TOWN OF MOORESVILLE

STORMWATER DESIGN MANUAL

March 2004

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1.0 Introduction

The Office of the Mooresville Department of Public Works (PWO) as required by the Town of Mooresville Stormwater Management Ordinance is providing the Stormwater Design Manual to provide guidelines for the engineering and design of stormwater systems and erosion control practices in the Town of Mooresville. This manual applies to all areas under the jurisdiction of the Town of Mooresville.

The fee schedule shall be as established by Ordinance 7-3-6. A copy of the Ordinance as of October 2003 is included in Appendix I.

A fee of $25.00 shall be charged to cover the costs of labor, materials, and equipment used in photocopying this Ordinance and the Town of Mooresville Stormwater Design Manual.

2.0 Required Submittals

All development projects submitted to the PWO shall include the following:

2.1 Plans

A complete set of plans on 24 by 36 inch sheets, signed and stamped by a registered professional. The plan sheets shall be provided with a 5'-, 10'-20'-30'-, 40'- or 50'- to 1" scale only and include at a minimum:

2.1.1 A title sheet with the project name and address, a county location map and a vicinity map clearly indicating the project location, the name, address and phone number of the developer/ owner and design engineering firm, and phone number of the PWO;

2.1.2 A plan sheet with the existing topography at no greater than a 2 foot contour interval, 1 foot being preferred; and providing a USGS/NAVD 29 reference datum benchmark. Single family structures may be exempted from this requirement by the PWO;

2.1.3 A plan sheet or sheets with the proposed development layout and grading. The topography should be at no greater than a 2-foot contour interval, 1 foot being preferred. All grade breaks should be defined and labeled with spot elevations. The grading plan shall also include the 100-year base flood elevation (BFE) as required in Section 4.5 with notation as to the source of the BFE (e.g. The Flood Insurance Rate Study, Plate 2c, 2001). All appropriate floodplains shall also be delineated and the source noted (e.g. FIRM Map 123456, dated May 3, 2001);

2.1.4 A plan and profile of the proposed storm sewer system for all projects. Easement lines and right-of-way limits shall be included and clearly labeled on the plan view;

2.1.5 A separate erosion and sediment control plan showing the location of all erosion control practices and including details of the installation methods shall be provided;

2.1.6 A detail sheet with installation and dimensional details for all proposed storm conveyances. Please refer to the appendix for standard details of conveyances accepted by the PWO;

2.1.7 A certified survey showing residential density, roadway and drainage easements and right-of-way.

2.2 Report

A drainage report. This drainage report shall include:

2.2.1 A drainage narrative. This narrative shall include a description of: the existing and proposed runoff patterns; the downstream receiving facilities; summary of all calculations; all assumptions used in the calculations;

2.2.2 Basin maps. Basin maps shall be submitted for the pre- and post-developed project and correspond to the calculations/computer models. These basin maps shall include all off-site basins, detention design basins, and pipe inlet / catch basin areas. Basin areas should be clearly labeled on the maps with respect to the basin labels used in the computer modeling;

2.2.3 Computer model input and output reports. The computer reports shall include all input parameters (time-of-concentration, basin areas, curve numbers, rainfall depths, rainfall distributions, etc.) and copies of the corresponding calculations. A node diagram shall be provided that summarizes the computer model routing. Summary reports showing all the inputs. Detailed hydrographs are optional and may be requested as required by the PWO;

2.2.4 A title sheet. The drainage report shall be signed, dated and stamped by a registered professional.

2.2.5 A written narrative is required with the submittal stating that the drainage plans are in compliance with the provisions of the

Town of Mooresville Stormwater Management Ordinance and this Stormwater Design Manual.

3.0 Hydrology – Runoff Estimation

The most critical parameter in stormwater engineering is estimating the amount and rate runoff will occur for rainfall events. This estimation first provides the basis for determining if detention is required and then the quantity of storage necessary. Two methods shall be considered acceptable by the PWO; the rational method, for development areas with a total watershed less than or equal to 10,000 sq. ft., and hydrograph generating / routing techniques for developments with a total watershed greater than 10,000 sq.ft. The same methodology must be used to determine the pre- and post-developed runoff rates.

3.1 Rational Method

The rational method is based on the equation,

Q = C i A

Where Q = is the peak runoff rate, cubic feet per second (cfs)

C = the runoff coefficient (Table 3.1.1)

i = the rainfall intensity (in/hr)

A = area of the drainage basin in acres.

The rainfall intensity is chosen corresponding to the time-of-concentration. The time-of-concentration shall be calculated as described in 3.2 below.

The following steps summarize the procedure:

- Determine the watershed area;
- Estimate from Table 3.1.1 the runoff coefficient C or the composite area runoff coefficient;
- Calculate the time-of-concentration (per Section 3.2);
- Determine the rainfall intensity (per Section 3.4.1).

3.2 Time-of-Concentration (Tc)

The time-of-concentration shall be determined using the Time of Concentration or Travel Time Worksheet in Technical Release 55 (TR-55). This method addresses the time-of-concentration in three parts, sheet flow, shallow concentrated flow and channel flow. A copy of the worksheet (Worksheet 3.2.1), a table of Manning's roughness coefficients for sheet flow (Table 3.2.2), and the graph for determining the average velocity for shallow concentrated flow (Figure 3.2.3) are provided in Appendix III. A minimum time-of-concentration of 5 minutes shall be used for all calculations. In addition, only a 5 minute time-of-concentration may be assumed for calculations. All other times-of-concentration must be supported with calculations.

3.3 Curve Number

The curve number shall be calculated using the TR-55 methodology. The composite curve number shall be calculated and documented using Worksheet 3.3.1 and Tables 3.3.2, 3.3.3 and 3.3.4 (from TR-55) as appropriate for the project site. The Worksheet and Tables are provided in Appendix III.

3.4 Rainfall

3.4.1 Intensities – Rational Method

The rainfall intensities for use in the rational method can be determined using the following equation:

$\mathbf{i = a / (t + b)^N}$ where:

i = intensity, in / hr

t = time (min)

a, b, and N are values from Table 3.4.1.1

These variables were determined from the Indianapolis Intensity-Duration-Frequency (IDF) curves. Table 3.4.1.2 provides intensities for specific durations and return periods.

3.4.2 Rainfall Depths – Hydrograph Methods

Rainfall depths for various storm durations and return periods are given in Table 3.4.2.1.

3.4.3 Rainfall Distribution – Hydrograph Methods

All hydrographs shall be generated using the appropriate Huff, 50% rainfall distribution. The Huff Distributions were derived from historical rainfall data in the Midwest. The first quartile is applicable to storm durations up to 6 hours, the second quartile applicable for storm duration of 6 up to 12 hours, third quartile for durations between 12 and 24 hours and the fourth quartile for storm durations of 24 hrs and greater.

A table of the Huff quartile ordinates is given in Appendix III (Table 3.4.3.1).

3.5 Downstream Analysis

Downstream analysis may be used, upon approval of the PWO, to demonstrate that a proposed development's runoff will not increase the peak runoff in the receiving watercourse if no detention is provided. The proposed development area must be 1% or less of the watershed area at the discharge location.

