STORMWATER TECHNICAL STANDARDS MANUAL

City of Washington

2024

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CITY OF WASHINGTON
Stormwater Technical Standards Manual

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Chapter 1
Applicable Policies

I. Introduction

a. The purpose of this Stormwater Technical Standards Manual is to establish design standards for stormwater management within a single document that can be easily referenced and to ensure quality design to minimize the impacts of development projects on the City's stormwater facilities. Refer to City of Washington Code of Ordinances: Chapter 53, for additional Stormwater Management requirements.

b. This document shall be considered as a companion document to the Ordinance. Whereas the ordinance contains the majority of the regulatory authority and the general requirements of comprehensive stormwater management, this document contains the necessary means and methods for achieving compliance with the Ordinance.

c. In addition to the stormwater standards provided in this document, the City of Washington may have adopted, or may adopt in the future, separate other technical standards regarding various aspects of stormwater conveyance systems that for various reasons may not have been incorporated in this technical standards document. In case there are conflicts between the requirements contained in this document and the ordinance, the requirements of the Ordinance should prevail.

d. For comprehensive technical guidance on calculations and modeling of stormwater quantity and quality infrastructure in Indiana, refer to the latest of the "Indiana LTAP Stormwater Drainage Manual."

e. This document contains formulas and methodologies for the review and design of both stormwater quantity and stormwater quality facilities. Chapter 2 through 6 contain stormwater conveyance and detention calculations and requirements. Chapter 7 contains information on erosion control requirements and other pollution prevention measures for active construction sites. Chapters 8 through 9 cover calculations required to properly size and design stormwater quality features that will treat runoff following construction completion. Chapter 10 includes lot building and grading and drainage standards. Best Management Practices (BMPs) for erosion control measures during the construction phase and for post-construction erosion and sediment control measures can be found in, in the Best Management Manual and Low Impact Design Manual included in this document, as well as the Indiana Stormwater Quality Manual. Several useful and necessary standard forms are in Appendix A.

II. Compliance Requirements

a. Those projects which cause a land disturbance of more than one acre and disturbances of land less than one acre of total land area that are part of a larger common plan of development or sale which will ultimately disturb one acre or more of total land area within the MS4 area must acquire a stormwater permit (SWP).

   i. Land disturbing activity means any manmade change of the land surface including, but not limited to removing vegetative cover that exposes the underlying soil, excavating, filling, and grading.

   ii. The following activities shall be considered land disturbances:
      1. Changing the contour of the land.
      2. Increasing the runoff rate or volume from the project site.
      3. Increasing the percentage of impervious area of the project site.
      4. Changing the project site's drainage pattern
      5. Creating a new stormwater facility or modifying an existing stormwater facility (even if under one acre).
      6. Creating an impoundment (even if under one acre).
      7. Restricting or potentially restricting pass-through flows from off-site (even if under one acre).
      8. Adding stormwater infrastructure including, but not limited to, culverts, catch basins, storm sewers, etc., which are to be maintained by the City of Washington (even if under one acre).

III. Plan Submittal

a. All project plans, specifications, and calculations shall be certified by a Professional Engineer or Land Surveyor registered in the State of Indiana.

b. All project plans, specifications and calculations shall be completed in accordance with the Washington, Indiana, Standards.

c. Plan Submittal and Review Process

   i. Required Submissions

      1. It is the responsibility of the project site owner to complete a Stormwater Permit Application for submission to the City Building Commissioner for review for each new development and redevelopment site. Components of the Construction/Land Disturbance Stormwater Permit Application shall include items as required by the IDEM Construction Stormwater General Permit.

      2. The project site owner shall submit an Operations and Maintenance (O&M)

Manual per the requirements as listed in this Chapter, Section VI.

3. The project site owner shall complete a Long-Term Maintenance Agreement with the City for all sites with a post-construction permanent best management measure installed.

4. The project site owner shall submit supporting calculations and documentation demonstrating the adequacy of the selected post-construction stormwater management measures.

5. Site Plan Review in front of the Plan Commission is required and is normally performed concurrently with the Construction/Land Disturbance Stormwater Permit Review.

IV. Inspection Requirements

a. The Project Site Owner or representative of the owner is required to perform inspections, also called project self-monitoring. Project self-monitoring must be performed by a trained individual according to City of Washington Code of Ordinances: Chapter 53.
b. Inspections shall be performed at all control measures every 7 days and within 24 hours of a ½-inch rain event.
    i. Project self-monitoring shall be documented in written form and be made available to the City upon request and in accordance with Chapter 7 of this manual.
c. Documentation of permittee performed inspections and inspection findings shall be kept on site and shall be made available within 48 hours of a request by the City or designated representative. Documentation must be submitted in a written format, and if delivered via email, must be legible and easily accessed for review. If inspections are not posted or timely submitted, as requested, will be assumed to indicate inspections were not performed and may result in corresponding enforcement procedures.

V. Maintenance Requirements

a. Maintenance must be performed under the direction and/or supervision of a trained individual.

b. Maintenance of erosion prevention, sediment control, and pollution prevention practices shall be performed according to the construction plan, stormwater pollution prevention plan, long-term operation and maintenance agreement, and operation and maintenance manual.

c. Maintenance activities shall be performed in accordance with action plans developed through the course of permittee-performed inspections and operation and maintenance manuals.

d. Corrective actions shall be tracked in the construction site inspection project management log with dates the correction action was complete. If steps were taken to address the deficiency the log should be detailed to provide the steps taken.

e. Ensure the stormwater pollution prevention plan is updated to include any changes and reflect field conditions.

VI. Operation and Maintenance Manual

a. An 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. The Operation and Maintenance (O&M) Manual shall be prepared by the design engineer and be submitted for review with the Stormwater Permit.

c. An O&M Manual must include a description of the maintenance guidelines for all post-construction stormwater measures to facilitate their proper long-term function.

d. 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.

e. When known at the time of plan submittal, the entity that will be responsible for operation and maintenance of the system must be provided a copy of the O&M Manual and Agreement to ensure they understand the requirements.

f. O&M Manual must include:

i. Contact information for all persons involved in the ownership of and maintenance activities, associated with the management of the permanent stormwater management measure and 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).

ii. 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. A copy of the O&M Manual shall be provided to each new owner before the transfer of ownership. The O&M Manual shall be signed by the new owner, notarized, and submitted to the City to be kept on record.

iii. 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:

1. The location of the stormwater management facilities and BMPs.
2. Plan and cross-section details, showing applicable features.
3. The flow of stormwater through the site, including an overview of the stormwater's path through the onsite stormwater facilities and BMPs.
4. 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.

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

i. Guidance on owner-required periodic inspections and inspections to be performed by the City.

ii. Guidance on routine maintenance including mowing, litter removal, woody growth removal, etc. to be performed by the owner.

iii. Guidance on remedial maintenance such as inlet replacement, outlet work, etc. to be performed by the owner.

iv. Guidance on sediment removal, both narrative and graphical, describing when sediment removal shall occur 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.

v. Instructions on inspection and clean-out of BMPs, sumps, trash screens, settling pits, and oil/grease collection chambers.

vi. Instructions on proper disposal of removed sediments, trash, debris, and other substances.

vii. Guidance and methods for preventing water stagnation and all recommended maintenance.

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

i. Operation and maintenance procedures and practices shall be reviewed and assessed annually.

ii. Access routes, including roadways and sidewalks, shall be inspected annually, and maintained as needed.

iii. Drainage structures and flow restrictors shall be inspected and cleaned semi-annually or per the manufacturer's recommendations, whichever is more stringent.

iv. 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.

v. The owner shall keep an updated log or inspection worksheets documenting the performance of the required operation and maintenance activities for perpetuity. Note the following within the inspection log:

1. Inspection dates,
2. Facility components inspected,
3. Facility condition, and
4. Any maintenance performed, or repairs made.

vi. Documentation must be produced upon the request of the City within 48-hours of the request.

vii. Vegetation shall be maintained on a regular basis per design specifications.

viii. Pest control measures shall be implemented to address insects, rodents, and other pests. Natural pest control is preferred over chemical treatments.

ix. Mechanical measures shall be maintained on a regular basis per the manufacturer's recommendations.

x. Native vegetation plantings shall have "No Mow" or signage as requested by the MS4 Coordinator.

xi. Underground vaults and structures shall include design measures to facilitate regular cleaning and maintenance and confined space entry procedures shall be followed.

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

j. An inspection and maintenance schedule, providing the routine examination of all stormwater management facilities and stormwater quality BMPs, shall be prepared in a tabular format, and included in the O&M Manual.

k. The O&M Manual shall include graphic documentation of drainage easement(s) around the stormwater management facilities and BMPs and access to those that do not adjoin a public right-of-way.

VII. Drainage Easements

a. Drainage easements must be provided for maintenance of the stormwater management system of publicly owned systems. Privately-owned ponds, detention/retention basins, permanent water quality BMPs, and LID practices must be contained within easements. Easements are not required for temporary private systems, such as permeable pavement, green roof, rain barrel(s), and other BMPs and LID practices as approved by the MS4 Coordinator.
b. Access easements must be provided from a public roadway to the drainage easement, for access to stormwater management facilities.
c. Structures, fences, obstruction, or landscaping may not be placed in an easement in a way that will impede the free flow of stormwater.
d. Drainage easements shall be maintained by the property owner.
e. Where the City of Washington is responsible for maintenance of the drainage system, regulated drainage easements of 75 feet from the top of bank on each side of the channel or each side of the tile centerline must be dedicated to The City of Washington.
f. All new channels, swales, drain tiles, inlet and outlet structures of detention and retention ponds and appurtenances thereto as required by section 3 of the City Stormwater Ordinance, that are installed on the municipal or school property shall be within easements and have clearly defined maintenance agreements.
g. Access easements of at least 20 feet are required, as defined by this section, and alternatives, including additional easement requirements, may be requested by the City Building Commissioner.
h. Table 1-1 on the following page, shows the easement required widths and situations.

TABLE 1-1

Area or Situation	Easement Width
Storm sewer (smaller than 24-in.)	20 feet, centered over sewer
Storm sewer (24-in. and larger)	30 feet, centered over sewer
Grassed waterways (including equivalent sized-lined channels)	Width of channel plus 15 feet, centered over waterway
Subsurface drain	20 feet, centered over drain
Open outlet channel (including equivalent sized-lined channels)	20 feet from top of each bank
Retention pond, detention basin, and/or permanent sediment basin	Elevation of the emergency spillway design flow, plus 20 feet (horizontally)
Underground detention facility	Detention facility footprint plus 15 feet in every direction (horizontally)
Permanent Stormwater BMP (above or below grade)	BMP footprint plus 15 feet in every direction (horizontally)
Emergency overflow and spillway routing path	A minimum of thirty (30) feet width along the centerline of emergency overflow route or the flow width required to accommodate the emergency spillway design flow, whichever is greater.
Access easement	20 feet wide from a public right-of-way to the stormwater infrastructure

VIII. Enforcement

a. If the City or its designated representative finds the permittee to be out of compliance with the inspections, maintenance requirements, or provisions of the Stormwater Management Chapter 53, the City, its designated representative, or his or her designee may give notice to the permittee. If at any point during the project, the contact information for the applicant changes, the updated information must be submitted to the City. Corrective action must be initiated on the day the deficiency was discovered, and if not resolved within 48 hours, then a temporary measure or installation of a new or replacement measure must be completed. If corrective action isn't completed within 48 hours, then an alternative compliance plan must be submitted for acceptance to the MS4 Coordinator. An alternative compliance plan must be accepted prior to the end of the initial 48 hours, or the deficiency may result in enforcement.

b. The City of Washington has established an enforcement schedule, as noted in the following table that standardizes the approach that the City of Washington may, in its discretion, employ in dealing with stormwater regulations offenses subject to this Ordinance and the associated Technical Standards document. When so employed, this Schedule shall apply separately to each offense in the following manner: The first offense is the underlying violation itself, while the subsequent offenses 2 thru 8 are failures of compliance:

TABLE 1-2

Offense #	Type of Response Anticipated
1st	Verbal Notice, Letter of violation or written warning and administrative penalty
2nd	Letter of Violation*, administrative penalty and/or Site Visit
3rd	Letter of Violation, administrative penalty and/or Site Visit
4th	Letter of Violation, administrative penalty and/or Site Visit
5th	Agreed Order, Administrative Penalty and/or Site Visit
6th	Administrative Order, Administrative Penalty and/or Site Visit
7th	Compliance schedule, administrative Penalty and/or Site Visit
8th	Litigation and Administrative Penalty
*Can be delivered electronically, to the permit holder's email address, or regular mail, as provided with the stormwater permit application.	

c. Likewise, in order to standardize the approach that the City of Washington may, in its discretion, employ in the imposition of Administrative Penalties, the City of Washington has established the following Schedule of Administrative Penalties. Again, the penalty for the 1st offense would apply to the violation itself, while the subsequent penalties 2 through 4 (as necessary) would apply to failures of meeting compliance. In its discretion, the City of Washington may impose additional penalties up to the amount specified in this Schedule.

TABLE 1-3

Fine Category	1st offense	2nd offense	3rd offense
Commercial lot or multi-parcel development (subdivision, commercial, industrial, institutional)	$500	$1,000	$2,500
Individual Lot (residential)	$150	$350	$750

Chapter 2
Methodology for Determination of Runoff Rates

I. Introduction

a. 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:

   i. Development sites less than or equal to 5 acres with a contributing drainage area of 50 acres or less and no depressional storage may utilize the rational method to determine runoff rates. Computer models which can generate hydrographs based on the time of concentration calculated using the TR-55 method and curve number calculation may also be used with a 24-hour duration NRCS Type 2 storm.

   ii. Development sites greater than 5 acres and/or with a contributing drainage area of over 50 acres shall utilize a computer model that can generate hydrographs based on the time of concentration calculated using the TR-55 time of concentration and curve number calculation methodologies.

b. The allowable release rate from any development site is 0.2 cubic feet per second per acre for 1 to 100-year return interval storms. The 2-year post development conditions cannot exceed 2-year predevelopment conditions.

II. Runoff Rate Determination Calculations

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

   $Q = (C)(I)(A)$

   where:

   Q = peak release rate in cubic feet per second

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

   I = average rainfall intensity 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 **Table 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 is to be used for all stormwater management projects within the City of Washington, 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 6). 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

Developed from the HERPICC Stormwater Drainage Manual

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

TABLE 2-4

Rainfall Intensities for Various Return Periods and Storm Durations						
Intensity (Inches/Hour)						
Duration	*Return Period (Years)*					
	2	5	10	25	50	100
5 Min.	5.62	6.66	7.50	8.57	9.41	10.2
10 Min.	4.39	5.18	5.79	6.55	7.13	7.70
15 Min.	3.57	4.24	4.75	5.40	5.89	6.38
30 Min.	2.39	2.90	3.30	3.81	4.21	4.60
1 Hr.	1.22	1.82	2.10	2.47	2.77	3.08
2 Hrs.	0.875	1.10	1.27	1.52	1.72	1.92
3 Hrs.	0.622	0.780	0.908	1.09	1.24	1.39
6 Hrs.	0.377	0.471	0.548	0.657	0.747	0.843
12 Hrs.	0.222	0.275	0.318	0.379	0.429	0.481
24 Hrs.	0.133	0.165	0.190	0.225	0.254	0.284

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

b. 24-hour Rainfall depth for various frequencies 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 and should be accepted by the City of Washington prior to their utilization.

TABLE 2-5

Rainfall Depths for Various Return Periods						
Depth (Inches)						
Duration	*Return Period (Years)*					
	2	5	10	25	50	100
24 Hrs.	3.20	3.96	4.57	5.41	6.11	6.82

Source: NOAA, National Weather Service, "Precipitation-Frequency Atlas of the United States", NOAA Atlas 14, Volume 2, Version 2, rev 2006, for Washington, 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**

Development sites with drainage areas greater than or equal to one square mile, or a 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.

d. No Net Loss Floodplain Storage Policy

Floodplains exist adjacent to all natural and constructed streams, regardless of contributing drainage area or whether they have been previously identified or mapped. Due to potential impacts of floodplain loss on peak flows in streams and on the environment, disturbance to floodplains should be avoided. When the avoidance of floodplain disturbance is not practical, the natural functions of floodplain should be preserved to the maximum extent possible.

Compensatory excavation 1.5 times the floodplain storage lost shall be required for all activities within floodplain of streams located in the City of Washington where drainage area of the stream is equal or larger than one square mile. The City of Washington may alter the compensation ratio, based on extenuating circumstances, for a specific project, for specific written reasons.

Compensatory storage is required when a portion of the floodplain is filled, occupied by a structure, or when as a result of a project a change in the channel hydraulics occurs that reduces the existing available floodplain storage. The compensatory storage should be located adjacent or opposite the placement of the fill and maintain an unimpeded connection to an adjoining floodplain area.

Chapter 3
Methodology for Determination of Retention/Detention Storage Volumes

I. Introduction

a. 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.

II. Post-Development Hydrologic Parameters

a. 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).

LID Exception: If Low Impact Development (LID) approach is pursued in satisfying the requirements noted in Chapter 8 (Post-Construction Stormwater Quality Management Standards), the post-developed CN for the protected undisturbed or restored disturbed areas meeting the requirements described in Chapter 8 and BMP fact sheets may be determined based on pre-development underlying soil layer.

III. Design Storm & Allowable Release Rates for Development Sites with On-Site Detention Facilities

a. 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 Technical Standards Manual.

IV. Design Storm & Allowable Release Rates for Development Sites Within a Designated Drainage Area Serviced by a Regional Detention Facility

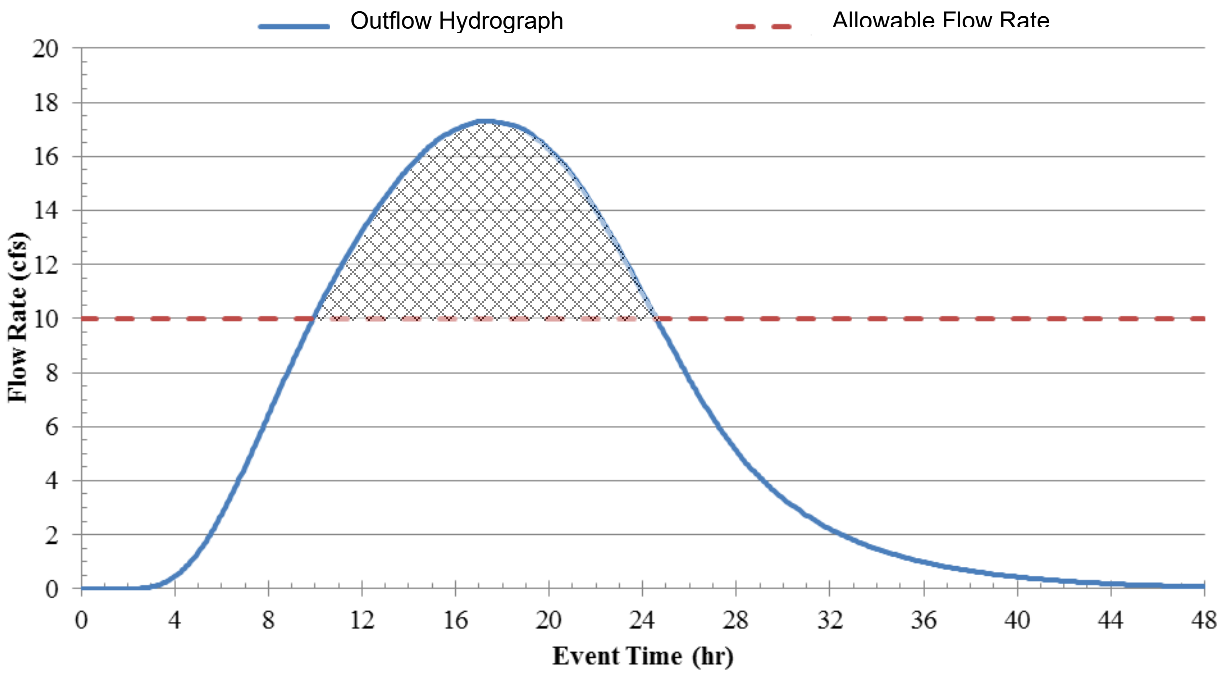
a. Development sites within Designated Drainage Areas making use of regional detention ponds are typically not required to provide on-site detention.

b. Where a regional detention facility is servicing or is planned to service a sub-watershed area, and that sub-watershed has been declared a Designated Drainage Area to raise the necessary Infrastructure Development Fees in lieu of providing on-site detention, the following method shall be used to determine the size of storage space that would have been required on-site. This estimated storage volume will be used to determine the fee based on the development site's proportionate share of regional detention storage.

c. The 24-hour NRCS Type 2 Rainfall Distribution shall be utilized to determine the required storage volume. The stormwater model should not include an on-site detention facility. The outflow hydrograph at the downstream-most point in the site's stormwater system shall be compared to the allowable release rate for the Designated Drainage Area to determine the required storage volume. The allowable release rate for a Designated Drainage Area shall be as defined by the resolution forming the Designated Drainage Area.

d. The storage volume shall be determined by calculating the volume of outflow from the site that exceeds the given allowable release rate. For example, if a 50-acre site is located in a Designated Drainage Area that has an allowable post-development 100-year release rate of 0.2 cfs/acre, the required storage volume for the site would be equal to the volume of water represented by the cross-hatched area in **Figure 3-1**.

FIGURE 3-1
Required Storage Volume Determination Example



Chapter 4
Storm Sewer Design Standards and Specifications

I. Introduction

a. 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 XIV. 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.

II. Design Storm Frequencies

a. 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 24-hour, 10-year return frequency storm calculated based on methodology described in Chapter 2. Additional discharges to storm sewer systems allowed in Section III. below of this Section must be considered in all design calculations. For Rational Method analysis, the duration shall be equal to the time of concentration for the drainage area. In computer-based analysis, the duration is as noted in the applicable methodology associated with the computer program.

b. Culverts shall be capable of accommodating peak runoff from a 24-hour, 50-year frequency storm when crossing under a road which is part of the INDOT Rural Functional Classification System or is classified as freeway, arterial, and/or collectors by the City of Washington Zoning Ordinance or provides the only access to and from any portion of any commercial or residential developments. 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 Washington, 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.

c. For portions of the system considered minor drainage systems, the allowable spread of water on Collector Streets 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.

d. 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.

e. Facilities functioning as a major drainage system as defined in the ordinance, must also meet IDNR design standards, in addition to the Washington, Indiana City Standards. In case of discrepancy, the most restrictive requirements shall apply.

f. For drainage easement requirements, see Chapter 1.

III. Determination of Hydraulic Capacity for Storm Sewers Using Manning's Equation

a. The determination of the hydraulic capacity for storm sewers is based on the Manning's open- channel flow equation:
Where:

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

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 hydraulic grade line in feet per foot
n = Manning's "n" roughness coefficient

b. 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	0.012	10
PVC	0.011	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). 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 Washington.

IV. 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. 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 STORMCAAD 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 Washington or designee.

V. Minimum Size for Storm Sewers

The minimum diameter of all storm sewers 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 Washington.

VI. Pipe Cover, Grade, and Separation from Sanitary Sewers and Water Mains

Pipe grade shall be such that, in general, a minimum of 2.0 feet of cover is maintained over the top of the pipe. If the pipe is to be placed under pavement, then the minimum pipe cover shall be 2.5 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 Washington. 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 2.0 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.

Based on Kutter's formula using an "n" value of 0.013, the following are the minimum slopes should be provided. Slopes greater than these are desirable:

Sewer Size	Minimum Slope in Feet Per 100 Feet
12 inch	0.22
14 inch	0.17
15 inch	0.15
16 inch	0.14
18 inch	0.12
21 inch	0.10
24 inch	0.08
27 inch	0.067
30 inch	0.058
36 inch	0.046

Storm sewers shall be laid at least 10 feet horizontally from any existing or proposed water main. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten-foot separation, the appropriate reviewing agency may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the storm sewer closer to a water main, provided that the water main is in a separate trench or on an undisturbed earth shelf located on one side of the storm sewer and at the elevation so the bottom of the water main is at least 18 inches above the top of the storm sewer.

VII. Alignment

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

VIII. Manholes/Inlets

All Inlets must be pre-stamped with an appropriate "clean water" message. 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 36 inches or a rectangular opening of no less than 22 inches by 22 inches. 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).

Manhole/inlet inside sizing shall be as shown in **Table 4-3**. Plans should note that all inlets and castings must be pre-stamped with a "clean water"," drains to a waterway", or a similarly worded message.

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"

IX. 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. An overload 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, or by using **Figure 4-1**. Further guidance regarding gutter spread calculation may be found in the latest edition of HERPICC 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

X. Installation and Workmanship

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. All storm sewer pipe outlets shall have poured in place toewalls with anchor bolts. 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 4-2** and **Figure 4-3**. 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 Washington. 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 Washington before maintenance sureties would be recommended to be released.

Based on the review of visual recordings, the City of Washington 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.

XI. Materials

Storm sewer manholes and inlets shall be constructed of cast in place concrete or precast 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 be extra-strength clay pipe (ASTM C-12), ductile iron pipe (AWWA C-151), poly vinyl chloride pipe (AASHTO M252), polyethylene pipe (AASHTO M252 or AASHTO M294), or concrete pipe (AASHTO M170). 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 Washington. Pipe joints shall be flexible and watertight and shall conform to the requirements of Section 906, of the latest edition of the INDOT "Standard Specifications". 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 concrete.

XII. 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.

XIII. Connections to Storm Sewer System

To allow any connections to the storm sewer system, provisions for the connections shall be shown in the drainage calculations for the system. Specific language shall be provided in the protective covenants, on the record plat, or with the parcel deed of record, noting the ability or inability of the system to accommodate any permitted connections, for example, sump pumps and footing drains.

1. Sump pumps installed to receive and discharge groundwater or other stormwater shall be connected to the storm sewer where possible or discharged into a designated storm drainage channel/swale. Sump pumps installed to receive and discharge floor drain flow or other sanitary sewage shall be connected to the sanitary sewers. A sump pump shall be used for one function only, either the discharge of stormwater or the discharge of sanitary sewage.
2. Footing drains and perimeter drains shall be connected to Manholes or Curb inlets, where possible, or to designated storm sewers or discharged into designated storm drainage channels/swales.
3. All roof downspouts, roof drains, or roof drainage piping 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 Washington 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.
5. Swimming Pool drains shall not be connected to the storm sewers.

In addition, none of the above-mentioned devices shall be connected to any street underdrains, unless specifically authorized by the City of Washington. Sub-drains shall be installed on all new developments by the developer.

XIV. Drainage System Overflow Design

Overflow path/ponding areas throughout the development resulting from a 100-year storm event shall be determined and 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 completely plugged.

The centerline of this 100-year overflow path shall be clearly shown as a distinctive line symbol on the plans. See Chapter 1, Section VII. for drainage easement requirements. This overflow path/easement area shall be shown on the plans as hatched area or another distinctive symbol. A statement shall be added to the plat that would refer the viewer to the construction plans to see the entire extent of overflow path as hatched areas. No fences or landscaping can be constructed within the easement areas that may impede the free flow of Stormwater. These areas are to be maintained by the property owners or be designated as common areas that are to be maintained by the homeowner's association. The Lowest Adjacent Grade for all residential, commercial, or industrial buildings shall be set a minimum of 1 foot above the noted overflow path/ponding elevation.

The overflow path/ponding may be modeled as successive series of natural ponds and open channel segments. 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, HEC-HMS, and HEC-1, combined with HEC-RAS. Other models may be acceptable and should be accepted by the City of Washington prior to their utilization.

Values in Table 4-5 may be utilized as an alternative to the above-noted detailed calculations for determining the required pad elevations of buildings near an overflow path.

If **Table 4-5** is used, the City of Washington reserves the right to require independent calculations to verify that the proposed building pads provide approximately 1 foot of freeboard above the anticipated overflow path/ponding elevations.

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 Washington official charged with the approval authority at the time of the acceptance, and (2) evidence of its construction and maintenance can be shown.

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 8. Channels should be modeled according to modeling techniques discussed in Chapter 7. 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 Washington 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 Washington 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 Street and Gutter Capacities (continuous grade)

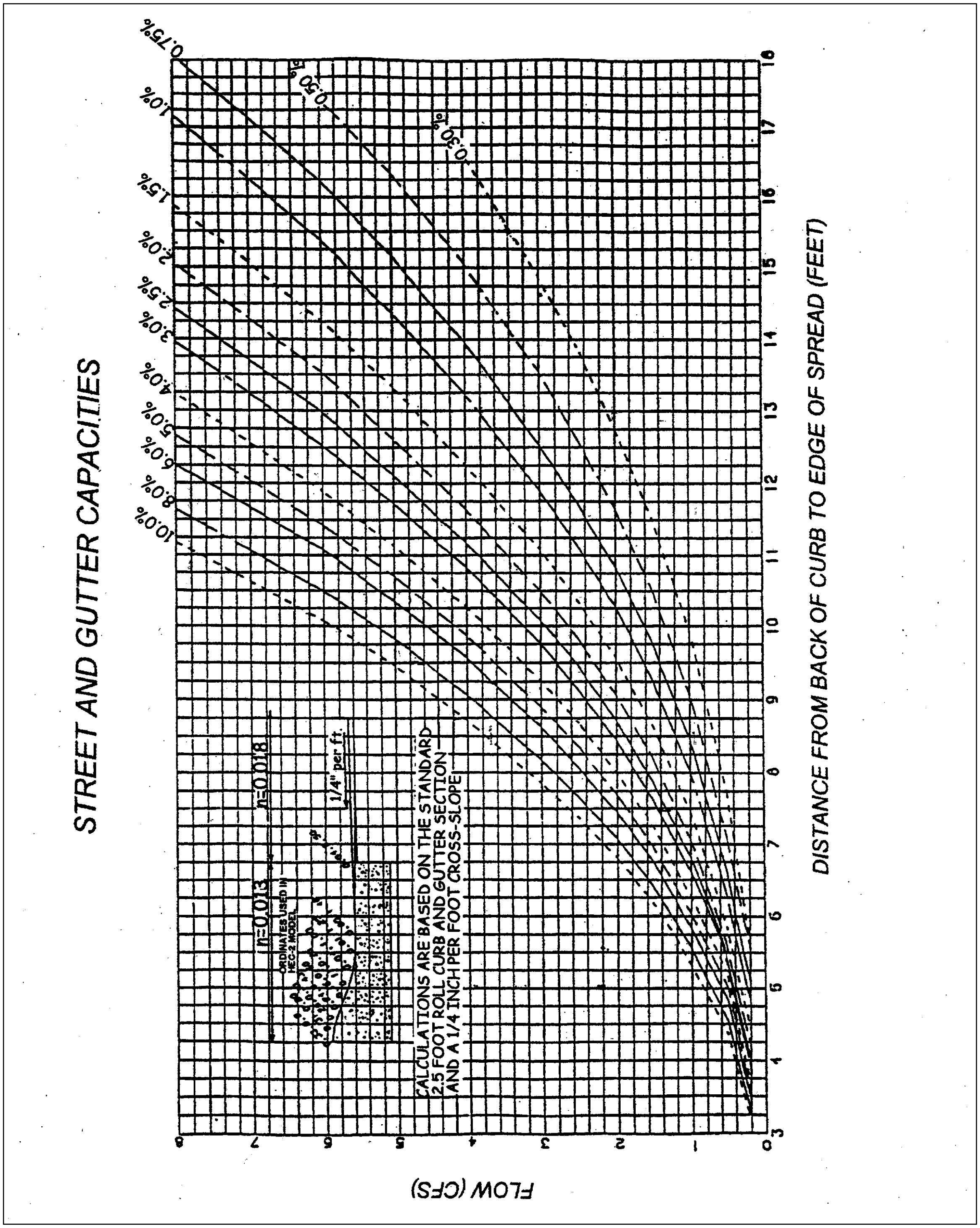
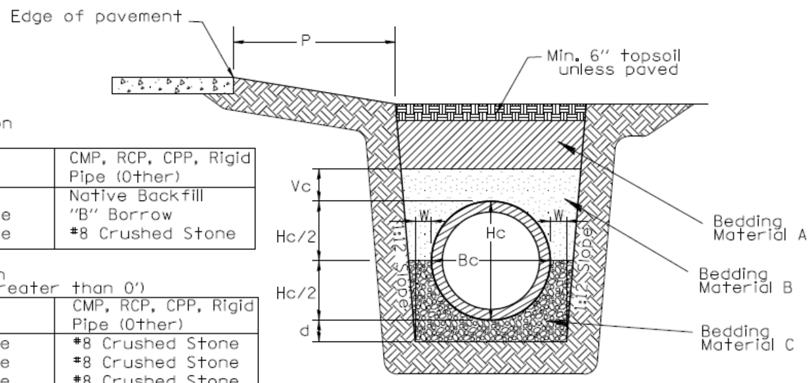


FIGURE 4-2

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

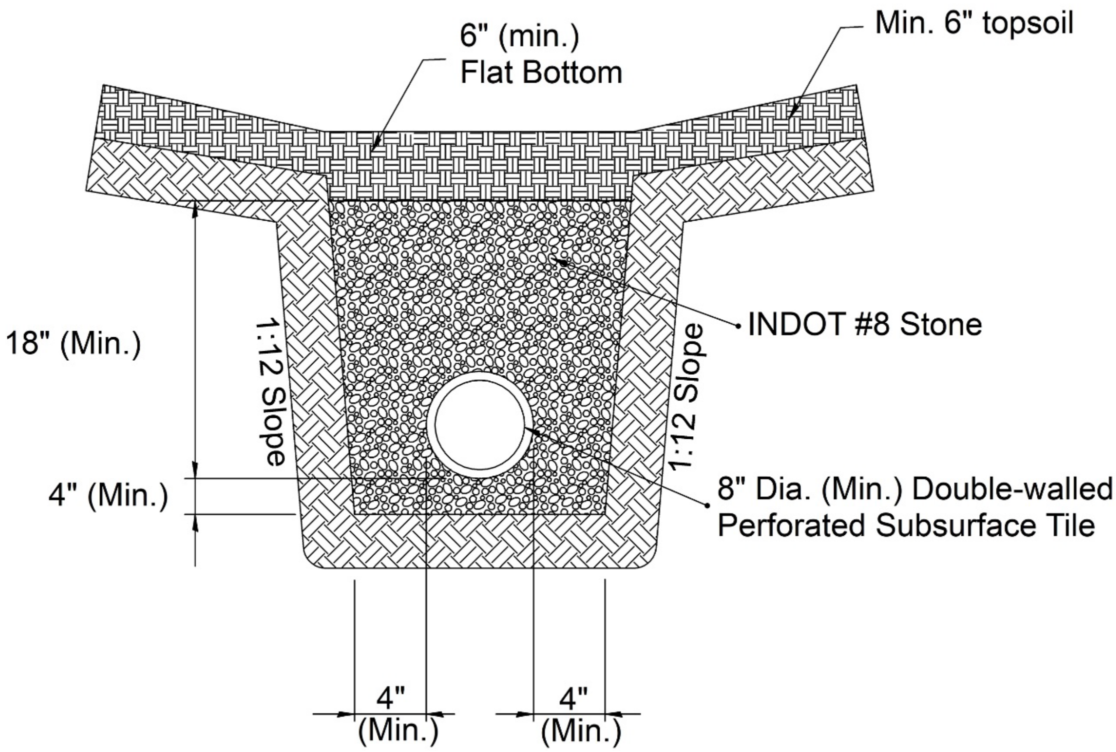
LEGEND

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 4-3
Bedding and Backfill for Sub-drains under Swales



Chapter 5
Open Channel Design

I. Introduction

a. All channels, whether private or public, and whether constructed on private or public land, shall conform to the 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 tributary off-site stormwater runoff based on the future developed condition (using Table 6-1 of this Technical Standard Manual). 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 XIV. 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.

