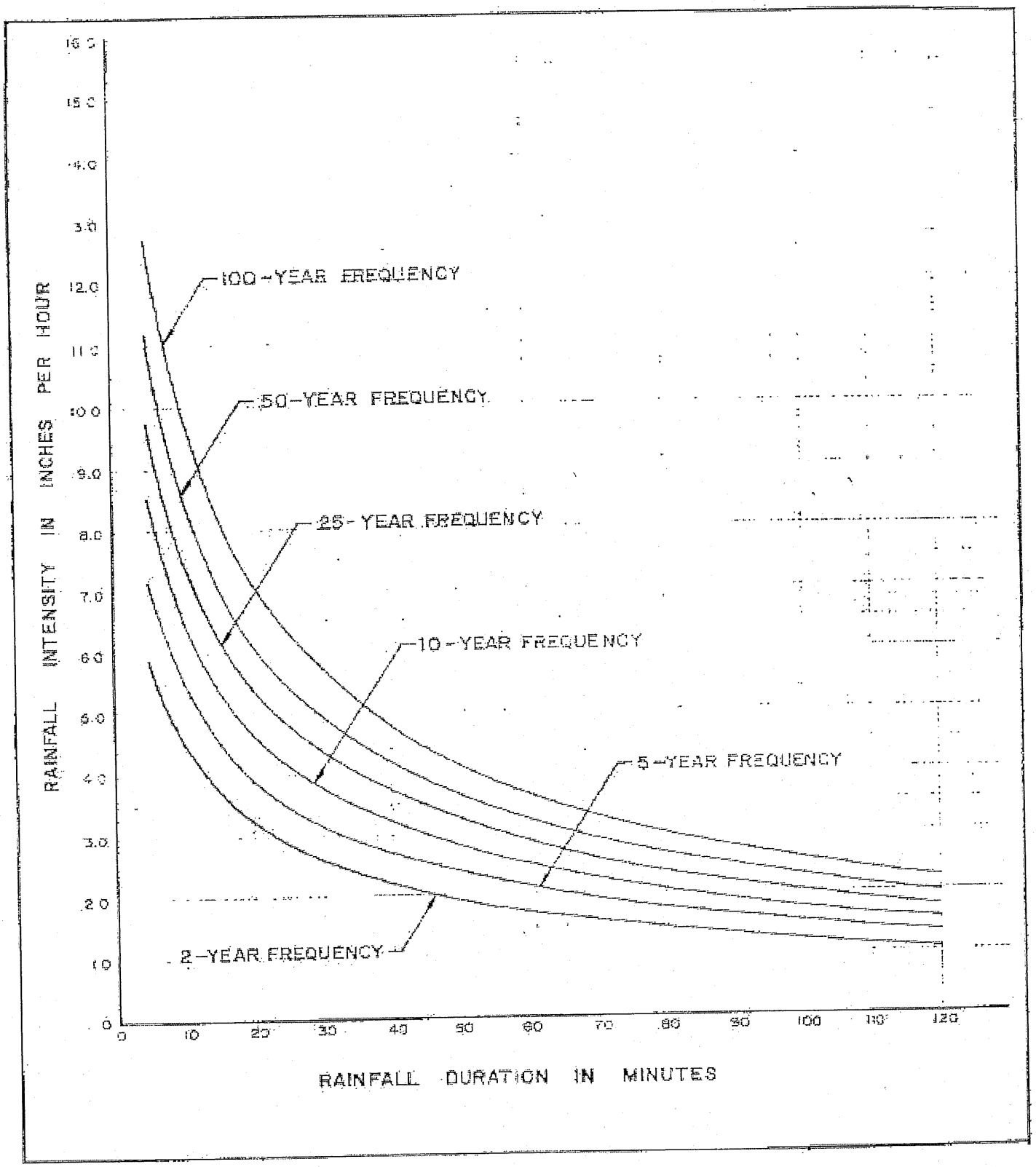

FIGURE 3.02

RAINFALL INTENSITY – DURATION FREQUENCY CURVES

(Use with Rational Method)

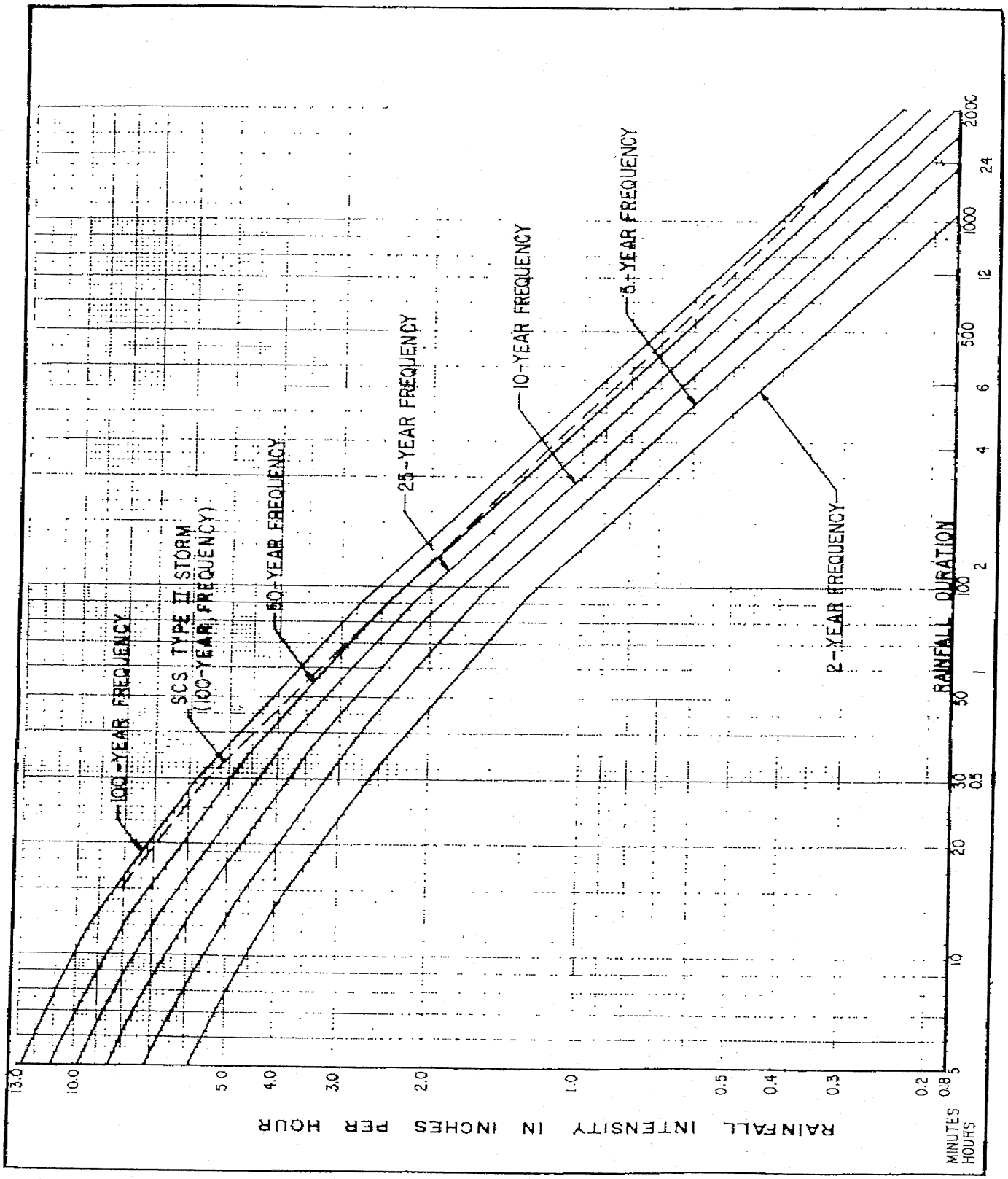

FIGURE 3.03

OVERLAND FLOW TIME
(Use with Rational Method Only)

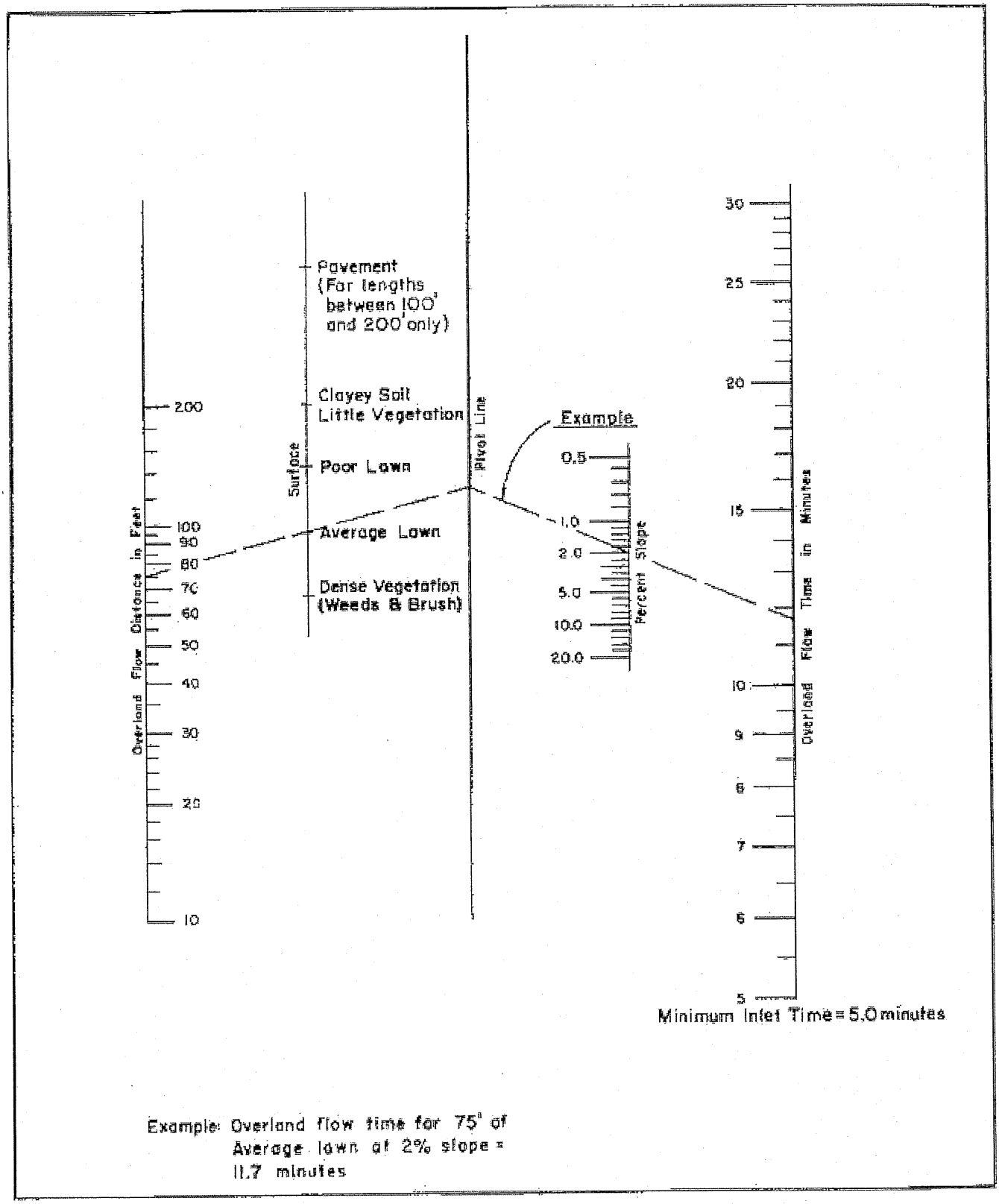

FIGURE 3.04

HOWARD COUNTY "C" FACTOR COMPUTATIONS

JOB NAME: ____________________ DPZ NO.:__________ DATE:__________

Area # Total Area __________

__________ l.f. pavement = __________ s.f. = __________ %@ __________ = __________
__________ building/roof = __________ s.f. = __________ %@ __________ = __________
__________ l.f. driveways = __________ s.f. = __________ %@ __________ = __________
__________ l.f. sidewalk = __________ s.f. = __________ %@ __________ = __________
__________ = __________ s.f. = __________ %@ __________ = __________
Soil Type __________
__________ s.f. lawn = __________ s.f. = __________ %@ __________ = __________
__________ s.f. woods = __________ s.f. = __________ %@ __________ = __________
__________ s.f. sparse veg. = __________ s.f. = __________ %@ __________ = __________
__________ s.f. bare soil = __________ s.f. = __________ %@ __________ = __________
__________ = __________ s.f. = __________ %@ __________ = __________
COMPOSITE "C" = __________

Area # __________ Total Area __________

__________ l.f. pavement = __________ s.f. = __________ %@ __________ = __________
__________ building/roof = __________ s.f. = __________ %@ __________ = __________
__________ l.f. driveways = __________ s.f. = __________ %@ __________ = __________
__________ l.f. sidewalk = __________ s.f. = __________ %@ __________ = __________
__________ = __________ s.f. = __________ %@ __________ = __________
Soil Type __________
__________ s.f. lawn = __________ s.f. = __________ %@ __________ = __________
__________ s.f. woods = __________ s.f. = __________ %@ __________ = __________
__________ s.f. sparse veg. = __________ s.f. = __________ %@ __________ = __________
__________ s.f. bare soil = __________ s.f. = __________ %@ __________ = __________
__________ = __________ s.f. = __________ %@ __________ = __________
COMPOSITE "C" = __________

Area # __________ Total Area __________

__________ l.f. pavement = __________ s.f. = __________ %@ __________ = __________
__________ building/roof = __________ s.f. = __________ %@ __________ = __________
__________ l.f. driveways = __________ s.f. = __________ %@ __________ = __________
__________ l.f. sidewalk = __________ s.f. = __________ %@ __________ = __________
__________ = __________ s.f. = __________ %@ __________ = __________
Soil Type __________
__________ s.f. lawn = __________ s.f. = __________ %@ __________ = __________
__________ s.f. woods = __________ s.f. = __________ %@ __________ = __________
__________ s.f. sparse veg. = __________ s.f. = __________ %@ __________ = __________
__________ s.f. bare soil = __________ s.f. = __________ %@ __________ = __________
__________ = __________ s.f. = __________ %@ __________ = __________
COMPOSITE "C" = __________

FIGURE 3.05

HOWARD COUNTY
RUNOFF CURVE NUMBER AND TIME OF CONCENTRATION

JOB NAME:_____ DPZ NO.:_____ DATE:_____

COMPUTED BY: _____ STUDY POINT: _____ CONDITION:_____ULTIMATE

CHECKED BY:_____ _____EXISTING

SOIL CLASS	HYDRO. SOIL GROUP	LAND USE	TREATMENT OR PRACTICE	HYDRO. COND.	RUNOFF CURVE NO.	AREA (ac)	RCN * AC
					TOTAL		

WEIGHTED RUNOFF CURVE NUMBER = $\frac{\text{TOTAL RCN * AC}}{\text{TOTAL ACRES}}$ =_____=_____USE: _____

SEG. ID	LENGTH (ft)	FLOW TYPE	SLOPE (%)	VEL. (fps)	TRAVEL TIME (hrs)
				TOTAL	

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CHAPTER 4

HYDRAULICS

CHAPTER 4

HYDRAULICS

4.1 CLOSED CONDUIT SYSTEMS

4.1.1 Storm Drain Design Criteria

A. Design Storm Criteria

1. Closed conduit drainage systems shall be designed for the 10- year storm. For drains in sumps within public rights-of-way or public easements, there shall be modifications of the "cA" and "I" computations to account for the 25-year storm event as set forth in the sample computations at the end of this chapter. For privately owned and maintained storm drain systems, the "cA" and "I" modifications shall not be required.

2. When a closed conduit system is installed to replace an open swale drainage system serving drainage areas of 30 acres or more and/or having a 10- year discharge of 100 cfs or more, the system shall be designed for the 100-year storm.

3. Inlet design shall be based on the 2-year ultimate condition storm.

4. Residential lot drainage patterns shall be in accordance with the requirements of Section 4.6 of this Design Manual.

B. Basic Equation

1. $Q = AV$

   Q = Discharge in cfs

   A = Cross-sectional area in ft^2

   V = Velocity in fps

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

   V = Velocity in fps

   n = Manning coefficient

   R = A/WP = Hydraulic Radius in ft

   WP = Wetted Perimeter in ft

   A = Cross-sectional Area in sqft

S = Slope in ft/ft

3. For pipes flowing full

$$V = \frac{0.59 D^{2/3} S_f^{1/2}}{n}$$

D = Diameter of pipe in ft

S_f = friction slope in ft/ft

4. See Table 4.01 for Manning's coefficients. Where drains composed of more than one material, a composite roughness coefficient must be determined in proportion to the wetted perimeter of the different materials.

C. Minimum and Maximum Velocities and Slopes

1. The minimum velocity in storm drains shall be 2 fps, which can be calculated on partial flow if necessary.

2. The maximum velocity in storm drains shall be 25 fps.

3. The minimum allowable slope for storm drains shall be 0.50%. The preferred minimum slope for storm drains shall be 1.0%

4. The maximum allowable slope for storm drains shall be 20%, beyond which suitably designed anchors shall be provided at a maximum of 15 feet spacing or as noted in the Design Manual Volume IV, Standard Specifications and Details for Construction.

D. Closed Conduit Criteria

1. The maximum spacing between access points (i.e., headwalls, manholes, inlets, junction chambers, etc.) shall be 400'.

2. The minimum size of pipes shall be 18 inches. A 15- inch pipe may be used from an inlet if the inlet's only flow is from surface runoff collected through the opening and/or grate of the inlet at the surface.

For private storm drain systems, a minimum pipe size of 12 inches is allowed for the first run of pipe only, excluding roof drains and other minor landscape type drain systems. The minimum pipe size for the remaining private storm drain system shall be 15 inches. Where the private storm drain system connects to a public storm drain system, that last run of pipe shall be a minimum of 18 inches. The minimum size of the roof drains and other minor landscape type drain systems to the storm drain system shall be 6". In certain stormwater management applications such as flow splitters, the minimum diameter of the pipe may be less than 6".

Storm drain computations shall be prepared on Figure 4.01, "Storm Drain Computations" form and submitted to the appropriate Department of Public Works or Department of Planning & Zoning agency for review and approval.

The design charts and tables, Figures 4.02 – 4.04 and Tables 4.03 – 4.05, are included in this Design Manual to assist in the design of the storm drainage system. It is the responsibility of the design professional to provide any and all support data, design charts, nomographs, etc, to the County for review with the design of the project.

3. The horizontal alignment of the pipes shall be:

   a. straight lines betweenaccess points whenever possible,

   b. perpendicular to the edge of the road if the pipe crosses the road (where feasible)

   c. when storm drain pipes (27 inches and larger only) must be laid on a curve, the pipe shall meet the minimum curvature according to Table4.02.

4. The minimum cover over pipes shall be in accordance with the minimums specified by the pipe manufacturer and the following:

   a. 18 inches measured between the crown of the pipe and the finished grade,

   b. when the pipe passes underneath pavement, 12 inches measured from the crown of the pipe to the bottom of the sub-base,

   c. 12 inches between the outside of the storm drain pipe and the outside of any utility pipe crossing.

5. Pipe sizes shall not be reduced in the direction of flow.

6. The minimum allowable gauge for aluminized corrugated metal pipe under County roadways is 14. With supporting justification, and at the sole discretion of the County, the gauge for the pipe may be reduced accordingly.

7. The hydraulic grade line shall be one foot below the top of the grate or bottom of the curb opening for the design storm.

8. Conduit Material Selection

   Conduit material shall meet the requirements as specified in Design Manual Volume IV, Section 900. Non-aluminized corrugated metal pipe may be used for driveway culverts. PVC pipe and corrugated aluminum alloy pipe may be considered on a case-by-case basis; the specific approval of the Chief, Bureau of Engineering or Chief, Development Engineering Division shall be required for installations using these pipes.

Aluminized corrugated metal pipe shall have a maximum diameter of 48 inches. The minimum gauge shall be 14, which shall be supported using the pH/Resistivity test (Figure 4.05). This test shall be based on a 50-year design life and shall accompany all preliminary designs submitted to the County. The test shall be performed for every pipe section, which has a different environment (pH and resistivity).

Aluminized corrugated metal pipe shall only be permitted on enclosed storm drain systems. Culverts shall be reinforced concrete pipe or structural plate arches. Stormwater management facilities that are publicly maintained shall use reinforced concrete pipe for the principal spillway and/or plastic PVC pipes for low flow devices where applicable.

High-density polyethylene smooth interior pipe shall have connections limited to bell-and spigot or bell/bell couplings with gaskets. Couplings shall be interchangeable with different manufacturers' pipe and provide a satisfactory connection. Installation of all pipes shall conform to current Howard County Design Manual Volume IV requirements. All HDPE pipes on publicly maintained facilities shall terminate in an aluminized CMP, an RCP end section, a concrete headwall, concrete endwall or storm drain structure such as a manhole or inlet. All end section connection details shall be placed on the plans accordingly.

Soils data justifying the pipe design shall be submitted to the Department of Public Works or the Development Engineering Division upon request.

The use of Gauge 12 or thicker Aluminized-CMP will preclude the need for support data.

9. At inlets, manholes, etc, the invert of the pipes upgrade shall be a minimum of 0.1 foot above the inverts of the pipes. In cases where the pipe size changes, the crown of the upstream pipe shall be no lower than the crown of the downstream pipe.

10. Where the drop in the main line through a storm drain structure is greater than that which can be accommodated by the shaped channel with the invert on a one- half horizontal to one vertical slope, the bottom of the structure shall be lined with granite blocks at least 4- inches thick. No shaped channel will be required for this construction; however the bottom of the structure shall slope at least on-half inch per foot toward the invert of the outlet pipe. Where the branch lines enter structures at a considerable elevation above the bottom of the structure, the shaped channel in the structure may be required to have a granite block lining. The jet flow impingement should be checked in such conditions using Figure 4.06.

11. Field connections of inlet leads into the main line pipe may be used only where the main line pipe involved is 33- inches in diameter and larger or as noted in the Design Manual Volume IV, Standard Specifications and Details for Construction. Whenever possible, the branch line should enter the main line at any angles less than 90 degrees angled in the direction offlow.

12. For upstream extensions of an existing storm drain facility, the capacity shall be checked for a minimum distance of 400' downstream to insure safe conveyance of the increased flow.

13. For storm drain systems that outfall into a retention pond, the outfall invert shall be no lower than the permanent pool water surface elevation. For storm drain systems that outfall into a forebay, the outfall invert shall be no lower than the forebay normal water surface elevation.

E. Inlet Design

1. Types of inlets

a. Curb opening inlets or combination inlets shall be used where curbs are either existing or proposed. Curb openings are preferred.

b. Depressed inlets shall not be used in traffic lanes.

c. In traffic lanes where grates are used, the grate must be bicycle safe.

d. Throat opening inlets and combination inlets may be used in sumps.

2. Inlet Spacing & Installation

a. In all sumps.

b. Upgrade of intersections and driveways except where 2-year flows are less than 2.0 cfs.

c. At intermediate points along streets where spread criteria and gutter capacity would be exceeded without inlets.

d. At least 85% interception of gutter flow shall be picked up under ultimate development conditions for the 2-year storm event.

e. Off-street inlets, which are not in traffic ways, may be yard inlets.

f. Maximum allowable spread of 2-year flow in travel ways within parking areas and within public right-of-ways shall not exceed 8 feet.

g. Maximum allowable 10-year flow in side ditches along roads shall be 5.0 cfs provided erosive velocities are not developed in the side ditch. When flows reach 5.0 cfs, an inlet shall be provided.

h. Maximum allowable 2-year flow across street intersections or driveways shall be 2.0 cfs.

i. Maximum allowable 2-year flow along curb fillets shall be 2.5 cfs.

j. Maximum allowable 2-year flow from Commercial, Apartment and Industrial developments to the County streets shall be 2.0 cfs. The Developer shall be required to provide on-site, privately maintained drainage systems for such developments, which may be connected to the existing County owned systems within the public right-of-way. If the existing County system is inadequate to carry the increased flow from the proposed development, the Developer shall be required to either restrict the runoff from the Developers site or improve the County system at the Developers expense.

k. Maximum allowable 2- year flow into any inlet shall not exceed 15.0 cfs in total from all directions, under any situation.

l. Maximum ponding depth of the 10-year flow at any inlet along a paved surface or curb and gutter shall not exceed 6".

m. The depth of the 10- year flow in a roadside ditch shall be limited to have at least a 0.5 ft. freeboard to the shoulder of the road.

n. Generally, inlets at intersections shall be located with the closest end of the inlet at a minimum of three (3) feet from the P.C. of the curb fillet.

3. Inlet Capacity

Inlet capacities shall be determined by either the Maryland State Highway Administration Highway Drainage Manual, the U.S. Department of Transportation, Federal Highway Administration, "Drainage of Highways Pavements", HEC No. 12, FHWA-TS-84-2002, or the capacity charts included in this Design Manual (Figures 4.07 – 4.14) taking into consideration, street grades, road cross slopes, gutter capacities and permissible spread of surface flow in the gutter.

In general, inlets shall be selected as to type and spacing to intercept a minimum of 85% of the gutter flow. The bypassed flow shall be intercepted by additional inlets at critical points where bypassing cannot be further permitted.

Curb opening inlets located in sump areas have a maximum capacity of 7.5 cfs per five (5) linear feet of throat opening. Inlets that are located in sump areas and that would receive overflow from other areas in the event of large storms or system malfunctions are to be provided with an additional five (5) linear feet of opening in addition to that required to intercept the design flow.

4. Off Street Inlets

Off street inlets, which are not in trafficways, such as those in grassed swales and paved areas, which are protected from traffic, may be open throated area inlets or swale inlets. Capacities for these types of inlets may be determined by the appropriate weir or orifice formula, using a broad-crested weir discharge

coefficient of 3.1 and an orifice discharge coefficient of 0.6. The maximum 10-year ponding depth shall be 6 inches.

5. All inlet computations shall be prepared on Figure 4.07, "Inlet and Gutter Computations" form and submitted to the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division for review and approval.

F. Gutter and Street Flow

1. Spread Criteria

a. The maximum spread within a public street shall be 8 feet for the 2- year storm under ultimate conditions.

b. When the cross-slope of the pavement is the same as the gutter, the computations shall be based on the following equation:

$$Q = 0.56(Z/n)S^{1/2}y^{8/3}$$

Q = discharge in cfs
Z = the reciprocal of the pavement cross-slope or the side slope in ft/ft
For example, for cross-slope of ¼" per foot or 2.08%, Z=46
n = Manning coefficient (normally 0.015 for pavement)
S = gutter slope in ft/ft
y = depth of flow in ft

When the cross-slope of the gutter differs from the cross-slope of the pavement, Figure 4.16 shall be used to determine the spread for the compound section.

2. The 10-year runoff depth in the gutter shall not exceed 0.5 feet for the standard curb or the water depth in the gutter shall not exceed 3" for the 2-1/2 inch rolled curb.

3. All gutter and spread computations shall be prepared on Figure 4.07, "Inlet and Gutter Computations" form and submitted to the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division for review and approval.

G. Closed Conduit Design Method

Closed conduit design shall be based on the hydraulic grade line method with pipes assumed to be flowing full. The losses are applied through the structures.

1. Hydraulic Gradient – The hydraulic gradient shall be determined starting at the downstream end of the proposed drainage system. Where a proposed drainage system is connected to an existing drainage system, the hydraulic gradient at the point of connection shall be determined from the hydraulic gradient computations

of the existing drainage system. Where no computations exist for the existing drainage system, the Federal Highway Administration nomographs for inlet control can be used.

Where the proposed drainage system discharges into a stream, flow conditions of this stream shall be investigated. Where the tailwater elevation is higher than the proposed crown elevation, the hydraulic gradient shall begin at this tailwater elevation. Where a free outfall condition exists, the hydraulic gradient shall begin at the crown of the proposed drain pipe.

Next, the friction loss (as discussed under "Friction Loss", this section) in the drain to the next new structure shall be added. Where the friction slope is less than the actual slope of the pipe, the hydraulic grade line shall be compared to the crown of the pipe. In no instance shall the hydraulic grade line be lower than the crown of the pipe.

Next, the loss in the structure (as discussed under "Head Loss in Structures, this section) shall be added. When the sum of the hydraulic grade elevation into the inlet plus the structure loss is less than the crown elevation of the upstream pipe, the hydraulic grade elevation shall become the crown of the pipe.

The hydraulic gradient to the upstream end of the proposed drainage system, shall be determined by adding a series of friction losses in sections of drains and losses in structures. When the storm drainage system terminates in an upstream headwall or end section, the water surface at the headwall or end section shall be determined by computing the entrance condition under both inlet and outlet control (as discussed under "Head Loss at Entrance Structures", this section).

For closed street sections, curb and gutter, the hydraulic gradient shall not be above an elevation 1 foot below the top of grate or bottom of curb opening not more than 6 feet above the crown of the pipe. In all other locations the hydraulic gradient shall not be above an elevation 1 foot below the established grade nor more than 6 feet over the crown of the pipe. For open road sections, shoulders and side ditches, the hydraulic gradient shall not be above an elevation 1 foot below the invert of the side ditch. Full consideration shall be given to possible future extensions of the system. If the hydraulic grade line (HGL) is more than 2 feet above the crown of any concrete pipe, rubber gaskets shall be provided at all the affected joints, as per ASTM C-361 or ASTM C-76 specifications. For any HDPE or Aluminized CMP, rubber gaskets shall also be provided in accordance with the manufacturers specifications. Profiles of the system shall clearly identify the affected sections of pipe and proper notations shall be included on the profiles.

2. Friction Losses – Head loss due to friction (H_f) in open channels and pipes with uniform flow shall be determined by the Manning Formula:

$$S_f = \frac{(nv)^2}{2.208\, r^{4/3}}$$

$$H_f = S_f \times L$$

S_f = the friction slope in ft of drain. For pipe laid on curves, "n" shall be increased by 0.001 for each 20 degrees of curvature.