Downstream analysis shall be performed by creating an existing conditions hydrograph for the watershed without the development area and an existing hydrograph for the proposed development. These two hydrographs are to be added together to determine the peak existing conditions flow. A third hydrograph of the proposed development conditions shall then be generated and added to the existing upstream watershed hydrograph to determine the developed peak flow. If there is no increase, then detention may be waived.

Downstream analysis may be performed for open channel areas only. Areas with significant pipe systems upstream or downstream of the subject site may not use downstream analysis. In addition the PWO reserves the right to require detention in lieu of downstream analysis as appropriate.

Downstream analysis submissions shall include basin maps, curve number documentation, Tc documentation, and all hydrograph inputs and outputs, etc.

4.0 Hydraulics

4.1 Detention Design

All detention ponds shall meet the minimum requirements of detaining the post-developed 100-year storm and releasing the runoff at the pre-developed 10-year peak storm release rate. Likewise, the post-developed 10-year peak storm shall be detained and released at the pre-developed 2-year peak storm release rate.

4.1.1 Rational Method

The rational method may be used for detention design on developments less than or equal to 10,000 sq. ft. contributing area. The allowable release rate shall be calculated using a runoff coefficient of 0.10.

4.1.2 Hydrograph Methods

Detention ponds collecting watersheds greater than 10,000 sq.ft. and facilities not designed using the rational method shall be designed by hydrograph routing techniques. The 0.5-, 1-, 2-, 3-, 6-, 12-, and 24-hour duration storms shall be routed to determine the peak release rates, maximum pond elevation and required peak volumes. The peak elevation shall be shown on the grading plan.

4.1.3 In-Line Detention

In-line detention should be avoided to the extent practicable. However, when in-line detention is proposed, the pond shall be designed using the characteristics of the site only as required in Section 4.1.2. A weir or other discharge structure shall be installed at the peak elevation as determined in Section 4.1.2 to accommodate the off-site or flow-through runoff.

4.2 Pipe Design

The minimum pipe diameter shall be 12 inches and the minimum full flow velocity shall be 2.0 fps for all pipes. Orifice plates shall be used when smaller openings are required to restrict flow. All pipes must have a minimum of 1.5 feet of cover and trash racks shall be provided for pipe inlets and outlets as well to prevent entry by wildlife or children.

Pipes must be designed to accommodate the 10-yr flow with the Hydraulic Grade Line (HGL) below the crown of the pipe. An overflow route to the detention facility shall be provided for flows greater than the 10-yr storm. If an overflow route is unavailable, then the pipes should be designed to

accommodate the 100-yr HGL below the top of casting elevations or within an easement.

Pipes may be designed using the Manning's equation. When the total design flow reaches 90% of the Manning's pipe capacity, hydraulic gradeline calculations shall be submitted to document the 10-year flow is below the crown of the pipe.

4.2.1 Manning's Equation

Manning's equation should be used for the design of all stormwater pipes. Manning's equation is given as the following:

$$\mathbf{Q = (1.49 / n)(A)(R^{2/3})(S^{1/2})}$$

Where Q = is the peak runoff rate, cubic feet per second (cfs)

n = the Manning's "n" value for pipes (Table 4.2.1.1)

A = the area of the pipe (ft^2)

P_w = the wetted perimeter of the pipe

R = the hydraulic radius of the pipe (A / P_w)

A storm sewer tabulation table and headloss computation table (Tables 4.2.1.2 and 4.2.1.3) are provided in Appendix IV.

4.2.2 Tailwater

The Manning's equation addresses only the flow conditions of the pipes and assumes a free outfall. When proposed pipe outfalls are submerged or may be subject to submergence, the starting depth of water (tailwater) shall be included in the analysis and sizing of the pipes. Pipes subject to submergence shall use, as a minimum, a starting tailwater condition equivalent to the 10-year elevation of the receiving facility. All tailwater analysis methods must be approved by the PWO.

4.3 Inlet Capacity and Gutter Spread

4.3.1 Inlet Capacity

Inlets shall be designed to properly convey the 10-yr storm event. Grate castings shall provide a sufficient grate opening to collect the 10-yr storm event with a maximum depth above the casting of 9" and shall not affect the surrounding structures. Emergency overflow routing should be provided for storm events greater than the 10-yr storm.

4.3.2 Gutter Spread

Inlets within all roadway gutterlines shall be spaced to provide a minimum open lane width of 12'. Inlets within multi-lane roadways (3 or more lanes) shall keep a minimum of one (1) 12' wide lane open in each direction. The gutter spread should be determined using the 10-yr storm event. The gutter spread shall be computed using the following equation:

$$\mathbf{Q = (0.56 / n)(S_x^{1.67})(S_L^{0.5})(T^{2.67})}$$

Where Q = is the peak flow through the gutter on each side of the inlet

n = the Manning's roughness coefficient (Table 4.3.2.2)

S_x = the cross slope of the pavement from the crown to the gutter (ft/ft)

S_L = the longitudinal grade/slope of the street (ft/ft)

T = the width of water extending into the roadway from the vertical gutter face (ft)

Once the peak gutter flow is determined, the maximum drainage area can be calculated using the rational method and the basin characteristics. For a basin consisting only of the roadway itself, the maximum area can be calculated by using a fixed width of the roadway from the crown to the curb and determining the total length required to achieve the maximum flow.

4.4 Open Channel/ Ditch / Swale Design

4.4.1 Capacity

Open channels (swales and ditches) shall be designed using the Manning's equation as outlined above in Section 4.2.1 and using Table 4.4.1.1. The channels should be designed to convey the 10-yr storm event within the banks. The 100-yr storm event should remain within the easement of the ditch. The side slopes on all drainage ditches shall be no steeper than 2 (horizontal) to 1 (vertical). The minimum slope for all grass-lined swales shall be 1.0%. Slopes less than 1.0% will be accepted with appropriate invert treatment. Invert treatment may consist of concrete paved channel, or a sub-surface underdrain. In no case shall a slope less than 0.30% be accepted for swales.

4.4.2 Lining

All channels shall be lined with material capable of withstanding the shear stress from the proposed design velocity. Channels that convey runoff with velocity greater than 5 fps will be required to have invert treatment. A table of channel linings and maximum velocities is provided in Appendix IV (Table 4.4.2.1).

4.5 Flood Modeling

The base flood elevation (BFE) shall be provided for all structures on properties adjoining a waterway draining 25 acres or more. The BFE from the Flood Insurance Rate Study (FIS) should be provided for stream locations that are in the study. The DNR BFE should be provide for FEMA unstudied areas with watersheds greater than 1.0 square miles. For watersheds less than 1.0 square miles and greater than 50 acres, the submitting engineer must determine the BFE. The US Army Corps of Engineers HEC-2 or HEC-RAS programs shall be acceptable methods. Any other methods must be approved by the PWO.

5.0 Detention Design Requirements

5.1 Bypass Flow

Detention facilities bypassing off-site flow shall provide adequate capacity for the design flow. The proposed bypass shall provide erosion protection, such as riprap over the entire bank for pond overflow weirs designed to bypass off-site runoff.

5.2 Emergency Spillway

An emergency spillway and/or emergency overflow route will be required on all detention facilities. The emergency spillway shall be designed to accommodate the 100-year peak storm inflow to the structure with 1 foot of freeboard above the maximum anticipated flow through the spillway. Where off-site flow is bypassed over the same structure, the spillway shall accommodate both the peak combined on-site 100-year flow and the off-site 100-year flow and maintain the 1 foot of freeboard above the maximum anticipated flow through the spillway.

