# CITY OF ANGOLA

# STORMWATER STANDARDS

Prepared for:

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# Chapter One

## INTRODUCTION

This document, the *City of Angola* Stormwater Technical Standards Manual, contains the necessary technical standards for administering the requirements of the *City of Angola* Stormwater Management Ordinance. This document should be considered as a companion document to the Ordinance. Whereas the Ordinance contains the majority of the regulatory authority and general requirements of comprehensive stormwater management, this document contains the necessary means and methods for achieving compliance with the Ordinance. In case there are conflicts between the requirements contained in this document and the Ordinance, the requirements of the Ordinance should prevail.

This document contains formulas and methodologies for the review and design of both stormwater quantity and stormwater quality facilities. Chapters 2 through 6 contain stormwater conveyance and detention calculations. Chapter 7 contains standards for erosion control and other pollution prevention measures for active construction sites. Chapters 8 through 9 cover standards and calculations methods required to properly size and design stormwater quality features that will treat runoff long-term following construction completion.

Chapter 10 contains standards regarding lot/building developments, including grading and building pad elevations, acceptable outlet and adjoining property impact requirements. Chapter 11 contains requirements for Operation and Maintenance of the developments stormwater system. A comprehensive glossary of terms is provided in Appendix A. Appendix B contains several useful and necessary standard forms.

The *City of Angola* Stormwater Management Ordinance and this Technical Standards Manual provide the general requirements and recommended/acceptable methods for design and review of stormwater quantity and quality infrastructure within *City of Angola*. For comprehensive technical guidance on calculations and modeling of stormwater quantity and quality infrastructure in Indiana, refer to the latest edition of the "Indiana LTAP Stormwater Drainage Manual". The Indiana Stormwater Quality Manual may also be used as a guidance for design standards.

A summary of the submittal requirements is included below:

A. **Construction Plans - Digital submittal shall depict the existing and proposed conditions. One (1) hard copy set of plans are required with submittal. Construction plans shall include:**
   1. Existing and Final Project Site Layout - Provide a project site layout that includes:
      a. Existing conditions and proposed site improvements, including roads, utilities, lot delineation and identification, proposed structures, and common areas.
      b. The boundaries of 100-year floodplains, floodway fringes, and floodways.
         1) The existing and proposed topography at a contour interval appropriate to indicate drainage patterns.
         2) The boundaries of natural features or unique resource areas that will be left undisturbed or preserved including, but not limited to, wetlands, steep slopes, riparian corridors, and natural buffers.
      c. Drainage Plan - Provide a drainage plan that includes:
         1) The location, size, and dimensions of all stormwater drainage systems, such as culverts, storm sewers, and conveyance channels.
         2) The locations of specific points where stormwater and non-stormwater discharges will leave the project site.

3) The locations where stormwater may be directly discharged into ground water, such as abandoned wells, sinkholes, or karst features.
4) The name(s) of the receiving water(s) and, when the discharge is to a system (storm sewer, stormwater management measure, etc.) owned/or operated by a municipality, city, town, or county, the name of the system operator and the ultimate receiving water.
5) The location, size, and dimensions of features, such as permanent retention or detention facilities, including man-made wetlands, designed for the purpose of stormwater management.

**B. Stormwater Drainage Technical Report – A written stormwater drainage technical report must contain a discussion of the steps taken in the design of the stormwater drainage system and include the following:**

1. The significant drainage problems associated with the project;
2. The analysis procedure used to evaluate these problems and to propose solutions;
3. Any assumptions or special conditions associated with the use of these procedures, especially the hydrologic or hydraulic methods;
4. The proposed design of the drainage control system; and
5. The results of the analysis of the proposed drainage control system showing that it does solve the project's drainage problems. Any hydrologic or hydraulic calculations or modeling results must be adequately cited and described in the summary description. If hydrologic or hydraulic models are used, the input and output files for all necessary runs must be included in the appendices. A map showing any drainage area subdivisions used in the analysis must accompany the report.

**C. Hydrologic/Hydraulic Analysis – A hydrologic/hydraulic analysis consistent with the methodologies, calculations, and other information identified in this document including the following:**

1. A hydraulic report detailing existing and proposed drainage patterns on the subject site. The report should include a description of present land use and proposed land use. Any off-site drainage entering the site should be addressed as well. This report should be comprehensive and detail all the steps the engineer took during the design process.
2. All hydrologic and hydraulic computations should be included in the submittal. These calculations should include, but are not limited to, runoff curve numbers and runoff coefficients, runoff calculations, stage-discharge relationships, times-of-concentration and storage volumes.
3. Copies of all computer runs. These computer runs should include both the input and the outputs. Electronic copies of the computer runs with input files must also be included. A set of exhibits should be included showing the drainage sub-areas and a schematic detailing of how the computer models were set up.
4. A conclusion which summarizes the hydraulic design and details how this design satisfies this chapter.

**D. Stormwater Pollution Prevention Plan (SWPPP) in accordance with Chapter 7.**

**E. Operation and Maintenance Manual in accordance with Chapter 11.**

**F. Sensitive Area information**

1. It is the intent of the City to direct the community's physical growth away from sensitive areas and towards areas that can support it without compromising water quality. In the event that a project site is determined to impact or discharge to a sensitive area or is located in an impact drainage area, the city may require more stringent stormwater quantity and quality measures than detailed in this chapter

or in the latest edition of the *Indiana Stormwater Quality Manual*. Requirements for sensitive areas shall include the following:

a) Determination of sensitive areas. Sensitive areas include highly erodible soils, wetlands, threatened or endangered species habitat, outstanding waters, impaired waters, recreational waters, and surface drinking water sources.
   1) Any discharge from a stormwater practice that is a Class V injection well shall meet the Indiana groundwater quality standards.
   2) If wetlands are suspected on a site, wetland delineation shall be completed in accordance with the methodology established by the U.S. Army Corps of Engineers (COE) and the wetland addressed in accordance with the COE requirements.
   3) If the presence of threatened or endangered species habitat is suspected on a site, the site must be evaluated and inspected by a professional experienced in such and the results reported to the city.
   4) Special terms and conditions for development determined to impact or discharge to any sensitive area shall be included in the Stormwater Management Approval.

**G. Drainage Easement.**

1. All post-construction stormwater quality and quantity management measures shall be contained within a drainage easement or common area. Drainage easements shall be sized according to the requirements of this manual and **Table 1-1**.

**Table 6-1: Drainage Easement Size Requirements**

| **Area or Situation** | **Easement Width** |
|---|---|
| Swales or Open Channel | 10 feet from top of bank on each side of the swale |
| New Drain Tiles and Storm Pipes (smaller than 24-inch) | 20 feet, centered over pipe |
| Storm Pipes (larger than 24-inch) | 30 feet, centered over pipe |
| Residential detention, retention or infiltration facility (surface) | Placed within a common area |
| Non-residential detention, retention or infiltration facility (surface) | Minimum of twenty (20) feet horizontally from the top of bank of the facility, or the 100-year pool if no defined top of bank is present |
| Emergency spillway and emergency access ramps. | At the elevation of the emergency spillway design flow plus 40 feet horizontally, centered over spillway from the crown of the emergency spillway to the point where the spillway enters the downstream drainage system. Access points and access ramps must also be included within the easement or common area. |
| Stormwater BMP | 20 feet from the outside of the footprint or 20 feet from the center of the unit (whichever is greater) and include the connecting manholes when in an off-line configuration |
| Flood routing path/ponding area | Minimum width of 30 feet flow width along the centerline of the flow path (15 feet from centerline on each side) |
| Access easement | 10 feet width from a public right-of-way |

# Chapter Two

# METHODOLOGY FOR DETERMINATION OF RUNOFF RATES

Runoff rates shall be computed for the area of the parcel under development plus the area of the watershed flowing into the parcel under development. The rate of runoff which is generated as the result of a given rainfall intensity may be calculated as follows:

## A. DEVELOPMENT SITES LESS THAN OR EQUAL TO 10 ACRES IN SIZE, WITH A CONTRIBUTING DRAINAGE AREA LESS THAN OR EQUAL TO 50 ACRES AND NO DEPRESSIONAL STORAGE

The Rational Method may be used. A computer model, such as TR-55 Natural Resource Conservation Service (NRCS), TR-20 (NRCS), HEC-HMS (COE), and HEC-1 (COE), that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies may also be used along with a 24-hour duration NRCS Type 2 storm. Note that for the purpose of determining the post-developed conditions curve numbers, due to significant disturbance to the upper soil layers during the construction activities, the initially determined hydrologic soil group for disturbed areas should be changed to the next less infiltrating capacity category (i.e., A to B, B to C, and C to D).

In the Rational Method, the peak rate of runoff, Q, in cubic feet per second (cfs) is computed as:

$$Q = CIA$$

Where: C = Runoff coefficient, representing the characteristics of the drainage area and defined as the ratio of runoff to rainfall.

I = Average intensity of rainfall in inches per hour for a duration equal to the time of concentration ($t_c$) for a selected rainfall frequency.

A = Tributary drainage area in acres.

Values for the runoff coefficient "C" are provided in **Tables 2-1** and **2-2**, which show values for different types of surfaces and local soil characteristics. The composite "C" value used for a given drainage area with various surface types shall be the weighted average value for the total area calculated from a breakdown of individual areas having different surface types. **Table 2-3** provides runoff coefficients and inlet times for different land use classifications.

Rainfall intensity shall be determined from the rainfall frequency data shown in **Table 2-4**.

In general, the time of concentration ($t_c$) methodology to be used for all stormwater management projects within *City of Angola* shall be as outlined in the U.S. Department of Agriculture (USDA) - NRCS TR-55 Manual. In urban or developed areas, the methodology to be used shall be the sum of the inlet time and flow time in the stormwater facility from the most remote part of the drainage area to the point under consideration. The flow time in the storm sewers may be estimated by the distance in feet divided by velocity of flow in feet per second. The velocity shall be determined by the Manning's Equation (see

Chapter 4). Inlet time is the combined time required for the runoff to reach the inlet of the storm sewer. It includes overland flow time and flow time through established surface drainage channels such as swales, ditches, and sheet flow across such areas as lawns, fields, and other graded surfaces.

**TABLE 2-1**

| **Urban Runoff Coefficients** | | | | |
|---|---|---|---|---|
| *Type of Surface* | *Runoff Coefficient "C" (by Storm Recurrence Interval)* | | | |
| | *< 25 year* | *25 year* | *50 year* | *100 year* |
| □ **Hard Surfaces** | | | | |
| Asphalt | 0.82 | 0.90 | 1.00 | 1.00 |
| Gravel | 0.85 | 0.94 | 1.00 | 1.00 |
| Concrete | 0.85 | 0.94 | 1.00 | 1.00 |
| Roof | 0.85 | 0.94 | 1.00 | 1.00 |
| □ **Lawns** (Sandy) | | | | |
| Flat (0-2% Slope) | 0.07 | 0.08 | 0.09 | 0.12 |
| Rolling (2-7% Slope) | 0.12 | 0.13 | 0.16 | 0.20 |
| Steep (Greater than 7% Slope) | 0.17 | 0.19 | 0.22 | 0.28 |
| □ **Lawns** (Clay) | | | | |
| Flat (0-2% Slope) | 0.16 | 0.18 | 0.21 | 0.26 |
| Rolling (2-7% Slope) | 0.21 | 0.23 | 0.28 | 0.35 |
| Steep (Greater than 7% Slope) | 0.30 | 0.33 | 0.40 | 0.50 |

*Source: HERPICC Stormwater Drainage Manual, July 1995, and other sources.*

**TABLE 2-2**

| Rural Runoff Coefficients | | | | |
|---|---|---|---|---|
| *Type of Surface* | *Runoff Coefficient "C" (by Storm Recurrence Interval)* | | | |
| | *< 25 year* | *25 year* | *50 year* | *100 year* |
| □ **Woodland** (Sandy) | | | | |
| Flat (0-2% Slope) | 0.10 | 0.11 | 0.13 | 0.17 |
| Rolling (2-7% Slope) | 0.25 | 0.28 | 0.33 | 0.41 |
| Steep (Greater than 7% Slope) | 0.30 | 0.33 | 0.40 | 0.50 |
| □ **Woodland** (Clay) | | | | |
| Flat (0-2% Slope) | 0.30 | 0.33 | 0.40 | 0.50 |
| Rolling (2-7% Slope) | 0.35 | 0.39 | 0.46 | 0.58 |
| Steep (Greater than 7% Slope) | 0.50 | 0.55 | 0.66 | 0.83 |
| □ **Pasture** (Sandy) | | | | |
| Flat (0-2% Slope) | 0.10 | 0.11 | 0.13 | 0.17 |
| Rolling (2-7% Slope) | 0.16 | 0.18 | 0.21 | 0.26 |
| Steep (Greater than 7% Slope) | 0.22 | 0.24 | 0.29 | 0.36 |
| □ **Pasture** (Clay) | | | | |
| Flat (0-2% Slope) | 0.30 | 0.33 | 0.40 | 0.50 |
| Rolling (2-7% Slope) | 0.36 | 0.40 | 0.48 | 0.59 |
| Steep (Greater than 7% Slope) | 0.42 | 0.46 | 0.55 | 0.69 |
| □ **Cultivated** (Sandy) | | | | |
| Flat (0-2% Slope) | 0.30 | 0.33 | 0.40 | 0.50 |
| Rolling (2-7% Slope) | 0.40 | 0.44 | 0.53 | 0.66 |
| Steep (Greater than 7% Slope) | 0.52 | 0.57 | 0.69 | 0.86 |
| □ **Cultivated** (Clay) | | | | |
| Flat (0-2% Slope) | 0.50 | 0.55 | 0.66 | 0.83 |
| Rolling (2-7% Slope) | 0.60 | 0.66 | 0.79 | 0.99 |
| Steep (Greater than 7% Slope) | 0.72 | 0.79 | 0.95 | 1.00 |

*Source: HERPICC Stormwater Drainage Manual, July 1995, and other sources.*

**TABLE 2-3**

| Runoff Coefficients by Land Use, Typical Inlet Times, and Storm Recurrence Interval | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Land Use* | *Runoff Coefficients "C" (by Storm Recurrence Interval)* | | | | | | | | | | | | *Inlet Time (Minutes) (4)* |
| | Flat (1) | | | | Rolling (2) | | | | Steep (3) | | | | |
| | *< 25 year* | *25 year* | *50 year* | *100 year* | *< 25 year* | *25 year* | *50 year* | *100 year* | *< 25 year* | *25 year* | *50 year* | *100 year* | |
| Commercial *(CBD)* | 0.75 | 0.83 | 0.99 | 1.00 | 0.83 | 0.91 | 1.00 | 1.00 | 0.91 | 1.00 | 1.00 | 1.00 | 5 |
| Commercial *(Neighborhood)* | 0.54 | 0.59 | 0.71 | 0.89 | 0.60 | 0.66 | 0.79 | 0.99 | 0.66 | 0.73 | 0.87 | 1.00 | 5 - 10 |
| Industrial | 0.63 | 0.69 | 0.83 | 1.00 | 0.70 | 0.77 | 0.92 | 1.00 | 0.77 | 0.85 | 1.00 | 1.00 | |
| Garden Apartments | 0.54 | 0.59 | 0.71 | 0.89 | 0.60 | 0.66 | 0.79 | 0.99 | 0.66 | 0.73 | 0.87 | 1.00 | |
| Churches | 0.54 | 0.59 | 0.71 | 0.89 | 0.60 | 0.66 | 0.79 | 0.99 | 0.66 | 0.73 | 0.87 | 1.00 | |
| Schools | 0.31 | 0.34 | 0.41 | 0.51 | 0.35 | 0.39 | 0.46 | 0.58 | 0.39 | 0.43 | 0.51 | 0.64 | 10 - 15 |
| Semi Detached Residential | 0.45 | 0.50 | 0.59 | 0.74 | 0.50 | 0.55 | 0.66 | 0.83 | 0.55 | 0.61 | 0.73 | 0.91 | |
| Detached Residential | 0.40 | 0.44 | 0.53 | 0.66 | 0.45 | 0.50 | 0.59 | 0.74 | 0.50 | 0.55 | 0.66 | 0.83 | |
| Quarter Acre Lots | 0.36 | 0.40 | 0.48 | 0.59 | 0.40 | 0.44 | 0.53 | 0.66 | 0.44 | 0.48 | 0.58 | 0.73 | |
| Half Acre Lots | 0.31 | 0.34 | 0.41 | 0.51 | 0.35 | 0.39 | 0.46 | 0.58 | 0.39 | 0.43 | 0.51 | 0.64 | |
| Parkland | 0.18 | 0.20 | 0.24 | 0.30 | 0.20 | 0.22 | 0.26 | 0.33 | 0.22 | 0.24 | 0.29 | 0.36 | To be Computed |

*Source: HERPICC Stormwater Drainage Manual, July 1995, and other sources.*

**Notes:**
**(1)** Flat terrain involves slopes of 0-2%.
**(2)** Rolling terrain involves slopes of 2-7%.
**(3)** Steep terrain involves slopes greater than 7%.
**(4)** Interpolation, extrapolation and adjustment for local conditions shall be based on engineering experience and judgment.

## B. DEVELOPMENT SITES GREATER THAN 10 ACRES IN SIZE OR CONTRIBUTING DRAINAGE AREA GREATER THAN 50 ACRES OR WITH SIGNIFICANT DEPRESSIONAL STORAGE

The runoff rate for these development sites and contributing drainage areas shall be determined by a computer model that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies. Note that for the purpose of determining the post-developed conditions curve numbers, due to significant disturbance to the upper soil layers during the construction activities, the initially determined hydrologic soil group for disturbed areas should be changed to the next less infiltrating capacity category (i.e., A to B, B to C, and C to D).

The 24-hour NRCS Type 2 Rainfall Distribution shall be utilized for runoff calculations. 24-hour Rainfall depth for various frequencies shall be taken from **Table 2-5**.

The NRCS Type 2 distribution ordinates are found in **Table 2-6**. This table should be used only when the rainfall distribution is not a default option in the computer program. Examples of computer models that can generate such hydrographs include TR-55 (NRCS), TR-20 (NRCS), and HEC-HMS (COE). These programs may be downloaded free of charge from the associated agencies' web sites. Other models may be acceptable on a case-by-case basis.