3. Head Losses in Structures – Design Figure 4.18, "Head Losses in Structures, Hydraulic Grade Line Method", show curves prepared for the determination of head loss in cut- ins, "y" branches, preformed concrete pipe fittings, manholes, brick bends (with or without connection and manhole) and junction chambers. These curves are based on surcharged pipes entering rectangular structures, but apply to monolithic structures as noted.

These curves are indicated as "A", "B", "C" and "D" losses in Figure 4.18. The "A" curve depicts loss due to entrance and exit. The "B" curve depicts velocity head where the head loss shall be the difference in velocity heads. Where the upstream velocity is greater, the apparent gain may be used to offset other head losses in the structure. The "C" curve depicts loss in a manhole due to a change in direction, loss for "y" branch and loss in brick bend. The "D" loss depicts loss due to incoming volume.

Refer to Figure 4.18 to determine the appropriate factors to apply to these losses for the particular hydraulic structures used.

4. Head Loss at Entrance Structures – Where the enclosed storm drain system accepts discharges from swales or open channels, the water surface elevations at the headwall or end section shall be established by analyzing the entrance for both inlet and outlet control for the design storm.

The water surface elevation under inlet and outlet control shall be established in accordance with the U.S. Department of Transportation, Federal Highway Administration, latest edition of the "Hydraulic Design Series No. 5, "Hydraulic Design of Highway Culverts", FHWA-IP-85-15.

A composite of both inlet and outlet control elevations can be obtained by using the "HY8 Culvert Analysis Microcomputer Program", FHWA Report No. FHWA-ED-87-101 as an alternative to the design charts. All input documentation must be submitted for review by the appropriate agency.

All hydraulic gradient computations shall be performed on the "Howard County Hydraulic Gradient and Headloss Computation Form", Figure 4.17, and submitted to the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division for review and approval.

Sample computations can be found in the appendix at the end of this chapter.

4.2 OPEN CHANNEL

4.2.1 Open Channel Design Criteria

A. Design Storm Criteria

1. Swales and roadside ditches shall be based on the 10- year storm frequency.

2. All other open channels, improved or natural, shall be designed or analyzed for capacity based on the 100-year frequency storm event.

3. Open channels designed for stream restoration or stabilization shall follow the requirements of Section 5.2.7.M of this design manual.

B. Velocities

1. For non-erodible linings the maximum velocity shall be 25 fps and the minimum velocity shall be 3 fps.

2. For vegetative and natural linings see table 4.06.

C. Open Channel Criteria

1. The design storm shall be based on ultimate development with no RCN credits being assumed.

2. The estimation of runoff shall be determined as described for closed conduit systems.

3. Manning's coefficients based on:

   a. existing conditions unless changes in the coefficients are included in the proposed project.

   b. the highest seasonal variation of the coefficient.

4. For improved channels, the profile and velocities of the natural stream shall be examined, both upstream and downstream of the proposed development **[[at]] WITHIN THE LIMITS OF** the following locations. **IF THE COUNTY DETERMINES THAT THE PROPOSED DEVELOPMENT WILL CREATE AN EROSIVE CONDITION WITHIN THESE LIMITS, THE APPLICANT OR DEVELOPER SHALL PROVIDE MITIGATION TO REMEDIATE THE CONDITION:**

   a. at the beginning and end of the improvements for all projects,

   b. within five (5) feet of the property line for all projects,

   c. two hundred (200) feet for projects with drainage areas less than 50 acres,

   d. five hundred (500) feet for projects with drainage areas between 50 and 200 acres,

e. one thousand (1000) feet for projects with drainage areas greater than two hundred (200) acres.

5. Riprap for energy dissipaters and for bend locations shall be sized for the 100- year velocity.

6. Safety fences or guardrails are required along public roads for all improved channels (other than local improvements on a natural stream), if the channel side slopes are steeper than 4:1 and the depth exceeds 3 feet. The safety fences and/or guardrails shall be DPW approved.

7. If a headwall or bridge height above the channel bottom exceeds six (6) feet, then channels which do not require a safety fence shall be required to provide guard rails, curbs, or other safety devices.

8. In non-erodible channels, the flat bottom may be sloped one to two percent to the center to define a low flow channel.

9. The waterway depth based on the design storm shall be five (5) feet or less for all improved channels. Where reconstruction of existing channels are required and existing channel are greater than five (5) feet in depth, the Director, Department of Public Works or the Chief, Development Engineering Division may waive this requirement.

10. Field run cross-sections are required for the final analysis of major drainage systems.

    a. Sections shall be obtained at regular intervals and at significant changes in stream characteristics such as changes in slope, meander, expansions, contractions, roughness, etc.

    b. The maximum spacing for sections shall be 200 feet. In critical areas, the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division may require that additional cross-sections be provided.

11. Location and alignment of drainage swales, ditches and channel shall be designed so that the original drainage course is changed as little as possible. However, except when the purpose of the design is stream restoration, it shall generally be considered desirable to eliminate bends, to cross existing and/or future streets normal to the street and to eliminate channel running through the center of a property where location near or on a property line is feasible. In all instances, the shape and size of all ditches shall be so designed as to create the most economically efficient and scour resistant channel as possible. The uses of ditches and swales with 4:1 or flatter slopes is greatly encouraged; however, the maximum side slopes permissible is 2:1 in existing ground and 1:1 in rock.

D. Open Channel Design Methods

1. For drainage areas less than thirty (30) acres, the depth of flow and velocity in the channel shall be computed using Manning's Equation. The required waterway area may be estimated by the relationship:

$$A = \frac{Q}{V} \qquad \text{Continuity Formula}$$

$$V = \frac{1.486\, r^{2/3}\, s^{1/2}}{n} \qquad \text{Manning's Formula}$$

These equations should be applied at representative cross-sections and at control sections (major cross-section changes).

2. For drainage areas over thirty (30) areas, the U.S. Army Corps of Engineers Computer Program HEC-RAS may be used to perform open channel analysis. The HEC-RAS submittals shall include input computations, cross-sections, and locations, and complete printout with profile and cross-section information. The Department of Public Works or the Department of Planning & Zoning/Development Engineering Division has the option of requesting a run of the HEC-RAS edit program.

3. The Department of Public Works or the Department of Planning & Zoning/Development Engineering Division reserves the right to request submission of diskettes of computer analysis or require that an alternative analysis be done.

4.3 CULVERTS, ARCHES AND BRIDGES

A. General Policy

1. As a general policy for all stream crossings, any obstruction or disturbance of a waterway needs to be avoided to the extent feasible. If a crossing is deemed necessary or unavoidable by the current subdivision regulations, any impacts shall be minimized to the extent practicable. If a proposed crossing is unavoidable and necessary, consideration shall be given to:

   a. Reduce the extent of the waterway obstruction.
   b. Maintain the existing hydraulic conveyance.
   c. Minimize the instability of the stream system.
   d. Minimize the segmentation of the riparian corridor.
   e. Provide for the passage of aquatic and other wildlife.

2. Generally, these goals are achieved, in order of preference, through the use of a:

   a. Bridge;
   b. Bottomless Culvert; or
   c. In-stream and Floodplain Culverts.

A determination of the most appropriate structure shall be based upon a comparison of various sizes and types of crossings along with their associated resource impacts, economics, long term maintenance requirements, resource values and sensitivities to disturbance, site constraints, safety and other criteria unique to the specific project.

B. Reports and Mitigation

1. A report justifying the type of stream crossing shall accompany the "SP", "P" or "SDP" initial plan submittal or with the subdivision waiver petition for the crossing.

2. Mitigation may be required for any impacts that cannot be avoided or minimized. Mitigation measures shall be determined on a case-by-case basis at the sole discretion of Howard County, the Maryland Department of the Environment or the Army Corps of Engineers.

4.3.1 Culvert, Arch and Bridge Design Criteria

A. Design Storm Criteria

1. Bridges, which are in the 100- year floodplain, shall pass the 100- year design storm. The 100- year storm shall not have more than a 1- foot increase in backwater above the existing 100-year water surface elevation. A freeboard of 1 foot between the 100-year water surface elevation and the highest point of the arch or the lowest chord of the bridge is required for the 100-year design storm.

2. Culverts and arches on public roads that are located in the 100- year floodplain shall pass the 100-year storm otherwise the following shall apply:

a.	Driveways	10 year
b.	Private Access Place	10 year
c.	Access Place/Access Street	25 year
d.	Minor Collector	25 year
e.	Major Collector	50 year
f.	Minor Arterial	100 year
g.	Intermediate Arterial	100 year
h.	Principal Arterial	100 year

The roads and/or driveways cannot be flooded on the above storm frequency. The water surface elevation shall be a minimum of 1 foot below the outside edge of pavement or the maximum HW/D = 1.5, whichever is less.

B. Culverts, Arches and Bridges Criteria

1. For bridge structures, the minimum freeboard between the underside of the superstructure and the design storms water surface elevation shall be one (1) foot.

2. The headwater pool of the structure should be as close to the existing water surface elevation as possible. Any increase in water surface elevation is subject to Department of Public Works or the Department of Planning & Zoning/Development Engineering Division review and approval.

3. In perennial streams, at least one culvert shall be one (1) foot lower than the final stream invert.

4. Arches and Bridges shall be used where:

   a. the quantity of flow is too great for a culvert,

   b. a culvert would cause an unacceptable obstruction to the floodplain,

   c. preservation of natural stream conditions is warranted such as perennial streams, floodplains, wetlands or passage of wildlife.

5. Embankments and grading around the substructure of an arch or bridge shall be protected where necessary.

6. Arch, Bridge and Culvert design shall be in accordance with Design Manual Volume III and with the "Standard Specifications for Highway Bridges".

7. Pipe or culvert openings larger than 50 inches rise adjacent to slopes steeper than 6:1 shall have headwalls with 5 foot high chain link fencing.

8. For structural plate pipe the bottom and corner plates should be 1 gauge thicker than the required AASHTO Specifications.

9. All Arch and Bridge footings shall be sufficiently protected from the effects of scour in accordance with Federal (HEC-18) and State (ABSCOUR) standards.

C. Culvert, Arch and Bridge Design Methods

1. Culverts shall be sized using the FHWA Design Series No. 5 and No. 10, the U.S. Army Corps of Engineers Computer Program HEC-RAS, the FHWA/HY-8 Computer Program or the FHWA Hydraulic Design Series No. 1, Hydraulics of Bridge Waterways. Inlet and outlet control should be computed.

2. Bridges shall be sized using the FHWA Design Series No. 5 and No. 10, the U.S. Army Corps of Engineers Computer Program HEC-RAS, the FHWA/HY-8 Computer Program or the FHWA Hydraulic Design Series No. 1, Hydraulics of Bridge Waterways. With submittals include input computations, cross-section and locations, and complete printout with profile and cross-sections.

3. When more appropriate, other methods may be used with the approval of the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division.

4. The Department of Public Works or the Department of Planning & Zoning/Development Engineering Division reserves the right to request the submission of a CD-ROM copy of the computer analysis.

4.4 ENERGY DISSIPATERS AND CHANNEL PROTECTION

4.4.1 Drop Structures, Gabions and Riprap Protection

A. Drop Structures

If drop structures are proposed as a means of dissipating energy at an outfall location, then the design professional is responsible for providing all backup computations, references and details to support the design.

B. Gabions

If gabions are proposed as a means of dissipating energy at an outfall location, then the design professional is responsible for providing all backup computations, references and details to support the design. A gabion profile, sections, details, and construction specifications are required on the design plans showing gabion dimensions, stone size, basket dimensions, filter fabric and existing and proposed grades.

C. Riprap

Riprap outfalls shall be designed in accordance with the "Maryland Standards and Specifications for Soil Erosion and Sediment Control", latest edition. The design professional shall provide design data for the outfalls on the design drawings. All construction specifications shall be provided on the drawings to include length, width, thickness of apron, a grouted riprap toe wall depth of 3' size of riprap, filter cloth specifications and other pertinent data as deemed necessary by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division. Riprap sizes specified on the design plans shall conform to the Maryland State Highway Administration size classifications (Class I, II, or III).

All design support data shall be included in the design computations and submitted to the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division for review and approval.

Computer programs for the computation of outfall effectiveness shall be approved by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division in writing prior to use by the design professional.

4.5 RESERVOIR ROUTING

4.5.1 Reservoir Routing Criteria

A. Drainage areas less than 2,000 acres shall be designed in accordance with the USDA-NRCS TR-20, TR-55 and the Maryland Conservation Practice Standards, Pond, (Code 378).

B. Drainage areas greater than 2,000 acres shall have the design method approved by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division.

4.6 RESIDENTIAL LOT DRAINAGE REQUIREMENTS

4.6.1 Drainage Swales and Surface Drainage Easements

A. Swales shall be designed to convey runoff from the 10-year frequency storm event.

B. The minimum distance of the centerline of a drainage swale or storm drain shall be 15 feet minimum to a residential structure and it is recommended that it be placed at the rear of the property beyond the BRL or in open space to maximize the use of the lot, except where swales or drain pipes pass between structures on both sides. When swales or storm drain pipes pass between residential units, the swale or pipe shall be centered when possible.

C. The maximum drainage area feeding any swale located in backyards shall be 2.5 acres. All flow shall be picked up by a closed conduit system upon the drainage area exceeding 2.5 acres.

D. The maximum drainage area to any swale between two (2) houses shall be 1.0 acre. If the distance between the two (2) houses is much greater than the typical 15 or 20 feet, a greater amount of flow may be allowed in the swale. A designed swale shall be shown on the plans with the typical section and hydraulic data.

E. The maximum drainage area allowed to cross a driveway on a pipestem lot shall be 1.0 acre. For driveways on pipestem lots with drainage areas exceeding 1.0 acre, a pipe will be required to safely convey the flow. The pipe can daylight on the other side of the driveway, subject to the 2.5 acre limitation above.

F. Required private surface drainage easements shall be used and granted to a Home Owners Association where applicable. The County shall be given enforcement responsibilities to insure that the easement is properly maintained and free of obstructions. The easement shall start at the next downstream property line after the swale accumulates 1.0 acre of drainage area. All easements shall be identified on the Site Development Plan (SDP) once final drainage paths are established and shall be recorded on a Final Plat. All easements shall be shown on the site development plan to provide notice to the homebuyers of their existence.

G. A more detailed study of the over- lot drainage patterns shall be required at the Preliminary Plan submittal. This study does not have to encompass the entire subdivision, only perceived trouble spots. Inlet locations shall be shown on the Final Road Construction Plans, as appropriate. Any required adjustments to the grades of the pipes and inlets may be made through the Red- line Revision process if the site development plan grades require different elevations than those on the approved Final Road Construction Plans. A flat grate type yard inlet shall be used and a safe overflow path shall be provided to the next downstream structure or conveyance system. Maximum 10-year ponding prior to overflow shall not exceed six (6) inches in case of blockage.

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REFERENCES

1. Chow, Van Te, Open Channel Hydraulics, McGraw-Hill Book Co., New York, 1959.

2. King, H.W., and Ernest F. Brater, Handbook of Hydraulics, Fifth Edition, McGraw-Hill Book Co., New York, 1963.

3. U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 5, Hydraulics.

4. U.S. Department of Interior, Bureau of Reclamation, Design of Small Dams, Second Edition, 1973.

5. Federal Highway Administration, "Hydraulic Design of Improved inlets for Culverts", Hydraulic Engineering Circular No. 13, Government Printing Office, Washington, D.C., August 1972.

6. Federal Highway Administration, "Hydraulic Design of Highway Culverts", Hydraulic Design Series No. 5, FHWA-IP-85-15, National Technical Information Center, Springfield, Virginia, September 1980.

7. U.S. Department of Agriculture, Soil Conservation Service, Engineering Field Manual, Washington, D.C., September 1969.

8. Federal Highway Administration, "Hydraulics of Bridge Waterways", Hydraulic Design Series No. 1, Government Printing Office, Washington, D.C., 1973.

9. U.S. Department of Transportation, Federal Highway Administration, Hydraulic Design Series No.3, Design Charts for Open Channel Flow, August 1961, Reprinted 1980, National Technical Information Service, Springfield, Virginia.

10. State of Maryland, Department of Transportation, State Highway Administration, Standards for Highways and Incidental Structures, Standard Type S Inlet and Combination Reticular Replacement Grate, Standard No. MD-379.08.

11. U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 4, Design of Roadside Drainage Channels, May 1965, Reprinted 1973, National Technical Information Service, Springfield, Virginia.

12. U.S. Department of Agriculture, Soil conservation Service, TR-49, Criteria for the Hydraulic Design of Impact Basins Associated with Full Flow in Pipe Conduits, March 1971.

13. Maryland Department of Transportation, State Highway Administration, Highway Drainage Manual. [[1981]] **MOST RECENT EDITION.**

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TABLES

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Table 4.01

MINIMUM ALLOWABLE MANNING COEFFICIENT – "n" FOR STORM DRAIN CONDUITS AND CHANNELS

Materials Description	Range		
Rubble or Riprap			
Concrete bottom, floated finished	0.020	to	0.024
Grouted sides	0.025		0.030
Ungrouted sides	0.030		0.035
Grouted bottom and sides	0.035		0.040
Ungrouted bottom and sides	0.035		0.050
Vegetal lined swales (varies with depth)			
Excavated Channels			
Earth, straight and uniform with short grasses, few weeds	0.027		0.033
Earth, winding and sluggish grass, some weeds	0.030		0.033
Earth, dense weeds or aquatic plants in deep channels	0.035		0.040
Earth bottom and rubble sides	0.030		0.035
Stoney bottom and weedy banks	0.035		0.040
Channels Not Maintained, Weeds and Brush Uncut			
Dense weeds, high as flow depth	0.080		0.120
Clean bottom, brush on sides	0.050		0.080
Same, highest stage of flow	0.070		0.110
Dense brush, high	0.100		0.140
Closed Conduits			
Brick	0.015		0.017
Cast Iron Pipe	0.013		0.015
Concrete (monolithic)			
Smooth forms	0.012		0.014
Rough forms	0.015		0.017
Concrete Pipe (Round and Elliptical)	0.013		0.015
*Corrugated Steel/Aluminum Alloy Pipe			
2-2/3 x1/2 helical corrugations			
12" – 36" diameter	0.018		0.021
42" – 96" diameter	0.022		0.026
*Corrugated Steel/Aluminum Alloy Pipe			
3 x 1 helical corrugations			
36" – 84" diameter	0.020		0.022
96" – 144" diameter	0.023		0.025
Corrugated Steel/Aluminum Alloy Pipe			
2-2/3 x 1/2 annular corrugations	0.023		0.025
Corrugated Steel/Aluminum Pipe			
3 x 1 annular corrugations	0.026		0.030
Structural Plate Pipe 6 x 2 Corrugations	0.032		0.036
Corrugate Steel/Aluminum Alloy/Pipe Arch	0.022		0.026
Corrugate Steel/Aluminum Alloy Pipe			
25% paved invert full flow	0.020		0.022
Corrugate Steel/Aluminum Alloy Pipe Arch			
40% paved invert full flow	0.019		0.021
Corrugate Steel/Aluminum Alloy Pipe			
100% paved	0.013		0.013
Vitrified Clay			
Pipes	0.013		0.015
Lined plates	0.015		0.017

*Limitations

While it is true that helical corrugated metal pipe may have a lower "n" value than annular corrugated metal pipe, care should be exercised in the use of the reduced values. Since the lower values depend upon the development of spiral flow across the entire cross -section of the pipe, the designer must confirm that fully developed spiral flow can occur in the design situation. It is recommended that the "n" values for the annular pipe be used under the following conditions:

1 - Partly full flow in the pipe
2 - Extremely high sediment load
3 - Short culverts less than 20 diameters
4 - Non-circular pipes
5 - Partially paved pipes

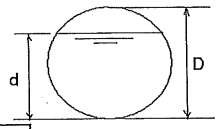
Open Channels		
Lined channel		
Asphalt	0.013	0.015
Brick	0.015	0.017
Concrete		
Trowel finish	0.013	0.015
Float or burlap drag finish	0.015	0.017
Gunite or unfinished	0.019	0.022

Table 4.02

MIMIMUM ALLOWABLE RADII FOR CURVES
(1/2" Joint Opening)

Pipe Size (in.)	4' Length Minimum Radius (ft.)	6' Length Minimum Radius (ft.)	8' Length Minimum Radius (ft.)
27	268	402	536
30	296	444	592
33	324	486	648
36	352	528	704
42	408	612	816
48	464	696	928
54	520	780	1,040
60	576	864	1,152
66	632	948	1,264
72	688	1,032	1,376
78	744	1,116	1,488
84	800	1,200	1,600
90	856	1,284	1,712
96	912	1,368	1,824
102	968	1,452	1,936
108	1,024	1,536	2,048
114	1,064	1,596	2,128
120	1,120	1,680	2,240

Table 4.03



TABULAR VALUES OF HYDRAULIC ELEMENTS OF PIPES (n CONSTANT)

$\frac{d}{D}$	$\frac{A}{D^2}$	$\frac{Qn}{D^{8/3}S^{1/2}}$	$\frac{Qc}{D^{5/2}}$	$\frac{d}{D}$	$\frac{A}{D^2}$	$\frac{Qn}{D^{8/3}S^{1/2}}$	$\frac{Qc}{D^{5/2}}$
0.01	0.0013	0.00007	0.0006	0.51	0.4027	0.239	1.4494
0.02	0.0037	0.00031	0.0025	.052	0.4127	0.247	1.5041
0.03	0.0069	0.00074	0.0055	0.53	0.4227	0.255	1.5598
0.04	0.0105	0.00138	0.0098	0.54	0.4327	0.263	1.6166
0.05	0.0147	0.00222	0.0153	0.55	0.4426	0.271	1.6741
0.06	0.0192	0.00328	0.0220	0.56	0.4526	0.279	1.7328
0.07	0.0242	0.00455	0.0298	0.57	0.4625	0.287	1.7924
0.08	0.0294	0.00604	0.0389	0.58	0.4724	0.295	1.8531
0.09	0.0350	0.00775	0.0491	0.59	0.4822	0.303	1.9147
0.10	0.0409	0.00967	0.0605	0.60	0.4920	0.311	1.9773
0.11	0.0470	0.01181	0.0731	0.61	0.5018	0.319	2.0410
0.12	0.0534	0.01417	0.0868	0.62	0.5115	0.327	2.1058
0.13	0.0600	0.01674	0.1016	0.63	0.5212	0.335	2.1717
0.14	0.0668	0.01952	0.1176	0.64	0.5308	0.343	2.2886
0.15	0.0739	0.0225	0.1347	0.65	0.5404	0.350	2.3068
0.16	0.0811	0.0257	0.1530	0.66	0.5499	0.358	2.3760
0.17	0.0885	0.0291	0.1724	0.67	0.5594	0.366	2.4465
0.18	0.0961	0.0327	0.1928	0.68	0.5687	0.373	2.5182
0.19	0.1039	0.0365	0.2144	0.69	0.5780	0.380	2.5912
0.20	0.1118	0.0406	0.2371	0.70	0.5872	0.388	2.6656
0.21	0.1199	0.0448	0.2609	0.71	0.5964	0.395	2.7416
0.22	0.1281	0.0492	0.2857	0.72	0.6054	0.402	2.8188
0.23	0.1365	0.0537	0.3116	0.73	0.6143	0.409	2.8977
0.24	0.1449	0.0585	0.3386	0.74	0.6231	0.416	2.9783
0.25	0.1535	0.0634	0.3667	0.75	0.6319	0.422	3.0606
0.26	0.1623	0.0686	0.3957	0.76	0.6405	0.429	3.1450
0.27	0.1711	0.0739	0.4259	0.77	0.6489	0.435	3.2314
0.28	0.1800	0.0793	0.4571	0.78	0.6573	0.441	3.3200
0.29	0.1890	0.0849	0.4893	0.79	0.6655	0.447	3.4111
0.30	0.1982	0.0907	0.5226	0.80	0.6736	0.453	3.5051
0.31	0.2074	0.0966	0.5569	0.81	0.6815	0.458	3.6020
0.32	0.2167	0.1027	0.5921	0.82	0.6893	0.463	3.7021
0.33	0.2260	0.1089	0.6284	0.83	0.6969	0.468	3.8062
0.34	0.2355	0.1153	0.6657	0.84	0.7043	0.473	3.9144
0.35	0.2450	0.1218	0.7040	0.85	0.7115	0.477	4.0276
0.36	0.2546	0.1284	0.7433	0.86	0.7186	0.481	4.1466
0.37	0.2642	0.1351	0.7836	0.87	0.7254	0.485	4.2722
0.38	0.2739	0.1420	0.8249	0.88	0.7320	0.488	4.4057
0.39	0.2836	0.1490	0.8672	0.89	0.7384	0.491	4.5486
0.40	0.2934	0.1561	0.9104	0.90	0.7445	0.494	4.7033
0.41	0.3032	0.1633	0.9546	0.91	0.7504	0.496	4.8724
0.42	0.3130	0.1705	0.9997	0.92	0.7560	0.497	5.0602
0.43	0.3229	0.1779	1.0459	0.93	0.7612	0.498	5.2727
0.44	0.3328	0.1854	1.0929	0.94	0.7662	0.498	5.5182
0.45	0.3428	0.1929	1.1410	0.95	0.7707	0.498	5.8119
0.46	0.3527	0.201	1.1900	0.96	0.7749	0.496	6.1785
0.47	0.3627	0.208	1.2400	0.97	0.7785	0.494	6.6695
0.48	0.3727	0.216	1.2908	0.98	0.7817	0.489	7.4063
0.49	0.3827	0.224	1.3427	0.99	0.7841	0.483	8.8261
0.50	0.3927	0.232	1.3956	1.00	0.7854	0.463	-------

Table 4.04

CONSTANTS FOR PIPE FLOW

Diameter (in)	Area (sqft	D^2 $(ft)^2$	$D^{2/3}$ $(ft)^{2/3}$	$D^{5/2}$ $(ft)^{5/2}$	$D^{8/3}$ $(ft)^{8/3}$	$Q/S^{0.5}$ for Manning's "n"					
						0.013	0.014	0.015	0.024	0.025	0.026
6	0.1963	0.2500	0.6300	0.1768	0.1575	5.61	5.21	4.86	3.04	2.92	2.80
8	0.3491	0.4444	0.7631	0.3629	0.3392	12.08	11.22	10.47	6.54	6.28	6.04
10	0.5454	0.6944	0.8855	0.6339	0.6150	21.90	20.34	18.98	11.86	11.39	10.95
12	0.7854	1.0000	1.0000	1.0000	1.0000	35.62	33.07	30.87	19.29	18.52	17.91
15	1.2272	1.5625	1.1604	1.7469	1.8131	64.57	59.96	55.96	34.98	33.58	32.29
18	1.7671	2.2500	1.3104	2.7557	2.9483	105.01	97.51	91.01	56.88	54.60	52.50
21	2.4053	3.0625	1.4522	4.0513	4.4474	158.39	147.08	137.27	85.80	82.36	79.20
24	3.1416	4.0000	1.5874	5.6569	6.3496	226.14	209.99	195.99	122.49	117.59	113.07
27	3.9761	5.0625	1.7171	7.5938	8.6927	309.59	287.48	268.31	167.70	160.99	154.80
30	4.9087	6.2500	1.8420	9.8821	11.5126	410.03	380.74	355.36	222.10	213.21	205.01
33	5.9396	7.5625	1.9629	12.5410	14.8441	528.68	490.92	458.19	286.37	274.91	264.34
36	7.0686	9.0000	2.0801	15.5885	18.7208	666.75	619.12	577.85	361.15	346.71	333.37
39	8.2958	10.5625	2.1941	19.0418	23.1751	825.39	766.43	715.34	447.09	429.20	412.70
42	9.6211	12.2500	2.3052	22.9177	28.2389	1,005.74	933.90	871.47	544.78	522.98	502.87
48	12.5664	16.0000	2.5198	32.0000	40.3175	1,435.92	1,333.36	1,244.47	777.79	746.68	717.96
54	15.9043	20.2500	2.7257	42.9567	55.1950	1,965.79	1,825.38	1,703.69	1,064.80	1,022.21	982.90
60	19.6350	25.0000	2.9240	55.9017	73.1004	2,603.50	2,417.54	2,256.37	1,410.23	1,353.82	1,301.75
66	23.7583	30.2500	3.1158	70.9425	94.2542	3,356.90	3,117.12	2,909.31	1,818.32	1,745.59	1,678.45
72	28.2743	36.0000	3.3019	88.1816	118.8694	4,233.58	3,931.18	3,669.10	2,293.19	2,201.46	2,116.79
78	33.1831	42.2500	3.4829	107.7168	147.1529	5,240.91	4,866.56	4,542.12	2,838.83	2,725.27	2,620.45
84	38.4845	49.0000	3.6593	129.6418	179.3060	6,386.05	5,929.90	5,534.58	3,459.11	3,320.75	3,193.03
90	44.1786	56.2500	3.8315	154.0470	215.5245	7,675.99	7,127.70	6,652.52	4,157.83	3,991.51	3,837.99
96	50.2655	64.000	4.0000	181.0193	256.0000	9,117.54	8,466.29	7,901.87	4,938.67	4,741.12	4,558.77
102	56.7450	72.2500	4.1650	210.6431	300.9196	10,717.37	9,951.84	9,288.38	5,805.24	5,573.03	5,358.68
108	63.6173	81.0000	4.3267	243.0000	350.4666	12,482.00	11,590.43	10,817.74	6,761.09	6,490.64	6,241.00
114	70.8822	90.2500	4.4856	278.1692	404.8209	14,417.85	13,388.01	12,495.47	7,809.67	7,497.28	7,208.93
120	78.5398	100.0000	4.6416	316.2278	464.1589	16,531.20	15,350.40	14,327.04	8,954.40	8,596.22	8,265.60

Table 4.05

ENTRANCE LOSS COEFFICIENTS FOR STORM DRAIN STRUCTURES							
Structure Type	Pipe Sizes (in)	Bell Mounted Developed Invert			Sharp Edged Developed Invert		
		Non	Half	Full	Non	Half	Full
Standard Manholes & Type A Inlets	12	0.18	0.16	0.01	0.16	0.40	0.03
	15	0.18	0.14	0.01	0.44	0.36	0.03
	18	0.17	0.13	0.01	0.42	0.31	0.03
	21	0.16	0.11	0.01	0.39	0.27	0.03
	24	0.14	0.09	0.01	0.36	0.23	0.03
	27	0.13	0.08	0.01	0.32	0.20	0.03
	30	0.12	0.06	0.01	0.29	0.16	0.03
	33	0.10	0.05	0.01	0.25	0.13	0.03
	36	0.08	0.04	0.01	0.21	0.10	0.03

Note: Entrance Loss Coefficients for Type C Manholes, Bend Structures and Junction Chambers are the same as for Fully Developed Inverts.