II. Design Storm Frequencies

a. Channels and swales shall be designed to accommodate peak runoff from a 10-year, return frequency storm calculated based on methodology described in Chapter 2 of this manual.

b. Channels with a capacity of more than 30 cubic feet per second shall be capable of accommodating a 24-hour, 50-year return frequency storm within the drainage easement.

c. Channel facilities functioning as a major drainage system, as defined in the ordinance, must also meet IDNR design standards in addition to the City of Washington standards. In case of discrepancy, the most restrictive requirements shall apply.

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

e. See Chapter 1, Section VII., for drainage easement requirements.

III. Open Channel Waterway Area Calculations

a. Velocity (V) of an open channel waterway shall be based on Manning's Equation:

$$V = \frac{1.49}{n} * R^{\frac{2}{3}}\sqrt{s}$$

where:

V = velocity of flow in feet per second

n = Manning's roughness coefficient

R = hydraulic radius in feet

S = slope of hydraulic gradeline in feet per foot

b. And, where:

$$A = Q/V$$

A = cross sectional area of channel in square feet

Q = discharge in cubic feet per second (cfs)

V = velocity of flow in feet per second

IV. Backwater Method for Drainage System Analysis

a. 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 Washington.

V. Channel cross-section and Grade

a. 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.

b. Where depth of design flow is slightly below critical depth, channels shall have freeboard adequate to cope with the effect of hydraulic jumps.
c. 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.
d. 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
Velocities for Vegetated-Lined Channels

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

VI. Side Slopes

a. 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.
b. 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.
c. 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.
d. 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.

VII. Channel Stability

a. Characteristics of a stable channel are:

  i. It neither promotes sedimentation nor degrades the channel bottom and sides.

  ii. The channel banks do not erode to the extent that the channel cross-section is changed appreciably.

  iii. Excessive sediment bars do not develop.

  iv. Excessive erosion does not occur around culverts, bridges, outfalls or elsewhere.

  v. Gullies do not form or enlarge due to the entry of uncontrolled flow to the channel.

b. Channel stability shall be determined for an aged condition and the velocity shall be based on the design flow or the bankfull flow, whichever is greater, using an "n" value for various channel linings as shown in **Tables 4-1 and 5-1**. In no case is it necessary to check channel stability for discharges greater than that from a 100-year frequency storm.

c. Channel stability shall be checked for conditions representing the period immediately after construction. For this stability analysis, the velocity shall be calculated for the expected flow from a 10-year frequency storm on the watershed, or the bankfull flow, whichever is smaller, and the "n" value for the newly constructed channels in fine-grained soils and sands may be determined in accordance with the "National Engineering Handbook 5, Supplement B, Soil Conservation Service" and shall not exceed 0.025. The allowable velocity in the newly constructed channel may be increased by a maximum of 20 percent to reflect the effects of vegetation to be established under the following conditions:

i. The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion controlling vegetation.
ii. Species of erosion controlling vegetation adapted to the area, and proven methods of establishment are shown.

ii. The channel design includes detailed plans for establishment of vegetation on the channel side slopes.

VIII. Drainage of Swales

a. All swales shall meet the following requirements and the specifications of the City of Washington or designee:
   i. Minimum swale flow line slopes are 0.5%. Swales with longitudinal slopes that are flatter than 1% shall consist of 6-inch thick rebar-reinforced concrete. The side slopes of swales shall not be steeper than a 4 (horizontal) to 1 (vertical) slope.
   ii. Maximum swale flow line slopes are 7%.
   iii. 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.
   iv. Unless designed to act as a stormwater quality BMP or lined with concrete, vegetated swales shall 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 4-3. Tile lines may be outletted through a drop structure at the ends of the swale or through a standard tile outlet. Before reaching an open channel, the perforated drain shall be connected to 10 feet of SDR # 40. Also, cleanout risers are to be installed at the high point as well as at the end of run.
   v. For Drainage Easement requirements, see Chapter 1.
   vi. Further guidance regarding this subject may be found in the latest edition of the Indiana Drainage Handbook.

IX. Appurtenant Structures

a. 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.

b. 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.

X. Disposal of Spoil

a. Spoil material resulting from clearing, grubbing, and channel excavation shall be disposed of in a manner that will.
   i. Minimize overbank wash.
   ii. 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.
   iii. Not hinder the development of travelways for maintenance.
   iv. Leave the right-of-way in the best condition feasible, consistent with the project purposes, for productive use by the owner.
   v. Be accepted by IDEM, IDNR, or USACE, if applicable.

XI. Materials

a. Materials acceptable for use as channel lining are:
   i. Grass
   ii. Revetment Riprap
   iii. Concrete
   iv. Hand Laid Riprap
   v. Precast Cement Concrete Riprap
   vi. Gabions
   vii. Straw, turf reinforcement mat, erosion control blanket, coconut coir or natural fiber netting, or other accepted material (to assist in final vegetation establishment).

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

XII. Drainage System Overflow Design

a. See Chapter 4, Section XIV.

Chapter 6
Stormwater Detention Design Standards for Peak Flow Control

I. Introduction

a. The following shall govern the design of any improvement with respect to the detention of stormwater runoff.

b. 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 "III". 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.

II. Suggested Calculation Sequences for Designing a Detention Pond for Peak Flow Control

a. In addition to the requirement for peak flow control through retention and/or detention, the Stormwater Management Ordinance and Technical Standards require the developer to address Channel Protection and Water Quality Control requirements discussed in Chapter 7. The proper way to accommodate the water quality, channel protection, and peak flow rate control of a site is to first consider addressing the water quality and channel protection volume requirements through conventional or LID approaches (as described in Chapter 7 and in the LID Manual, included as part of the Technical Standards Manual) and then determine the size and dimensions of the required retention or detention storage for peak flow rate control.

   Chapter 8 provides several BMPs and options to address the channel protection volume and water quality requirements. However, in many cases, providing some level of extended detention may become necessary to meet those requirements. While such extended detention is best provided in a separate facility, many developers choose to combine the needed extended detention feature with the detention pond needed for peak runoff rate control of the site into one facility.

   A combined facility must accommodate the channel protection volume, water quality volume, and design storm detention to meet allowable release rate requirements while also meeting channel protection or water quality detention time requirements.

These requirements can be challenging to meet, especially with additional considerations needed for bypassing runoff from off-site areas. The following are suggested calculation sequences for designing a detention pond for peak flow control only, and for combining extended detention with peak flow control. However, every site is different and depending on the site conditions and the layout of the pond, there may be other ways to design the pond such that all the pond's objectives are met.

b. All detention/retention facilities, including underground facilities, shall have an upstream BMP designed in accordance with Chapter 7.

c. Peak flow control only
   i. Determine the main outlet's control elevation.
   ii. Route the on-site 10-year and 100-year inflow hydrographs through the pond (by temporarily ignoring off-site flows) and size the main outlet to limit peak outflows to the allowable release rates. If an orifice needs to be used to limit the outflow, use the actual orifice size needed to meet the release rate requirements, unless the calculated diameter is less than 4 inches, in which case the minimum 4-inch orifice diameter shall be used. The resulting maximum water surface elevation is the top of peak flow control storage for on-site flows. If no off-site flows are routed through the detention facility, then this will be the pond's 100-year elevation and the emergency spillway invert elevation is also set at this elevation.
   iii. Off-site flows that are bypassed (no detention) through the site detention pond (rather than bypassed around the pond), should be routed through a separate outlet (such as a drop inlet structure) with its control elevation set at the on-site 100-year pond elevation determined in Step 2. The 100-year pond elevation is determined by routing the on-site and off-site 100-year inflow hydrographs through the pond. Ideally, a separate emergency spillway should be provided with an invert elevation set at the combined (on-site and off-site) 100-year ponding elevation. A less desirable option would be to route the off-site flows through the emergency spillway with the invert elevation set at the on-site 100-year ponding elevation as determined in Step 2. However, since this would result in water flowing over the emergency spillway more frequently, this option may require additional erosion control measures based on the estimated frequency of use. Additional discussion on managing off-site runoff is contained in Section "IV. c." of this chapter.

d. Combined Peak Flow Control and Extended Detention
   i. Calculate the extended detention storage volume as needed to address the requirements noted in Chapter 8. Also, note that there may be no need to provide extended detention, depending on the approach used to address water quality and channel protection volume requirements.

ii. Determine the outlet control elevation. This will be the bottom of the extended detention storage volume, and the permanent pool elevation if a wet-bottom pond is used.

iii. Design the pond to provide the extended detention storage volume determined in Step 1, and assuming no outflow through the pond outlet. The top of this storage volume will be the invert elevation of the main outlet.

iv. Route the on-site 10-year and 100-year inflow hydrographs through the pond (with the initial elevation at normal pool, i.e., the bottom of extended detention space) and size the main outlet to limit peak outflows to the allowable release rates. If an orifice will need to be used to limit the outflow, use the actual orifice size needed to meet the release rate requirements, unless the calculated diameter is less than 6 inches, in which case the minimum 6-inch orifice diameter shall be used. The resulting maximum water surface elevation is the top of peak flow control storage for on-site flows. If no off-site flows are routed through the detention facility, then this will be the pond's 100-year elevation and the emergency spillway invert elevation is also set at this elevation.

v. Off-site flows that are bypassed (no detention) through the site detention pond (rather than bypassed around the pond), should be routed through a separate outlet (such as a drop inlet structure) with its control elevation set at the on-site 100-year pond elevation determined in Step 2. The 100-year pond elevation is determined by routing the on-site and off-site 100-year inflow hydrographs through the pond. Ideally, a separate emergency spillway should be provided with an invert elevation set at the combined (on-site and off-site) 100-year ponding elevation. A less desirable option would be to route the off-site flows through the emergency spillway with the invert elevation set at the on-site 100-year ponding elevation as determined in Step 2. However, since this would result in water flowing over the emergency spillway more frequently, this option may require additional erosion control measures based on the estimated frequency of use. Additional discussion on managing off-site runoff is contained in Section IV c. of this chapter.

vi. Determine the size and design the retention/extended detention storage drain in a manner to meet the extended detention minimum and maximum emptying time requirements discussed in Chapter 8, using both on-site and, if applicable, off-site runoff. If an orifice is required to control the flow of the extended detention drain, the minimum orifice size shall be 4 inches. However, depending on the proposed clog-free design and the proposed maintenance schedule of the extended detention storage drain structures, a smaller orifice than 4 inches may be allowed on a case-by-case basis.

vii. To make sure that the addition of the release through the drain will not cause the on-site only allowable release rate to be exceeded, reroute the on-site 10-year and 100-year inflow hydrographs through the pond (with the initial elevation at normal pool, i.e., the bottom of extended detention space), this time allowing water to also leave through the extended detention storage drain as the pond fills up. If the total peak outflow discharge exceeds the on-site only allowable release rate, the size of the main outlet orifice may need to be reduced or the storage volume increased.

Note that in some instances such as relatively small development sites less than 10 acres or sites with highly restrictive site-specific maximum allowable release rates, when the required outlet orifice size and/or the required size of the extended detention drain will be small, the calculated drain time may extend beyond the maximum required 48-hour emptying time. Often, the situation can be addressed through enlarging the pond volume or reconfiguring the pond's shape. When the situation cannot be resolved in a reasonable manner despite those attempts, the City of Washington or designee may, on a case-by-case basis, allow deviation from the required orifice size, maximum allowable release, or emptying time after considering reasonable options and examining the potential impacts on downstream or upstream areas. Economic factors shall not be considered for this determination.

The following shall govern the design of any improvement with respect to the retention/detention of stormwater runoff for peak flow control.

III. Acceptable Detention Facilities

a. 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.

IV. Allowable Release Rates

a. General Release Rates

Control devices shall limit the discharge to a rate such that the post-developed release rate from the site is no greater than 0.2 cfs per acre of development. The above fixed general release rates may be set at a lower value by the City of Washington for geographical areas determined as Impact Drainage Area or for certain watersheds if more detailed data becomes available as a result of comprehensive watershed studies conducted and/or formally approved and adopted by the City of Washington. The applicant shall confirm the applicable release rates with the City of Washington or designee prior to initiating the design calculations to determine whether a basin-specific release rate has been established for the watershed of their interest or whether the site is located within a designated or an Impact Drainage Area.

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.

b. Site-Specific Release Rates for Sites with Depressional Storage

For sites where depressional storage exists, the general release rates provided above may have to be further reduced. If depressional storage exists at the site, site-specific release rates must be calculated according to methodology described in Chapter 2, accounting for the depressional storage by modeling it as a pond whose outlet is a weir at an elevation that stormwater can currently overflow the depressional storage area. Post developed release rate for sites with depressional storage shall be the 2-year pre-developed peak runoff rate for the post-developed 10-year storm and 10-year pre-developed peak runoff rate for the post-developed 100-year storm. In no case shall the calculated site-specific release rates be larger than general release rates provided above.

Note that by definition, the depressional storage does not have a direct gravity outlet but if in agricultural production, it is more than likely drained by a tile and should be modeled as "empty" at the beginning of a storm. The function of any existing depressional storage should be modeled using an event hydrograph model to determine the volume of storage that exists and its effect on the existing site release rate. To prepare such a model, certain information must be obtained, including delineating the tributary drainage area, the stage-storage relationship and discharge-rating curve, and identifying the capacity and elevation of the outlet(s).

The tributary area should be delineated on the best available topographic data. After determining the tributary area, a hydrologic analysis of the watershed should be performed, including, but not limited to, calculation of the appropriate composite runoff curve number and time of concentration. Stage-storage data for the depressional area should be obtained from the site topography. The outlet should be clearly marked, and any calculations performed to create a stage-discharge rating curve must be included with the stormwater submittal.

Also note that for determining the post-developed peak runoff rates, the depressional storage must be assumed to be filled unless the City of Washington can be assured, through dedicated easement, that the noted storage will be preserved in perpetuity.

c. 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.

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 Washington when the ratio of off-site area to on-site area is larger than 5:1.

d. Downstream Restriction

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 Washington, 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 Washington 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.

As an alternative to reduction of release rates, the City of Washington may require the applicant to pursue alleviating downstream restrictions. The applicant would be responsible for obtaining all permits and consents required and for incurring all expenses involved in such undertaking.

e. Documentation of Results

The results of the allowable release rate determinations (if retaining the entire required peak flow rate volume is not feasible) as well as the modeling simulation results must be summarized in a table that shall be included in the Stormwater Drainage Technical Report and on the Drainage Plan. The table must include, for each eventual site outlet, the pre-developed acreage tributary to each eventual site outlet, the unit discharge allowable release rate used, the resulting allowable release rate in cfs for the post-developed 10-year and 100-year events, pre-developed 2-year flow rates in cfs as well as pre- and post-developed flow rates for 2-, 10-, and 100-year events. The worksheet provided as Table 6-1 should be filled for each final site outlet.

TABLE 6-1

SITE OUTLET #	ITEM	PRE-DEVELOPMENT					POST-DEVELOPMENT				
		D.A. (ac)	Depress. Storage? (yes/no)	2-Yr.	10-Yr.	100-Yr.	D.A. (ac)	Depress. Storage? (yes/no)	2-Yr.	10-Yr.	100-Yr.
1	Default Unit Discharge Allowable Release Rate (cfs/acre)									0.2	0.2
	Basin-Specific Unit Discharge Allowable Release Rate, if any (cfs/acre)										
	Unit Discharge Allowable Release Rate Based on D/S Restrictions, if any (cfs/acre)										
	Adopted Unit Discharge Allowable Release Rate (cfs/acre)										
	Contributing Area of Development Site (ac) and Allowable Release Rate (cfs)										
	Total Contributing DA (ac) and Modeling Results (cfs)							No			

V. General Detention Basin Design Requirements

a. 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.

b. 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.

c. No detention facility or other water storage area, permanent or temporary, shall be constructed under or within twenty (20) feet of any pole or high voltage electric line. Likewise, poles or high voltage electric lines shall not be placed within twenty (20) feet of any detention facility or other water storage area.

d. Detention facilities shall be separated from parking lots and roadways by no less than one right-of-way width, measured from the top of bank or the 100-year pool if no defined top of bank is present, using the most restrictive right-of-way possible. If the width of the right-of-way is less than 50 feet, then the minimum distance between top of bank and road right-of-way shall be increased to 50 feet. Use of guardrails, berms, or other structural measures may be considered in lieu of the above-noted setbacks.

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

f. 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 drainpipes outleting into the pond shall not be submerged.

g. Use of fences around all retention/detention ponds is encouraged to assure safety. Unless specifically required by the City of Washington, the decision to use fencing around retention/detention ponds are left to the owner or the developer. Recommendations contained within this document do not relieve the applicant and owner/developer from the responsibility of taking all necessary steps to ensure public safety with regards to such facilities.

h. 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.

i. Emergency overflow facilities such as a weir or spillway shall be provided 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.

   Emergency overflow facilities shall be designed to convey, without overtopping the detention facility banks, one and one-quarter (1.25) times the peak inflow discharge resulting from the 100-year design storm event runoff from the entire contributing watershed draining to the detention/retention facility, assuming post-development condition on-site and existing condition off-site. The length of the weir is to be determined using the weir equation, with the overflow weir control elevation at the Pond's 100-year elevation (pond is assumed full to the overflow weir control elevation), discharge equal to 1.25 times the peak 100-year inflow, and the maximum head being the difference between the weir control elevation and the top of the bank.

   The emergency overflow routing from the emergency overflow facility to an adequate receiving system must be positive (by gravity) and shown on the construction plans. It must be sized to accommodate the design flow of the pond's emergency overflow weir. For drainage easement requirements, see Chapter 1. This emergency overflow path/easement area shall be shown on the plans as hatched area or another distinctive symbol. No fences or landscaping can be constructed within the easement areas. The Lowest Adjacent Grade of all residential, commercial, or industrial buildings along this emergency overflow route shall be set a minimum of 2 feet above the flood elevation along the route, calculated based on the pond's emergency overflow weir design discharge.

j. 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.

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

l. No 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 either platted or legally described and recorded as a perpetual stormwater easement.

m. For Drainage Easement Requirements, see Chapter 1. Within this easement area, no trees shall be planted within 50 feet of any pipe outlet entering the pond or the outlet for the pond.

   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, as required by the City Building Commissioner or MS4 Coordinator.

VI. Additional Requirements for Wet-bottom Facility Design

a. 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:

   i. 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, safety ledge, and BMPs as required below. Construction trash or debris shall not be placed within the permanent pool.

b. All wet detention/retention ponds must be constructed in as natural a shape (footprint) as possible and have a vegetated safety ledge (approximately 6 inches below normal pool) and/or have native vegetation planted on the pond banks to create a riparian buffer (minimum 10 feet wide). Native vegetation can be installed as container grown plants or as seed at the time of construction. 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 ponds 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.

c. For wet-bottom facilities without a security fence, a maintenance ledge ten (10) feet in width is required and shall be installed approximately 12 inches above the permanent water level and a safety ledge ten (10) feet in width is required and shall be installed approximately 6 inches below the permanent water level. If a non-vegetated safety ledge is installed, the depth of the safety ledge shall be approximately 18 inches below normal pool. The slope between the two ledges shall be stable and protected from erosion with hard armoring or bioengineered techniques.

   For wet-bottom facilities with a security fence, a maintenance ledge six (6) feet in width is required and shall be installed approximately 12 inches above the permanent water level and a safety ledge six (6) feet in width is required and shall be installed approximately 6 inches below the permanent water level. If a non-vegetated safety ledge is installed, the depth of the safety ledge shall be approximately 18 inches below normal pool. The slope between the two ledges shall be stable and protected from erosion with hard armoring or bioengineered techniques.

   The maintenance ledge may be waived if pond side slopes above normal water are 6:1 or flatter.

d. Prior to final acceptance of construction and release of bonds, danger signs warning of deep water, possible flood conditions during storm periods, or other dangers, shall be installed at an interval of 400 feet around the perimeter of wet-bottom facilities without a vegetated safety ledge, riparian buffer, or a security fence. Maintenance of the warning signs shall be the responsibility of the owner or the homeowners' association.

e. 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.

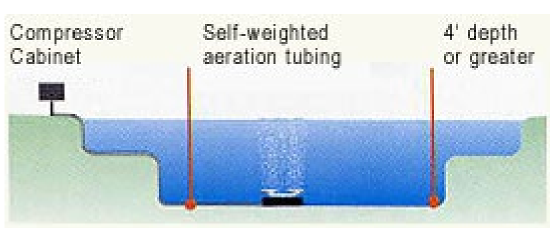
f. A safety ramp exit from the lake shall be required in all cases and shall have a minimum width of twenty (20) feet and exit slope of 6 horizontal to 1 vertical (6:1). The safety ramp shall be constructed of suitable material to prevent structural instability due to vehicles or wave action. Adequate 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.

g. In addition to provisions specified in Section IV e. of this Chapter (if applicable), parks, playgrounds, and athletic fields shall be separated from all stormwater detention facilities by no less than 100 feet, measured from the 100-year pool of the pond. Trails and sidewalks shall be separated from all stormwater detention facilities by no less than 25 feet, measured from the 100-year pool of the pond.

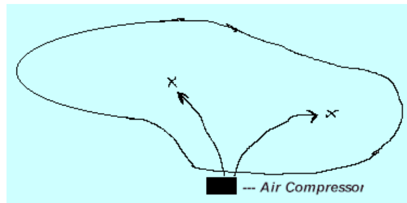
h. Periodic maintenance is required in lakes to control weed and larval growth. The facility shall also be designed to provide for the easy removal of sediment that will accumulate during periods of reservoir operation. A means of maintaining the designed water level of the lake during prolonged periods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

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

j. 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.

k. 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 with 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.

VII. Additional Requirements for Dry-bottom Facility Design

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

  i. Provisions shall be incorporated into facilities for complete interior drainage of dry bottom facilities, including the provisions of natural grades to outlet structures (if any), longitudinal and transverse grades to perimeter drainage facility. 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.

  ii. For residential developments, unless the facility is fully fenced in and gated, the maximum planned depth of stormwater stored shall not exceed four (4) feet.

iii. 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.

VIII. Detention Facilities in Floodplains

a. No detention facilities are allowed within FEMA regulatory Floodplains.

IX. Joint Development of Control Systems

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

X. Diffused Outlets

a. 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 for diffused outlet drains shall be at the discretion of the City of Washington.

XI. IDNR Requirements

a. Any construction in the floodway of a stream with a drainage area of one square mile or more must satisfy IDNR permit requirements.

XII. Allowance for Sedimentation

a. 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.

XIII. Maintenance

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

Chapter 7
Erosion Control Practices and Construction Phase BMPs

I. Introduction

a. 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.

II. Pollutants of Concern During Construction

a. The major pollutant of concern during construction is sediment. Natural erosion processes are accelerated at a project site by the construction process for a number of reasons, including the loss of surface vegetation and compaction damage to the soil structure itself, resulting in reduced infiltration and increased surface runoff. Clearing and grading operations also expose subsoils which are often poorly suited to re-establish vegetation, leading to longer-term erosion problems.

   Problems associated with construction site erosion include transport of pollutants attached to transported sediment; increased turbidity (reduced light) in receiving waters; recreational use impairment. The deposited sediment may pose direct toxicity to wildlife or smother existing spawning areas and habitat. This siltation also reduces the capacity of waterways, resulting in increased flood hazards to the public.

   Other pollutants of concern during the construction process are hazardous wastes or hydrocarbons associated with the construction equipment or processes. Examples include concrete washout, paints, solvents, and hydrocarbons from refueling operations. Poor control and handling of toxic construction materials pose an acute (short-term) or chronic (long-term) risk of death to aquatic life, wildlife, and the general public.

III. Erosion and Sediment Control Requirements

a. **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 Washington.

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

ii. 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.

iii. 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.

iv. 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.

v. 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, BMP Manual, and LID Manual.

vi. 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:

1. 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.
2. Cleared sediment must be redistributed or disposed of in a manner that is in accordance with all applicable statutes and regulations.
3. 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.

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

c. 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.

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

e. 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.

f. Topsoil must be preserved, unless infeasible. The MS4 Coordinator may require soil testing and if soil is found to not meet the soil requirements to support vegetation, then a plan to supplement the existing soil by means of amendments may be required.

g. 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.
   i. Natural buffers must be preserved, including the entire buffer bordering and/or surrounding the water resource. Existing buffers:
      1. 50 feet or more in width must be preserved to a minimum of 50 feet.
      2. 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.
   ii. Runoff directed to the natural buffer must be:
      1. Treated with appropriate erosion and sediment control measures prior to discharging to the buffer.
      2. Managed with appropriate runoff control measures to prevent erosion from occurring within the buffer area.
   iii. Further information regarding buffer requirements is contained in IDEM's "Implementation of Buffers" guidance document.

h. 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, BMP Manual, and LID Manual.

i. 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.

j. All stormwater management measures necessary to meet the requirements of this permit, must be maintained. Alternative measures must be selected and implemented, as necessary.

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

   i. 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, City's BMP Manual, and City's LID Manual or other authoritative sources, that minimizes the discharge of the sediment.

   ii. A visible sheen and/or pollutants are present at a level that requires additional treatment and/or an alternate permit.

l. 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 stormwater runoff or wind. Waste materials and unused building materials must be managed and disposed of in accordance with all applicable statutes and regulations.

m. 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:

   i. 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:

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

ii. 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.

n. Concrete and cementitious wash water areas, where cementitious wash water is to be temporarily collected and contained, 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. Wash water must be removed (pumped) for appropriate off-site disposal.

o. Fertilizer applications associated with the stabilization plan for the project must meet the following requirements:
   i. 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.
   ii. 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.
   iii. Avoid applying fertilizer immediately prior to precipitation events that are anticipated to result in stormwater runoff from the application area.

p. 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:
   i. A spill prevention and response plan, meeting the requirements in 327 IAC 2-6.1, must be completed.
   ii. 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.
   iii. Manage the following activities:
      1. Fueling and maintenance of equipment.
      2. Washing of equipment and vehicles.
      3. Storage, handling, and disposal of construction materials, products, and wastes.
      4. Application of pesticides, herbicides, insecticides, and fertilizers
      5. Dispensing and utilization of diesel fuel, oil, hydraulic fluids, other petroleum products, and other chemicals.
      6. Handling and disposal of hazardous wastes, including, but not limited to paints, solvents, petroleum-based products, wood preservatives, additives, curing compounds, and acids.
      7. Washing applicators and containers used for paint, grout, or other materials.

q. Personnel associated with the project must be informed of the terms and conditions of this permit and the requirements within the SWPPP. The permittee is required to document this process. 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:
   i. General contractors, construction management firms, grading or excavating contractors, and trade industry representatives (i.e. concrete industry) associated with the overall project.
   ii. Contractors or individual lot operators that have primary oversight on individual building lots.
   iii. Those responsible for the implementation of the SWPPP, and the installation, repair, and maintenance of stormwater measures.
   iv. Those responsible for the application and storage of treatment chemicals.
   v. Those responsible for administering the self-monitoring program (SMP).

r. 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:
   i. 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 (b)1 of the City of Washington Stormwater Management Ordinance.
   ii. The NPDES permit number(s), upon receipt.
   iii. The location of the construction plan/SWPPP if the project site does not have an on-site location to store the plan.

s. Cationic polymers are not authorized for use The use of anionic polymers 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 Washington is required. An email notification prior to the use of the polymer to the IDEM Stormwater Program is acceptable. The site owner or representative must provide a written notice via email to the MS4 Coordinator at least seven days prior to the on-site use of polymers.

t. 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:

i. Development and submittal of a removal and restoration plan to ensure the methodology chosen will not result in further degradation of the resource.
ii. Permission by a property owner when the restoration activity requires access to a property owned by another entity or individual.
iii. Additional permits prior to initiation of the work.

IV. Stabilization Requirements

a. Stabilization requirements described in this Chapter apply to all land-disturbing activities.

b. 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:

i. Stabilization must be initiated by the end of the seventh day when 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.

ii. 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.

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

i. 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:

1. 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.

2. 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.

3. Projects on land used for agricultural purposes when:

   a) Stabilization is completed in accordance with the above Stabilization Requirements (in b. i. and ii.) as land-disturbance progresses. Land that is returned to agricultural production must be temporarily or permanently seeded upon completing land-disturbing activities.

   b) Stabilization requirements may be waived by the inspecting authority if the project site does not pose a threat of discharging sediment.

ii. Disturbed areas, not previously used for agricultural production, such as filter strips, must be returned to their pre-disturbance land use.

d. 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.

V. Design Requirements

a. 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:

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

ii. 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.

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

iv. 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.

v. 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.

vi. 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.

VI. Monitoring and Management Requirements

a. A trained individual, acceptable to the City of Washington shall monitor project construction and stormwater activities. These shall include:

i. 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:

  i. 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.

  ii. 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:
    a) The vegetative cover fails or there is evidence of erosion in the identified area.
    b) The City of Washington requires monitoring to resume.

ii. A complete written evaluation report which must include:

1. Name of the individual performing the evaluation, including printed name, title, and signature (electronic signatures are acceptable).
2. Date of the evaluation.
3. 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.
4. Observations of project performance in relation to:
    a) Implementation of the stormwater pollution prevention plan.
    b) Assessment of existing stormwater measures based on industry standards and maintenance standards to ensure each measure is operational and functioning properly.
    c) Additional measures necessary in the event an existing measure fails or is not present in the landscape.
    d) 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.
5. 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, presence of floatables, settled/suspended solids, foam, oil sheen, and any other visible sign that may be attributed to operations occurring on the project site.
6. Detail of corrective action recommended and/or completed. Corrective action includes, but is not limited to:
    a) Repairing, modifying, or replacing any stormwater management measure.
    b) Clean-up and proper disposal of spills, releases, or other deposits.
    c) Remedying a permit violation.
    d) Taking reasonable steps to remediate, minimize or prevent the discharge of pollutants associated with the construction activity until a permanent corrective solution is initiated.
    e) Restoring an impacted area and/or removing accumulated sediment, provided appropriate permission and permits are obtained to conduct the activity.
7. 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:

a) 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.
b) 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.
c) If corrective action cannot be achieved within the timelines outlined in a) or b) above, a reason for incompletion must be provided and documented, including the anticipated completion date.