**TABLE 2-4**

| **Rainfall Intensities for Various Return Periods and Storm Durations** | | | | | | |
|---|---|---|---|---|---|---|
| *Duration* | *Intensity (Inches/Hour)* | | | | | |
| | *Return Period (Years)* | | | | | |
| | 2 | 5 | 10 | 25 | 50 | 100 |
| 5 min | 0.472 | 0.568 | 0.642 | 0.738 | 0.811 | 0.883 |
| 10 min | 0.737 | 0.882 | 0.991 | 1.13 | 1.23 | 1.33 |
| 15 min | 0.901 | 1.08 | 1.22 | 1.39 | 1.52 | 1.65 |
| 30 min | 1.21 | 1.48 | 1.69 | 1.97 | 2.18 | 2.38 |
| 1 hr | 1.48 | 1.86 | 2.15 | 2.55 | 2.87 | 3.19 |
| 2 hr | 1.75 | 2.22 | 2.59 | 3.09 | 3.50 | 3.93 |
| 3 hr | 1.88 | 2.37 | 2.76 | 3.31 | 3.76 | 4.23 |
| 6 hr | 2.23 | 2.80 | 3.27 | 3.94 | 4.50 | 5.10 |
| 12 hr | 2.56 | 3.20 | 3.74 | 4.48 | 5.12 | 5.80 |
| 24 hr | 2.84 | 3.54 | 4.10 | 4.88 | 5.52 | 6.19 |

*Source: NOAA, National Weather Service, "Precipitation-Frequency Atlas of the United States", NOAA Atlas 14, Volume 2, Version 3, rev 2006, for Angola, Indiana. (values for intermediate durations can be logarithmically interpolated.) (All rainfall intensities are based on Annual Maximum series)*

**TABLE 2-5**

| Rainfall Depths for Various Return Periods | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Duration* | *Depth (Inches)* | | | | | | |
| | *Return Period (Years)* | | | | | | |
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 24 Hrs. | 2.36 | 2.84 | 3.54 | 4.10 | 4.88 | 5.52 | 6.19 |

*Source: NOAA, National Weather Service, "Precipitation-Frequency Atlas of the United States", NOAA Atlas 14, Volume 2, Version 2, rev 2006, for Angola, Indiana. (Rainfall depths for 2- through 100-year storm are based on annual maximum series. 1-year rainfall depth is based on partial duration series)*

**TABLE 2-6**

| NRCS Type II Rainfall Distribution Ordinates | | | | | |
|---|---|---|---|---|---|
| *Cumulative Storm Time (hr)* | *Cumulative Percent of Storm Depth* | *Cumulative Storm Time (hr)* | *Cumulative Percent of Storm Depth* | *Cumulative Storm Time (hr)* | *Cumulative Percent of Storm Depth* |
| 0.00 | 0 | 8.25 | 12.6 | 16.50 | 89.3 |
| 0.25 | 0.2 | 8.50 | 13.3 | 16.75 | 89.8 |
| 0.50 | 0.5 | 8.75 | 14 | 17.00 | 90.3 |
| 0.75 | 0.8 | 9.00 | 14.7 | 17.25 | 90.8 |
| 1.00 | 1.1 | 9.25 | 15.5 | 17.50 | 91.3 |
| 1.25 | 1.4 | 9.50 | 16.3 | 17.75 | 91.8 |
| 1.50 | 1.7 | 9.75 | 17.2 | 18.00 | 92.2 |
| 1.75 | 2 | 10.00 | 18.1 | 18.25 | 92.6 |
| 2.00 | 2.3 | 10.25 | 19.1 | 18.50 | 93 |
| 2.25 | 2.6 | 10.50 | 20.3 | 18.75 | 93.4 |
| 2.50 | 2.9 | 10.75 | 21.8 | 19.00 | 93.8 |
| 2.75 | 3.2 | 11.00 | 23.6 | 19.25 | 94.2 |
| 3.00 | 3.5 | 11.25 | 25.7 | 19.50 | 94.6 |
| 3.25 | 3.8 | 11.50 | 28.3 | 19.75 | 95 |
| 3.50 | 4.1 | 11.75 | 38.7 | 20.00 | 95.3 |
| 3.75 | 4.4 | 12.00 | 66.3 | 20.25 | 95.6 |
| 4.00 | 4.8 | 12.25 | 70.7 | 20.50 | 95.9 |
| 4.25 | 5.2 | 12.50 | 73.5 | 20.75 | 96.2 |
| 4.50 | 5.6 | 12.75 | 75.8 | 21.00 | 96.5 |
| 4.75 | 6 | 13.00 | 77.6 | 21.25 | 96.8 |
| 5.00 | 6.4 | 13.25 | 79.1 | 21.50 | 97.1 |
| 5.25 | 6.8 | 13.50 | 80.4 | 21.75 | 97.4 |
| 5.50 | 7.2 | 13.75 | 81.5 | 22.00 | 97.7 |
| 5.75 | 7.6 | 14.00 | 82.5 | 22.25 | 98 |
| 6.00 | 8 | 14.25 | 83.4 | 22.50 | 98.3 |
| 6.25 | 8.5 | 14.50 | 84.2 | 22.75 | 98.6 |
| 6.50 | 9 | 14.75 | 84.9 | 23.00 | 98.9 |
| 6.75 | 9.5 | 15.00 | 85.6 | 23.25 | 99.2 |
| 7.00 | 10 | 15.25 | 86.3 | 23.50 | 99.5 |
| 7.25 | 10.5 | 15.50 | 86.9 | 23.75 | 99.8 |
| 7.50 | 11 | 15.75 | 87.5 | 24.00 | 100 |
| 7.75 | 11.5 | 16.00 | 88.1 | | |
| 8.00 | 12 | 16.25 | 88.7 | | |

*Source: National Resources Conservation Service (NRCS), "TR-20 Computer Program for Project Formulation Hydrology", page F9, May 1982.*

NOTE: For use only when SCS Type II rainfall distribution is not a default option in the computer program.

## C. DEVELOPMENT SITES WITH DRAINAGE AREAS GREATER THAN OR EQUAL TO ONE SQUARE MILE

For the design of any major drainage system, as defined in **Appendix A**, the discharge must be obtained from, or be accepted by, the IDNR. Other portions of the site must use the discharge methodology in the applicable section of this Chapter.

# Chapter Three

## METHODOLOGY FOR DETERMINATION OF RETENTION/DETENTION STORAGE VOLUMES

The required volume of stormwater storage for all development sites shall be computed using a computer model that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies. Examples of computer models that can generate such hydrographs include TR-55 (NRCS), TR-20 (NRCS), and HEC-HMS (COE). Other models may be acceptable on a case-by-case basis.

### A. POST-DEVELOPMENT HYDROLOGIC PARAMETERS

Note that for the purpose of determining the post-developed conditions curve numbers, due to significant disturbance to the upper soil layers during the construction activities, the initially determined hydrologic soil group for disturbed areas should be changed to the next less infiltrating capacity category (i.e., A to B, B to C, and C to D).

### B. DESIGN STORM & ALLOWABLE RELEASE RATES FOR DEVELOPMENT SITES WITH ON-SITE DETENTION FACILITIES

The 24-hour NRCS Type 2 Rainfall Distribution shall be utilized to determine the required storage volume. The allowable release rates shall be determined based on methodologies provided in Chapter 6 of this document.

### C. DEVELOPMENT SITES SERVICED BY A REGIONAL DETENTION FACILITY

Development sites making use of regional or master-planned stormwater detention areas must include the following information in a stormwater drainage technical report:

1. Design assumptions, drainage basin maps and calculations from the master planned drainage report for the proposed development area.
2. Written narrative, drainage basin maps and supporting calculations demonstrating that the master-planned assumptions will be achieved.

# Chapter Four

## STORM SEWER DESIGN STANDARDS AND SPECIFICATIONS

All storm sewers, whether private or public, and whether constructed on private or public property shall conform to the design standards and other requirements contained herein. Proposed storm sewer systems must be sized and designed to convey at least the 10-year frequency on-site stormwater runoff, as well as the anticipated 10-year frequency tributary off-site stormwater runoff based on the future developed condition (using Table 6-1 of the Technical Standards). An analysis of the emergency routing of stormwater runoff through the subject development must be provided to confirm that the development will not obstruct the free flow of floodwaters from the tributary off-site property in its current condition and after development. In addition, the Drainage System Overflow Design must be completed in accordance with Section M of this chapter to ensure the safe routing of flood waters through the subject development with the tributary off-site property in its current condition and after development.

### A. DESIGN STORM FREQUENCIES

1. All storm sewers, inlets, catch basins, and street gutters shall accommodate (subject to the "allowable spread" provisions discussed later in this Section), as a minimum, peak runoff from a 10-year return frequency storm calculated based on methodology described in Chapter 2. Additional discharges to storm sewer systems allowed in Section L below of this Section must be considered in all design calculations.

2. Culvert capacities for conveyance under interior local, collector, or arterial streets without roadway overtopping shall be the runoff resulting from the 25-year, 50-year, and 100-year frequency storms, respectively, for off-site areas under existing condition and on-site areas under post-developed conditions. Driveway culvert capacities shall be capacities required for the street classification to which the driveway connects. Greater culvert capacity shall be required to protect the finished floor elevation of buildings from the post-developed 100-year frequency storm when, in the opinion of the design engineer or the *City of Angola*, the finished floor elevation is threatened. If the street or road provides the only access to or from any portion of any commercial or residential development, the crossing shall be designed for a minimum of 100-year frequency storm.

3. For portions of the system considered minor drainage systems, the allowable spread of water on Collector Streets for the design storm is limited to maintaining two clear 10-foot moving lanes of traffic. One lane is to be maintained on Local Roads, while other access lanes (such as a subdivision cul-de-sac) can have a water spread equal to one-half of their total width.

4. To ensure access to buildings and allow the use of the roadway by emergency vehicles during storms larger than the design storm, an overflow channel/swale between sag inlets and overflow paths or basin shall be provided at sag inlets so that the maximum depth of water that might be ponded in the street sag shall not exceed 7 inches measured from elevation of gutter. All water shall be contained in the right-of-way for a 100-year storm.

5. Facilities functioning as a major drainage system as defined in **Appendix A** must also meet IDNR design standards in addition to the *City of Angola* standards. In case of discrepancy, the most restrictive requirements shall apply.

6. New drain tiles and pipes, smaller than 24 inches in diameter, shall be placed in a 20-foot easement and shall be designated on the record plat as 20-foot Utility and Surface Drainage Easement. Pipes that are 24 inches or larger in diameter, shall be placed in a 30-foot easement and shall be designated on the record plat as 30-foot Utility and Surface Drainage Easement. Wider easements may be required by the *City of Angola* or designee when the depth of pipe is greater than 6 to 10 feet, depending on the pipe size.

## B. DETERMINATION OF HYDRAULIC CAPACITY FOR STORM SEWERS USING MANNING'S EQUATION

Determination of hydraulic capacity for storm sewers sized by the Rational Method analysis must be done using Manning's Equation. where:

$$V = (1.486/n)(R^{2/3})(S^{1/2})$$

Then:

$$Q=(V)(A)$$

Where:

Q = capacity in cubic feet per second
V = mean velocity of flow in feet per second
A = cross sectional area in square feet
R = hydraulic radius in feet
S = slope of the energy grade line in feet per foot
n = Manning's "n" or roughness coefficient

The hydraulic radius, R, is defined as the cross-sectional area of flow divided by the wetted flow surface or wetted perimeter. Allowable "n" values and full-flow maximum permissible velocities for storm sewer materials are listed in **Table 4-1**.

**TABLE 4-1**

| Typical Values of Manning's "n" | | |
|---|---|---|
| *Material* | *Manning's "n"* | *Maximum Velocities (feet/second)* |
| □ **Closed Conduits** | | |
| Concrete | 0.013 | 10 |
| Vitrified Clay | 0.013 | 10 |
| HDPE & Polypropylene | 0.012 | 10 |
| PVC | 0.012 | 10 |
| □ **Circular CMP, Annular Corrugations, 2 2/3 x ½ inch** | | |
| Unpaved | 0.024 | 7 |
| 25% Paved | 0.021 | 7 |
| 50% Paved | 0.018 | 7 |
| 100% Paved | 0.013 | 7 |
| Concrete Culverts | 0.013 | 10 |
| HDPE or PVC | 0.012 | 10 |
| □ **Open Channels** | | |
| Concrete, Trowel Finish | 0.013 | 10 |
| Concrete, Broom Finish | 0.015 | 10 |
| Gunite | 0.018 | 10 |
| Riprap Placed | 0.030 | 10 |
| Riprap Dumped | 0.035 | 10 |
| Gabion | 0.028 | 10 |
| New Earth **(1)** | 0.025 | 4 |
| Existing Earth **(2)** | 0.030 | 4 |
| Dense Growth of Weeds | 0.040 | 4 |
| Dense Weeds and Brush | 0.040 | 4 |
| Swale with Grass | 0.035 | 4 |

*Source of manning "n" values: HERPICC Stormwater Drainage Manual, July 1995.*

**(1)** New earth (uniform, sodded, clay soil)
**(2)** Existing earth (fairly uniform, with some weeds).

## C. BACKWATER METHOD FOR PIPE SYSTEM ANALYSIS

For hydraulic analysis of existing or proposed storm drains which possess submerged outfalls, a more sophisticated design/analysis methodology than Manning's equation will be required. The backwater analysis method provides a more accurate estimate of pipe flow by calculating individual head losses in pipe systems that are surcharged and/or have submerged outlets. These head losses are added to a known downstream water surface elevation to give a design water surface elevation for a given flow at the desired upstream location.

Tailwater conditions assumed for this computation should be verified by appropriate calculations. Total head losses may be determined as follows:

Total head loss = frictional loss + manhole loss + velocity head loss + junction loss

Various computer modeling programs such as HYDRA, ILLUDRAIN, and STORMCAD are available for analysis of storm drains under these conditions. Computer models to be utilized, other than those listed, must be accepted by the *City of Angola*.

## D. MINIMUM SIZE FOR STORM SEWERS

The minimum diameter of all storm sewer outlets within a detention basin shall be 12 inches. When the minimum 12-inch diameter pipe will not limit the rate of release to the required amount, the rate of release for detention storage shall be controlled by an orifice plate or other device, subject to acceptance of the *City of Angola*. The minimum allowable orifice size is 4 inches in diameter. When an orifice is less than 12-inches, an anti-clog device is required.

## E. PIPE COVER, GRADE, AND SEPARATION FROM SANITARY SEWERS

Pipe grade shall be such that, in general, a minimum of 3.0 feet of cover is maintained over the top of the pipe. If the pipe is to be placed under pavement, or within 5 feet of the pavement, then the minimum pipe cover shall be 4 feet from top of pavement to top of pipe. Pipe cover less than the minimum may be allowed per manufacturer's specifications or recommendation and used only upon written acceptance from the City of Angola. Uniform slopes shall be maintained between inlets, manholes and inlets to manholes. Final grade shall be set with full consideration of the capacity required, sedimentation problems, and other design parameters. Minimum and maximum allowable slopes shall be those capable of producing velocities of between 2.5 and 10 feet per second, respectively, when the sewer is flowing full. Maximum permissible velocities for various storm sewer materials are listed in **Table 4-1**. A minimum of 1.5 feet of vertical separation between storm sewers and sanitary sewers shall be required. When this is not possible, the sanitary sewer must be encased in concrete or ductile steel within 5 feet, each side, of the crossing centerline.

## F. ALIGNMENT

Storm sewers shall be straight between manholes and/or inlets.

## G. MANHOLES/INLETS

Manholes and/or inlets shall be installed to provide human access to continuous underground storm sewers for the purpose of inspection and maintenance. The casting access minimum inside diameter shall be no less than 22 inches or a rectangular opening of no less than 22 inches by 22 inches. Steps shall be provided in structures deeper than 4 feet, with the first step at the depth of 2 feet and the following steps spaced every 1 foot until the bottom is reached. When grade adjustments of manholes and inlets are required in the field to meet finish design or existing curb grade, adjustment rings with a maximum height of 12 inches may be used.

Manholes shall be provided at the following locations:

1. Where two or more storm sewers converge.
2. Where pipe size or the pipe material changes.
3. Where a change in horizontal alignment occurs.
4. Where a change in pipe slope occurs.
5. At intervals in straight sections of sewer, not to exceed the maximum allowed. The maximum distance between storm sewer manholes shall be as shown in **Table 4-2**.

**TABLE 4-2**

| Maximum Distance Between Manholes | |
|---|---|
| **Size of Pipe (Inches)** | **Maximum Distance (Feet)** |
| 12 through 42 | 400 |
| 48 and larger | 600 |

In addition to the above requirements, a minimum drop of 0.1 foot through manholes and inlet structures should be provided. When changing pipe size, match crowns of pipes, unless detailed modeling of hydraulic grade line shows that another arrangement would be as effective. Pipe slope should not be so steep that inlets surcharge (i.e. hydraulic grade line should remain below rim elevation).

Plans should note that all Inlets and castings must be pre-stamped with a “clean water” message.

Manhole/inlet inside sizing shall be as shown in **Table 4-3**.

**TABLE 4-3**

| Manhole/Inlet Inside Sizing | | |
|---|---|---|
| **Depth of Structure** | **Minimum Diameter** | **Minimum Square Opening** |
| Less than 5 feet | 36 inches | 36" x 36" |
| 5 feet or more | 48 inches | 48" x 48" |

## H. INLET SIZING AND SPACING

Inlets or drainage structures shall be utilized to collect surface water through grated openings and convey it to storm sewers, channels, or culverts. The inlet grate opening provided shall be adequate to pass the design 10-year flow with 50% of the sag inlet areas clogged. Inlets shall be provided so that surface water is not carried across or around any intersection nor for a distance greater than five hundred (500) feet. An overflow channel from sag inlets to the overflow channel or basin shall be provided at sag inlets. Inlet design and spacing may be done using the hydraulic equations by manufacturers or orifice/weir equations. Use of the U.S. Army Corps of Engineers HEC-12 computer program is also an acceptable method. Gutter spread on continuous grades may be determined using the Manning's equation. Further guidance regarding gutter spread calculation may be found in the latest edition of LTAP Stormwater Drainage Manual, available from the Local Technical Assistance Program (LTAP). At the time of printing of this document, contact information for LTAP was:

Indiana LTAP
Purdue University
Toll-Free: (800) 428-7369 (Indiana only)
Phone: (765) 494-2164
Fax: (765) 496-1176
Email: inltap@ecn.purdue.edu
Website: www.purdue.edu/INLTAP/

## I. INSTALLATION AND WORKMANSHIP

Bedding and backfill materials around storm sewer pipes, sub-drains, and the associated structures are limited to: #8 crushed stone, hand-tamped or walked-in; “B” borrow, compacted to 95% Standard Proctor density; flowable fill; and native or structural backfill, compacted to 95% Standard Proctor density. The specific location requirements for the use of these materials are dependent on pipe location in relation to pavement structures and on pipe material as detailed in Figure 4-1 and Figure 4-2. The specifications for the construction of storm sewers and sub-drains, including backfill requirements, shall not be less stringent than those set forth in the latest edition of the INDOT, "Standard Specifications". Additionally, ductile iron pipe shall be laid in accordance with American Water Works Association (AWWA) C-600 and clay pipe shall be laid in accordance with either American Society of Testing Materials (ASTM) C-12 or the appropriate American Association of State Highway and Transportation Officials (AASHTO) specifications. Dips/sags on newly installed storm systems will not be allowed. Also, infiltration from cracks, missing pieces, and joints would not be allowed. Variations from these standards must be justified and receive written acceptance from the City of Angola.

The point of commencement for laying a storm sewer pipe shall be the lowest point in the proposed sewer line. All pipes shall be laid, without break, upgrade from structure to structure. Bedding and backfill materials around storm sewer pipes, sub-drains, and the associated structures shall be per Figures 4-1 and 4-2.

Dips/sags on newly installed storm systems will not be allowed. Also, infiltration from cracks, missing pieces, and joints will not be allowed. Variations from these standards must be justified and receive written acceptance from the *City of Angola*. To verify that all enclosed drains and sewers are functioning properly, all storm sewers including sub-drains shall be cleaned and televised with visual recordings (via closed circuit television). Two visual recordings will be scheduled, 30 days after installation and at least 90 days prior to the expiration of the maintenance bond. Reports summarizing the results of the noted visual recordings shall be reviewed and accepted by the *City of Angola* before maintenance sureties would be recommended to be released.

Based on the review of visual recordings, the *City of Angola* shall determine the need for additional inspection of the storm sewers or sub-drains to assess the condition of the system. Newly installed storm systems covered under the maintenance bond shall meet the minimum requirements established in the AASHTO Culvert and Storm Drain Inspection Guide constituting a Condition Rating of 1 or “Good” as defined in Section 4, Condition Rating System and as established below in **Table 4-4.**

**TABLE 4-4**

| Pipe Inspection Criteria | |
|---|---|
| ***Material*** | ***(1) Good Rating Condition*** |
| HDPE, PVC or PP | Barrel maintains round shape with less than 5% vertical deformation of original ID. No indication of wear, abrasion, splits or cracking. |
| Concrete | No measurable crack width greater than 0.01 in. No spalling, slabbing, delamination, scaling or abrasion. |
| CMP | Barrel maintains round shape with less than 5% vertical deformation of inside diameter. No dents, rust, abrasion or localized damage. |

## J. MATERIALS

Storm sewer manholes and inlets shall be constructed of cast in place concrete or pre-cast reinforced concrete. Material and construction shall conform to the latest edition of the Indiana Department of Transportation (INDOT) "Standard Specifications", Sections 702 and 720.