5.3 Dry Pond Requirements

Dry detention ponds shall have:

- A minimum 1% bottom slope within the pond must be maintained to the outlet, or;
- Acceptable invert treatment (paved invert, underdrains, etc.) must be installed when a minimum 1% slope is unable to be maintained;

- In no case shall the bottom slope of the dry detention be less than 0.3%;

- A bank slope of 3:1 or shallower for grass side slopes;

5.4 Wet Pond Requirements

Wet ponds shall include:

- A minimum depth of 8 feet from the normal pool elevation to the bottom of the pond;

- A maximum vegetative bank slope of 3:1 above the normal pool level and continuing 10' into the pond below the normal pool level;

- A maximum side slope below the normal pool of 2:1;

5.5 Dams and Embankment Requirements

Dams and Embankments shall:

- Demonstrate suitable foundation materials and or contain a suitable cutoff to prevent excessive seepage;

- Be designed with an appropriate core fill and an antiseep collar;

- Have a suitable top width and finished side slopes;

- Have a minimum acceptable freeboard and appropriately sized emergency spillway.

5.6 Parking Lot Detention Requirements

Parking Lot Detention Facilities:

- May not accept runoff from off-site drainage basins;

- May not pond to a depth greater than 10";

- Have an appropriate emergency overflow route;

5.7 Underground Detention Requirements

Underground Detention Facilities:

- May not accept runoff from off-site drainage basins;

- Must include emergency overflow facilities including a flow path.

Appropriate details of each pond design must be included on the plans. The appropriate normal pool elevation, 2-yr, 10-yr, and 100-yr water surface elevations must also be indicated on the grading plan.

6.0 Emergency Access Easements

Emergency access easements (easement) shall be provided for all stormwater conveyances and facilities to be maintained by Town of Mooresville. In addition, easements shall be provided for all conveyances, including ponds, carrying runoff from off-site drainage basins and for any pond serving greater than 5 acres. Regulated Drains (proposed and existing) may have additional easement requirements to ensure the provisions of this Manual and the Town of Mooresville Stormwater Management Ordinance are met. The PWO shall be contacted to determine any special requirements prior to design. All stormwater conveyances must be centered within the required easement.

Stormwater BMP's used for the water quality requirements must maintain easements as well. Stormwater ponds shall maintain the same easement as required for a detention facility. Off-line manufactured BMP's structures should maintain an easement that includes the connecting manholes and the weir structure. All easements should be clearly included on the plans. Water quality easements should be included in the O&M manual as outlined in Section 9.3. On a case-by-case basis the PWO may determine additional easement requirements. The PWO may require such additional easement requirements as are necessary to ensure the provisions of this Manual and the Town of Mooresville Stormwater Management Ordinance are met. The following table summarizes the easement widths required

Table 6.0

Stormwater Facility Description	**Minimum Easement (ft)**
Detention Pond/Facility (Serving > 5.0 ac) (including all stormwater pond BMP's)	20 horizontally from the 100-year elevation of the pond – Detention facilities shall not be constructed within the public right-of-way.
Storm Sewer Pipe and structures (< 3 feet diameter)	20 (10' from center of pipe/structure)
Storm Sewer Pipe and structures (> or = 3 feet diameter)	25 (12.5' from center of pipe/structure)
Drainage Ditch	30
Drainage Swale	20
Structural and Manufactured BMP's	20 from the outside of BMP – Manufactured BMP units must maintain 20 from the center of the unit or 10 from the outside of the unit (whichever is greater) and include the connecting manholes when in an off-line configuration

7.0 Materials

7.1 Storm Sewer Pipe Materials

Storm sewers shall be defined as a network of pipe conduits and concrete manholes and/or inlet structures, which collect and convey stormwater (surface or subsurface water) from one facility to another facility.

Subsurface drainage tiles, underdrains, roof downspouts and drains, building drains, and foundation drains are not considered as part of the requirements for storm sewers.

The following is a table that outlines pipe materials and the appropriate type of facility that each material may be used. Public facilities are classified as any stormwater facility located within the public right-of-way or drainage easement maintained by the PWO or any state, town or city departments. Private facilities include all privately owned and maintained stormwater facilities outside of the public right-of-way or drainage easement.

Table 7.1

MATERIALS	PUBLIC FACILITIES	PRIVATE FACILITIES
Reinforced Concrete Pipe (RCP) – All pipe sizes (ASTM C 76)	YES	YES
Elliptical RCP – All pipe sizes (ASTM C 507)	YES	YES
Pre-cast RCP Box Culverts Sections– All sizes (ASTM C 789)	YES	YES
Bituminous Coated Corrugated Metal Pipe (CMP) – All sizes	YES	YES
Arch CMP – All pipe sizes	YES	YES
Galvanized CMP – All pipe sizes (ASTM A 444, A 760)	YES	YES
High Density Polyethylene Pipe (HDPE) – 12" – 24"	YES	YES
High Density Polyethylene Pipe (HDPE) – 27" – 48"	PER PWO APPROVAL	YES
Polyvinyl Chloride (PVC) – 12" – 24"	YES	YES
Polyvinyl Chloride (PVC) – 27" – 36"	PER PWO APPROVAL	YES
Other	PER PWO APPROVAL	PER PWO APPROVAL

7.2 Subsurface Drainage Tiles

Subsurface tiles (all underdrains, roof downspouts and drains, building drains, and foundation drains) shall not accept any surface water flows. Any system designed to collect surface runoff shall be designed to the minimum pipe standards in Section 7.1 above. Subsurface systems shall provide a cleanout at a minimum interval of 500'. Connections to the main storm sewer system must be at an approved structure. Subsurface

drain connections to other subsurface drains may utilize approved wye and/or tee connections.

Accepted pipe materials to be used for subsurface tiles are outlined in the table below:

MATERIALS	ASTM
Corrugated Polyethylene tubing and fittings – up to10”	F 405 & F 667
Corrugated Polyvinyl Chloride (PVC) tubing and fittings – up to 10”	F 800
PVC corrugated pipe with smooth interior walls and fittings – up to 10”	F 949

The minimum cover above subsurface tiles shall be 18” and must be properly bedded with #8 stone. See standard detail in Appendix VIII for additional bedding requirements.

7.3 Manhole and Box Inlet Materials

A storm sewer manhole or concrete box inlet structure must be installed at the end of each conduit segment; at all changes in material, grade, size, and alignment of the storm sewer pipe; at all pipe connections; and at a maximum interval of 400’.

Wyes, tees, and elbows may be used for underground detention facilities as allowed by the PWO. Underground detention facilities must include appropriate risers to provide for maintenance access to the detention facility. In addition, manufactured yard inlets may be used for private stormwater facilities per the discretion of the PWO.

Outlet structures must consist of a concrete box inlet or manhole with appropriate weir or orifice cut-outs. In no case shall a vertical standpipe be used in place of a manhole or inlet.

Benchwalls shall be shaped and formed within each manhole and inlet to provide a smooth conveyance of flows through the structure. The benchwalls shall form a clearly defined channel, to a minimum height of 50% of the diameter of the pipe, and constructed at a minimum ½” per foot slope to the manhole wall. A standard benchwall detail is provided in Appendix VIII.