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

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

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

VII. Project Documentation Requirements

a. The following project documentation shall be developed and maintained:

i. Maintain a project management log that contains:

1. 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.

2. Information related to all project activities including, but not limited to:
a) SMP reports.
b) Regulatory inspections.
c) Responses to a compliance action or enforcement action.
d) 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.

ii. 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 the City of Washington within forty-eight (48) hours of a request.

VIII. Common Control Practices

a. 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.

IX. Individual Lot or Parcel Controls

a. 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:

   i. Protect adjacent properties from sedimentation.
   ii. Prevent mud/sediment from depositing on the street.
   iii. Protect drainageways from erosion and sedimentation.
   iv. Prevent sediment laden water from entering storm sewer inlets.

b. This can be accomplished using numerous erosion and sediment control measures. Individual lot permit request form, plot plan review form and detailed requirements, including a standard erosion control plan for individual lots, are provided in Appendix B. The standard plan includes perimeter protection, stabilized construction entrance, drop inlet protection, stockpile containment, stabilized drainage swales, downspout extensions, temporary seeding and mulching, incremental stabilization, and permanent vegetation. 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.

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

   i. 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.

   ii. Install perimeter protection at construction limits. Position the fence or filter sock to intercept runoff prior to entering drainage swales.

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

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

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

   vi. Perform primary grading operations.

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

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

   ix. Construct the home and install utilities.

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

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

   xii. Grade the site to final elevations.

   xiii. Install permanent seeding or sod.

d. 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 "Individual Lot Erosion and Sediment Control Plan and Certification" form and other resources in Appendix B as well as the latest information posted on IDEM's website.

Chapter 8
Post-Construction BMP Design

I. Introduction

a. It is recognized that developed areas, as compared to undeveloped areas, generally have increased imperviousness, decreased infiltration rates, increased runoff rates, and increased concentrations of pollutants such as fertilizers, herbicides, greases, oil, salts, and other pollutants. As new development and re-development continues within City Corporate limits, measures must be taken to intercept and filter pollutants from stormwater runoff prior to reaching creeks, streams, and rivers. Through the use of adequately selected, designed, installed, and maintained Best Management Practices (BMPs), stormwater runoff will be managed and treated to reduce or eliminate harmful amounts of sediment, nutrients, and other contaminants.

b. It is also recognized that another major source of pollution in many Indiana streams, including those within the City of Washington, is the streambank erosion associated with urbanizing watersheds. Stream channels develop their shape in response to the volume and rate of runoff that they receive from their contributing watersheds. Research has shown that in hydrologically stable watersheds, the stream flow is responsible for most of the shaping of the channel (called the bankfull flow) occurs between every one to two years. When land is developed, the volume and rate of runoff from that land increases for these comparatively small flooding events that are not normally addressed by the detention practices and the stream channel will adapt by changing its shape. As the stream channel works to reach a new stable shape, excess erosion occurs. As new development and re-development continues within City of Washington, measures must be taken to minimize the impact of such development or re-development on streambank erosion. Through the use of adequately selected, designed, installed, and maintained, Best Management Practices (BMPs), the volume and rate of runoff for channel-forming flows will be reduced in an attempt to minimize increased streambank erosion in the receiving streams and channels.

c. Requirements of the Ordinance and this Technical Standards Manual with regards to the channel protection and water quality protection can be satisfied through a variety of methods that can be broadly categorized under two general approaches:

    i. Conventional Approach

    ii. Low Impact Development (LID) Approach

d. This Chapter establishes minimum standards for the selection and design of post-construction water quality and channel protection 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 channel protection volume (CPv), water quality volume (WQv), and for flow-through BMPs the water quality discharge rate (Qwq), as appropriate. For Conventional approach, the methodology for calculating the CPv, WQv, and Qwq values is provided in Chapter 9. For LID approach, alternative methods of calculating these values are provided in Section VI. of this Chapter.

II. Post-Construction BMPs Performance Criteria

a. Channel protection is typically achieved by matching the post-construction runoff volume and rate to the pre-conversion (prior to any historical land conversion by man) condition for all runoff events up to the bankfull flow. The bankfull flow in most Indiana streams correlates with the 1.5- to 2-year flood event flow. However, due to difficulties in determining the pre-conversion conditions, the net control of runoff resulting from a 1-year, 24-hour storm in proposed conditions (rather than the alternative method of determining increase in 2-year, 24-hour storm over pre-conversion conditions) is established as the City of Washington standard for channel protection.

b. City of Washington has adopted a policy that the measurement of stormwater runoff quality will be based on the management of the Total Suspended Solids (TSS). These requirements are adopted as the basis of the City of Washington stormwater quality management program for all areas within the Corporate City limits.

c. For the purpose of these Standards, the control of channel protection volume and post-construction stormwater runoff quality is assumed satisfactory when the appropriate number of pre-approved structural BMPs, tiered in accordance to the total site disturbed area as shown in Table 8-1 below, are designed, installed, and operated in accordance with the BMP and LID Manual included within this Stormwater Technical Standards Manual). If a BMP is selected that is not included in the reference manuals, approvals of alternative BMPs may be provided by the City MS4 Coordinator.

TABLE 8-1

Total Property/Development Area	Post-Construction BMP Requirement*
0 to less than 1 acre	Water Quality BMP Not Required
At least 1 acre	At least 1 BMP to provide 80% TSS reduction
At least 10 acres	Channel Protection Volume **

* These BMPs are in addition to any pre-treatment that may be required for hot spots.

** When the CPv is controlled with BMPs that also meet the stormwater quality performance criteria in Section II., often no additional water quality BMP is necessary. An additional water quality BMP may be required if the CPv is not believed to adequately address water quality requirements.

III. Pollutants of Concern After Construction Stabilization

a. There are three major sources of pollutants for a stabilized construction site:
   i. Deposition of atmospheric material (including wind-eroded material and dust)
   ii. General urban pollution (thermal pollution, litter)
   iii. Pollutants associated with specific land uses

b. It should be noted that some pollutants accumulate on impervious surfaces. This accumulated material is then subject to being washed into watercourses during storm events. It is for this reason that fish kills often occur during a rain event with a substantial prior rainless period. This is also the reason that the most hazardous driving conditions are realized after the initial onset of a storm event, when deposited oil has not yet washed into adjacent conveyance systems.

c. Pollutants of concern include:

   i. Sediment is the major pollutant of concern during active construction. Natural erosion processes are accelerated at a project site by the construction process for several reasons, including the loss of surface vegetation and compaction damage to the soil structure itself, resulting in reduced infiltration and increased surface runoff. After the construction is completed, other chemicals that are released to surface waters from industrial and municipal discharges and polluted runoff from urban and agricultural areas continue to accumulate to harmful levels in sediments.
   ii. Toxic chemicals from illegal dumping and poor storage and handling of materials. Industrial sites pose the most highly variable source of this pollution due to the dependency of the specific process on the resulting pollution amounts and constituents. During construction, these chemicals can pose acute (short-term) or chronic (long-term) risk to aquatic life, wildlife, and the general public.
   iii. Bacteria from illicit sanitary connections to storm sewer systems, combined sewers, leaking septic systems, wildlife, and domestic animal waste. Bacteria pathogens pose a direct health risk to humans and aquatic life.

iv. Nutrients can be released from leaking septic systems or applied in the form of fertilizers. Golf courses, manicured landscapes and agricultural sources are the primary land uses associated with excess fertilization. Excessive nutrients in the local ecosystem are the source of algal blooms in ponds and lakes. These excessive nutrients also lead to acceleration of the eutrophication process, reducing the usable lifespan of these water bodies. Nitrogen and phosphorus are the primary nutrients of concern.
v. Oxygen demand can be impacted by chemicals transported on sediment, by nutrients, and other pollutants (such as toxic chemicals). Reduced levels of oxygen impair or destroy aquatic life.
vi. Oils and hydrocarbons accumulate in streets from vehicles. They can also be associated with fueling stations and illicit dumping activities. Oils and hydrocarbons pose health risk to both aquatic and human health.
vii. Litter, including floatables, can result in a threat to aquatic life. The aesthetic impact can also reduce the quality of recreational use.
viii. Metals can be associated with vehicular activity (including certain brake dusts), buildings, construction material storage, and industrial activities. Metals are often toxic to aquatic life and threaten human health.
ix. Chlorides (salts) are historically associated with deicing activities. Chlorides are toxic to native aquatic life (verses saltwater aquatic life). Communities should consider a combination of sand to replace or supplement their deicing activities with chlorides. In addition, salt stockpiles should remain covered.
x. Thermal effects can be introduced by the removal of shade provided by riparian trees, as well as impervious channel linings, such as concrete, which release stored heat to water passing over them. Other sources of elevated temperature include effluent from power plants and industrial activities. Thermal pollution can threaten aquatic habitat, including fish species and beneficial water insects. Of particular concern are salmonid streams, due to the effect of thermal pollution on spawning for this particular species.

IV. Water Quality Characteristics by Land Use

a. Direct water quality sampling is not required at this time by IDEM. However, water quality characteristics are strongly tied to land use. For the purpose of these standards, all proposed developments and re-developments shall be assumed to involve increased levels of floatables, TSS, TP, TN, and metals. Additional pollutants may also be expected at certain types of developments and specific sites, as identified in the Stormwater Pollution Prevention Plan for the site (including, if applicable, those pollutants found to be the cause of the receiving stream to be listed in IDEM 303(d) list).

V. Conventional Approach Procedures

a. The following procedures shall be followed according to the Conventional approach:

<u>Step 1: Provide BMPs to address Channel Protection Volume</u>

In a conventional approach, the receiving channel is protected through retaining or the extended detention (if retaining and infiltration methods are considered ineffective/ inappropriate for the site). The BMPs must be sized for 1-year, 24-hour storm event for the entire site, excluding any protected undisturbed areas as acceptable to the City of Washington and based on the contributing watershed of each outlet. The methodology for calculating the Channel Protection Volume (CPv) is according to that discussed in Chapter 9 of this Standards Manual. When using retention or wet/dry extended detention, only 10% of the maximum stored volume can be left in the basin after 36 hours from maximum storage time (or 48 hours from the start of storm) and no more than 40% of the maximum stored volume can be released within the first 12 hours. To ensure that adequate retention/detention volume is available within the facility over the years, the facility should be designed for long-term sediment accumulation. If long-term sediment accumulation cannot be adequately provided for in the pond, or if the pond is intended to provide sediment control during the construction phase of the project, forebays near inlets can be included to help manage sediment accumulation. Forebays do not require a hard maintenance surface and shall not be visibly disconnected from the pond by rip rap or other berm structures.

Since, by design, 90% of the original volume will be available within 48 hours of start of each storm event (assumed to be about 36 hours from when the Channel Protection pool is full), the volume in the pond associated with the channel protection (CPv) may be assumed empty for the purpose of peak flow retention/detention analysis discussed in Chapter 6. In addition, the volume provided for channel protection would also count as one BMP towards the water quality requirements, provided that the facility meets the design criteria in the fact sheet and additional pre-treatment and/or wetland fringe can be provided to assure the performance criteria noted in Section II. of this Chapter are met.

Step 2: Provide BMPS to address Water Quality Management

When the channel protection volume is controlled with BMPs that also meets the stormwater quality performance criteria in Section II. (including both the required type and the number of BMP(s) in series), often no additional calculation or BMP implementation is necessary. If the channel protection volume is not controlled through practices that also meet the stormwater quality performance criteria in Section II., additional BMPs will be required. City of Washington has designated several pre-approved structural BMP methods (as shown in the BMP Manual and LID Manual, included in this Technical Standards Manual and listed in Table 8-2 through 8-5). The BMPs can be used alone or in combination to achieve the stormwater quality performance criteria noted in Section II. of this Chapter. Details regarding the applicability and design of these pre-approved BMPs, including the effectiveness of these BMPs in treating pollutants of concern (including, if applicable, those pollutants found to be the cause of the receiving stream to be listed in the IDEM 303(d) list), are contained within the BMP Manual and LID Manual.

b. Innovative BMPs, including but not limited to, BMPs not previously accepted by City of Washington must be certified by a Professional Engineer licensed in State of Indiana and approved through City of Washington. ASTM standard methods must be followed when verifying performance of new measures. New BMPs, individually or in combination, must meet the performance criteria noted in Section III. of this Chapter, including the capture and removal of floatables. All innovative BMPs must have a low to medium maintenance requirement to be considered by the City of Washington. Testing to establish the pollutant removal rate must be conducted by an independent testing facility, not the BMP manufacturer. The accepted design flow rate for a Water Quality Device shall be the flow value at which the claimed removal rate for TSS is equaled or exceeded based on the unit's efficiency curve (flow rate versus removal rate graph).

TABLE 8-2

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 BMP and LID manual included in this Technical Standards Manual.

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.

VI. Low Impact Development (LID) Approach Procedures

a. Low Impact Development (LID) stormwater management design approaches are fundamentally different from conventional design approaches and challenge traditional thinking regarding development standards, watershed protection, and public participation. LID combines fundamental hydrologic concepts with many of today's common stormwater strategies, practices, and techniques to reshape development patterns in a way that maintains natural watershed hydrologic functions. When a county or community has a stormwater user fee system based on imperviousness, the utilization of LID approach will often result in reduced stormwater user fee for non-residential lots, because LID reduces overall imperviousness of the lot. The five principles of LID are:

i. Conservation of existing natural and topographic features;
ii. Minimization of land clearing and impervious surfaces;
iii. Maintain or lengthen the pre-developed time of concentration;
iv. Installation of integrated structural best management practices; and
v. Use of pollution prevention measures and practices.

Several methods for achieving the above principals are outlined below. In addition to methods described in this Standards Manual, there are several readily available references which provide details on incorporating LID practices into site development. One of the most recent, comprehensive resources for incorporating LID practices into site development design is "Low Impact Development Manual for Michigan: A Design Guide for Implementers and Reviewers" available online at www.semcog.org/LowImpactDevelopment.aspx. The noted resource was used extensively for the development of LID section in this Standards Manual.

b. The following steps shall be followed for the LID approach:

Step 1: Minimize Disturbed Areas and Protect Sensitive Areas

- Map sensitive areas such as waterbodies, floodplains, and natural flow paths. Identify hydrologic soil types on the maps. Show elevations and identify critical slopes of 15 percent to 25 percent and above 25 percent. Show areas of known contamination. Also show existing structures and infrastructure.
- Determine the total area of impervious surface existing prior to development.
- Note the seasonal high groundwater level.
- Designate sensitive areas that are proposed to be protected as part of the proposed layout.
- Lay out the proposed development, minimizing disturbance and avoiding the sensitive areas, utilizing existing soils.
- Utilize the non-structural BMPs listed in Table 8-3 to properly protect sensitive areas so they maintain their pre-development state and runoff characteristics. Reference the City's LID Manual for further details.

TABLE 8-3

Pre-approved BMPs with Treatment Area Reduction Recognitions for LID Approach

BMP[A]	Runoff Reduction Recognition[B]
Protect Sensitive Areas	Area (acres complying with the requirements of this BMP) can be subtracted from site development area for Channel Protection Volume and Water Quality Volume/Rate calculations.
Protect Riparian Buffers	Area (acres complying with the requirements of this BMP) can be subtracted from site development area for Channel Protection Volume and Water Quality Volume/Rate calculations.
Minimize Total Disturbed Area	Area (acres complying with the requirements of this BMP) can be subtracted from site development area for Channel Protection Volume and Water Quality Volume/Rate calculations.
Reduce Impervious Surfaces	Area (acres complying with the requirements of this BMP) can be subtracted from site development area for Channel Protection Volume and Water Quality Volume/Rate calculations.
Protect Natural Flow Pathways	Area (acres complying with the requirements of this BMP) can be subtracted from site development area for Channel Protection Volume and Water Quality Volume/Rate calculations.
Cluster-Type Development	Area (undisturbed acres complying with the requirements of this BMP) can be subtracted from site development area for Channel Protection Volume and Water Quality Volume/Rate calculations.

Notes:

A. In using and crediting these BMPs, applicants must meet the review criteria located within the discussion of each BMP provided in the BMP Manual and LID Manual.

B. If the LID track is pursued, reduced CNs (associated with pre-developed underlying soil types instead of the normal requirement of assigning the post-development CN according to the next lower infiltration soil group) for areas protected by these BMPs may be used for determining the post-developed runoff rates and volumes for larger events (up to and including the 100-year event).

- As shown in Table 8-3, when using the LID Approach (and certain other circumstances determined as appropriate by the City of Washington), any area that is set aside and protected as described in those BMPs may be subtracted from site development area for purposes of determining Channel Protection Volume calculations and water quality volume/rate calculations.
- Since the LID track is being used, for determining the 10-year and 100-year runoff and peak discharges, the CN associated with the original, pre-development soil groups (instead of the normal requirement of assigning the post-development CN according to the next lower infiltration soil group) may be used for these areas.
- The runoff reduction recognition only works with designs based on the Curve Number or CN method of analysis utilizing non-composite CN determination methods.

Step 2: <u>Restore Disturbed Areas</u>

- For the LID Approach, runoff reduction recognitions are used in the design process to emphasize the use of BMPs that, when applied, restore/alter the disturbed area in a way that reduces the volume of runoff from that area.
- Runoff reduction recognition is provided for the BMPs listed in Table 8-4 because they enhance the response of a piece of land to a storm event rather than treat the runoff that is generated. These BMPs are encouraged because they are relatively easy to implement over structural controls, require little if any maintenance, and the land they are applied to remains open to other uses.
- Runoff reduction recognition is applied by reducing the default CN value so that the amount of runoff generated from an event is reduced.
- The runoff reduction recognition only works with designs based on the CN method of analysis utilizing non-composite CN determination methods.
- Fact sheets for these BMPs are provided in the City's BMP and LID Manuals.

TABLE 8-4
Pre-approved BMPs with Runoff Reduction Recognitions for Restoring Disturbed Areas as Part of LID Approach

BMP[A]	Runoff Reduction Recognition[B]
Minimize Soil Compaction	Area (acres complying with the requirements of this BMP) can be assigned a CN based on the pre-developed soil group conditions instead of the normal requirement of assigning the post-development CN according to the next lower infiltration soil group.
Protection of Existing Trees within disturbed areas (part of Protect Sensitive Areas)	Trees protected under the requirements of this BMP can be assigned a CN based on the pre-developed soil group conditions at a rate of 800 square feet per tree instead of the normal requirement of assigning Post-developed CN according to the next lower infiltration soil group for the acres covered by the tree area.
Soil Amendment and Restoration	Area (acres complying with the requirements of this BMP) can be assigned a CN based on the pre-developed soil group conditions instead of the normal requirement of assigning the post-development CN according to the next lower infiltration soil group.
Native Revegetation	Proposed trees and shrubs to be planted under the requirements of this BMP can be assigned a CN based on the pre-developed soil group conditions at a rate of 200 square feet per tree and 25 square feet per shrub instead of the normal requirement of assigning Post-developed CN according to the next lower infiltration soil group for the acres covered by the existing land use area.
Riparian Buffer Restoration	Proposed trees and shrubs to be planted under the requirements of this BMP can be assigned a CN based on the pre-developed soil group conditions at a rate of 200 square feet per tree and 25 square feet per shrub instead of the normal requirement of assigning Post-developed CN according to the next lower infiltration soil group for the acres covered by the existing land use area.

Notes:

A. In using and crediting these BMPs, applicants must meet the review criteria located within the discussion of each BMP provided in the BMP and LID Manual.

B. If the LID track is pursued, reduced CNs (associated with pre-developed underlying soil types instead of the normal requirement of assigning the post-development CN according to the next lower infiltration soil group) for areas covered by these BMPs may be used for determining the post-developed runoff rates and volumes for larger events (up to and including the 100-year event).

Step 3: Minimize Imperviousness

- The BMPs listed in Table 8-5 are designed to reduce the volume of runoff from hard surfaces such as roads, sidewalks, parking areas, roofs, etc. Runoff reduction recognition is used to encourage these practices and recognize their runoff reduction impacts when LID Approach is being pursued. Fact sheets for these BMPs are provided in the Town's BMP and LID Manuals.

TABLE 8-5
Pre-approved BMPs with Runoff Reduction Credits
for Reducing Imperviousness as Part of LID Approach

BMP[A]	Runoff Reduction Recognition[B]
Porous Pavement	Area covered by Porous Pavement with a minimum of 8 inch washed aggregate base may be assigned a weighted CN value of 87 (instead of CN of 98 normally used for impervious surfaces) for the purpose of Channel Protection Volume calculations. Use a weighted CN of 74 for the purpose of Water Quality Volume calculations, if needed. Note: If this BMP is specifically designed to provide permanent volume reduction through infiltration or through providing detention storage within the aggregate void, the volume reduction recognition discussed in Step 5 should be pursued instead of the CN reduction recognition, assuming CN of 98.
Vegetated Roof	Vegetated roofs are designed to reduce runoff volumes. However, the volume reduction is highly dependent on the media and planting used, with the calculation methods very complex at times. In lieu of calculating the volume reduction benefits, the roof area with vegetated roof with a minimum media depth of 4 inches and a void ratio of 0.3 (as described in the fact sheet) may be assigned a weighted CN of 87 (instead of CN of 98 normally used for impervious surfaces) for the purpose of Channel Protection Volume calculations. Use a weighted CN of 74 for the purpose of Water Quality Volume calculations, if needed.

Chapter 9
Methodology for Determination of Required Sizing of BMPs

I. Introduction

a. This Chapter describes the acceptable methods for calculating Channel Protection Volume, Water Quality Volume, and Flow-Through BMP Flow Rate associated with Conventional Stormwater Management Approach (acceptable methods associated with the LID Stormwater Management Approach are discussed in Chapter 8). Channel Protection is achieved through retention or extended detention of runoff volume for 1-year, 24-hour storm event. Structural Water Quality treatment is achieved by treating the first inch of rainfall, either through retention/detention BMPs or by Flow-through BMPs. Detention/Retention BMPs impound (pond) the runoff to be treated, while flow-through BMPs treat the runoff through some form of filtration process.

II. Retention/Detention BMP Sizing

a. Channel Protection Volume

Channel Protection Detention/Retention BMPs must be designed to store the channel protection volume. The channel protection volume, CPv, is the storage needed to retain or detain the runoff to the receiving stream from the 1-year, 24-hour rainfall.

The methodology for calculating the Channel Protection Volume (CPv) for each of site's final outlets using computer models or manual calculation is as follows:

i. Computer Model: Use acceptable computer models (listed in Chapter 2) to determine the total runoff volume for the site contributing to each site's outlet, utilizing 1-year, 24-hour rainfall depth with Soil Conservation Service (SCS) type 2 storm distribution, drainage area, and the composite CN calculated for the site, according to the Soil Conservation Service (SCS) CN loss method along with SCS unitless hydrograph methodology.

ii. Manual Calculation: If calculating manually, use the following formula:

$$CPv\ (ft3)\ =\ Qv\ x\ 1/12\ x\ A$$

Where,

A = total post-construction site area contributory to each outlet (ft^2)

Qv = Runoff Depth (in) = $(P – 0.2S)^2/(P + 0.8S)$

P = 1-Year, 24 Hr Rainfall (in)

S = (1000/CN) – 10

b. Water Quality Volume

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.

A calculation methodology similar to that described for the channel protection volume may be utilized, except that the rainfall depth (P) will be equal to 1, instead of the 1-year, 24-hour depth.

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 run-on 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 on-site channel protection volume plus the water quality volume for the off-site sources.

III. Flow Through BMP Sizing

a. 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 City's BMP and LID Manual within this technical standards manual.

   i. 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:

      1. The MTD must be offline and located upstream of detention facilities (if any).
      2. The MTD must provide complete and unobstructed access to the entire bottom of the system from grade level, if applicable, for ease of maintenance.
      3. 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.
      4. 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.
      5. 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 III. b. 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.

ii. 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)

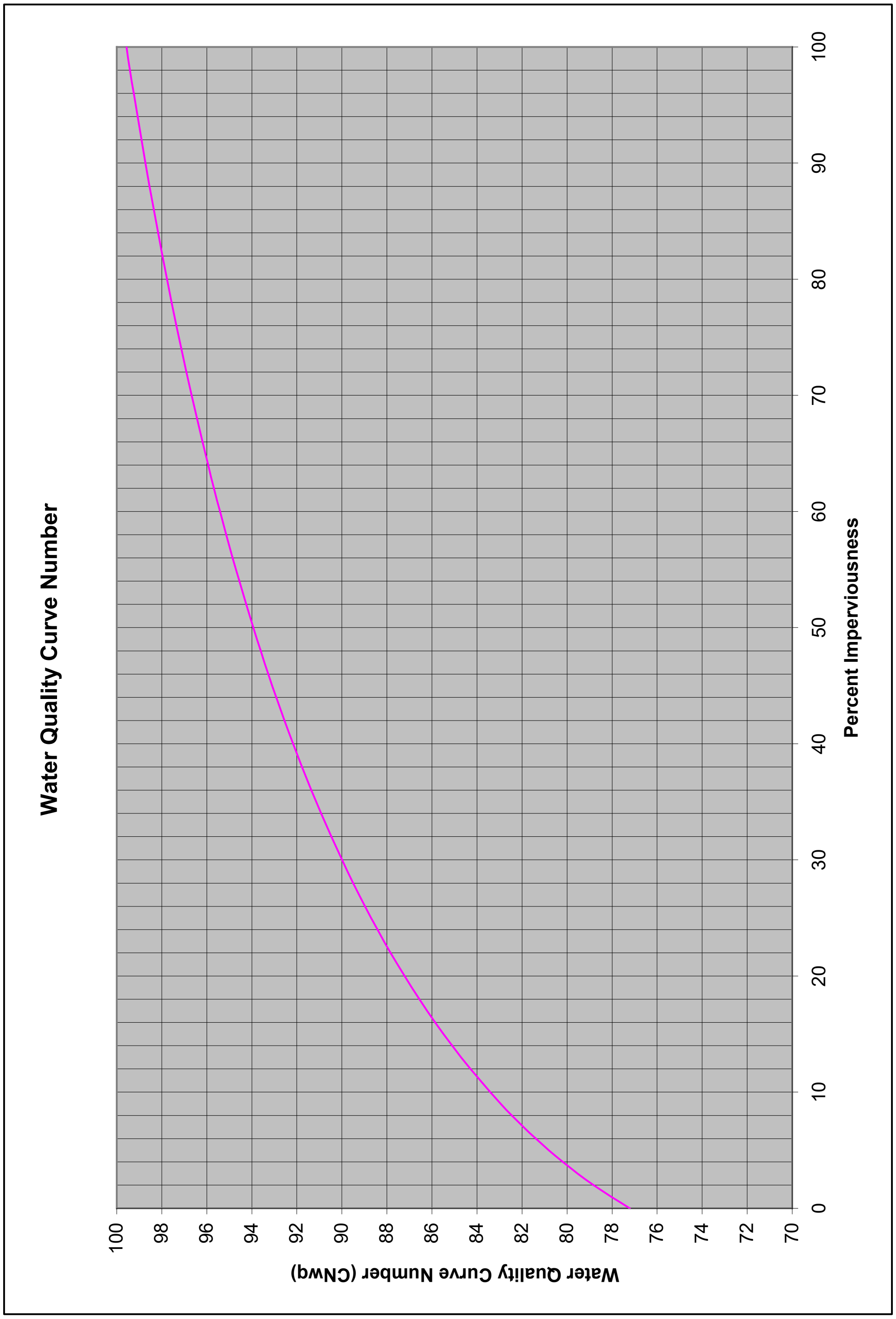
Rv=volumetric runoff coefficient (see previous section)

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.

FIGURE 9-1

Curve Number Calculation for Water Quality Storm Event



Chapter 10

Lot/Building Grading and Drainage Standards

I. Grading and Building Pad Elevations

a. Minimum Federal and State Requirements
For all structures located in the Special Flood Hazards Area (SFHA) as shown on the FEMA maps and/or that mapped by the IDNR based on Best Available Data, the Lowest Floor elevation, including basement, shall be at or above the flood protection grade (FPG) and therefore have a minimum of 2 feet of freeboard above the 100-year flood elevation.

b. Additional Local Requirements
FPG for all buildings located within or adjacent to SFHA shall be shown on the secondary plat.

For all structures located outside SFHA or an IDNR designated floodplains that are subject to flooding from a detention/retention pond, the lowest adjacent grade (LAG) of all residential, commercial, or industrial buildings shall have a minimum of 2 feet of freeboard above the 100-year flood elevation or the emergency overflow weir elevation, whichever is higher.

For all structures located outside SFHA or an IDNR designated floodplains that are subject to flooding from a stream or an open ditch or other waterway (an area along a stream with no floodplain designation or an area adjacent to a designated floodplain with ground elevation below 100-year flood elevation plus 2 feet), the LAG of all residential, commercial, or industrial buildings shall have a minimum of 2 feet of freeboard above the 100-year flood elevation of that open ditch or waterway.

For all structures fronting a flooding source other than a swale or an emergency flood route, the floor of any basements or crawl spaces (if provided) shall be a minimum of 1 foot above the normal pool level (if pond) or the 2-year flood level (if a stream or an open ditch).

In addition, special considerations, based on detailed geotechnical analysis, should be made prior to considering placement of any basement below the 100-year flood elevation of an adjacent flooding source or pond.

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.

II. Lot Drainage

a. 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 Washington 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 Washington 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 manmade features on their lots.

III. Acceptable Outlet and Adjoining Property Impacts Policies

a. 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 Washington 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 Washington storm drain, or natural watercourse (as determined or approved by the City of Washington) 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 Washington.

Chapter 11

Special Standards for Proposed Solar Farms

I. Special Standards

a. Solar development has expanded over the last several years as Indiana and other states have invested in this important resource to further greenhouse gas emission reductions. The large amount of impervious surface inherent in the construction of a large-scale solar array entails challenges not encountered in traditional development projects. If not properly managed through appropriate design and mitigation measures, stormwater discharged during and after the construction of solar arrays can be a significant source of pollution resulting from increased runoff, erosion, and sedimentation, which can adversely impact adjoining properties, streams, wetlands, or other natural resources. Solar installations must be properly designed to assure soil stabilization, minimize soil disturbance and soil compaction, and address ineffective controls to manage the total runoff volume and velocity that can lead to the loss of topsoil, erosion and sediment discharges from disturbed areas and stormwater outlets, and erosion along downstream channels and streambanks. The ability to address such significant environmental problems during construction and post-construction becomes more difficult as site imperviousness increases.

   Solar projects that use traditional elevated solar panels are unique because they contain an impervious surface (elevated solar panel) that often has a pervious surface (vegetation) underneath the panel. Stormwater runoff from solar projects is generated primarily from rain that falls on access roads, inverter pads, and solar panels. Water that falls off solar panels runs across the panel to the dripline, and eventually falls to the underlying surface. Some of this water will infiltrate and some will run-off downslope and eventually off site.

   One of the most notable impacts that solar sites have on water quality is the potential for erosion and/or scour at the dripline. To minimize the erosion and/or scour at the dripline, the lowest vertical clearance of any solar array shall be no greater than 10 feet. Also, erosion prevention and sediment control Best Management Practices (BMPs) as detailed in Chapter 7 of these Standards must be utilized during construction.

In addition to providing construction BMPs, Solar projects must adhere to the post-construction stormwater management requirements, including providing the required Water Quality Volume (WQv) and Channel Protection Volume (CPv) described in Chapter 8 of these Standards, as well as peak flow control (detention) requirements described in Chapter 6. However, because solar farms—particularly the panels— have unique characteristics, not like constructing a building or road, they often inherently include stormwater disconnection features that qualifies them for recognition/credit afforded to the Stormwater Disconnection BMP, which similar to typical solar panel farms rely on maintaining sheet flow and infiltration in adequately-sized, vegetative areas receiving runoff. The Stormwater Disconnection BMP is detailed in OCRA Green Infrastructure Curriculum and Training resources web page: [OCRA Green Infrastructure Stormwater Disconnection BMP-Fact-Sheets.pdf (in.gov)]). Per recommendations from the Center for Watershed Protection, the following Stormwater Disconnection recognitions/credits are established as part of these standards for solar farms that meet the conditions stated in these standards:

i. WQv: Up to 100% of the required Water Quality Volume, proportionate to the percentage of total disconnected area to total site impervious area, may be subtracted from the required WQv.

ii. CPv: For determining the Channel Protection Volume (CPv), the post-construction CN for the impervious area treated by the stormwater disconnection BMP may be determined assuming the treated area is "wood in good condition" (for the next less infiltrating hydrologic soil group than the pre-construction hydrologic soil group, since the area underneath panels is assumed disturbed/compacted during construction).

iii. Qp (2, 10, 100): For determining the peak flow controls (detention), the post-construction CN for the area treated by the stormwater disconnection BMP, needed for determining post-construction peak flows (Qp) for 2, 10, and 100-year storms, may be determined assuming the treated area is "wood in good condition" (for the next less infiltrating hydrologic soil group than the pre-construction hydrologic soil group, since the area underneath panels is assumed disturbed/compacted during construction).

b. In order for the solar farm developments to be eligible for Stormwater Disconnection BMP recognitions/credits, the following design and construction guidelines must be met (Items d and g are required for all proposed solar farms regardless of whether Stormwater Disconnection recognition/credit is being sought):

i. Roadways, gravel surfaces, transformer pads, and level spreaders within the solar field are considered effective impervious cover for the purposes of calculating Water Quality Volume (WQv), Channel Protection Volume (CPv), and post-construction peak flows.

ii. All solar panels in the array should also be considered additional effective impervious cover for the purposes of calculating the WQv, CPv, and post-construction peak flow unless ALL the following conditions are met:

1. The vegetated area receiving runoff between rows of solar panels is equal to or greater than the average width of the row of solar panels draining to the vegetated area.