Table 4.06

LIMITING VELOCITIES FOR DITCHES AND CHANNELS		
Lining Type	Allowable Velocities (fps)	Remarks
Earth, without vegetation	1.0 to 3.0	USE SOIL STABILIZATION MATTING OVER SEED AND MULCH FOR CONSTRUCTION ITEMS
Seed & Mulch	2.5	"
Grains, Stiff Stemmed Grasses	2.0 to 3.0	"
Bunch Grass	2.0 to 4.0	"
Solid Sodding	4.0	"
Stiff Clay or Clay & Gravel	3.0 to 5.0	"
Fine Gravel	5.0	"
Well-established Grasses, Short pliant blades	5.0	"
Soil Stabilization Matting Over Seed & Mulch	5.0	-
Shale & Rock	5.6	-
Course Gravel	6.0	-
Riprap	Varies	Refer to SHA 61.1-405.1
Concrete Channel	No. Maximum	-

Note: This chart based on SHA 61.1-405.0, dated 1994.

FIGURES

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Figure 4.01

STORM DRAIN COMPUTATIONS

PROJ. NAME: _____ SHEET_____of_____

COMP. BY: _____

DATE: _____

CHECKED BY: _____

DATE: _____

DESIGNFREQUENCY: _____ YR.

(SEAL)

PIPE															
FROM NO.	TO NO.	INC. AREA (AC)	TOTAL AREA (AC)	C	CXA	SUM (CXA)	TIME (MIN)	I (IN/HR)	Q (CFS)	DES. SLOPE (%)	DIAMETER (IN)	VELOCITY (FPS)	LENGTH (FT)	TIME (MIN)	REMARKS

Figure 4.02

RISER INFLOW CURVES

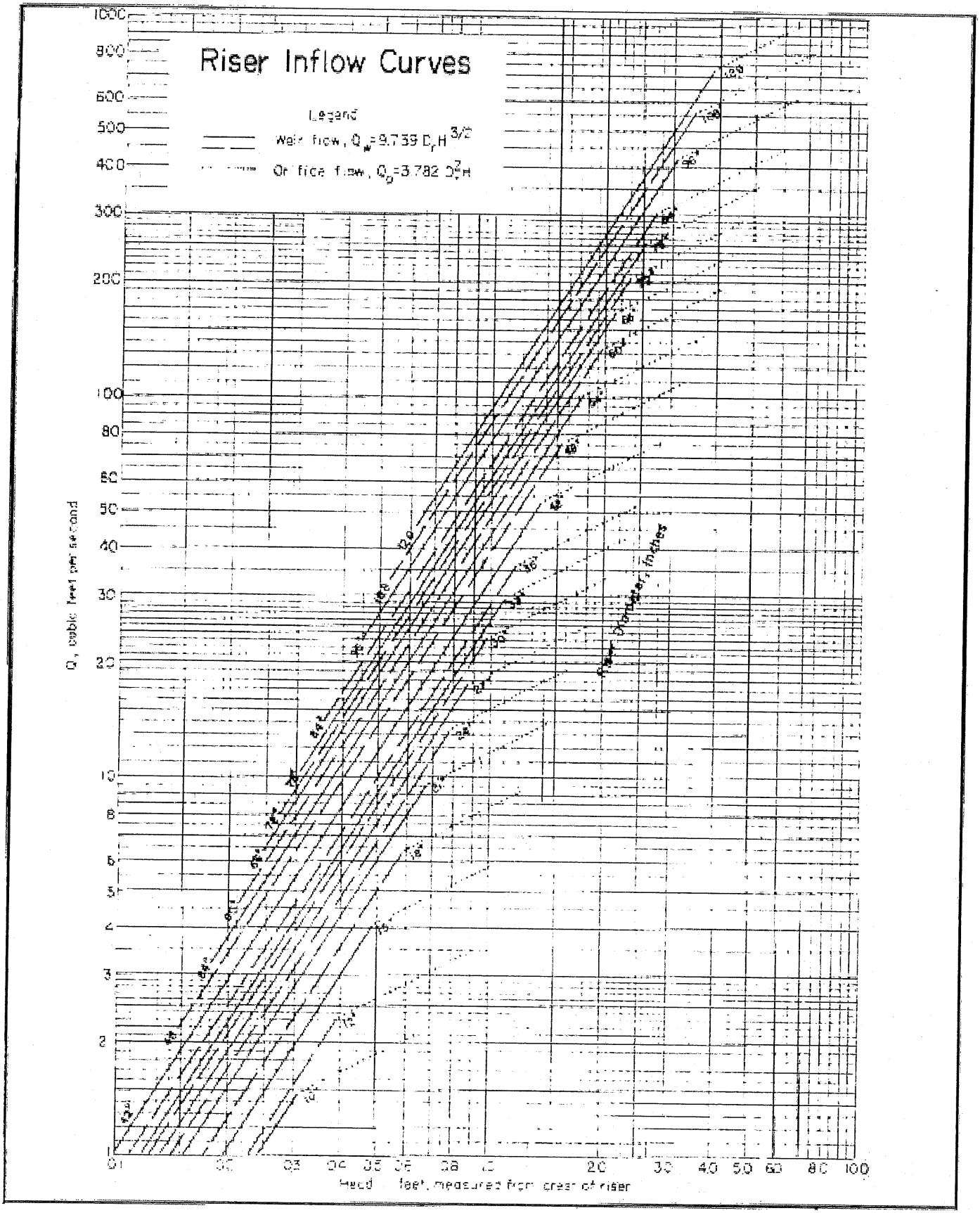


Figure 4.03

CURVES FOR DETERMINING THE NORMAL DEPTH

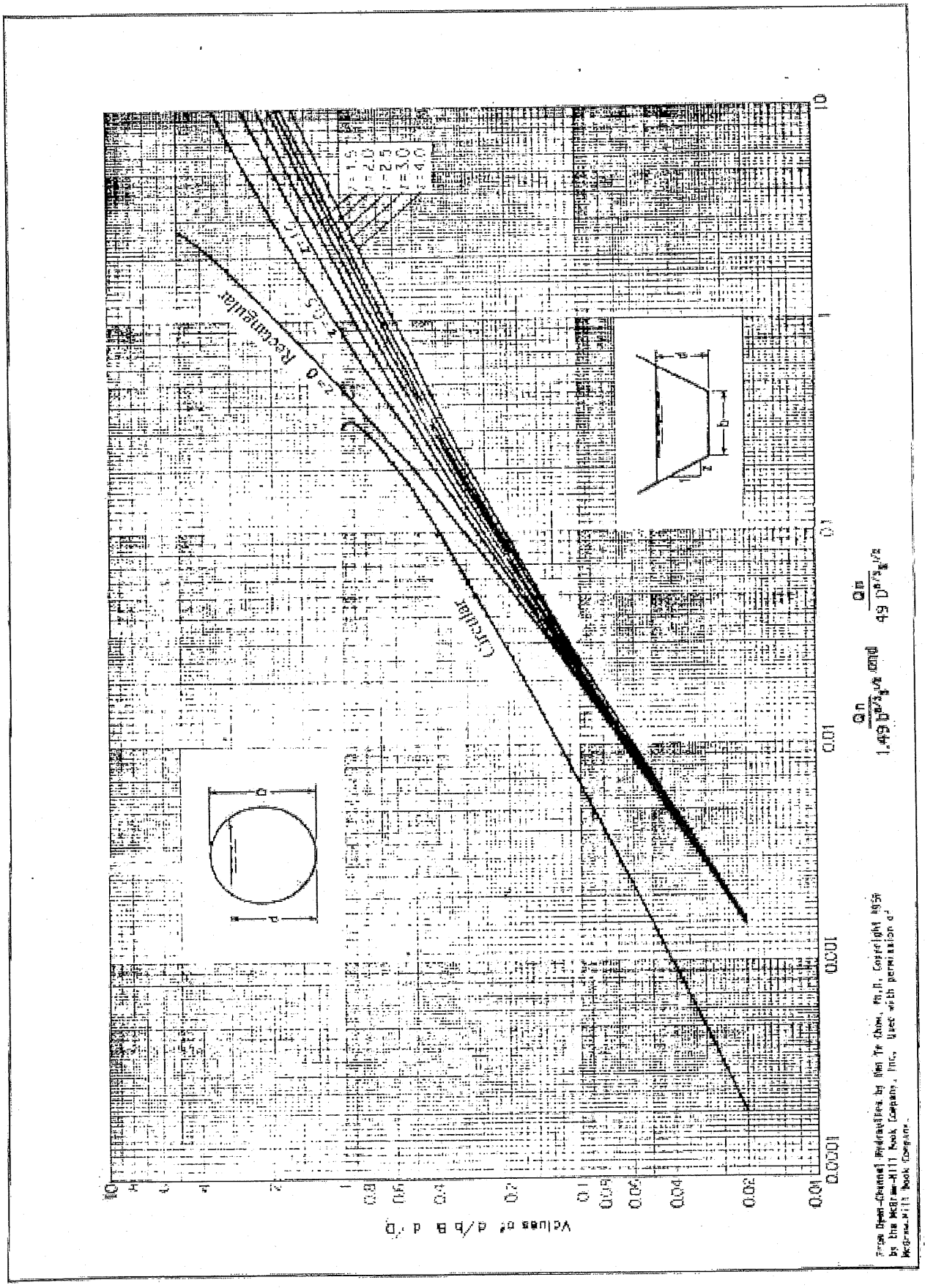


Figure 4.04

CURVES FOR DETERMINING THE CRITICAL DEPTH

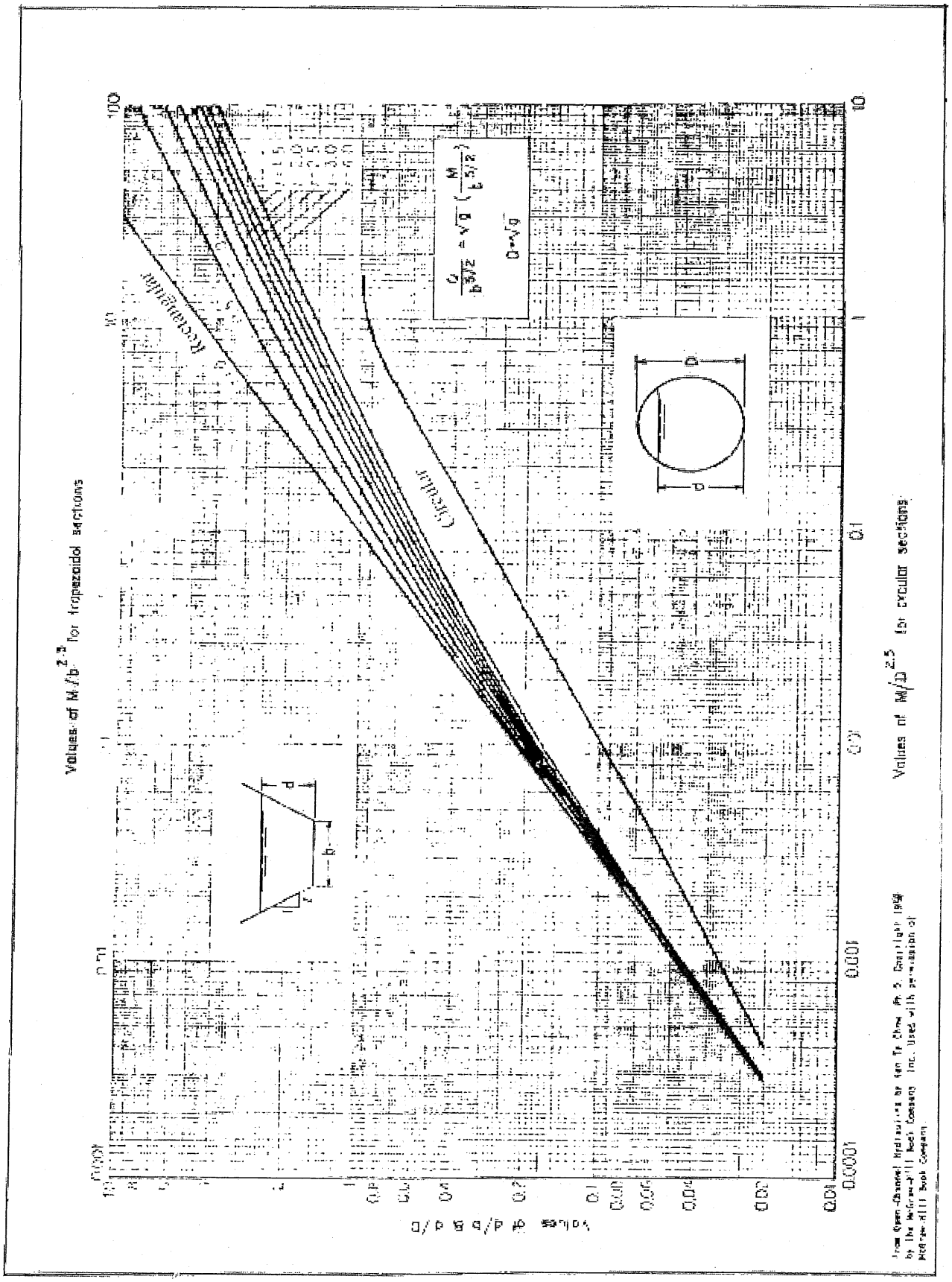


Figure 4.05

CMP GAUGEDETERMINATION

Note: This test will not be required when 12- gauge pipe is used.

Project Name: _____

Date: _____

Pipe Location: _____

*Soil Type: _____

*PH of Soil: _____

Minimum Resistivity: _____

Average Life: _____

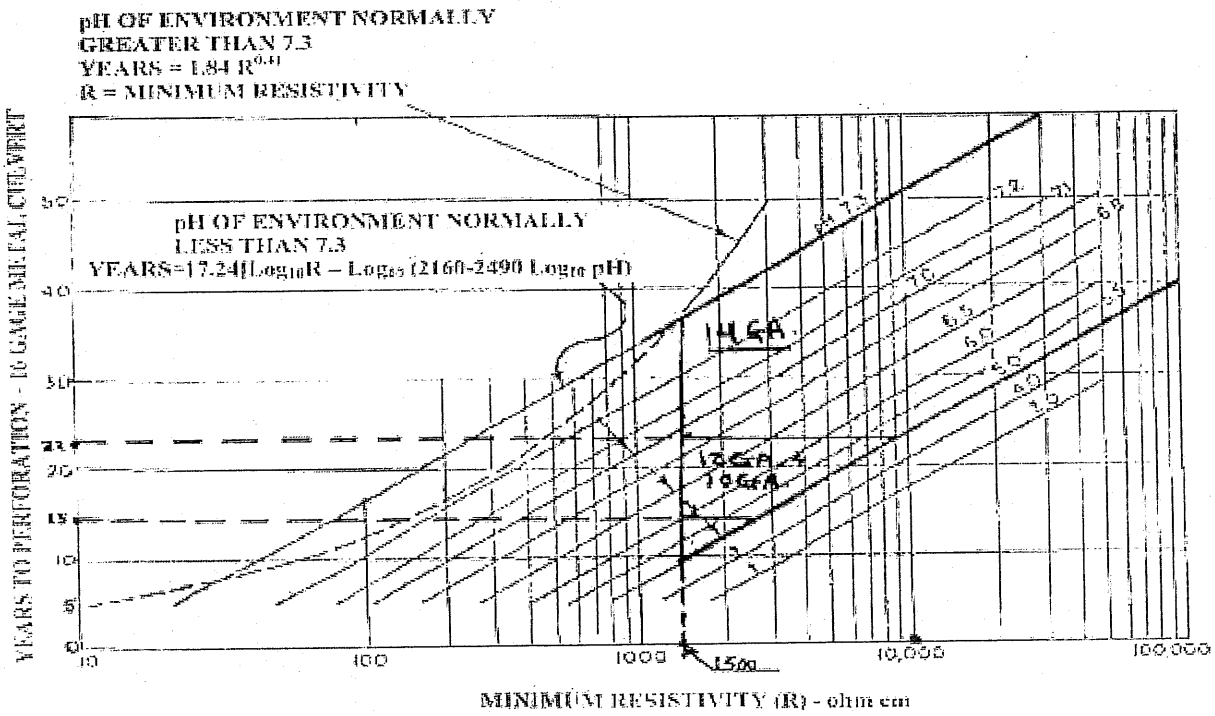
Certification: _____

Name PE No.

Aluminized Type 2				
Thick. (ins)	0.064	0.079	0.109	0.138
Gauge	16	14	12	10
Factor	2.0	2.3	2.8	3.3

Galvanized				
Thick. (ins)	0.079	0.109	0.138	0.168
Gauge	14	12	10	8
Factor	1.3	1.8	2.3	2.8

Multiply years to perforation by factor for increase in metal gauge.



Notes:

1 – Minimum average life of 50 years is required.

2 – Only aluminized corrugated metal pipe (AASHTO M-274-84) is allowed.

3 – The DPW or DPZ/DED reserve the right to review soil test data and/or request additional information.

*BackfillEnvironment

Figure 4.06

IMPINGEMENT CURVES

	Horizontal Distance from Beginning of Drop (ft)																
Vel (fps)	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Drop (ft)																	
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	0.70	0.88	1.06	1.23	1.41	1.59	1.76	1.94	2.11	2.29	2.47	2.64	2.82	3.00	3.17	3.35	3.52
1.0	1.00	1.25	1.50	1.74	1.99	2.24	2.49	2.74	2.99	3.24	3.49	3.74	3.99	4.24	4.49	4.74	4.98
1.5	1.22	1.53	1.83	2.14	2.44	2.75	3.05	3.36	3.66	3.97	4.27	4.58	4.88	5.19	5.49	5.80	6.10
2.0	1.41	1.76	2.11	2.47	2.82	3.17	3.52	3.88	4.23	4.58	4.93	5.29	5.64	5.99	6.34	6.70	7.05
2.5	1.58	1.97	2.36	2.76	3.15	3.55	3.94	4.33	4.73	5.12	5.52	5.91	6.30	6.70	7.09	7.49	7.88
3.0	1.73	2.16	2.59	3.02	3.45	3.88	4.32	4.75	5.18	5.61	6.04	6.47	6.91	7.34	7.77	8.20	8.63
3.5	1.87	2.33	2.80	3.26	3.73	4.20	4.66	5.13	5.60	6.06	6.53	6.99	7.46	7.93	8.39	8.86	9.33
4.0	1.99	2.49	2.99	3.49	3.99	4.49	4.98	5.48	5.98	6.48	6.98	7.48	7.98	8.47	8.97	9.47	9.97
4.5	2.11	2.64	3.17	3.70	4.23	4.76	5.29	5.82	6.34	6.87	7.40	7.93	8.46	8.99	9.52	10.04	10.57
5.0	2.23	2.79	3.34	3.90	4.46	5.02	5.57	6.13	6.69	7.24	7.80	8.36	8.92	9.47	10.03	10.59	11.15
5.5	2.34	2.92	3.51	4.09	4.68	5.26	5.84	6.43	7.01	7.60	8.18	8.77	9.35	9.94	10.52	11.11	11.69
6.0	2.44	3.05	3.66	4.27	4.88	5.49	6.10	6.72	7.33	7.94	8.55	9.16	9.77	10.38	10.99	11.60	12.21
6.5	2.54	3.18	3.81	4.45	5.08	5.72	6.35	6.99	7.62	8.26	8.90	9.53	10.17	10.80	11.44	12.07	12.71
7.0	2.64	3.30	3.96	4.62	5.28	5.93	6.59	7.25	7.91	8.57	9.23	9.89	10.55	11.21	11.87	12.53	13.19
7.5	2.73	3.41	4.10	4.78	5.46	6.14	6.83	7.51	8.19	8.87	9.56	10.24	10.92	11.60	12.29	12.97	13.65
8.0	2.82	3.52	4.23	4.93	5.64	6.34	7.05	7.75	8.46	9.16	9.87	10.57	11.28	11.98	12.69	13.39	14.10
8.5	2.91	3.63	4.36	5.09	5.81	6.54	7.27	7.99	8.72	9.45	10.17	10.90	11.63	12.35	13.08	13.81	14.53
9.0	2.99	3.74	4.49	5.23	5.98	6.73	7.48	8.22	8.97	9.72	10.47	11.22	11.96	12.71	13.46	14.21	14.95
9.5	3.07	3.84	4.61	5.38	6.15	6.91	7.68	8.45	9.22	9.99	10.75	11.52	12.29	13.06	13.83	14.59	15.36
10.0	3.15	3.94	4.73	5.52	6.30	7.09	7.88	8.67	9.46	10.25	11.03	11.82	12.61	13.40	14.19	14.97	15.76
10.5	3.23	4.04	4.85	5.65	6.46	7.27	8.08	8.88	9.69	10.50	11.31	12.11	12.92	13.73	14.54	15.34	16.15
11.0	3.31	4.13	4.96	5.79	6.61	7.44	8.27	9.09	9.92	10.75	11.57	12.40	13.23	14.05	14.88	15.70	16.53
11.5	3.38	4.23	5.07	5.92	6.76	7.61	8.45	9.30	10.14	10.99	11.83	12.68	13.52	14.37	15.21	16.06	16.90
12.0	3.45	4.32	5.18	6.04	6.91	7.77	8.63	9.50	10.36	11.22	12.09	12.95	13.81	14.68	15.54	16.40	17.27
12.5	3.52	4.41	5.29	6.17	7.05	7.93	8.81	9.69	10.57	11.45	12.34	13.22	14.10	14.98	15.86	16.74	17.62
13.0	3.59	4.49	5.39	6.29	7.19	8.09	8.99	9.88	10.78	11.68	12.58	13.48	14.38	15.28	16.17	17.07	17.97
13.5	3.66	4.58	5.49	6.41	7.33	8.24	9.16	10.07	10.99	11.90	12.82	13.74	14.65	15.57	16.48	17.40	18.31
14.0	3.73	4.66	5.60	6.53	7.46	8.39	9.33	10.26	11.19	12.12	13.06	13.99	14.92	15.85	16.79	17.72	18.65
14.5	3.80	4.75	5.69	6.64	7.59	8.54	9.49	10.44	11.39	12.34	13.29	14.24	15.18	16.13	17.08	18.03	18.98
15.0	3.86	4.83	5.79	6.76	7.72	8.69	9.65	10.62	11.58	12.55	13.51	14.48	15.44	16.41	17.37	18.34	19.30
15.5	3.92	4.91	5.89	6.87	7.85	8.83	9.81	10.79	11.77	12.76	13.74	14.72	15.70	16.68	17.66	18.64	19.62
16.0	3.99	4.98	5.98	6.98	7.98	8.97	9.97	10.97	11.96	12.96	13.96	14.95	15.95	16.95	17.94	18.94	19.94

Figure 4.07

INLET & GUTTER COMPUTATIONS

PROJ. NAME: _____ SHEET_____of_____

COMP. BY: _____

DATE: _____

CHECKED BY: _____

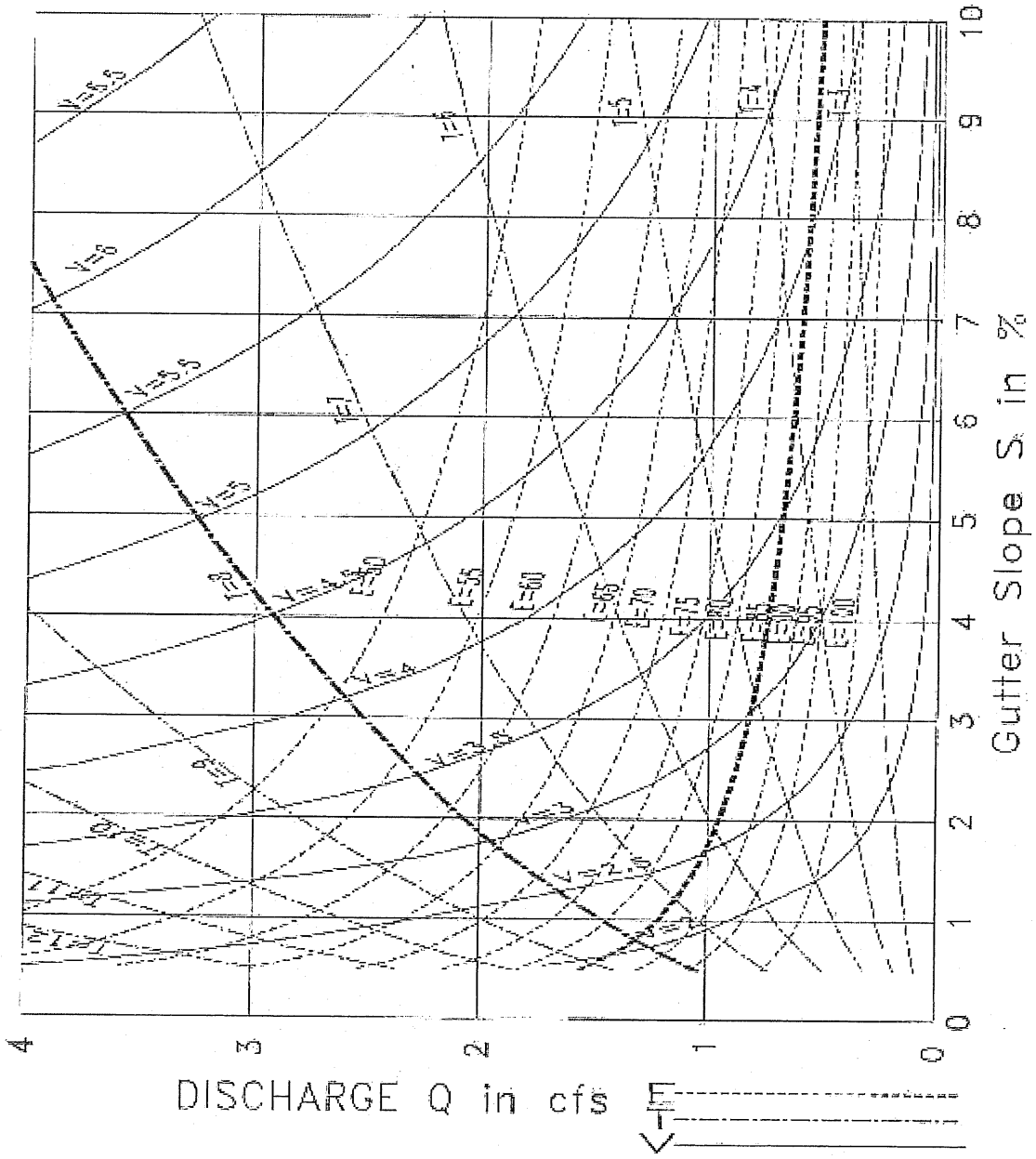
DATE: _____

DESIGN FREQUENCY: _____ YR.

(SEAL)

INLET NO.	AREA AC.	TIME (MIN)	C	CXA	I (N/HR)	Q (CFS)	Q bypass (CFS)	STREET GRADE (%)	INLET TYPE	INLET CAPACITY (CFS)	SPREAD (FT)	Q BYPASS (CFS)	TO INLET NO.	REMARKS

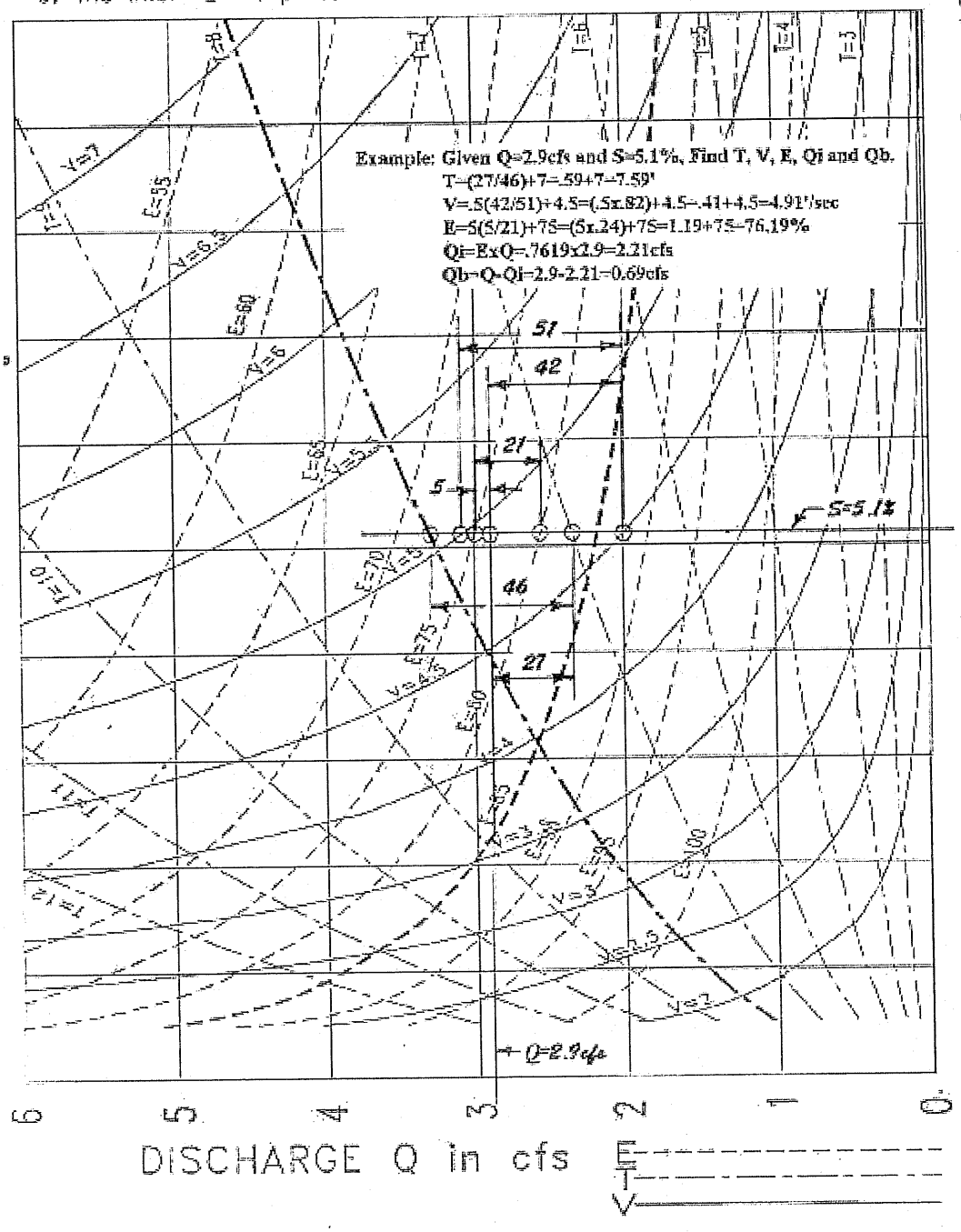
Chart prepared by Howard County, Bureau of Engineering; based on the method presented in HEC No. 12, FHWA-TS-84-202, Drainage of Highway Pavements. This Chart is to be used for the 5 foot curb opening inlet with Sx=0.02 ft/ft, Sw=0.0417 ft/ft, W=1 ft and n=0.015. The curves are developed, based on discharge "Q" in cfs versus Gutter flow line "S" in percent to obtain width of gutter spread "T" in feet, velocity in the gutter "V" in fps and the efficiency of the inlet "E" in percent.