All manhole and box inlets must be placed on a minimum 6" stone bedding to provide a stable base. Standard details for manholes, inlets and other stormwater conveyances are provided in Appendix VIII.

8.0 Standard Details

Standard details for manholes, inlets, pipe bedding swales and other common stormwater conveyances are provided in Appendix VIII at the end of the manual.

9.0 Water Quality

Unless judged by the PWO for a project to be exempt, the following criteria shall be addressed for stormwater management at all sites:

The plan sheets shall specify stormwater best management practices (BMPs) (stormwater quality treatment systems) to be implemented, operated and maintained to meet water quality requirements. Because water quality requirements vary depending on the uses of the water bodies in the watershed, a framework methodology is provided here.

9.1 Treatment Objective

Town of Mooresville has adopted a policy that the control of stormwater runoff quality countywide will be based on the management of total suspended solids (TSS). It should also be noted that control of sediment is required for construction site runoff countywide.

For new development areas that disturbs more than ten thousand square feet of land the structural BMPs shall be designed to comply with this manual. It is presumed that a BMP complies with this standard if it is:

- sized to capture the prescribed water quality volume (WQ_v) or water quality treatment rate,
- constructed properly, and
- maintained regularly.

The following requirements shall be fulfilled:

(1) All stormwater runoff generated from land development and land use conversion activities shall not discharge untreated stormwater runoff directly into a jurisdictional wetland or local water body without adequate treatment. Where such discharges are proposed, the impact of the proposal on the wetland shall be assessed using a method acceptable to the PWO. In no case shall the impact be any

less than allowed by the Army Corp of Engineers (ACOE) or IDEM.

(2) Infiltration practices shall not be allowed where stormwater is generated from highly contaminated source areas as recognized by the EPA, IDEM or the PWO; where stormwater is carried in a conveyance system that also carries contaminated, non-stormwater discharges; where stormwater is being managed in a designated groundwater recharge area; and under certain geologic conditions (e.g., karst) that prohibit the proper pretreatment of stormwater.

(3) Land development projects shall comply with the water quality performance-based criteria in accordance with the following:

A BMP shall be located, designed, and maintained to achieve the target pollutant removal efficiencies to effectively reduce the pollutant load to the required level.

(4) Stormwater discharges to critical areas with sensitive resources (i.e., cold water fisheries, shellfish beds, swimming beaches, recharge areas, water supply reservoirs) may be subject to additional criteria, or may need to utilize or restrict certain stormwater management practices at the discretion of the PWO.

(5) Industrial sites which are listed under the Standard Industrial Code are required to prepare and implement a stormwater pollution prevention plan, and shall file a notice of intent (NOI) under the provisions of the National Pollutant Discharge Elimination System (NPDES) general permit. The stormwater pollution prevention plan requirement applies to both existing and new industrial sites.

(6) Stormwater discharges from land uses or activities with higher potential pollutant loadings may require the use of specific structural BMPs and pollution prevention practices at the discretion of the PWO.

(7) Prior to design, applicants are required to consult with the PWO to determine if they are subject to additional stormwater design requirements.

(8) Discharges will not be allowed directly into sinkholes or fractured bedrock, without treatment that results in discharge meeting Indiana ground water quality standards as referenced in 327 IAC 2-11.

(9) Any stormwater practice that is a Class V injection well must ensure that the discharge from such practices meets Indiana ground water quality standards as referenced in 327 IAC 2-11.

9.2 Plan Requirements

Pursuant to the Ordinance all Stormwater Management Plans must include the following:

(1) Location, dimensions, detailed specification, and construction details of all post construction stormwater quality treatment BMPs.

(2) A description of those measures (BMPs) that will be installed to treat stormwater discharges that will occur after construction activities completed.

(3) A sequence describing when each post construction stormwater quality treatment BMP will be installed.

(4) Stormwater quality treatment BMPs that will remove or minimize pollutants from stormwater run-off.

(5) Stormwater quality treatment BMPs that will be implemented to prevent or minimize adverse impacts to stream and riparian habitat.

(6) An Operation and Maintenance manual.

9.3 Operations and Maintenance Manual

Each BMP on a site must have an operations and maintenance (O&M) manual. The O&M manual must be submitted with the Stormwater Management Plan. The approved O&M manual must be signed by and provided to the BMP owner and the PWO. The O&M manual will include the following:

(1) BMP owner name and contact person, address, and contact information, i.e. business phone, fax, email, pager, cell phone, etc. as appropriate;

(2) Site drawings clearly indicating the location of the BMP and including plan and cross-sectional details, showing the BMP and applicable features. Dimensions, easements (as previously defined in this manual), outlet works, forebays, signage, connecting

structures, weirs, invert elevations, etc. should be clearly indicated on the plans and details;

(3) Guidance on both owner-required periodic inspections and inspections to be performed by the PWO;

(4) Guidance on routine maintenance, including mowing, litter removal, woody growth removal, etc.;

(5) Guidance on remedial maintenance, such as inlet replacement, outlet work, etc.;

(6) Guidance on sediment removal, both narrative and graphical, describing when sediment removal shall occur in order to insure that the BMP remains effective as a water quality and/or quantity control device;

(7) A statement that the PWO has the right to enter the property to inspect the BMP;

(8) A tabular schedule showing inspections and maintenance requirements; and

(9) Identification of the property/BMP owner as the party responsible for maintenance, including cost.

(10) A text or graphic narrative of the easement around the BMP.

Completed inspection forms must be maintained by the BMP owner and produced upon request by the PWO. The PWO must be notified of any changes in BMP ownership, major repairs or BMP failure in writing within 30 days of the change. The letter should be addressed to:

Stormwater BMP Modifications
Mooresville Department of Public Works
4 Harrison Street
Mooresville, IN 46158

In the event that the PWO finds a BMP in need of maintenance or repair, the PWO will notify the BMP owner of the necessary maintenance or repairs and give the landowner a timeframe for completing the maintenance or repairs. If the maintenance or repairs are not completed within the designated timeframe, the PWO shall perform the repairs or maintenance and bill the landowner for the actual costs for the work.

9.4 Water Quality Volume / Rate Calculations

In order to protect and maintain water quality, a portion of the stormwater runoff created by the development project must be treated. BMPs may be designed to treat on a volumetric basis or flow rate basis. The runoff volume to be treated or the peak flow rate to be treated by a BMP shall be determined by the following methods.

9.4.1 Water Quality Volume

The volume of stormwater runoff to be captured, stored and treated is called the Water Quality Volume ("WQv").

a. The formula for determining WQv is:

$$\mathbf{WQv = \frac{(P)\,(Rv)\,(A)}{12}}$$

where:

WQv = water quality volume (acre-feet)
P = rainfall depth (inches); the volume of rainfall for 90% of the storm events which produce runoff in the watershed annually (e.g., 1.0 inches)
A = project area (acres)
Rv = volumetric runoff coefficient; [0.05 + 0.009(I)], where I is the percent impervious cover on the site as defined by the area that does not have permanent vegetative or permeable cover.

9.4.2 Water Quality Treatment Rates

The peak water quality treatment rate shall be determined using hydrograph generation methods. The hydrograph shall use the Huff 1st Quartile, 50% distribution with a 0.5 inch rainfall and a one hour storm duration. The peak rate of this hydrograph shall be used as the minimum water quality treatment rate.