2. Overall site conditions and solar panel configuration within the array are designed and constructed such that the runoff remains as sheet flow across the entire site. Design array to ensure a perpendicular layout of drip edge to slope direction or install devices such as a Level Spreader to ensure sheet flow from the drip edge. Level Spreaders shall be designed in accordance with the Level Spreader fact sheet contained in Appendix-C-BMP-Fact-Sheets.pdf (in.gov).

3. The following conditions are satisfied regarding the design of the post-construction slope of the site:

   - For slopes less than or equal to 5%, appropriate vegetation shall be established as indicated in Figure 13-1, below.

   - For slopes greater than 5%, but less than 10%, practices including, but not limited to, the use of level spreaders, infiltration trenches, or similar energy dissipating practices as described in Figure 13-2, below, shall be used to ensure long term sheet flow conditions.

- For slopes equal to or greater than 10% and less than 15%, the Plan includes specific engineered stormwater control measures, such as level spreaders, infiltration trenches, or similar energy dissipating practices, with detailed specifications that are designed to provide permanent stabilization and non-erosive conveyance of runoff to the property line of the site or downgradient from the site.

- Slopes greater than 15% are not qualified for a stormwater disconnection recognition/credit.

4. The lowest vertical clearance of the solar panels above the ground should not be greater than ten (10) feet. The panels should, however, be at an adequate height to support vegetative growth and maintenance beneath and between the panels. If the lowest vertical clearance of the solar panels above the ground is greater than ten (10) feet, non-vegetative control measures will be necessary to prevent/control erosion and scour along the drip line or otherwise provide energy dissipation from water running off the panels.

5. Disconnecting impervious surfaces works best in undisturbed soils. To minimize disturbance and compaction, construction vehicles and equipment should avoid areas used for disconnection during installation of the solar panels. Hydrologic Soil Group D soils or soils that are compacted by construction equipment may need to be tilled to a depth of four to six inches and/or amended to increase permeability.

6. Groundcover vegetation must be maintained in good condition in those areas receiving disconnected runoff. Areas receiving runoff should be protected (e.g., planting shrubs or trees along the perimeter) from future compaction. Vegetated areas shall not be subject to chemical fertilization or herbicides/pesticides except for those applications that are necessary to get vegetation established and which follow an approved Erosion and Sediment Pollution Control Plan.

   To maximize the potential for infiltration and reduce maintenance, the use of native deep-rooted vegetative cover under the panels and between the panel rows is highly encouraged. To achieve a native deep-rooted vegetative cover, a mixture of perennial grasses and wildflowers is recommended with a diversity of forbs or flowering plants that bloom throughout the growing season. Blooming shrubs may also be used in buffer areas as appropriate for visual screening. Perennial vegetation (grasses and forbs) should be native to Indiana, but where appropriate to the vegetative management plan goals, may also include other naturalized and non-invasive species which provide wildlife habitat for pollinators.

7. A fifty (50) foot buffer should be maintained between any part of the solar array and any "watercourse" or "waterbody) as that term is defined in Appendix A of these standards. The buffer shall consist of undisturbed existing vegetation or native shrub plantings.

8. Similar to other post-construction BMPs, the vegetated area underneath the panels, the vegetated area receiving runoff, and any buffer areas will need to be mapped, maintained in accordance with the stormwater Management operation and maintenance manual, and covered by the recorded maintenance agreement described in Chapter 8 of these standards.

Depending on the layout and number of panels installed, the stormwater disconnection BMP may address some or all of the stormwater management requirements (WQv) for an individual project. Where the imperviousness is high or there is other infrastructure (e.g., access roads, transformers), additional runoff may need to be treated. Further reduction in the remaining required Water Quality, Channel Protection, and Peak flow control volumes is possible through utilizing the BMPs described as part of the LID track in Chapter 8 of these standards.

A solar panel project should ideally be installed and placed outside of the floodplain or detention facilities. If proposed to be placed within a floodplain or in a dry detention facility, panels (all tilt positions) must be installed at or above the flood protection grade (2 feet above the BFE) or at or above the 100-year emergency overflow of the detention facility plus one foot. This includes all electrical systems associated with the panels. If the solar array project is proposed within floodway portion of the floodplain, the project shall also require a Construction in Floodway Permit from the IDNR.

Figure 11-1

Typical Solar Panel Installation with Slopes ≤ 5%

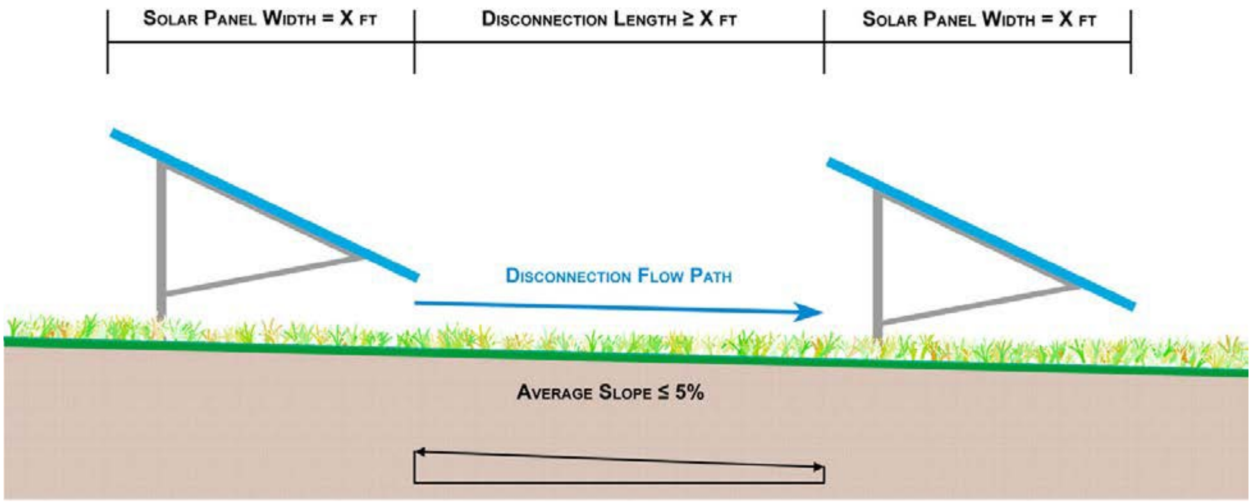
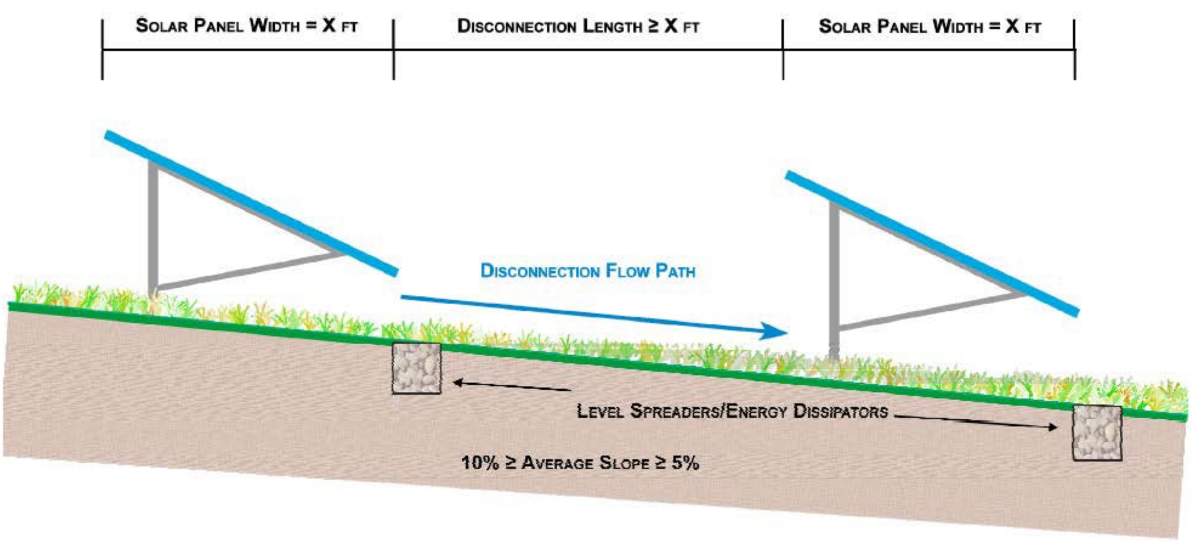


Figure 11-2

Typical Solar Panel Installation with Slopes > 5% and ≤ 10%



Source: Maryland Department of the Environment: Stormwater Design Guidance – Solar Panel Installations

BEST MANAGEMENT PRACTICES (BMP) MANUAL

City of Washington

2024

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BMP 1 SILT FENCE

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Silt fence is utilized as a means to trap sediment from small, disturbed areas by reducing the velocity of sheet flow. Silt fences capture sediment by ponding water to allow deposition, not by filtration.

Silt fence is not recommended for use as a diversion and should never be used across a stream, channel, ditch, swale, or anywhere that concentrated flow is anticipated.

Specifications: Limited to one quarter acre of drainage area per 100 linear feet of fence.

Silt fence has a six-month maximum effective service life and must be replaced if the project is not completed.

Silt fence shall be a minimum height of 18 inches and a maximum height of 30 inches above ground level.

Support posts shall be spaced 8 feet maximum if fence is supported by wire mesh fencing and 6 feet maximum for extra-strength fabric without wire backing.

Spacing between rows of silt fence shall be per the slope steepness restriction table below:

Percent Slope		Maximum Distance
< 2%	< 50:1	100 feet

2% - 5%	50:1 - 20:1	75 feet
5% - 10%	20:1 - 10:1	50 feet
10% - 20%	10:1 - 5:1	25 feet
> 20%	> 5:1	15 feet

TSS Removal Rates per USEPA:

Average TSS removed	Soil classification
80-90%	Sand
50-80%	Silt-loam
0-20%	Silt-clay-loam

Refer to the Washington, Indiana, standards and ordinances.

Materials: Fabric shall be woven or non-woven geotextile fabric meeting the specified minimums as outlined in the table below:

Physical Property	Woven Geotextile Fabric	Non-Woven Geotextile Fabric
Filtering efficiency	85%	85%
Standard textile strength at 20% elongation	30 lbs per linear inch	50 lbs per linear inch
Extra textile strength at 20% elongation	50 lbs per linear inch	70 lbs per linear inch
Slurry flow rate	0.3 gal/min/square feet	4.5 gal/min/square feet
Water Flow Rate	15 gal/min/square feet	220 gal/min/square feet
UV resistance	70%	85%
Post spacing	7 feet	5 feet

Support posts shall be 2-by-2-inch hardwood or steel posts.

Installation: The location of the silt fence shall be parallel to the contour of the slope and at least 10 feet beyond the toe of the slope in order to provide a sediment storage area. The ends of the silt fence shall be turned up slope such that the point of contact between the ground and the bottom of the fence end terminates at a higher elevation than the top of the fence at its lowest point.

Silt fence shall be installed per the manufacturer's instructions and recommendations. At a minimum, silt fence shall be trenched into the soil a minimum of 8 inches deep in a v-shaped or flat bottom trench and secured by filling the trench with soil along the entire fence line.

Maintenance: The silt fence shall be inspected within 24 hours of a rain event and at least once every 7 days at minimum. Any fabric tears, decomposition or inefficiencies in the silt fence shall be replaced immediately.

Deposited sediment shall be removed when it reaches half the height of the silt fence at the silt fence's lowest point or is causing the fabric to bulge.

Take care to avoid undermining the silt fence during clean out.

After the contributing drainage area has been stabilized, remove the fence and sediment deposits, bring the disturbed area to grade, and stabilize the area.

BMP 2 ROCK CHECK DAM

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Rock check dams are utilized to reduce erosion in a drainage channel by slowing the velocity of flow.

Specifications: Two-acre maximum contributing drainage area per check dam.

Rock check dams shall have a 2 feet maximum dam height with the center of the dam at least 9 inches lower than the points of contact between the uppermost points of the dam and channel banks.

Rock check dams have an 80% design removal efficiency goal for TSS in the inflow.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Utilize an 8-ounce or heavier nonwoven geotextile fabric.

INDOT revetment riprap shall be used for the dam and well-graded INDOT CA No. 5 aggregate shall be used as filter medium.

Installation: Excavate a cutoff trench into the swale banks and extend it a minimum of 18 inches beyond the top of bank. Place the rock in the cutoff trench and channel to the limits described above.

Extend the rock a minimum of 18 inches beyond the top of bank to keep overflow water from undercutting the dam as it re-enters the channel.

Dams shall be placed so that the upstream dam toe elevation and the overflow weir of the downstream dam top elevation are the same.

Stabilize the channel above the uppermost check dam.

Erosion resistant lining shall extend at least 6 feet below the lowest check dam.

Maintenance: Inspect check dams and the channel after each rain event and repair any damage immediately. If significant erosion occurs between the check dams, install a riprap liner in that portion of the channel.

Remove sediment accumulated behind each check dam as needed to maintain channel capacity, to allow drainage through the dam, and to prevent large flows from displacing sediment.

Add aggregate to the dams as needed to maintain design height and cross section.

When the dams are no longer needed, remove the aggregate and stabilize the channel using an erosion resistant lining if necessary.

BMP 3 TEMPORARY SEDIMENT TRAP

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment, Floatable Materials

Partially Targeted Pollutants: None

Purpose: Temporary sediment traps are utilized to minimize release from construction areas by pooling stormwater runoff, allowing sufficient retention time for settling of suspended soil particles, and to minimize offsite sedimentation by trapping sediment at designated locations accessible for cleanout.

Specifications: Five-acre maximum drainage area per sediment trap. Typically, a two-year structure life. Proper maintenance will extend the life of the measure. On average, 60% TSS reduction can be obtained through the use of a temporary sediment trap.

The pool area shall be a minimum of 1,800 cubic feet per acre of the watershed's total contributing area with side slopes at 2:1 or flatter and a length to width ratio of 2:1 or greater in line with the flow. The calculated dimension for a sediment trap shall be shown in the plan profile to aid in proper installation.

The sediment trap pond should completely drain within 48 hours to 72 hours of a rain event. The outlet should have a capacity designed for a 2-year frequency, 24-hour rain event.

Temporary sediment trap spillway shall be in accordance with the following table:

Drainage Area (acres)	Minimum Bottom Width (feet)
1	4
2	6
3	8
4	10
5	12

Refer to the Washington, Indiana, standards and ordinances.

Materials: Temporary sediment traps shall be constructed utilizing INDOT revetment riprap, INDOT CA No. 5 aggregate, and geotextile fabric.

Installation: Clear, grub, and strip all vegetation and root mat from the embankment area.

Create embankment using compacted material free of roots, brush, and debris. Overfill the embankment 6 inches to allow for settling.

Excavate a trapezoidal stone outlet section from the compacted embankment.

Install geotextile and place specified stone to the lines and grades shown in the Construction Details.

Stabilize the embankment and other disturbed areas with seed and mulch or another suitable erosion resistant cover.

Maintenance: Sediment traps shall be inspected weekly and following each rain event and immediately repaired if damaged. Check embankment for any erosion and holes and repair. Remove sediment when it has accumulated to one half the design depth. Check sediment trap pool area side slopes for erosion and repair. If the spillway gravel facing is clogged, replace it with INDOT CA No. 5 aggregate. Inspect vegetation and seed again, if necessary.

Check the spillway depth periodically to ensure a minimum 18-inch depth from the lowest point of the settled embankment to the highest point of the spillway crest. Fill any low areas to maintain the design elevation.

BMP 4 CONCRETE WASHOUT

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Illicit discharge

Partially Targeted Pollutants: Construction Waste

Purpose: Concrete washout systems are implemented to reduce the discharge of pollutants associated with concrete washout waste. Performing concrete washout in designated areas and into specifically designed systems reduces the impact concrete washout can have on the environment.

Specifications: Install concrete washout prior to delivery of concrete.

Do not wash out concrete trucks or equipment into the storm sewer system, storm drains, wetlands, streams, rivers, creeks, ditches, or streets.

Install systems at strategic locations that are convenient and in close proximity to work areas and in sufficient number to accommodate the demand for disposal. On average 7 gallons of water is used per chute washout. Calculate the daily needs by multiplying the number of concrete loads which will be needed in one day by 7 gallons to determine the volume of washout needed.

Locate concrete washout systems at least 50 feet away from bodies of water or conveyance systems. Refer to the Washington, Indiana, standards and ordinances.

Materials: Utilize a minimum of 10-mil polyethylene sheeting that is free of holes, tears, and other defects. Sheeting shall be of an appropriate size to fit the washout system without seams or overlap of lining.

The washout system shall be constructed of sandbags, soil material, or other appropriate materials.

Metal pins or staples with a minimum of 6 inches in length, sandbags or alternative fasteners shall be used to secure the polyethylene lining to the containment system.

Installation: Construct a washout base or utilize a sealed container, suitable for the concrete trucks to access for washing their equipment and chutes. Install the polyethylene lining and secure it with pins, staples, or other fasteners.

Place flags, safety fencing, or equivalent warning to provide a barrier to construction equipment and other traffic.

Install signage that indicates concrete washout areas.

Maintenance: Inspect daily and after each rain event. When possible, cover prior to rain event.

Excess concrete shall be removed when the washout system reaches 50% of its capacity. Dispose of all concrete in a legal manner. Maintain a 12” freeboard at all times to account for rainwater accumulation.

Inspect construction activities on a regular basis to ensure suppliers, contractors, and others are utilizing the designated washout areas.

When concrete washout areas are no longer required, they shall be closed. All hardened concrete and other materials shall be properly disposed of, and land disturbances associated with the system shall be backfilled, graded, and stabilized.

BMP 5 FILTER TUBE/FILTER SOCK

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: To trap sediment by intercepting runoff and reducing the velocity of sheet flow or concentrated flow (limited application). Filter socks capture sediment by ponding water to allow settling and deposition.

Specifications: Limited to one-quarter acre per 100 linear feet of barrier. Further restricted by slope steepness.

For slope application, filter tube is to be installed parallel to the contour 10 feet horizontally past the toe of slope.

For channel/swale application, filter tube is to be installed perpendicular to channel flow. Channel/swale applications are limited to less than one acre of drainage area and a larger product is to be utilized, typically 18 or more inches in diameter.

Filter tube may be utilized as drop inlet protection.

Locate filter tube where accessible for maintenance.

Filter tubes average 90% oil and TSS removal.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Geotextile fabric sock or a non-biodegradable netting matrix.

Specifications for filler materials are as follows:

1. Compost/Mulch Specifications:

   Feedstock's may include, but are not limited to, well-composted vegetable matter, leaves, yard trimmings, food scraps, composted manures, paper fiber, wood bark, Class A bio solids (as defined in federal regulations 40 CFR Part 503), or any combination thereof.

   Compost shall be produced using an aerobic composting process meeting CFR 503 regulations, including time and temperature data indicating effective weed seed, pathogen and insect larvae kill.

   Compost shall be well decomposed, stable, and weed free with variable particle size with maximum dimensions of two inches in length, one-half inch in width, and one-half inch in depth. It shall be refuse free (less than one percent by weight), free of any contaminants and materials toxic to plant growth, inert materials not to exceed one percent by dry weight, with a pH of 5.5 to 8.0 a carbon-nitrogen ratio which does not exceed 100, and moisture content not to exceed 45 percent by dry weight.

2. Aggregate Specifications:

   INDOT CA No. 5 or No. 8 aggregate.

3. Straw, Excelsior, etc. are to be premanufactured.

   2 x 2 inch hardwood or steel posts are to be utilized for anchoring.

Bonding agents are optional. Tackifiers, flocculants, or microbial additives may be used to remove sediment and/or additional pollutants from stormwater runoff. (All additives combined with compost materials should be tested for physical results at a certified erosion and sediment control laboratory and biologically tested for elevated beneficial microorganisms at a United States Compost Council, Seal of Testing Assurance approved testing laboratory.)

Installation: Lay out the location of the filter tube barrier so that it is parallel to the contour of the slope and at least 10 feet beyond the toe of the slope to provide a sediment storage area. Turn the ends of the filter tube barrier up slope such that the point of contact between the ground and the bottom of the filter tube barrier end terminates at a higher elevation than the top of the filter sock barrier at its lowest point.

Excavate a trench with a depth and width equal to at least one-fourth the diameter of the filter tube or follow the manufacturer's recommendations. Where applicable, the trench may also be excavated upslope of a curb or sidewalk. Placing the product against the curb or sidewalk will provide additional stability and resistance to surface flow.

Construct the filter tube or utilize a pre-manufactured product. For compost use a pneumatic blower or similar device to provide adequate and consistent fill in the tube. (Seed or sod may be applied at the time of installation for permanent applications.)

If more than one tube is placed in a row, the tube should be overlapped with both ends of the overlapping tube on the ground; not abutted or stacked.

Anchor the filter tube barrier in place by driving posts through the center of or immediately downstream of the barrier and into the underlying soil material. Posts should be spaced no more than five feet apart and driven a minimum of 18 inches deep into the soil. The stake should be flush with the top of the tube. Wedge the stake when possible

Backfill the trench with excavated soil placed against the filter tube barrier to ground level on the down- slope side and to two inches above ground level on the up-slope side of the filter tube barrier. Compact the fill material to keep it in place.

Maintenance: Inspect once every 7 days and after each rain event.

Remove accumulated sediment when it reaches one-quarter the height of the filter tube.

Inspect to ensure that the tube is maintaining its integrity and producing adequate flow.

Repair eroded and damaged areas within 24 hours.

If ponding becomes excessive, tube should be removed and either reconstructed or new product installed.

Traffic shall not be permitted to cross the filter tube.

After the contributing drainage area has been stabilized, remove the filter tube and sediment deposits, bring the disturbed area to grade, and stabilize the area.

BMP 6 TEMPORARY DIVERSION

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Temporary diversions are used to temporarily direct stormwater runoff in a controlled manner to a desired location; especially to protect work areas and to manipulate watershed areas for sizing of sediment control measures.

Specifications: The maximum contributing drainage area for temporary diversions is 3 acres.

Temporary diversions shall be designed for a peak runoff from a 2-year frequency, 24-hour duration rain event.

Side slopes shall be a ratio of 2:1 or flatter with a minimum top width of 2 feet.

Refer to the Washington, Indiana, standards and ordinances.

Installation: Lay out the diversion by setting grade and alignment to fit site needs and topography maintaining a stable, positive channel grade towards the outlet.

Remove and properly dispose of brush, trees, and other debris from the foundation area.

Construct the diversion to dimensions and grades shown in the construction plans.

Construct the diversion ridge in 6-inch to 8-inch lifts. Compact each lift by driving wheels of construction equipment along the ridge. Overfill and compact the ridge to design height plus 1% to allow for settlement.

Stabilize channels used to transport temporarily diverted stormwater and outlets prior to or during construction of the diversion and divert sediment-laden stormwater flow to a temporary sediment trap or a temporary dry sediment basin.

Maintenance: Inspect within 24 hours of each rain event and at least once every seven

calendar days.

Remove sediment from the channel to maintain positive grade.

Check outlets and make necessary repairs immediately.

Adjust ridge height to prevent overtopping.

After the contributing drainage area has been stabilized, remove the temporary diversion, bring the disturbed area to grade, and stabilize the area.

BMP 7 TEMPORARY SLOPE DRAIN

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Temporary slope drains are utilized to temporarily convey stormwater runoff down the face of a slope without causing erosion. Use in combination with drainage channel or swale at the top of the slope to direct water to the pipe or culvert used to convey water down a slope where there is a high potential for erosion.

Specifications: Temporary slope drains shall be designed for peak runoff from a 2-year frequency, 24- hour duration rain event.

Typically, this measure is used for less than 2 years during grading operations until permanent drainage structures are installed or slopes are permanently stabilized.

The area that a temporary slope drain shall not exceed 5 acres.

The outlet pipe shall extend beyond the toe of slope and terminate on a stable, minimum 4-foot long level section.

Fill shall be used and compacted over the pipe to a minimum of a depth of one foot to 1.5 feet, width of 4 feet, and a height that is 6 inches higher than the diversion ridge to divert runoff to the temporary slope drain.

Pipe selection shall be in accordance with the following table:

Maximum Drainage Area Per Pipe (acres)	Minimum Pipe Diameter (inch)
0.50	8
0.75	10
1.00	12
> 1.00	Individually designed

When water reaches the temporary slope drain, with proper installation and maintenance, the measure will be 100% effective at not adding TSS to the discharge.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Pipe shall be strong and flexible, such as heavy duty, non-perforated, corrugated

plastic. A flared-end or "T" type end section shall be utilized for the inlet.

Wooden stakes or rebar shall be utilized to anchor the slope drain.

Installation: Temporary slope drains shall be placed on undisturbed soil or well compacted fill. The slope drain inlet shall be at the bottom of the diversion channels. Connect the pipe to the inlet section.

Construct the diversion ridge by placing fill over the pipe in 6-inch lifts. Compact each lift by hand tamping under and around the inlet and along the pipe.

The top of fill shall be 6 inches higher than the adjoining diversion.

All pipe connections shall be watertight and secure so that joints will not separate in use.

Anchor the pipe to the face of the slope with stakes spaced no more than 10 feet apart. Extend the pipe beyond the toe of slope to a stable grade. Protect the outlet from erosion.

Grade the diversion channel at the top of the slope toward the temporary slope drain (slope <

2%). Stabilize all disturbed areas following installation.

Maintenance: Inspect weekly and following each rain event. Remove sediment from the channel and reinforce the ridge as needed.

Check the inlet for sediment and trash accumulation.

Check the fill over the pipe for settlement, cracking, or piping holes and repair any problems immediately.

Check for holes where the pipe emerges from the dike and repair any problems immediately.

Check the conduit for evidence of leaks or inadequate anchoring and repair any problems immediately.

Check the outlet for erosion or sedimentation and clean and repair or extend if necessary.

After the contributing drainage area has been stabilized, remove the slope drain and sediment deposits, bring the disturbed area to grade, and stabilize the area.

BMP 8 BASKET CURB INLET PROTECTION

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: Floatable Materials

Purpose: Basket curb inlet protection is utilized to minimize sediment from entering the storm system while still allowing runoff to enter the storm sewer system.

Specifications: Basket curb inlet protection shall be limited to a one quarter of an acre maximum contributing drainage area.

Basket curb inlet protection shall be designed to handle the runoff from a 2-year, 24-hour duration rain event entering a storm drain without bypass flow.

Filter sock inlet protection is preferred to basket curb inlet protection in already developed areas. It is the site owner and contractor's responsibility to prevent flooding that may be caused by restricting inlet intake capacity. A representative from the site owner or contractor shall be onsite during any storm in excess of the 2-year 24-hour duration rain event.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Basket curb inlet protection shall be constructed of a metal frame or basket with a top width and length such that the frame fits into the inlet.

Geotextile fabric shall be in accordance with the following table:

Physical Property	Woven Geotextile Fabric	Non-Woven Geotextile Fabric
Filtering efficiency	85%	85%
UV resistance	70%	85%
Standard tensile strength at 20% elongation	30 lbs per linear inch	50 lbs per linear inch
Extra tensile strength at 20% elongation	50 lbs per linear inch	70 lbs per linear inch
Slurry flow rate	0.3 gal/min/square feet	4.5 gal/min/square feet
Water flow rate	15 gal/min/square feet	220 gal/min/square feet

Installation: Install basket curb inlet protection as soon as inlet boxes are installed or prior to land disturbing activities for existing inlets.

If necessary, adapt basket dimensions to fit inlet box dimensions.

Remove the grate and install the frame into the grate opening. Cut and install geotextile fabric according to the manufacturer's recommendations. Replace the grate.

Maintenance: Inspect daily and after each rain event and remove sediment. Replace or clean geotextile fabric as needed and following any rain event. Remove tracked sediment from the street, without flushing with water, to reduce the sediment load on the curb inlet.


BMP 9 GRAVEL DONUT DROP INLET PROTECTION

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: Floatable Materials

Purpose: Gravel donut drop inlet protection is utilized to capture sediment at the approach to a storm drain inlet allowing full use of the storm drain system during construction.

Specifications: Gravel donut drop inlet protection is limited to a maximum of one acre of contributing drainage area.

Gravel donut drop inlet protection shall be designed to handle runoff from a 2-year frequency, 24-hour duration rain event entering a storm drain without bypass flow.

The outside side slopes of the aggregate donut shall be at a 2:1 ratio or flatter. The inside side slopes of the aggregate donut shall be at a 3:1 ratio or flatter.

The height of the aggregate donut shall be 12 inches to 24 inches above the top of the inlet.

Keep the minimum volume of excavated area around the drop inlet at approximately 1800 ft^3/acre disturbed.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Gravel donut drop inlet protection shall be constructed of INDOT uniform B riprap and INDOT CA No. 5 aggregate.

Installation: Excavate an area a minimum of 8 inches deep and 12 inches wide immediately out from the storm drain.

Around the excavated area, lay a ring of INDOT Uniform B Riprap to a height of 9 inches to 21 inches above the top of the inlet.

Cover the outside face of the ring with at least 12 inches of INDOT CA No. 5 aggregate, maintaining the slopes listed above.

Place INDOT CA No. 5 aggregate in the 12 inchwide excavation, from the toe of the inside slope to the inlet structure.

Maintenance: Inspect the structure daily and after each storm event. Remove sediment and make necessary repairs immediately.

When the contributing drainage area has been stabilized, remove, and properly dispose of any unstable sediment and construction material and restabilize.

BMP 10 WELDED WIRE INLET PROTECTION

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: Floatable Materials

Purpose: Welded wire inlet protection is utilized to capture sediment at the approach to a storm drain inlet allowing full use of the storm drain system during construction.

Specifications: Welded wire inlet protection is limited to a maximum of one acre of contributing drainage area.

Welded wire inlet protection shall be designed to handle runoff from a 2-year frequency, 24-hour duration rain event entering a storm drain without bypass flow.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Welded wire inlet protection shall be constructed of 6-inch by 6-inch welded wire mesh formed of 10-gauge steel conforming to ASTM A-185 with geotextile fabric fastened by rings constructed of wire conforming to ASTM A-641, A-809, and A-938.

Installation: Geotextile shall be wrapped 3-inches over the top member of the 6-inch by 6-inch welded wire mesh and shall be secured with fastening rings through both geotextile layers and close around a steel member at 6-inches on center.

Geotextile shall be secured to the sides of the welded wire mesh with fastening rings at a spacing of one per square foot except for the bottom 2 inches, which shall extend past the welded wire and be left unsecured for entrenchment.

Welded wire assembly shall be formed into a minimum 42-inch diameter circle or 42 inch by 42 inch square with a minimum of 3 inches of overlap on the ends secured by wire or zip ties.

Welded wire assembly shall be placed in a 6-inch-deep trench and backfilled and compacted over the geotextile flap.

Maintenance: Inspect the welded wire inlet protector weekly and after each rain event.

If geotextile tears, starts to decompose, or in any way becomes ineffective, replace the affected portion immediately. Replace welded wire inlet protector at least every 6 months.

Remove the deposited sediment when it reaches half the height of the assembly at its lowest point or it is causing the structure to shift. Take care to avoid undermining the assembly during clean out.

After the contributing drainage area has been stabilized, remove the assembly and sediment deposits, bring the disturbed area to grade, and stabilize.

BMP 11 TEMPORARY CONSTRUCTION ENTRANCE

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: None

Partially Targeted Pollutants: Sediment, Nutrients, Oil & Grease

Purpose: The purpose of the temporary gravel construction entrance is to provide ingress and egress to a construction site and minimize tracking of mud and sediment onto public roadways.