HOWARD COUNTY, MARYLAND DEPARTMENT OF PUBLIC WORKS	INLET CAPACITY 5 FOOT CURB OPENING INLET Sx = 2%	DESIGNED BY T.J.W.
Approved _____ Chief, Bureau of Engineering	Figure 4.08 Date 7/24/95 Revised _____	CHECKED BY P.M.T.
		DRAWN BY A.U.B.

FILE CHT2-5.DWG

Chart prepared by Howard County, Bureau of Engineering, based on the method presented in HEC No. 12, FHWA-TS-84-202, Drainage of Highway Pavements. This Chart is to be used for the 10 foot curb opening inlet with Sx=0.02 ft/ft, Sw=0.0417 ft/ft, W=1 ft. and n=0.015. The curves are developed, based on discharge "Q" in cfs versus Gutter flow line "S" in percent to obtain width of gutter spread "T" in feet, velocity in the gutter "V" in fps and the efficiency of the inlet "E" in percent.



HOWARD COUNTY, MARYLAND
DEPARTMENT OF PUBLIC WORKS

Approved _____
Chief, Bureau of Engineering

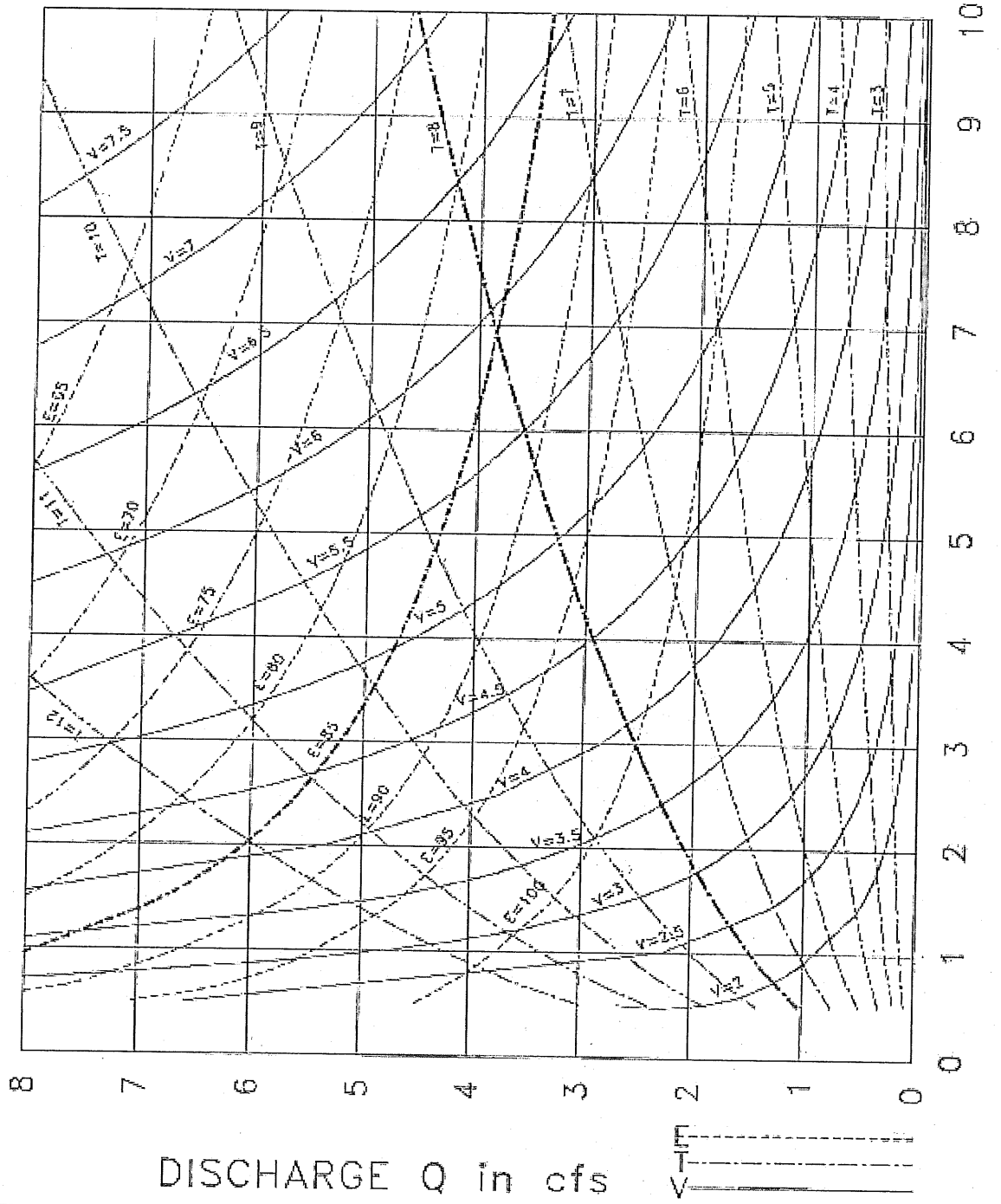
INLET CAPACITY
10 FOOT CURB OPENING INLET
Sx = 2%

Figure 4.09
Date 7/24/98 Revised _____

DESIGNED BY T.J.W.
CHECKED BY P.M.T.
DRAWN BY A.U.B.

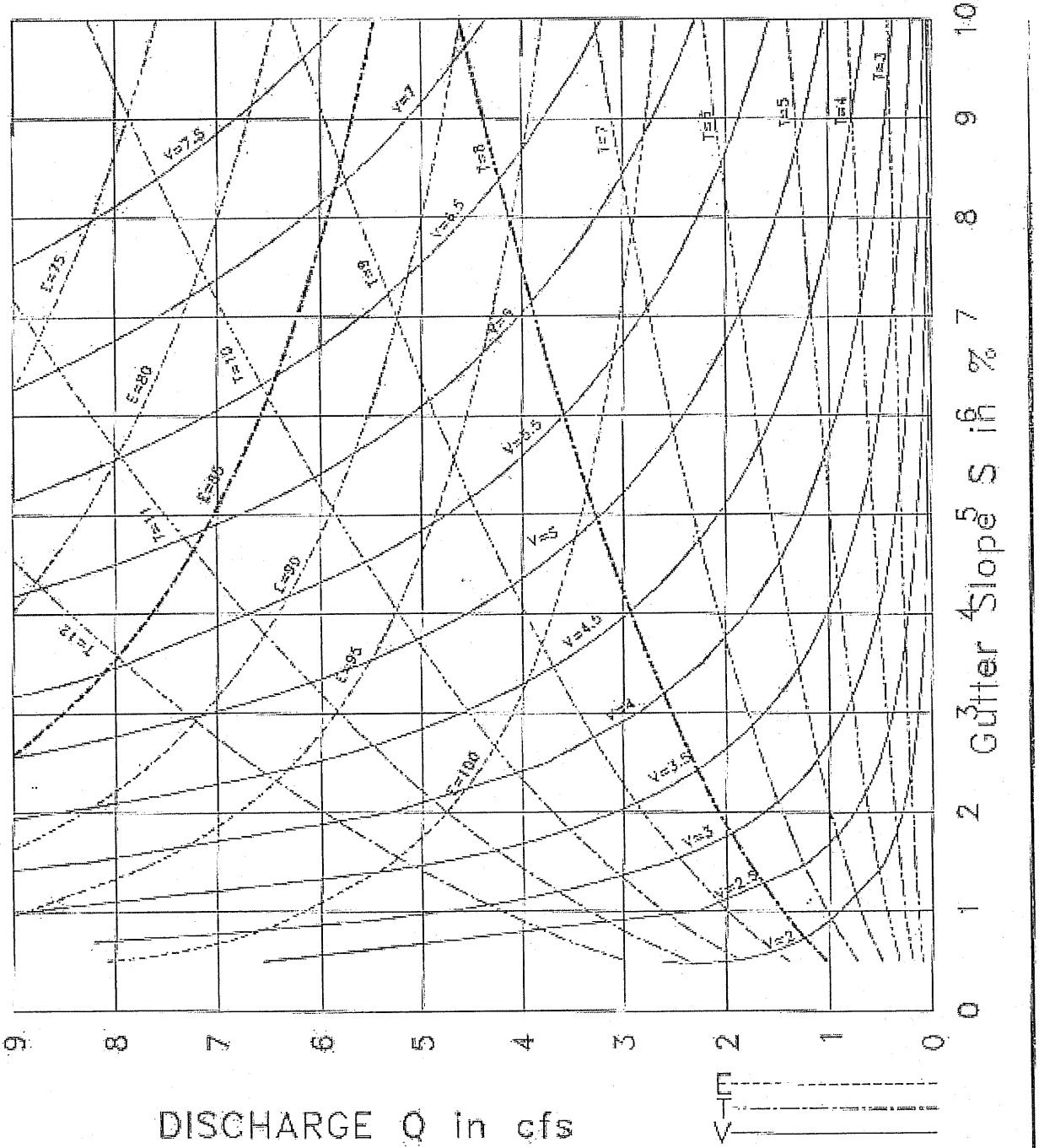
FILE: CHT2-10.DWG

Chart prepared by Howard County, Bureau of Engineering, based on the method presented in HEC No. 12, FHWA-TS-84-202, Drainage of Highway Pavements. This Chart is to be used for the 15 foot curb opening inlet with Sx=0.02 ft/ft, Sw=0.0417 ft/ft, W=1 ft and n=0.015. The curves are developed, based on discharge "Q" in cfs versus Gutter flow line "S" in percent to obtain width of gutter spread "T" in feet, velocity in the gutter "V" in fps and the efficiency of the inlet "E" in percent.



HOWARD COUNTY, MARYLAND DEPARTMENT OF PUBLIC WORKS Approved _____ Chief, Bureau of Engineering	INLET CAPACITY 15 FOOT CURB OPENING INLET Sx = 2% Figure 4.10 Date 7/24/95 Revised _____	DESIGNED BY T.J.W. CHECKED BY P.M.T. DRAWN BY A.U.B.

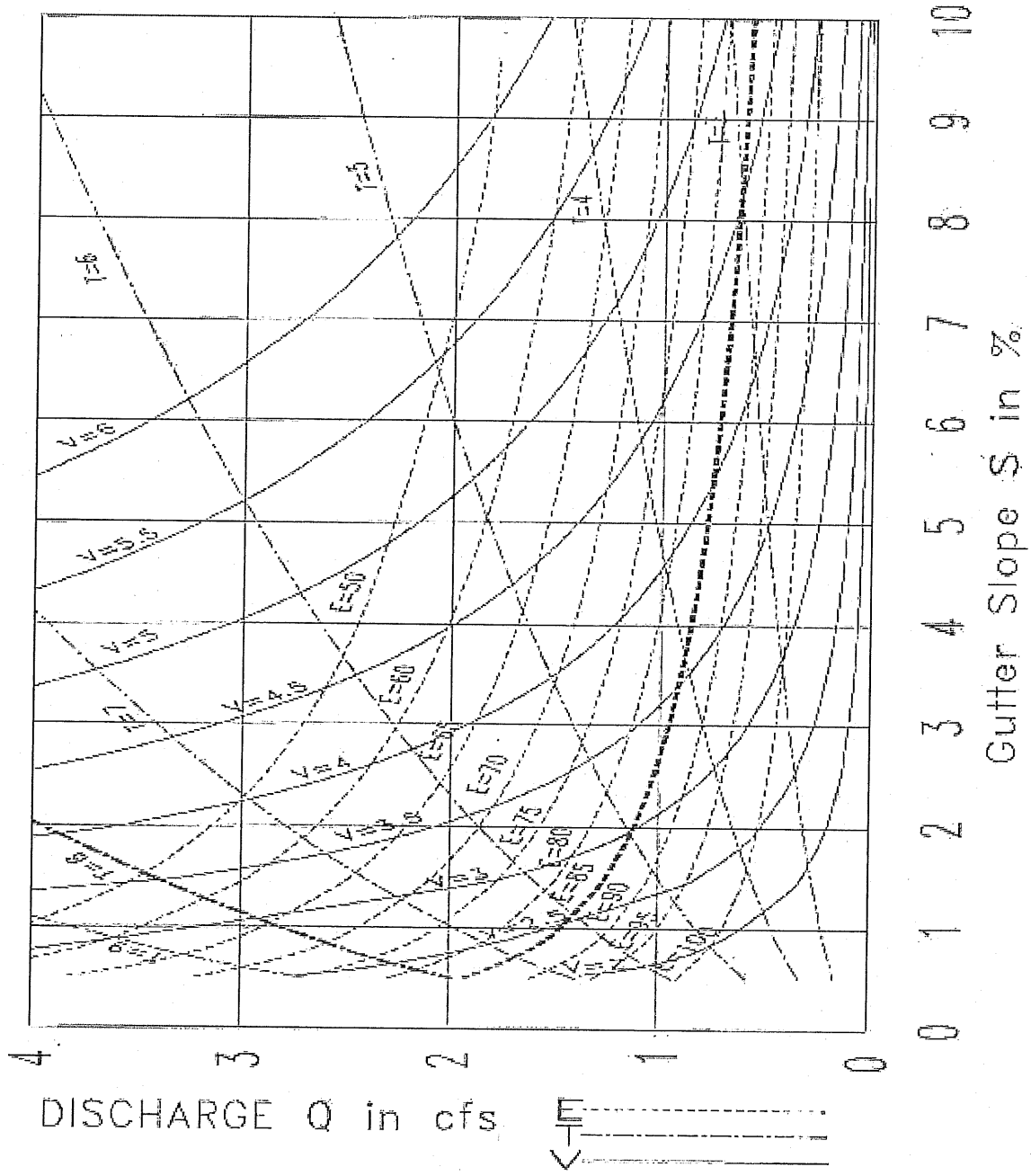
Chart prepared by Howard County, Bureau of Engineering, based on the method presented in HEC No. 12, FHWA-TS-84-202, Drainage of Highway Pavements. This Chart is to be used for the 20 foot curb opening inlet with Sx=0.02 ft/ft, Sw=0.0417 ft/ft, W=1 ft and n=0.015. The curves are developed, based on discharge "Q" in cfs versus Gutter flow line "S" in percent to obtain width of gutter spread "T" in feet, velocity in the gutter "V" in fps and the efficiency of the inlet "E" in percent.



HOWARD COUNTY, MARYLAND DEPARTMENT OF PUBLIC WORKS Approved _____ Chief, Bureau of Engineering	INLET CAPACITY 20 FOOT CURB OPENING INLET Sx = 2% Figure 4.11 Date 1/24/95 Revised _____	DESIGNED BY T.J.W. CHECKED BY P.M.T. DRAWN BY A.U.B.

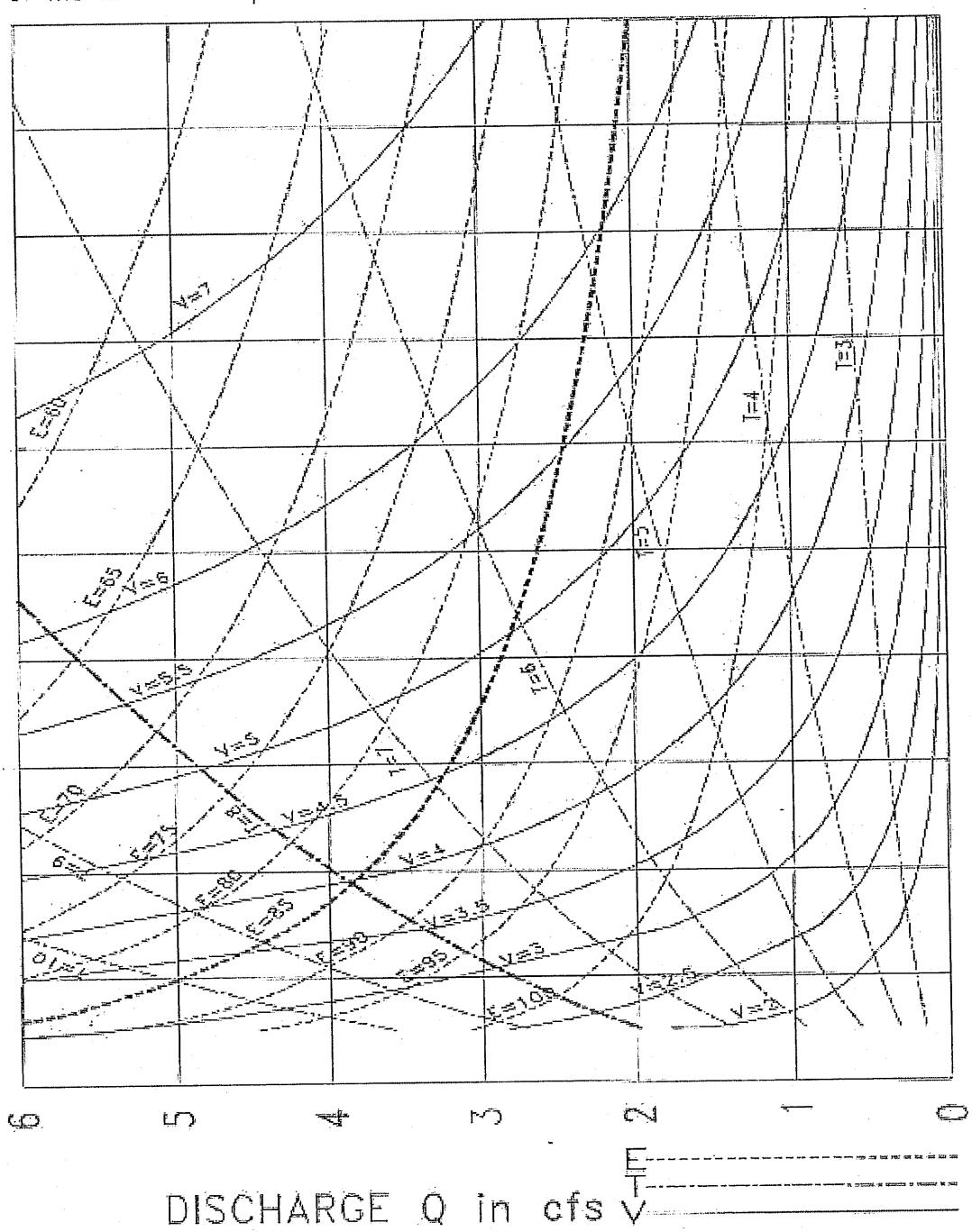
FILE: CHT2-20.DWG

Chart prepared by Howard County, Bureau of Engineering, based on the method presented in HEC No. 12, FHWA-TS-84-202, Drainage of Highway Pavements. This Chart is to be used for the 5 foot curb opening inlet with Sx=0.03 ft/ft, Sw=0.0417 ft/ft, W=1 ft and n=0.015. The curves are developed, based on discharge "Q" in cfs versus Gutter flow line "S" in percent to obtain width of gutter spread "T" in feet, velocity in the gutter "V" in fps and the efficiency of the inlet "E" in percent.



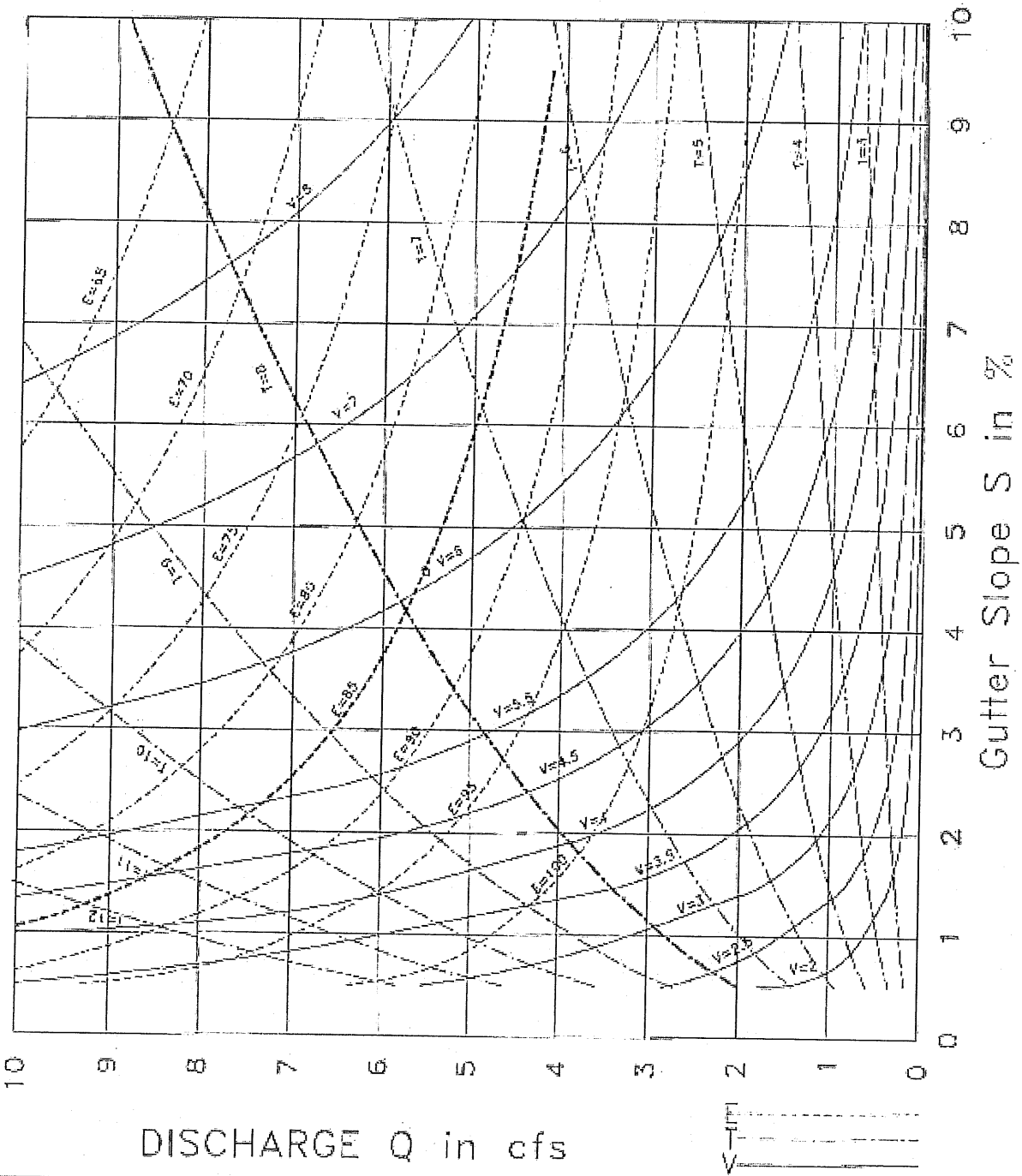
HOWARD COUNTY, MARYLAND DEPARTMENT OF PUBLIC WORKS Approved _____ Chief, Bureau of Engineering	INLET CAPACITY 5 FOOT CURB OPENING INLET Sx = 3% Figure 4.12 Date 7/24/95 Revised _____	DESIGNED BY T.J.W. CHECKED BY P.M.T. DRAWN BY A.U.B.

Chart prepared by Howard County, Bureau of Engineering, based on the method presented in HEC No. 12, FHWA-TS-84-202, Drainage of Highway Pavements. This Chart is to be used for the 10 foot curb opening inlet with Sx=0.03 ft/ft, Sw=0.0417 ft/ft, W=1 ft and n=0.015. The curves are developed, based on discharge "Q" in cfs versus Gutter flow line "S" in percent to obtain width of gutter spread "T" in feet, velocity in the gutter "V" in fps and the efficiency of the inlet "E" in percent.



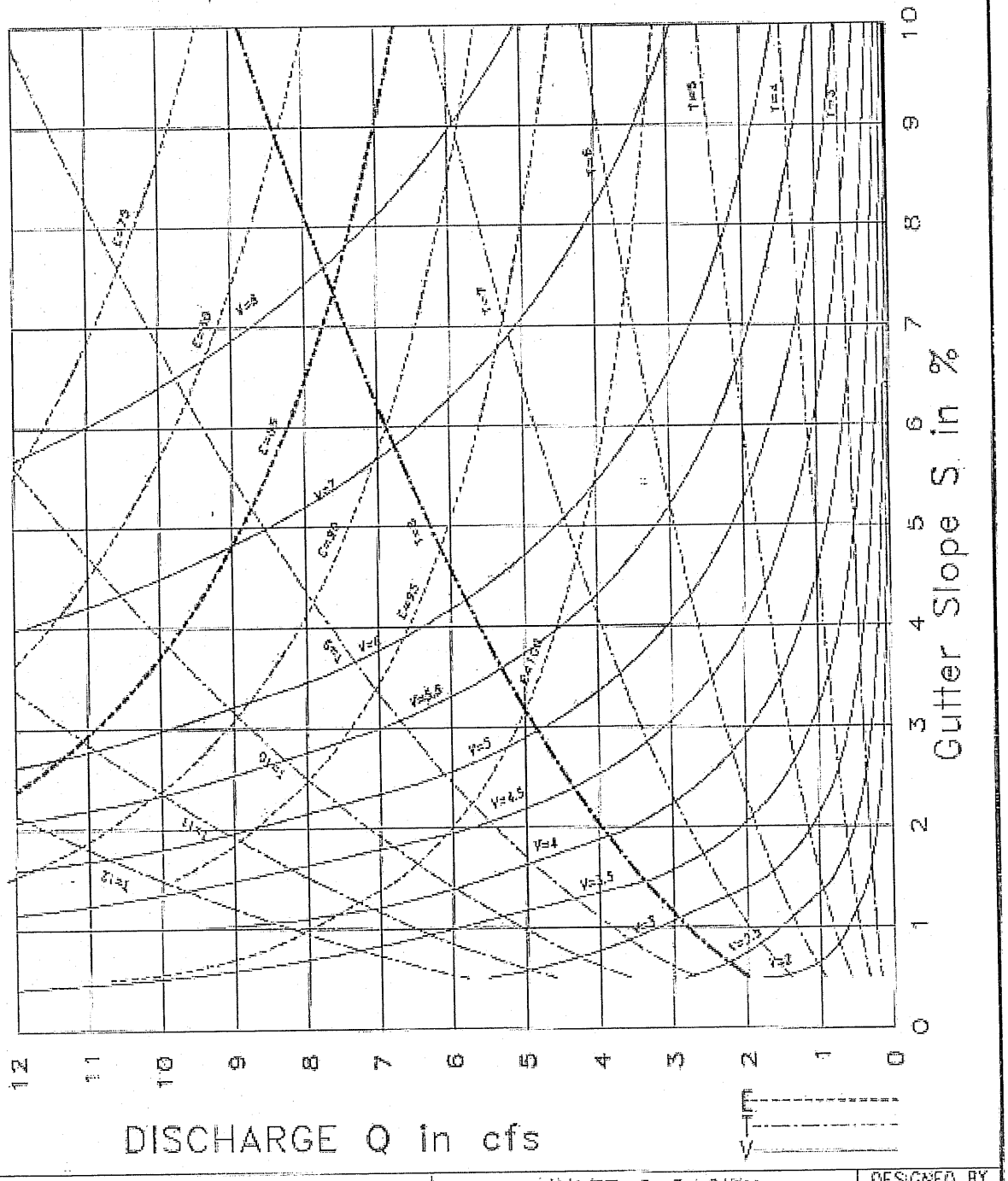
HOWARD COUNTY, MARYLAND DEPARTMENT OF PUBLIC WORKS Approved _____ Chief, Bureau of Engineering	INLET CAPACITY 10 FOOT CURB OPENING INLET Sx = 3% Figure 4.13 Date 7/24/99 Revised _____	DESIGNED BY T.J.W. CHECKED BY P.M.T. DRAWN BY A.U.B.

Chart prepared by Howard County, Bureau of Engineering, based on the method presented in HEC No. 12, FHWA-TS-84-202, Drainage of Highway Pavements. This Chart is to be used for the 15 foot curb opening inlet with Sx=0.03 ft/ft, Sw=0.0417 ft/ft, W=1 ft and n=0.015. The curves are developed, based on discharge "Q" in cfs versus Gutter flow line "S" in percent to obtain width of gutter spread "T" in feet, velocity in the gutter "V" in fps and the efficiency of the inlet "E" in percent.