Documentation for all proposed manufactured BMPs shall be provided clearly demonstrating the BMP will remove 80% of the particles listed below at this peak flow rate.

Runoff Particle Distribution

Particle Size (μm)	% of TSS
250	20
125	40
75	40

9.5 Pretreatment

Several practices that are not capable of providing water quality treatment can nonetheless function in a pretreatment role or as a supplemental practice. These practices can often be incorporated into the Stormwater Management Plan design as pretreatment devices, to treat a small portion of a site, or in retrofit or redevelopment applications. Some of these practices, including dry ponds and underground storage vaults, can be used to meet water quantity goals such as channel protection and flood control requirements. In addition, some of these practices may be helpful to reduce the total volume of runoff from a site or to disconnect impervious surfaces. Some practices not currently deemed effective for stand-alone water quality treatment include:

- Catch basin inserts
- Dry ponds
- Underground vaults (designed for flood control)
- Oil/grit separators
- Filter strips
- Grass channels (includes ditches designed primarily for conveyance as well as modified practices that can achieve some pollutant removal)
- Deep sump catch basins
- On-line storage in the storm drain network
- Porous pavement

9.6 Primary Treatment

Effective storm water management is often achieved from a management systems approach. A combination of BMPs can be used to meet the water quality treatment requirements.

9.7 Specific Practices

The principles and practices provided by the State in Rule 13 (327 IAC 15-13) and in Rule 5 (327 IAC 15-5) are to be followed in the development of all water quality treatment options. Rule 13 (327 IAC 15-13) and Rule 5 (327 IAC 15-5) do not give specific requirements for use of various practices leaving that to the localities. The designer and operator shall rely on the EPA's Stormwater Phase II Menu of Best Management Practices (BMPs) as well as the Indiana BMP manual (as it is developed and updated), currently under development by the State of Indiana, for detailed design, construction and maintenance criteria for water quality treatment. Stormwater quality treatment systems will be approved on a case-by-case basis by the PWO. As the PWO develops a more specific and comprehensive menu of stormwater treatment BMPs that information will be included in updated versions of this Manual

9.8 Regional Stormwater Management Plans

Applicants are directed to communicate with PWO prior to submitting an application for stormwater management plan approval to determine if a Regional Stormwater Management Plan has been developed for the applicable watershed. If such a plan is in existence, the applicant must provide stormwater management water quality treatment on-site in accordance with the provisions of the regional plan, and other management provisions as specified by the PWO.

10.0 Soil Erosion and Sedimentation Control

The purpose of this section is to control soil erosion, sediment damages, and related environmental damage by requiring adequate provisions for surface water retention and drainage and for the protection of exposed soil surfaces in order to promote the safety, public health, convenience, and general welfare of the citizens of Town of Mooresville.

The volume and rate of any stormwater discharges allowed under this Manual must be managed to prevent the physical degradation of receiving waters, such as by streambank scour and erosion. The following requirements are necessary for soil erosion and sedimentation control:

(1) All persons who cause, in whole or in part, any earth change to occur shall provide soil erosion and sedimentation control so as to adequately prevent soils from being eroded and discharged or deposited onto adjacent properties or into a stormwater drainage system, a public street or right of way, wetland, creek, stream, water body, or floodplain.

(2) All development shall be in accordance with all applicable federal, state and local ordinances, rules and regulations.

(3) During any earth change, which exposes soil to an increased risk of erosion or sediment track-out, the property owner and other persons causing or participating in the earth change shall do the following:

(a) Comply with the stormwater management standards of this Manual.

(b) Obtain and comply with the terms of a soil erosion and sedimentation control permit if required by law.

(c) Prevent damage to any public utilities or services within the limits of grading and within any routes of travel or areas of work of construction equipment.

(d) Prevent damage to or impairment of any water body on or near the location of the earth change or affected thereby.

(e) Prevent damage to adjacent or nearby land.

(f) Apply for all required approvals or permits prior to the commencement of work.

(g) Proceed with the proposed work only in accordance with the approved plans and in compliance with this manual.

(h) Maintain all required soil erosion and sedimentation control measures, including but not limited to, measures required for compliance with the terms of this manual.

(i) Promptly remove all soil, sediment, debris, or other materials applied, dumped, tracked, or otherwise deposited on any lands, public streets, sidewalks, or other public ways or facilities, including catch basins, storm sewers, ditches, drainage swales, or water bodies. Removal of all such soil, sediment, debris or other materials within twenty-four (24) hours shall be considered prima facie compliance with this requirement, unless such materials present an immediate hazard to public health and safety.

(j) Refrain from grading lands at locations near or adjoining lands, public streets, sidewalks, alleys, or other public or private property without providing adequate support or other measures so as to protect such other lands, streets, sidewalks or other property from settling, cracking or sustaining other damage.

(k) Request and obtain inspection of soil erosion and sedimentation control facilities, by the PWO or their designee. Qualified personnel provided by the owner or operator shall inspect construction sites for which the PWO or their designee will not perform inspections. The qualified person shall inspect all disturbed areas which are not finally stabilized, storage areas of possible polluting agents such as paints, solvents, fuels, fertilizers and pesticides that are exposed to precipitation, structural control measures and locations of vehicle entrance and exit at least once every seven (7) calendar days and, for sites which disturb greater than 10,000 sq. ft., within 24 hours of the end of a storm that is 0.5 inches or greater. Inspections will continue until all disturbed areas are stabilized, structural controls are removed or converted to stormwater management facilities, and stored materials are removed from exposure. Corrective action will be taken for all noted deficiencies. Such actions will be initiated within 24 hours of inspection notification.

(l) Follow the minimum design standards of this manual to protect properties and receiving waterways downstream of any land development project from erosion and damage due to increases in volume, velocity and frequency of peak flow rate of stormwater runoff.

(4) Land alterations, including regrading, which strip the land of vegetations, shall be accomplished in a manner, which minimizes erosion or the addition of sediments to natural and manmade drainageways. This will reduce the impact on adjacent properties and water quality of receiving waters. Whenever feasible, natural vegetation shall be retained, protected and supplemented.

(5) Cut and fill operations shall be kept to a minimum to ensure conformity with existing topography to reduce the potential erosion. Applicants shall follow the procedures and comply with the requirements of Rule 5 (327 IAC 15-5), regarding sediment and erosion control during construction.

(6) Sediment controls shall be installed whenever runoff from disturbed portions of the parcel will leave the parcel. Sediment controls may include vegetative buffer strips, filter barriers, sediment basins, debris basins or silt traps. Vegetative buffer strips shall only be used where runoff is dispersed and exits the parcel as sheet flow. Filter barriers shall not be used in areas of concentrated flow. Synthetic filter fences are more effective than straw bales and shall be used in series. Straw bales shall also be anchored with stakes and grounded to reduce unfiltered underflow by burying the lower 3 inches of each bale.

(7) Any flow from a disturbed parcel shall pass through a vegetative filter barrier or sediment basin before entering a storm drain inlet. Existing inlets or those being constructed in a disturbed area shall have all flow diverted away from them, be plugged or protected by a filter. Downstream development parcels shall be protected from increases in volume, velocity, and sediment load or peak flow rates.