Specifications: The entrance shall be placed to avoid steep slopes, blind spots, or curves on public roads.

The temporary gravel construction entrance should be the full width of the roadway entrance/exit or a minimum of 12 feet wide and a minimum of 50 feet in length. Ideally, if space allows, the entrance should be a minimum length of 150 feet.

The entrance shall be a minimum of 6 inches thick. Rock shall be underlain with nonwoven geotextile fabric.

The overall effectiveness in percentage of soil removal from vehicles, preventing tracking sediment, can range from less than 30%, and up to 60%, but is highly dependent on design, installation, frequency of use, and maintenance.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Utilize INDOT CA No. 2 aggregate for the base.

Utilize INDOT CA No. 53 washed aggregate to top-dress.

Geotextile fabric shall be used as a separation layer to prevent intermixing of aggregate and the underlying soil material.

Manufactured products may be used in lieu of aggregate and must be approved by the City Engineer prior to use.

Installation: Remove all vegetation and other objectionable material from the foundation area and grade the foundation and crown for positive drainage.

If longitudinal slope is in excess of 2%, construct a water bar (ridge) approximately 15 feet from the entrance to divert runoff away from the road.

Install pipe under the pad to maintain proper public road drainage if necessary.

If wet conditions are anticipated place geotextile fabric on the graded foundation to improve stability.

Place aggregate to proper dimensions and grade as shown on the erosion control plan. Leave the surface smooth and sloped for drainage.

Top-dress the drive with INDOT CA No. 53 washed aggregate.

Divert all surface runoff and drainage from the stone pad to a sediment trap or basin.

Maintenance: Inspect daily and after each storm event or heavy use. Reshape the pad and top-dress as needed for drainage and runoff control.

Immediately remove mud and sediment tracked or washed onto public roads by brushing or sweeping. Flushing should only be used if the water is conveyed to a sediment trap or basin or vacuumed up.

BMP 12 RIPRAP

CONSTRUCTION PHASE AND POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Riprap is a permanent layer of large, angular stone, utilized to protect and stabilize slopes or areas of concentrated flow and subject to erosion by water.

Specifications: Riprap shall be placed at a slope with a ratio of 2:1 or flatter.

The minimum thickness of riprap shall be two times the designed stone diameter plus the depth of the bedding material.

When used around waterways, additional permits may be needed, and site design must take into consideration the normal wildlife movement and not be a hazard to wildlife or to vehicle traffic.

Riprap maximum size based on velocity of flow	
Velocity (feet per second)	Dmax (inches)
5.0	6
8.5	12
10	18
12	24
15	36

Refer to the Washington, Indiana, standards and ordinances.

Materials: Riprap shall be hard, angular, and weather resistant. Riprap shall have a specific gravity of at least 2.5.

Riprap shall be of a size and gradation that will withstand velocities of stormwater discharge flow design. Riprap size will increase with velocity.

Riprap shall be a well-graded mixture of stone with 50% of the stone pieces by weight larger than the designed size. No more than 15% of the pieces by weight should be less than 3 inches.

Riprap should always be underlain by a non-woven geotextile fabric.

Installation: Excavate only deep enough for both filter and riprap. Compact any fill material to the density of the surrounding undisturbed soil.

Cut a keyway in stable material at the base of the slope to reinforce the toe. Keyway depth shall be one and a half times the design thickness of the riprap (minimum 2 feet) and should extend a horizontal distance equal to the design thickness (minimum 1 foot 6 inches).

Place geotextile fabric on the smoothed foundation, overlapping the edges a minimum of 12 inches. Secure with anchor pins spaced every 3 feet along the overlap.
Immediately after installing the geotextile fabric add the riprap to full thickness in one operation.

Do not dump through chutes or use any method that causes segregation of rock sizes or that will dislodge or damage the underlying geotextile fabric.

If fabric is damaged, remove the riprap and repair by adding another layer of fabric overlapping the damaged area by a minimum of 12 inches.

Place similar aggregate in voids to form a dense, uniform, well graded mass. Blend the riprap surface smoothly with the surrounding area to eliminate protrusions or over falls.

Maintenance: During construction, inspect periodically for displaced aggregate material, slumping, and erosion at edges, especially downstream or downslope, after rain events, and at a minimum every 7 days.

Replace rock or other components that have become dislodged.

Immediately repair damages to geotextile fabric.

Inspect riprap for signs of erosion and scour or sediment accumulation.

Remove accumulated material including sediment, trash, and woody debris from riprap.

If riprap stones continue to wash away, replace them with larger stones.

For permanent installations, inspect riprap every 6 months.

BMP 13 ENERGY DISSIPATOR (OUTLET PROTECTION)

CONSTRUCTION PHASE AND POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: To prevent erosion at the outlet of a channel or conduit by reducing the velocity of stormwater flow and dissipating its energy.

Specifications: Outlet protection shall be designed for the peak runoff from a 10-year, 24-hour storm event or the design discharge of the water conveyance structure, whichever is greater.

Maximum velocity through the outlet protection shall be 10 feet per second.

The tailwater depth shall be determined immediately below the structure outlet and based on design discharge plus other contributing flows. Apron length and width shall be determined based upon tailwater conditions.

Outlet protection shall be aligned straight with channel flow. If a curve is necessary to align the apron with the receiving stream, locate the curve in the upstream section of the apron.

Plunge pools, stilling basin, or impact basins, may be necessary with higher velocities.

When using riprap, outlet protection thickness shall be 1.2 times the maximum stone diameter for a d50 stone size of 15 inches or larger and 1.5 times the maximum stone diameter for a d50 stone size of 15 inches or less.

Pipe Size (in)	Average Riprap Diameter (in)	Apron Width (ft)	Apron Length (ft)
8	3	2 to 3	5 to 7
12	5	3 to 4	6 to 12
18	8	4 to 6	8 to 18
24	10	6 to 8	12 to 22
30	12	8 to 10	14 to 28
36	14	10 to 12	16 to 32

Place energy dissipation for temporary and permanent outlets within 24 hours after connection to a surface water or permanent stormwater treatment system.
Refer to the Washington, Indiana, standards and ordinances.

Materials: For short term application, temporary energy dissipators at construction sites, often include riprap aprons. Permanent dissipators will be decided on during the design phase of the project and based on erosive force estimates and the final aesthetics desired. When using riprap, it will be hard and angular, highly weather resistant, with a specific gravity of at least 2.5, and size and gradation that will withstand velocities of stormwater discharge design flow.

Riprap shall be a well-graded mixture of stone with 50 percent of the stone pieces, by weight, larger than the d50 size and the diameter of the largest stone equal to 1.5 times the d50 size.

Turf reinforcement products, concrete, gabion baskets, grouted riprap, interlocking concrete blocks, drop structures, and cabled concrete are alternative options to riprap.

Installation: Divert surface water runoff around the structure during construction so that the site can be properly dewatered for foundation preparation.

For installation of riprap aprons, excavate foundation and apron area subgrades below design elevation to allow for thickness of the filter medium and riprap. Compact any fill used in subgrade preparation to the density of surrounding undisturbed soil material. Remove roots and debris then smooth subgrade enough to protect geotextile fabric from tearing. Place geotextile fabric or aggregate bedding material (for stabilization and filtration) on the compacted and smoothed foundation. Install riprap to the lines and elevations shown in the construction plans. Blend riprap smoothly to surrounding grade. If the channel is well defined, extend the apron across the channel bottom and up the channel banks to an elevation of six inches above the maximum tailwater depth or to the top of the bank, whichever is less. If geotextile fabric tears when placing riprap, repair immediately by laying and stapling a piece of fabric over damaged area, overlapping the undamaged areas by at least 12 inches.

When using a manufactured product, such as turf reinforcement mats or tied concrete block, the manufacturer's specifications for installation and design standards must be followed. All permanent dissipators will be identified within the design of the project.

Maintenance: Inspect within 24 hours of a rain event and at least once every 7 calendar days during construction.
Inspect for stone displacement; replace stones ensuring placement at finished grade. Check for erosion or scouring around sides of the apron; repair immediately.
Check for piping or undercutting; repair immediately.

BMP 14 EROSION CONTROL BLANKET

CONSTRUCTION PHASE AND POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Erosion control blankets are utilized to prevent erosion by protecting the soil from rainfall impact, overland water flow, concentrated runoff, and wind. They are also used to provide temporary surface stabilization, to anchor mulch in critical areas, to reduce soil crusting, and to conserve soil moisture and increase seed germination and seedling growth.

Specifications: The effective service life of an erosion control blanket is dependent upon the material used; follow manufacturer's recommendations.

Erosion control blankets shall be used on all slopes steeper than 3:1. Staples, pins, or stakes shall be used to prevent movement or displacement of the blanket. Erosion control blankets must be installed within 24 hours of seeding.

Erosion control blankets typically can reduce erosion potential by 90%.
Refer to the Washington, Indiana, standards and ordinances.

Materials: Erosion control blankets shall be made of organic mulch incorporated with a natural fiber or similar netting material.
6-inch to 12-inch non-metallic staples, pins, or stakes shall be utilized to secure the blanket.

Installation (Flowline Application): Prepare soil before installing blankets including any necessary application of lime, fertilizer, or seed.

Begin at the top of the channel by anchoring the blanket in a 6 inch deep by 6-inch-wide trench with approximately 12 inches of blanket extended beyond the upslope portion of the trench. Anchor the blanket with a row of staples/stakes approximately 12 inches apart in the bottom of the trench. Backfill and compact the trench after stapling. Apply seed to compacted soil and fold remaining 12-inch portion of blanket back over seed and compacted soil. Secure blanket over compacted soil with a row of staples or stakes spaced approximately 12 inches apart across the width of the blanket.

Roll center blanket in direction of water flow in the bottom of the channel. Blankets will unroll with appropriate side against the soil surface. All blankets must be securely fastened to soil surface by placing staples or stakes in appropriate locations as recommended by the manufacturer.

Place consecutive blankets end over end (shingle style) with a 4 inch to 6-inch overlap. Use a double row of staples staggered 4 inches apart and 4 inches on center to secure blankets. Joints are to be staggered in subsequent rows.

Full length edge of blankets at top of side slopes shall be anchored with a row of staples or stakes approximately 12 inches apart in a 6 inch deep by 6 inch wide trench. Backfill and compact the trench after stapling.

Adjacent blankets shall be overlapped approximately 4 inches to 6 inches and stapled. To ensure proper seam alignment, place the edge of the overlapping blanket even with the colored seam-stitch on the blanket being overlapped.

In high flow channel applications, a staple check slot is recommended at 30-foot to 40-foot intervals. Use a double row of staples staggered 4 inches apart and 4 inches on center over entire width of the channel.

The terminal end of the blankets must be anchored with a row of staples or stakes approximately 12 inches apart in a 6 inch deep by 6 inch wide trench. Backfill and compact the trench after stapling.

Installation (Slope Application): Prepare soil before installing blankets, including any necessary application of lime, fertilizer, or seed.

Begin at the top of the channel by anchoring the blanket in a 6 inch deep by 6-inch-wide trench with approximately 12 inches of blanket extended beyond the upslope portion of the trench. Anchor the blanket with a row of staples or stakes approximately 12 inches apart at the bottom of the trench. Backfill and compact the trench after stapling. Apply seed to compacted soil and fold remaining 12-inch portion of blanket back over seed and compacted soil. Secure blanket over compacted soil with a row of staples or stakes across the width of the blanket spaced approximately 12 inches apart.

Roll the blankets either down or horizontally across the slope. Blankets will unroll with appropriate side against the soil surface. All blankets must be securely fastened to soil surface by placing staples/stakes in appropriate locations as recommended by the manufacturer.

The edges of parallel blankets shall be stapled with approximately 2 inches to 5 inches overlap depending on the blanket type. To ensure proper seam alignment, place the edge of the overlapping blanket even with the colored seam stitch on the previously installed blanket.

Consecutive blankets spliced down the slope must be placed end over end with an approximate 3-inch overlap. Staple through overlapped area, approximately 12 inches apart across entire blanket width.

Maintenance: Inspect the erosion control blanket installation site immediately after seeding to verify seed coverage. Inspect within 24 hours of each rain event and at least once every seven calendar days.
Check for erosion or displacement of the blanket. If any area shows erosion, pull back that portion of the blanket covering the eroded area, add soil and tamp, reseed the area, then replace and staple the blanket.

BMP 15 VEGETATED SWALE

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: Floatables, Nutrients

Purpose: Vegetated swales are utilized to convey stormwater runoff through and from the site. While moving through the swale, runoff velocity is greatly reduced allowing biofiltration, infiltration, and settling of larger suspended particles.

Specifications: Given adequate subsurface soil infiltration properties, the design of vegetated swales is centered around two parameters: establishing low flow velocities and maximizing surface area for infiltration. Velocities below 1.5 feet per second promote deposition of suspended sediments and increase hydraulic residence time, maximizing treatment time within the swale. Swales designed with cross sections that maximize ground to water contact have increased infiltration and reduced runoff volume.

Siting, design, installation, and maintenance are critical to the performance of swales as a water quality measure. These systems should be designed by a professional proficient in hydrology and stormwater design and in accordance with Chapter 7 of the City of Washington Stormwater Technical Standards Manual.

Typical storm intensities should be calculated for each specific site location.

Swale design should be based on flow rate, not volume. Runoff should pass from the upstream end to the downstream end of the swale in ten minutes.

Swale should be designed to effectively handle runoff from a one-inch, 24-hour storm event and efficiently pass excess runoff from larger storms (e.g., 10-year storm events).

Perforated pipe underdrains are required if the slope is less than 1 percent.

Materials: Soil infiltration rates between 0.5 and 3.0 inches per hour are preferred.

Ideally, the clay content of the soil should be less than 20 percent, the silt/clay content should be less than 40 percent, and both should be in the U.S. Department of Agriculture Natural Resources Conservation Service hydrologic groups A or B.

Coarse, highly permeable soils should be avoided because they have shorter infiltration times and are less conducive to supporting growth of vegetation.

Impermeable soils facilitate ponding and should be avoided.

The bottom of the swale should be at a minimum of two feet above the seasonal water table or bedrock. Less desirable soils can be amended to improve infiltration characteristics.

Vegetation should be limited to perennial grasses, grass-legume mixes, and prairie mixes.

Species of vegetation chosen should have a dense growth habit and be able to tolerate extended periods of flooding (up to 48 hours).

Vegetative species can be selected to target different types of pollutants. Vegetation height should be maintained at a minimum height of three to four inches.

Installation: Parabolic or trapezoidal cross sections maximize infiltration. Triangular cross sections should be avoided as they concentrate flow and promote channel erosion.

Side slopes should be relatively flat (3:1 or flatter).

Channel bottom width should be between two feet and eight feet (based on cross-sectional area required channel flow).

Swale gradients (slopes) of one to two percent are recommended. Swale length should be a minimum of 200 feet to encourage deposition.

Maintenance: Mowing (minimum height of 3 to 4 inches) is required as needed during growing season depending upon vegetation planted.

Inspect for and correct erosion problems twice during the first year and annually thereafter.

Remove sediment, trash, and debris from the annually or more frequently if needed.

Remove sediment from the swale when sediment reaches 25 percent or more of swale volume.

Monitor vegetative growth annually to determine if an alternative grass species is more conducive to site conditions.

Remove woody vegetation annually to maintain flow.

BMP 16 DRY DETENTION BASIN

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: Floatables

Purpose: Dry detention basins are constructed basins that collect, temporarily hold, and gradually release excess stormwater from storm events. Detention is achieved through the use of an outlet control structure that regulates the rate of stormwater outflow. Unlike wet ponds, dry detention basins are designed to drain completely between storm events, thereby attenuating peak flows associated with storm events.

Specifications: Proper design, siting, installation, and maintenance of dry detention and extended dry detention basins are critical if they are to function properly and efficiently. Therefore, these measures should be designed by a professional proficient in hydrology and stormwater design.

Refer to Chapter 8 of the City of Washington Stormwater Technical Standards Manual for design parameters. The design of a dry extended detention basin may still require stormwater quality measures for pretreatment above the basin, but also incorporates several design modifications that may address water quality objectives. These design specifications and modifications are listed below.

Low flow channels should be incorporated into the design of dry detention basins to reduce erosion as runoff enters the pond and to route storm events to the outlet, thereby reducing ponding and providing adequate drainage of the basin. These channels shall be permeable and impermeable concrete is not allowed.

Extended dry basins should be limited to drainage areas of ten acres or more in order to maintain an orifice opening at the outlet that is sufficiently large to prevent clogging. Basins can be constructed on sites with slopes up to 15 percent, provided the slope within the basin can be made relatively flat to ensure proper design flow. Soils are rarely a limiting factor. Ideally, the basin should be sited on soil with infiltration rates of less than three inches per hour. Sites with highly permeable soils or in a karst landscape may require an impermeable liner or other modification to protect ground water, especially if the basin is being constructed for treatment of runoff from a "hotspot" area. In all cases, the ground water level should remain below the base of the pond at all times to allow the pond to dry out. Site selection should be chosen to maximize flow path length between the inlet and outlet and allow for maximum stormwater detention and release capability of the basin.

A pretreatment BMP is required at the basin inlet to treat the water quality volume or flowrate. Forebays are not an approved measure.

Dry extended detention basins should have a shape with a length to width ratio of at least 3:1 in order to maximize retention time and maximize the length of the flow path between the inlet and outlet. In the event that this shape is not feasible, engineered structures (baffles and internal grading) which convey the water through the basin with the desired flow rate and residence time may be incorporated into the basin design.

All basin side slopes should be limited to a ratio of 3:1. The side slopes of vegetated embankments should be designed at 3:1 (horizontal to vertical). Riprap protected embankments should be no steeper than 2:1. A minimum of one foot of freeboard is recommended above the 100-year storm volume. A geotechnical engineer should evaluate slope stability on sites where the embankment berm is in excess of ten feet. Slopes should be planted immediately with a quick rooting annual as well as long term perennials in order to stabilize slopes and prevent erosion. Basin bottom slopes should be on the order of two percent to achieve complete drainage, but site-specific design criteria may be required to establish appropriate grade.

The basin's drawdown time should be regulated by a standpipe, gate valve, orifice plate, or notched weir. Outlet structures should be designed to allow the controlled release of detained stormwater runoff and should include measures to deter clogging by debris (e.g., trash racks, skimmers, etc.). Outlet structures should be designed with stability in mind and should be resistant to frost heaving and failure under saturated conditions. All outlet structures must include a stable nonerosive spillway on their downstream side to prevent scour associated with the discharge from the basin.

Basins shall incorporate an emergency spillway capable of safely passing a minimum of a 100-year flow event efficiently through the basin. These spillways should be reinforced and capable of withstanding significant flood conditions. Measures should be taken to stabilize an outlet apron on the downstream side of the emergency spillway so as to reduce the risk of berm failure from scour in a high flow situation. A stabilized outlet apron must be located on the downstream side of the emergency spillway to reduce the risk of embankment failure as a result of scour in a high-flow situation.

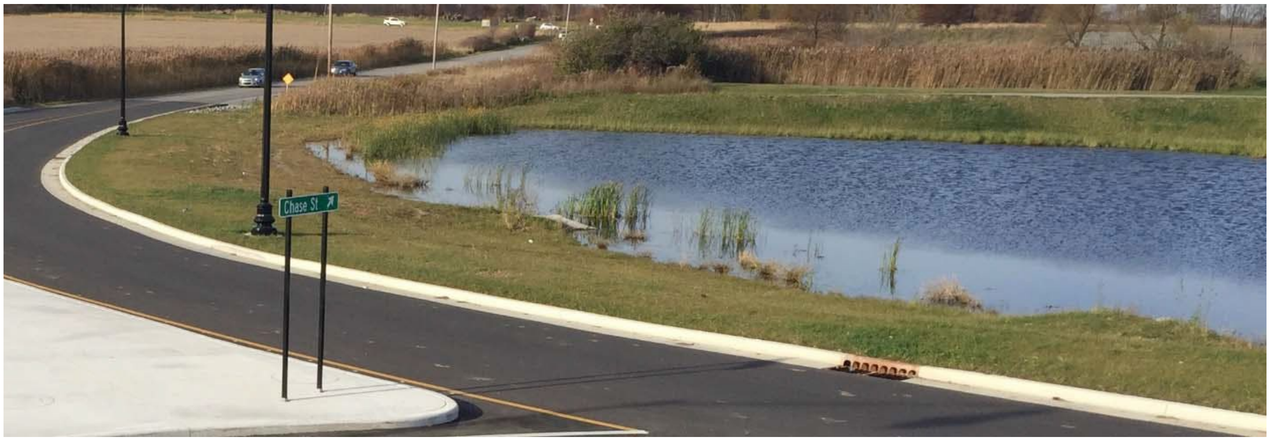
Refer to the Washington, Indiana, standards and ordinances.

Maintenance: Inspect for erosion along pond surfaces two times per year.

Annually inspect for embankment damage, monitor sediment accumulation in the upstream BMP.

Restore dead or damaged ground cover via sodding or seeding as needed.

Remove litter and debris from basin inlet and outlet monthly.



BMP 17 WET DETENTION POND

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: Nutrients

Purpose: Wet detention ponds, including stormwater ponds, retention ponds, and wet extended detention ponds, are constructed basins that contain a permanent pool of water and treat polluted stormwater runoff. The purpose of a wet detention pond is to detain stormwater runoff long enough for contaminated sediments to settle and remain in the pond and allow the water in the pond to be displaced by the next rain event. This sedimentation process removes particulates, organic matter, and metals from the water while nutrients are removed through biological uptake. By capturing and retaining runoff, wet ponds control both stormwater quantity and quality.

Specifications: Proper design, siting, installation, and maintenance of wet detention ponds are critical if they are to function properly and efficiently. Therefore, these measures should be designed by a professional proficient in hydrology and stormwater design.

The site shall be selected with adequate base-flow to maintain a permanent pool. Underlying soils within hydrologic soil groups C and D are typically adequate to maintain a permanent pool.

The contributing drainage area should be adequate to maintain the minimum water level in the permanent pool. Typically, the drainage area will be a minimum of 25 acres. However, this may need to be adjusted based on design and site characteristics.

Wet detention ponds are to be designed to control multiple types of storm events (e.g., two- and/or 10-year storms) and safely pass the 100-year storm event.

The depth of the permanent pool is typically between three to eight feet. If the pond is too deep, thermal stratification and anoxic conditions may develop. If it is too shallow, trapped sediments could become resuspended. Deeper depths near the outlet may yield cooler temperatures and mitigate downstream thermal impacts. A minimum depth of 10 feet is required if the pond is to contain fish.

A 3:1 length-to-width ratio is used when water quality is of concern. Higher ratios will decrease the potential of short-circuiting and will increase sedimentation within the permanent pool.

Shoreline slopes between 5:1 and 10:1 allow for easy access for maintenance.

The side slopes of the permanent pool should be no steeper than 4:1 and shall include a 10-foot safety ledge.

Ponds are to be wedge-shaped to allow flow to enter the pond and gradually spread out, thereby minimizing potential of little or no-flow zones.

The layout of the pond should provide access areas to conduct maintenance.

The pond should contain a discharge riser and low flow drain with adjustable gate valve allowing for gradual discharge.

An upstream stormwater quality BMP is required to treat the water quality volume or flowrate. Forebays are not approved.

Emergency spillways are to be sized to safely convey large flood events that exceed a 100-year rain event.

A vegetative buffer around the pond will protect banks from erosion and remove pollutants from overland flow.

Alternative designs for traditional wet detention ponds include wet extended detention ponds, micropool extended detention ponds, and multiple pond systems.

Refer to the Washington, Indiana, standards and ordinances.

Maintenance: If wetland components are present, inspect for invasive vegetation and remove twice per year.

Inspect for damage and monitor for sediment accumulation in the wet detention pond and upstream BMP annually and after large storm events.

Repair undercut and eroded areas as needed.

Clear debris from the inlet and outlet structures and ensure they are operational monthly.

Remove sediment from the permanent pool when volumes are reduced by 25 percent or the pond is eutrophic every 20 to 25 year.


BMP 18 SUBSURFACE DETENTION

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: None

Partially Targeted Pollutants: Sediment

Purpose: Subsurface detention systems are designed to store stormwater runoff and release the stormwater to a receiving water. Retention systems are designed to provide infiltration, stormwater storage, and ground water recharge where it would otherwise be impossible due to extensive impervious surfaces.

Specifications: Siting, design, installation, and maintenance of subsurface detention/retention systems are critical if they are to function properly and efficiently. Therefore, these systems, and especially the stormwater component, should be designed by a professional proficient in hydrology and stormwater design.

Refer to Chapter 8 of the City of Washington Stormwater Technical Standards Manual for design parameters.

Retention systems designed to provide infiltration must consider the soil properties where the system will be installed. They are best suited to well-drained soils with a seasonal water table well below the structure to allow for infiltration. Typical soil infiltration rates should range from .5 to 3.0 inches per hour.

To achieve a water quality benefit, pretreatment of stormwater is required. Stormwater may be pretreated by incorporating an oil-grit separator, hydrodynamic separator, grass swales, wetland/pond system, or other measures into the design of the storage system.

Areas should be as level as possible in order to maximize infiltration rates across the entire structure.

Both grids and pipe systems have backfill requirements (which must be adhered to) specific to the device.

Outflow locations (if used) must prevent concentrated flow conditions from developing within the subsurface storage unit.

Maintenance "ports" should be installed at strategic points to allow for easy inspection and maintenance of the structures.

Maintenance: In high sediment flow conditions, pretreatment is necessary to reduce accumulation in the subsurface detention system. Maintenance of these pretreatment structures can be frequent. The structures themselves should remain relatively maintenance free if proper precautions are taken to limit the amount of sediment and debris that is allowed to accumulate inside the grid or pipe system.

BMP 19 GRAVITY OIL-GRIT SEPARATOR

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment, Floatable Materials, Oil & Grease

Partially Targeted Pollutants: Phosphorous, Nitrogen

Purpose: Gravity oil-grit separators are primarily intended as pretreatment for other structural stormwater quality measures for stormwater runoff from high-density sites.

Specifications: Contributing area to each unit shall be determined based on manufacturer's recommendations.

Total wet storage area shall be at least 400 cubic feet per acre of contributing area. The following rates can be used conservatively for design purposes:

Substance	Percent Removed
Total Suspended Solids	40
Total Phosphorous	5
Total Nitrogen	5

Installation shall be per manufacturer's recommendations.

Maintenance: The frequency of inspection is dependent upon land use, climate conditions and design. At a minimum, the unit shall be inspected quarterly. Follow manufacturer's maintenance instructions.

BMP 20 HYDRODYNAMIC SEPARATOR

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment, Floatable Materials

Partially Targeted Pollutants: Oil & Grease

Purpose: Hydrodynamic separators are modifications of traditional oil/grit separators that commonly rely on vortex-enhanced treatment of stormwater runoff for pollutant removal.

Specifications: Hydrodynamic separators, individually or in combination, must meet or exceed an 80% TSS removal rate of particles smaller than 125 microns in diameter without re-entrainment. Testing to establish the TSS removal rate of a BMP shall be conducted by an independent testing facility.

Floatable controls shall be incorporated in order to capture and remove floating debris during routine maintenance.

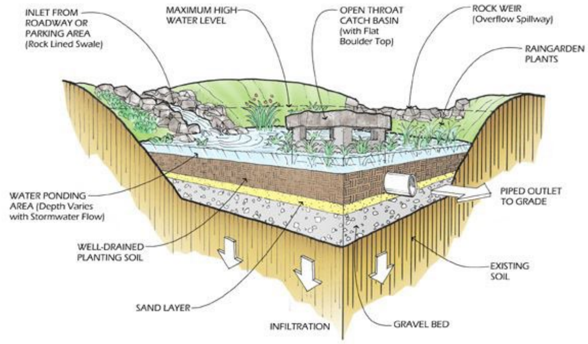
There are a number of different structures on the market that utilize hydrodynamic separation. Hydrodynamic separators utilized in the City of Washington are required to be certified by a Professional Engineer licensed in the State of Indiana and approved by the Washington City Engineer.

Hydrodynamic separators shall be installed per manufacturer's recommendations.

Maintenance: Frequent inspection and cleanout is critical for proper operation. Follow manufacturer's recommendations for inspection and maintenance schedules.

Hydrodynamic separators shall have an easy, unobstructed access from the top of the unit to allow for inspection, cleanout, and maintenance. The access point shall be located such that is easily and safely accessible with a vacuum truck.

Maintenance typically involves utilizing a vacuum truck to remove accumulated oil, floatable materials, and sediment.



BMP 21 BIORETENTION

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Phosphorous, Metals, TSS, Organics, Bacteria

Partially Targeted Pollutants: Nitrogen

Purpose: Bioretention systems are shallow, landscaped depressions that are designed to treat stormwater runoff from impervious surfaces.

Specifications: Siting, design, installation, and maintenance of bioretention systems are critical elements to consider if they are to function properly and efficiently.

The drainage area is not to exceed 5 acres. The ideal drainage area is one-quarter acre to two acres. Multiple bioretention areas may be required for larger drainage areas.

The bioretention area should be 5 to 10 percent of the imperious surfaces within the drainage area. Bioretention areas are to be a minimum of 10 feet wide by 20 feet long.

A ponding depth of 6 to 9 inches is recommended to provide adequate storage. Slopes shall be 5 percent or flatter.

The bottom of the bioretention system is to be 3 feet or more above the high-water table to minimize the potential for groundwater contamination.

Elements of a bioretention system include a pretreatment area (typically a vegetative filter strip), sand/gravel substrate, organic mulch area, planting soil bed, under drain, overflow structure, and native plants.

A licensed Landscape Architect and/or licensed Professional Engineer should handle specific design of the rain garden as well as specific types of plants, which would be unique for each site.

The licensed Landscape Architect and/or licensed Professional Engineer's specific design must be acceptable by the City and the plan must include supporting sample results, which show the soils are suitable. Soil characteristics must meet suitable ranges to support the biotic community above and below the ground.

The planting plan shall include sequence of construction; a description of the contractor's responsibilities; a planting schedule and installation specifications; initial maintenance requirements; and a warranty period stipulating requirements for plant survival.

Maintenance: Frequent inspection and cleanout is critical for proper operation.

Water plants as necessary.

Add mulch once per year and replace the entire mulch area once every two to three years.
Annually test soil pH. Replace soils when levels of pollutants reach toxic levels that decrease the effectiveness of the system.

Inspect inflow points for sediment accumulation and possible clogging twice per year.

Remove litter and debris at least monthly.

BMP 22 CONSTRUCTED WETLANDS

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: TSS, Hydrocarbons, Bacteria

Partially Targeted Pollutants: Phosphorous, Nitrogen, Carbon, Metals

Purpose: Constructed wetlands are man-made systems that utilize wetland plantings and permanent pools of varying depths to control the quantity and quality of stormwater runoff.

Specifications: Constructed wetlands are to be designed by a professional proficient in hydrology and stormwater design.
Minimum contributing drainage is 10 acres. Pocket wetlands can be constructed for a contributing drainage area as low as one acre.

A minimum dry weather flow path ratio of 2:1 to 3:1 is preferred from inflow to outflow.

Pretreatment of runoff should be provided by incorporating an upstream measure.

Permeable soils are not well suited for constructed wetlands. Soils within the hydrologic soil groups B, C, and D are usually best suited.

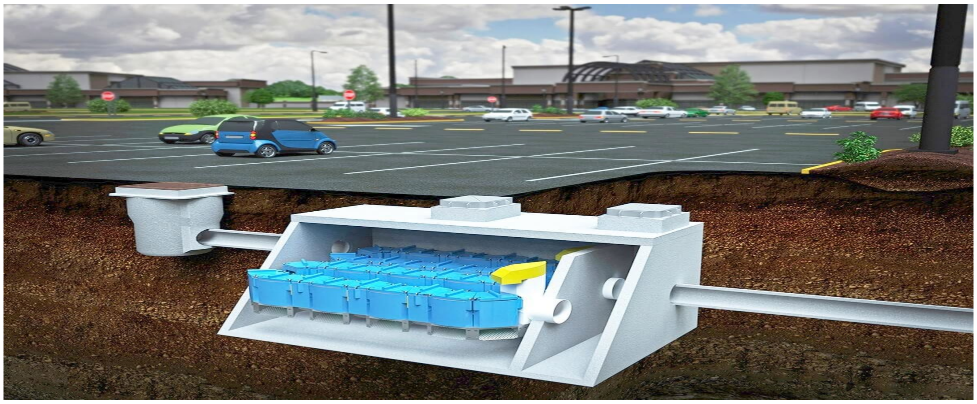
Maintenance: Frequent inspection and cleanout is critical for proper operation.

Replace wetland vegetation to maintain 50 percent coverage for wetland plants one time after the second growing season.

Clean and remove debris from inlet and outlet structures at least quarterly.