HOWARD COUNTY, MARYLAND DEPARTMENT OF PUBLIC WORKS Approved _____ Chief, Bureau of Engineering	INLET CAPACITY 15 FOOT CURB OPENING INLET Sx = 3% Figure 4.14 Date 7/24/98 Revised _____	DESIGNED BY T.J.W. CHECKED BY P.M.T. DRAWN BY A.U.B.

Chart prepared by Howard County, Bureau of Engineering, based on the method presented in HEC No. 12, FHWA-TS-84-202, Drainage of Highway Pavements. This Chart is to be used for the 20 feet curb opening inlet with Sx=0.03 ft/ft, Sw=0.0417 ft/ft, W=1 ft and n=0.015. The curves are developed, based on discharge "Q" in cfs versus Gutter flow line "S" in percent to obtain width of gutter spread "T" in feet, velocity in the gutter "V" in fps and the efficiency of the inlet "E" in percent.



HOWARD COUNTY, MARYLAND DEPARTMENT OF PUBLIC WORKS Approved _____ Chief, Bureau of Engineering	INLET CAPACITY 20 FOOT CURB OPENING INLET Sx = 3% Figure 4.15 Date 7/24/95 Revised _____	DESIGNED BY T.J.W. CHECKED BY P.M.T. DRAWN BY A.U.B.

Figure 4.16

NOMOGRAPHS FOR TRIANGULAR GUTTERS

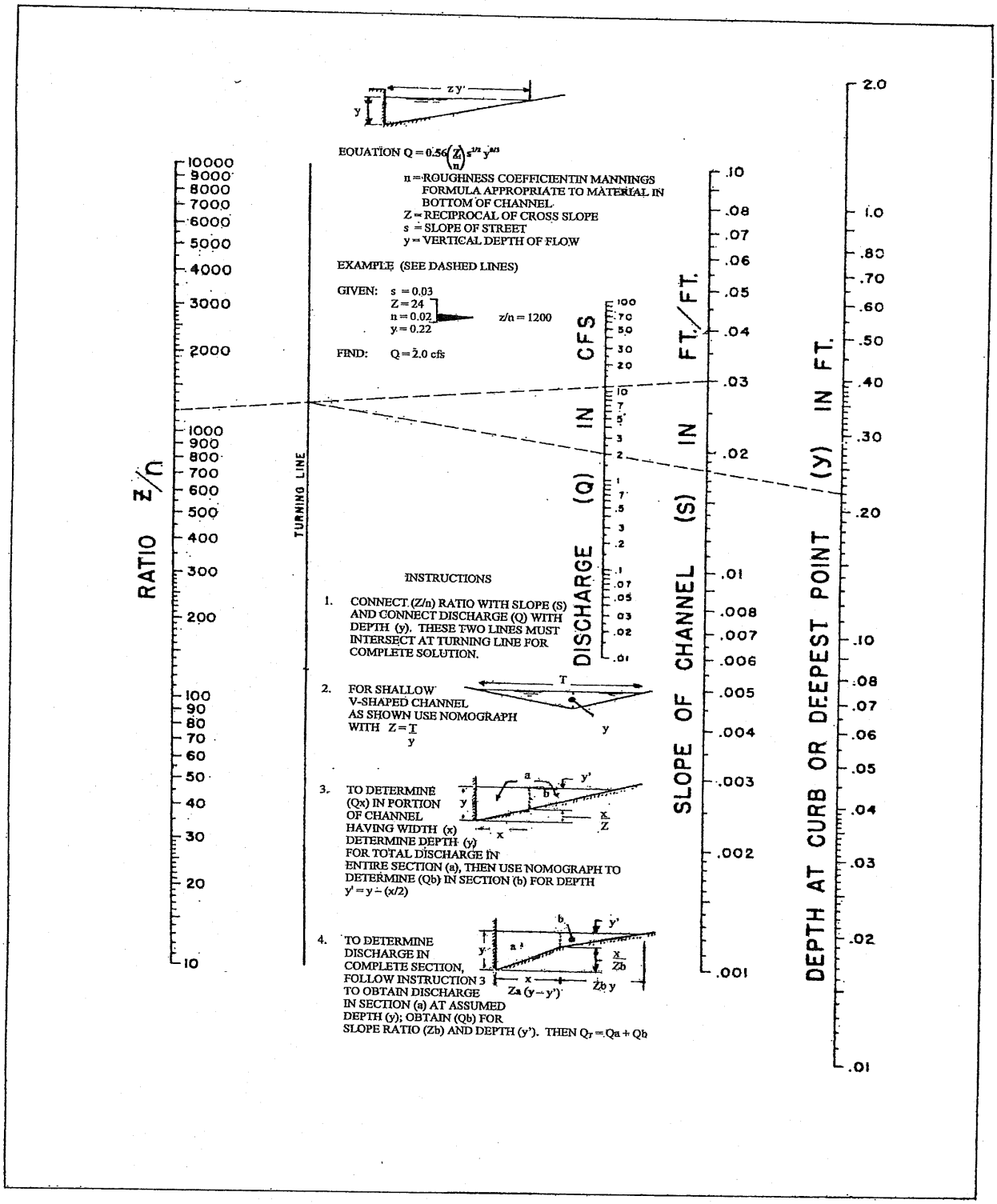


Figure 4.17

HOWARD COUNTY
HYDRAULIC GRADIENT AND HEADLOSS COMPUTATION FORM

JOB NAME: ______________________ DPZ NO.: __________ DATE: __________

ELEV. = __________
HGL= __________

FROM ______ TO ______ ______ FT @ ______ %

@STRUCTURE NO. ______

				LOSS NO		FACTOR		LOSS
Q1 = ______	V1 = ______	A =	______		X	______	=	______
Q2 = ______	V2 = ______	B =	______		X	______	=	______
Q3 = ______	V3 = ______	C =	______		X	______	=	______
	______	D =	______		X	______	=	______
						TOTAL	=	______

HGL = __________

ELEV. = __________
HGL= __________

FROM ______ TO ______ ______ FT @ ______ %

@STRUCTURE NO. ______

				LOSS NO		FACTOR		LOSS
Q1 = ______	V1 = ______	A =	______		X	______	=	______
Q2 = ______	V2 = ______	B =	______		X	______	=	______
Q3 = ______	V3 = ______	C =	______		X	______	=	______
	______	D =	______		X	______	=	______
						TOTAL	=	______

HGL = __________

ELEV. = __________
HGL= __________

FROM ______ TO ______ ______ FT @ ______ %

@STRUCTURE NO. ______

				LOSS NO		FACTOR		LOSS
Q1 = ______	V1 = ______	A =	______		X	______	=	______
Q2 = ______	V2 = ______	B =	______		X	______	=	______
Q3 = ______	V3 = ______	C =	______		X	______	=	______
	______	D =	______		X	______	=	______
						TOTAL	=	______

HGL = __________

ELEV. = __________
HGL= __________

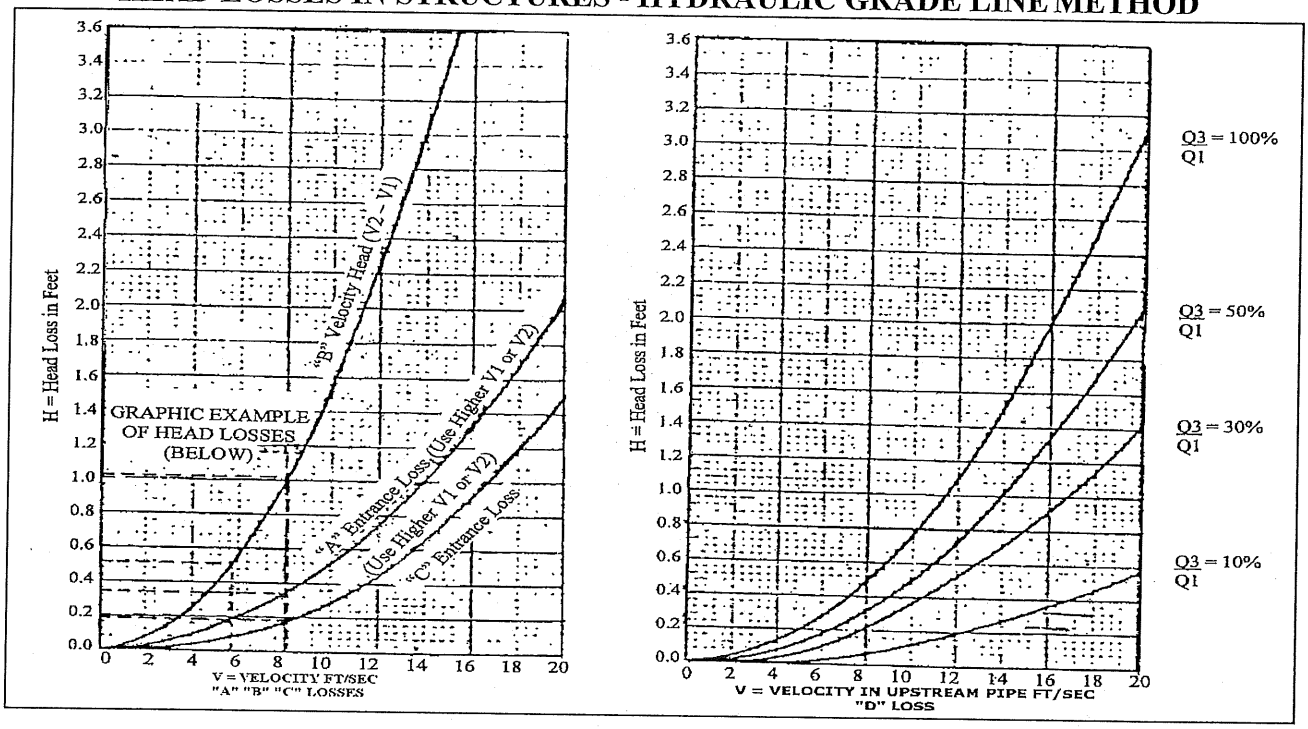
FROM ______ TO ______ ______ FT @ ______ %

@STRUCTURE NO. ______

				LOSS NO		FACTOR		LOSS
Q1 = ______	V1 = ______	A =	______		X	______	=	______
Q2 = ______	V2 = ______	B =	______		X	______	=	______
Q3 = ______	V3 = ______	C =	______		X	______	=	______
	______	D =	______		X	______	=	______
						TOTAL	=	______

HGL = __________

Figure 4.18
HEAD LOSSES IN STRUCTURES - HYDRAULIC GRADE LINE METHOD



MULTIPLES APPLICABLE TO LOSSES THRU STRUCTURES**

TYPE STRUCTURE	LOSSES A	B	C	D	TYPE STRUCTURE	LOSSES A	B	C	D
WYES & FULLY DEVELOPED INVERTS	0	1	1/2	1/2	90 DEGREE BEND STRUCTURE	0	1	1	1
MANHOLES W/ 90 DEG. BEND (24" & SMALLER PIPE)	1	1	3	1	45 DEGREE BEND STRUCTURE	0	1	2/3	1
MANHOLES W/ 45 DEG. BEND (24" & SMALLER PIPE)	1	1	1	1	90 DEGREE BEND W/ CONNECTION	0	1	1 1/2	1
MANHOLES W/ 30 DEG. BEND (24" & SMALLER PIPE)	1	1	2/3	1/2	45 DEGREE BEND W/ CONNECTION	0	1	1	1/2
MANHOLES W/ 0 DEG. BEND (24" & SMALLER PIPE)	1	1	0	1/2	90 DEGREE BEND W/ CONNECTION & MANHOLE	0	1	2	1/2
MANHOLES W/ 90 DEG. BEND (27" & LARGER PIPE)	1/3	1	3	1	45 DEGREE BEND W/ CONNECTION & MANHOLE	0	1	1 1/2	1
MANHOLES W/ 45 DEG. BEND (27" & LARGER PIPE)	1/3	1	1 1/2	1	JUNCTION CHAMBER	0	1	1	1
MANHOLES W/ 30 DEG. BEND (27" & LARGER PIPE)	1/3	1	1	1/2	JUNCTION CHAMBER & MANHOLE	0	1	1 1/2	1/2
MANHOLES W/ 0 DEG. BEND (27" & LARGER PIPE)	1/3	1	0	1/2					

** Multiples apply to one-half developed invert. For non-developed inverts multiply by 1.5 (Except for B loss.)

EXAMPLES

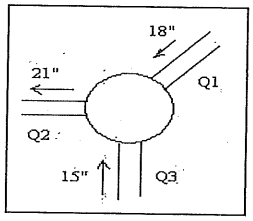
MANHOLE

Q1 = 10.2, Q2 = 19.5, Q3 = 9.3

V1 = 5.7, V2 = 3.1

HEAD LOSSES

A =	0.34
B = 1.02 - 0.51 =	0.51
C	0.18
D =	0.20
TOTAL	1.23



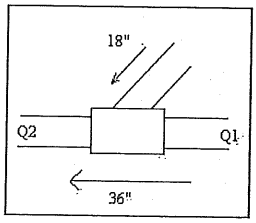
WYE BRANCH

Q1 = 40, Q2 = 44

V1=5.7, V2 = 6.2

HEAD LOSSES

A =	0.00
B = 0.58 - 0.51 =	0.07
C = 0.10 x 0.50 =	0.05
D =	0.03
TOTAL	0.15



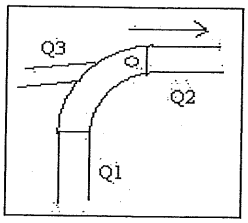
MANHOLE & CONNECTION

Q1 = 150, Q2 = 180, Q3 = 303

V1 = 11.9, V2 = 14.1

HEAD LOSSES

A	0
B = 3.30 - 2.28 =	1.10
C = 2.0 x 0.69 =	1.38
D =	0.35
TOTAL	2.83



TYPICAL JUNCTION CHAMBER

Q1 = 130, Q2 = 195, Q3 = 65

V1 = 13.5, V2 = 12.3

HEAD LOSSES

A =	0.00
B = 2.35 - 2.85 =	-0.50
C	0.60
D = 0.50 x 0.94 =	0.47
TOTAL	0.57

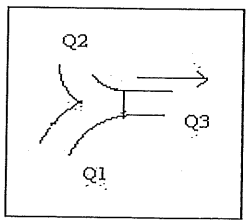
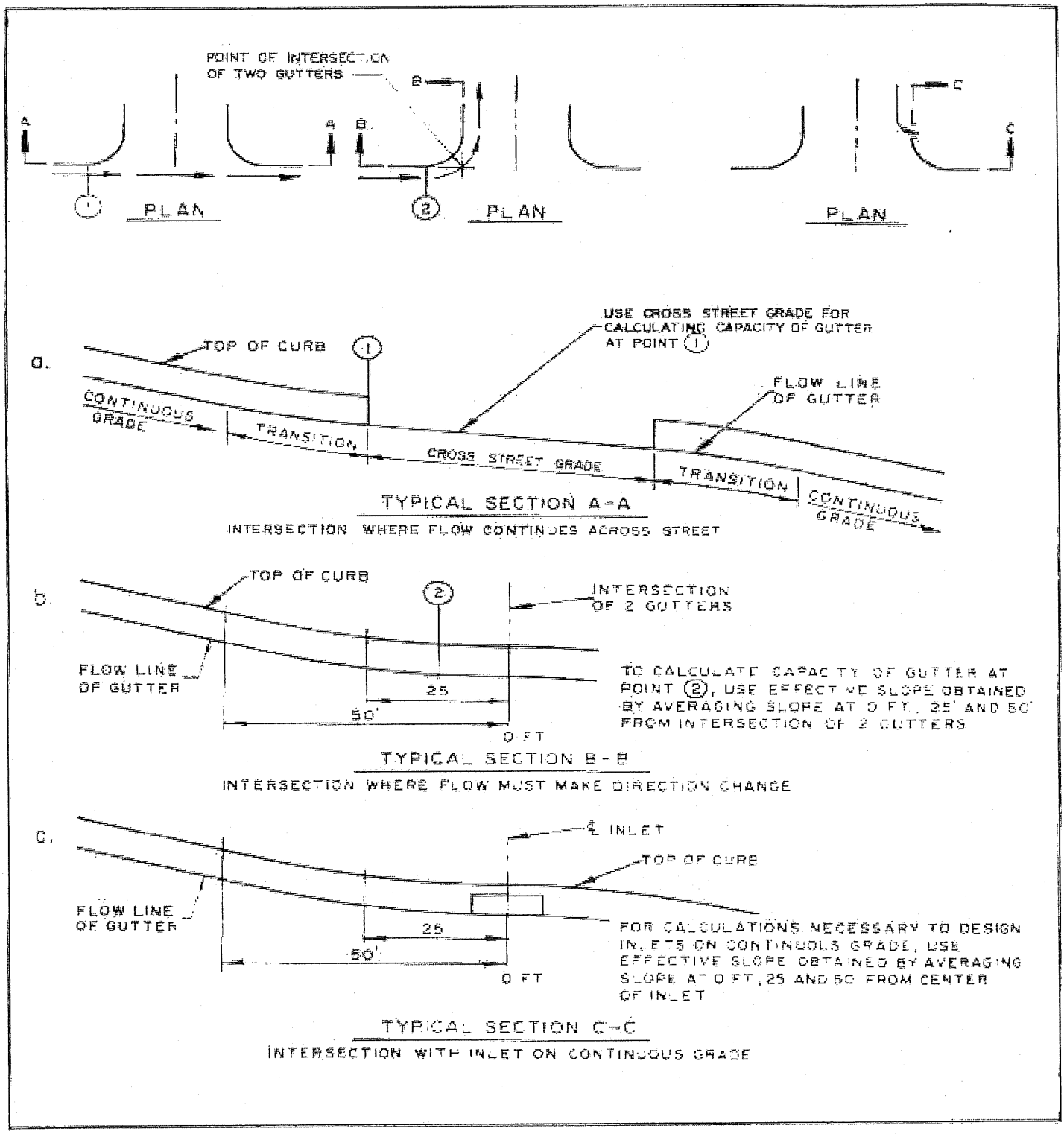


Figure 4.19

INTERSECTION SLOPE MODIFICATIONS



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SAMPLE COMPUTATIONS

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STORM DRAIN COMPUTATIONS

PROJ. NAME: SAMPLE COMPUTATIONS
COMP. BY: PMT
DATE: 5/95
CHECKED BY:
DATE:

SHEET 1 of 1

DESIGNFREQUENCY: 10 YR.

(SEAL)

PIPE															
FROM NO.	TO NO.	INC. AREA (AC)	TOTAL AREA (AC)	C	CXA	SUM (CXA)	TIME (MIN)	I (IN/HR)	Q (CFS)	DES. SLOPE (%)	DIAMETER (IN)	VELOCITY (FPS)	LENGTH (FT)	TIME (MIN)	REMARKS
I3	I1	1.0	1.0	0.53	0.53 / 0.60	0.60	10.0	6.60 / 7.50	4.0	0.37	15	3.2	24	0.1	SUMP
I2	MH1	1.1	1.1	0.48	0.53	0.53	10.0	6.60	3.5	0.28	15	2.8	150	0.9	
MH1	I1	-	1.1	-	-	0.53	-	-	3.5	0.11	18	1.9	90	0.8	
I1	HW1	0.8	2.9	0.44	0.35 / 0.41	1.54	11.7	6.13 / 7.10	9.4	0.18	24	3.0	100	0.6	SUMP

SUMP EXAMPLES (For Publicly Maintained Systems Only)

		Inlet3	Inlet1
Increm. Area =		1.0	0.8
"C" Factor =		0.53	0.44
C*A	=	(0.53)(1.0)	(0.44)(0.8)
	=	0.53	0.35
25 Year Intensity =		7.50	7.10
10 Year Intensity =		6.60	6.13
Adjusted C*A =		(0.53)(7.50/6.60)	(0.35)(7.10/6.13)
	=	0.60	0.41
Sum of C*A =		0+0.60	0.60+0.53+0.41
	=	0.60	1.54
Q (cfs)	=	(0.60)(6.60)	(1.54)(6.13)
	=	4.0	9.4

INLET & GUTTER COMPUTATIONS

PROJ. NAME: SAMPLE COMPUTATIONS
COMP. BY: PMT
DATE: 5/95
CHECKED BY:
DATE:

SHEET 1 of 1

DESIGNFREQUENCY: 2 YR.

(SEAL)

INLET NO.	AREA AC.	TIME (MIN)	C	CXA	I (N/HR)	Q (CFS)	Q bypass (CFS)	STREET GRADE (%)	INLET TYPE	INLET CAPACITY (CFS)	SPREAD (FT)	Q BYPASS (CFS)	TO INLET NO.	REMARKS
I3	1.0	10.0	0.53	0.53	4.50	2.4	-	LP	A-10	15.0	7.0	-	-	
I2	1.1	10.0	0.48	0.53	4.50	2.4	-	2.5	A-10	2.2	8.0	0.2	I1	
I1	0.8	10.0	0.44	0.35	4.50	1.6	1.8	LP	A-10	15.0	5.5	-	-	

HOWARD COUNTY
HYDRAULIC GRADIENT AND HEADLOSS COMPUTATION FORM

JOB NAME: SAMPLE COMPUTATIONS DPZ NO.: _____ DATE: 5/95

FROM HW1 TO I1 100 FT @ 0.14 %

ELEV. = 107.50
HGL= 0.14
107.64
TP = 108.00

@STRUCTURE NO. I1 (Assume manhole w/90 degree bends)

				LOSS NO		FACTOR		LOSS
Q1 =	4.0	V1 =	3.2	A = 0.08	X	1	=	0.08
Q2 =	9.4	V2 =	3.0	B = 0.15 – 0.16	X	1	=	-0.01
Q3 =	3.5	V3 =	1.9	C = 0.08	X	3	=	0.24
				D = 0.04	X	1	=	0.04
						TOTAL	=	0.35

HGL = 108.35

FROM I1 TO I3 24 FT @ 0.37 %

ELEV. = 108.35
HGL= 0.09
TP = 108.44

@STRUCTURE NO. _____ (Terminal Inlet)

				LOSS NO		FACTOR		LOSS
Q1 =		V1 =		A =	X		=	
Q2 =		V2 =		B =	X		=	
Q3 =		V3 =		C =	X		=	
				D =	X		=	
						TOTAL	=	

HGL = _____

FROM I1 TO MH1 90 FT @ 0.11 %

ELEV. = 108.35
HGL= 0.10
108.45
TP = 110.00

@STRUCTURE NO. MH1 (Manhole w/0 degree bend)

				LOSS NO		FACTOR		LOSS
Q1 =	3.5	V1 =	2.8	A = 0.09	X	1	=	0.09
Q2 =	3.5	V2 =	1.9	B = 0.06 – 0.18	X	1	=	-0.12
Q3 =		V3 =		C = 0.02	X	0.67	=	0.01
				D = 0.00	X	0.50	=	0.00
						TOTAL	=	-0.02

HGL = 110.10
TP = 110.75

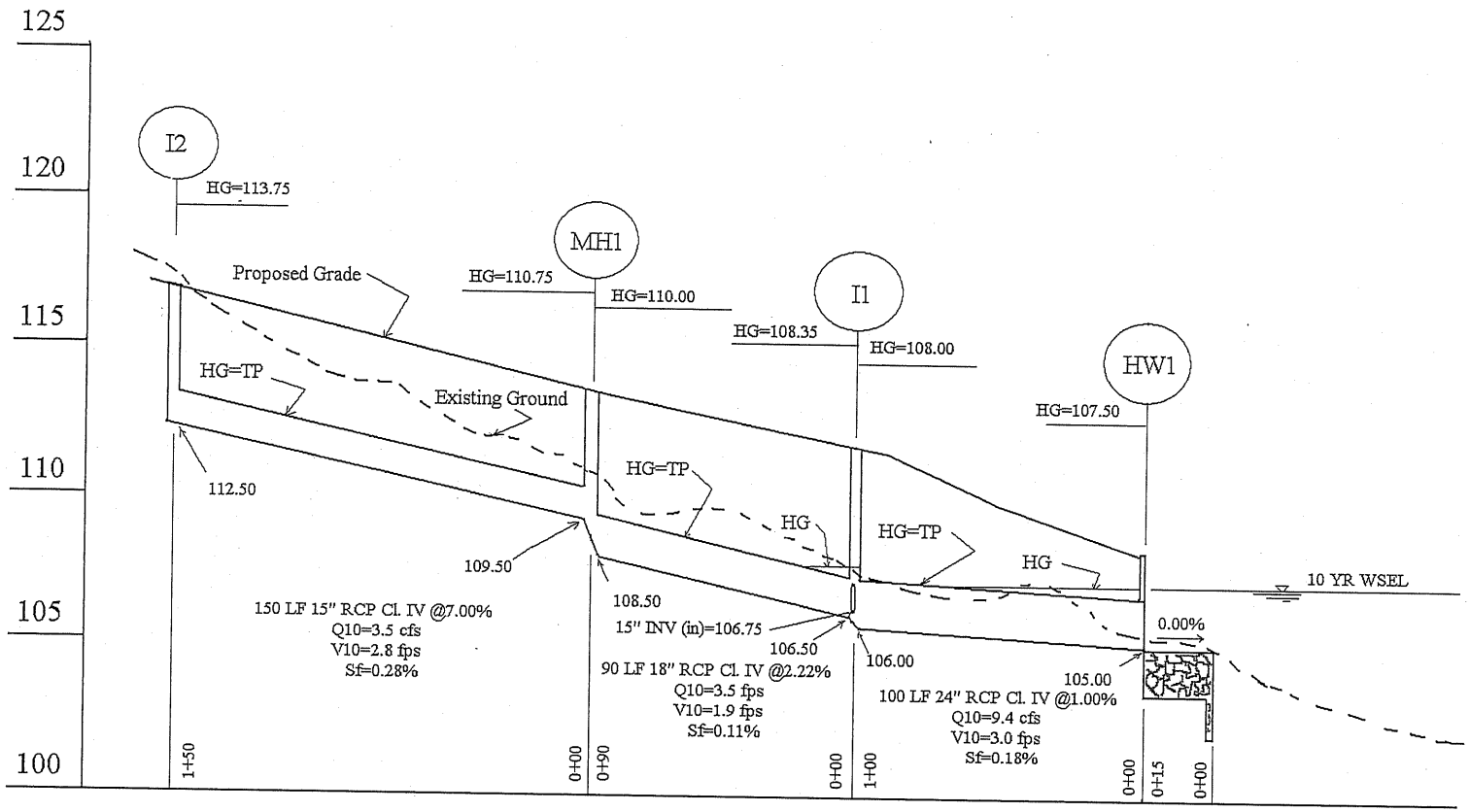
FROM MH1 TO I2 150 FT @ 0.28 %

ELEV. = 110.75
HGL= 0.42
111.17
TP = 113.75

@STRUCTURE NO. I2 (Terminal Inlet)

				LOSS NO		FACTOR		LOSS
Q1 =		V1 =		A =	X		=	
Q2 =		V2 =		B =	X		=	
Q3 =		V3 =		C =	X		=	
				D =	X		=	
						TOTAL	=	

HGL = _____



SAMPLE - STORM DRAIN PROFILE

(Not to Scale)

CHAPTER 5

STORMWATER MANAGEMENT

CHAPTER 5

STORMWATER MANAGEMENT

5.1 INTRODUCTION

Stormwater management may be defined as the control of the volume, rate and quality of stormwater runoff.

The purpose of stormwater management is to protect, maintain and enhance the public health, safety and general welfare by establishing minimum requirements and procedures to control the adverse impacts associated with increased stormwater runoff as a result of development. The goal is to manage stormwater by using environmental site design (ESD) to the maximum extent practicable (MEP) to maintain after development as nearly as possible, the predevelopment runoff characteristics, and to reduce stream channel erosion, pollution, siltation and sedimentation, and local flooding, and use appropriate structural best management practices (BMPs) only when necessary. The intent of these practices is to restore, enhance, and maintain the chemical, physical, and biological integrity of streams, minimize damage to public and private property, and reduce the impacts of land development.

The Stormwater Management Act of 2007 (Act) further requires that the Code of Maryland Regulations (COMAR) be modified and a model ordinance developed for the purpose of implementing environmental site design (ESD) to the maximum extent practicable (MEP). Significant changes to COMAR and the 2000 Maryland Stormwater Design Manual, Volumes I & II (MDE Design Manual) were adopted in May 2009. These changes specify how ESD is to be implemented, the MEP standard is to be met, and the review of erosion and sediment control and stormwater management plans is to be integrated.

The Act defines ESD as "...using small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of land development on water resources." ESD also includes conserving natural features, drainage patterns, and vegetation; minimizing impervious surfaces; slowing down runoff; and increasing infiltration. This definition, along with COMAR modifications and the minimum content of county and municipal ordinances specified below, will require major changes to the way runoff is managed in the State. Also, stormwater management for new development and redevelopment will be conceived, designed, reviewed, and built differently from procedures used prior to passage of the Act.

5.1.1 Incorporation by Reference

For the purpose of this Manual, the following documents are incorporated by reference:

A. The 2000 Maryland Stormwater Design Manual, Volumes I and II (Maryland Department of the Environment, April, 2000) (MDE Design Manual) and all subsequent revisions, are incorporated by reference by (governing authority/agency) and shall serve as the official guide for stormwater management principles, methods, and practices.

B. USDA Natural Resources Conservation Service Maryland Conservation Practice Standard Pond Code 378 (January 2000).

C. Howard County Code, Title 18, Subtitle 9 (current).

5.2 STORMWATER MANAGEMENT CRITERIA

The regulatory definition for MEP consists of two parts. The first is subjective and requires that all reasonable opportunities for using ESD planning techniques and practices are exhausted. Like the definition, the threshold for meeting the MEP standard consists of two parts. First, MEP is met if channel stability and predevelopment groundwater recharge rates are maintained and nonpoint source pollution is minimized. In both the definition and performance threshold, the second condition is the same; structural stormwater practices may be used only if determined to be absolutely necessary. While some flexibility and best professional judgment will be needed to determine when these first conditions are met, the second condition is straightforward. Local plans review and approval agencies should not approve structural BMPs if ESD options are available.