(8) The duration of time, which an area remains exposed, shall be kept to a practical minimum and the area stabilized as quickly as possible. Temporary vegetation or mulch shall be used to protect exposed areas during development. For areas subject to daily disturbance, a weighted cover of impermeable material may be used, if approved by the PWO.

(9) Stockpiles shall be located outside of drainageways and the 100-year floodplain if possible. It may be necessary to divert drainage around a stockpile that must be located in a drainageway.

(10) Soil stabilization shall be maintained in an effective condition throughout construction until permanent vegetation stabilization is achieved.

(11) Permanent vegetation or structural erosion control devices shall be installed as soon as practical after as-built topographic conditions are finalized.

(12) Permanent stabilization requires permanent structures, pavement or vegetation sufficiently mature to withstand annual climate cycle or permanent mulch.

10.1 Plan Requirements

If the owner or operator is required to prepare an erosion and sedimentation control plan (ESCP) under Rule 5 (327 IAC 15-5) and/or Rule 6 (327 IAC 15-6) and/or Rule 13 (327 IAC 15-13), all applicable state and federal permits or notices for land disturbing activities shall be obtained or filed prior to commencement of land disturbing activities. All applicable state or federal standards shall be adhered to when conducting land-disturbing activities. For land disturbances within the MS4 area that are greater than or equal to 10,000 sq. ft. copies of all applications, letters of intent submittals, plans and other erosion and sediment control related information shall be submitted to the PWO. The construction project site owner shall also submit a copy of the application directly to the IDEM.

If an ESCP is prepared, it shall be prepared under the supervision of, and certified by a registered professional and shall include at a minimum the requirements as specified in Rule 5 (327 15-5).

10.2 General Criteria for Erosion and Sediment Control Practices

(1) Perimeter Control and Sediment Trapping – Perimeter control and other sediment trapping measures shall be installed as specified on the approved plan, including: construction access drives, straw bale dams and fabric fencing, temporary sediment traps, sediment basins, and diversions. Also storm drain system inlet shall be protected from sedimentation.

(2) Vegetative Control – Disturbed areas, which are at finish grade, shall be permanently seeded within seven (7) days. At the discretion of the PWO, barren areas to be rough graded and left undisturbed for more than thirty (30) days shall be established with temporary vegetation; and dormant seeding will be required during seasonal periods (October through February) for those barren areas to be left undisturbed for one-hundred and twenty (120) days or longer.

(3) Slope Protection – Slope protection shall be provided by use of temporary and permanent diversion dikes, vegetative cover, and slope drains. Concentrated stormwater flows shall not be allowed to flow down cut or fill slopes without proper slope stabilization.

(4) Protection of Outlet Channel – Concentrated stormwater runoff leaving a development site shall be outlet to an open channel, storm sewer pipe inlet or culvert, which is capable of receiving this discharge. Runoff velocities shall be controlled during all storm events, up to the 100-year return interval storm, so that the peak runoff velocity during and after the completion of the land alteration approximates existing conditions.

(5) Waste, Debris, and Pollution Elimination – Appropriate measures shall be taken to minimize or eliminate wastes and unused building materials and all pollutants from being carried from the site by runoff. Proper storage, handling and use of al potentially polluting substances shall be employed.

(6) Roadways – Public and private roadways shall be kept clear of accumulated sediment. Bulk clearing of accumulated sediment shall not include flushing the area with water.

10.3 Specific Practices

The principles and practices provided by the State in Rule 5 (327 15-5) are to be followed in the development of all ESCPs. Rule 5 (327 15-5) does

not give specific requirements for use of various practices leaving that to the localities. The designer and operation shall rely on the Indiana Handbook for Erosion Control in Developing Areas (HECDA) or an approved equivalent for detailed design, construction and maintenance criteria for all erosion control practices. The manual can be obtained from:

Urban Conservation Program
Division of Soil Conservation
Indiana Department of Natural Resources
402 West Washington Street, Rm W-265
Indianapolis, Indiana 46204-2748
317-232-4180

11.0 Deviation from Approved Plans

Any significant deviation or change in the detailed plans and specifications after granting of the Stormwater Management Plan Approval (SWMPA) shall be filed in duplicate with and approved by the PWO prior to the time land alteration involving the change occurs. Copies thereof, if approved, shall be attached to the original plans and specifications.

12.0 Enforcement

In the case of non-compliance with this Ordinance or the Stormwater Design Manual, the PWO has the right to issue abatement orders, stop work orders, injunctions, and revoke permits.

If work for which the Stormwater Management Plan Approval (SWMPA) is required is commenced by the applicant without compliance with the provisions of the Town of Mooresville Stormwater Management Ordinance, the review fee shall be increased to $500.00. If work for which the SWMPA is required is completed or substantially completed by the applicant without compliance with the provisions of the Town of Mooresville Stormwater Management Ordinance, the review fee shall be increased to $2,500.00.

The PWO may revoke a SWMPA where the application, plans, or other supporting documents reflect either:

- A false statement or misrepresentation as to material fact; or
- Failure to comply with the requirements of this manual

Whenever the PWO discovers the existence of any of the circumstances listed below, they are empowered to issue an order requiring the

suspension of the land alteration. The stop-work order shall be in writing and shall state to what land alteration it is applicable and the reason for its issuance. One (1) copy of the stop-work order shall be posted on the property in a conspicuous place and one (1) copy shall be delivered to the permit applicant, and if conveniently possible to the person doing the land alteration and to the owner of the property or his agent. The stop work order shall state the conditions under which land alteration may be resumed. A stop-work order shall be issued if:

- Land alteration is occurring in violation of a drainage requirement and in such manner that if land alteration is allowed to proceed, there is a probability that it will be substantially difficult to correct the violation; or
- Land alteration has been accomplished in violation of a drainage requirement and fifteen (15) calendar days has elapsed since written notice of the violation or noncompliance was either posted on the property in a conspicuous place or given to the person doing the land alteration, without the violation or noncompliance being corrected; or
- Land alteration for which a SWMPA is required is proceeding without a SWMPA being in force. In such an instance the stop-work order shall indicate that the effect of the order terminates when the required SWMPA is obtained.

Appendix III

TYPE OF SURFACE	RUNOFF COEFFICIENT
Non-Urban Areas	
Bare Earth	0.55
Steep Grassed Areas (slope 2:1)	0.60
Turf Meadows	0.25
Forested Areas	0.20
Cultivated Fields	0.30
Urban Areas	
All Watertight Roof Surfaces	0.90
Pavement (concrete, asphalt)	0.85
Gravel	0.85
Impervious Soils (Heavy)	0.55
Impervious Soils (with turf)	0.45
Slightly Pervious Soil	0.25
Slightly Pervious Soil (with turf)	0.20
Moderately Pervious Soil	0.15
Moderately Pervious Soil (with turf)	0.10
Business, Commercial & Industrial	0.85
Apartments & Townhouses	0.70
Schools & Churches	0.55
Single Family Lots < 10,000 ft^2	0.45
Lots < 12,000 ft^2	0.45
Lots < 17,000 ft^2	0.40
Lots > ½ Acre	0.35
Park, Cemetery or Unimproved Area	0.30

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Table 3.1.1 (TR-55 Table 3-1) : Runoff Coefficient's for use in the Rational Method calculations for Pipe, Channel and Detention Design

Worksheet 3: Time of Concentration (T_c) or travel time (T_t)

Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

Check one: ☐ T_c ☐ T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

	Segment ID		
1. Surface description (table 3-1)			
2. Manning's roughness coefficient, n (table 3-1)			
3. Flow length, L (total L † 300 ft) ft			
4. Two-year 24-hour rainfall, P_2 in			
5. Land slope, s ft/ft			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\, s^{0.4}}$ Compute T_t hr		+	=

Shallow concentrated flow

	Segment ID		
7. Surface description (paved or unpaved)			
8. Flow length, L ft			
9. Watercourse slope, s ft/ft			
10. Average velocity, V (figure 3-1) ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t hr		+	=

Channel flow

	Segment ID		
12. Cross sectional flow area, a ft^2			
13. Wetted perimeter, p_w ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft			
15 Channel slope, s ft/ft			
16. Manning's roughness coefficient, n			
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V ft/s			
18. Flow length, L ft			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) Hr			

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Worksheet 3.2.1: Time of Concentration or Travel Time Worksheet

SURFACE DESCRIPTION	n
Smooth Surfaces (concrete, asphalt, gravel, bare soil)	0.011
Fallow (no residue)	0.05
Cultivated Soils:	
Residue cover </= 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short Grass Praire	0.15
Dense Grass	0.24
Bermuda Grass	0.41
Range (natural)	0.13
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80

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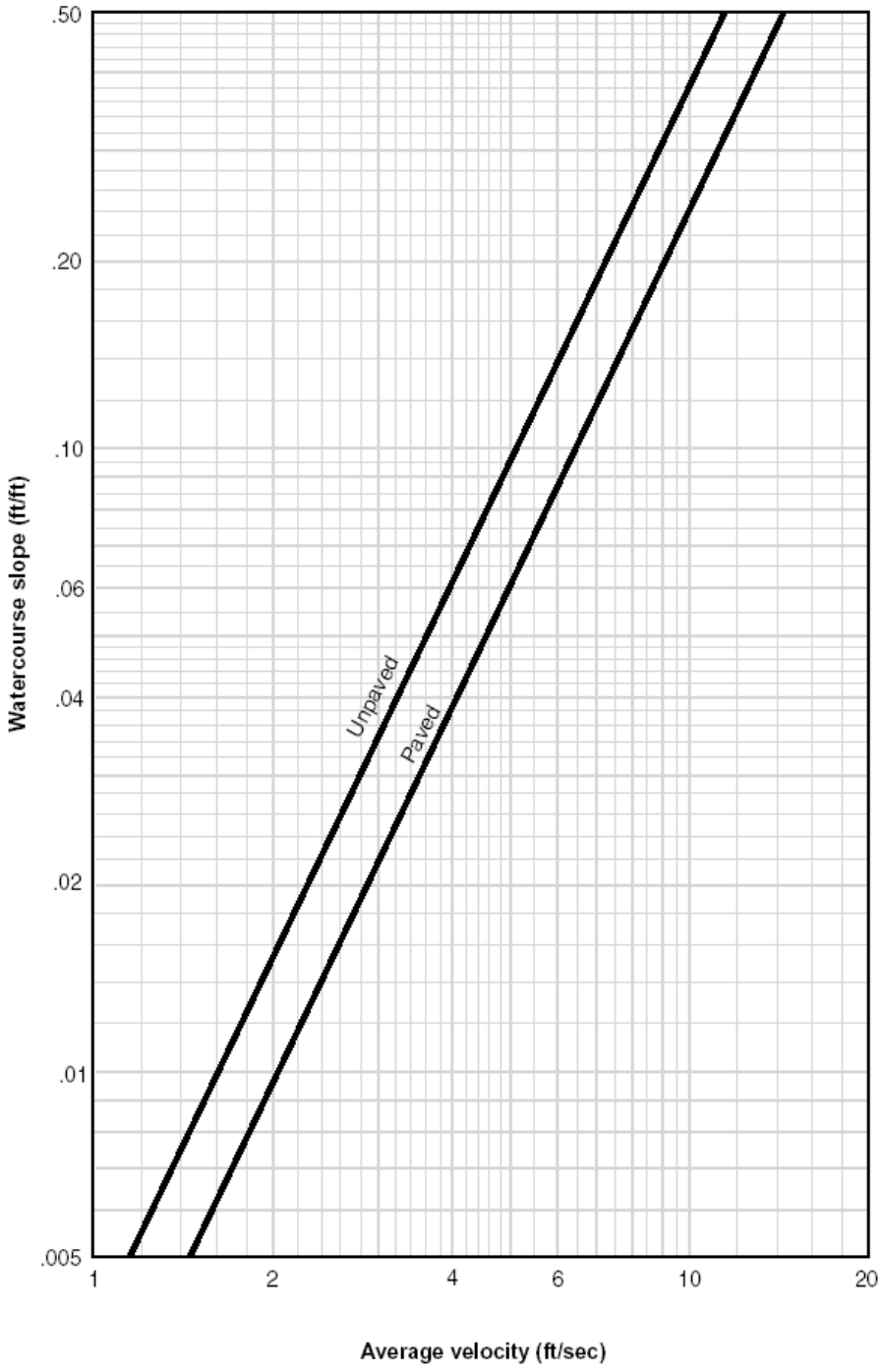
Table 3.2.2 (TR-55 Table 3-1): Roughness coefficient's (Manning's n) for sheet flow to be used in Time-of-Concentration calculations

Figure 3-1 Average velocities for estimating travel time for shallow concentrated flow



3–2 (210-VI-TR-55, Second Ed., June 1986)

Figure 3.2.3 (TR-55 Figure 3-1): Average Velocities for Estimating Travel Time for Shallow Concentrated Flow.

Worksheet 2: Runoff curve number

Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ _	CN 1/	Area ☐ acres ☐ mi² ☐ %	Product of CN x area
1/ Use only one CN source per line				Totals ➡		

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = _____ = _____ ; Use CN ➡ ☐

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Worksheet 3.3.1 (TR-55 Worksheet 2): Runoff Curve Number Worksheet

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2/]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 3.3.2 (TR-55 Table 2-2a): Runoff Curve Numbers for Urban Areas

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1/]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2/]	Hydrologic condition [3/]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and I_a=0.2S

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 3.3.3 (TR-55 Table 2-2b): Runoff Curve Numbers for Cultivated Agricultural Lands

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 3.3.4 (TR-55 Table 2-2c): Runoff Curve Numbers for Other Agricultural Lands

Return Period	a	b	N	R^2
2	32.852	7	0.7780	0.99966
5	46.060	8	0.7859	0.99958
10	56.974	9	0.7953	0.99952
25	72.739	10	0.8115	0.99942
50	84.475	11	0.8147	0.99940
100	92.718	11	0.8145	0.99942

Table 3.4.1.1: IDF EQUATION VALUES

		Return Period – Rainfall Intensity (in/hr)					
Hours	**Minutes**	**2**	**5**	**10**	**25**	**50**	**100**
0.08	5	4.75	6.14	6.99	8.08	8.83	9.69
0.17	10	3.63	4.75	5.48	6.40	7.07	7.77
0.25	15	2.97	3.92	4.55	5.34	5.94	6.53
0.5	30	1.98	2.64	3.09	3.65	4.10	4.50
1	60	1.25	1.67	1.96	2.31	2.62	2.88
2	120	0.76	1.02	1.20	1.40	1.59	1.75
3	180	0.56	0.75	0.88	1.03	1.17	1.29
6	360	0.33	0.44	0.52	0.60	0.68	0.75
12	720	0.20	0.26	0.30	0.35	0.39	0.43
24	1440	0.11	0.15	0.17	0.20	0.22	0.25