Pipe and fittings used in storm sewer construction shall conform to the latest edition of the INDOT "Standard Specifications", Section 907 and 908. In addition, ductile iron pipe and fittings shall conform to AWWA C-151. Polyethylene pipe used for private storm sewers shall conform to ASTM F2648 or INDOT specifications. Other pipe and fittings not specified herein or in Sections 907-908 of the latest edition of the INDOT "Standard Specifications" may be used only when specifically authorized by the *City of Angola*. Pipe joints shall be flexible and leak resistant as defined in AASHTO R82, with a maximum leakage rate of 200 gal/in.-dia/mi/day. **If the storm sewer pipe is to be placed within a road right-of-way or in an area subject to loading, the pipe and fittings shall be reinforced concrete (RCP) or corrugated polypropylene (CPP).**

## K. SPECIAL HYDRAULIC STRUCTURES

Special hydraulic structures required to control the flow of water in storm runoff drainage systems include junction chambers, drop manholes, stilling basins, and other special structures. The use of these structures shall be limited to those locations justified by prudent planning and by careful and thorough hydraulic engineering analysis. Certification of special structures by a certified Structural Engineer may also be required.

## L. CONNECTIONS TO STORM SEWER SYSTEM

Engineer shall approve any connections to the storm sewer system.

1. **Sump pumps** installed to receive and discharge groundwater or other stormwater shall be connected to a sub-surface drain provided by the developer. A stormwater sump pump shall only be used for the discharge of stormwater.

2. **Footing drains and perimeter drains** shall be discharged over land where possible, or connected to storm manholes or curb inlets if approved by the City.

3. All **roof downspouts**, roof drains, or roof drainage piping of residential developments shall discharge onto the ground and shall not be directly connected to the storm drainage system. Variation from this requirement may be requested and granted by the *City of Angola* in special circumstances. No downspouts or roof drains shall be connected to the sanitary sewers.

4. **Garage and Basement floor drains** shall not be connected to the storm sewers. These drains may be routed to a properly designed wet well.

5. **Swimming Pool drains** shall not be connected to the storm sewers.

In addition, none of the above-mentioned drains shall be connected to any road sub-drain/street underdrains, unless requested as a variance and specifically authorized by the *City of Angola*. Sub-drains may be installed on all new developments as approved by Engineer.

## M. DRAINAGE SYSTEM OVERFLOW DESIGN

Overflow path/ponding areas throughout the development resulting from a 100-year storm event, calculated based on all contributing drainage areas, on-site and off-site, in their proposed or reasonably anticipated land use and with storm pipe system assumed full at the beginning of the design storm. The centerline of this 100-year overflow path shall be clearly shown as a distinctive hatched area on the plans, and a minimum width of 30 feet flow width along the centerline of the flow path (15 feet from centerline on each side) designated as permanent drainage easements. A continuous flood route from the sag inlets to the final outfall shall be shown and the minimum 30-feet along the centerline contained within an easement or road right-of-way regardless of the 100-year storm event ponding elevation. No fences or landscaping should be constructed within the easement areas. These areas are easements that are to be maintained by the property owners or be designated as common areas to be maintained by the homeowners association.

The minimum adjacent grade of the portion of any residential, commercial, or industrial building (the ground elevation next to the building after construction is completed that sits adjacent to the emergency flood route or may be subject to flooding by the emergency flood route) shall be a minimum of 1 foot above the estimated 100-year elevation of the emergency flood route assuming that all stormwater pipes are fully clogged. The required minimum adjacent grade of buildings adjacent to an overflow path is provided in **Table 4-5** or as alternatively calculated as discussed below.

**TABLE 4-5**

| Minimum Building Adjacent Grade with Respect to Overflow Path Invert Elevations | | |
|---|---|---|
| **Drainage Area (Acres)** | **Minimum Building Adjacent Grade Above Overflow Path Invert (Feet)[1]** | **Minimum Building Adjacent Grade Above Overflow Path Invert, if Overflow Path is in the Street (Feet)[1]** |
| Up to 5 | 2.50 | 1.50 |
| 6-10 | 3.00 | 1.50 |
| 11-15 | 3.25 | 1.75 |
| 16-20 | 3.50 | 1.75 |
| 21-30 | 4.00 | 2.00 |
| 30-50 | 4.25 | 2.00 |

*Notes: [1] The overflow path Invert refers to the elevation of the flow line of the emergency flow route (typically in the form of a channel, swale, or gutter) nearest to the upstream end of a building*

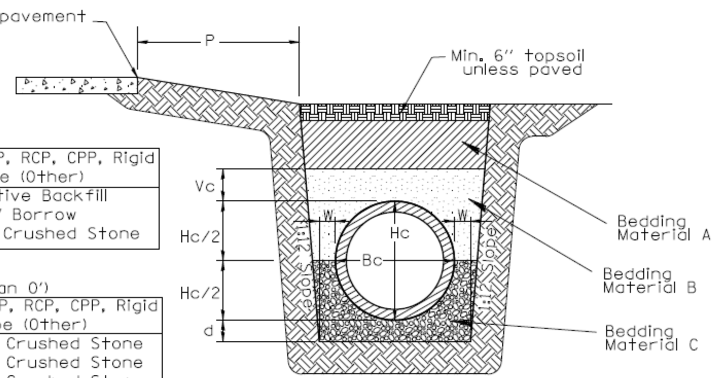
As an alternative to using default values in Table 4-5, the overflow path/ponding may be modeled as successive series of natural ponds and open channel segments. For simplification, occasional ponding along the overflow path may be ignored. If explicitly modeled, ponds should be modeled similar to that discussed for modeling depressional areas in Chapter 6. Channels should be modeled according to modeling techniques discussed in Chapter 5. The calculations for determining the 100-year overflow path/ponding elevations may be based on hand calculation methods utilizing normal depth calculations and storage routing techniques or performed by computer models. Examples of computer models that either individually or in combination with other models can handle the required computations include TR-20 and HEC-HMS, combined with HEC-RAS. Other models may be acceptable on a case-by-case basis.

Simply using the values in Table 4-5 is preferred over the much more complicated detailed modeling of the overflow/ponding areas. However, regardless of the methodology used, the *City of Angola* reserves the right to require independent calculations to verify that the proposed building minimum adjacent grade facing the flood route or the portion of building having a potential to be subject to flooding by the flood route provide adequate freeboard above the anticipated overflow path/ponding elevations.

The Lowest Adjacent Grade (LAG) requirements for buildings adjacent to other flooding sources are discussed in Chapter 10 of this Manual. In case there is more than one flooding source applicable to a building site, the highest calculated LAG for the building shall govern the placement of the building on that site.

In the case of existing upstream detention, an allowance equivalent to the reduction in flow rate provided may be made for upstream detention only when: (1) such detention and release rate have previously been accepted by the *City of Angola* or other official charged with the approval authority at the time of the acceptance, and (2) evidence of its construction and maintenance can be shown.

**FIGURE 4-1**
**Bedding and Backfill Standards for Storm Sewers**




Bedding Material Designation
(P greater than 5')

| | PVC, HDPE | CMP, RCP, CPP, Rigid Pipe (Other) |
|---|---|---|
| Material A | Native Backfill | Native Backfill |
| Material B | #8 Crushed Stone | "B" Borrow |
| Material C | #8 Crushed Stone | #8 Crushed Stone |

Bedding Material Designation
(P less than than 5', but greater than 0')

| | PVC, HDPE | CMP, RCP, CPP, Rigid Pipe (Other) |
|---|---|---|
| Material A | #8 Crushed Stone | #8 Crushed Stone |
| Material B | #8 Crushed Stone | #8 Crushed Stone |
| Material C | #8 Crushed Stone | #8 Crushed Stone |

Bedding Material Designation
(Pipe Under Pavement or Driveway)

| | PVC, HDPE | CMP, RCP, CPP, Rigid Pipe (Other) |
|---|---|---|
| Material A | Pipe Not Allowed | #8 Crushed Stone |
| Material B | | #8 Crushed Stone |
| Material C | | #8 Crushed Stone |

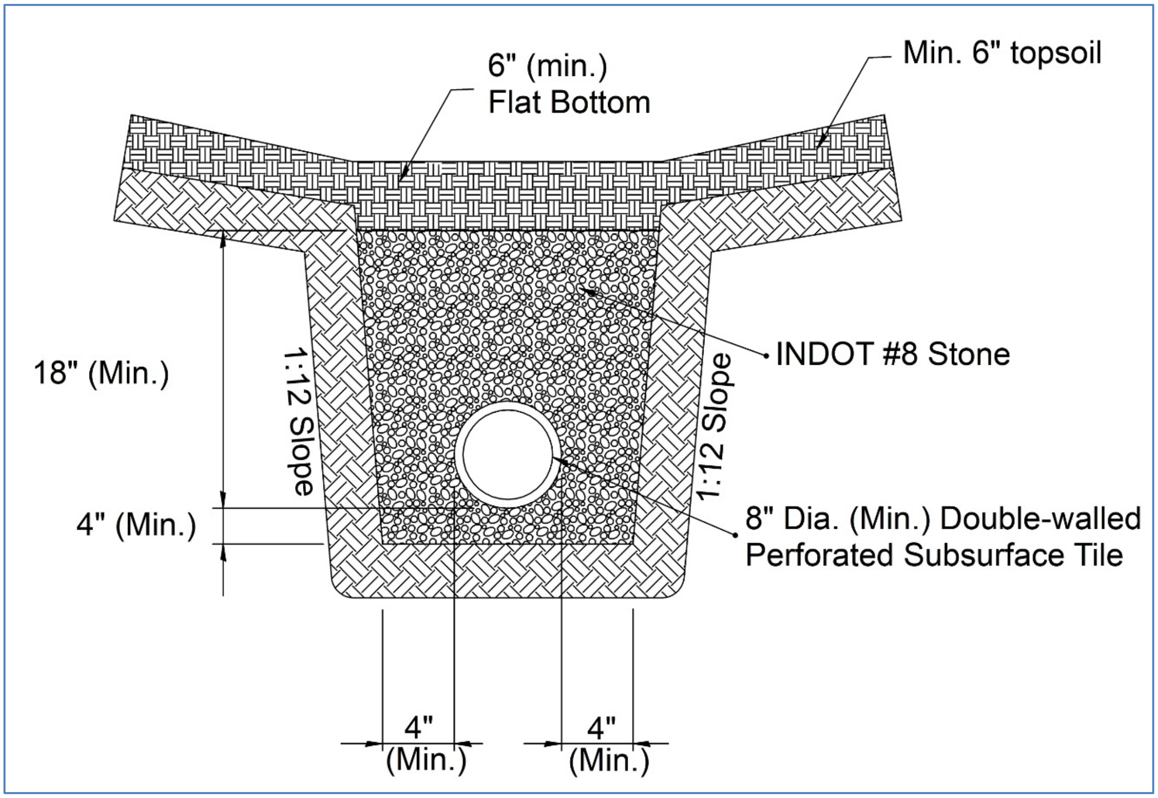
LEGEND

P = Distance from edge of pavement
Hc = Outside diameter or rise
Bc = Outside diameter or span
d = Depth of bedding material below pipe
= 8" min. for fill height up to 16'
= 12" min for fill height of 16' or more
Vc = 12" for Bc up to 18"
= 18" for Bc > 18"
W = 0.3 Bc or 9", whichever is greater

NOTES:

1. INDOT Type 1 pipe required for storm sewers/culverts under pavement
2.. INDOT Type 2 pipe required for storm sewers/culverts outside of pavement
3. All bedding shall be installed in 6" to 12" balanced lifts
4. For backfill purposes, paved shoulders, curbs, gutters, and sidewalkss are considered pavement
5. Flowable backfill shall be encased by a minimum of 2 feer of compacted earth backfill
6. CPP stands for "Corrugated Polypropylene Pipe", Rigid Pipe (Other) includes DIP, VCP, etc.

**FIGURE 4-2**
**Bedding and Backfill Standards for Sub-drains under Swales**



# Chapter Five

# OPEN CHANNEL DESIGN STANDARDS AND SPECIFICATIONS

All channels, whether private or public, and whether constructed on private or public land, shall conform to the design standards and other design requirements contained herein. Unless specifically referenced in a particular provision, the standards contained in this Chapter refer to open channels and not swales. Proposed open channels must be sized and designed to convey at least the 10-year frequency on-site stormwater runoff, as well as the anticipated 10-year frequency tributary off-site stormwater runoff based on the future developed condition (using Table 6-1 of the Technical Standards). An analysis of the emergency routing of stormwater runoff through the subject development must be provided to confirm that the development will not obstruct the free flow of floodwaters from the tributary off-site property in its current condition and after development. In addition, the Drainage System Overflow Design must be completed in accordance with Section M of Chapter 4 to ensure the safe routing of flood waters through the subject development with the tributary off-site property in its current condition and after development.

## A. DESIGN STORM FREQUENCIES

1. All channels and swales shall accommodate, as a minimum, peak runoff from a 10-year return frequency storm calculated based on methodology described in Chapter 2.

2. Channels with a carrying capacity of more than 30 cfs at bank-full stage shall be capable of accommodating peak runoff for a 50-year return frequency storm within the drainage easement.

3. Channel facilities functioning as a major drainage system, as defined in **Appendix A**, must also meet IDNR design standards in addition to the *City of Angola* standards. In case of discrepancy, the most restrictive requirements shall apply.

4. The 10-year storm design flow for residential rear and side lot swales shall not exceed 4 cfs. Unless designed as a Post-construction stormwater quality BMP, the maximum length of rear and side lot swales before reaching any inlet shall not exceed 400 feet.

5. Regardless of minimum design frequencies stated above, the performance of all parts of drainage system shall be checked for the 100-year flow conditions to ensure that all buildings are properly located outside the 100-year flood boundary and that flow paths are confined to designated areas with sufficient easement.

6. A minimum of 10 feet from top of the bank on each side of a new channel shall be designated on the recorded plat as a Drainage Easement. No landscaping is allowed within any Drainage Easement, except for a filter strip or suitable grass that shall be installed along the top of bank.

## B. DETERMINATION OF CHANNEL WATERWAY AREA USING MANNING'S EQUATION

The waterway area for channels shall be determined using Manning's Equation, where:

$$A = Q/V$$

A = Waterway area of channel in square feet

Q = Discharge in cubic feet per second (cfs)

V = Steady-State channel velocity, as defined by Manning's Equation (See Chapter 4)

## C. BACKWATER METHOD FOR DRAINAGE SYSTEM ANALYSIS

The determination of 100-year water surface elevation along channels and swales shall be based on accepted methodology and computer programs designed for this purpose. Computer programs HEC-RAS, HEC-2, and ICPR are preferred programs for conducting such backwater analysis. The use of other computer models must be accepted in advance by the *City of Angola*.

## D. CHANNEL CROSS-SECTION AND GRADE

1. The required channel cross-section and grade are determined by the design capacity, the material in which the channel is to be constructed, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains, tributary ditches, or streams. The channel grade shall be such that the velocity in the channel is high enough to prevent siltation but low enough to prevent erosion. Velocities less than 2 feet per second for the design storm are not acceptable, as siltation will take place and ultimately reduce the channel cross-section area. The maximum permissible velocities in vegetated-lined channels are shown in **Table 5-1.** In addition to existing runoff, the channel design should incorporate increased runoff due to the proposed development.

2. Where depth of design flow is slightly below critical depth, channels shall have freeboard adequate to cope with the effect of hydraulic jumps.

3. Along the streets and roads, the bottom of the ditch should be low enough to install adequately sized driveway culverts without creating "speed bumps". The driveway culvert inverts shall be designed to adequately consider upstream and downstream culvert elevations. Use of open channels and swales within the road right of way is only allowed in special circumstances when no other viable option exists. The applicant must consult with the *City of Angola* Engineer prior to design.

4. Flow of a channel into a closed system is prohibited, unless runoff rate and head loss computations demonstrate the closed conduit to be capable of carrying the 100-year channel flow for developed conditions, either entirely or in combination with a defined overflow channel, with no reduction of velocity.

**TABLE 5-1**

| Maximum Permissible Velocities in Vegetal-Lined Channels **(1)** | | | |
|---|---|---|---|
| *Cover* | *Channel Slope Range (Percent)* **(3)** | *Permissible Velocity* **(2)** | |
| | | *Erosion Resistant Soils (ft. per sec.)* **(4)** | *Easily Eroded Soils (ft. per sec.)* **(4)** |
| Bermuda Grass | 0-5<br>5-10<br>Over 10 | 8<br>7<br>6 | 6<br>5<br>4 |
| Bahia<br>Buffalo Grass<br>Kentucky Bluegrass<br>Smooth Brome<br>Blue Grama | 0-5<br>5-10<br>Over 10 | 7<br>6<br>5 | 5<br>4<br>3 |
| Grass Mixture<br>Reed Canary Grass | **(3)** 0-5<br>5-10 | 5<br>4 | 4<br>3 |
| Lespedeza Sericea<br>Weeping Lovegrass<br>Yellow Bluestem<br>Redtop<br>Alfalfa<br>Red Fescue | **(4)**<br>0-5<br>5-10 | 3.4 | 2.5 |
| Common<br>Lespedeza **(5)**<br>Sudangrass **(5)** | **(6)**<br>0-5 | 3.5 | 2.5 |

**(1)** From Soil Conservation Service, SCS-TP-61, "Handbook of Channel Design for Soil and Water Conservation".
**(2)** Use velocities exceeding 5 feet per second only where good channel ground covers and proper maintenance can be obtained.
**(3)** Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
**(4)** Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
**(5)** Annuals - use on mild slopes or as temporary protection until permanent covers are established.
**(6)** Use on slopes steeper than 5 percent is not recommended.

## E. SIDE SLOPES

1. Earthen channel side slopes shall be no steeper than 3 horizontal to 1 vertical (3:1). Flatter slopes may be required to prevent erosion and for ease of maintenance.
2. Where channels will be lined with riprap, concrete, or other acceptable lining method, side slopes shall be no steeper than 2 horizontal to 1 vertical (2:1) with adequate provisions made for weep holes.
3. Side slopes steeper than 2 horizontal to 1 vertical (2:1) may be used for lined channels provided that the side lining is designed and constructed as a structural retaining wall with provisions for live and dead load surcharge.
4. When the design discharge produces a depth of greater than three (3) feet in the channel, appropriate safety precautions shall be added to the design based on reasonably anticipated safety needs at the site.

## F. CHANNEL STABILITY

1. Characteristics of a stable channel are:

   a. It neither promotes sedimentation nor degrades the channel bottom and sides.
   b. The channel banks do not erode to the extent that the channel cross-section is changed appreciably.
   c. Excessive sediment bars do not develop.
   d. Excessive erosion does not occur around culverts, bridges, outfalls or elsewhere.
   e. Gullies do not form or enlarge due to the entry of uncontrolled flow to the channel.

2. Channel stability calculations shall be provided.

## G. DRAINAGE OF SWALES

All swales shall meet the following requirements and the specifications of the *City of Angola* or designee:

1. Minimum swale flow line slopes are 0.5%. The side slopes of swales shall not be steeper than a 3 (horizontal) to 1 (vertical) slope.

2. Maximum swale flow line slopes are 7%.

3. All flow shall be confined to the specific easements associated with each rear and side lot swale that are part of the minor drainage system.

4. Vegetated swales may have a double-walled 8-inch sub-surface drain with a minimum cover of 18 inches to dry the swales. Typical detail of a swale with sub-surface drain is shown on Figure 4-2. Tile lines may be outletted through a drop structure at the ends of the swale or through a standard tile outlet.

5. A minimum of 10 feet from top of the bank on each side of the swale shall be designated on the recorded plat as a Drainage Easement.