In addition to the State regulations, section 5.2 of the latest edition of the MDE Design Manual also includes standards for MEP compliance. The primary MEP standard is to use ESD to reduce post development runoff to levels found in natural, forested conditions. This requires capturing and treating from 1 to 2.6 inches of rainfall depending on site and design conditions (e.g., soils, proposed imperviousness). When this goal is met, the Cp_v, WQ_v, and Re_v requirements are addressed. Designers will be responsible for determining specific rainfall targets for their projects using the methods outlined in section 5.2.

There is a secondary standard that must be considered when assessing MEP compliance. ESD must be used to treat runoff from 1 inch of rainfall to address both WQ_v and Re_v requirements. This is a minimum level of compliance, not a contingency standard that is used when specific rainfall targets cannot be met. Designers must capture and treat at least 1 inch of rainfall while using ESD to reduce runoff and achieve specified goals.

5.2.1 Stormwater Control Requirements

A. The minimum stormwater control requirements shall require that the planning techniques, nonstructural practices, and design methods specified in the MDE Design Manual be used to implement ESD to the MEP. The use of ESD planning techniques and treatment practices must be exhausted before any structural BMP is implemented. Stormwater Management for development projects shall be designed in accordance with the Howard County Code, Title 18, Subtitle 9. Information found in this design manual is supplemental to the requirements found in the code and MDE Design Manual referenced above.

The county reserves the right, on a case-by-case basis, to require that management measures be provided as necessary to maintain the post-development peak discharges for a 24-hour, 1-year, 10-year, 25-year and/or 100-year frequency storm events at a level that is equal to or less than the respective 24-hour, 1-year, 10-year, 25-year and/or 100-year predevelopment peak discharge rates, through stormwater management practices that control volume, timing and rate of runoff. **EXCEPT WITHIN INFILL DEVELOPMENT, STORAGE[[Storage]]** volume and RCN reductions by the use of Alternative Surfaces and Nonstructural Practices may be considered for only the 1- year event.

The 10-year design storm event shall be employed when there is no control over infrastructure and the conveyance system is at design capacity, or it is determined that downstream flooding (based on recorded historical flooding problems) will occur as the result of the proposed development. The 100-year design storm event is to be employed to prevent flood damage from large frequency storm events, to maintain the boundaries of the 100-year floodplain and protect the physical integrity of BMP structures. Storage volume and RCN reductions by the use of non-structural credit practices shall not be considered when designing for the Overbank or Extreme Flood Protection.

The upstream drainage areas to the Cabin Branch crossing Shaffers Mill Road, a tributary to the Dorsey Branch crossing Dorsey Mill Road and the drainage area associated with Bonnie Branch, which parallels Bonnie Branch Road, shall be required to provide10-year peak management control. Additional stream systems may be included at the sole discretion of Howard County.

The **[[**upstream drainage areas to the**]]** **ENTIRE** Tiber Branch **WATERSHED** above the Patapsco River **[[**and the Hudson Branch above the Tiber Branch**]]** and tributary drainage areas to the Deep Run above any railroad crossings shall be required to provide 10-year and 100-year peak management control. Additional stream systems may be included at the sole discretion of Howard County.

B. The use of ESD planning techniques and treatment practices shall not conflict with existing State law or local ordinances, regulations, or policies. Howard County shall modify planning and zoning ordinances and public works codes to eliminate any impediments to implementing ESD to the MEP according to the MDE Design Manual.

C. Redevelopment

The goal of the current redevelopment regulations is to gain water quality treatment on existing developed lands while supporting County initiatives to improve urban communities. Redevelopment projects offer unique challenges and stormwater management ordinances need to be tailored to consider County goals, available resources, and application of stormwater practices within Howard County.

Redevelopment Planning Process:
The design and review processes for any redevelopment project need to consider the many constraints that limit effective implementation of stormwater practices. Factors such as underground infrastructure may restrict available facility options, while existing storm drain elevations may dictate how runoff flows through and off a site. This information and other existing conditions should be evaluated during the concept phase of project planning in order to assess all options for ESD implementation and other possible stormwater solutions.

Alternative Management Strategies:
Alternative management strategies may be considered after all opportunities for using ESD have been exhausted during the planning process. Alternative strategies and policies for meeting stormwater requirements may include, on-site and off-site structural BMPs, retrofitting existing structural BMPs, stream restoration, trading policies with other

pollution control programs, watershed management plans, and fees-in-lieu. On a case by case basis, MDE and Howard County Department of Planning and Zoning will determine the conditions, criteria, and program directives dedicated to implementing stormwater management when an alternative or other policy is used to meet redevelopment requirements.

5.2.2 Design Considerations

A. Where a stormwater plan shows an increase of runoff from the site in excess of 2.0 cfs for the 1-year storm event, it may be requested of the developer to analyze the downstream impacts up to 500 ft of the outfall at the property line to insure safe conveyance to an adequate outfall and to obtain from the adjacent property owners any easements or other necessary property interest concerning the flowage of water.

B. When slopes warrant a spreading device adjacent to a wooded conservation area, an infiltration berm shall be used. If constraints prohibit the use of an infiltration berm, a gravel diaphragm or level spreader may be used.

5.2.3 Design Requirements

A. Runoff shall be computed using the USDA SCS TR-55 or TR-20 methodologies as described in Chapter 6 of this design manual. Do not use TR-55 Figures 2-1, 2-3, Exhibit 4-I, Exhibit 4-IA, 4-III. The TR-55 methodology for computation of runoff shall be limited to analysis of a single drainage area. The TR-20 methodology may be used in all cases and shall be used when multiple drainage areas are analyzed or the single drainage area exceeds 100 acres.

B. The measured area of a site that does not have vegetative or permeable cover shall be considered total impervious cover. Estimates of proposed imperviousness may be used during the planning process where direct measurements of impervious cover may not be practical. Estimates should be based on actual land use and homogeneity and may reflect NRCS land use/impervious cover relationships (see Table 2.2a in TR-55, USDA-NRCS, 1986) where appropriate. The percent imperviousness (%I) may be calculated from measurements of site imperviousness.

C. Details and supporting computations, signed and sealed by the appropriate design professional, registered in the State of Maryland, shall be provided for all non-standard structures.

D. The appropriate checklist for stormwater management facilities shall be complied with and submitted with the design plans for the development signed and sealed by the appropriate design professional, registered in the State of Maryland. The current checklists are available from the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division.

E. If a site contains an area with no proposed disturbance or impervious area, which does not drain to a BMP, that specific area does not have to be considered for stormwater management.

F. Where deemed necessary by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division, the developer shall submit to the appropriate agency an analysis of the impacts of stormwater flows downstream in the watershed. The analysis shall include hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing on a dam, highway, structure, or natural point of restricted stream flow. The analysis shall be performed to a point where either:

1. The first downstream tributary, or a point downstream, whose drainage area equals or exceeds the contributing area to the facility; or

2. The first downstream tributary whose peak discharge exceeds the largest designed release rate of the facility.

The designed release rate of the structure shall be modified if any increase in downstream flooding or stream channel erosion would result at the downstream dam, highway, structure, or natural point of restricted stream flow. The release rate of the structure shall meet the minimum control requirements.

G. Maintenance (in addition to the MDE Design manual, the following are also required)

1. Stormwater management facilities shall have adequate access for maintenance.

   (a) If the stormwater management facility is not immediately adjacent to a county roadway, an access easement from a county roadway, marked by bollards, capable of allowing maintenance equipment to reasonably access the facility shall be provided.

   (b) Facilities, which are to be owned/or maintained by the county, shall have their access in fee simple ownership or by easement across HOA or other type of open space.

2. Stormwater management facilities required for commercial and condominium or apartment developments shall be maintained by the property owner. Stormwater management facilities required for single-family detached or single-family attached developments serving more than one lot shall be maintained in accordance with Figure 5.03.

3. County maintenance responsibility for jointly maintained or public facilities located on HOA property shall be limited to the structural maintenance of the man-made elements of the facility (e.g. pipes, headwalls, riprap, dams and risers, etc.). County maintenance responsibilities shall also include removal of accumulated sediment. HOA is responsible for all other facility maintenance.

4. Landscape maintenance shall include pruning, mulching, repair and replacement of dead or dying "planted" vegetation that is an inherent part of the BMP function. The maintenance responsibilities shall be included in the Homeowner's Association By-Laws.

5. Maintenance of the facilities shall be as specified for the type of facility designed in accordance with the criteria outlined in the latest edition of the MDE Design Manual, and as outlined in Figure 5.03.

H. Wetlands Mitigation

Wetlands mitigation areas may not be part of a stormwater management facility to be owned and/or maintained by the county, except for county capital projects or with the written approval of the Director of the Department of Public Works or the Chief, Development Engineering Division.

I. Geotechnical Requirements

A soils analysis is required for all stormwater management facilities. The analysis shall be in accordance with the requirements as stipulated in the current edition of the MDE Design Manual, and shall include:

1. The minimum soil boring depth shall be to the seasonal high ground water table; five feet below the bottom of an infiltration or storage device; equal to the embankment height plus five (5) feet; or to refusal.

2. Soil boring information shall be provided for each known borrow area to be used in the construction of the facility.

3. Laboratory testing shall include such appropriate tests as permeability analysis, grain size, liquid limit, plastic limit, natural moisture, compaction tests, consolidation and shear tests as deemed necessary by the appropriate design professional for each specific application.

4. Provide seepage and uplift analysis when deemed necessary by the appropriate design professional.

5. For infiltration trenches and underground facilities, at least two soil borings are required; there shall be at least one boring at each end of the structure.

6. Soil boring information shall be in the Unified Soil Classification System

7. Underground water table shall be shown if encountered for all soil borings.

8. For infiltration facilities, the infiltration rate shall be provided based on in-situ permeability tests as described in Appendix D.1 of the MDE Design Manual. A minimum of two (2) in-situ tests shall be required for each facility. The minimum allowable infiltration rate shall be 1.02 inch per hour.

9. A geotechnical report prepared, signed and sealed by the appropriate design professional, registered in the State of Maryland shall be submitted and shall contain conclusions and recommendations regarding specific practice requirements.

10. Boring locations shall be shown on the plans as required by specific practice.

J. All structural BMP facilities outlined in the MDE Design Manual shall be required to be located on open space lots within the appropriate easements. The easements shall follow the standard nomenclature of Howard County. BMPs on individual lots such as dry wells, rain gardens and overland flow used to obtain stormwater management disconnection credits shall not be required to have easements. Instead, a note shall be placed on the plat as follows:

"LOTS X, Y AND Z HAVE DRY WELLS (or RAIN GARDENS) ON THEM TO MEET ESD PRACTICES. OPERATION AND MAINTENANCE SCHEDULES HAVE BEEN RECORDED WITH THE HOMEOWNERS ASSOCIATION DOCUMENTATION. FAILURE TO INSTALL OR MAINTAIN THESE FACILITIES MAY RESULT IN THE LOSS OF STORMWATER MANAGEMENT APPROVAL."

K. A landscape plan shall be required for all stormwater management facilities in accordance with the current MDE Design Manual and the Howard County Landscape Manual. Where stormwater management facilities are located in a residential neighborhood, signage shall be required around the limits of the functional landscaping to indicate that no mowing or disturbance is allowed in the specific area.

5.2.4 Criteria for ESD Practices

ESD practices shall be used to the MEP. The following are Howard County requirements for specific credits to be used along with requirements shown in the MDE Design Manual:

1. [M-7] Rain Gardens - All raingardens shall have a minimum planting soil depth of 24". All raingardens shall be designed with an appropriate underdrain which outfalls no closer than 5-feet from the property line. Raingardens shall not be located within 10-feet of a proposed structure. A soil boring, verifying groundwater or bedrock, shall be located within 50-feet of each raingarden.

2. [M-8] Swales – Where swales are designed to treat WQv, internal slopes shall not exceed 4% and must be in cut soils. If slopes greater than 4% cannot be avoided, check dams may be utilized up to 8% to reduce runoff velocity. Swale slopes greater than 8% cannot be used to treat WQv.

   The swale shall also be checked to insure that it meets the normal open channel design parameters listed in Section 4.2 of this design manual.

   Gabion (adjacent to wooded areas) or wooden check dams (adjacent to developed lots) within swales shall be allowed within the right-of-way for publicly maintained facilities. All open channel systems serving more than one lot and being used to meet stormwater management criteria shall be placed within Open Space, a public right-of-way, or a public easement. Under drains are required in all Bio-Swales. ESD depth is permitted to exceed 4" adjacent to check dams.

   The centerline of all open channel systems shall be located a minimum 25' from any residential structure. The open channel system shall be designed to convey the stormwater runoff from a 10-year frequency storm event.

3. Level Spreaders

If the use of Infiltration Berms is not feasible due to physical constraints, level spreaders can be used to meet the Sheet Flow to Conservation Areas under the following:

(a) The purpose of a level spreader is to create a sheet flow condition when the average slope of 5% has been exceeded within the contributing area that is to receive the credit. Maximum contributing flow lengths to the device shall be in accordance with MDE Design Manual.

(b) The level spreader shall be constructed with the top of the device at an equal elevation at all points along the length of the device.

(c) The spreader device shall be located on the residential property, outside the buildable lot area. The device shall not cross property lines.

(d) The level spreader may be constructed in accordance with MDE Appendix D.8. or may be constructed by a 2' wide by 1.5' deep trench filled with clean, washed stone (1.5" - 2.5" BRG preferred) lined with filter fabric on all sides and bottom of the trench.

(e) A detail of the level spreader with material specifications shall be provided on the final plans.

(f) The level spreader shall be installed after the contributing site has been stabilized unless filter fabric is placed over the device immediately after construction to divert sediment from entering the device. After the site has been stabilized and with the inspector's approval, the fabric may be removed.

(g) Maintenance shall be performed by the owner of the level spreader when sediment is visually apparent within the stone voids. The portion of the stones that are affected shall be removed and replaced with clean stone.

(h) The level spreader device shall be located both horizontally and vertically on the as-built grading certificate. Elevations shall be taken on the low side of the spreader at the stone/ground interface or at the top of the concrete lip. Spot shots shall be taken every five (5) feet and at each end. The level spreader shall be constructed to within 6" to 8" of the design elevation to be considered as having acceptable vertical tolerances.

5.2.5. Criteria For Structural Practices

Design criteria and operation and maintenance requirements for specific stormwater management practices shall be in accordance with approved methodologies as specified in the latest edition of the MDE Design Manual and as follows only after ESD to the MEP has been exhausted:

A. General Design Criteria

1. All facilities, either public or private, shall comply with the most recent edition of MD-378. If the limits as specified in MD-378 are exceeded, then approval is required from the MDE. In some cases, approval of the facility by the MDE may be required in addition to HSCD approval.

2. A pond buffer shall be provided for all stormwater management facilities in accordance with the criteria set forth in the MDE Design Manual. The minimum distance from the end of the outlet structure, including riprap exit channel, or edge of an underground facility, to the downstream property line shall not be less than 25 feet. Along other parts of the facility, the minimum distance from the toe of embankment or top of cut to the property lines, public easements, rights-of-way and structures shall be 25'. For structures adjacent to the facility where the top of cut cannot be defined and the grading condition encroaches onto a residential lot, the distance from the 100-year water surface elevation within the facility or the edge of an underground facility shall be 25' minimum horizontal and two (2) feet minimum vertical to the lowest floor elevation of a habitable structure.

3. The design of the control structure shall include an analysis of barrel vs. riser control. The table in Figure 5.01 can be used to summarize outflow data for the control structure.

4. Anti-seep collars or filters diaphragms shall be used on all stormwater management facilities as required by MD-378. The phreatic line shall be assumed as being 4:1 from the 10-year design storm elevation.

   It is the responsibility of the design professional to obtain the current edition of MD-378 from the Howard Soil Conservation District prior to the design of a stormwater management facility, as the most current edition shall govern.

5. Concrete cradles shall be provided based on SCS TR-46, "A-2" concrete cradle. Modifications for multiple pipes shall be shown on the detail sheet for construction.

6. Cutoff and core trenches shall be required for all facilities in accordance with the current MD-378 requirements. For those facilities not governed by MD-378 [with an embankment of 4' or greater], cutoff and core trenches may also be required. The limits of the cutoff and core trenches shall be determined on a case-by-case basis but in no case shall be less than 2 feet.

7. A floatation analysis shall be required for each control structure. A factor of safety of 1.5 shall be maintained for all structures.

8. For ponds with maintenance benches, all storm drain outfalls shall be located beyond the bench. The bench may be elevated to allow for the pipe crossing with a two (2) foot minimum cover over the pipe.

9. For ponds with permanent pools, provide a hood, inverted elbow or other device over the low flow orifice opening to prevent oils and other floatable objects from leaving the pond during low frequency storm events. The hood should extend at least 12 inches below the surface of the permanent pool. Adequate clearance shall be provided below the inverted elbow to avoid blockage (minimum one (1) foot).

   If it can be incorporated into the design, the elbow or hood should draw from the bottom 1/3 of the permanent pool to provide for a cooler discharge and to minimize the effects of thermal pollution.

10. Maintenance

   (a) A 12-foot wide level area surrounding the facility providing direct vehicular access to the maintenance bench shall be provided (level means 3% or less cross-slope). This requirement, that the access area surround the facility, may be reduced to a minimum one-half of the facility only if a turnaround area is provided near the embankment area sufficient for maintenance vehicle mobility (minimum size 30' x 30').

   (b) The maximum allowable access grade shall be 10% on grass and 12% with crushed stone or other reinforced surface.

   (c) The minimum allowable access easement width shall be 20 feet. At least 12 feet must be clear for vehicular passage without riding on pathways unless the pathway section will accommodate the maintenance vehicles.

   (d) An on-site stockpile area shall be provided in proximity to the maintenance access for temporary drying of cleaned out material from the pond basin. It shall not be located within non-tidal wetlands and/or saved tree areas. The county reserves the right to require mitigation of wetlands and/or tree save areas that are disturbed due to placement of the on-site material.

   In lieu of providing an on-site stockpile area, cleaned out material may be transported off-site to an approved stockpile area. A note to this effect shall be provided on the plans and included in the Operation & Maintenance Schedule required to be placed on the plans.

11. Fencing

   County policy is not to fence stormwater management facilities except as determined by the Director of the Department of Public Works and the Chief, Development Engineering Division. At the option of the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division, fences or landscaping may be required when a stormwater management facility is adjacent to sidewalks, pathways, schools, playgrounds or when other extenuating circumstances prevail. Maintenance of the fence or landscaping shall remain with the property owner and not with the county unless otherwise agreed to.

12. Geotechnical Requirements

(a) Soil boring information shall be obtained from a minimum of two borings along the centerline of the embankment, one of which shall be at the control structure or barrel and the other one at the emergency spillway, with an additional boring in the pool area (minimum total of three borings required). This can be done by either standard penetration testing or test pits.

(b) Provide settlement analysis of embankment slope for both construction and rapid draw down cases when deemed necessary by the appropriate design professional.

(c) Bearing strength (number of blows), shall be required for embankment foundation borings only.

B. Retention Ponds – Wet Basins (P-2 Wet Pond, P-4 Multiple Pond, P-5 Pocket Pond)

Additional requirements for designs in Howard County consist of the following:

1. A forebay with a volume of 363 cft per acre of impervious cover within the drainage area shall be located at each inlet to the facility. This volume shall be in addition to the design storage volume required. The forebay may be located within the permanent pool area at the entrance to the facility. The required forebay volume shall not be included in the WQv required for sizing the permanent pool.

2. A maintenance bench shall be provided 1 foot above the normal pool elevation suitable for access for maintenance and emergency vehicles to serve as a safety feature. The bench shall have a minimum slope of two (2) percent toward the normal pool. The bench shall be 12' minimum width and may require stabilization with 6" of CR-6 or other accessible material as the vehicle access road leading to the outfall, inlet structure and forebay only. All other areas of the bench shall be stabilized with vegetation. Stabilization requirements shall be at the sole discretion of the county.

3. For wet ponds deeper than two (2) feet, an underwater bench shall be provided extending five (5) feet into the normal pool. The bench shall be flat or up to a two (2) percent grade and shall be 6" to 1' below the normal pool elevation and extend around the entire perimeter of the pool. This bench shall be planted with wetland vegetation to act as a physical barrier restricting access to the pool.

4. All wet ponds shall have drains located at or near the outlet structure with the valve stem anchored to the control structure and extending to the top of the riser for maintenance access. The drain shall be adequately sized to drain the pond within 24 hours under normal flow conditions.

5. For ponds with a micropool, the micropool shall be located at the control structure.

6. Maintenance Requirements

(a) Removal of sediment when accumulation exceeds 50% of the design storage volume. In forebays, removal of sediment when the accumulation exceeds 50% of the forebay volume.

(b) Removal of accumulated paper, trash and debris as necessary.

(c) Vegetation growing on the embankment top and faces of the forebay or basin is not allowed to exceed 18 inches in height at any time.

(d) Annual inspection and repair of the structure.

(e) Corrective maintenance is required any time a forebay does not drain within 60 hours (i.e., no standing water is allowed unless designed for).

(f) Maintenance of pond landscaping shall include replacement of dead or dying vegetation, as necessary.

C. Extended Detention Ponds - Wet (P-1 Micro-pool ED Pond, P-3 Wet ED Pond, W-2 ED Wetlands) or Dry

Additional requirements for designs in Howard County consist of the following:

1. For extended detention ponds, the one-year frequency storm shall be detained for 24 hours. In essence, the detention time will be the difference between the center of mass of the inflow and outflow hydrographs. In the event that the analysis using the USDA-NRCS TR-20 computer hydrograph routing gives results that do not yield a 24-hour time difference, the county will consider that extended detention has been provided if the design methodology has been followed and the resulting detention time is no less than 18 hours. For Class III and IV waterways, the time difference shall be no less than 10 hours and no more than 12 hours.

2. The desirable minimum size of the low flow orifice shall be 3 inches. The absolute minimum orifice size shall be 1-1/2 inches with the appropriate orifice protection. The minimum diameter of the low flow pipe shall be 6 inches.

3. A forebay with a volume of 363 cft per acre of impervious cover within the drainage area shall be located at the inlet to the facility. This volume shall be in addition to the design storage volume required. The required forebay volume shall not be included in the required extended detention volume.

4. A safety bench 5 foot wide shall be placed one (1) to 1.5 feet below the designed Cpv control elevation. The 5 foot safety bench shall always be provided within the micro-pool area. The safety bench shall not be required for basins with extended detention depth averaging less than two (2) feet across the floor.

5. For micro-pool and all shallow facilities, a maintenance bench shall be provided to the control structure and forebay suitable for access for maintenance and emergency vehicles to serve as a safety feature. The bench shall have a minimum cross slope of two (2) percent toward the normal pool. The bench shall be 12' minimum width and may require stabilization with 6" of CR-6 or other accessible material as the vehicle access road leading to the outfall, inlet structure and forebay only. All other areas of the bench shall be stabilized with vegetation. Stabilization requirements shall be at the sole discretion of the county.

6. Maintenance Requirements

(a) Removal of sediment when accumulation exceeds 30% of the design storage volume. In forebays, removal of sediment shall occur when the accumulation exceeds 50% of the forebay volume.

(b) Removal of accumulated paper, trash and debris as necessary.

(c) Vegetation growing on the embankment top and faces is not allowed to exceed 18 inches in height at any time.

(d) Annual inspection and repair of the structure.

(e) Corrective maintenance is required any time an extended detention basin does not drain within 60 hours (i.e., no standing water is allowed).

(f) Corrective maintenance is required any time the forebay does not drain down completely within 60 hours (i.e., no standing water is allowed).

(g) Maintenance of pond landscaping shall include replacement of dead or dying vegetation, as necessary.

D. Detention Ponds – Dry Basins

All detention ponds shall be designed to conform to MD-378 criteria and these standards.

1. Access shall be provided to the bottom of the pond at the control structure and to the forebay.

2. A forebay with a volume of 363 cft per acre of impervious cover within the drainage area shall be located at the inlet to the facility. This volume shall be in addition to the design storage volume required.

3. The bottom of the dry detention facility shall be at least 4 feet above any groundwater. Underdrain systems shall not be permitted which are used to drain groundwater from under the facility to meet this requirement.

4. Maintenance Requirements

(a) Removal of sediment when accumulation exceeds 30% of the design storage volume. In forebays, removal of sediment shall occur when the accumulation exceeds 50% of the forebay volume.

(b) Removal of accumulated paper, trash and debris as necessary.

(c) Vegetation growing on the embankment top and faces is not allowed to exceed 18 inches in height at any time.

(d) Annual inspection and repair of the structure.

(e) Corrective maintenance is required any time the forebay does not drain down completely within 60 hours (i.e., no standing water is allowed).

(f) Maintenance of pond landscaping shall include replacement of dead or dying vegetation, as necessary.

E. Underground Facilities – Private Only F-2 Underground Sand Filter, Underground Quantity Control

Underground facilities are defined as the use of attenuation pipes, structures or other structural measures used to provide stormwater management.

Underground stormwater management facilities shall be required to meet the following criteria:

1. Design Requirements

(a) Delineate the outfall or downstream storm drainage system.

(b) Delineate the extent of the underground facility. Label manhole locations allowing access for maintenance. An access manhole shall be provided at all corners and for each underground attenuation pipe. Access shall be outside of traveled areas and behind curb lines.

(c) Show the 100-year ponding and/or safe overflow pathways.

(d) Show all utilities and maintain a 5' horizontal minimum distance away from the utilities and a 10' clearance from all utility easements.

(e) Provide crossover connector pipes between storage pipes.

(f) Provide a profile of the entire system with inverts, pipe sizes, pipe type and slopes indicated. A 0.5% slope is preferred in the attenuation facility to allow for positive drainage, however, a 0% slope is satisfactory.

(g) Provide a 10-year Hydraulic Grade Line through the facility.

(h) Provide details of the controls used for attenuation.

(i) Provide a minimum of 48" diameter pipes for storage for ease of maintenance and inspection.

(j) Provide gauge and corrugation size for metal pipes.

(k) All access points shall be vented and be wide enough to accommodate maintenance personnel with breathing equipment.

(l) Provide cross sections and plan view.

(m) Provide watertight joints at all pipe connections (for reinforced concrete pipe, ASTM C-361, Rubber Gasket Pipe).

(n) Provide a note on plan that all debris is to be kept out of the facility during and after construction.

(o) Retention underground shall not be permitted.

(p) Infiltration trenches shall not be allowed below the attenuation pipes.

(q) The low-flow opening on the control structure must be protected with a trash rack.

(r) All metal surfaces shall be galvanized and painted with two coats of battleship gray paint or equivalent.

(s) The control structure shall be composed of the same material as the pipe attenuation facility.

2. Computations

(a) Provide all structural computations and information for non-standard structures or modified structures. Computations shall include all reinforcing steel, span widths and other structural information necessary to determine loading factors. Structures must be designed to handle H-20 loading. The structural computations must be signed and sealed by an appropriate design professional licensed in the State of Maryland.

(b) Anti-floatation analysis is required to check for buoyancy if the facility is located within groundwater as stipulated by the soil borings. Anchors shall be designed to counter buoyancy by at least 1.5 factor of safety.

(c) Inlet capacity computations for underground facilities must be shown that inlets are capable of handling the design storm use in the underground facility.

(d) The low-flow opening on the control structure must be protected with a trash rack computed as 3 times the area of the opening.

(e) Provide HGL computations and consider tailwater conditions if applicable.

3. All underground facilities shall have a pretreatment device to minimize sedimentation within the facility. The pretreatment device shall be cleaned as deemed necessary by manufacturer's recommendations or as specified on the required Operation & Maintenance Schedule. The underground facility shall be maintained in accordance with the specified Operation & Maintenance Schedule accordingly.

F. Stormwater Management Retrofits

Stormwater management retrofit of any existing facility which is to be used to improve the management or treatment of stormwater runoff shall meet the following requirements:

1. For new development and redevelopment, stormwater management retrofits of any existing facility shall comply with the requirements of this design manual.

2. For capital projects, stormwater management retrofits used to address the negative and inefficiencies of facilities designed in accordance with previous design standards, or new facilities used to improve stormwater management quantity or quality in watersheds where no facilities were previously utilized, the facilities shall be designed to meet ESD to the MEP. The Department of Public Works shall determine the scope, intent and design standards of the work to be performed. Plans and computations shall state the intent of the retrofit design and show through descriptions, calculations, drawings or other information that the intent has been met to the maximum extent practical.

5.3 PLATS AND PLANS

5.3.1 Plats

All subdivision plats shall clearly indicate easements, lots and parcels, which are dedicated for stormwater management facilities and their access roads. A note shall be provided in the general Notes on the plat indicating how stormwater management has been provided ~~for~~.

5.3.2 Stormwater Management Plans and Computations

The stormwater management documents shall contain supporting computations, drawings and sufficient information describing the manner, location and type of measures in which stormwater runoff will be managed for the entire development. The appropriate checklist shall be used to develop the stormwater management documents and shall be submitted with the construction drawings. The current checklists can be obtained from the Department of Public Works and/or the Department of Planning & Zoning/Development Engineering Division.

5.3.2. Review and Approval of Stormwater Management Plans

For any proposed development, the owner/developer shall submit multi-step stormwater management plans to Howard County for review and approval. Each plan submittal shall include the minimum content specified in the Howard County Code.

Howard County may grant a Stormwater Management Alternative Compliance or Waiver to the Stormwater Management Criteria in accordance with the guidelines set forth in the Howard County Code Section 18, Subtitle 9.

5.4 MAINTENANCE AND INSPECTION

5.4.1 Maintenance

Maintenance shall be according to the provisions specified in the current edition of the Maryland Stormwater Design Manual, Volumes I & II and this design manual for each specific type of stormwater management system.

5.4.2 Inspection

A. Inspection Schedule and Reports

1. The developer shall notify the county at least 48 hours before commencing any work in conjunction with the stormwater management plan and upon completion of a project when a final inspection will be conducted.

2. Regular inspections shall be made and documented for each ESD planning technique and practice at the stages of construction specified in the Design Manual by Howard County, its authorized representative, or certified by a professional engineer licensed in the State of Maryland. At a minimum, all ESD and other nonstructural practices shall be inspected upon completion of final grading, the establishment of permanent stabilization, and before issuance of use and occupancy approval.