Monitor wetland vegetation and perform replacement plantings as necessary semi-annually.

Annually inspect for the stability of the original depth zones and micro-topographic features, invasive vegetation, and damage to the embankment and inlet/outlet structures, repair as necessary.



BMP 23 HYDROCARBON FILTERS

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: TSS, Hydrocarbons, Coolant and Oil Fluids

Partially Targeted Pollutants: Phosphorous, Lead, Zinc, Copper

Purpose: Hydrocarbon Filters are used to reduce oil, grease, debris, and suspended solids through gravity, centrifugal force, or other methods. BMP's such as these can be useful in areas susceptible to spills or petroleum products, such as fueling stations.

Specifications: Hydrocarbon Filter, individually or in combination, must meet or exceed an 80% TSS removal rate of particles smaller than 125 microns in diameter without re-entrainment. Testing to establish the TSS removal rate of a BMP shall be conducted by an independent testing facility.

Floatable controls shall be incorporated in order to capture and remove floating debris during routine maintenance.

There are a number of different structures on the market that utilize hydrocarbon filters. Hydrocarbon filters utilized in the City of Washington are required to be certified by a Professional Engineer licensed in the State of Indiana and approved by the Washington City Engineer.

Hydrocarbon filters shall be installed per manufacturer's recommendations.

Maintenance: Frequent inspection and cleanout are critical for proper operation.

Follow manufacturer's recommendations for inspection and maintenance schedules.

Hydrocarbon filters shall have easy, unobstructed access from the top of the unit to allow for inspection, cleanout, and maintenance. The access point shall be located such that is easily and safely accessible with a vacuum truck.

Maintenance typically involves utilizing a vacuum truck to remove accumulated petroleum, floatable materials, and sediment.

BMP 24 HYBRID-TURF MAT

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Hybrid erosion control methods are a combination of synthetic control method with the benefits of natural vegetation to create a high strength matting or cover for soil surfaces.

Specifications: Typically, the hybrid turf mat is woven or stitched into patterns or extruded in random patterns to create a porous mat, with varied thicknesses and heights. The mat will provide rigid framework for holding seeds in place longer and establishing consistent vegetative stands and promoting a solid base for plant root protection from all types of erosion.

The effective service life of a hybrid-turf mat is dependent upon the material used; follow manufacturer's recommendations.

The mat can be used on 1:1 slopes or shorelines with a wave height up to 1.5 feet. Ensure staking is completed to secure the mat in place and obtain maximum product potential.

Performance Properties		
Velocity	Shear Stress	Tensile Strength
20 ft/s	10 lbs/sf	363 lbs/ft

Refer to the Washington, Indiana, standards and ordinances.

Materials: Products come in rolls and mats which conform to ASTM D6460.

Installation: Hybrid turf mats shall be placed on seeded soil. Prepare the seedbed, ensuring the surface is smooth, eliminating all existing rills, soil clods, sticks and rocks larger than 2 inches in diameter. Ensure all soil that is used to fill rills is adequately compacted before seedbed preparation.
Apply seed, fertilizer, and other soil amendments at the specified rates, either by broadcasting, drilling or hydro-seeding.

Select appropriate anchors based on soil type and consistency. Anchor each section per the manufacturer's specifications.

To use on slopes: Anchor the top of the mat, either by installing a 6-inch covered anchor trench or double row anchor check. Unroll the mat, ensuring the simulated turf is on tip and fabric backing is against the soil surface. Ensure the mat is not stretched too tight and it maintains continuous fabric contact with the underlying soil surface. Ensure the material is overlapped at the seams (2-inch overlap), or as manufacturer recommends. Anchor the mat to the soil. If there are areas where some wrinkles remain, additional anchors may be necessary to ensure good fabric-to-soil contact.

To use in channels: Position and anchor the mats at the culvert outfall and/or in-flow end of channel, securing with a single row of anchors spaced 1-foot apart. Seam any adjacent mats by butting mat edges together an anchor on a 1.5-foot center, along 3.0-foot mat edges, or 2.0-foot centers along 4-foot mat edges. Anchor mats at top of side-slopes with a single row of anchors spaced 1-foot apart.

To use in shorelines: Position and anchor the leading edges of mats at the top of, or over the shoulder of shoreline slope and secure with a single row of anchors spaced 1-foot apart. Seam adjacent mats by butting edges together and anchor on a 1.5-foot center along 30-foot mat edges or 2.0-foot centers along 4-foot mat edges. Secure mat body with anchors.

Maintenance: Inspect weekly and following each rain event. Restore dead or damaged ground cover via seeding as needed.

BMP 25 TIED CONCRETE BLOCK MAT

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Tied concrete block mat is utilized for stabilizing slopes, channels, low water crossings, inlet/outlet protection and shorelines. It consists of concrete blocks locked together and embedded into a high-strength geo-grid and capable of being vegetated.

Specifications: Concrete blocks, consisting of 6.5" x 6.5" with a 2.25" profile, locked together and embedded into a high-strength geo-grid. The blocks have 1.5" spacing between the blocks to allow optional vegetation and give the mat flexibility.

When installed in a stream channel, ensure native vegetation approved by the Indiana Department of Natural Resources or per waterway permits. Perennial vegetation will add to the benefits of tied concrete block mat in areas where vegetation is not needing mowed or kept low near roadway clear zones.

When installing on steep slopes, channels, or stream banks engineered with live staking or native vegetation, the anchors shall exhibit an engineered downward force over the polypropylene grid between the tied concrete blocks.

Standard anchors used are #3 Rebar bent into a "U" shaped 18" in length or percussion anchors with designed cross plates.

Key areas for considering anchoring are the leading edges, seams, and overlaps. The engineer shall design, with assistance from the manufacturer, the spacing layout of the anchored system.

Vegetative support will assist in maintaining and preserving the life span of the geogrid.

Tied concrete block mat is capable of handling 30 ft./sec. and 24 PSF.

Performance Standards			
Bed Slope:	Tested Value:	Test:	Limiting Value30%:
30%	Shear Stress	ASTM 6460	1149 Pa
20%	Velocity	ASTM 6460	9.1 m/s

Refer to the Washington, Indiana, standards and ordinances.

Materials: Tied concrete block mat is a manufactured product comprised of tied concrete blocks with a double layered underlayment, which is comprised of high-strength biaxial geogrid, 5-pick leno weave, and erosion control blanket.

Installation: Provide the proper equipment to place the mat that will not damage the mat material or disturb the topsoil subgrade and seed bed.

Prepare the subgrade as detailed in the plans. Ensure all subgrade surfaces are free of all rocks, stones, sticks, roots, and other protrusions or debris of any kind that would result in an individual block being raised more than ¾" above the adjoining blocks. When seeding is shown on the plans, provide subgrade material that can sustain growth.

The subgrade should be graded into a parabolic or trapezoidal shape to concentrate flow to middle of mat(s).

Spread seed on the prepared topsoil before placing the concrete mats.

Install mats to the line and grade, as shown on the plans and per the manufacturer's guidelines.

Provide a minimum 18" deep concrete mat embedment toe trench at all edges exposed to concentrated flows, or per plans. Recess exterior edges subject of sheet flow a minimum of 12" or greater if shown on plans.

Anchor or fasten the mats as recommended by the manufacturer or engineer to meet site conditions.

In ditch or channel applications, if the seams run parallel to the flow line in the ditch or channel, an extension of geogrid and specified underlayment shall be provided at a length recommended by the manufacturer or engineer for the site conditions. This extension shall be placed entirely beneath the adjacent upstream mats and anchored using U-anchors or zip ties at manufacturer's or engineer's recommended spacing. If zip ties are used, they shall encompass three cords of geogrid of either adjacent mat. Parallel seams in the center of the ditch shall be avoided when possible.

Seams perpendicular to the flow line shall utilize extensions of geogrid and underlayment executed as in parallel seams or shall be shingled at the manufacturer's or engineer's recommendation. If shingled, seams shall be completed with the downstream mat recessed a minimum of 3 blocks under the upstream mat and fastened together along the seam at 2 ft. maximum spacing if required by manufacturer or engineer.

Maintenance: Routine maintenance can include mowing on stabilized areas and weed eating around wet areas.

The vegetated concrete block mat can be mowed over with commercial mowing equipment.

Do not spray with weed or grass killers, instead use a selective herbicide to control invasive plants.

Maintain adjacent vegetation. Exposed soil above and along the sides of Flexamat should be seeded or covered.

Repair any rills or gullies that can affect upstream/downstream or top of slope terminations.

Check panel seams for any separation.

Inspect outlets that enter the concrete block mat or abutment failure or loss of stabilization.

BMP 26 GABION BASKETS

POST-CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Gabion baskets are large rectangular wire mesh boxes that are filled with large stone or riprap. Gabions can be used in drainage channels, low retaining walls, bridge abutments and approaches, culvert headwalls, flow aprons, or drop structures.

Specifications: A gabion wall is the equivalent of a gravity-design retaining wall. Analysis for a gabion wall should include basic computation for structural failure such as sliding, overturning, and settlement.

Walls over 4 feet require the design of a Professional Engineer.

Place geotextile fabric beneath gabions to maintain separation from underlying soils.

Filter fabric must be used in stream channels to avoid loss of fine-grained soils. Ensure the filter fabric is anchored securely using anchor trenches, stakes, staples sewing or a combination of methods.

The wire mesh must be galvanized to resist rust. In addition to being galvanized, the wire mesh can be coated with PVC to further resist deterioration.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Thin wire mesh, typically galvanized to resist rust.

Riprap is used for filling the gabion baskets.

Tools to secure the tops of the baskets after filled.

Additional materials for anchoring as specified by the Engineer.

Installation: Installation of gabions must be in accordance with the manufacturer's instructions and according to the design documents. Installation should be accomplished within 1 to 2 days. Clear and grade the area of trees, brush, vegetation, and unsuitable soils. Provide equipment access as necessary for earthwork and handling of large rocks.

Prepare the subgrade to the specified depth necessary for installation of gabions.

Compact subgrade to firmly to prevent slumping or undercutting.

Excavate anchor trenches as necessary for installation of geotextile filter fabric.

Install geotextile filter fabric. Be sure the geotextile filter fabric is placed so it isn't stretched too tight and makes continuous contact with the ground. Secure the fabric by using anchor trenches, stakes, staples, sewing, or as approved by the engineer and supported by the manufacturer.

Place a layer or aggregate or sand as a bedding layer (4 inches thick for bedding).

Fold each gabion panel to the proper shape, using heavy gauge wire as recommended by the manufacturer. Lace all contact edges for adjacent gabions as construction proceeds. Stagger and interlock joints for gabion walls.

Ensure the gabions are properly squared and vertical. Place stone in lifts of 12" thick.

Ensure stone surfaces bear against each other for structural integrity.

Close lids securely using lace or other fasteners as recommended by the manufacturer. If the wire mesh has been cut, then securely fasten to other parts of the gabion structure.

Maintenance: Inspect gabion installation regularly for settlement, scour, damaged wire mesh, or wire corrosion.

Periodically check for excessive growth of bushes, trees, weeks, and other vegetation.

Remove vegetation as needed to maintain channel flow capacity and prevent damage to gabions.

BMP 27 BAFFLE SYSTEMS

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: Floatables

Purpose: Temporary sediment traps and basins are designed to temporarily pool runoff water to allow sediment to settle before the water is discharged. Porous Baffle systems can be used inside a temporary sediment basin to reduce the velocity and turbulence of water flowing through the structure by spreading the flow across the entire width of the basin. The reduction of turbulent flow facilitates the settling of sediment and improves sediment retention efficiency for sediment detainment structures. Baffles can increase the sediment trapping efficiency by increasing the residency time for sediment to settle out.

Specifications: Access is needed for sediment removal and must be maintained to ensure the baffles continue to function as designed.

Baffles should be at least as tall as the overflow of the basin.

Spacing between baffles shall be determined by the designer and shall allow at least three rows of baffles, with a minimum space of ten feet between each baffle.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Porous baffle system material consisting of either Turf Reinforcement Matting (TRM) or coconut erosion control blanket, or excelsior erosion control blanket.

The TRM must be composed of non-degradable synthetic fibers, filaments, nets, processed into a permanent, three-dimensional matrix. The non-degradable three-dimensional matrix may be infilled with coconut or excelsior materials. Do not use TRMs infilled with straw.

When using coconut erosion control blanket, or excelsior blanket material, ensure the blankets are made of undyed and unbleached 100% natural fibers that are biodegradable. Do not use erosion control blankets made of straw.

Stake the porous baffle equipment with steel posts. Do not use wood posts. Minimum length of posts must be 5 feet, with minimum yield strength of 50,000 psi, painted with a water based baked enamel paint, and has a soil stabilization plate made of 15-gauge steel with a minimum cross section area of 17 square inches. Add soil stabilization plates every 6 inches of post length past 5.0 feet.

Installation: Ensure the basin is debris free, smooth, and level and dry enough to install. Ensure porous baffle systems are installed perpendicular to flow within the sediment control structure. Install porous baffle systems across the entire width of the sediment basin/dam. Ensure the basin is at least 25 feet in length and install the baffles equal distance apart to ensure proper flow mixing.

Porous Baffle Row	Installation Location
1	¼ Length of Basin
2	½ Length of Basin
3	¾ Length of Basin

Install posts on 4-foot centers across the basin. Ensure the posts are driven at least 2 feet depth. Attach the porous baffle system material to the upstream side of the steel posts by using heavy-duty plastic ties, or wire ties that are evenly spaced and placed in a manner to prevent sagging or tearing of the fabric. Attach ties spaced at 6-inch intervals.

Use 12-inch anchors (stakes, pins, or staples) spaced on 1-foot intervals to secure the porous baffle system material to the bottom and up the sediment basin/dam embankments.

Avoid utilizing joints to adhere pieces of porous baffle material together to meet the required length. Consider the length needed and purchase a roll of material and cut to fit in place.

Maintenance: Inspect weekly and following each rain event. Remove sediment when it reaches 50% of the height of the first baffle row.

Check where runoff has eroded a channel beneath the porous baffle, or where the porous baffle has sagged or collapsed. Ensure the porous baffle material stays securely installed along the basin sides and in the bottom. Ensure the porous baffle system does not sag across the top of the porous baffle system. Replace the material if torn or if evidence of deterioration is noted.

Replace the porous baffle material whenever it has deteriorated to the extent that it reduces the effectiveness of the porous baffle system. Maintain access to the porous baffles and replace immediately if the baffle collapses, tears, decomposes or becomes ineffective.

BMP 28 DEWATERING FILTER BAG

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Filter bags are used to prevent water pollution from the discharge of sediment during dewatering of construction sites. The filter bag collects sediment and debris from water that is pumped through the bag constructed out of geotextile fabric, from ditches, runoff collection ponds, drilling, and construction sites. Filter bags are not suggested to be used on clean water that is being pumped around or diverted from a construction activity.

Specifications: Select and design the dewatering practices that are appropriate for the pumping or discharge rate and the removal of the target soil particle.

Locate and install dewatering practices so that discharges from the practice will not come in contact with or flow across exposed soil. Discharge to a stable surface.

Avoid discharging to steep slopes.

When discharging to a waterway or wetlands, do not discharge at a rate that will increase erosion or flood elevations in the receiving water.

Do not discharge at a rate that increases erosion or flooding on off-site properties.

Do not discharge into Karst features or other direct groundwater connections.

Ensure the dewatering filter bag is placed on a level flat surface, with secondary containment on the down gradient side of the level pad.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Use a UV resistant, non-woven geotextile fabric bag that is sewn into a completely enclosed bag. Ensure the dewatering bag is sewn with high strength double stitched seams. Use a dewatering bag that has a sewn in sleeve to receive the pump discharge hose.

Geotextile Filter Bag Minimum Properties		
Property	Test Method	Value
Mass Per Unit Area	ASTM D-5261	8 oz/yd^2
Grab Tensile Strength	ASTM D-4632	180 lbs
Grab Elongation	ASTM D-4632	50%
Trapezoid Tear Strength	ASTM D-4533	80 lbs
CBR Puncture Strength	ASTM D-6241	475 lbs
Water Flow Rate	ASTM D-4491	70 gal/min/ft^2
Apparent Opening Size	ASTM D-4751	80 U.S. Sieve
UV Resistance (500 hours)	ASTM D-4355	70%

Level flat surface should be layered with geotextile fabric and riprap.

Secondary containment can be comprised of materials such as a riprap check dam, or filter sock.

Installation: Dewatering filter bags shall not be placed, whole or partially, within waterways or wetlands.

Elevate filter bags to allow water to flow out of the bottom of the bag. Install the filter bag on a level surface to prevent it from rolling into the waterway and for the area to temporarily become saturated.

Ensure the hose is connected to the filter bag securely before turning on the pump. Install a secondary containment on the down-gradient side of the filter bag to assist in sediment removal and slowing down the discharge prior to entering the waterway.

Maintenance: Dewatering filter bags should be removed and replaced once they are half full.

Frequently inspect the filter bag when in operation.

Inspect bags for holes, rips, and tears.

If the receiving waters show any signs of turbid water, erosion, or sediment accumulation, discharges shall be stopped immediately once safety and property damage concerns have been addressed.

Store additional bags out of direct sunlight and in a way to reduce the potential for bags to get punctured by equipment, traffic, or other sharp objects.

BMP 29 ROCK FILTER BERM

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Rock filter berms are a perimeter control of aggregate used to intercept stormwater runoff from a disturbed area and allow the temporary pooling and deposition of sediment prior to discharging off-site or to a waterbody. The rock filter berm is not intended to impound the water.

Specifications: Rock filter berms should be at least ten feet from the base of a slope, installed on a flat surface prior to the waterbody or perimeter of the project, not impeding on the natural riparian buffer or existing natural vegetation.

The maximum height of the rock filter berms should be 2.0 feet and 2:1 side slopes.

The table below provides the limitations for use of the rock filter berm:

Slope Steepness Restrictions		
Percent Slope		Maximum Distance
< 2%	< 50:1	400 feet
2%-5%	50:1 to 20:1	300 feet
5%-10%	20:1 to 10:1	200 feet
10%-20%	10:1 to 5:1	100 feet
> 20%	> 5:1	60 feet

Do not install multiple rows of rock filter berms.

Control the watershed to the rock filter berm by installing J-hooks to maximize water storage within each section of rock filter berm. Each section of rock filter berm separated by J-hooks must not exceed 1 acre.

J-hooks must be a minimum of 6 inches higher than the top elevation of the perimeter rock berm.

Design Limitations	
Berm height:	2 to 3 feet
Top width:	1 foot
Front slope:	2:1 or flatter
Back slope:	2:1 or flatter
Pooling side face of berm:	Filter stone (compacted INDOT #5 or #8 stone) 1 foot high X 4 inches wide
Geotextile:	Located under the total width of the berm and extending 3.0 feet downstream of berm

Refer to the Washington, Indiana, standards and ordinances.

Materials: Use geotextile fabric, revetment riprap or class 1 or 2 riprap, and filter stone.

Level flat surface should be layered with geotextile fabric and riprap.

Installation: The drainage areas should not exceed 50 acres.

Install the rock filter berm on the contour, with the ends turned upslope to prevent discharges from bypassing the measure.

Install measures upslope of the rock filter berm to lessen the amount of sediment in the runoff.

Maintenance: Initial inspections should ensure the rock filter berm is intercepting all upslope runoff from disturbed areas.

Inspect weekly and after rain events.

Check for #5 or #8 filter stone on front face of dam.

Geotextile under dam should extend 3 feet downstream of the berm.

Inspect for channel erosion.

Remove sediment once it reaches one-half the height of the berm.

Ensure the rock filter berm maintains the initial configuration and ponding/filtration/flow function are maintained. Check berm for scouring, where overflows of the berm may occur. Check the berms and note any areas where runoff has blown out or bypassed the bermed areas. Look for washouts, undercutting and end bypasses along berms.

Repair or replace rock filter berms found to be non-functional, due to severe weather conditions, age, extended use, damage, or other causes.

If the rock filter berm is frequently overloaded, based on frequent maintenance, install additional upgradient erosion prevention and/or sediment control practices or redundant measures to eliminate the overloading and amend the stormwater pollution prevention plan to identify the additional measures.

When all areas above the rock filter berm have been stabilized, the temporary rock filter berm must be removed. After removing the temporary rock filter berm, collect and dispose of the accumulated sediment, and fill and compact holes, trenches, depressions, or any other ground disturbance to blend with the surrounding landscape. Stabilize the area with seed, mulch, or sod per the final stabilization plans.

BMP 30 ROCK HORSESHOE

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Rock horseshoe is a sediment control measure that is utilized as an outlet protection device in a sediment pond to minimize sediment leaving a construction site via a sediment basin or outlet connected to a direct conveyance channel. The rock horseshoe, or arc, is constructed out of geotextile fabric, INDOT Revetment Riprap, and #5 or #8 filter stone.

Specifications: Drainage area should not exceed 5 acres.

Rock horseshoe can be used in front of an inlet to a culvert, pipe, stormwater inlet, and sediment basin inlet or outlet.

Ensure there is enough area for sufficient pooling of run-off prior to the rock horseshoe.

Rock horseshoes are not allowed to be placed in a jurisdictional waterway.

For culverts, pipes, or inlet applications the rock horseshoe shall be designed for a 2-year frequency, 24-hour duration storm event.

For use with a sediment basin the rock horseshoe shall meet discharge requirements for sediment basins.

The crest elevation should be the same as the top elevation of the dewatering zone. The weir length/flow depth: flow over the weir for a 2-year frequency, 24-hour duration storm event should be below the emergency spillway and at a velocity that will not displace the riprap. Minimum height is to be 2 feet above the bottom orifice or outlet structure elevation.

Spillway spacing from inlet: 1 foot minimum from toe of the berm back slope to inlet or culvert invert (sufficient distance to minimize horseshoe aggregate from entering the inlet).

Front slope of horseshoe (pooling side): 2:1 or flatter.

Back slope of horseshoe (inlet side): 2:1 or flatter.

Pooling side face of horseshoe: Is covered with facing stone 1 foot thick of INDOT #8 filter stone.

Horseshoe termination ends: Extend aggregate horseshoe up the embankment to prevent flow around end points. The horseshoe ends need to be a minimum of 6 inches higher than the spillway crest.

Embankment side protection: Where embankment slope is to grade stabilize with seeding and mulching and prevent or divert sediment-laden run-off from entering the backside of the horseshoe from the embankment area.

For unstabilized (rough and not to final grade) embankment situations: To prevent inflows of sediment-laden run-off from entry behind the rock horseshoe utilize control options such as: diversion berms, filter sock/filter tube, riprap stabilization, or other methods of stabilization.

Outlet apron to culvert or structure inlet: Stabilize the flow path from the toe of the horseshoe to the inlet with riprap 1 foot thick (minimum) with the top of riprap being flush with the invert/opening.

Ensure the outlet is stabilized with stone, vegetation, geotextile, or other approved material.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Use geotextile fabric, revetment riprap, and filter stone.

Level flat surface should be layered with geotextile fabric and riprap. Add the filter stone to the upstream or front face of the rock horseshoe.

Installation: Install the rock horseshoe in front of the outlet, arcing towards the stabilized armor surrounding the outlet structure, to prevent erosion at the structure.

Install additional erosion and sediment control measures within the watershed of the disturbed area.

Maintenance: Initial inspections should ensure the rock horseshoe is intercepting discharges from the basin, and flow is passing through the measure.

Inspect every seven days, and within 24 hours of a rain event. Ensure water is passing through the measure and conduct maintenance on the face of the measure if the water is no longer passing through. Redressing the filter stone as needed.

Remove sediment once it reaches one-half the height of the rock horseshoe.

Ensure the rock horseshoe maintains the initial configuration and ponding/filtration/flow function are maintained. Check rock horseshoe for scouring, where overflows of the rock horseshoe may occur. Check the rock horseshoe and note any areas where runoff has blown out or bypassed the rock horseshoe. Look for washouts, undercutting and end bypasses along rock horseshoe.

Repair or replace rock horseshoe found to be non-functional, due to severe weather conditions, age, extended use, damage, or other causes.

If the rock horseshoe is frequently overloaded, based on frequent maintenance, install additional upgradient erosion prevention and/or sediment control practices or redundant measures to eliminate the overloading and amend the stormwater pollution prevention plan to identify the additional measures.

When all areas above the rock horseshoe have been stabilized, the temporary rock horseshoe must be removed. After removing the temporary rock horseshoe, collect and dispose of the accumulated sediment, and fill and compact holes, trenches, depressions, or any other ground disturbance to meet final grade. Stabilize the area with seed and mulch, or per the final stabilization plans.

BMP 31 FLOATING SKIMMER

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Floating skimmer is a sediment control measure which draws the water from just below the water surface, allowing clarified water to release from a basin. When the water level in the basin is down, the skimmer rests on a rock dam to prevent muddy water from discharging and the outlet from clogging with sediment.

Specifications: Floating skimmers shall be designed to dewater sediment basin from the top of the riser within 48 hours.

A portion of the floating skimmer must be visible above the water surface at all times.

Inlets to the floating skimmer must not be submerged more than six inches below the water surface.

All floating skimmers should include a floatable maintenance rope and trash guard.

Include a shallow pit, with minimum dimensions of 4 feet by 4 feet with a minimum depth of 2 feet. Install revetment riprap to the top elevation of the skimmer pit.

Ensure the top elevation of the skimmer pit is lower than the invert of the outlet barrel from the riser.

Ensure a rock dam is constructed for the skimmer to rest when the water level is low so that the skimmer doesn't get buried in the sediment.

Ensure the outlet of the basin is stabilized with stone, vegetation, geotextile, or other approved material.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Components of the floating skimmer varies based on device type and design. Floating skimmers shall have a flexible joint at the connection with the riser pipe.

Installation: All floating outlet device joints or connections shall be securely fastened. Ensure they are watertight. The skimmer shall be connected to the outlet by a flexible pipe to the outlet structure.

Secure the floating outlet to prevent excessive side to side movement.

Install a rock dam for the floating skimmer to rest on when the water level is down.

Install additional erosion and sediment control measures within the watershed of the disturbed area.

Maintenance: Initial inspections should ensure the floating skimmer is intercepting discharges from the basin, and flow is passing through the measure.

Inspect every seven days, and within 24 hours of a rain event.

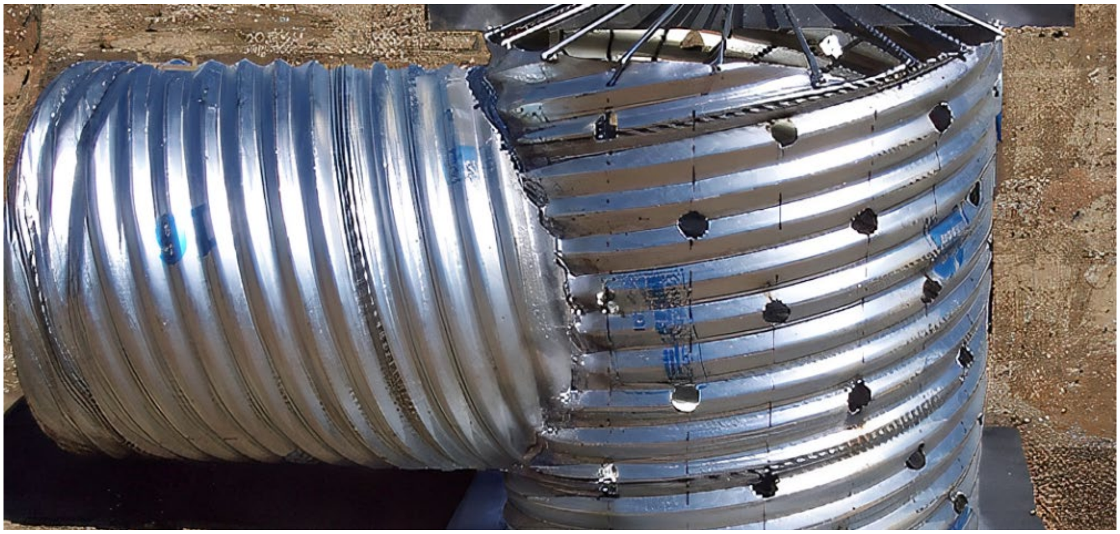
Ensure the basin is draining within 48 hours. If flow is restricted, conduct maintenance on the floating outlet to remove debris, trash, or clogged materials.

Replace any buoys which are no longer floating.

Repair or replace floating skimmer found to be non-functional, due to severe weather conditions, age, extended use, damage, or other causes.

Do not use floating skimmers during cold weather periods where freezing conditions could potentially occur.

Once the contributing drainage area has been stabilized, the floating skimmer can be removed.



BMP 32 PERFORATED RISER INLET

CONSTRUCTION PHASE BMP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: A perforated riser is a vertical standpipe, that has been drilled with regularly spaced holes, designed to control the dewatering time of a sedimentation basin. The openings in the standpipe will allow water to enter the outlet from the water storage zone and extract water from low in the water column of a sediment basin.

Specifications: The number of columns of holes within the perforated riser pipe, the vertical spacing between the holes, and the diameter of the holes must be selected carefully. The perforated riser shall be designed to allow the water to be released within a 24–48-hour period.

Ensure the holes in the riser pipe are at least a ½" and the diameter of the pipe is at least 8".

The lifetime of this temporary structure is 2 years.

The height of the perforated riser shall be at least two feet and shall be the top elevation of the dewatering zone.

A filter stone cone will be placed surrounding the riser pipe and be a minimum of 1 foot thick.

Wire mesh with 1/4-to-3/8-inch square openings shall wrap the perforated riser pipe at least to the height of the filter stone cone located at the base.

A trash guard shall be installed at the top of the riser standpipe.

An anti-floatation block shall be implemented.

Ensure the outlet of the basin is stabilized with stone, vegetation, geotextile, or other approved material.

The perforated riser can remove up to 80% of the fines suspended in the detained water.

Refer to the Washington, Indiana, standards and ordinances.

Materials: Components of the perforated riser include PVC pipe, corrugated metal pie, dual wall drain tile, or similar pipe.

A tee connector between the riser and outlet pipe.

Trash guard, INDOT #8 filter stone, concrete anti-floatation block, and square wire mesh.

Installation: Install riser on a firm, even foundation.

Perforate the riser pipe with ½" holes spaced 3 inches apart vertically and horizontally. Perforations shall extend from the top elevation to the bottom elevation of the dewatering zone.

Attach the riser pipe to the outlet pipe with a watertight connector.

Install the trash guard to the riser pipe.

If an antivortex device is required, install.

Embed the riser pipe in at least 1 foot of concrete and a minimum of 6 inches beyond the perimeter of the pipe.

Wrap the perforated riser with wire mesh.

Place an aggregate cone around the perforated riser consisting of #8 filter stone.

Install additional erosion and sediment control measures within the watershed of the disturbed area.

Maintenance: Initial inspections should ensure the perforated riser is intercepting discharges from the basin, and flow is passing through the measure.

Inspect every seven days, and within 24 hours of a rain event.

Ensure the basin is draining within 72 hours. If flow is restricted, conduct maintenance on the perforated riser pipe to remove debris, trash, or clogged materials.

Replace filter stone around the base of the perforated riser pipe if the basin is not draining within the 72-hour time period.

Remove trash/debris from the top of the riser.

Once the contributing drainage area has been stabilized, the perforated riser can be removed.

LOW IMPACT DESIGN (LID) MANUAL

City of Washington

2024

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LID 1 RAIN GARDEN

Purpose: Rain gardens are shallow depressions with engineered soils and specific plants to help in the infiltration of water and breakdown of pollutants, oils, metals, and others through microorganisms on plant roots from run-off of buildings, roads and/or parking lots. They additionally provide habitat and help with reducing stormwater runoff and flooding.

Recommended Applications: Recommended applications include, but are not limited to, parking lot islands, commercial developments, campus developments, residential developments and other areas that have significant area for water absorption. A minimum of 10 feet away from buildings is recommended for the installation of a rain garden so moisture does not penetrate the foundation. Rain gardens cannot be located over a septic field and will be most effective in a full to partial sun site.

Benefits: Benefits include Pollutant Treatment (solids, nutrients, metals, oils, etc.), reduction of velocity and volume of stormwater run-off, groundwater recharge, micro habitat, aesthetic improvement (compared to lawn or hardscape), minimal maintenance (if installed correctly), and an education opportunity for the public.

Design Criteria: It is best for run-off into a rain garden to be pretreated through a swale or other method to reduce the volume of sediments entering into (or clogging) the rain garden.

Plants should be native and selected based on their tolerance to harsh conditions, including long dry periods, long wet periods, winter snow storage, salt, and sand.

Soil compaction rates should be checked following construction to be sure there isn't a high compaction rate. Compaction is one of the leading causes of a failed rain garden. Subsoil tests should be done before construction to check if the water is percolating through at appropriate rates (1 inch per hour). If the subsoil has poor percolation rates and amending the soil does not help, an underdrain must be used to provide an outlet from the rain garden, to avoid standing water and mosquito problems. If the depth to groundwater is less than two feet, the site shall not be used or considered for a rain garden.