6. Further guidance regarding this subject may be found in the latest edition of the Indiana Drainage Handbook.

## H. APPURTENANT STRUCTURES

The design of channels will include provisions for operation and maintenance and the proper functioning of all channels, laterals, travelways, and structures associated with the project. Recessed inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the design of channel improvements. The design will also provide for necessary floodgates, water level control devices, and any other appurtenance structure affecting the functioning of the channels and the attainment of the purpose for which they are built.

The effects of channel improvements on existing culverts, bridges, buried cables, pipelines, and inlet structures for surface and subsurface drainage on the channel being improved and laterals thereto shall be evaluated to determine the need for modification or replacement. Culverts and bridges which are modified or added as part of channel improvement projects shall meet reasonable standards for the type of structure and shall have a minimum capacity equal to the design discharge or governmental agency design requirements, whichever is greater.

## I. DISPOSAL OF SPOIL

Spoil material resulting from clearing, grubbing, and channel excavation shall be disposed of in a manner that will:

1. Minimize overbank wash.

2. Provide for the free flow of water between the channel and floodplain boundary unless the valley routing and water surface profiles are based on continuous dikes being installed.

3. Not hinder the development of travelways for maintenance.

4. Leave the right-of-way in the best condition feasible, consistent with the project purposes, for productive use by the owner.

5. Be accepted by the IDNR or COE, if applicable.

## J. MATERIALS

Materials acceptable for use as channel lining are:

1. Grass
2. Revetment Riprap
3. Concrete
4. Hand Laid Riprap
5. Precast Cement Concrete Riprap
6. Gabions
7. Straw, Coconut Mattings, or other accepted material (only until grass is established)

Other lining materials must be accepted in writing by the *City of Angola*. Materials shall comply with the latest edition of the INDOT, "Standard Specifications".

## K. DRAINAGE SYSTEM OVERFLOW DESIGN

See Chapter 4, Section M.

# Chapter Six

## STORMWATER DETENTION DESIGN STANDARDS

Basins shall be constructed to retain and/or temporarily detain the stormwater runoff that exceeds the maximum peak release rate authorized by the Ordinance and these technical standards. The required volume of storage provided in these basins, together with such storage as may be authorized in other on-site facilities, shall be sufficient to control excess runoff from the 10-year or 100-year storm as explained below in Section B. Also, basins shall be constructed to provide adequate capacity to allow for sediment accumulation resulting from development and to permit the pond to function for reasonable periods between cleanings.

### A. ACCEPTABLE DETENTION FACILITIES

The increased stormwater runoff resulting from a proposed development should be retained (if possible) and detained on-site (if retention is not feasible due to limited infiltration capacity) by the provisions of appropriate above- or below-ground wet bottom or dry bottom detention facilities, parking lots, or other acceptable techniques. Measures that retard the rate of overland flow and the velocity in runoff channels shall also be used to partially control runoff rates.

### B. ALLOWABLE RELEASE RATES

1. General Release Rates
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.

If the downstream receiving channel or pipe is inadequate to accommodate the post-developed flow, then the release rate must be further reduced.

The minimum allowable orifice size is 4 inches in diameter. When an orifice is less than 12-inches, an anti-clog device is required.

For sites where the pre-developed area has more than one (1) outlet, the release rate should be computed based on pre-developed discharge to each outlet point. The computed release rate for each outlet point shall not be exceeded at the respective outlet point even if the post-developed conditions would involve a different arrangement of outlet points.

2. Management of Off-site Runoff
Runoff from all upstream tributary areas (off-site land areas) may be bypassed around the retention/detention facility without attenuation. Such runoff may also be routed through the detention/retention facility, provided that a separate outlet system or channel is incorporated for the safe passage of such flows, i.e., not through the primary outlet of a detention facility. Unless the pond is being designed as a regional detention facility, the primary outlet structure shall be sized and the invert elevation of the emergency overflow weir determined according to the on-site runoff only. Once the size and location of primary outlet structure and the invert elevation of the emergency overflow weir

are determined by considering on-site runoff, the 100-year pond elevation is determined by routing the entire inflow, on-site and off-site, through the pond.

Note that the efficiency of the retention/detention facility in controlling the on-site runoff may be severely affected if the off-site area is considerably larger than the on-site area. As a general guidance, on-line detention may not be effective in controlling on-site runoff where the ratio of off-site area to on-site area is larger than 5:1. Additional detention (above and beyond that required for on-site area) may be required by the *City of Angola* when the ratio of off-site area to on-site area is larger than 5:1.

3. Downstream Restrictions
   In the event the downstream receiving channel or storm sewer system is inadequate to accommodate the post-developed release rate provided above, then the allowable release rate shall be reduced to that rate permitted by the capacity of the receiving downstream channel or storm sewer system. Additional detention, as determined by the *City of Angola*, shall be required to store that portion of the runoff exceeding the capacity of the receiving sewers or waterways. When such downstream restrictions are suspected, the *City of Angola* may require additional analysis to determine the receiving system's limiting downstream capacity.

   If the proposed development makes up only a portion of the undeveloped watershed upstream of the limiting restriction, the allowable release rate for the development shall be in direct proportion to the ratio of its drainage area to the drainage area of the entire watershed upstream of the restriction.

## C. GENERAL DETENTION BASIN DESIGN REQUIREMENTS

1. The retention/detention facility shall be designed in such a manner that a minimum of 90% of the maximum volume of water stored and subsequently released at the design release rate (if not retaining the entire peak flow rate volume) shall not result in a storage duration in excess of 48 hours from the start of the storm unless additional storms occur within the period. In other words, the design shall ensure that a minimum 90% of the original retention/detention capacity is restored within 48 hours from the start of the design 100-year storm.

2. The 100-year elevation of stormwater retention/detention facilities shall be separated by not less than 25 feet from any building or structure to be occupied. The Lowest Adjacent Grade (including walkout basement floor elevation) for all residential, commercial, or industrial buildings shall be set a minimum of 2 feet above the 100-year pond elevation or 2 feet above the emergency overflow weir elevation, whichever is higher. In addition to the Lowest Adjacent Grade requirements, any basement floor must be at least a foot above the normal water level of any wet-bottom pond or the local groundwater table, whichever is higher, to avoid the overuse of sump pumps and frequent flooding of the basement.

3. No detention facility or other water storage area, permanent or temporary, shall be constructed under or within ten (10) feet of any pole or high voltage electric line. Likewise, poles or high voltage electric lines shall not be placed within ten (10) feet of any detention facility or other water storage area.

4. Detention facilities shall be separated from parking lots and roadways by an appropriately selected and designed method of safety barrier, such as guard rails, bollards, or other physical barriers capable of deterring the passage of a vehicle into the pond.

5. Slopes no steeper than 3 horizontal to 1 vertical (3:1) for safety, erosion control, stability, and ease of maintenance shall be permitted.

6. Safety screens having a maximum opening of four (4) inches shall be provided for any pipe or opening end sections 12-inch in diameter or larger. Storm drain pipes outletting into the pond shall not be submerged.

8. Outlet control structures shall be designed to operate as simply as possible and shall require little or no maintenance and/or attention for proper operation. For maintenance purposes, the outlet from the pond (if any) shall be a minimum of 0.5 foot above the normal water level of the receiving water body. They shall limit discharges into existing or planned downstream channels or conduits so as not to exceed the predetermined maximum authorized peak flow rate. If an outlet control structure includes an orifice to restrict the flow rate, such orifice shall be no less than 4 inches in diameter.

9. Off-site flows greater than the allowable release rate for the facility shall be conveyed through the emergency spillway, not through the primary outlet structure. Unless the pond is being designed as a regional detention facility, the primary outlet structure shall be sized and the invert elevation of the emergency overflow weir determined according to the on-site runoff only and all other flows shall be either retained or safely bypassed through the emergency overflow weir.

   An emergency overflow/spillway shall be designed for the release of exceptional storm runoff or in emergency conditions should the normal discharge devices become totally or partially inoperative. The overflow facility shall be of such design that its operation is automatic and does not require manual attention. At a minimum, emergency spillways shall be capable of handling 125% of the peak inflow into the pond resulting from the 100-year storm event from the entire contributing watershed in the post-developed condition.

10. Grass or other suitable vegetative cover shall be provided along the banks of the retention/detention storage basin. Vegetative cover around detention facilities should be maintained as appropriate.

11. Debris and trash removal and other necessary maintenance shall be performed on a regular basis to assure continued operation in conformance to design.

12. For ponds serving residential properties, residential lots or any part thereof shall be used for any part of a detention basin assumed full to the 100-year water surface elevation or the emergency overflow weir elevation, whichever is higher. Detention basins, assumed full to the 100-year water surface elevation or the emergency overflow weir elevation, whichever is higher, shall be placed within a common area.

13. For ponds serving non-residential properties, a minimum of twenty (20) feet horizontally from the top of bank of the facility, or the 100-year pool if no defined top of bank is present, shall be dedicated as permanent stormwater easement.

14. No trees shall be planted within 50 feet of any pipe outlet entering the pond or the outlet for the pond.

15. In addition, an exclusive easement to assure access to the pond from an adjacent public street/road right of way shall be required. No above-ground utilities or other obstruction that may hinder access shall be allowed within this exclusive access easement. Additional access easements may be required for larger ponds.

## E. ADDITIONAL REQUIREMENTS FOR WET-BOTTOM FACILITY DESIGN

Where part of a detention facility will contain a permanent pool of water, all the items required for detention storage shall apply. Also, a controlled positive outlet will be required to maintain the design water level in the wet bottom facility and provide required detention storage above the design water level. However, the following additional conditions shall apply:

1. Facilities designed with permanent pools or containing permanent lakes shall have a water area of at least one-half (0.5) acre with a minimum depth of eight (8) feet over the majority of pond area. If fish are to be used to keep the pond clean, a minimum depth of approximately ten (10) feet shall be maintained over at least 25 percent of the pond area. The remaining pond area shall have no extensive shallow areas, except as required to install the safety ramp, maintenance ledge, and BMPs as required below. Construction trash or debris shall not be placed within the permanent pool.

2. All wet detention/retention ponds must be constructed in as natural a shape (footprint) as possible. If native vegetation is planted on the pond banks, signage must be provided indicating that it is a natural "Do Not Mow" area. The vegetation should be planted in a manner so as not to hide or disguise the pond's edge. Maintenance of the vegetated barrier shall be the responsibility of the owner or the homeowners' association. All pond slopes shall be 3:1 (horizontal to vertical) or flatter.

3. A maintenance ledge six (6) feet in width is required and shall be installed approximately 18 inches above the permanent water level of wet-bottom detention facilities. Side slopes above the maintenance ledge (except for the safety ramp area) shall be 3:1 or flatter.

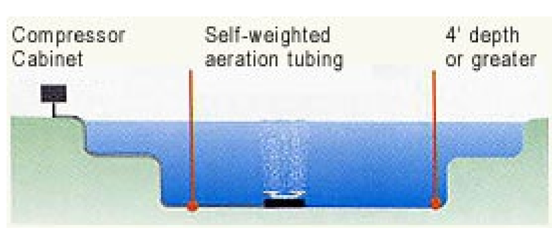
4. If a retaining wall is used below the normal pool of wet detention pond, the wall shall have either steps or a ladder incorporated into the construction at the center of the wall span.

4. A safety ramp exit from the wet bottom facilities shall be required in all cases and shall have a minimum width of twenty (20) feet and exit slope of 6 horizontal to 1 vertical (6:1). The safety ramp shall be constructed of suitable material to prevent structural instability due to vehicles or wave action. Adequate access to the safety ramp shall be provided by locating it adjacent to public right-of-way or by providing a clear route recorded within an access easement or a common area.

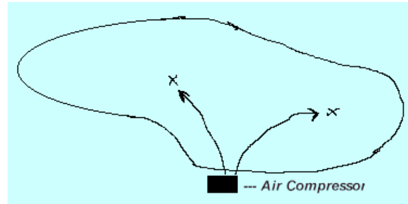
5. Periodic maintenance is required in lakes to control weed and larval growth. The facility shall also be designed to provide for the easy removal of sediment that will accumulate during periods of reservoir operation. A means of maintaining the designed water level of the lake during prolonged periods of dry weather may also be required.

6. For maintenance purposes, the outlet of storm sewers entering the pond shall be a minimum of 0.5 foot above the normal pool level.

7. Methods to prevent pond stagnation, including but not limited to surface or sub-surface aeration or destratification facilities that can, at the minimum, achieve one complete pond volume turnover per day should be considered. Figure below shows a typical diffuser aeration system that consists of a quiet air compressor at the shore, aeration tubing, and one or more sets of diffuser head(s).




Irregularly shaped ponds should be treated as two or three separate ponds. Likewise, larger ponds will also need multiple aeration units.




Design calculations to substantiate the effectiveness of proposed aeration facilities shall be submitted with final engineering plans. Design calculations should, at a minimum, indicate that the device and/or series of devices are providing a minimum volume turnover of once per 24 hours over the majority of the pond volume (i.e. pump radius of influence calculations, etc.). Agreements for the perpetual operation and maintenance of aeration facilities by the property owner or the HOA shall be prepared similar to that noted for post-construction BMPs noted in Chapter 8 of these Technical Standards.

If the detention pond is also proposed to be used as a post-construction stormwater BMP, alternative means of aeration (such as diffuser aeration systems) shall be used that would not result in re-suspension of sediment particles and would not prevent the efficient settling of sediment particles.

11. If the facility is being located near an airport, a minimum horizontal separation distance between the airport property and the pond will need to be provided in accordance to Federal Aviation Administration (FAA) advisory Circular 150/5200-33, titled “Hazardous Wildlife Attractions On or Near Airports” and dated 8/28/2007, or the latest update of the same.

## F. ADDITIONAL REQUIREMENTS FOR DRY-BOTTOM FACILITY DESIGN

In addition to general design requirements, retention/detention facilities that will not contain a permanent pool of water shall comply with the following requirements:

1. Unless designed as a retention facility, a 6-inch underdrain with a minimum of 1.5 feet of cover shall be provided within all dry-bottom ponds. Additional provisions shall be incorporated into facilities for complete interior drainage of dry bottom facilities if needed, including the provisions of natural grades to outlet structures (if any), longitudinal and transverse grades to perimeter drainage facility, paved gutters, or the installation of subsurface drains. If a 6-inch underdrain with a minimum of 1.5 feet of cover is not feasible, one or more of the additional provisions shall be included in the design to ensure the complete interior drainage of the dry-bottom facility.

2. In excavated retention/detention facilities, a minimum side slope of 3:1 shall be provided for stability. In the case of valley storage, natural slopes may be considered to be stable.

## G. PARKING LOT STORAGE

Paved parking lots may be designed to provide temporary detention storage of stormwater on all or a portion of their surfaces. Outlets for parking lot storage of stormwater will be designed so as to empty the stored waters slowly. Depths of storage shall be limited to a maximum depth of seven (7) inches so as to prevent damage to parked vehicles and so that access to parked vehicles is not impaired. Ponding should in general, be confined to those positions of the parking lots farthest from the area served.

## H. DETENTION FACILITIES IN FLOODPLAINS

If detention storage is provided within a 100-year floodplain, only the net increase in storage volume above that which naturally existed on the floodplain shall be credited to the development. In order to be hydraulically effective, the rim elevation of such detention pond, including any open spillways, should be at or above the 100-year floodplain elevation and, unless the detention pond storage is provided entirely above the 100-year flood elevation, any pipe outlets must be equipped with a backflow prevention device. A detention pond constructed within the 100-year floodplain and utilizing a backflow prevention device will eliminate the floodplain storage that existed on the detention pond site and will therefore require compensatory floodplain storage. The detention analysis for a detention pond in the floodplain must consider appropriate tailwater impacts and the effect of any backflow prevention device.

## H. JOINT DEVELOPMENT OF CONTROL SYSTEMS

Stormwater control systems may be planned and constructed jointly by two or more developers as long as compliance with this Ordinance is maintained.

## I. DIFFUSED OUTLETS

When the allowable runoff is released in an area that is susceptible to flooding or erosion, the developer may be required to construct appropriate storm drains through such area to avert increased flood hazard caused by the concentration of allowable runoff at one point instead of the natural overland distribution. The requirement of diffused outlet drains shall be at the discretion of the *City of Angola*.

## J. IDNR REQUIREMENTS

Refer to floodplain requirement in Chapter 18.168 of the Angola Municipal Code.

## K. ALLOWANCE FOR SEDIMENTATION

Retention/detention basins shall be designed with an additional ten (10) percent of available capacity to allow for sediment accumulation resulting from development and to permit the pond to function for reasonable periods between cleanings. Basins should be designed to collect sediment and debris in specific locations, such as a forebay, so that removal costs are kept to a minimum. For wet-bottom ponds, the sediment allowance may be provided below the permanent pool elevation. No construction trash or debris shall be allowed to be placed within the permanent pool. If the pond is used as a sediment control measure during active construction, the performance sureties will not be released until sediment has been cleaned out of the pond and elevations and grades have been reestablished as noted in the accepted plans.

## L. MAINTENANCE

The routine maintenance of stormwater detention facilities (i.e. trash pickup, aeration, weed control, sediment removal, etc.) is the responsibility of the owner or Homeowners' Association.

# Chapter Seven

# CONSTRUCTION SITES STORMWATER POLLUTION PREVENTION STANDARDS

The requirements contained in this chapter are intended to prevent stormwater pollution resulting from soil erosion and sedimentation or from mishandling of solid and hazardous waste. Practices and measures included herein should assure that no foreign substance, (e.g., sediment, construction debris, chemicals) be transported from a site and allowed to enter any drainageway, whether intentionally or accidentally, by machinery, wind, rain, runoff, or other means.

## A. EROSION AND SEDIMENT CONTROL REQUIREMENTS

**General and Implementation Requirements** - The following general and implementation requirements apply to all land-disturbing activities and shall be considered in the preparation of a SWPPP within the corporate boundaries of the *City of Angola*.

1. Trained Individuals must be utilized for activities associated with the development and design of the SWPPP, stormwater measure implementation, and stormwater project management.

2. Minimize the potential for soil erosion by designing a development that fits the topography and soils of the site. Unless needed to meet requirements and goals of the development, steep slopes should be avoided, and natural contours should be followed.

3. All activities on a site should be conducted in a logical sequence and in accordance with the site's construction phasing plan so that the smallest practical area of land will be exposed for the shortest practical period of time during development.

4. The length and steepness of designed slopes should be minimized to reduce erosion potential. Drainage channels and swales must be designed and adequately protected so that their final gradients and resultant velocities will not cause erosion in the receiving channel or at the outlet. Methods for determining acceptable velocities are included in this Stormwater Technical Standards Manual as well as in the IDEM Stormwater Quality Manual.

5. Sediment-laden water which otherwise would flow from the project site shall be managed by appropriate erosion and sediment control measures to minimize sedimentation to receiving waters and adjacent properties as discussed in the IDEM Stormwater Quality Manual and other authoritative sources.

6. Public roadways and roadways not exclusive to construction traffic shall be kept cleared of accumulated sediment that is a result of runoff or tracking. The following minimum conditions are applicable:

   a. Clearing of sediment must not include the utilization of mechanical methods that will result in mobilization of dust off the project site or flushing the area with water unless the flushed water is directed to an appropriate sediment control measure.
   b. Cleared sediment must be redistributed or disposed of in a manner that is in accordance with all applicable statutes and regulations.
   c. Sediment discharged or tracked onto roadways that are open to traffic must be removed as directed by a regulatory authority or at a minimum, removed by the end of the same day.

7. Phasing of construction activities must be used, when feasible, to minimize the footprint of disturbed unstable areas.

8. Collected runoff leaving a project site must be either discharged directly into a well-defined, stable receiving channel, or diffused and released to adjacent property without causing an erosion or pollutant problem to the adjacent property owner.

9. Natural features, including wetlands and sinkholes, shall be protected from pollutants associated with stormwater runoff, through appropriate stormwater management and/or treatment measures.

10. Soil compaction is to be minimized, especially in areas where permanent vegetation will be re-established and/or areas that are designated to infiltrate stormwater for the post-construction phase.