3. Written inspection reports shall include:

   (a) Date and location of the inspection;

   (b) Whether construction was in compliance with the approved stormwater management plan;

   (c) Any variations from the approved construction specifications; and

   (d) Any violations that exist.

4. The owner/developer and on-site personnel shall be notified in writing when violations are observed. Written notification shall describe the nature of the violation and the required corrective action.

5. No work shall proceed until the county inspects and approves the work previously completed and furnishes the developer with the results of the inspection reports after completion of each required inspection.

B. Inspection Requirements During Construction

1. At a minimum, regular inspections shall be made and documented at the following specified stages of construction:

(a) Ponds

(i) upon completion of excavation to sub-foundation and when required, installation of structural supports or reinforcement for structures, including but not limited to core trenches for structural embankments, inlet and outlet structures, anti-seep collars or filter diaphragms, watertight connectors on pipes and trenches for enclosed storm drain facilities;

(ii) during placement of structural fill, concrete and installation of piping and catch basins;

(iii) during backfill of foundation and trenches;

(iv) during embankment construction; and

(v) upon removal of any temporary sediment control feature or devices; and

(vi) upon completion of final grading and establishment of permanent stabilization.

(b) Wetlands

(i) at stages specified for pond construction;

(ii) during and after wetland reservoir plantings; and

(iii) during the second growing season to verify a vegetation survival rate of at least 50 percent.

(c) Infiltration trenches

(i) during excavation to subgrade;

(ii) during placement of backfill of underdrain systems and observation wells;

(iii) during placement of geotextiles and all filter media;

(iv) during construction of appurtenant conveyance systems such as diversion structures, pre-filters, filters, outlets and flow distribution structures; and

(v) upon completion of final grading and establishment of permanent stabilization.

(d) Infiltration basins

(i) at stages specified for pond construction; and

(ii) during placement and backfill of underdrain system.

(e) Filtering systems

(i) during excavation to subgrade;

(ii) during placement and backfill of underdrain system:

(iii) during placement of geotextiles and all filter media:

(iv) during construction of appurtenant conveyance systems such as diversion structures, pre-filters, filters, outlets and flow distribution structures; and

(v) upon completion of final grading and establishment of permanent stabilization.

(f) Open channel systems

(i) during excavation to subgrade;

(ii) during placement and backfill of underdrain systems for dry swales:

(iii) during installation of diaphragms, check dams, or weirs; and

(iv) upon completion of final grading and establishment of permanent stabilization.

(g) Non-structural practices

(i) upon completion of final grading;

(ii) upon the establishment of permanent stabilization; and

(iii) before the issuance of the final certificate of occupancy approval.

2. The county shall enforce the design plans in accordance with procedures stipulated by the County Code.

3. Once construction is complete, an as-built plan certification shall be submitted by the appropriate design professional licensed in the State of Maryland to ensure that constructed stormwater management practices and conveyance systems comply with the specifications contained in the approved plans. At a minimum, as-built certification shall include a set of drawings comparing the approved stormwater management plan with what was constructed. The county reserves the right to require additional information it deems necessary to ensure compliance with the approved plans.

4. The county shall submit notice of construction completion to the Maryland Department of the Environment, on a form supplied by MDE for each structural stormwater management practice within 45 days of construction completion. If BMPs requiring HSCD approval are constructed, notice of construction completion shall also be submitted to HSCD.

REFERENCES

1. Maryland Department of the Environment, Water Management Administration, Stormwater Design Manual, Volume I & II, latest edition.

FIGURES

Figure 5.01

COMPOSITE DISCHARGE TABLE

WSEL	STAGE 1 LOW FLOW		STAGE 2 FLOW		STAGE 3 FLOW		BARREL CONTROL				WSEL INSIDE RISER	Q TOTAL (cfs)	REMARKS
							INLET		OUTLET				
	H (ft)	Q (cfs)	H (ft)	Q (cfs)	H (ft)	Q (cfs)	HW/D	Q (cfs)	H (ft)	Q (cfs)			

Figure 5.02

STORMWATER MANAGEMENT STAGE/STORAGE TABULATION

JOB NAME:____________________ JOB NO:____________ DATE:____________

COMPUTED:____________ STUDY POINT:____________ CONDITION: ___EXISTING

CHECKED:____________ ___PROPOSED

WSEL	AREA (sqft)	AVERAGE AREA (sqft)	CHANGE in HEAD (ft)	CHANGE in VOLUME (cft)	TOTAL VOLUME (cft)	TOTAL VOLUME (ac-ft)

Figure 5.03

Stormwater Management Ownership & Maintenance Responsibility

SWM Code	BMP Type	County Ownership & Maintenance Responsibility	Private Ownership & Maintenance Responsibility
P-1	Micro pool ED	Y/ All except Landscaping & Plantings	S/ Landscaping & Plantings or, Y/all
P-2	Wet Pond	Y/ All except Landscaping & Plantings	S/ Landscaping & Plantings or, Y/all
P-3	Wet ED Pond	Y/ All except Landscaping & Plantings	S/ Landscaping & Plantings or, Y/all
P-4	Multiple Pond	Y/ All except Landscaping & Plantings	S/ Landscaping & Plantings or, Y/all
P-5	Pocket Pond	Y/ All except Landscaping & Plantings	S/ Landscaping & Plantings or, Y/all
W-1	Shallow Wetland	Y/ Embankment, Riser, Mucking	S/ Landscaping & Plantings or, Y/all
W-2	ED Wetland	Y/ Embankment, Riser, Mucking	S/ Landscaping & Plantings or, Y/all
W-3	Pocket/Wetland	Y/ Embankment, Riser, Mucking	S/ Landscaping & Plantings or, Y/all
W-4	Pocket Wetland	Y/ Embankment, Riser, Mucking	S/ Landscaping & Plantings or, Y/all
I-1	Infiltration Trench	N	Y/All
I-2	Infiltration Basin	N	Y/All
F-1	Surface Sand Filter	N/ if Cpv not provided in facility Y/ with Cpv, Dam only	Y/All Y/Sand Filter and Underdrain
F-2	Underground Sand Filter	N	Y/Observation well, No PVC, Lock cap
F-3	Perimeter Sand Filter	N	Y/All
F-4	Organic Filter	N	Y/All
F-5	Pocket Sand Filter	N	Y/All
F-6	Bioretention	N	Y/All
O-1	Dry Swale	N	Y/All
O-2	Wet Swale	N	Y/All
A-1	Green Roofs	N	Y/All
A-2	Permeable Pavements	N	Y/All
A-3	Reinforced Turf	N	Y/All
N-1	Disconnection of Rooftop Runoff	N	Y/All
N-2	Disconnection of Non-Rooftop Runoff	N	Y/All
N-3	Sheetflow to Conservation Areas	N	Y/All
M-1	Rainwater Harvesting	N	Y/All
M-2	Submerged Gravel Wetlands	N	Y/All
M-3	Landscape Infiltration	N	Y/All
M-4	Infiltration Berms	N	Y/All
M-5	Dry Wells	N	Y/All
M-6	Micro-Bioretention	Y/ All except Landscaping, mulch& Plantings	Y/All
M-7	Rain Gardens	N	Y/All
M-8	Swales	Y/ All except Landscaping, mulch & Plantings	Y/All
M-9	Enhanced Filters	N	Y/All

Note: Y = Yes
N = No
S = Shared

General Notes:

1 No public facility on Private Opens Space lots.
2 Landscaping costs for the BMP shall be added to the pond bond amount.
3 All SWM facilities on Commercial sites shall be Privately Owned and Maintained
4 SWM facilities on residential lots shall treat only that lot.
5 For Bioretention and other facilities on lots, no easements will be required, however, a maintenance agreement and a note on the Record Plat shall be required for continual ownership and maintenance.
6 The on-lot private SWM shall become part of the builder grading certification required for the U&O.

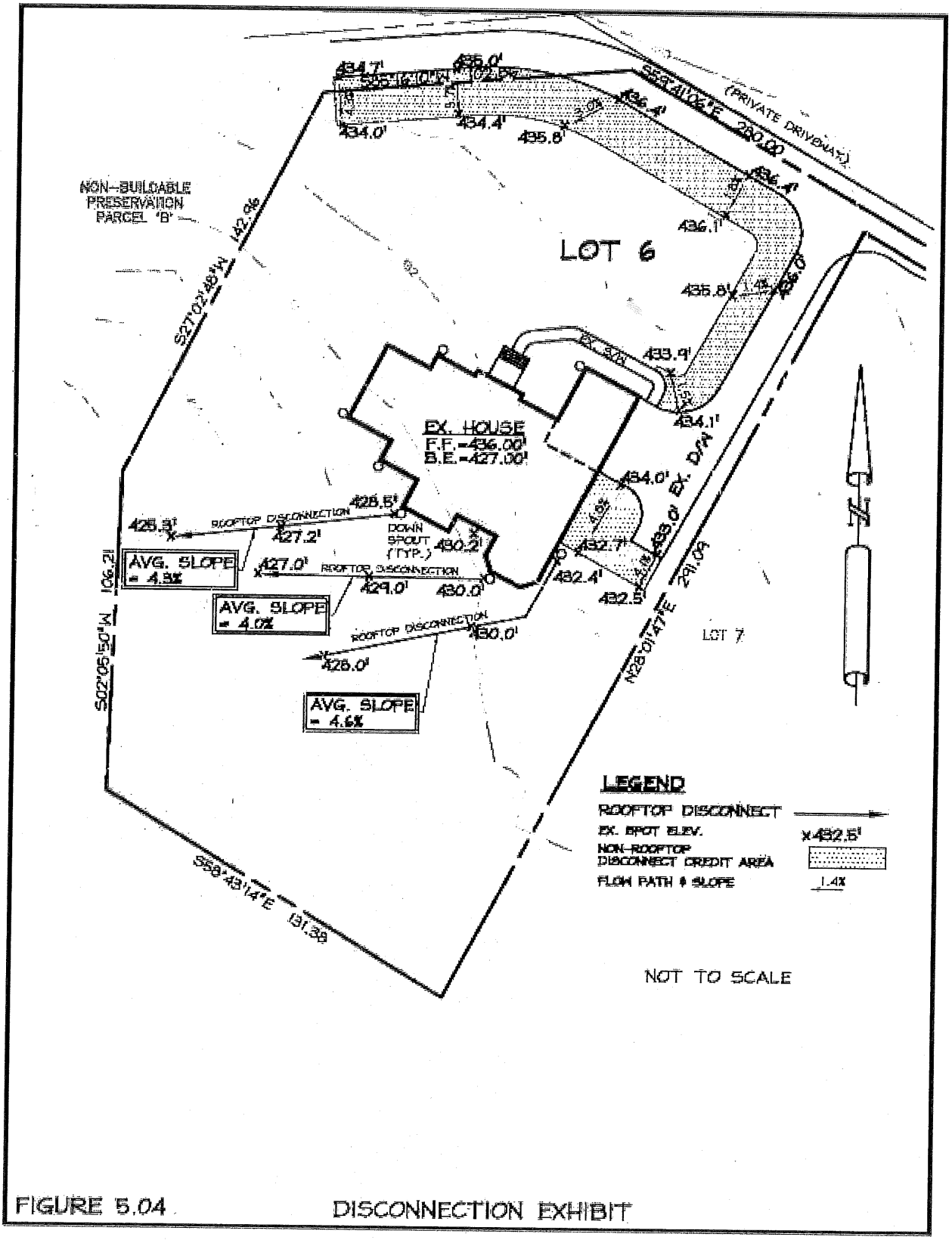


FIGURE 5.04 DISCONNECTION EXHIBIT

CHAPTER 6

FLOODPLAIN MANAGEMENT

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CHAPTER 6

FLOODPLAIN MANAGEMENT

6.1 INTRODUCTION

Floodplain management goals are to reduce the existing flood hazards, to preserve the environmental qualities of the County and to protect and insure the continued health, safety and welfare of the general public.

6.2 JURISDICTION

1. The delineation of all 100-year floodplains shall be approved by Howard County as part of the building permit process or the subdivision and site plan review process.

2. The County will review, approve, deny or make recommendations for encroachments, obstructions, dams, changes in cross section or other modification of the 100-year floodplain.

3. The County will take special interest in work within or adjacent to a floodplain, which may impact natural resources. It is the intent of the County to maintain, and where practical, to enhance these resources.

4. Howard County works cooperatively with regulatory agencies of the State, and reserves the right to comment and make recommendations on requests for permits made to a State regulatory agency.

6.3 POLICY

The reduction of the cross section of any stream or body of water, including reduction of the floodplain, is contrary to the public interest.

1. Howard County discourages any grading in the 100-year floodplain. Proposals to grade and/or fill the floodplain in order to create buildable lots are prohibited.

2. All proposals to fill in portions of the floodplains or otherwise reduce the cross section shall be accompanied by hydraulic calculations indicating effects of such filling and shall be supported by a description of the benefits to be expected. The Howard County Code does not permit the construction of new residential, industrial, institutional or commercial buildings within the 100-year floodplain.

3. If the 100-year ultimate floodplain is increased, then appropriate flowage easements must be granted by all affected property owners and the design approved by the Department of Public Works, the Department of Planning & Zoning/Development Engineering Division or where necessary, by the Maryland Department of the Environment, Water Management Administration.

4. Existing buildings within the 100- year floodplain are regarded as non-conforming uses and will be treated as such. If the floodplain cannot be altered, flood proofing of such buildings may be encouraged where feasible. The County's ultimate policy regarding buildings where flood proofing is not feasible is to seek their removal from the 100-year floodplain. In some areas, the County may exercise its power of eminent domain, subject to appropriate capital project authorization.

5. For developing adjacent to the floodplain, see Section 3.100,II(107), of the Howard County Code amending Subsection 2102.4 of the BOCA Code.

6.4 DELINEATIONS

On all subdivision plats and site plans, the 100- year floodplain shall be shown for all drainage areas of 30 acres or larger or those having a 10-year runoff in excess of 100 cfs.

Surveyed cross sections, based on Howard County monuments, shall be provided at a maximum 200 feet apart and at the following additional locations: at bridges (three cross-sections), at changes in stream slope, at bends in the stream, at contractions in the stream, at expansions in the stream, in stream changes in the Manning's roughness coefficients. Other cross section spacing shall be approved for large water courses at the discretion of the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division.

6.5 ACCEPTABLE STUDIES

6.5.1 Acceptable Study Criteria

The floodplains may be determined by the following methods:

A. Hydrology by TR-55, TR-20 or Rational Method (see Chapter 3). Hydraulics by the standard step method or HEC-RAS.

B. Floodplain studies previously completed for land development purposes may be used when the following conditions are met:

1. The study must be relatively recent. That is, the study must contain information, which is current enough to the floodplain determination and computed by acceptable methods as noted in Chapters 3 and 4.

2. All base data changes, which have occurred since the completion of the previous approved study, must be accounted for (e.g., bridges or culverts installed since the previous study).

3. The previously approved study on file with the County cannot be referenced. The applicant must provide the complete study. It is the applicant's responsibility to obtain the study from its owner.

The Department of Public Works or the Department of Planning & Zoning/Development Engineering Division reserves the right to reject or require modifications to a study regardless of the previous acceptance of the study.

C. County Watershed Model Studies are developed for the purpose of the initial identification of the 100- year floodplains and complying with the Federal Flood Insurance program.

County studies are to be used in the following ways:

1. Property or structures which are "obviously not critical". The criteria for "obviously not critical" shall be that all potential building sites are at least 15 feet above the approximate 100-year floodplain and all required minimum lot areas are at least five feet above the approximate 100-year floodplain. Where the delineation of the floodplain is "obviously not critical" to the proposed development, Manning's Equation may be used to determine the floodplain elevation in homogeneous streams. The standard step method or HEC-RAS shall be used at bridges or culverts or other irregular steam sections.

2. For cases where the hydrologic/hydraulic data are relatively good, the County will provide the 100-year flow rate and an elevation at a specific location, which may be used as a benchmark for the required study.

3. For cases where the hydrologic/hydraulic data area questionable, the applicant shall be required to survey and develop a hydrologic and hydraulic study.

6.6 REQUIREMENTS FOR FLOODPLAIN STUDIES

1. Subject to approval by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division.

2. Consistent with applicable State and Federal regulations. For example, the water surface elevations as shown on the Flood Insurance Rate Maps shall be the minimum acceptable water surface elevations for existing channel conditions. (Subject to approval by Department of Public Works or the Department of Planning & Zoning/Development Engineering Division.)

3. Prepared by a registered design professional licensed to practice in the State of Maryland, sealed, signed and dated.

4. Conform to current criteria published herein.

5. Conform to other requirements as directed by the appropriate approval agency.

6. Based on the 100-year flood event, for the ultimate development; in keeping with the land use condition as specified in the general plan and/or the most updated zoning map within the watershed, whichever is more restrictive.

7. Valid hydrologic analysis of rainfall, runoff and conveyance.

8. If storage effects are significant, volume as well as peak flow shall be evaluated.

9. Limits of 100- year floodplain before and after channel improvements shall be shown on site plan and storm drain plan.

10. Subject to the approval of Department of Public Works or the Department of Planning & Zoning/Development Engineering Division, floodplain studies for streams with less than a 30-acre watershed may be exempted from the requirements of these criteria. This is at the sole discretion of the County.

11. Areas outside the property limits, which are affected by any water surface rise resulting from the development, shall be acquired by the applicant for use as a suitable floodplain easement. If no floodplain (ultimate) is on record then the before and after differential shall be established and easements sought. If the floodplain (ultimate) is on record and the property development causes any increase, then the differential shall be accommodated in an easement.

    If the development does not create a 100-year discharge different than that used in the of-record floodplain then the developer shall not be required to obtain offsite flowage easements, unless an obstruction created by the development causes a greater elevation even with no greater discharge.

12. Consider backwater conditions, local obstructions and the partial or complete failure of any enclosed storm drain system. (Consideration must be given to the overflow path, to examine flood impacts in the event of system failure.)

13. All areas within a floodplain shall be encompassed by a dedicated floodplain easement whether it is for public use or for use as a private park, or as homeowner's open space. Such a dedication or floodplain easement shall be recorded among the land records of Howard County, and such recorded documents shall note that the floodplain easement may be used for utility lines, storm drainage facilities or stormwater management facilities, shall include provisions for ingress and egress by authorized personnel, and shall be designated as a 100-Year Floodplain, Drainage & Utility Easement.

14. Existing uses in the floodplain may be flood-proofed, but not otherwise expanded or enlarged as provided in the County Code, Section 3107.2.2, provided this does not raise the flood level.

15. Floodplain areas, based on studies meeting the criteria herein, shall be determined to compute net tract area, cluster open space, or net lot area, for zoning purposes. FOR THIS PURPOSE ONLY, the floodplain areas of streams having watersheds of less than 30 acres may be excluded. Unless the approval noted in Item (10) above is granted by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division, such areas are still subject to the study requirements.

16. New development shall not be permitted within the designated ultimate floodplain channel based on existing or proposed channel conditions.

17. The approval of the ultimate floodplain for existing or proposed channel conditions will not be released until the technical design is approved by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division.

18. Floodplain areas which are to be left in an open and natural state shall be denoted on the subdivision plat as a Public 100-Year Floodplain, Drainage & Utility Easement and shall be recorded in the County Land Records, even if they are to become a public park or recreation areas maintained by a designated responsible public agency. With the exception of stormwater management facilities, structures shall not be built that would interfere with the flood conveyance capacity of the easement area. Any increase of the ultimate flood elevation due to construction of stormwater management facilities shall require an additional floodplain easement. Downstream structures within or adjacent to then floodplain shall not be impacted by any increased waters. This may require storage of the ultimate 100- year storm event.

6.7 ITEMS (DATA/INFORMATION) NEEDED FROM DESIGN PROFESSIONAL

The following items are needed from either the developer or the design professional, when a floodplain study is submitted to the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division for review.

6.7.1 Report

The report shall include a general description of the project and a written summary of the computation's methodology. As a minimum, the following information shall be provided by the design professional:

A. Brief description of existing site conditions;

B. A detailed description of proposed site conditions including a copy of the development plan;

C. If channel modifications are proposed, include a copy of design plans which have been submitted;

D. Explanation of all assumptions made in computations. Reference computational procedures and equations taken from manuals, books, etc. Reference survey data used and coordination with datum used from existing studies. Include implications to existing FEMA studies and disposition. What the design professional may perceive as obvious may not be obvious to the reviewer;

E. Explanation of how the HEC-RAS cross-section information was generated. (Field survey or consultant generated topographic map with minimum 2- foot contour intervals. Howard County aerial topography shall not be used within the property boundary);

F. Explanation of how the starting water surface elevation was determined;

G. Ranges of Manning's "n" values for both channel and overbanks, any assumptions used and a statement on how "n" values were determined (photographs accompanying the report shall be required verifying conditions);

H. The computations, printout (and disc for future incorporation in the watershed model and/or LOMR);

I. Any other pertinent information, which will aid reviewers in expediting the review process (correspondence, intra/inter-agency agreements, etc.).

6.7.2 Hydrology

A. Drainage area map identifying each sub-watershed and flow path used for Tc calculation with segments labeled for both existing and proposed channel conditions;

B. Back-up calculations for the time of concentration determination;

C. Soil map with sub-watershed boundaries drawn on it;

D. Zoning map and land use map with sub-watershed boundaries drawn on it (the worst case shall govern in generation of expected runoff);

E. Watershed schematic;

F. Back-up calculations for stage-discharge and discharge-area relationships for the channel routing rating tables;

G. Back-up calculations for stage-discharge and stage-storage relationships for the reservoir routing rating tables; and

H. Upon approval of the floodplain study, a CD-ROM shall be provided to the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division, containing digital information of all plans, computations and design reports signed and sealed by the appropriate design professional, registered in the State of Maryland, so that the county can maintain a digital record of all floodplains being developed.

6.7.3 Hydraulics

A. Detailed bridge information including:

1. bridge geometry such as opening, material, length, invert elevations, aprons, channel protection, etc.

2. back-up calculations for bridge parameters to include those used for the bridge/culvert input data in the HEC-RAS model.

3. road profile with survey control data.

4. inlet control vs. outlet control computation.

B. HEC-RAS cross-section plots;

C. Computer disk consisting of HEC-RAS input files; and

D. Floodplain maps indicating location of HEC-RAS cross-sections, flood elevations (existing and proposed) at each cross-section, floodplain boundary (existing and proposed), proposed changes of the stream, houses, survey control data, ties to traverse line, etc.

6.8 REVIEW CRITERIA

6.8.1 Hydrology

A. Drainage Area Maps

1. The drainage area maps should show the existing and proposed topography with sub-watersheds delineated. (As a minimum, USGS, or Howard County's topographic map should be used.)

B. Runoff Curve Numbers

1. The RCN shall be computed based on ultimate land use taken for the most recent zoning map or land use map (worst case) and the soil types based on the Howard County Soil Survey or boring logs. (Making the assumption that the land will remain undeveloped is unacceptable.)

C. Time of Concentration

1. The travel time method shall be used following the procedures outlined in the latest edition of the USDA-NRCS TR-55 computations.

2. The flow path and segments used to determine the Tc for each sub-watershed should be clearly identified on the drainage area map.

3. P100=**[[**7.2**]]8.51** inches shall be used in the equation to determine sheet flow travel time. The sheet flow length shall not be more than 100 feet.

4. Manning's "n" factor for sheet flow shall reflect ultimate land use condition (for existing and proposed conditions).

5. Computations shall be provided for determination of channel flow velocity. When available, the velocity should be taken from HEC-RAS output.

D. Rating Tables for Channel Routing

1. Rating tables for stage-discharge and stage-end area relationships should be generated from reliable analysis such as HEC-RAS modeling. (Identify sections used.)

2. Rating tables shall be adjusted to reflect proposed channel conditions.

E. Rating Tables for Reservoir Routing

1. The most recent and updated topographic information shall be used to determine stage-storage relationship. Howard County's 5-ft topographic map is a minimum. If 2-ft topographic maps are available, they shall be used.

2. Elevation interval (H) between A1 and A2 shall not be greater than 2.0 feet when the following equation is used to estimate the available storage:

   S = (A1+A2)/2 x ?H

3. The flood elevation calculated from the TR-20 run and the predicted flood elevation calculated from the HEC-RAS run shall be within 0.5 foot of each other.

4. Rating tables shall reflect the proposed channel conditions.

5. In the event that a riser is proposed for a stormwater management facility, the following procedures shall be used to determine the stage-discharge relations:

   a. Compute, for each discharge (Qout), the headwater elevation for the outflow pipe for inlet and outlet control conditions. Select the higher elevation as WSEL (h) inside the riser.

   b. Assume a WSEL (H) outside the riser. Compute discharge entering the riser at each opening using flow equation (weir or orifice flow). For weir flow conditions, if tailwater (h, determined at step "a.") is above weir crest then adjust the discharge for submerged effect.

   c. Add the computed discharges entering the weir at each opening together to determine the total discharge entering the riser (Qin). Compare Qin versus Qout. If different, assume a different WSEL (H) outside the riser and repeat steps a. and b.

F. Storm Events

1. The 24-hour rainfall amount for the 100- year storm event in Howard County is **[[**7.2**]]8.51** inches. Use rainfall distribution Type II and Antecedent Moisture Condition II.

G. TR-20 Standard Control

1. The "network" shall be reflective of the drainage area maps.

2. Reach lengths shall reflect the floodplain length if flow is primarily overbank or channel length of flow is primarily in the channel. Reach lengths used in the TR- 20 must agree with those shown on the topographic maps and reflected in the HEC-RAS runs.

3. Input data used in the TR-20 run must be consistent with the back-up calculations generated for:

   Drainage Area
   Runoff Curve Number
   Time of Concentration
   Rating Tables for both Channel
   & Reservoir Routines

4. Final drainage area used in the TR-20 analysis shall reflect actual watershed drainage area.

6.8.2 Hydraulics

A. Reach Lengths

1. Reach lengths shall reflect the floodplain length if flow is primarily overbank or channel length is primarily in the channel. Reach lengths used in the TR-20 shall agree with those shown on the topographic maps and reflected in the HEC-RAS runs.

2. Existing and proposed channel condition's reach length shall correspond to the computed distances used on the base mapping.

B. Loss Coefficients

1. Manning's "n" values should reflect actual field conditions.

2. Proper expansion and contraction coefficients should be used.

C. HEC-RAS Cross Sections

1. HEC-RAS cross-sections shall be generated from field survey or two- foot topography. Cross sections taken from Howard County's 5-foot topography are unacceptable.

D. Starting Water Surface Elevation

Water surface elevations can be obtained from the following sources whichever is the highest:

1. When available, the starting water surface elevation input in the HEC-RAS model should be a known water surface elevation.

2. Most recently approved FEMA study (with the approval of the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division.

3. Comprehensive Watershed Management Study prepared by Howard County.

4. The design professional should contact the appropriate agency directly to inquire about the availability and acceptability of a floodplain study. Previously approved maps may be viewed by the design professional at County offices to determine adjacent floodplain conditions.

5. If a known WSEL is unavailable, the design professional shall extend the study downstream to the nearest structure (road, pond, etc.) that would have a backwater impact. As a last resort, the normal depth computations in the HEC- RAS boundary conditions should be used. When the normal depth method is utilized, the study shall be extended a minimum of 500 feet downstream of the site (Howard County's topography may or may not be acceptable for off-site area). If the computed WSEL is assumed to be critical depth, the appropriate information shall be entered into the HEC-RAS boundary condition data.

E. Bridge Modeling

1. Headwater elevation at bridges/culverts can be determined using the HEC-RAS bridge routines or by hand computations. Due to their flexibility in handling different flow regimes, we encourage the use of the HEC-RAS bridge routines. For complicated flow situations, the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division reserves the right to require the use of the bridge routine. When using the bridge routines, the modeler should pay particular attention to the requirements in the HEC-RAS users manual.

2. Top widths at upstream and downstream face of bridge must be reasonably encroached. For pressure or low flow condition, top width should be the same as the bridge opening. For weir flow, top width should be limited to bridge opening, and velocity head should not be much more than 0.5 feet at upstream face of bridge.

3. More detailed evaluation is required to verify the adequacy of critical depth and bridge cross sections. For low flow or pressure flow conditions, modeling should reflect proper expansion of flow downstream of bridge and contraction of flow upstream of the bridge.

4. If storage is considered behind the bridge, the flood elevation calculated from the TR-20 run should be reasonably close to energy grade calculated from HEC-RAS (0.5' max.).

Should the design professional prefer to determine headwater elevation using hand computation, the Federal Highway Administration pipe/culvert charts shall be utilized. It is emphasized that the outlet control charts assume pipe flowing full. Tailwater shall be considered in analyzing outlet control. For low flow conditions, the bridge routine shall be used. The bridge routine is the preferred method to compute weir flow. If hand computations are used, explain all assumptions (determination of C, L and H) and document references.

F. Super-critical Flow

1. For super-critical flow condition, due to large velocity head, 100- year floodplain delineation should reflect HEC-RAS energy grade elevations.

G. Proposed Channel Modifications

1. When channel modifications are being proposed, a HEC-RAS model shall be prepared for both existing and proposed channel conditions. The models should be extended upstream until the water surface elevations converge. Off-site areas affected by water surface rise shall be acquired by the developer for use as a suitable floodplain easements.

H. Divided Flow

1. All notes and remarks in the HEC-RAS output should be reviewed. Any discrepancies should be addressed, errors should be corrected and warnings investigated, modified and as a last resort, explained in the narrative.

I. Critical Depth

1. When the program cannot balance water surface elevation, critical depth is assumed for the cross section and a message to that effect is printed by the program. The design professional must verify the adequacy of all critical depth messages. The analysis should consist of:

   a. Check coding of stream data information.

   b. Confirm location of bank stations to ensure that they reflect actual field conditions. Locating bank stations far apart will cause too much water to flow in the channel with a lower Manning's "n" value.

   c. Additional cross sections may be needed to be inserted in order to preserve the assumptions of gradually varied flow. Check top-widths at cross sections for realistic transition of flow between cross sections.

   d. Sensitivity analysis for increasing Manning's "n" value for channel and overbanks. Computer runs shall be included in the submission package.

   e. If message occurs at numerous cross sections, the program should be rerun for super-critical flow.

   f. As a last resort, persistent messages should be explained.