Table 3.4.1.2: IDF Table

		Return Period – Rainfall Depth (in)					
Hours	**Minutes**	**2**	**5**	**10**	**25**	**50**	**100**
0.08	5	0.40	0.51	0.58	0.67	0.74	0.81
0.17	10	0.61	0.79	0.91	1.07	1.18	1.30
0.25	15	0.74	0.98	1.14	1.34	1.49	1.63
0.5	30	0.99	1.32	1.55	1.83	2.05	2.25
1	60	1.25	1.67	1.96	2.31	2.62	2.88
2	120	1.52	2.04	2.40	2.80	3.18	3.50
3	180	1.68	2.25	2.64	3.09	3.51	3.87
6	360	1.98	2.64	3.12	3.60	4.08	4.50
12	720	2.40	3.12	3.60	4.20	4.68	5.16
24	1440	2.64	3.60	4.08	4.80	5.28	6.00

Table 3.4.2.1: IDD Table

	Cumulative Storm Rainfall (percent) for Given Storm Type			
Cumulative Storm Time (Percent)	**First Quartile**	**Second Quartile**	**Third Quartile**	**Fourth Quartile**
5	16	3	3	2
10	33	8	6	5
15	43	12	9	8
20	52	16	12	10
25	60	22	15	13
30	66	29	19	16
35	71	39	23	19
40	75	51	27	22
45	79	62	32	25
50	82	70	38	28
55	84	76	45	32
60	86	81	57	35
65	88	85	70	39
70	90	88	79	45
75	92	91	85	51
80	94	93	89	59
85	96	95	92	72
90	97	97	95	84
95	98	98	97	92

(SOURCE: Rainfall Frequency Atlas of the Midwest by Huff and Angel)

Table 3.4.3.1: Median Time Distributions of Heavy Storm Rainfall at a Point

Appendix IV

Pipe Material	Manning's n
Concrete Pipe	0.012
Concrete Boxes	0.012
Corrugated Metal Pipe or Pipe Arch	
2 2/3" x ½" Helical Corrugation	0.022
2 2/3" x ½" Annular Corrugation	0.022
15" to 36"	0.025
42" to 96"	0.024
3" x 1" Corrugation	0.027
5" x 1" Corrugation	0.025
Structural Plate Pipe or Pipe Arch	
6" x 2" Corrugation	0.033
9" x 2½" Corrugation	0.035
Spiral Ribbed Corrugated Metal Pipe	0.013
Smooth High Density Polyethylene (HDPE)	0.012
Smooth Lined Interior Polyvinyl Chloride (PVC)	0.012
Smooth Interior Corrugated HDPE	0.012
Ductile Iron Pipe	0.012

Table 4.2.1.1: Manning's "n" Values for Pipes

Storm Drain Computation Sheet

DATE _____ **PROJECT** _____ **ROUTE** _____

COMPUTED BY:_____ **CHECKED BY:**_____ **SHEET**_____**OF**_____

Station		Length (ft)	Drainage Area (acres)		Runoff Coefficient C	A x C		Flow Time (min)		Rainfall Intensity (in/hr)	Total Runoff Q (cfs)	Diameter of Pipe (in)	Slope of Pipe (ft/ft)	Flowing Full Velocity	Upstream Invert Elevation	Downstream Invert Elevation	Manhole Invert Drop	Depth of Cover
From	To		Increment	Total		Increment	Total	To Upper End	In Section									

Worksheet 4.2.1.2 (INDOT Figure 36-12F): Storm Drain Computation Sheet

Hydraulic Grade Line Computation Sheet

DATE _____ **PROJECT** _____ **ROUTE** _____

COMPUTED BY:_____ **CHECKED BY:**_____ **SHEET**_____**OF**_____

Station	TW	D_O	Q_O	L_O	V_O	$V_o^2/2g$	H_O	Sf_O	H_f	K_O	C_D	C_d	C_Q	C_P	C_B	K	$K(V_o^2/2g)$	EGL_O 2+7	EGL 10+18+19	HGL EGL-7	TOC ELEV
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14	15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)

Worksheet 4.2.1.3 (INDOT Figure 36-13D): Hydraulic Grade line Computation Sheet

INLET COMPUTATION SHEET

DATE _____ **PROJECT** _____ **ROUTE** _____

COMPUTED BY:_____ **CHECKED BY:**_____ **SHEET**_____**OF**_____

Location		Gutter Discharge (Design Frequency _____)					Gutter Discharge (Allowable Spread _____)								Inlet Discharge			Remarks
Inlet No.	Stat.	Drain Area "A" (acre)	Runoff Coefficient "C"	Time of Concentration "T_c" (min.)	Rainfall Intensity "i" (in/hr)	Flow "Q" (cfs)	Grade "S_o" (ft/ft)	Cross Slope "S_x" (ft/ft)	Prev. Runby (cfs)	Total Gutter Flow (cfs)	Depth "d" (ft)	Gutter Width "W" (ft)	Spread "T" (ft)	W/T	Inlet Type	Intercept "Q_i" (cfs)	Runby "Q_r" (cfs)	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Worksheet 4.3.2.1 (INDOT Figure 36-10K): Inlet Spacing and Gutter Spread Computation Sheet

Type of Gutter or Pavement	Manning's "n"
Concrete	0.012
Asphalt Pavement:	
Smooth Texture	0.013
Rough Texture	0.016
Concrete Gutter – Asphalt Pavement:	
Smooth	0.013
Rough	0.015
Concrete Pavement:	
Float Finish	0.014
Broom Finish	0.016
For Gutters with small slope, where sediment may	
Accumulate, increase the "n" values above by:	0.002

USDOT, FHWA, HDS-3 (1961)

Table 4.3.2.2: Roughness coefficient's (Manning's n) for Street and Pavement Gutters

Open Channel Surface Material	n
Concrete	0.012
Gravel Bottom with sides:	
Concrete	0.020
Mortared Stone	0.023
Rip-Rap	0.033
Natural Stream Channels:	
Clean, Straight Stream	0.030
Clean, Winding Stream	0.040
Winding with weeds and pools	0.050
With Heavy Brush and Timbers	0.100
Flood Plains:	
Pasture	0.035
Field Crops	0.040
Light Brush and Weeds	0.050
Dense Brush	0.070
Dense Trees	0.100

Chow, 1959

Table 4.4.1.1: Roughness coefficient's (Manning's n) for Open Channel Surfaces

Typical Maximum Velocities for Open Channel Linings

Open Channel Lining Material	Desirable Maximum Velocity (ft/s)
Concrete, Trowel Finish	15
Concrete, Broom or Float Finish	15
Rip-Rap	10
Gabions	10
New Earth (Uniform, Sodded, Clay)	3-5
Existing Earth (Fairly Uniform, With Some Weeds	3-5
Dense Weeds	3-5
Swale with Grass	3-5

Table 4.4.2.1: Desirable Maximum Velocities for Open Channel Linings