11. Topsoil must be preserved, unless infeasible.

12. Existing natural buffers that are adjacent to waters of the state must be preserved to promote infiltration and provide protection of the water resource, unless infeasible. Activities performed by a county drainage board under IC 36-9-27 are excluded.

    a. Natural buffers must be preserved, including the entire buffer bordering and/or surrounding the water resource. Existing buffers:

        i. 50 feet or more in width must be preserved to a minimum of 50 feet.
        ii. less than 50 feet in width must be preserved in their entirety. May be enhanced with vegetation that is native and promotes ecological improvement and sustainability.

    b. Runoff directed to the natural buffer must be:

        i. treated with appropriate erosion and sediment control measures prior to discharging to the buffer.
        ii. managed with appropriate runoff control measures to prevent erosion from occurring within the buffer area.

    c. Further information regarding buffer requirements is contained in IDEM's "Implementation of Buffers" guidance document.

13. Minimize the generation of dust through dust suppression techniques to prevent deposition into waters of the state and areas located beyond the permitted boundaries of the site as discussed in the IDEM Stormwater Quality Manual and other authoritative sources.

14. A stable construction site access measure must be provided at all points of construction traffic ingress and egress to the project site. Where the selected measure is not effective, an alternative measure or additional controls must be utilized to minimize tracking. Alternative measures may include, but are not limited to, wheel wash systems and rumble strips.

15. During the period of construction activities, all stormwater management measures necessary to meet the requirements of this permit must be maintained. Alternative measures must be selected and implemented, as necessary.

16. Discharge water from dewatering of ground water from excavations, trenches, foundations, etc. must not be discharged when:

a. Sediment-laden water is not first directed to an appropriate sediment control measure or a series of control measures, as per IDEM Stormwater Quality Manual and other authoritative sources, that minimizes the discharge of the sediment.
b. A visible sheen and/or pollutants are present at a level that requires additional treatment and/or an alternate permit.

17. Appropriate measures must be implemented to eliminate wastes or unused building materials including, but not limited to garbage, debris, cleaning wastes, wastewater, concrete washout, mortar/masonry products, soil stabilizers, lime stabilization materials, and other substances from being carried from a project site by runoff or wind. Wastes and unused building materials must be managed and disposed of in accordance with all applicable statutes and regulations.

18. Construction and domestic waste must be managed to prevent the discharge of pollutants and windblown debris. Surplus plastic or hardened concrete/cementitious materials are not required to be placed in trash receptacles and are considered clean fill that may be reused, disposed of on-site, or recycled in accordance with applicable state and federal regulations. Management of waste materials may include, but are not limited to:

    a. Waste containers (trash receptacles), when selected to manage waste, must be managed to reduce the discharge of pollutants and blowing of debris. Receptacles that are not appropriately managed will require alternatives that include but are not limited to:

        i. A cover (e.g., lid, tarp, plastic sheeting, temporary roof) to minimize exposure of wastes to precipitation or
        ii. A similarly effective method designed to minimize the discharge of pollutants.

    b. Waste that is not disposed of in trash receptacles must be protected from exposure to the weather and/or removed at the end of the day from the site and disposed of properly.

19. Concrete and cementitious wash water areas, where cementitious fluids are permissible, must be identified for the site and the locations clearly posted. Wash water must be directed into leak-proof containers or leak-proof containment areas which are located and designed to divert runoff away from the measure and sized to prevent the discharge and/or overflow of the cementitious wash water. If not evaporated, wash water must be removed (pumped) for appropriate off-site disposal.

20. Fertilizer applications associated with the stabilization plan for the project must meet the following requirements:

    a. Apply fertilizer at a rate and amount as determined by a soil analysis or in accordance with the Indiana Stormwater Quality Manual or similar guidance documents.
    b. Apply fertilizer at an appropriate time of year for the project location, taking into consideration proximity to a waterbody, and preferably timed to coincide with the period of maximum vegetative uptake and growth.
    c. Avoid applying fertilizer immediately prior to precipitation events that are anticipated to result in stormwater runoff from the application area.

21. Proper storage and handling of materials, such as fuels or hazardous wastes, and spill prevention and clean-up measures must be implemented to minimize the potential for pollutants to contaminate surface or ground water or degrade soil quality. To meet this requirement:

    a. A spill prevention and response plan, meeting the requirements in 327 IAC 2-6.1, must be completed.
    b. Proper project management and the utilization of appropriate measures including, but not limited to, eliminating a source or the exposure of materials must be completed.

c. Manage the following activities:

   i. Fueling and maintenance of equipment.
   ii. Washing of equipment and vehicles.
   iii. Storage, handling, and disposal of construction materials, products, and wastes.
   iv. Application of pesticides, herbicides, insecticides, and fertilizers
   v. Dispensing and utilization of diesel fuel, oil, hydraulic fluids, other petroleum products, and other chemicals.
   vi. Handling and disposal of hazardous wastes, including, but not limited to paints, solvents, petroleum-based products, wood preservatives, additives, curing compounds, and acids.
   vii. Washing of applicators and containers used for paint, grout, or other materials.

22. Personnel associated with the project must be informed of the terms and conditions of this permit and the requirements within the SWPPP. The permittee shall document this process, and provide to the City upon request. Information must be provided through written notification, contracts, or other means (i.e., pre-construction meetings) that effectively communicates the provisions and requirements of the permit and SWPPP. Personnel may include, but are not limited to:

    a. General contractors, construction management firms, grading or excavating contractors, and trade industry representatives (i.e., concrete industry) associated with the overall project.
    b. Contractors or individual lot operators that have primary oversight on individual building lots.
    c. Those responsible for the implementation of the SWPPP, and the installation, repair, and maintenance of stormwater measures.
    d. Those responsible for the application and storage of treatment chemicals.
    e. Those responsible for administering the self-monitoring program (SMP).

23. A notice must be posted near the main entrance of the project site or at a publicly accessible location. For linear project sites, such as a pipeline or highway, the notice must be placed in a publicly accessible location near the project field office.

    The notice must be maintained in a legible condition and include:

    a. A copy of the completed IDEM NOI or a document, such as the Permit Summary Report & Notice of Sufficiency letter produced by IDEM's online ePortal system, that at a minimum contains the information referenced in Section 6 (c)1 of the *City of Angola* Stormwater Management Ordinance.
    b. The NPDES permit number(s), upon receipt.
    c. The location of the construction plan/SWPPP if the project site does not have an on-site location to store the plan.

24. The use of anionic polymers (cationic polymers are not authorized for use) on the project site are authorized for sediment control provided their use is in conformance with current State of Indiana standards and specifications and the use is identified in the stormwater pollution prevention plan (SWPPP). If use of a polymer is not in the SWPPP and is selected at a later date, notification to IDEM and the *City of Angola* is required. An email notification prior to the use of the polymer to the IDEM Stormwater Program is acceptable. For projects regulated by a MS4 notification must follow the local process for the use of polymers.

25. Restoration and/or clean-up may be required for those areas impacted by sediment or other pollutant discharges. These activities will be performed as directed by the inspecting authority and may require:

    a. Development and submittal of a removal and restoration plan to ensure the methodology chosen will not result in further degradation of the resource.
    b. Permission by a property owner when the restoration activity requires access to a property owned by another entity or individual.

c. Additional permits prior to initiation of the work.

**Stabilization Requirements -** The following stabilization requirements apply to all land-disturbing activities:

1. Un-vegetated areas that are left idle or scheduled to be left inactive must be temporarily or permanently stabilized with measures appropriate for the season to minimize erosion potential. To meet this requirement, the following apply:

   a. Stabilization must be initiated by the end of the seventh day the area is left idle. The stabilization activity must be completed within fourteen (14) days after initiation. Initiation of stabilization includes, but is not limited to, the seeding and/or planting of the exposed area and applying mulch or other temporary surface stabilization methods where appropriate. Areas that are not accessible due to an unexpected and disruptive event that prevents construction activities are not considered idle.
   b. Areas that have been compacted may be excluded from the stabilization requirement when the areas are intended to be impervious surfaces associated with the final land use, provided runoff from the area is directed to appropriate sediment control measures.

2. Final stabilization of a project site is achieved when:

   a. All land-disturbing activities have been completed and a uniform (evenly distributed, without large bare areas) perennial vegetative cover with a density of seventy percent (70%) has been established on all unpaved disturbed areas, and areas not covered by permanent structures, or equivalent permanent stabilization measures have been employed. This requirement does not apply to:

      i. Landscaping that is part of the final project plan is considered stable when the plan has been fully implemented and areas not being vegetated are stable with a non-erosive material and/or product.
      ii. Projects or specific stormwater measures that utilize native vegetation and/or special vegetative plantings that are either required by a water quality permit/authorization or part of the design and functionality of a stormwater measure provided the activity does not pose a threat that will result in off-site sedimentation.
      iii. Projects on land used for agricultural purposes when:
         a) Stabilization is completed in accordance with the above Stabilization Requirements (in 1. a. and b.) as land-disturbance progresses. Land that is returned to agricultural production must be temporarily or permanently seeded upon completing land-disturbing activities. Stabilization requirements may be waived by the inspecting authority if the project site does not pose a threat of discharging sediment.
         b) Disturbed areas, not previously used for agricultural production, such as filter strips, must be returned to their pre land disturbance use.

   b. Specific projects, due to function and/or operation, may necessitate that an area remain disturbed. Only the minimum operational area is allowed to remain disturbed. This option primarily applies to off-road recreational commercial operations but may apply to other land use types upon determination by the regulating entity.

**Design Requirements -** The following design requirements apply to all land-disturbing activities and shall be considered in the selection, design, and implementation of all stormwater quality and management measures contained in the SWPPP:

1. Sound engineering, agronomic, and scientific principles must be utilized for measures contained in the SWPPP.

2. Appropriate measures must be planned, designed, and installed as part of an erosion and sediment control system and in accordance with the site's construction phasing plan.

3. Stormwater runoff leaving the project site must be discharged in a manner that is consistent with this ordinance, state, or federal law.

4. Collected runoff leaving the project site must be directed to an established vegetated area, when feasible and applicable, to increase pollutant removal and maximize stormwater infiltration and then either discharged directly into a well-defined, stable receiving conveyance or diffused and released without causing erosion at the point of discharge.

5. Conveyance systems must be designed taking into consideration both peak flow and total volume and must be adequately protected so that their final gradients and resultant velocities are unlikely to cause erosion at the outlet or in the receiving channel, based on known conditions of the discharge at the time of design to accommodate post-construction conditions.

6. Sediment basins, where feasible, must withdraw water from the surface of the water column unless equivalent sediment reduction can be achieved by use of alternative measures. Alternative measures include but are not limited to increasing the basin length to width ratio to 4:1 or greater, implementation of porous baffles, use of flocculants/polymers, and/or phasing of project land disturbance that also incorporates a rapid stabilization program. During freezing conditions, the implementation of alternative withdrawal methods may be utilized.

**Monitoring and Management Requirements -** A trained individual, acceptable to the *City of Angola* shall monitor project construction and stormwater activities. These shall include:

1. A written evaluation of the entire project site, with the exception of those areas that are considered unsafe. The evaluation must be performed by a trained individual and completed:

    a. Twenty-four (24) hours prior to a qualifying precipitation event or by the end of the next business day following each measurable storm event (excludes accumulated snow events); which is defined as a precipitation accumulation equal to, or greater than, one-half (0.50) inch of rainfall within a 24-hour period. If no rain event occurs within the work week a minimum of one inspection must occur. In the event of multiple qualifying events during the work week, no more than three (3) inspections would be required to meet the self-monitoring commitment.
    b. At a minimum of one (1) time per month for specific areas within the project which are stabilized with permanent vegetative cover at seventy (70) percent density and/or erosion resistant armoring is installed. A reduction to once per month is also applicable for the entire project site for stabilized common areas, basins, conveyances, outfalls, and inactive building sites. Prior to reducing the monitoring to monthly, records must identify the area and the date the area became eligible for monthly monitoring. Weekly monitoring as identified in (a) above must resume if one or more of the following occurs:
        i. The vegetative cover fails or there is evidence of erosion in the identified area.
        ii. The *City of Angola* requires monitoring to resume.

2. A complete written evaluation report which must include:

    a. Name of the individual performing the evaluation, including printed name, title, and signature (electronic signatures are acceptable).

b. Date of the evaluation.

c. Amount of precipitation, when the evaluation is conducted after a measurable storm event. Recorded rainfall may be documented utilizing an on-site rain gauge or storm event information from a weather station that is representative of the project location.

d. Observations of project performance in relation to:
   i. Implementation of the stormwater pollution prevention plan.
   ii. Assessment of existing stormwater measures based on industry standards and maintenance standards as identified in Section 5. of the Site Improvement Permit Application Form (found in Appendix B1 of this document) to ensure each measure is operational and functioning properly.
   iii. Additional measures necessary in the event an existing measure fails or is not present in the landscape.
   iv. Impacts including, but not limited to, sediment discharges, erosion, discharges that results in bank erosion, and operational activities that have the potential to generate pollutants and unauthorized discharges.

e. Documentation of an actual discharge that is visible during the assessment, the location of the discharge and a visual description of the discharge. The visual description includes, but is not limited to, color (turbidity reading is an option), odor, floatables, settled/suspended solids, foam, oil sheen, and any other visible sign that may be attributed to operations occurring on the project site.

f. Detail of corrective action recommended and/or completed. Corrective action includes, but is not limited to:
   i. Repairing, modifying, or replacing any stormwater management measure.
   ii. Clean-up and proper disposal of spills, releases, or other deposits.
   iii. Remedying a permit violation.
   iv. Taking reasonable steps to remediate, minimize or prevent the discharge of pollutants associated with the construction activity until a permanent corrective solution is initiated.
   v. Restoring an impacted area and/or removing accumulated sediment, provided appropriate permission and permits are obtained to conduct the activity.

g. A timeline for which the corrective action will occur to remediate the discharge of pollutants. The established corrective action, at a minimum, must be initiated:
   i. On the day the deficiency was discovered or when it is not practical to initiate on the discovery date, no later than forty- eight (48) hours for the repair of a measure or installation of a temporary measure until a new and/or replacement measure is installed as specified in item ii) below.
   ii. Within seven (7) days of discovery for the installation of a new (alternative) measure or replacement of an existing measure unless a shorter timeframe is required as part of a regulatory inspection. The inspecting authority may also allow additional time to take corrective action.
   iii. If corrective action cannot be achieved within the timelines outlined in i) or ii) above, a reason for incompletion must be provided and documented, including the anticipated completion date.

h. Documentation of corrective action taken from the previous self-monitoring report.

3. Maintaining the SMP reports at the site or at an easily accessible location (refer to Project Documentation Requirements below).

4. Providing all reports for the project site to *City of Angola* within forty-eight (48) hours of a request. Electronic copies are acceptable, provided they are in a format consistent with the paper record.

**Project Documentation Requirements –** The following project documentation shall be developed and maintained:

1. Maintain a project management log that contains:

   a. Information related to all off-site borrow sites, disposal areas, and staging areas, including the location of each activity as it is identified and/or selected.

   b. Information related to all project activities including, but not limited to:
      i. SMP reports.
      ii. Regulatory inspections.
      iii. Responses to a compliance action or enforcement action.
      iv. Records showing the dates of all SWPPP modifications. The records must include the name of the person authorizing each change and a summary of all changes.

2. Ensure the SWPPP and supporting documentation associated with the SMP and project management log are accessible at the project site office or in the possession of on-site individuals with responsibility for the overall project management or associated with the management and operations of construction activities. This information must be provided to *City of Angola* within forty-eight (48) hours of a request.

## B. COMMON CONTROL PRACTICES

All erosion control and stormwater pollution prevention measures required to comply with the Ordinance or these Technical Standards shall meet the design criteria, standards, and specifications similar to or the same as those outlined in the "Indiana Stormwater Quality Manual" (ISWQM), or other comparable and reputable references. Please note that pursuant to IC 13-18-27, MS4-designated entities may not require erosion and sediment control measures/BMPs that are more stringent than the measures/BMPs required by the IDEM general permit.

## C. INDIVIDUAL LOT OR PARCEL CONTROLS

Although individual lots within a larger development may not appear to contribute as much sediment as the overall development, the cumulative effect of lot development is of concern. The same is true for individual parcels of land of any size that are not associated with a larger development. From the time construction on an individual lot begins, until the individual lot is stabilized, the builder must take steps to:

- protect adjacent properties from sedimentation
- prevent mud/sediment from depositing on the street
- protect drainageways from erosion and sedimentation
- prevent sediment laden water from entering storm sewer inlets.

This can be accomplished using numerous erosion and sediment control measures. Individual lot plot plan review form and detailed requirements, including an example erosion control plan for individual lots, are provided in Appendix B. Every relevant measure should be installed at each individual lot site. Note that construction site discharge must be contained and treated within each individual lot (or a group of individual lots being constructed by one builder) and is not allowed to be discharged offsite.

Construction sequence on individual lots and parcels should be as follows:

1. Clearly delineate areas of trees, shrubs, and vegetation that are to be undisturbed. To prevent root damage, the areas delineated for tree protection should be at least the same diameter as the crown.

2. Install silt fence at as needed for sediment control at points where sheet runoff flows offsite. Position the fence to intercept runoff prior to entering drainage swales or other waterbodies.

3. Avoid disturbing drainage swales if vegetation is established. If drainage swales are bare, install erosion control blankets or sod to immediately stabilize.

4. Install drop inlet protection for all inlets on the property.

5. Install stable construction entrance that extends from the street to the building pad.

6. Perform primary grading operations.

7. Contain erosion from any soil stockpiles created on-site with an appropriate sediment control measure around the base.

8. Establish temporary seeding and straw mulch on disturbed areas.

9. Construct the home and install utilities.

10. Install downspout extenders once the roof and gutters have been constructed. Extenders should outlet to a stabilized area.

11. Re-seed any areas disturbed by construction and utilities installation with temporary seed mix within 3 days of completion of disturbance.

12. Grade the site to final elevations.

13. Install permanent seeding or sod.

All erosion and sediment control measures must be properly maintained throughout construction. Temporary and permanent seeding should be watered as needed until established. For further information on individual lot and parcel erosion and sediment control, please see the resources in Appendix B as well as the latest information posted on IDEM's website.

# Chapter Eight

# POST-CONSTRUCTION STORMWATER QUALITY MANAGEMENT STANDARDS

## A. INTRODUCTION

The City of Angola has adopted a policy that the control of stormwater runoff quality will be based on the management of Total Suspended Solids (TSS) and floatables. This requirement is being adopted as the basis of the City of Angola stormwater quality management program for all areas of jurisdiction.

This section of the manual establishes minimum standards for the selection and design of construction water quality BMPs. The information provided in this chapter establishes performance criteria for stormwater quality management and procedures to be followed when preparing a BMP plan for compliance. Post-Construction BMPs must be sized to treat the water quality volume, WQv, for detention-based BMPs or the water quality discharge, Qwq, for flow-through BMPs. Chapter 9 provides the methodology for calculating the WQv and Qwq values.

BMPs noted in this chapter refer to post-construction BMPs, which continue to treat stormwater after construction has been completed and the site has been stabilized. Installing certain BMPs, such as bioretention areas and sand filters, prior to stabilization can cause failure of the measure due to clogging from sediment. If such BMPs are installed prior to site stabilization, they should be protected by traditional erosion control measures.

Conversely, detention ponds and other BMPs can be installed during construction and used as sediment control measures. In those instances, the construction sequence must require that the pond is cleaned out with pertinent elevations and storage and treatment capacities reestablished as noted in the accepted stormwater management plan.

This Chapter establishes minimum standards for the selection and design of post-construction water quality BMPs. The information provided in this Chapter establishes performance criteria for stormwater quality management and procedures to be followed when preparing a BMP plan for compliance. Post-construction BMPs must be sized to treat the water quality volume (WQv), and for flow-through BMPs the water quality discharge rate (Qwq), as appropriate. The methodology for calculating the WQv and Qwq values is provided in Chapter 9.