A minimum of 18 inches of uncompacted, engineered and permeable soil shall be placed in, at least, the base of the rain garden. The engineered soil should have an infiltration rate of at least 1 inch per hour. If high water volumes are expected or existing soil has a percolation rate less than 1 inch per hour, also include an underdrain or other overflow structure. If existing soil is desired to be used, but does not pass a percolation test, an on-site mixture of compost and/or sand (or any other addition that will increase the percolation of stormwater) can be done with equipment, like a tiller, that will sufficiently mix without compacting the soil. An additional percolation test shall be done after mixing the soil to ensure proper drainage before planting the rain garden.

The rain garden needs to be designed for a minimum of a 2-year storm event (sizing and treating). The area of coverage, or contributing area, for a rain garden can vary from 2,000 square feet (residential) to 10,000 square feet (commercial or other) depending on the application. This area should be designed as deemed appropriate based on the site amenities and functions.

Construction shall be by low contact pressure equipment, excavators and/or backhoes and shall operate from adjacent ground.

If there is existing desirable vegetation, measures should be taken to have the least amount of impact/removal of this vegetation.

A licensed Landscape Architect and/or licensed Professional Engineer should handle specific design of the rain garden as well as specific types of plants, which would be unique for each site. The licensed Landscape Architect and/or licensed Professional Engineer's specific design must be acceptable by the City and the plan must include supporting sample results, which show the soils are suitable. Soil characteristics must meet suitable ranges to support the biotic community above and below the ground.

The planting plan shall include sequence of construction; a description of the contractor's responsibilities; a planting schedule and installation specifications; initial maintenance requirements; and a warranty period stipulating requirements for plant survival.

Maintenance: Quarterly inspection to confirm the rain garden system is working correctly and proper disposal of any sediments that are clogging the system.

Vegetation management is needed to reduce weeds and reestablish any plants that do not survive. This can include mowing, spot spraying, controlled burning, and/or re-planting.

If compaction occurs for any reason, measures shall be taken to mitigate the compaction. Compaction can be mitigated in a variety of ways, one of which could be tilling the soil from a location outside of the rain garden.

Inspect rain garden after a large storm event where water is sitting. Water should drain within 48 hours, and if it doesn't, some modifications to the system may be necessary (check compaction rates of soil, add an inlet, or add an underdrain).

Examples: For a list of specific plant types, see your local native plant nursery which specializes in ecological and native plant services or see www.indianantiveplants.org for a list of native plant resources.

For rain gardens that are going to be visible to the public eye, a more aesthetic look may be desirable, and therefore a higher count of wildflowers and shrubs could be used. This type will likely be in residential and commercial settings.
For rain gardens that are not visible to the public eye and are serving more as a functional piece of stormwater management, less wildflowers and shrubs could be used and more grasses/sedges could be used. This type will likely be in an industrial setting.

A typical stormwater seed mix will include seven sedges, two rushes, four grasses, and twelve wildflowers/shrubs. Also included in that is a temporary cover crop, including both Common Oat and Annual Rye.

Some situations may benefit from utilizing plugs rather than seeding for aesthetics, soil stabilization, etc.

The wetland indicator status states the following:

1) Seven sedges:
    a. Four should be of an obligate wetland status (almost always wet, rarely found in uplands)
    b. Two should be of a facultative wetland status (usually wet, but occasionally found in uplands)
    c. One should be of a facultative status (either wet or dry)

2) Two rushes
    a. One should be of an obligate wetland status (almost always wet, rarely found in uplands)
    b. One should be of a facultative wetland status (usually wet, but occasionally found in uplands)

3) Four grasses
    a. One should be of a facultative status (either wet or dry)
    b. Two should be of an obligate wetland status (almost always wet, rarely found in uplands)
    c. One should be of an obligate upland status (rarely wet, almost always found in uplands)

4) Twelve Wildflowers/Shrubs
    a. Five should be of an obligate wetland status (almost always wet, rarely found in uplands)
    b. Four should be of a facultative wetland status (usually wet, but occasionally found in uplands)

Three should be of a facultative or facultative upland status (occasionally wet, but usually found in uplands).

LID 2 NATIVE PLANTS

Purpose: Native plants are used for many reasons, one of which is the grass or wildflowers (prairie environment) deep root system. This root system, as opposed to a typical turf grass whose roots are only a few inches deep, can stretch up to 8 feet deep and beyond. Because of this expansive root system, native plants reduce the amount of run-off by a higher absorption rate, filter pollutants, and prevent erosion. A few other reasons native plants are used are their higher survivability (than non-native), their ability to adapt to our climate and soils, and less required irrigation.

Recommended Applications: Native plants can and should be used in every application. There is a wide range of color, texture, seasonal interest, and sizes that can be utilized in an interesting and beautiful landscape design, avoiding any use of non-native or invasive species. Using "non-native plants" can cause potential risk of disease and/or invasion of insects harmful to plants, especially when coming from another country, and can risk introducing invasive species, choking out many native plants that are not highly established.

Benefits: Benefits include less invasive plants (which can cause disease and a monoculture), pollutant treatment (solids, metals, oils, etc.), reduction of erosion, reduction in velocity and volume of stormwater run-off, groundwater recharge, micro habitat, aesthetic improvement (compared to lawn or hardscape), minimal maintenance (if installed correctly), cost savings due to less maintenance (mowing, irrigation, pesticides, fertilizer), and education opportunity for the public. Native plants also create natural habitats for wildlife and reduce the likelihood of disease and pests of plants, which come from non-native/invasive species.

Design Criteria: A licensed Landscape Architect or licensed Professional Engineer should handle the specific design of native plants to ensure the correct use and application of native plants, including soil types, moisture requirements, lighting, and correct size for location. The planting plan shall include sequence of construction; a description of the contractor's responsibilities; a planting schedule and installation specifications; initial maintenance requirements; and a warranty period stipulating requirements for plant survival.

Reference Indiana Native Plant Society (INPS) at www.indiananativeplants.org, Invasive Plant Species Assessment Working Group (IPSAWG) at www.invasivespecies.in.gov, and/or "101 Trees of Indiana" by Marion T. Jackson, to know what plants are native and what are invasive to be sure no invasive plants are planted.

Maintenance: Vegetation management is needed to reduce weeds and reestablish any plants that do not survive. This can include annual mowing, spot spraying for weeds, or re-planting.

There may be some initial watering needed to establish the plants, but once the plants are established, minimal to no watering should be necessary.

Examples: Native plant choices are dependent on site conditions and the client's preference. The above references give a great start on what plant choices to make. Depending on the site, it may need an aesthetic look, where many wildflowers could be chosen with a touch of native grasses. Some wildflowers commonly used are Black-Eyed Susan (Rudbeckia), Purple Coneflower (Echinacea), Wild Bergamont (Monarda), Aster Varieties, and Coreopsis Varieties.

Native grass varieties include Sedge Varieties (Carex), Rush Varieties (Scirpus), Big Bluestem (Andropogon), Little Bluestem (Schizachyrium), Side-Oats Grama (Bouteloua), Switch Grass (Panicum), Indian Grass (Sorghastrum), and many others. See above resources for additional native plant choices, including trees and shrubs.

LID 3 RAIN BARREL

Purpose: Rain barrels are typically used in unison with downspouts of buildings. They provide storage of stormwater and can be used for grey water irrigation of plants. Rain barrels are typically used in a smaller setting. Another type of stormwater storage is a cistern, which is usually a bigger system for larger areas of roof runoff.

Recommended Applications: Rain barrels can be used on most residential, commercial and institutional properties. Proper means must be taken to ensure that any overflow of water can go into open green spaces to infiltrate, instead of going back into storm sewers or foundations of buildings.

Benefits: Benefits include reduction in the volume of stormwater runoff, reduction in the amount of water consumption for non-potable uses, reduction in utility costs (if a lot of water is used), groundwater recharge, minimal maintenance (if installed correctly), and an education opportunity for the public.

Design Criteria: It is best, if water is being discharged from the rain barrel regularly, to provide enough capacity for storm events. However, discharging too often could lead to the need for supplemental irrigation source. Care should be taken in choosing the correct rain barrel size to properly hold and discharge stormwater after rain events.

Place a screen at the bottom of the downspout to minimize the amount of leaves and other debris entering the rain barrel.

The rain barrel should be screened with plants or other landscape features to avoid tampering problems and to also make a more aesthetic treatment.

Overflow from the rain barrels should be directed towards another low impact development, including but not limited to, a rain garden, infiltration basin, bioswale, filter strip, or another form of filtering/infiltration system.

Maintenance: The rain barrel must be sealed during warm months to avoid mosquitos and other bugs or pests and be drained prior to winter, to avoid freezing.

Periodically inspect, clean, and dispose of any particles or debris in the rain barrel and downspout.

LID 4 PERMEABLE PAVING

Purpose: Permeable pavement is used to infiltrate stormwater runoff from roads, sidewalks and parking lots, reducing the amount of storm runoff, oils, and other sediments into storm systems, decreasing the amount of flooding, and overall reducing pollution to receiving waters.

Recommended Applications: Permeable paving can be applied in many low-volume, low-speed situations, including parking lots, driveways, sidewalks, utility and access roads, emergency access lanes, fire lanes, and alleys.

Benefits: Benefits include reduction in the volume of stormwater runoff, pollutant treatment (solids, metals, oils, etc.), groundwater recharge, reduced heat island effect, minimal maintenance (if installed correctly) and education opportunity for the public.

Design Criteria: It is only appropriate to use this type of pavement for low-volume, low-speed traffic, or parking areas because it has a lower load-bearing capacity than traditional pavement.

It is highly recommended that care be taken when placing permeable pavement of any kind, especially when in close proximity or downstream of a high pollutant level area, as this could cause groundwater contamination. If the project site is near a high pollutant area, the user should consider using a different low impact development treatment to better treat the pollutants and not cause groundwater contamination, such as a bioswale or rain garden.

If a post treatment option using vegetation is considered for stormwater overflow from the permeable pavement, the plant selection shall be drought tolerant. Drought tolerance is necessary in this treatment because the amount of water is less since it will mostly be permeating into the pavement before overflowing into the post treatment option. Such post treatment options could be a rain garden or bioswale.

Typically, it is recommended that surrounding areas should not drain into a permeable pavement site without pretreatment to remove excess sediment. Sediment transported from surrounding areas can soak into the voids of the pavement, reducing the effectiveness of the permeable pavement. If soil impediment cannot be avoided, use curbs to redirect the flow of stormwater from surrounding areas or use a pretreatment method such as inlet sediment traps or other filtering device.

Design and installation should follow the concrete industry standards and specifications.

Pavement design should allow for water to completely drain, from 12 hours minimum to 72 hours maximum. Soil should be uncompacted, engineered, and permeable for quick percolation. If it seems that water does not infiltrate quickly, consider using an underdrain in addition to the permeable paving.

There are several different types of permeable paving options, some of which include the standard pour of permeable concrete (or asphalt), eco-pavers, or grid systems. There are several different types of eco- pavers and these typically use a system that has small or large openings between pavers. These openings can be filled with a fine stone or a soil & seed mix, depending on the desired function and look. Grid systems are typically used with gravel or seeding and are structurally sound for the same applications as permeable pavement and eco-pavers.

A typical cross section of porous pavement should include porous concrete (or asphalt) that is 4 to 6 inches thick with 15 to 25% void space for high percolation, a stone subsurface that contains 1.5-inch to 2.5-inch aggregate which is typically 6 inches thick and has geotextile nonwoven fabric to allow water to drain but limit particles to flow into soil around it, and an uncompacted, engineered and permeable soil subgrade to avoid stress on subgrade.

A typical cross section of eco-pavers should include the paver which would be filled with either a fine stone or a soil & seed mix that is a varying depth depending on the thickness of the paver. Below the paver should be a 1” depth of a sand setting bed on top of a 3-4” depth of compacted subbase (or aggregate). Below the compacted subbase should be a geotextile fabric on top of existing subgrade.

A typical cross section of a gravel grid system should include the grid or ring system with geotextile fabric attached, on top of compacted sandy gravel base to a depth determined by an engineer based on load requirements (typically anywhere from 6 to 12 inches). The base material would then be on top of compacted subgrade. This ring system should then be filled with 3/16” to 3/8” angular, uniform size and washed gravel.

A typical cross section of a grass grid system should include the grid or ring system on top a hydrogrow mix to help the grass grow quickly. This will then be on top of compacted sandy gravel base to a depth determined by an engineer based on load requirements (typically anywhere from 6 to 12 inches). The base material would then be on top of compacted subgrade. This ring system should then be filled with clean and sharp concrete sand and then topped with a thin-cut sod, washed sod or hydroseeding.

A professional with expertise in hydrology and stormwater design, including a licensed engineer and/or licensed/certified permeable pavement company, should be consulted to determine the appropriate application, design, and options of this pavement. The manufacturer’s recommendations on these products must be followed, as each specific type of product may vary in requirements and/or restrictions.

Maintenance: Periodic inspection and proper disposal of any particles or debris.

With pavers, special care needs to be taken with snowplows, like any paver, so that they aren’t uprooted by the plow being too low and knocking the paver out of place. In addition to snowplows, it is also recommended as a preventative measure to use a street sweeper or vacuum truck a couple times a year to clean out any unnecessary clogging of the pavers. Choosing the correct and best sweeper is essential in caring for the pavers.

LID 5 GREEN ROOF

Purpose: Green roofs are surfaces on top of buildings which are vegetated and assist in managing run- off quality and quantity before entering into the local storm system.

Recommended Applications: Green roofs can be applied on any new building design and can also be retrofitted for existing buildings, including residential, commercial, industrial and institutional. Green roofs can be used on flat or pitched roofs.

Benefits: Benefits include pollutant treatment (solids, metals, oils, etc.), reduction in velocity and volume of stormwater run-off groundwater recharge, micro habitat, decreased roof maintenance, lower heating and cooling costs (natural insulation from media and plants), reduced noise, reduced heat island effect, aesthetic improvement, minimal maintenance (if installed correctly), and education opportunity for the public.

Design Criteria: The determination of whether the green roof is a shallow or deep system depends on the load-bearing capacity of the building. Depths can vary from 2 inches to 12 inches of growth media. However, the roof structure must be evaluated by a structural engineer for super-imposed dead loads, which would include the total weight of roof materials (including plant and soil) and snow, and live loads.

Vegetative roof cover should be designed to hold a two-year storm without any surface run-off. However, each roof is unique and consideration of drainage patterns and/or an overflow structure should be made by a licensed Landscape Architect or licensed Professional Engineer.

State or local standards must be followed in regard to wind resistance of rooftop elements. Uplift pressure is an important safety consideration because the vegetated roof provides the load for waterproofing and root barriers.

A fairly intense cross section is required for a green roof and measures must be taken to confirm the correct structural cross section is supplied. Typically this includes some variation of the following: a waterproofing membrane that must be durable with vegetative cover, as well as properly sealed, or flashed, to reduce chance of failure; membrane protection; a root barrier with geotextile fabric so damage is not done to roof structure; insulation, drainage, aeration and water storage cells; growth media that is not clay, no more than 15% organic, and has a maximum moisture capacity of 30% to 40%; and vegetation that should be drought tolerant with consideration given to root depths (based on media depth). If the area includes high wind velocities, measures shall be taken to avoid any wind uplift and can be accomplished by some sort of erosion control measure.

If the site is particularly dry or receives little to no rain, irrigation may need to be considered so the planting media does not die out. If this is the case, then consulting a licensed Landscape Architect will be necessary.

With the waterproofing membrane, testing shall be done for water tightness before any additional layers are installed. This shall be properly sealed, or flashed, to reduce or eliminate the chance of failure.

Pitched roofs must have an additional measure to ensure no sliding occurs. This is typically in the form of a pre-planted panel which locks into the existing shingles or other roof material. This can also include a form of erosional control to prevent sliding of soil and other materials. The maximum slope for a green roof is about 25%.

Plant choices must be chosen based on the root depths of each plant (typically a very shallow root system is necessary); depending on how deep the growth media on the roof is expected to be. This must be done so that the existing roofing, if retrofitted, is not damaged by the root system.

An architect should be involved in designing the waterproofing system of the roof. A structural engineer should be involved from the beginning of the project to properly determine load-bearing capacity. A landscape architect should be involved in designing the other portions of the green roof, including plantings, soil medias, irrigation, and drainage.

While standard weight limits can be given, each building is unique and its structural capacity should not be assumed. Typically, 125 pounds/square foot between columns on the structure is needed to accommodate a roof garden, however a structural engineer should be consulted because every roof and building structure is unique.

Maintenance: Regular inspection of roof membrane system and drainage paths.

Vegetation management needed to reduce weeds and reestablish any plants that do not survive.

If the project deems necessary, annually check on the waterproofing system, and verify that it is watertight below plant and soil cover.

LID 6 VEGETATED FILTER STRIP

Purpose: Vegetated Filter Strips help to slow down and reduce run-off of impervious surfaces by retaining a pervious surface with vegetated cover. Filter strips also serve as a treatment system for run-off, reducing pollutants such as solids, metals, and oils. Ideally, the vegetative cover will be well established and deep-rooted native plants.

Recommended Applications: Filter strips can be used for residential developments, commercial developments, along roadsides, along parking lots, and in any other situation where there is opportunity for green space between impervious surfaces. Filter strips can also serve as a buffer between an impervious surface and a stream, wetland, or other body of water.

Benefits: Benefits include pollutant treatment (solids, nutrients, metals, oils, etc.), reduced flow (cubic feet per second) in pipe, groundwater recharge, micro habitat, aesthetic improvement (compared to hardscape), minimal maintenance (if installed correctly), and protection of wet habitat (stream or wetland).

Design Criteria: Minimum recommended length is 25 feet. Filter strips less than 25 feet are acceptable but are less effective.

If the filter strip is serving as a buffer for a stream or wetland, it should be as close to the same width as the impervious surface as possible.

Filter Strips should have a gentle to flat slope. However, the slope is dependent on the conditions of the site and the existing watershed slope. A good range is from 1% to 3%. If existing conditions restrict this, the absolute maximum is 8% slope, although all measures should be taken to make this as flat as possible. Cross slope should be 1% or less if possible.

A filter strip is to be designed for a minimum 10-year storm event.

Soil investigation and percolation testing is necessary to be sure the site is appropriate, and if the soils are not appropriate, an amendment to increase permeability would be necessary.

A minimum of 18 inches of uncompacted, engineered, and permeable soil shall be placed in the filter strip. The engineered soil should have an infiltration rate of at least 1 inch per hour will infiltrate. If high water volumes are expected, or less than 1 inch per hour, consider also including an underdrain or other overflow structure. If existing soil is to be used, but does not pass a percolation test, an on-site mixture of compost and/or sand (or any other addition that will increase the percolation of stormwater) can be performed with equipment, such as a tiller, that will sufficiently mix without compacting the soil. An additional percolation test shall be done after mixing the soil to ensure proper drainage before planting the filter strip.

If there is existing desirable vegetation, measures should be taken to have the least amount of impact/removal of this vegetation.

Ideally, only native plants which can tolerate salt, long periods of wet weather, and long periods of drought should be used. There should be 80% vegetative cover. See "Native Plants" section for typical plant varieties.

A licensed Professional Engineer or licensed Landscape Architect should handle specific design of the filter strip. The licensed Landscape Architect and/or Licensed Professional Engineer's specific design must be acceptable by the City and the plan must include supporting sample results, which show the soils are suitable. Soil characteristics must meet suitable ranges to support the biotic community above and below the ground.

The planting plan shall include sequence of construction; a description of the contractor's responsibilities; a planting schedule and installation specifications; initial maintenance requirements; and a warranty period stipulating requirements for plant survival.

Maintenance: Periodic inspection and proper disposal of any sediments, trash or large debris. If the site allows for a trash receptacle or other container, it should be highly considered for proper disposal of trash or cigarette butts.

Vegetation management is needed to reduce weeds and reestablish any plants that do not survive. This can include mowing, trimming, removal of invasive species, and/or re-planting.

LID 7 BIOSWALE

Purpose: Bioswales can serve as a more environmentally sound alternate to, or in conjunction with, storm sewers or concrete ditches. Bioswales slow the flow of stormwater runoff (sometimes significantly more than that of a pipe or a paved ditch), absorb some of that flow, and filter out pollutants.

Recommended Applications: Bioswales can be used in a variety of applications, including but not limited to roadside drainage, parking lots, commercial developments, campus developments, and residential developments.

Benefits: Benefits include reduced erosion and channel flow on open land, reduced flow (cubic feet per second) in pipe, pollutant treatment (solids, nutrients, metals, oils, etc.), groundwater recharge, micro habitat, aesthetic improvement (compared to paved ditch), minimal maintenance (if installed correctly), and education opportunity for the public.

Design Criteria: Bioswales need to be designed to a 10-year storm event, minimum.

Soil investigation and percolation testing is necessary to be sure the site is appropriate, and if the soils are not appropriate, an amendment with more sand would be necessary. A minimum of 18 inches of uncompacted, engineered, and permeable soil shall be placed at the bottom of the bioswale, with a typical width of 2 feet to 6 feet. The engineered soil should have an infiltration rate of at least 1 inch per hour.

If high water volumes are expected or existing soil has a percolation rate less than 1 inch per hour, also include an underdrain or other overflow structure. If existing soil is desired to be used, but does not pass a percolation test, an on-site mixture of compost and/or sand (or any other addition that will increase the percolation of stormwater) can be done with equipment, such as a tiller, that will sufficiently mix without compacting the soil. An additional percolation test shall be done after mixing the soil to ensure proper drainage before planting the bioswale.

Check-dams, turf reinforcement mats, erosion control blankets, or other erosion control measures should be considered depending on the velocity of flow to ensure that flows do not become erosive.

Plants should be native and selected based on their tolerance to harsh conditions, including long dry periods, long wet periods, winter snow storage, salt, and sand. See below as well as "Native Plants" section for typical plant varieties.

Longitudinal slope should not exceed 3%, preferable 1% or less, and side slopes should not exceed 2:1 (3:1 preferable, or whatever mower specifications require).

If there is desirable existing vegetation, measures should be taken to have the least amount of impact/removal of this vegetation.

A licensed Landscape Architect and/or licensed Professional Engineer should handle specific design of the bioswale. The licensed Landscape Architect and/or licensed Professional Engineer's specific design must be acceptable by the City and the plan must include supporting sample results, which show the soils are suitable. Soil characteristics must meet suitable ranges to support the biotic community above and below the ground.

The planting plan shall include sequence of construction; a description of the contractor's responsibilities; a planting schedule and installation specifications; initial maintenance requirements; and a warranty period stipulating requirements for plant survival.

Maintenance: Periodic inspection and proper disposal of any sediment, trash or large debris.

Vegetation management is needed to reduce weeds and reestablish any plants that do not survive. This can include mowing, controlled burn, and/or re-planting.

Examples: For a list of specific plant types, consult a local native plant nursery which specializes in ecological and native plant services or see www.indiananativeplants.org for a list of native plant resources.

For bioswales that are going to be visible to the public eye, a more aesthetic look would be desirable, and therefore a higher count of wildflowers and shrubs could be used. This type will likely be in residential and commercial settings.

For bioswales that are not visible to the public eye and are serving more as a functional piece of stormwater management, less wildflowers and shrubs could be used and more grasses/sedges could be used. This type will likely be in an industrial setting.

For all bioswale plants, a typical swale seed mix will include seven sedges, five grasses, and fourteen wildflowers/shrubs. Also included in that is a temporary cover crop, including both Common Oat and Annual Rye. This temporary cover crop is used because it will take time for the native grasses and wildflowers to establish fully, whereas the temporary will pop up almost immediately.

Some situations may benefit from utilizing plant plugs instead of seeding for aesthetics, soil stability the wetland indicator status states the following:

1) Seven sedges:
    a. Six should be of an obligate wetland status (almost always wet, rarely found in uplands)
    b. One should be of a facultative wetland status (usually wet, but occasionally found in uplands)
2) Five grasses
    a. One should be of an obligate wetland status (almost always wet, rarely found in uplands)
    b. Two should be of a facultative wetland status (usually wet, but occasionally found in uplands)
    c. Two should be of a Facultative status (either wet or dry)
3) Fourteen Wildflowers/Shrubs
    a. Seven should be of an obligate wetland status (almost always wet, rarely found in uplands)
    b. Three should be of a facultative wetland status (usually wet, but occasionally found in uplands)
    c. Three should be of a facultative status (either wet or dry)
    d. One should be of a facultative upland status (occasionally wet, but usually found in uplands)

LID 8 INFILTRATION BASIN

Purpose: Infiltration basins help reduce erosion from high velocity stormwater runoff by holding water in its basin as it slowly percolates underground, infiltrating, purifying, and recharging the groundwater.

Recommended Applications: Infiltration basins can be used in most developed or developable areas where there is open land for the holding basin.

Infiltration basins are to be located a minimum of 10 feet from any building to protect the buildings foundation.

Benefits: Benefits include groundwater recharge, micro habitat, aesthetic improvement (compared to lawn or hardscape), minimal maintenance (if installed correctly), and education opportunity for the public.

Design Criteria: Infiltration basins need to be designed for a minimum of a 2-year storm event.

If the basin is off of a parking lot or roadway, pretreatment measures should be taken to minimize sediment that comes into the basin, including a swale, rain garden or another system that would filter out pollutants. If large amounts of contaminants enter the basin it can cause groundwater contamination.

There should be one or several overflow structures (with erosion control measures) included for the possibility of a storm event exceeding the design capacity; this can be an inlet, catch basin, underdrain, or another form of overflow structure.

Soil investigation and percolation testing is necessary to ensure the site is appropriate, and if the soils are not appropriate, an amendment with more sand or other approved material would be necessary.

The area for the basin should be a level (less than 1%), uncompacted site, with little to no disturbance of vegetation. If excavation must happen to accomplish the design, extra care shall be taken in order to cause minimal compacting.

A minimum of 18 inches of uncompacted, engineered, and permeable soil shall be placed in the infiltration basin. The engineered soil should have an infiltration rate of at least 1 inch per hour. If high water volumes are expected or existing soil has a percolation rate less than 1 inch per hour, also include an underdrain or other overflow structure. If existing soil is desired to be used, but does not pass a percolation test, an on- site mixture of compost and/or sand (or any other addition that will increase the percolation of stormwater) can be done with equipment, such as a tiller, that will sufficiently mix without compacting the soil. An additional percolation test shall be done after mixing the soil to ensure proper drainage before planting the infiltration basin.

Berms can be used as a way to reduce the amount of excavation.

If there is existing desirable vegetation, measures should be taken to have the least amount of impact/removal of this vegetation.

A licensed Landscape Architect and/or licensed Professional Engineer should handle specific design of the bioswale. The licensed Landscape Architect and/or licensed Professional Engineer's specific design must be acceptable by the City and the plan must include supporting sample results, which show the soils are suitable. Soil characteristics must meet suitable ranges to support the biotic community above and below the ground.

The planting plan shall include sequence of construction; a description of the contractor's responsibilities; a planting schedule and installation specifications; initial maintenance requirements; and a warranty period stipulating requirements for plant survival.

Maintenance: Periodic inspection of inlet or catch basin to confirm the system is working correctly, properly disposing of any sediment that is clogging the system.

Vegetation management is needed to reduce weeds and reestablish any plants that do not survive. Sediment removal and proper disposal, as needed.

If compaction happens from mowers or vehicles driving over the basin, measures shall be taken to reduce and mitigate compaction, including limiting all traffic on and around the rain garden.

Inspect basins after large storm events. Water should drain within 48 hours, and if it doesn't, some modifications to the system may be necessary (check compaction rates on soil, add an inlet, or add an underdrain). Water pooled over 48 hours could cause a mosquito problem.

LID 9 HYBRID DITCH

Purpose: Hybrid ditches look like a typical open ditch on the surface, however underneath there is a perforated pipe surrounded by pervious stone and sand that operates similar to a French drain to provide storage and filtration of stormwater runoff.

Recommended Applications: Hybrid ditches are able to utilize where traditional ditches have been installed in the past. Hybrid ditches are especially helpful when dealing with flatter slopes.

Benefits: Benefits include a smaller footprint than deeper ditches when dealing with flatter slopes, reduction of stormwater flow rate, lowers the water table when it is high, can recharge the water table when it is low, and filters sediments and pollutants from surface runoff.

Design Criteria: Side slopes of hybrid ditch shall be 3:1 or flatter.

A typical hybrid ditch cross section will include plantings, topsoil, a 50/50 mix of topsoil and sand, filter fabric, No. 8 washed stone backfill around a perforated HDPE pipe, and No.8 washed stone bedding.

Maintenance: Periodic inspection of inlets or catch basins to confirm the system is working correctly, properly disposing of any sediment that is clogging the system.

Vegetation management is needed to reduce weeds and reestablish any plants that do not survive. Sediment removal and proper disposal, as needed.

LID 10 PRESERVING EXISTING RIPARIAN BUFFER

Purpose: Natural buffers are complex ecosystems that help provide food and habitat for stream communities. Buffers comprised of mature trees provide shading to the aquatic resource lowering the water temperature, providing bank stability and improving habitat. Preserving existing natural buffers that are adjacent to waterways to promote water quality. and planning around the existing vegetation promotes stream.

Recommended Applications: Buffers that exist prior to development should be evaluated in the planning stage. Buffers can be used to enhance a development to create areas that are aesthetically pleasing and benefit both people and wildlife. Preserving existing natural buffers that are adjacent to waterways (riparian buffers), promote infiltration and provide protection of the water resource.

Benefits: Benefits include Pollutant Treatment (solids, nutrients, metals, oils, etc.), reduction of velocity and volume of stormwater run-off, groundwater recharge, micro habitat, aesthetic improvement (compared to lawn or hardscape), minimal maintenance (if installed correctly), and an education opportunity for the public.

Design Criteria: Natural riparian buffers bordering and/or surrounding a water resource that are 50 feet or more in width must be preserved to a minimum of 50 feet. Less than 50 feet in width must be preserved in their entirety. The natural riparian buffer may be enhanced with vegetation that is native and promotes ecological improvement and sustainability.

During construction all run-off directed to the natural buffer must be pretreated with appropriate erosion and sediment control measures prior to discharging to the buffer.

Run-off must be managed with an energy dissipator, or like, to prevent erosion from occurring within the buffer area.

Discharges to the buffer after the completion of the project should include pretreatment through an appropriate post-construction stormwater measure prior to discharging to the buffer.

Maintenance: Limit disturbances to the existing buffer during the construction phase and ensure only treated stormwater run-off reaches the buffer.

Sediment control measures must be installed in locations between a disturbed area and the buffer. If sediment control measures fail and sediment is discharged into the preserved buffer area, the sediment discharge should be removed with minimal impact to the buffer, and the sediment control measure should be repaired and-or replaced.



LID 11 OPEN CHANNEL/TWO STAGE DITCH

Purpose: A two-stage ditch is a modified in channel design to account for a vegetated bench within the ditch, as well as the normal low-flow channel. The bench is an area that is planned for flooding during higher flows.

Recommended Applications: Use for agricultural ditches, which experience bank erosion or for undersized ditches. Use for ditches with a grade of less than 2%.

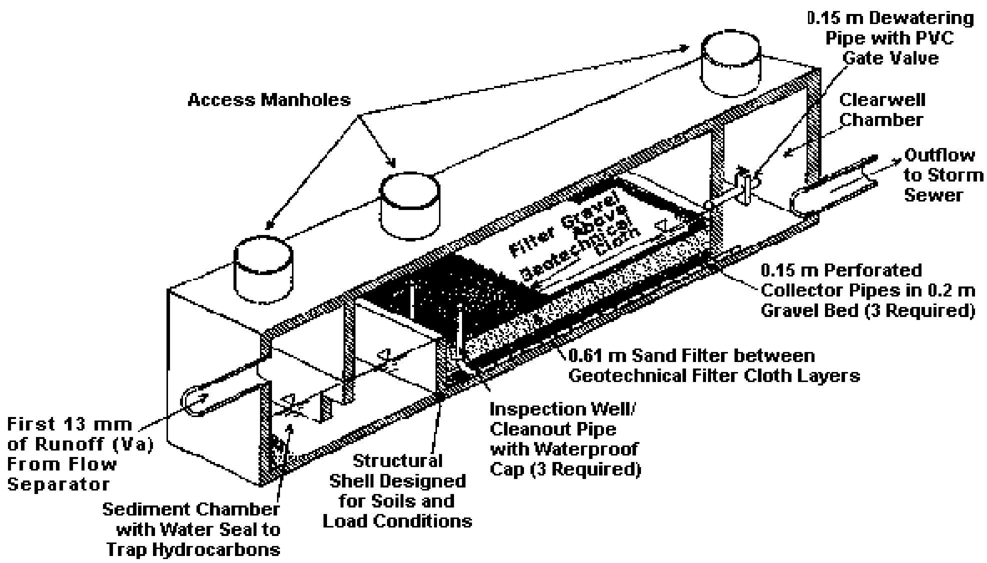
Benefits: After installation of the two-stage ditch, the channel is less prone to accumulate sediment and need less maintenance over the lifetime of the ditch. The low flow will stay within the banks and the flood flows stay within the second stage. The wider ditch will slow down the speed of the flood waters and reduce the height of the water in the ditch. The banks are likely to be more stable, and tile outlets will be submerged less often and will not be clogged by sediment deposits.