J. Floodplain Fill

1. By County Code, Section 16.702, fill in the floodplain is not allowed except for permitted road crossings, trench backfill and stormwater management

embankments crossing the stream channel. Excavation may be allowed on a case-by-case basis.

6.8.3 Others

When all review comments have been addressed to the agency's satisfaction, floodplain approval for the existing channel conditions will be released. However, for proposed channel conditions, the approval will be withheld until the proposed plan has been approved by the agency and the technical plan matches with what is shown in the floodplain study.

6.9 FLOODPLAIN EASEMENT REQUIREMENTS

When a floodplain issue is involved in any development project at grading permit stage and/or record plat stage, the design professional is required to identify on the plat an easement area which encompasses the 100- year floodplain. In order to meet this requirement the following guidelines must be met:

6.9.1 Guidelines

A. Prior to delineating an easement area, an approved floodplain study must be provided. Both the floodplain and its easement must be delineated on the floodplain map. The floodplain easement with water surface elevations noted shall be shown on the Final Plat.

B. The approved floodplain study must be recognized by the Department of Public Works or the Department of Planning & Zoning/Development Engineering Division (i.e., current FEMA, DPW Comprehensive Management Plans, Adopted Private Study).

C. The Department of Public Works or the Department of Planning & Zoning/Development Engineering Division will review the development plan with consideration of the approved floodplain study.

D. The Department of Public Works or the Department of Planning & Zoning/Development Engineering Division will coordinate the recordation of the easement to ensure compatibility with the approved technical plan. Note: It's the design professional's responsibility to make sure plans match.

E. The floodplain easement shall be recorded by dedication of the floodplain on the plat of subdivision.

F. Upon request, the distribution of the floodplain easement to appropriate agencies will follow the recordation.

6.9.2 Submission Requirements

The submission requirements are basically the same as those for storm drain easements. Some additional information/data are as follows:

A. Easement information to be recorded should be submitted to the Department of Public Works.

B. Submit all supporting documents to aid in recordation of easement (e.g., deeds, previous easement description, plans, etc.)

6.9.3 Clarifications

A. It is the developer's or design professional's responsibility to contact the Maryland Department of the Environment/Water Management Administration to verify the need for a waterway construction permit whether or not a disturbance to the floodplain is anticipated or proposed. Both State and County restrictions may apply.

B. Final Letter of Map Revision (LOMR) – It is the policy of the Federal Emergency Management Agency (FEMA) within six (6) months after the completed construction of a project for which a "Conditional Letter of Map Revision" has been approved, that a "Final Letter of Map Revision" be requested and documents submitted for approval. The package must be submitted to the Department of Public Works/Bureau of Environmental Services of Howard County Government for review and if acceptable, will be forwarded to FEMA for their approval. The following information must be included in the package:

1. "As-Built" plans of the floodplain modification project certified by a registered design professional licensed to practice in the State of Maryland.

2. HEC-RAS hydraulic models of the 10-, 50-, 100- and 500-year storm events representing "As-Built" conditions.

3. TR-20 run based on "As-Built" conditions for the ultimate 100- year design storm.

4. Topographic mapping of the 100- and 500-year flood boundaries based on the "As-Built" conditions.

C. If an approved floodplain study exists for the site or adjacent site, it is the responsibility of the design professional to inquire about its' adequacy on each specific project.

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REFERENCES

1. Prince Georges County, Department of Environmental Resources, Division of Environmental Management, Watershed Protection Branch, Stormwater Design Manual, April 1991.

2. U.S. Army Corps of Engineers, HEC-RAS River Analysis System, [[Version 1, July 1995]] **LATEST VERSION.**

3. Federal Highway Administration, Hydraulic Design of Highway Culverts, Hydraulic Design Series No. 5, FHWA-IP-85-15, National Technical Information Service, Springfield, Virginia, September 1980.

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CHAPTER 7

SEDIMENT AND EROSION CONTROL

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CHAPTER 7

EROSION AND SEDIMENT CONTROL

7.1 INTRODUCTION

The Department of Public Works fully supports and cooperates with the efforts of the Howard [[Coil]]**SOIL** Conservation District (HSCD) in achieving soil erosion and sediment control. Under State and County law, the HSCD has review and approval jurisdiction for these controls. However, through its' Department of Inspections, Licenses, and Permits, the County provide the necessary field inspection for erosion and sediment control facilities and practices.

The Patuxent River Watershed Sediment Control Law of 1969 and subsequent legislation enables the implementation of erosion and sediment control practices.

As a result of experience gained on the application of these practices, the Maryland Department of the Environment (MDE) has developed a publication, Maryland Standards and Specifications for Soil Erosion and Sediment Control. These standards and specifications, or subsequent revisions thereof, shall be the basis for soil erosion and sediment control in Howard County.

The interests of Howard County will be served by adherence to the requirements and approval of the Howard Soil Conservation District. The County's further interests concern coordination of the erosion and sediment control with other components of the storm drainage system, the provision of standard details, application of erosion control to storm drains and supplemental requirements related to both health and safety.

7.2 COORDINATION WITH OTHER DRAINAGE FEATURES

Just as storm drainage systems should be planned, along with other features, from the inception of the project, so also should the soil erosion and sediment control features. If drainage and the control features are planned simultaneously, the result should function better and usually be more economical.

One of the policies of Howard County is to preserve the natural beauty of its streams. Good storm drainage design, stormwater management and erosion and sediment control all contribute to this goal. In some cases, however, "the cure may be worse than the disease". Ill-conceived sediment basin locations located in wooded areas can destroy the natural beauty of a stream valley. Wherever possible, sediment basins should not be located in wooded areas. If there is no reasonable alternative, the area enclosed by an elevation equal to the top of the principal spillway shall be cleared of all trees, brush and fallen timber before the basin is placed into operation.

Filtration BMP's such as bioretention, surface sand filters, underground sand filters, perimeter sand filters, organic filters and pocket sand filters and non-structural BMP's such as dry wells, dry swales, wet swales, level spreaders and Rev storage devices, shall not serve as a sediment control device during construction. The erosion and sediment control plans shall clearly indicate how sediment will be prevented from entering the filtration area.

7.3 STANDARD DETAILS

Howard County does not have any standard details for erosion and sedimentation control. All erosion and sedimentation control plans are required to be approved by the Howard Soil Conservation District. It is therefore recommended that HSCD be contacted for the latest details. The publication, Maryland Standards for Soil Erosion and Sediment Control, can be obtained from the HSCD or the Maryland Department of the Environment (MDE) and is a useful reference when developing erosion and sediment control plans. Since the County will inspect erosion and sediment control facilities and practices, the County requires that a copy of the standard details and erosion/sedimentation control plans be available on all grading and storm drain construction sites. The details must be indicated on the construction plans and in some cases; sizes or dimensions must be shown.

7.4 EROSION CONSIDERATIONS

7.4.1 Channel Velocities

Allowable velocities have been established by the MDE for various natural soil and vegetatively lined channels. These velocities are repeated in Table 7.1 and 7.2 respectively. The average channel and overbank velocities for a 10- year design frequency shall not exceed these values. For the 100-year design frequency they may be exceeded by 25% before channel protection or improvements are required.

7.4.2 Outlet Velocities

Normally where closed conduit or improved channel discharges into a natural or vegetal lined channel the outlet velocity may exceed the allowable velocity of the receiving channel. In such cases, some sort of energy dissipater will be required to reduce the velocity. Similarly, development in portions of a watershed and the subsequent increase in storm flow rates may cause excessive flow velocity in downstream reaches of the natural channel. Energy dissipaters might be required to eliminate erosion and should be used where appropriate.

Where the receiving channel width is not well defined, or is a natural channel, a method presented by MDE is recommended. The curves are based on maximum and minimum tailwater conditions, and are given in Figures 7.1 and 7.2 respectively.

A. The MDE method has a 0% channel slope.

B. The MDE method stone diameter is the median stone size, d_{50}, which is about 2/3 the maximum size.

EXAMPLE 7.4.2-1

RIPRAP SIZE AND LENGTH DETERMINATION

GIVEN:

A 36-inch diameter pipe discharges 75 cfs into a riprap channel.

REQUIRED:

Determine the maximum riprap size and length for both maximum and minimum tailwater conditions. Also determine the width of the riprap for the condition of no well- defined channel.

SOLUTION:

Enter Figures 7.1 and 7.2 with the pipe size and discharge values and read the d_{50} and L_a values.

Maximum Tailwater	Minimum Tailwater
From Figure 7.1	From Figure 7.2
$d_{50} = 0.4$ ft.	$d_{50} = 0.8$ ft.
$L_a = 35$ ft.	$L_a = 26$ ft.

The maximum riprap size is $1.5 \times d_{50}$

$d_{max.} = (1.5)(0.4)$
$= 0.6$ ft.

$d_{max.} = (1.55)(0.8)$
$= 1.2$ ft.

From Figures 7.1 and 7.2 the widths for no well-defined downstream channel are:

$W = D + 0.4L_a$
$= 3 + (0.4)(35)$
$= 17$ ft.

$W = D + L_a$
$= 3 + 26$
$= 29$ ft.

7.5 SUPPLEMENTAL REQUIREMENTS

These requirements are concerned with health and safety aspects of sediment basins. The structural design of any dam for a sediment basin shall conform to the criteria and requirements of the Howard Soil Conservation District of the Maryland Department of the Environment, as appropriate.

The sediment deposits and any long-term ponding of water in the basin may create a health or safety hazard. To minimize these potential hazards the following are required:

1. All sediment basins shall have suitable warning signs posted around their perimeter at intervals no greater than 100 feet. Signs shall not be nailed to trees.

2. All sediment traps and basins in residential areas or in residential developments expected to have occupancy before their removal shall be fenced if the maximum depth for the sediment volume exceeds 18 inches. Fencing shall be equivalent to snow fencing in height, ability to be seen and ability to restrict inadvertent passage.

3. All sediment basins serving drainage areas greater than 10 acres or having a depth to the sediment cleanout level greater than 3 feet shall be equipped with a subsurface drain system to dewater the sediment.

   If permanent stormwater management ponds are utilized for temporary sediment control, then all such permanent ponds must be designed to function as sediment basins while the contributing drainage areas remain disturbed. In some cases the HSCD may waive this requirement as circumstances warrant.

REFERENCES

1. [[1994]] Maryland Standards and Specifications for Soil Erosion and Sediment Control, the Maryland [[department]]**DEPARTMENT** of the Environment, Water Management Administration, **LATEST EDITION.**

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TABLES

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Table 7.1

ALLOWABLE VELOCITIES FOR NATURAL CHANNELS2
(Not Completely Line with Vegetation)

Lining	Allowable Velocity, fps
Sand and Sandy Loam	2.5
Silt Loam	3.0
Sandy Clay Loam	3.5
Clay Loam	4.0
Clay, Fine Gravel and Graded Loam to Gravel	5.0
Graded Silt to Cobbles	5.5
Shale, Hardpan and Course Gravels	6.0

Table 7.2

ALLOWABLE VELOCITIES FOR GRASSED CHANNELS

No.	Lining	Range of Channel Gradient (Percent)	Allowable Velocity (fps)
A.	Vegetative 1/		
	1) Tufcote, Midland and Coastal, Bermudagrass 2/	0 to 5.0	6
		5.1 to 10.0	5
		Over 10.0	4
	2) Reed Canarygrass Kentucky 31 Tall Fescue Kentucky Bluegrass	0 to 5.0	5
		5.1 to 10.0	4
		Over 10.0	3
	3) Red Fescue Redtop	0 to 5.0	2.5
	4) Annual 3/ Small Grain (Rye, Oats, Barley Millet) Ryegrass	0 to 5.0	2.5
B.	Vegetative with Stone Center for base flow		As determined for vegetative portion from A above.

1/ To be used only below stabilized or protected areas

2/ Common Bermudagrass is a restricted noxious weed in Maryland

3/ Annual – Use only as temporary protection until permanent vegetation is established.

FIGURES

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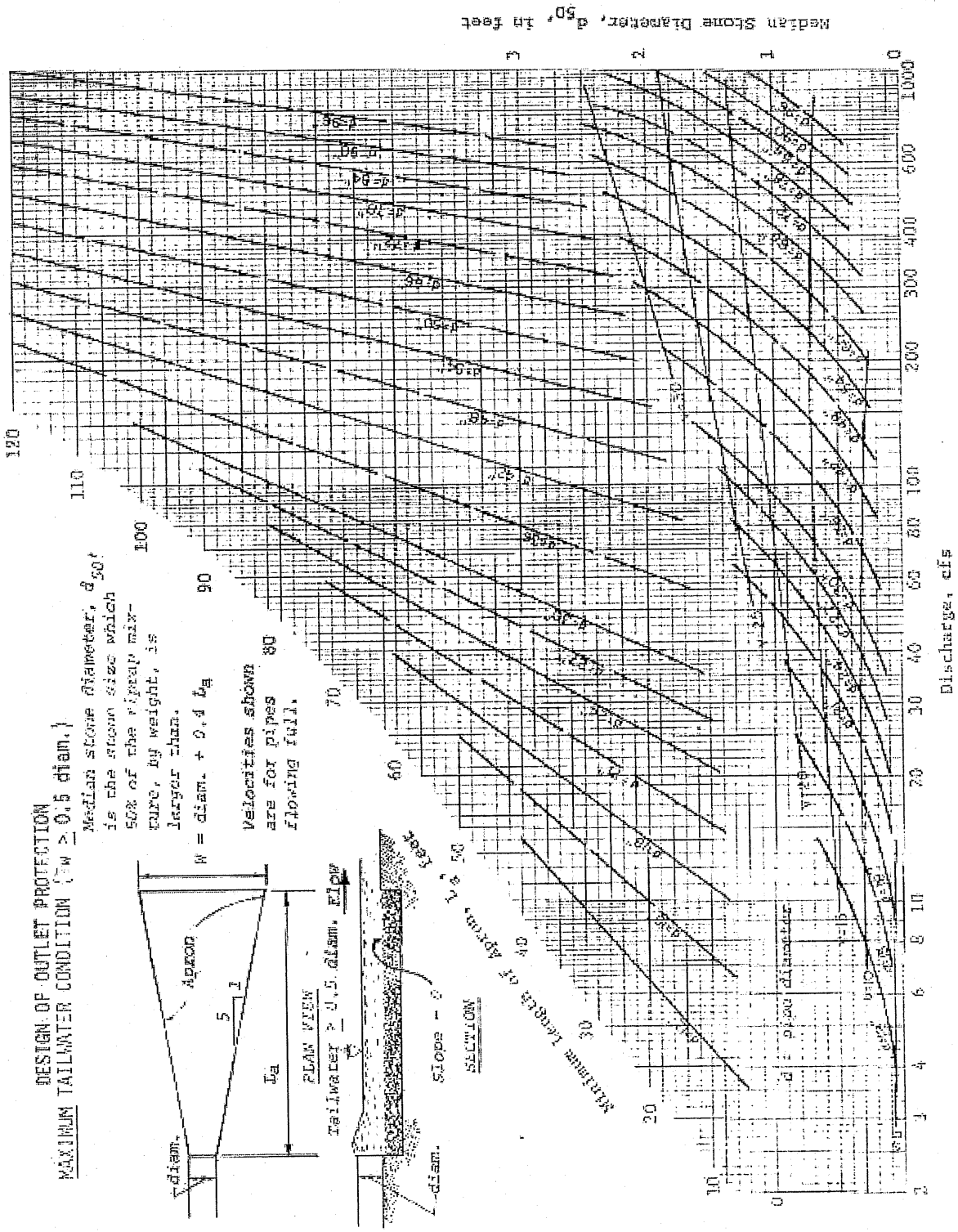
Figure 7.1

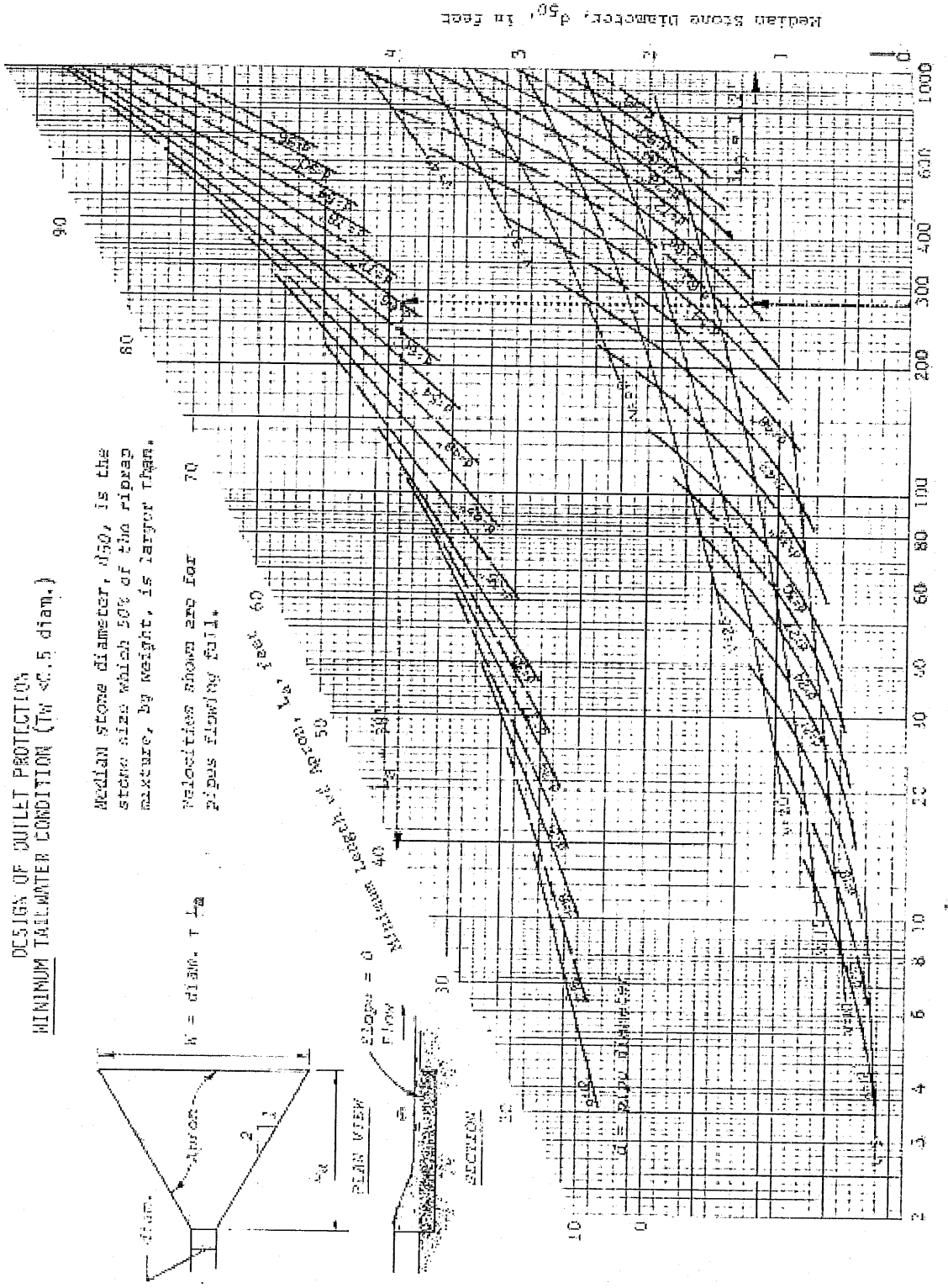
PIPE OUTLET PROTECTION – MAXIMUM TAILWATER



Design Guide MD#8 Riprap Design Methods
NRCS Engineering, Maryland
Draft April, 2003

Figure 7.2

PIPE OUTLET PROTECTION – MINIMUM TAILWATER



Amendment 1 to Council Resolution No. 94-2017

BY: Chairperson at the request of the County Executive

Legislative Day No. 10
Date: July 3, 2017

Amendment No. 1

(1. Council Bill No. 79-2016 required that the rainfall amount for the 100-year storm be 8.51 inches. Because the rainfall amount for the 100-year storm is changing from 7.2 inches to 8.51 inches, other rainfall amounts need to be amended accordingly.

2. This amendment also amends the whereas clauses to add that, not only is the rainfall amount for the 100-year storm changing, but that other rainfall totals are being amended accordingly.)

On page 1, in line 12, after "79" insert, "regarding the 100-year storm event and rainfall amounts for other storm events need to be amended accordingly as required by Section 18.913(c) of the County Code".

In the Design Manual, attached to the Resolution as Exhibit A, on page 3-4, under item B, in the chart titled "Rainfall for 24-hour Storm Duration":

a. Strike "2.6" and substitute "2.64";
b. Strike "3.2" and substitute "3.19";
c. Strike "4.2" and substitute "4.10";
d. Strike "5.1" and substitute "4.91";
e. Strike "5.6" and substitute "6.14";
f. Strike "6.3" and substitute "7.23".

ADOPTED 7/3/17
FAILED
SIGNATURE Jessica Feldmark

County Council of Howard County, Maryland

2017 Legislative Session

Legislative Day No. 9

Resolution No. 94 -2017

Introduced by: The Chairperson at the request of the County Executive

A RESOLUTION revising Volume I (Storm Drainage) of the Design Manual to mandate a specified amount of rainfall for 100-year storms; to clarify provisions related to open channels; to amend provisions related to stormwater management facilities in Howard County; to make technical changes; and generally related to Volume I, Storm Drainage, of the Design Manual.

Introduced and read first time _____, 2017.

By order _____
Jessica Feldmark, Administrator

Read for a second time at a public hearing on _____, 2017.

By order _____
Jessica Feldmark, Administrator

This Resolution was read the third time and was Adopted___, Adopted with amendments___, Failed___, Withdrawn___, by the County Council on _____, 2017.

Certified By _____
Jessica Feldmark, Administrator

NOTE: [[text in brackets]] indicates deletions from existing law; TEXT IN SMALL CAPITALS indicates additions to existing law; Strike-out indicates material deleted by amendment; Underlining indicates material added by amendment.

WHEREAS, by passage of Council Resolution No. 38-2010, the County Council approved a revision to Chapter 5 of Volume I (Storm Drainage) of the Design Manual submitted by the County Executive; and

WHEREAS, on December 5, 2016, the Council passed Council Bill No. 79-2016 (CB 79) which became effective on December 9, 2016; and

WHEREAS, CB 79 requires that for all purposes of calculating a 100 year storm event, 8.51 inches of rainfall be used; and

WHEREAS, in accordance with CB 79, Volume I has been updated at Section 3.2.3 to include the changes reflected in CB 79; and

WHEREAS, there are additional changes proposed to Volume I of the Design manual including the following:

1. Section 4.2, Open Channel, is amended to require that the profile and velocity of an improved channel be examined and addressed within the limits of the noted distances and not just at the specifically noted distances;
2. Section 5.2, Stormwater Management Criteria, is amended to no longer allow certain storage volume and Runoff Curve Number (RCN) reductions for in-fill developments; and
3. Minor technical changes, mostly to refer to the most recent versions of publications; and

WHEREAS, changes are shown on pages 3-4, 4-10, 4-19, 5-2, 5-3, 6-7, 6-8, 6-15, 7-1, and 7-5 of the attached Design Manual; and

NOW, THEREFORE, BE IT RESOLVED by the County Council of Howard County, Maryland this _____ day of _____, 2017 that it approves the revised Volume I (Storm Drainage) of the Design Manual.

AND BE IT FURTHER RESOLVED, by the County Council of Howard County, Maryland that the Director of the Department of Public Works is authorized to publish Volume I (Storm Drainage), to correct obvious errors in section references, section numbers and references to existing law, capitalization, spelling, grammar, headings and similar matters, and to make any modifications necessary to the Table of Contents.

Inlet time includes overland flow time and travel time through swales, ditches and gutters. The minimum inlet time shall be 5 minutes for commercial developments and 10 minutes for residential developments.

Overland flow time can be computed using Figure 3.03 or the method found in the USDA-NRCS TR-55. The maximum flow length shall be limited to 100 feet.

The design professional should use the forms available in the TR-55 Manual or may use the Howard County standard from Figure 3.05, "Runoff Curve Number and Time of Concentration".

E. Special Considerations

If the rational method is used for design, the following peculiarity should not be overlooked:

Apparent Reduction in Peak Discharge: In many watersheds, particularly where the mainstream channel is in a natural condition and there are not significant tributaries, the intensity values associated with the time of concentration based on travel time in the mainstream will decrease faster than the total area of the watershed increases. This results in a decrease in the product of i times A and hence the peak runoff as the design proceeds downstream. For such a condition, the runoff shall not be decreased, but the greatest upstream value of peak runoff shall be used until a point is reached for which the peak runoff again increases.

3.2.3 USDA-NRCS TR-20 and TR-55 Hydrograph Methods

The USDA-NRCS method is described in the Urban Hydrology for Small Watersheds, Technical Release No. 55. A similar computerized version of this method is the USDA-NRCS TR-20.

This method uses three variables to estimate runoff: rainfall, antecedent moisture conditions and hydrologic soil-cover complex.

The design professional should consult the TR-20 user's manual for an explanation of methodologies and equation parameters.

A. The following criteria shall be observed when using the TR-55 or TR-20 models:

1. Runoff curve number, RCN, computations shall be provided along with a soil survey map and a zoning map of the area to be developed.

2. In computing the existing conditions runoff curve numbers, the existing ground cover shall be assumed to be Meadow in Good Condition, Woods or Impervious Area. In computing the proposed conditions runoff curve numbers, Zoning shall be used for the developed areas, Paving shall be assumed for all rights-of-way, use-in-common driveways (over 200') within the access easement, gravel roads and dirt roads and grass and woods in good condition shall be used if areas are to be left in their natural state.

The design professional should use the forms available in the TR-55 Manual or may use the Howard County standard form Figure 3.05, "Runoff Curve Number and Time of Concentration"

3. Sheet flow length of 100' or less shall be used.

4. When computing the travel time for sheet flow, use the 24-hour rainfall for the 2-year design storm.

5. Schematic diagrams shall be provided for all TR-20 routings. Also, indicate on the TR-20 input and output the hydrographs and routings for all design storms under consideration.

6. The antecedent moisture condition II shall be used.

7. In the TR-20 computer analysis provide the "FULL PRINT" and "SUMMARY" options.

8. Provide verification for all rating curves used in the TR-20 reach routing analysis.

9. Provide the hydrograph at the point of discharge from the site and/or stormwater management facilities for the site.

B. Current rainfall depths for Howard County shall be used for all TR-55 and TR-20 analysis and are listed as follows:

Rainfall for 24- hour Storm Duration

1 yr.	=	2.6 inches
2 yr.	=	3.2 inches
5 yr.	=	4.2 inches
10 yr.	=	5.1 inches
25 yr.	=	5.6 inches
50 yr.	=	6.3 inches
100 yr.	=	**8.51**[[7.2]] inches

The type II synthetic storm distribution must be used. When using the TR-20 computer program the County recommends the use of the recently developed 0.1 hour rainfall table (Table 3.03). The standard 0.25 hour table available with the latest version of the TR-20 program is acceptable.

C. Additional requirements:

1. The Department of Public Works or the Department of Planning & Zoning/Development Engineering Division has the option of requesting a run of the TR-20 edit program.

Amendment 1 to Council Resolution No. 94-2017

BY: Chairperson at the request of the County Executive

Legislative Day No. 10
Date: July 3, 2017

Amendment No. 1

(1. Council Bill No. 79-2016 required that the rainfall amount for the 100-year storm be 8.51 inches. Because the rainfall amount for the 100-year storm is changing from 7.2 inches to 8.51 inches, other rainfall amounts need to be amended accordingly.

2. This amendment also amends the whereas clauses to add that, not only is the rainfall amount for the 100-year storm changing, but that other rainfall totals are being amended accordingly.)

On page 1, in line 12, after "79" insert, "regarding the 100-year storm event and rainfall amounts for other storm events need to be amended accordingly as required by Section 18.913(c) of the County Code".

In the Design Manual, attached to the Resolution as Exhibit A, on page 3-4, under item B, in the chart titled "Rainfall for 24-hour Storm Duration":

a. Strike "2.6" and substitute "2.64";
b. Strike "3.2" and substitute "3.19";
c. Strike "4.2" and substitute "4.10";
d. Strike "5.1" and substitute "4.91";
e. Strike "5.6" and substitute "6.14";
f. Strike "6.3" and substitute "7.23".

Howard County

Internal Memorandum

Subject: Council Testimony and Fiscal Impact Statement for Council Resolution No. 94-2017

To: Lonnie Robbins
Chief Administrative Officer

Through: James M. Irvin
Department of Public Works

From: Mark Richmond
Stormwater Management Division, Department of Public Works

Date: May 30, 2017

The Administration is seeking Council approval of an amendment to Volume 1 (Storm Drainage) of the Howard County Design Manual.

On December 9, 2016, the County Council passed Council Bill 79-2016 which changed the 24-hour rainfall to be 8.51 inches for stormwater management computations versus 7.2 inches, which was requirement prior to the effective date of CB 79. The attached Design Manual update incorporates this change in 24-hour rainfall amounts.

CB 79-2016 also reiterates that 100-year stormwater quantity control is required in the Tiber Branch Watershed and provides a map that defines the watershed limits. The attached update to the Design Manual is proposed to reflect this requirement of CB 79-2016.

The Design Manual update also makes two clarifications as follows. The first clarification is in Section 4.2 OPEN CHANNEL, which will now require that the profile and velocity of an improved channel be examined and addressed within the limits of the noted distances and not just at the specifically noted distances. The second clarification is in Section 5.2 STORMWATER MANAGEMENT CRITERIA, which will no longer allow storage volume and RCN reductions per Alternative Surfaces and Nonstructural Practices for in-fill developments.

The Design Manual update also proposes to correct several typographic errors, noting "latest edition" for several reference documents where the Design Manual currently refers to an older version.

There is no fiscal impact to the update to Volume I (Storm Drainage) of the Design Manual.

cc: Jennifer Sager