Infiltration measures, when selected, must take into consideration the pollutants associated with run-off and the potential to contaminate ground water resources. Where there is a potential for contamination, implement measures that pre-treat run-off to eliminate or reduce the pollutants of concern.

New retail gasoline outlets and new MS4 fueling areas or those that replace their existing tank systems, regardless of size are required to install appropriate measures to reduce lead, copper, zinc, and polyaromatic hydrocarbons in stormwater run-off.

All BMPs must be contained within an easement or common area and be provided with an access easement.

## B. INNOVATIVE BMPs

BMPs not previously accepted by the City of Angola must be certified by a professional engineer and accepted through the City of Angola. ASTM standard methods must be followed when verifying performance of new measures.

New BMPs, individually or in combination, must meet the 80% TSS removal rate at 50-125 micron range (silt/fine sand) without reintrainment, must capture floatables and must have a low to medium maintenance requirement to be considered by the City of Angola. Testing to establish the TSS removal rate must be conducted by an independent testing facility, not the BMP manufacturer.

## C. PRE-APPROVED BMPs

City of Angola has designated 11 pre-approved BMP methods to be used alone or in combination to achieve the 80% TSS removal stormwater quality goals for a given project. These BMP measures are listed along with their anticipated average TSS removal rates in Table 8-1. Pre-approved BMPs have been proven/are assumed to achieve the average TSS removal rates indicated in Table 8-1. Applicants desiring to use a different TSS removal rate for these BMPs must follow the requirements discussed above for Innovative BMPs. Details regarding the applicability and design of these pre-approved BMPs are contained within fact sheets presented in Appendix D.

Note that a single BMP measure may not be adequate to achieve the water quality goals for a project. It is for this reason that a "treatment train", a number of BMPs in series, is often required for a project.

**TABLE 8-1**
**Pre-approved Post-Construction BMPs for Conventional Approach**

| BMP[A] | Typical % Removal Efficiency[B] |
|---|---|
| | TSS |
| Bioretention | 90[C] |
| Constructed Wetland | 67[C] |
| Underground Detention | 70 |
| Extended Detention/Dry Pond | 72 |
| Infiltration Basin (including retention ponds with pretreatment) | 90[C] |
| Infiltration Trench | 90[C] |
| Constructed (Sand) Filter | 70[C] |
| Water Quality Device | VARIES[D] |
| Vegetated Filter Strip | 78[C] |
| Vegetated Swale | 81[C] |
| Wet Ponds/Retention Basin | 80 |

Notes:

A. Detailed specifications for these BMPs are provided in the fact sheets contained in the appendices provided in the Indiana Office of Community and Rural Affairs (OCRA) Green Infrastructure Curriculum and Training web resources (Appendix-C-BMP-Fact-Sheets.pdf (in.gov)).

B. Removal rates shown are based on typical results. Unless otherwise shown, data extracted from various data sources. These rates are also dependent on proper installation and maintenance. The ultimate responsibility for determining whether additional measures must be taken to meet the Ordinance requirements for site-specific conditions rests with the applicant.
C. IDEM Stormwater Quality Manual, 2007.
D. The removal rate for this category varies widely between various models and manufacturers. The acceptable treatment rate for these devices shall be based on that currently certified by the New Jersey Department of Environmental Protection (NJDEP). Further details on acceptable Water Quality Devices and their treatment rates are provided in Chapter 9.

# Chapter Nine

# METHODOLOGY FOR DETERMINATION OF REQUIRED SIZING OF BMPs

## A. INTRODUCTION

Structural Water Quality BMPs are divided into two major classifications: detention BMPs and Flow-through BMPs. Detention BMPs impound (pond) the runoff to be treated, while flow through BMPs treat the runoff through some form of filtration process.

## B. RETENTION/DETENTION BMP SIZING

Water Quality Detention BMPs must be designed to store the water quality volume for treatment. The water quality volume, WQv, is the storage needed to capture and treat the runoff from the first one inch of rainfall. The water quality volume is equivalent to one inch of rainfall multiplied by the volumetric runoff coefficient (Rv) multiplied by the site area.

Alternatively, a simpler methodology may be used for calculation of WQv as follows:

$$WQv = (P)\ (Rv)\ (A)\ /\ 12$$

where:
WQv = water quality volume for each site's outlet (acre-feet)
P = 1 inch
Rv = volumetric runoff coefficient
A = area in acres

The volumetric runoff coefficient is a measure of imperviousness for the contributing area, and is calculated as:

$$Rv = 0.05 + 0.009(I)$$

Where:
I is the percent impervious cover

For example, a proposed commercial site will be designed to drain to three different outlets, with the following drainage areas and impervious percentages:

| Subarea ID | On-site Contributing Area (acres) | Impervious Area % | Off-Site Contributing Area (acres) |
|---|---|---|---|
| A | 7.5 | 80 | 0.0 |
| B | 4.3 | 75 | 0.0 |
| C | 6.0 | 77 | 0.0 |

Calculating the volumetric runoff coefficient for subareas A, B and C yields:

Rv (subarea A) = 0.05+0.009(80) = 0.77
Rv (subarea B) = 0.05+0.009(75) = 0.73
Rv (subarea C) = 0.05+0.009(77) = 0.74

The water quality volumes for these three areas are then calculated as:

WQv (subarea A) = (1")(Rv)(A)/12 = 0.77(7.5)/12 = 0.47 acre-feet
WQv (subarea B) = 0.73(4.3)/12 = 0.26 acre-feet
WQv (subarea C) = 0.74(6.0)/12 = 0.37 acre-feet

Note that this example assumed no offsite sources of discharge through the water quality BMPs. If there were significant sources of off-site runoff (sometimes called runon for upstream areas draining to the site), the designer would have the option of bypassing off-site runoff around the on-site systems, or the detention BMP should be sized to treat the off-site sources.

## C. FLOW THROUGH BMP SIZING

Flow-through BMPs are designed to treat runoff at a calculated water quality treatment flow rate through the system. Examples of flow through BMPs include catch basin inserts, sand filters, and grassed channels. Another flow through BMP is a manufactured treatment device such as a hydrodynamic separator, manufactured infiltration chambers, or other similar type of device discussed in the Water Quality Devices Fact Sheet (https://www.in.gov/ocra/2367.htm)

1. Requirements for Manufactured Treatment Devices

   Stormwater Manufactured Treatment Devices (MTD), also known as Hydrodynamic separators are proprietary, and usually include a pollutant-water separation component. The MTD should be sized to treat flows up to, and including, the Water Quality Treatment Rate (Qwq) calculated for each project site outlet. To be acceptable, the MTD should meet the following criteria:

   - The MTD must be offline and located upstream of detention facilities (if any).
   - The MTD must provide complete and unobstructed access to the entire bottom of the system from grade level, if applicable, for ease of maintenance.
   - The MTD, or the treatment train (if applicable) that includes the MTD as one of its components, must have the ability to capture or skim pollutants including but not limited to: floating oils / immiscible materials.
   - The MTD, or the treatment train (if applicable) that includes the MTD as one of its components, must have the ability to capture both floating and suspended solid material (trash, organic material, etc.) and other pollutants.
   - The MTD shall be a manufactured system currently certified by the New Jersey Department of Environmental Protection (NJDEP). A list of NJDEP- MTDs certified for 50% and 80% TSS removal are provided in a table located at http://www.nj.gov/dep/stormwater/treatment.html.

To obtain the maximum flow rate for various models of a MTD that is listed in the NJDEP-certified list, the latest verification report from NJCAT Verification Database must be used. A link to the database is provided right above the NJDEP-certified list table.

In summary, the following steps should be used to determine whether a proposed MTD unit is NJDEP-certified and to determine the accepted maximum flow rate for that unit.

**Step 1:** Determine if the MTD is NJDEP-certified for 50% treatment rate (when the MTD will be used in a treatment train) or 80% treatment rate (when the MTD will be used alone):

a) Go to http://www.nj.gov/dep/stormwater/treatment.html
b) Look up the name of the MTD in the first column of the table
c) Look up the Certified TSS Removal Rate of that MTD in the fourth column

**Step 2:** Determine the maximum accepted flow rate:

a) Click the link “Certification” in the second column of the NJDEP-certified list table referenced in Step 1. In some cases, a table of MTD model versus the NJDEP-certified maximum flow rate is included in the certification letter. In that case, skip to sub-step “g)” (below). If not continue to the sub-step “b)” (below)
b) Click the “Click here” link above the NJDEP-certified list table to access NJCAT Verification Database
c) Find the name of the MTD manufacturer of interest in first column
d) Find the latest entry (one with the latest verification date shown in third column) for that particular MTD
e) Click the report download link in the fourth column
f) Find the Table in the report (typically towards the end of the report) that lists various MTD model sizes along with the NJDEP 50% (or 80%, if appropriate) TSS Maximum Treatment Flow Rate
g) The selected model should have a maximum flow rate that is equal or larger than the site’s required treatment flow rate as determined in Section C.2 of this Chapter.

Note that the NJDEP-certified manufactured system treatment rates for units not equipped with special filters reflect a standard certified 50% TSS reduction at the listed certified treatment flow rate. Therefore, to achieve the 80% TSS removal requirement, either a treatment train with a conventional listed in Table 8-1 (except for another MTD or a sand filter) must be used or a filtration system must be used instead in accordance with the NJDEP methodology. The treatment train shall not include more than one MTD.

Also, note that multiple inlet or units in series configurations are not accepted unless the NJCAT certification and NJDEP verification is specifically done for such an arrangement.

2. Calculating the Required Treatment Flow Rate (Qwq)

The following procedure should be used to estimate peak discharges for flow through BMPs (adopted from Maryland, 2000). It relies on the volume of runoff computed using the Small Storm Hydrology Method (Pitt, 1994) and utilizes the NRCS, TR-55 Method.

Using the WQv methodology, a corresponding Curve Number (CNwq) is computed utilizing the following equation:

$$CNwq = \frac{1000}{\left[10 + 5P + 10Qa - 10\sqrt{Qa^2 + 1.25QaP}\right]}$$

where:
CNwq = curve number for water quality storm event

$P$ = 1” (rainfall for water quality storm event)
$Qa$ = runoff volume, in inches = 1”×Rv = Rv (inches)
Rv=volumetric runoff coefficient (see previous section)

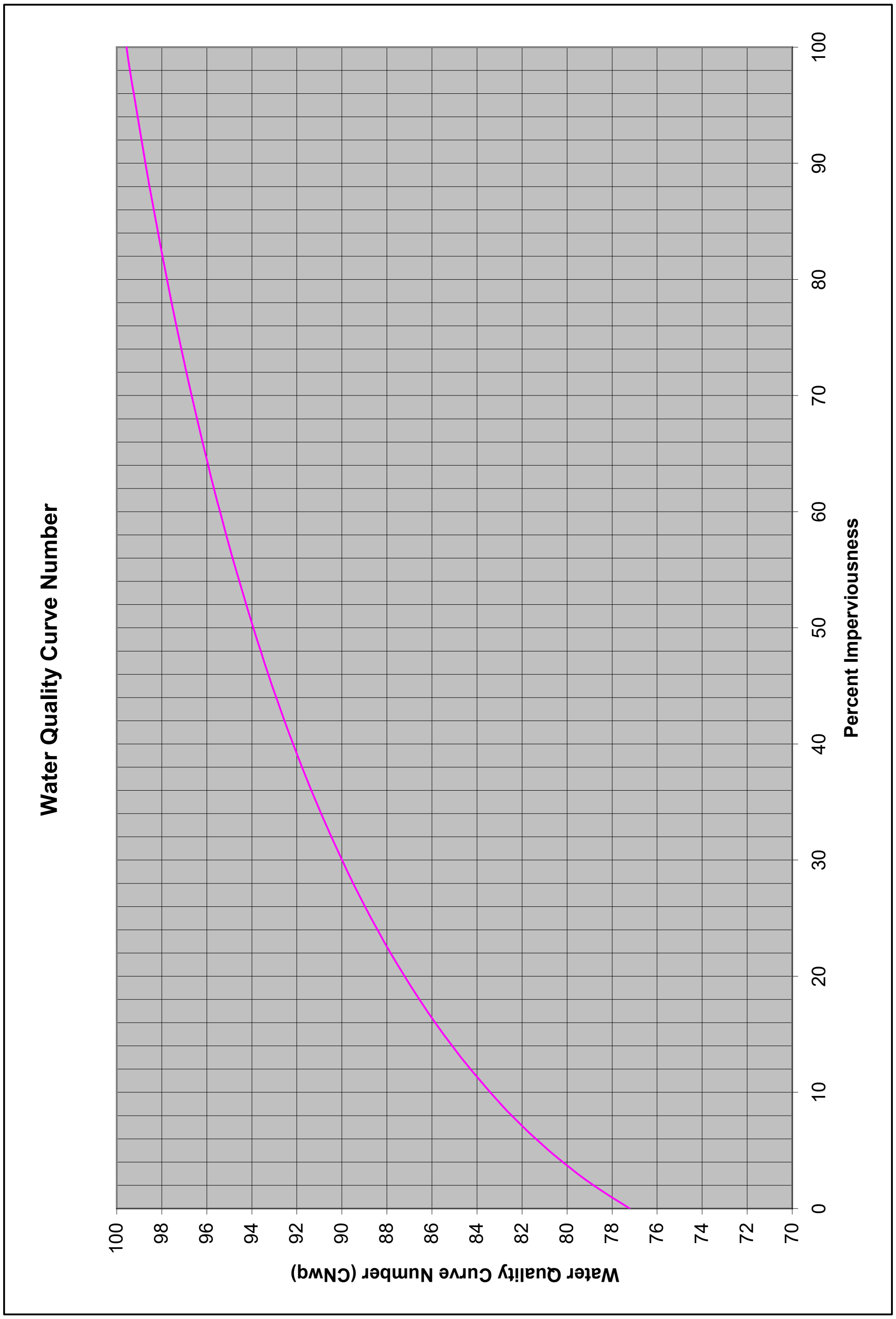
Due to the complexity of the above equation, the water quality curve number is represented as a function of percent imperviousness in **Figure 9-1**.

The water quality curve number, CNwq, is then used in conjunction with the standard calculated time-of-concentration, tc, and drainage area as the basis input for TR-55 calculations. Using the SCS Type II distribution for 1 inch of rainfall in 24-hours, the water quality treatment rate, Qwq, can then be calculated.

**REFERENCES**


1. Maryland Stormwater Design Manual, Volume II, Appendix D.10, 2000
2. Pitt, R., 1994, Small Storm Hydrology. University of Alabama - Birmingham. Unpublished manuscript. Presented at design of stormwater quality management practices. Madison, WI, May 17-19, 1994.
3. Schueler, T.R. and R.A. Claytor, 1996, Design of Stormwater Filter Systems. Center for Watershed Protection, Silver Spring, MD.
4. United States Department of Agriculture (USDA), 1986. Urban Hydrology for Small Watersheds. Soil Conservation Service, Engineering Division. Technical Release 55 (TR-55).

**Figure 9-1**
**Curve Number Calculation for Water Quality Storm Event**



# Chapter Ten

# LOT/BUILDING GRADING AND DRAINAGE STANDARDS

## A. GRADING AND BUILDING PAD ELEVATIONS

For all structures adjacent to an emergency flood route (also referred to as overflow path/ponding areas), the minimum adjacent grade of the portion of the structure (the ground elevation next to the building after construction is completed that sits adjacent to the emergency flood route or may be subject to flooding by the emergency flood route) shall be a minimum of 1 foot above the estimated 100-year elevation of the emergency flood route assuming that all stormwater inlets and pipes are fully clogged, with no discharge into the storm sewer system. The building adjacent grade requirements (including default elevations above the overflow route bottom) for buildings adjacent to overflow path/ponding areas are further discussed in Chapter 4 of this Manual.

For all structures adjacent to a road, the building's lowest entry elevation that is adjacent to and facing a road shall be a minimum of 2 feet above the road elevation (elevation of the gutter at the center of the lot) so that the road drainage is not directed against the building.

There shall be a positive slope drainage away from the building with maximum yard slopes that are 3:1 where soil has been disturbed during construction processes. Finished floor elevation or the lowest building entry elevation must be no less than 6 inches above finished grade around the building.

In addition to any other provisions in the Ordinance or these Standards, no buildings shall be placed within 25 feet from the top of the bank of any existing or proposed stream, drain, or watercourse, regardless of the contributing drainage area or the bank height.

## B. LOT DRAINAGE

All lots shall be laid out so as to provide drainage away from all buildings, and individual lot drainage shall be coordinated with the general stormwater drainage pattern for the subdivision. Drainage shall be designed so as to avoid the concentration of stormwater runoff from a lot onto adjacent lots. Each lot owner shall maintain the lot grade, as it relates to stormwater drainage, in compliance with the approved construction plans.

No part of the lot area of any lot may contain land that is utilized as retention or detention facility or drainage pond, contains a watercourse, or is within a floodway. Where a watercourse separates the buildable area of the lot from the street by which it has access, provisions shall be made for the installation of a culvert or other appropriate structure, as approved by the *City of Angola* or designee. If a subdivision contains an existing or to be developed waterbody, watercourse, or portion thereof, appropriate documentary assurances acceptable to the *City of Angola* shall be provided for the maintenance of such waterbody or watercourse.

It shall be the property owners' responsibility to maintain the natural features on their lots and to take preventive measures against any and all erosion and/or deterioration of natural or man-made features on their lots.

## C. ACCEPTABLE OUTLET AND ADJOINING PROPERTY IMPACTS POLICIES

Design and construction of the stormwater facility shall provide for the discharge of the stormwater runoff from off-site land areas as well as the stormwater from the area being developed (on-site land areas) to an acceptable outlet(s) (as determined by the *City of Angola*) having capacity to receive upstream (off-site) and on-site drainage. A Roadside Ditch is generally not considered an adequate outlet. The flow path from the development outfall(s) to a regulated drain, a *City of Angola* storm drain, or natural watercourse (as determined or approved by the *City of Angola*) shall be provided on an exhibit that includes topographic information. Any existing field tile encountered during the construction shall also be incorporated into the proposed stormwater drainage system or tied to an acceptable outlet.

If an adequate outlet is not located on site, then off-site drainage improvements may be required. Those improvements may include, but are not limited to, extending storm sewers, clearing, dredging and/or removal of obstructions to open drains or natural water courses, and the removal or replacement of undersized culvert pipes as required by the *City of Angola*.

# Chapter 11

## OPERATION AND MAINTENANCE

### A. Operation and Maintenance Manual

An Operation and Maintenance (O&M) Manual shall be provided for all ponds, stormwater components (pipes, swales, structures, etc.), stormwater quantity and quality BMPs, and low-impact development facilities/BMPs to facilitate their proper long-term function.

### B. O&M Manual Requirements

1. It is the designer's responsibility to determine which additional operation and maintenance measures are necessary to prolong the optimal function of the facility.
2. An O&M Manual that includes a description of the maintenance guidelines for all post-construction stormwater measures to facilitate their proper long-term function.
3. The O&M Manual must be signed and provided to future parties who will assume responsibility for the operation and long-term maintenance of the post-construction stormwater measures.
4. When known at the time of plan submittal, the entity that will be responsible for operation and maintenance of the system.

### C. O&M Manual Content

All O&M Manuals shall include the following information, at a minimum:

1. Owner Information. The first section of the manual shall contain information about all people involved with the operations and maintenance of the facility. This section shall list the names and contact information of all responsible parties, including property owner(s), maintenance staff, and person(s) responsible for performing inspections. The responsibilities of each individual shall be clearly defined. Contact information shall include business or mobile phone number, address for giving notice, and email address (if available).
2. An acknowledgement statement signed by the owner and notarized. The signed and approved O&M Manual shall be recorded with the property by the County Recorder's office
3. Site Map. The O&M Manual shall include a site map and exhibits drawn to a legible scale on 8.5-inches by 11-inches or 11-inches by 17-inches sized paper that clearly indicates the following:
   a. The location of the stormwater management facilities and BMPs.
   b. Plan and cross-section details, showing applicable features.
   c. The flow of stormwater through the site, including an overview of the stormwater's path through the onsite stormwater facilities and BMPs.
   d. Dimensions, easements, outlets/discharge points and outfall locations, drainage patterns, stormwater runoff flow directions, the extent and depth (elevation) of high water levels, flood routing path, signage, connecting structures, weirs, invert elevations, structural controls used to control stormwater flows, and other relevant features.