Design Criteria: Determine the capacity for open channels according to procedures applicable to the purposes of the channel and according to related engineering standards and guidelines in approved references. Design must consider low flow, average flows, frequent storm flows, and high (infrequent) storm flows.

Determine the water surface profile r hydraulic grade line for design flow using guidelines for hydraulic design in NRCS TR-210-25 and/or NRCS NEH, Par 654. Select a Manning's n value for the condition representing an aged channel. Base the selection on the expected vegetation and other factors such as the level of maintenance prescribed in the operation and maintenance plan. Establish the required flow capacity by considering volume-duration removal rates, peak flow, or a combination of the two, as determined by the topography, purpose of the channel, desired level of protection and economic feasibility. Design conditions cannot result in flood impacts to adjacent properties without addressing through the appropriate authorities.

Creating a low bench will likely require the top width of the ditch to be greater than what would be required for a traditional trapezoidal channel. This would result in ROW costs and surrendering of surrounding agricultural production land. The landowner could offset the costs by getting the lower bench considered for buffer conservation programs. Designers can verify the applicability of the buffer conservation program by looking into the drainage easement standards.

Maintenance: After construction of the two-stage ditch and final establishment of vegetation the ditch is likely to require less maintenance as well as the system will have improved conveyance capacity, be more self-sustaining, and create and maintain improved aquatic habitat.



LID 12 SAND FILTER

Purpose: A sand filter can be utilized to capture and treat stormwater runoff which is expected to contain high levels of pollutants. The sand filter will act as a pretreatment and temporarily storing the runoff to remove the large particle sediment and allowing the runoff to percolate through the filter's sand media. As a result, the water quality improves.

Recommended Applications: Sand Filters are primarily used as water quality BMPs; however, the water quality volume entering the filter is detained and released at a rate potentially capable of providing downstream channel erosion control.

Peak rate control of the 10-year and greater storm events is typically beyond the capacity of the stormwater filtering systems and may require the use of a separate structural peak rate reduction facility.

Sand filters are most commonly used in urbanized settings where runoff is generated from areas with imperviousness from 67-100%.

Sand filters are best suited for small drainage areas.

The three most common sand filters are the D.C Underground Vault, Delaware, and Austin Surface.

Maximum Drainage Area:

Filter type	Appropriate Drainage Shed
D.C. Underground Vault	.25-1.25
Delaware	1.25 Maximum
Austin Surface	Greater than 1.25

Benefits: A 75% - 90% TSS removal rate is estimated with the use of a sand filter.

Design Criteria: Stormwater filtering systems should be designed to operate exclusively by gravity flow.

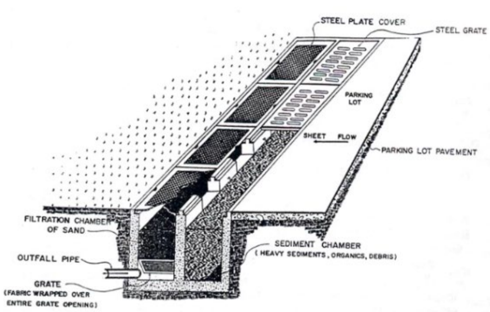
Surface sand filter: The surface sand filter uses a flow splitter to divert runoff into an off-line sedimentation chamber. The chamber may be either wet or dry and is generally used for pre-treatment. Runoff is then distributed into the second chamber, which consists of a sand filter bed (around 18 inches) and temporary runoff storage above the bed. Pollutants are trapped or strained out at the surface of the filter bed. The filter bed surface may have a sand or grass cover. A series of perforated pipes located in a gravel bed collect the runoff passing through the filter bed and return it to the stream or channel at a downstream point. If underlying soils are permeable, and groundwater contamination unlikely, the bottom of the filter bed may have no lining, and the filtered runoff may be allowed to infiltrate.

Underground sand filter: The underground sand filter was designed for sites where space is at a premium. The underground sand filter is a three-chamber underground vault with accessible manholes or grate openings. The vault can be either on-line or off-line in the storm drain system. The first chamber is used for pre-treatment and relied on a wet pool as well as temporary runoff storage. It is connected to the second sand filter chamber by an inverted elbow, which keeps the filter surface free from trash and oil. The filter bed is 18 inches in depth and may have a protective screen of gravel or permeable geotextile to limit clogging. During a storm, the water quality volume is temporarily stored in both the first and second chambers. Flows in excess of the filter's capacity are diverted through an overflow weir. Filtered runoff is collected, using perforated underdrains that extend into the third overflow chamber.

Pollutant removal effectiveness for underground sand filters (%):

Study	TSS	TP	TKN	NO_3	Metals	Bacteria	Comments
Bell et. Al., 1995	79	65	NA	(-53)	25-91	NA	Delaware sand filter
Horner and Horner, 1995	<81	43-60	NA	NA	22-66	NA	Delaware sand filter, oil and grease removal at >80%

Perimeter sand filter: The perimeter sand filter consists of two parallel trench-like chambers, installed along the perimeter (Delaware Sand Filter). Parking lot runoff enters the first chamber, which has a shallow permanent pool of water. The first trench provides pre-treatment before the runoff spills into the second trench, which consists of a sand layer (12-18 inches). During a storm event, runoff is temporarily ponded above the normal pool and sand layer. When both chambers fill up to capacity, excess parking lot runoff is routed to a bypass drop inlet. The remaining runoff is filtered through the sand, collected by underdrains, and delivered to a protected outflow point.



The liner should be located 2-4 feet above the high-water table. A high-water table could flood the filter system. Additionally, buoyancy calculations must be performed, and additional weight provided within the filter as necessary to prevent floatation.

Ensure there is easy site access and adequate pre-treatment.

Ensure the drainage area is fully stabilized prior to bringing the practice online.

Maintenance: More frequent maintenance will be required if the sand filters are planned for receiving flows with hydrocarbons.

The most frequent maintenance concern for filters is surface and underdrain clogging. Clogging occurs at the inlets and outlets and the filter surface. Materials that are collected by the system, consisting of fines, hydrocarbons, algal matter, and organic matter can clog the filter surface, inlet, and outlets. Inspect the inlets, outlets and contributing drainage area monthly and remove any trash and debris.

Ensure sediment is cleaned out of chamber when it accumulates to a depth equal to ½ the total depth to the outlet, or when greater than 1.5 feet, whichever is less. Clean the sediment chamber outlet when drawdown times exceed 36 hours. Remove trash and debris routinely.

Remove silt and sediment from the filter bed when the accumulation exceeds one inch.

When water ponds on the surface of the filter bed for more than 48 hours, the top few inches of discolored filter bed material should be removed and replaced with fresh material. Removed sediments should be disposed of in a landfill.

Replace any filter fabric that has become clogged.

Annually inspect the filter bed to ensure it is clean of sediment and the sediment chamber is not more than 6 inches of sediment. Make sure there is no evidence of spalling, or cracking of concrete, which would be signs of deterioration of the concrete. Inspect grates and inlets and outlets, to ensure there is no evidence of erosion and repair or replace any damaged structural parts. Stabilize any erosion that is observed. Ensure the flow is not bypassing the system and there are no odors detected outside the system.

Replace the top 2-5 inches of sand filter media every 3 to 5 years. More often replacement is necessary for areas with higher sediment yield or high oil and grease.

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APPENDIX A

STANDARD FORMS

Project Information		
Project Name:		Date:
General Location:		
Total Site Acreage:		
Proposed Land Disturbance Acreage:		
Form Completed By (Name):		
Application Fee:		

Owner Applicant Information		
Owner Name:	Phone #:	Email:
Engineer Company:		
Engineer Name:	Phone #:	Email:
Brief Project Purpose and Description:		

Construction Plans General Requirements

Ensure the Construction Stormwater Pollution Prevention Plan includes the items which are required by the Stormwater Ordinance, Stormwater Technical Standards Manual, and Indiana Department of Environmental Management Construction Stormwater General Permit. Enter the SWP(3) / Plan set sheet reference for each requirement:

Page #/Sheet #	Plan Requirement
	Index of the location of required plan elements in the construction plan
	A vicinity map depicting the project site location in relationship to recognizable local landmarks, towns, and major roads
	Narrative of the nature and purpose of the project

Page #/Sheet #	Plan Requirement
	Latitude and longitude to the nearest fifteen (15) seconds
	Legal description of the project site
	11 X 17-inch plat showing building lot numbers/boundaries and road layout/names
	Boundaries of the one hundred (100) year floodplains, floodway fringes, and floodways
	Land use of all adjacent properties
	Identification of a U.S. EPA approved or established TMDL
	Name(s) of the receiving water(s)
	Identification of discharges to a water on the current 303d list of impaired waters and the pollutant(s) for which it is impaired
	Soil map of the predominant soil types
	Identification and location of all known wetlands, lakes and water courses on or adjacent to the project site (construction plan, existing site layout)
	Identification of any other state or federal water quality permits or authorizations that are required for construction activities
	Identification and delineation of existing cover, including natural buffers
	Existing topography at a contour interval appropriate to indicate drainage patterns
	Location(s) of where run-off enters the project site
	Location(s) of where run-off discharges from the project site prior to land disturbance
	Location of all existing structures on the project site
	Existing permanent retention or detention facilities, including manmade wetlands, designed for the purpose of stormwater management
	Locations where stormwater may be directly discharged into ground water, such as abandoned wells, sinkholes, or karst features
	Size of the project area expressed in acres
	Total expected land disturbance expressed in acres
	Proposed final topography

Page #/Sheet #	Plan Requirement
	Locations and approximate boundaries of all disturbed areas
	Location, size, and dimensions of all stormwater drainage systems, such as culverts, storm sewers, and conveyance channels
	Locations of specific points where stormwater and non-stormwater discharges will leave the project site
	Location of all proposed site improvements, including roads, utilities, lot delineation and identification, proposed structures, and common areas
	Location of all on-site soil stockpiles and borrow areas
	Construction support activities that are expected to be part of the project
	Location of any in-stream activities that are planned for the project including, but not limited to stream crossings and pump arounds
	Description of the potential pollutant generating sources and pollutants, including all potential non-stormwater discharges
	Stable construction entrance locations and specifications
	Specifications for temporary and permanent stabilization
	Sediment control measures for concentrated flow areas
	Sediment control measures for sheet flow areas
	Run-off control measures
	Stormwater outlet protection locations and specifications
	Grade stabilization structure locations and specifications
	Dewatering applications and management methods
	Measures utilized for work within waterbodies
	Maintenance guidelines for each proposed temporary stormwater quality measure
	Planned construction sequence describing the relationship between implementation of stormwater quality measures in relation to land disturbance
	Provisions for erosion and sediment control on individual building lots regulated under the proposed project

Page #/Sheet #	Plan Requirement
	Material handling and spill prevention and spill response plan meeting the requirements in 327 IAC 2-6.1
	Material handling and storage procedures associated with construction activity
	Description of pollutants and their sources associated with the proposed land use
	Description of proposed post-construction stormwater measures
	Plan details for each stormwater measure
	Sequence describing stormwater measure implementation
	Maintenance guidelines for proposed post-construction stormwater measures
	Entity that will be responsible for operation and maintenance of the post-construction stormwater measures

City of Washington

Construction/ Stormwater Pollution Prevention Plan Technical Review
City of Washington Ordinance 53.51
IDEM Construction Stormwater General Permit:
https://www.in.gov/idem/stormwater/construction-land-disturbance-permitting/
(INRA00000 effective 12/18/2021)

Construction/Stormwater Pollution Prevention Plan Technical Review and Comment

Project Name: **Scope of Project:** **County(ies):** Daviess **Latitude:** **Longitude:**	**Plan Submittal Date:** Click here to enter a date. **Plan Review Date:** **March 10, 2023**

Plan Preparer: **Affiliation:**
Address:
City: **State:** IN **Zip:**
Phone: **Cell Phone:** **Email:**

Project Site Owner: **Company Name (if applicable):**
Address:
City: **State:** IN **Zip:**
Phone: Cell Phone: **Email:**

Plan Reviewer: **Affiliation:** BF&S **On behalf of:** City of Washington
Address: 210 N Mill St Suite 101
City: Plainfield **State:** IN **Zip:** 46168
Phone: **Cell Phone:** 317 **Email:**

Plan Review Status:		
☐	**Plan is Adequate**	A comprehensive plan review has been completed and it has been determined that the plan satisfies the minimum requirements of the City of Washington and the Construction Stormwater General Permit INRA00000 (Effective 12-18-2021).
☐	**Preliminary Review**	A comprehensive review will not be completed at this time. The plan review authority reserves the right to perform a comprehensive review at a later date, and revisions may be required at that time.
☐	**Conditional Acceptance**	Acceptance of the plan is conditional. The conditional acceptance is contingent upon addressing the issues identified in the comment sections.
☐	**Plan is Deficient**	Significant deficiencies were identified and must be addressed. Refer to the comment sections.

Action:	
☐	**Submit a Notice of Intent:** • Submit the Notice of Intent (NOI) online through the IDEM Regulatory ePortal. It is required to upload a copy of this review form when submitting the NOI through the IDEM Regulatory ePortal: (https://stormwater.idem.in.gov/ncore/external/home)
☐	**Do not file a Notice of Intent or commence land-disturbing activities:** Deficiencies must be adequately addressed and an acceptable plan review completed.
☐	**Comments:** Refer to Plan Review Comments Sections of this document.
☐	**Revisions:** Update and submit the revised Construction/Stormwater Pollution Prevention Plan as indicated below.
	☐ Update and submit a complete plan set that addresses plan deficiencies.
	☐ Update and submit a document (narrative and/or plan sheets) that address plan deficiencies.
	☐ Update and submit a complete plan set that addresses plan deficiencies. A comprehensive plan review will not be completed.

Plan Review Information

- *The technical review and comment is intended to evaluate the completeness of the Construction/Stormwater Pollution Prevention Plan for the project. The Plan submitted was not reviewed for the adequacy of engineering design. All measures included in the plan, as well as those recommended in the comments should be evaluated as to their feasibility by a qualified individual with structural measures designed by a qualified engineer. The Plan has not been reviewed for other local, state, or federal permits that may be required to proceed with this project.*
- *Additional information, including design calculations may be requested to further evaluate the plan.*
- *All proposed stormwater pollution prevention measures and those referenced in this review must meet the design criteria and standards set forth in the "Indiana Stormwater Quality Manual" from the Indiana Department of Environmental Management or similar Guidance Documents.*
- *Construction activities and unforeseen weather conditions may affect the performance of the erosion and sediment control system, individual measures, or the effectiveness of the plan. The plan must be a flexible document, with provisions to modify or substitute measures as necessary to ensure compliance.*

Section A: Construction Plan Elements

Adequate	Deficient	NA	A	*The construction plan elements include general information associated with the project site that are critical for the evaluation of the stormwater pollution prevention plan component. This information includes, but is not limited to an index, resource information, reference maps, grading information, project layout and design, and drainage plan*
☐	☐	☐	**1**	Index of the location of required plan elements in the construction plan
☐	☐	☐	**2**	A vicinity map depicting the project site location in relationship to recognizable local landmarks, towns, and major roads
☐	☐	☐	**3**	Narrative of the nature and purpose of the project
☐	☐	☐	**4**	Latitude and longitude to the nearest fifteen (15) seconds
☐	☐	☐	**5**	Legal description of the project site
☐	☐	☐	**6**	11 X 17-inch plat showing building lot numbers/boundaries and road layout/names
☐	☐	☐	**7**	Boundaries of the one hundred (100) year floodplains, floodway fringes, and floodways
☐	☐	☐	**8**	Land use of all adjacent properties
☐	☐	☐	**9**	Identification of a U.S. EPA approved or established TMDL
☐	☐	☐	**10**	Name(s) of the receiving water(s)
☐	☐	☐	**11**	Identification of discharges to a water on the current 303d list of impaired waters and the pollutant(s) for which it is impaired
☐	☐	☐	**12**	Soil map of the predominant soil types
☐	☐	☐	**13**	Identification and location of all known wetlands, lakes and water courses on or adjacent to the project site (construction plan, existing site layout)
☐	☐	☐	**14**	Identification of any other state or federal water quality permits or authorizations that are required for construction activities
☐	☐	☐	**15**	Identification and delineation of existing cover, including natural buffers
☐	☐	☐	**16**	Existing topography at a contour interval appropriate to indicate drainage patterns
☐	☐	☐	**17**	Location(s) of where run-off enters the project site
☐	☐	☐	**18**	Location(s) of where run-off discharges from the project site prior to land disturbance
☐	☐	☐	**19**	Location of all existing structures on the project site
☐	☐	☐	**20**	Existing permanent retention or detention facilities, including manmade wetlands, designed for the purpose of stormwater management
☐	☐	☐	**21**	Locations where stormwater may be directly discharged into ground water, such as abandoned wells, sinkholes, or karst features

☐	☐	☐	**22**	Size of the project area expressed in acres
Adequate	**Deficient**	**NA**	**A**	*The construction plan elements include general information associated with the project site that are critical for the evaluation of the stormwater pollution prevention plan component. This information includes, but is not limited to an index, resource information, reference maps, grading information, project layout and design, and drainage plan*
☐	☐	☐	**23**	Total expected land disturbance expressed in acres
☐	☐	☐	**24**	Proposed final topography
☐	☐	☐	**25**	Locations and approximate boundaries of all disturbed areas
☐	☐	☐	**26**	Location, size, and dimensions of all stormwater drainage systems, such as culverts, storm sewers, and conveyance channels
☐	☐	☐	**27**	Locations of specific points where stormwater and non-stormwater discharges will leave the project site
☐	☐	☐	**28**	Location of all proposed site improvements, including roads, utilities, lot delineation and identification, proposed structures, and common areas
☐	☐	☐	**29**	Location of all on-site soil stockpiles and borrow areas
☐	☐	☐	**30**	Construction support activities that are expected to be part of the project
☐	☐	☐	**31**	Location of any in-stream activities that are planned for the project including, but not limited to stream crossings and pump arounds

Section A – Comments:

- Evaluate areas with potential waters of the state and, where required, verify if permits/authorizations are required prior to any impacts to waters of the state. These potential resources include areas with hydric soil, hydrophytic vegetation, pooling water, or evidence of flowing water such as swales, ditches, drains, or natural conveyances. Evaluation of hydric soil, hydrophytic vegetation, or pooling water should conform to the US Army Corps of Engineers Wetlands Delineation Manual," Technical Report Y-87-1, and the applicable regional supplement https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/reg_supp/. Avoidance and minimization of impacts to waters of the state should be prioritized.
-

Section B: Stormwater Pollution Prevention Plan – Erosion and Sediment Control/Project Site Management				
Adequate	Deficient	NA	B	*The construction component of the Stormwater Pollution Prevention Plan includes stormwater quality measures to address erosion, sedimentation, and other pollutants associated with land disturbance and construction activities. Proper implementation of the plan, maintenance of measures, and administering a self-monitoring program is required to manage the project site to minimize the discharge of sediment and other pollutants. Construction activities and unforeseen weather conditions may affect the performance of the erosion and sediment control system, individual measures, or the effectiveness of the plan. The plan must be a flexible document, with provisions to modify or substitute measures as necessary to ensure compliance.*
☐	☐	☐	1	Description of the potential pollutant generating sources and pollutants, including all potential non-stormwater discharges
				Where applicable, Items in 2 through 10 below will be evaluated for Location, dimensions, detailed specifications, and construction details
☐	☐	☐	2	Stable construction entrance locations and specifications
☐	☐	☐	3	Specifications for temporary and permanent stabilization
☐	☐	☐	4	Sediment control measures for concentrated flow areas
☐	☐	☐	5	Sediment control measures for sheet flow areas
☐	☐	☐	6	Run-off control measures
☐	☐	☐	7	Stormwater outlet protection locations and specifications
☐	☐	☐	8	Grade stabilization structure locations and specifications
☐	☐	☐	9	Dewatering applications and management methods
☐	☐	☐	10	Measures utilized for work within waterbodies
☐	☐	☐	11	Maintenance guidelines for each proposed temporary stormwater quality measure
☐	☐	☐	12	Planned construction sequence describing the relationship between implementation of stormwater quality measures in relation to land disturbance
☐	☐	☐	13	Provisions for erosion and sediment control on individual building lots regulated under the proposed project
☐	☐	☐	14	Material handling and spill prevention and spill response plan meeting the requirements in 327 IAC 2-6.1
☐	☐	☐	15	Material handling and storage procedures associated with construction activity

Section B – Comments:

- The Construction Stormwater General Permit (CSGP) requires all sites to have a trained individual monitor and manage all stormwater activities. IDEM defines a trained individual as – an individual who is trained and experienced in the principles of stormwater management, including erosion and sediment control as is demonstrated by completion of coursework, state registration, professional certification, or annual training that enable the individual to make judgments regarding stormwater management, treatment, and monitoring.

  In keeping with the requirements of the CSGP, please be ready to provide credentials for the trained individual responsible for overseeing this project during the preconstruction meeting.

- Stormwater quality measures for the reduction of sediment have not been evaluated for adequacy of design. The proposed measures included in this SWP3 are being accepted based on the design engineer's submittal.

Section C: Stormwater Pollution Prevention Plan – Post-Construction				
Adequate	**Deficient**	**NA**	**C**	*The post-construction component of the Stormwater Pollution Prevention Plan includes the implementation of stormwater quality measures to address pollutants that will be associated with the final project land use. Post-construction stormwater measures should be functional upon completion of the project. Long term functionality of the measures is critical to their performance and should be monitored and maintained.*
☐	☐	☐	**1**	Description of pollutants and their sources associated with the proposed land use
☐	☐	☐	**2**	Description of proposed post-construction stormwater measures
☐	☐	☐	**3**	Plan details for each stormwater measure
☐	☐	☐	**4**	Sequence describing stormwater measure implementation
☐	☐	☐	**5**	Maintenance guidelines for proposed post-construction stormwater measures
☐	☐	☐	**6**	Entity that will be responsible for operation and maintenance of the post-construction stormwater measures

Section C – Comments:

- Post-construction stormwater quality and quantity measures have not been evaluated for adequacy of design. The proposed measures included in this SWP3 are being accepted based on the design engineer's submittal.
- The rate of stormwater run-off and/or volume from the project site must meet local requirements to address stormwater quantity as established by ordinance or other regulatory mechanism. When a local requirement does not exist, the post-development run-off discharge from the project site must not exceed the pre-development discharge based on the two-year, ten-year, and one-hundred-year peak storm events.
-

STORM WATER MANAGEMENT PRACTICES MAINTENANCE AGREEMENT

THIS STORM WATER MANAGEMENT PRACTICES MAINTENANCE AGREEMENT ("Agreement") is made this _______ day of __________, 20____, by and between the **City of Washington, Indiana**, a municipal corporation, with principal offices located at 101 NE 3rd Street, Washington, IN 47501, hereinafter "(City)" and __________________________________ a _____________________ with principal offices located at ___________________________________, hereinafter "(Owner)".

_________________________________, as "Owner(s)" of the property described below, in accordance with the City's Regulations, agrees to install and maintain storm water management practice(s) on the subject property in accordance with approved plans and conditions. The Owner further agrees to the terms stated in this Agreement to ensure that the storm water management practice(s) continues serving the intended function in perpetuity. This Agreement includes the following exhibits:

Exhibit A: Legal Description of the real estate for which this Agreement applies ("Property").

Exhibit B: Location map(s) showing a location of the Property and an accurate location of each storm water management practice affected by this Agreement.

Exhibit C: Long-term Maintenance Plan that prescribes those activities that must be carried out to maintain compliance with this Agreement.

Note: After construction has been verified and accepted by the City for the storm water management practices, an addendum(s) to this Agreement shall be recorded by the Owner showing design and construction details and provide copies of the recorded document to the City. The addendum may contain several additional exhibits.

Through this Agreement, the Owner(s) hereby subjects the Property to the following covenants, conditions, and restrictions:

1. The Owner(s), at its expense, shall secure from any affected owners of land all easements and releases of rights-of-way necessary for utilization of the storm water practices identified in Exhibit B and shall record them in the Daviess County Recorder's Office. These easements and releases

of rights-of-way shall not be altered, amended, vacated, released, or abandoned without prior written approval of the City.

2. The Owner(s) shall be solely responsible for the installation, maintenance and repair of the storm water management practice, drainage easements and associated landscaping identified in Exhibit B in accordance with the Maintenance Plan (Exhibit C).
3. No alterations or changes to the storm water management practice(s) identified in Exhibit B shall be permitted unless they are deemed to comply with this Agreement and are approved in writing by the City.
4. The Owner(s) shall retain the services of a qualified inspector (as described in Exhibit C – Maintenance Requirement 1) to operate and ensure the maintenance of the storm water management practice(s) identified in Exhibit B in accordance with the Maintenance Plan (Exhibit C).
5. The Owner(s) shall annually, by December 30th, provide to the City records (logs, invoices, reports, data, etc.) of inspections, maintenance, and repair of the storm water management practices and drainage easements identified in Exhibit B in accordance with the Maintenance Plan. Inspections are required at least after every major rain event.
6. The City or its designee is authorized to access the Property as necessary to conduct inspections of the storm water management practices or drainage easements to ascertain compliance with this Agreement and the activities prescribed in Exhibit C. Upon written notification from the City or its designee of required maintenance or repairs, the Owner(s) shall complete the specified maintenance or repairs within a reasonable time frame determined by the City. The Owner(s) shall be liable for the failure to undertake any maintenance or repairs so that the public health, safety and welfare shall not be endangered nor the road improvement damaged.
7. If the Owner(s) does not keep the storm water management practice(s) in reasonable order and condition, or complete maintenance activities in accordance with the Plan contained in Exhibit C, or the reporting required in paragraph 3 above, or the required maintenance or repairs under paragraph 4 above within the specified time frames, the City is authorized, but not required, to perform the specified inspections, maintenance or repairs in order to preserve the intended functions of the practice(s) and prevent the practice(s) from becoming a threat to public health, safety, general welfare or the environment. In the case of an emergency maintenance or repairs, the City may levy the costs and expenses of such inspections, maintenance, or repairs plus a ten percent (10%) administrative fee against the Owner(s). If the City undertakes to perform any maintenance which the Owner(s) is required to perform, the City may obtain, assert, and file a lien against the Property for expenses incurred by the City in performing the maintenance by filing a notice of lien in the Daviess County Recorder's Office upon the Property. If said costs and expenses are not paid by the Owner(s) within thirty (30) days after the City mails its invoice, then the Owners shall pay in addition to said costs and expenses, all costs of litigation, including attorney fees which are incurred by the City in filing and enforcing its lien.
8. The Owner(s) hereby conveys to the City an easement over, on and in the Property described in Exhibit A for the purpose of access to the storm water management practice(s) for the inspection, maintenance and repair thereof, in the event that the Owner(s) fails to properly inspect, maintain and repair the practice(s).

9. The Owner(s) agrees that this Agreement shall be recorded, and that the Property described in Exhibit "A" shall be subject to the covenants and obligations contained herein, and this Agreement shall bind all current and future owners of the Property and shall run with title to the Property.
10. The Owner(s) agrees, in the event that the Property is sold, transferred or leased, to provide information to the new owner, operator, or lessee regarding proper inspection, maintenance and repair of the storm water management practice(s). The information shall accompany each deed transfer and include Exhibits B and C and this Agreement.
11. The Owner(s) agrees that the rights, obligations and responsibilities hereunder shall commence upon execution of the Agreement.
12. The parties whose signatures appear below hereby represent and warrant that they have the authority and capacity to enter this Agreement and bind the respective parties hereto.
13. The Owner, its agents, representatives, successors and assigns shall defend, indemnify and hold the City of Washington harmless from and against any claims, demands, actions, damages, injuries, costs or expenses of any nature whatsoever (hereinafter "Claims"), fixed or contingent, known or unknown, arising out of or in any way connected with the design, construction, use, maintenance, repair or operation (or omissions in such regard) of the storm drainage system referred to in the permit as Exhibit "C" hereto, appurtenances, connections and attachments thereto which are the subject of this Agreement. This indemnity includes any costs, expenses and attorney fees incurred by the City in connection with such Claims or the enforcement of this Agreement.

IN WITNESS WHEREOF, the City and Owner have executed this Agreement on the day and year first above written.

By: ____________________________________

Its: ____________________________________

STATE OF INDIANA)
) SS:
COUNTY OF Daviess)

The foregoing instrument was acknowledged before me on this ________day of _____________, 20 __.

____
Notary Public

_________________County of Indiana
Commission Expires on: __________________________

My Commission No.:_______________________

City of Washington
a municipal corporation

By: ____________________________________

Its: ____________________________________

STATE OF INDIANA)
) SS:
COUNTY OF Daviess)

The foregoing instrument was acknowledged before me on this ________day of _____________, 20 __.

____
Notary Public

_________________County of Indiana
Commission Expires on: _________________________

My Commission No.:_______________________

Instrument Drafted by: ____________________________________

I affirm, under the penalties for perjury, that I have taken reasonable care to redact each Social Security number in this document, unless required by law. ______________________________

WHEN RECORDED RETURN TO:

Washington Stormwater Department
304 E Oak Street
Washington, IN 47501
ATTN: Storm Water Coordinator

Exhibit A – Legal Description (Sample)

The following description and site plan identify the land parcel(s) affected by this Agreement. [Note: An example legal description is shown below. This exhibit must be customized for each site, including the minimum elements shown. It must include a reference to a Subdivision Plat, Certified Survey number, or Condominium Plat, and a map to illustrate the affected parcel(s).]

Project Identifier: *(Name of Subdivision)*

Acres: *(Number of Acres)*

Date of Recording: *Date plat is recorded. Recorded Deed if not Subdivision Plat*

Map Produced by: *(Name of Engineering Firm preparing plans.)*

Type of Storm Water Management Practice(s): *(Retention Basin/ Detention Basin/Bio Swales/etc.)*

Legal Description: *(Legal description of property involved. If no land division is involved, enter legal description as described on the property title here.)*

Attach Site Plan Here
Showing Storm Water
/Drainage Easements

<u>Drainage Easement Restrictions:</u> Shaded Area on map indicates a drainage easement for storm water collection, conveyance and treatment. No buildings or other structures are allowed in these areas. No grading or filling is allowed that may interrupt storm water flows in any way. See Exhibit C for specific maintenance requirements for storm water management practices within this area. See Subdivision plat or details on location.

Exhibit B – Location Map (Sample)

Storm Water Management Practices Covered by this Agreement

[An example location map and the minimum elements that must accompany the map are shown below. This exhibit must be customized for each site. Map scale must be sufficiently large enough to show necessary details.]

The storm water management practices covered by this Agreement are depicted in the reduced copy of a portion of the construction plans, as shown below. The practices include the following; *[describe each storm water management practices that are included within the development named below].* All of the noted storm water management practices are located within drainage easements.

Subdivision Name: (*Name of subdivision)*

Storm Water Management Practices: *(Describe each Storm Water Management Practice)*

Location of Practices: *(Describe location of each Storm Water Management Practice)*

Titleholders: *(Name of each person that has a legal interest in the Property.) For privately owned storm water management practices, the names of titleholder(s) must include all parcels that drain to the facility which is the subject of this Agreement.*

Plan View of Storm Water Practices

Attach site plan that shows all easements and storm water management practices here.

Exhibit C – Storm Water Practice Maintenance Plan

This Exhibit C explains the basic function of each of the storm water practices listed in Exhibit B and provides the minimum specific maintenance activities and frequencies for each practice. The maintenance identified by the Owner should follow the maintenance activities listed in the manufacturers' or manufacturer's specifications or as detailed below. Vehicle access to the storm water practices is shown on Exhibit B. Any failure of a storm water practice that is caused by lack of maintenance will subject the Owner(s) to enforcement of the provisions listed in the Agreement by the City of Washington.

This exhibit must be customized for each site. The minimum elements of this Exhibit C include*: a description of the drainage area and the installed storm water management practices, a description of the specific maintenance activities for each practice which should include in addition to specific actions*:

- Employee training and duties *(describe details).*
- Routine Service Requirements.
- Operating, inspection and maintenance schedules.
- Detailed construction drawings showing all critical components and their elevations.
- Define or identify the qualified inspector (see Section 4).

References:

Place all reference materials used to detail the maintenance requirements and operating requirements of the storm water management practice.