### D. O&M Practices

Each stormwater management facility and BMP shall require specific inspection and maintenance procedures. Guidance shall be written in simple, layman's terms, including:

1. Guidance on owner-required periodic inspections.
2. Guidance on routine maintenance including mowing, litter removal, woody growth removal, etc. to be performed by the owner.
3. Guidance on remedial maintenance such as inlet replacement, outlet work, etc. to be performed by the owner.
4. Guidance on sediment removal, describing when sediment removal shall occur in order to ensure that the stormwater management facility or BMP remains effective as a stormwater management device. Guidance shall include instructions as to how the depth of sediment shall be measured and at what measurement removal will be required.
5. Instructions on inspection and clean-out of BMPs, sumps, trash screens, settling pits, and oil/grease collection chambers.
6. Instructions on proper disposal of removed sediments, trash, debris, and other substances.
7. Guidance and methods for preventing water stagnation and all recommended maintenance.

### E. O&M Inspection & Maintenance

The minimum requirements below shall also be incorporated into the inspection and maintenance regimen and clearly documented in the O&M Manual.

1. Operation and maintenance procedures and practices shall be reviewed and assessed annually.
2. Access routes, including roadways and sidewalks, shall be inspected annually and maintained as needed.
3. Drainage structures and flow restrictors shall be inspected and cleaned semi-annually or per the manufacturer's recommendations, whichever is more stringent.
4. Volume control facilities and BMPs shall be inspected semi-annually and after significant rainfall events exceeding 1.5-inches, or per the manufacturer's recommendations, whichever is more stringent.
5. The owner shall keep an updated log or inspection worksheets documenting the performance of the required operation and maintenance activities for perpetuity. Note inspection dates, facility components inspected, facility condition, and any maintenance performed, or repairs made. Documentation must be produced upon the request of the City within 48-hours of the request.
6. Vegetation shall be maintained on a regular basis per design specifications.
7. Pest control measures shall be implemented to address insects, rodents, and other pests. Natural pest control is preferred over chemical treatments.
8. Mechanical measures shall be maintained on a regular basis per the manufacturer's recommendations.
9. Native vegetation plantings shall have "No Mow" or other appropriate signage.
10. Underground vaults and structures shall include design measures to facilitate regular cleaning and maintenance. Confined space entry procedures shall be followed.

### F. Right-of-Entry Statement

The O&M Manual shall include a statement that the city has the right to enter the property to inspect the stormwater management facility or BMP. The statement shall be signed and notarized.

### G. Implementation Schedule

An inspection and maintenance schedule shall be prepared in a tabular format and included in the O&M Manual. This schedule shall provide for routine examination of all stormwater management facilities and BMPs.

### H. Drainage Easement(s) Documentation

The O&M Manual shall include documentation of drainage easement(s) around the stormwater management facilities and BMPs. The documentation must be in graphic format.

# APPENDIX A
ABBREVIATIONS AND DEFINITIONS

APPENDIX A

# ABBREVIATIONS AND DEFINITIONS

## ABBREVIATIONS

| | |
|---|---|
| **BMP** | Best Management Practice |
| **CFS** | Cubic Feet Per Second |
| **CN** | Curve Number |
| **COE** | United States Army Corps of Engineers |
| **CWA** | Clean Water Act |
| **E&SC** | Erosion and Sediment Control |
| **EPA** | Environmental Protection Agency |
| **FEMA** | Federal Emergency Management Agency |
| **FPG** | Flood Protection Grade |
| **GIS** | Geographical Information System |
| **IDEM** | Indiana Department of Environmental Management |
| **IDNR** | Indiana Department of Natural Resources |
| **INDOT** | Indiana Department of Transportation |
| **LAG** | Lowest Adjacent Grade |
| **MS4** | Municipal Separate Storm Sewer System |
| **NAVD** | North American Vertical Datum of 1988 |
| **NGVD 1929** | National Geodetic Vertical Datum of 1929 |
| **NRCS** | USDA-Natural Resources Conservation Service |
| **NPDES** | National Pollutant Discharge Elimination System |
| **POTW** | Publicly Owned Treatment Works |
| **SFHA** | Special Flood Hazard Area |
| **SWPPP** | Stormwater Pollution Prevention Plan |
| **Tc** | Time of Concentration |
| **TMDL** | Total Maximum Daily Load |
| **TSS** | Total Suspended Solids |
| **USDA** | United States Department of Agriculture |

## DEFINITIONS

**Antecedent Runoff Condition**. The index of runoff potential before a storm event. The index, developed by the Soil Conservation Service (SCS), is an attempt to account for the variation of the SCS runoff curve number (CN) from storm to storm.

**Backflow Preventer**. Device that allows liquids to flow in only one direction in a pipe. Backflow preventers are used on sewer pipes to prevent a reverse flow during flooding situations.

**Backwater.** The rise in water surface elevation caused by some obstruction such as a narrow bridge opening, buildings or fill material that limits the area through which the water shall flow.

**Base Flood Elevation**. The water surface elevation corresponding to a flood having a one percent probability of being equaled or exceeded in a given year.

**Base Flood**. See "Regulatory Flood".

**Base Flow.** Stream discharge derived from groundwater sources as differentiated from surface runoff. Sometimes considered to include flows from regulated lakes or reservoirs.

**Basement.** A building story that is all or partly underground but having at least one-half of its height below the average level of the adjoining ground. A basement shall not be counted as a story for the purpose of height regulations.

**Best Management Practices**. Design, construction, and maintenance practices and criteria for stormwater facilities that minimize the impact of stormwater runoff rates and volumes, prevent erosion, and capture pollutants.

**Buffer Strip.** An existing, variable width strip of vegetated land intended to protect water quality and habitat.

**Building.** See “structure”.

**Catch Basin.** A chamber usually built at the curb line of a street for the admission of surface water to a storm drain or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.

**Centerline of Channel.** The thalweg of a channel.

**Channel Improvement**. Alteration, maintenance, or reconstruction of the channel area for the purpose of improving the channel capacity or overall drainage efficiency. The noted "improvement" does <u>not</u> necessarily imply water quality or habitat improvement within the channel or its adjacent area.

**Channel**. A portion of a natural or artificial watercourse which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. It has a defined bed and banks which serve to confine the water.

**Class V injection well.** A type of well, which typically has a depth greater than its largest surface dimension, emplaces fluids into the subsurface, and does not meet the definitions of Class I through Class IV wells as defined under 40 CFR 146.5. While the term includes the specific examples described in 40 CFR 144.81, septic systems that serve more than one (1) single-family dwelling or provide service for non-domestic waste, dug wells, bored wells, improved sinkholes, french drains, infiltration sumps, and infiltration galleries, it does not include surface impoundments, trenches, or ditches that are wider than they are deep.

**Closed Conduit**. A pipe, tube, or tile used for transmitting water.

**Combined Sewer Overflow**. A system designed and used to receive and transport combined sewage so that during dry periods the wastewater is carried to a treatment facility. During storm events, the excess water is discharged directly into a river, stream, or lake without treatment.

**Compensatory Storage.** An artificial volume of storage within a floodplain used to balance the loss of natural flood storage capacity when artificial fill or substructures are placed within the floodplain.

**Comprehensive Stormwater Management Program**. A comprehensive stormwater program for effective management of stormwater quantity and quality throughout the community.

**Constructed Wetland.** A man-made shallow pool that creates growing conditions suitable for wetland vegetation and is designed to maximize pollutant removal.

**Construction activity**. Land disturbing activities, and land disturbing activities associated with the construction of infrastructure and structures. This term does not include routine ditch or road maintenance or minor landscaping projects.

**Construction plan.** A representation of a project site and all activities associated with the project. The plan includes the location of the project site, buildings and other infrastructure, grading activities, schedules for implementation and other pertinent information related to the project site. A stormwater pollution prevention plan is a part of the construction plan.

**Construction site access.** A stabilized stone surface at all points of ingress or egress to a project site, for the purpose of capturing and detaining sediment carried by tires of vehicles or other equipment entering or exiting the project site.

**Construction Support Activities.** Include but are not limited to the following: concrete or asphalt batch plants, equipment staging yards, material storage areas, excavated material disposal areas, borrow areas. Such activities must not support multiple, unrelated projects, be a commercial/industrial operation, or continue to operate beyond the completion of the construction activity for the project it supports.

**Contiguous.** Adjoining or in actual contact with.

**Contour.** An imaginary line on the surface of the earth connecting points of the same elevation.

**Contractor or subcontractor.** An individual or company hired by the project site or individual lot owner, their agent, or the individual lot operator to perform services on the project site.

**Control Structure**. A structure designed to control the rate of flow that passes through the structure, given a specific upstream and downstream water surface elevation.

**Conveyance.** Any structural method for transferring stormwater between at least two points. The term includes piping, ditches, swales, curbs, gutters, catch basins, channels, storm drains, and roadways.

**Crawl Space**. Low space below first floor of a house where there has not been excavation deep enough for a basement, usually less than seven (7) feet in depth, but where there is access for pipes, ducts, utilities and similar equipment.

**Cross-Section**. A graph or plot of ground elevation across a stream valley or a portion of it, usually along a line perpendicular to the stream or direction of flow.

**Crown of Pipe.** The elevation of top of pipe.

**Cubic Feet Per Second (CFS).** Used to describe the amount of flow passing a given point in a stream channel. One cubic foot per second is equivalent to approximately 7.5 gallons per second.

**Culvert.** A closed conduit used for the conveyance of surface drainage water under a roadway, railroad, canal or other impediment.

**Curve Number (CN).** The Soil Conservation Service index that represents the combined hydrologic effect of soil, land use, land cover, hydrologic condition and antecedent runoff condition.

**Dam.** A barrier to confine or impound water for storage or diversion, to prevent gully erosion, or to retain soil, sediment, or other debris.

**Damage.** Measurable rise in flood heights on buildings currently subject to flooding, flooding of buildings currently not subject to flooding and increases in volume or velocity to the point where the rate of land lost to erosion and scour is substantially increased.

**Datum**. Any level surface to which elevations are referred, usually Mean Sea Level.

**Depressional Storage Areas**. Non-riverine depressions in the earth where stormwater collects. The volumes are often referred to in units of acre-feet.

**Design Storm**. A selected storm event, described in terms of the probability of occurring once within a given number of years, for which drainage or flood control improvements are designed and built.

**Detention Basin.** A facility constructed or modified to restrict the flow of stormwater to a prescribed maximum rate, and to detain concurrently the excess waters that accumulate behind the outlet.

**Detention Facility.** A facility designed to detain a specified amount of stormwater runoff assuming a specified release rate. The volumes are often referred to in units of acre-feet.

**Detention Storage.** The temporary detaining of storage of stormwater in storage facilities, on rooftops, in streets, parking lots, school yards, parks, open spaces or other areas under predetermined and controlled conditions, with the rate of release regulated by appropriately installed devices.

**Detention.** Managing stormwater runoff by temporary holding and controlled release.

**Detritus.** Dead or decaying organic matter; generally contributed to stormwater as fallen leaves and sticks or as dead aquatic organisms.

**Developer.** Any person financially responsible for construction activity, or an owner of property who sells or leases, or offers for sale or lease, any lots in a subdivision.

**Development**. Any man-made change to improved or unimproved real estate including but not limited to:

1. Construction, reconstruction, or placement of a building or any addition to a building;
2. Construction of flood control structures such as levees, dikes, dams or channel improvements;
3. Construction or reconstruction of bridges or culverts;
4. Installing a manufactured home on a site, preparing a site for a manufactured home, or installing a recreational vehicle on a site for more than hundred eight (180) days;
5. Installing utilities, erection of walls, construction of roads, or similar projects;
6. Mining, dredging, filling, grading, excavation, or drilling operations;
7. Storage of materials; or
8. Any other activity that might change the direction, height, or velocity of flood or surface waters.

“Development” does not include activities such as the maintenance of existing buildings and facilities such as painting, re-roofing, resurfacing roads, or gardening, plowing and similar agricultural practices that do not involve filling, grading, excavation, or the construction of permanent buildings.

**Discharge.** In the context of water quantity provisions, usually the rate of water flow, i.e., a volume of fluid passing a point per unit time commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, or millions of gallons per day. In the context of water quality provisions, the discharge means any addition of liquids or solids to a water body or a flow conveyance facility.

**Disposal.** The discharge, deposit, injection, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land/or water so that the solid waste or hazardous waste, or any constituent of the waste, may enter the environment, be emitted into the air, or be discharged into any waters.

**Ditch**. A man-made, open drainageway in or into which excess surface water or groundwater drained from land, stormwater runoff, or floodwaters flow either continuously or intermittently.

**Drain.** A buried slotted or perforated pipe or other conduit (subsurface drain) or a ditch (open drain) for carrying off surplus groundwater or surface water.

**Drainage Area.** The area draining into a stream at a given point. It may be of different sizes for surface runoff, subsurface flow and base flow, but generally the surface runoff area is considered as the drainage area.

**Drainage.** The removal of excess surface water or groundwater from land by means of ditches or subsurface drains. Also see Natural drainage.

**Drop Manhole.** Manhole having a vertical drop pipe connecting the inlet pipe to the outlet pipe. The vertical drop pipe shall be located immediately outside the manhole.

**Dry Well.** A type of infiltration practice that allows stormwater runoff to flow directly into the ground via a bored or otherwise excavated opening in the ground surface.

**Duration.** The time period of a rainfall event.

**Earth Embankment.** A man-made deposit of soil, rock, or other material often used to form an impoundment.

**Emergency Spillway.** Usually, a vegetated earth channel used to safely convey flood discharges around an impoundment structure.

**Environment.** The sum total of all the external conditions that may act upon a living organism or community to influence its development or existence.

**Erosion and sediment control measure.** A practice, or a combination of practices, to control erosion and resulting sedimentation.

**Erosion and sediment control system.** The use of appropriate erosion and sediment control measures to minimize sedimentation by first reducing or eliminating erosion at the source and then as necessary, trapping sediment to prevent it from being discharged from or within a project site.

**Erosion control plan.** A written description and site plan of pertinent information concerning erosion control measures designed to meet the requirements of the Ordinance or these Standards.

**Erosion.** The wearing away of the land surface by water, wind, ice, gravity, or other geological agents. The following terms are used to describe different types of water erosion:

- *Accelerated erosion* -- Erosion much more rapid than normal or geologic erosion, primarily as a result of the activities of man.
- *Channel erosion* -- An erosion process whereby the volume and velocity of flow wears away the bed and/or banks of a well-defined channel.
- *Gully erosion* --An erosion process whereby runoff water accumulates in narrow channels and, over relatively short periods, removes the soil to considerable depths, ranging from 1-2 ft. to as much as 75-100 ft.
- *Rill erosion*--An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils.
- *Splash erosion*--The spattering of small soil particles caused by the impact of raindrops on wet soils; the loosened and spattered particles may or may not be subsequently removed by surface runoff.
- *Sheet erosion*--The gradual removal of a fairly uniform layer of soil from the land surface by runoff water.

**Farm or Field Tile.** A pipe installed in an agricultural area to allow subsurface drainage of farmland for the purpose of agricultural production.

**FEMA.** The Federal Emergency Management Agency.

**Filter Strip.** Usually a long, relatively narrow area (usually, 20-75 feet wide) of undisturbed or planted vegetation used near disturbed or impervious surfaces to filter stormwater pollutants for the protection of watercourses, reservoirs, or adjacent properties.

**Final stabilization.** The establishment of permanent vegetative cover or the application of a permanent non-erosive material to areas where all land disturbing activities have been completed and no additional land disturbing activities are planned under the current permit.

**Floatable.** Any solid waste that will float on the surface of the water.

**Flood (or Flood Waters)**. A general and temporary condition of partial or complete inundation of normally dry land areas from the overflow, the unusual and rapid accumulation, or the runoff of surface waters from any source.

**Flood Elevation.** The elevation at all locations delineating the maximum level of high waters for a flood of given return period.

**Flood Hazard Area.** Any floodplain, floodway, floodway fringe, or any combination thereof which is subject to inundation by the regulatory flood; or any flood plain as delineated by Zone X on a Flood Hazard Boundary Map.

**Flood Protection Grade (FPG).** The elevation of the regulatory or 100-year flood plus two (2) feet of freeboard if the flooding source is a lake, pond, stream, or an open channel/ditch (or 1 foot of freeboard if the flooding source is an overflow path/ponding area provided that the elevation of the overflow path/ponding area is calculated based on the assumption of fully plugged storm pipe system).

**Floodplain**. The channel proper and the areas adjoining the channel which have been or hereafter may be covered by the regulatory or 100-year flood. Any normally dry land area that is susceptible to being inundated by water from any natural source. The floodplain includes both the floodway and the floodway fringe districts.

**Floodway Fringe.** That portion of the flood plain lying outside the floodway, which is inundated by the regulatory flood.

**Floodway.** The channel of a river or stream and those portions of the floodplains adjoining the channel which are reasonably required to efficiently carry and discharge the peak flow of the regulatory flood of any river or stream.

**Footing Drain.** A drain pipe installed around the exterior of a basement wall foundation to relieve water pressure caused by high groundwater elevation.

**Forebay (or Sediment Forebay).** A small pond placed in front of a larger retention/detention structure such as a wet pond, dry pond, or wetland to intercept and concentrate a majority of sediment that is coming into the system before it reaches the larger structure.

**Freeboard.** An increment of height added to the base flood elevation to provide a factor of safety for uncertainties in calculations, unknown local conditions, wave actions and unpredictable effects such as those caused by ice or debris jams. (See Flood Protection Grade).

**French Drain**. A drainage trench backfilled with a coarse, water-transmitting material; may contain a perforated pipe.

**Gabion.** An erosion control structure consisting of a wire cage or cages filled with rocks.

**Garbage.** All putrescible animal solid, vegetable solid, and semisolid wastes resulting from the processing, handling, preparation, cooking, serving, or consumption of food or food materials.

**Geographical Information System**. A computer system capable of assembling, storing, manipulation, and displaying geographically referenced information. This technology can be used for resource management and development planning.

**Grade.** (1) The inclination or slope of a channel, canal, conduit, etc., or natural ground surface usually expressed in terms of the percentage the vertical rise (or fall) bears to the corresponding horizontal distance. (2) The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared to a design elevation for the support of construction, such as paving or the laying of a conduit. (3) To finish the surface of a canal bed, roadbed, top of embankment, or bottom of excavation, or other land area to a smooth, even condition.

**Grading.** The cutting and filling of the land surface to a desired slope or elevation.

**Grass.** A member of the botanical family Poaceae , characterized by blade-like leaves that originate as a sheath wrapped around the stem.

**Ground Cover (horticulture).** Low-growing, spreading plants useful for low-maintenance landscape areas.

**Groundwater Recharge.** The infiltration of water into the earth. It may increase the total amount of water stored underground or only replenish supplies depleted through pumping or natural discharge.

**Groundwater.** Accumulation of underground water, natural or artificial. The term does not include man-made underground storage or conveyance structures.

**Habitat.** The environment in which the life needs of a plant or animal are supplied.

**Hard Surface.** See “Impervious Surface.”

**High Water.** Maximum designed permitted, or regulated water level for an impoundment.

**Hydraulic Grade Line (HGL).** For Channel flow, the HGL is equal to the water surface whereas for pressure flow is the piezometric surface.

**Hydraulics.** A branch of science that deals with the practical application of the mechanics of water movement. A typical hydraulic study is undertaken to calculate water surface elevations.

**Hydrograph.** For a given point on a stream, drainage basin, or a lake, a graph showing either the discharge, stage (depth), velocity, or volume of water with respect to time.

**Hydrology.** The science of the behavior of water in the atmosphere, on the surface of the earth, and underground. A typical hydrologic study is undertaken to compute flow rates associated with specified flood events.

**IDEM.** Indiana Department of Environmental Management.

**IDNR**. Indiana Department of Natural Resources.

**Impaired Waters.** Waters that do not or are not expected to meet applicable water quality standards, as included on IDEM’s CWA Section 303(d) List of Impaired Waters.

**Impervious surface.** Surfaces, such as pavement and rooftops, which prevent the infiltration of stormwater into the soil.

**Individual building lot.** A single parcel of land within a multi-parcel development.

**Individual lot operator.** A contractor or subcontractor working on an individual lot.

**Individual lot owner.** A person who has financial control of construction activities for an individual lot.

**INDOT.** Indiana Department of Transportation. Generally used here to refer to specifications contained in the publication "INDOT Standard Specifications."

**Infiltration practices.** Any structural BMP designed to facilitate the percolation of run-off through the soil to ground water. Examples include infiltration basins or trenches, dry wells, and porous pavement.

**Infiltration**. Passage or movement of water into the soil.

**Inlet.** An opening into a storm drain system for the entrance of surface stormwater runoff, more completely described as a storm drain inlet.

**Intermittent Stream.** A stream which carries water a considerable portion of the time, but which ceases to flow occasionally or seasonally because bed seepage and evapotranspiration exceed the available water supply.

**Invert.** The inside bottom of a culvert or other conduit.

**Junction Chamber.** A converging section of conduit, usually large enough for a person to enter, used to facilitate the flow from one or more conduits into a main conduit.

**Land-disturbing Activity.** Any man-made change of the land surface, including removing vegetative cover that exposes the underlying soil, excavating, filling, transporting and grading.

**Larger common plan of development or sale.** A plan, undertaken by a single project site owner or a group of project site owners acting in concert, to offer lots for sale or lease; where such land is contiguous, or is known, designated, purchased or advertised as a common unit or by a common name, such land shall be presumed as being offered for sale or lease as part of a larger common plan. The term also includes phased or other construction activity by a single entity for its own use.

**Lowest Adjacent Grade**. The elevation of the lowest grade adjacent to a structure, where the soil meets the foundation around the outside of the structure (including structural members such as basement walkout, patios, decks, porches, support posts or piers, and rim of the window well.

**Lowest Floor**. Refers to the lowest of the following:

1. The top of the basement floor;
2. The top of the garage floor, if the garage is the lowest level of the building;
3. The top of the first floor of buildings constructed on a slab or of buildings elevated on pilings or constructed on a crawl space with permanent openings; or
4. The top of the floor level of any enclosure below an elevated building where the walls of the enclosure provide any resistance to the flow of flood waters unless:

   a] The walls are designed to automatically equalize the hydrostatic flood forces on the walls by allowing for the entry and exit of flood waters, by providing a minimum of two openings (in addition to doorways and windows) having a total area of one (1) square foot for every two (2) square feet of enclosed area subject to flooding. The bottom of all such openings shall be no higher than one (1) foot above grade.

   b] Such enclosed space shall be usable only for the parking of vehicles or building access.

**Major Drainage System.** Drainage system carrying runoff from an area of one or more square miles.

**Manhole.** Storm drain structure through which a person may enter to gain access to an underground storm drain or enclosed structure.

**Manning Roughness Coefficient or Manning's "n" Value.** A dimensionless coefficient ("n") used in the Manning's equation to account for channel wall frictional losses in steady uniform flow.

**Measurable storm event.** A precipitation event that results in a total measured precipitation accumulation equal to, or greater than, one-half (0.5) inch of rainfall.

**Minor Drainage Systems.** Drainage system carrying runoff from an area of less than one square mile.

**Mulch.** A natural or artificial layer of plant residue or other materials covering the land surface which conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

**National Geodetic Vertical Datum of 1929**. The nationwide, Federal Elevation datum used to reference topographic elevations to a known value.

**National Pollution Discharge Elimination System (NPDES)**. A permit developed by the U.S. EPA through the Clean Water Act. In Indiana, the permitting process has been delegated to IDEM. This permit covers aspects of municipal stormwater quality.

**Natural Drainage.** The flow patterns of stormwater run-off over the land in its pre-development state.

**Normal Depth.** Depth of flow in an open conduit during uniform flow for the given conditions.

**North American Vertical Datum of 1988 (NAVD 1988).** The nationwide, Federal Elevation datum used to reference topographic elevations to a known value.

**Off-site.** Everything not located at or within a particular site.

**Off-site Land Areas**. Those areas that by virtue of existing topography naturally shed surface water onto or through the developing property.

**100-Year Frequency Flood**. See "regulatory flood".

**On-Site.** Located within the controlled or urbanized area where runoff originates.

**Open Drain.** A natural watercourse or constructed open channel that conveys drainage water.

**Open Space.** Any land area devoid of any disturbed or impervious surfaces created by industrial, commercial, residential, agricultural, or other man-made activities.

**Orifice.** A device which controls the rate of flow from a detention basin.

**Outfall.** The point, location, or structure where a pipe or open drain discharges to a receiving body of water.

**Outlet.** The point of water disposal from a stream, river, lake, tidewater, or artificial drain.

**Overland Flow**. Consists of sheet flow, shallow concentrated flow and channel flow.

**Peak Discharge (or Peak Flow).** The maximum instantaneous flow from a given storm condition at a specific location.

**Perennial Stream.** A stream that maintains water in its channel throughout the year.

**Permanent stabilization.** The establishment, at a uniform density of seventy percent (70%) across the disturbed area, of vegetative cover or permanent non-erosive material that will ensure the resistance of the soil to erosion, sliding, or other movement.

**Pervious.** Allowing movement of water.

**Pesticides.** Chemical compounds used for the control of undesirable plants, animals, or insects. The term includes insecticides, herbicides, algicides, rodenticides, nematicides, fungicides, and growth regulators.

**Phasing of construction.** Sequential development of smaller portions of a large project site, stabilizing each portion before beginning land disturbance on subsequent portions, to minimize exposure of disturbed land to erosion.

**Piping.** The formation of "pipes" by underground erosion. Water in the soil carries the fine soil particles away, and a series of eroded tubes or tunnels develop. These openings will grow progressively larger and can cause a dam failure.

**Pollutant of concern.** Any pollutant that has been documented via analytical data as a cause of impairment in any waterbody.

**Private Drain**. A drain that: (1) Is located on land owned by one person or by two or more persons jointly; and (2) was not established under or made subject to any drainage statute.

**Professional Engineer**. A person licensed under the laws of the State of Indiana to practice professional engineering.

**Project site owner.** The person required to submit a site improvement permit application and required to comply with the terms of the ordinance or these Technical Standards, including a developer or a person who has financial and operational control of construction activities, and project plans and specifications, including the ability to make modifications to those plans and specifications.

**Project site.** The entire area on which construction activity is to be performed.

**Qualified professional.** An individual who is trained and experienced in stormwater treatment techniques and related fields as may be demonstrated by state registration, professional certification, experience, or completion of coursework that enable the individual to make sound, professional judgments regarding stormwater control or treatment and monitoring, pollutant fate and transport, and drainage planning.

**Rainfall Intensity.** The rate at which rain is falling at any given instant, usually expressed in inches per hour.

**Reach.** Any length of river, channel or storm drain.

**Receiving Stream or Receiving Water.** The body of water into which runoff or effluent is discharged. The term does not include private drains, unnamed conveyances, retention and detention basins, or constructed wetlands used as treatment.

**Recharge.** Replenishment of groundwater reservoirs by infiltration and transmission from the outcrop of an aquifer or from permeable soils.

**Recurrence Interval**. A statistical expression of the average time between floods equaling or exceeding a given magnitude.

**Redevelopment.** Alterations of a property that change a site or building in such a way that there is disturbances of one (1) acre or more of land. The term does not include such activities as exterior remodeling.

**Regulated Drain.** A drain subject to the provisions of the Indiana Drainage Code, I.C.-36-9-27.

**Regulatory or 100-Year Flood.** The discharge or elevation associated with the 100-year flood as calculated by a method and procedure which is acceptable to and approved by the Indiana Department of Natural Resources and the Federal Emergency Management Agency. The "regulatory flood" is also known as the "base flood".

**Regulatory Floodway.** See Floodway.

**Release Rate** - The amount of stormwater release from a stormwater control facility per unit of time.

**Reservoir**. A natural or artificially created pond, lake or other space used for storage, regulation or control of water. May be either permanent or temporary. The term is also used in the hydrologic modeling of storage facilities.

**Retail gasoline outlet.** An operating gasoline or diesel fueling facility whose primary function is the resale of fuels. The term applies to facilities that create five thousand (5,000) or more square feet of impervious surfaces, or generate an average daily traffic count of one hundred (100) vehicles per one thousand (1,000) square feet of land area.

**Retention basin.** A type of storage practice, that has no positive outlet, used to retain stormwater run-off for an indefinite amount of time. Runoff from this type of basin is removed only by infiltration through a porous bottom or by evaporation.

**Retention.** The storage of stormwater to prevent it from leaving the development site. May be temporary or permanent.

**Retention Facility.** A facility designed to completely retain a specified amount of stormwater runoff without release except by means of evaporation, infiltration or pumping. The volumes are often referred to in units of acre-feet.

**Return Period** - The average interval of time within which a given rainfall event will be equaled or exceeded once. A flood having a return period of 100 years has a one percent probability of being equaled or exceeded in any one year.

**Revetment.** Facing of stone or other material, either permanent or temporary, placed along the edge of a stream to stabilize the bank and protect it from the erosive action of the stream.

**Riprap.** Broken rock, cobble, or boulders placed on earth surfaces, such as the face of a dam or the bank of a stream, for protection against the action of water (waves). Revetment riprap is material graded such that: (1) no individual piece weighs more than 120 lbs. and (2) 90-100% will pass through a 12-inch sieve, 20-40% through a 6-inch sieve, and not more than 10% through a 3-inch sieve.

**Riverine**. Relating to, formed by, or resembling a stream (including creeks and rivers).

**Runoff Coefficient** - A decimal fraction relating the amount of rain which appears as runoff and reaches the storm drain system to the total amount of rain falling. A coefficient of 0.5 implies that 50 percent of the rain falling on a given surface appears as stormwater runoff.

**Runoff.** That portion of precipitation that flows from a drainage area on the land surface, in open channels, or in stormwater conveyance systems.

**Sand.** (1) Soil particles between 0.05 and 2.0 mm in diameter. (2) A soil textural class inclusive of all soils that are at least 70% sand and 15% or less clay.

**Scour.** The clearing and digging action of flowing water.

**Sediment.** Solid material (both mineral and organic) that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface.

**Sediment Forebay.** See "Forebay".

**Sedimentation**. The process that deposits soils, debris and other unconsolidated materials either on the ground surfaces or in bodies of water or watercourses.

**Seepage.** The passage of water or other fluid through a porous medium, such as the passage of water through an earth embankment or masonry wall.

**Sensitive Water.** A water body in need of priority protection or remediation based on its:

providing habitat for threatened or endangered species,

usage as a public water supply intake,

relevant community value,

usage for full body contact recreation,

exceptional use classification as found in 327 IAC 2-1-11(b), outstanding state resource water classification as found in 327 IAC 2-1-2(3) and 327 IAC 2-1.5-19(b).

**Silt Fence**. A fence constructed of wood or steel supports and either natural (e.g. burlap) or synthetic fabric stretched across area of non-concentrated flow during site development to trap and retain on-site sediment due to rainfall runoff.

**Silt.** (1) Soil fraction consisting of particles between 0.002 and 0.05 mm in diameter. (2) A soil textural class indicating more than 80% silt.

**Site.** The entire area included in the legal description of the land on which land disturbing activity is to be performed.

**Slope.** Degree of deviation of a surface from the horizontal, measured as a numerical ratio or percent. Expressed as a ratio, the first number is commonly the horizontal distance (run) and the second is the vertical distance (rise)--e.g., 2:1. However, the preferred method for designation of slopes is to clearly identify the horizontal (H) and vertical (V) components (length (L) and Width (W) components for horizontal angles). Also note that according to international standards (Metric), the slopes are presented as the vertical or width component shown on the numerator--e.g., 1V:2H. Slope expressions in the Ordinance or these Technical Standards follow the common presentation of slopes--e.g., 2:1 with the metric presentation shown in parenthesis--e.g., (1V:2H). Slopes can also be expressed in "percent". Slopes given in percent are always expressed as (100*V/H) --e.g., a 2:1 (1V:2H) slope is a 50% slope.

**Soil.** The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

**Solid Waste.** Any garbage, refuse, debris, or other discarded material.

**Special Flood Hazard Area**. An area that is inundated during the 100-Year flood.

**Spill.** The unexpected, unintended, abnormal, or unapproved dumping, leakage, drainage, seepage, discharge, or other loss of petroleum, hazardous substances, extremely hazardous substances, or objectionable substances. The term does not include releases to impervious surfaces when the substance does not migrate off the surface or penetrate the surface and enter the soil.

**Spillway** - A waterway in or about a hydraulic structure, for the escape of excess water.

**Stilling Basin** - A basin used to slow water down or dissipate its energy.

**Storm Duration.** The length of time that water may be stored in any stormwater control facility, computed from the time water first begins to be stored.

**Storm Event.** An estimate of the expected amount of precipitation within a given period of time. For example, a 10-yr. frequency, 24-hr. duration storm event is a storm that has a 10% probability of occurring in any one year. Precipitation is measured over a 24-hr. period.

**Storm Frequency.** The time interval between major storms of predetermined intensity and volumes of runoff--e.g., a 5-yr., 10-yr. or 20-yr. storm.

**Storm Sewer.** A closed conduit for conveying collected stormwater, while excluding sewage and industrial wastes. Also called a storm drain.

**Stormwater Drainage System** - All means, natural or man-made, used for conducting stormwater to, through or from a drainage area to any of the following: conduits and appurtenant features, canals, channels, ditches, storage facilities, swales, streams, culverts, streets and pumping stations.

**Stormwater Facility.** All ditches, channels, conduits, levees, ponds, natural and man-made impoundments, wetlands, tiles, swales, sewers and other natural or artificial means of draining surface and subsurface water from land.

**Stormwater Pollution Prevention Plan.** A plan developed to minimize the impact of stormwater pollutants resulting from construction activities.

**Stormwater Quality Measure.** A practice, or a combination of practices, to control or minimize pollutants associated with stormwater runoff.

**Stormwater runoff.** The water derived from rains falling within a tributary basin, flowing over the surface of the ground or collected in channels or conduits.

**Stormwater.** Water resulting from rain, melting or melted snow, hail, or sleet.

**Stream.** See “Intermittent Stream”, “Perennial Stream”, “Receiving Stream”.

**Structure.** Refers to a structure that is principally above ground and is enclosed by walls and a roof. The term includes but is not limited to, a gas or liquid storage tank, a manufactured home or a prefabricated building, and recreational vehicles to be installed on a site for more than 180 days.

**Structural Engineer**. A person licensed under the laws of the State of Indiana to engage in the designing or supervising of construction, enlargement or alteration of structures or any part thereof.

**Subarea/Sub-basin**. Portion of a watershed divided into homogenous drainage units which can be modeled for purposes of determining runoff rates. The subareas/sub-basins have distinct boundaries, as defined by the topography of the area.

**Subdivision.** Any land that is divided or proposed to be divided into lots, whether contiguous or subject to zoning requirements, for the purpose of sale or lease as part of a larger common plan of development or sale.

**Subsoil**. The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below which roots do not normally grow.

**Subsurface Drain.** A pervious backfilled trench, usually containing stone and perforated pipe, for intercepting groundwater or seepage.

**Sump Pump**. A pump that discharges seepage from foundation footing drains.

**Surcharge.** Backup of water in a sanitary or storm sewer system in excess of the design capacity of the system.

**Surface Runoff.** Precipitation that flows onto the surfaces of roofs, streets, the ground, etc., and is not absorbed or retained by that surface but collects and runs off.

**Suspended Solids.** Solids either floating or suspended in water.

**Swale.** An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water. Swales conduct stormwater into primary drainage channels and may provide some groundwater recharge.

**Tailwater.** The water surface elevation at the downstream side of a hydraulic structure (i.e. culvert, bridge, weir, dam, etc.).

**Time of Concentration (tc)**. The travel time of a particle of water from the most hydraulically remote point in the contributing area to the point under study. This can be considered the sum of an overland flow time and times of travel in street gutters, storm sewers, drainage channels, and all other drainage ways.

**Topographic Map**. Graphical portrayal of the topographic features of a land area, showing both the horizontal distances between the features and their elevations above a given datum.

**Topography**. The representation of a portion of the earth's surface showing natural and man-made features of a given locality such as rivers, streams, ditches, lakes, roads, buildings and most importantly, variations in ground elevations for the terrain of the area.

**Topsoil.** (1) The dark-colored surface layer, or a horizon, of a soil; when present it ranges in depth from a fraction of an inch to 2-3 ft. (2) Equivalent to the plow layer of cultivated soils. (3) Commonly used to refer to the surface layer(s), enriched in organic matter and having textural and structural characteristics favorable for plant growth.

**Toxicity.** The characteristic of being poisonous or harmful to plant or animal life. The relative degree or severity of this characteristic.

**Trained individual.** An individual who is trained and experienced in the principles of stormwater quality, including erosion and sediment control as may be demonstrated by state registration, professional certification (such as CESSWI and/or CPESC certification), or other documented and applicable experience or coursework as deemed sufficient by the *City of Angola* that enable the individual to make judgments regarding stormwater control or treatment and monitoring.

**Tributary**. Based on the size of the contributing drainage area, a smaller watercourse which flows into a larger watercourse.

**Turbidity.** (1) Cloudiness of a liquid, caused by suspended solids. (2) A measure of the suspended solids in a liquid.

**Underdrain**. A small diameter perforated pipe that allows the bottom of a detention basin, channel or swale to drain.

**Uniform Flow**. A state of steady flow when the mean velocity and cross-sectional area remain constant in all sections of a reach.

**Urbanization.** The development, change or improvement of any parcel of land consisting of one or more lots for residential, commercial, industrial, institutional, recreational or public utility purposes.

**Vegetative practices.** Any nonstructural or structural BMP that, with optimal design and good soil conditions, utilizes various forms of vegetation to enhance pollutant removal, maintain and improve natural site hydrology, promote healthier habitats, and increase aesthetic appeal. Examples include grass swales, filter strips, buffer strips, constructed wetlands, and rain gardens.

**Vegetative Stabilization.** Protection of erodible or sediment producing areas with: permanent seeding (producing long-term vegetative cover), short-term seeding (producing temporary vegetative cover), or sodding (producing areas covered with a turf of perennial sod-forming grass).

**Water Quality.** A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

**Water Resources.** The supply of groundwater and surface water in a given area.

**Water Table.** (1) The free surface of the groundwater. (2) That surface subject to atmospheric pressure under the ground, generally rising and failing with the season or from other conditions such as water withdrawal.

**Waterbody.** Any accumulation of water, surface, or underground, natural or artificial.

**Watercourse.** Any river, stream, creek, brook, branch, natural or man-made drainageway in or into which stormwater runoff or floodwaters flow either continuously or intermittently.

**Watershed**. The region drained by or contributing water to a specific point that could be along a stream, lake or other stormwater facilities. Watersheds are often broken down into subareas for the purpose of hydrologic modeling.

**Waterway.** A naturally existing or man-made open conduit or channel utilized for the conveyance of water.

**Weir.** A channel-spanning structure for measuring or regulating the flow of water.

**Wet-Bottom Detention Basin (Retention Basin)** - A basin designed to retain a permanent pool of water after having provided its planned detention of runoff during a storm event.

**Wetlands**. Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.