STORMWATER

ELKHART COUNTY

FIELD OFFICE TECHNICAL MANUAL

PREPARED BY
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INTRODUCTION

We in Indiana have been blessed with a seemingly endless supply of clean water which nourishes our bodies as well as the environment in which we live. Clean water is indeed the one thing that all living things rely on to grow and flourish. For that reason, it is our responsibility to protect this precious resource from becoming polluted as a result of actions we take or actions we fail to take in the course of our everyday endeavors.

This manual presents what we feel is a commonsense approach to protecting our water from the effects of land disturbing activities associated with construction as well as agriculture. In compiling this manual, we have addressed the minimum state regulations set forth in Rule 5 and Rule 13. We do not feel it is necessary to go above and beyond the minimum standards if they are applied to every project properly. This is not to say that situations may arise which require more than the minimum- that's where the common sense comes into play. It is up to the designers and builders to recognize those situations when they arise, and we trust that they will do what is necessary to maintain the integrity of their projects.

Some people will say that Rule 5 and Rule 13 place too much of a burden on the developer or property owner, that the regulations infringe upon the right to use your property as you see fit. This is a narrow-minded attitude which, in the long run, can only hurt the environment and adversely impact our quality of life. Taking responsibility for our actions with regard to our environment is really a small price to pay for what we all get in return

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Background and Purpose

This manual, as amended from time to time, is a written source of instruction for complying with Elkhart County's ("County") stormwater management standards. The County's stormwater management standards are developed from and within the parameters of state regulations under Rule 5 and Rule 13 and related state statutes. It is important that this manual be referenced throughout the construction process. This is not meant to be a contract document or design standard. Except for extenuating or unique circumstances, the following instructions in this manual must be followed. Any exception to this manual for extenuating or unique circumstances must have advance approval in writing by Elkhart County. Complying with the instruction set forth in this manual and obtaining Elkhart County approval for preconstruction, construction, and post construction actions is not a guaranty that stormwater issues will not arise in the future or that changes, maintenance, or repair will not be necessary to address the issues. The manual is divided into three parts: Pre-Construction, Construction, and Post Construction.

Pre-Construction details the process for which every site must follow to be fully permitted in stormwater to begin construction. References to drainage calculations, plan requirements, Stormwater Pollution Prevention Plan (SWPPP) requirements, and the County review process can all be found in this section.

Construction details Best Management Practices (BMPs) that must be used to aid in erosion and sediment control.

Post Construction details BMPs that must be in place permanently to properly manage stormwater. BMPs that fall under Low Impact Development (LID) can also be found in this section.

Good stormwater management is important to preserve and maintain the waterways within Elkhart County. Failure to plan and design sites correctly can lead to harmful pollutants entering the soil and water on or adjacent to a site. It is the responsibility of site owners, developers, designers, contractors, and county inspectors to assure that sites during and after construction properly managed and treat stormwater.

Design and Calculations

All drainage calculations and design must be done in accordance with the most current edition of the *Elkhart County Highway Street Standards*. Detailed calculations must be shown on the plans. Drainage calculations must account for both the on and offsite contributing watershed. Offsite contributing watershed runoff can either be stored on site or allowed to pass through and release in a manner approved by Elkhart County. All sites require retention and/or detention basins to control stormwater runoff.

Detention basins must use a one hundred (100) year storm event calculated for the peak storage rate within a twenty-four (24) hour period using the appropriate tables in the *Elkhart County Highway Street Standards*. The maximum allowable release rate for detention basins must not exceed the downstream channel capacity or the ten (10) year undeveloped rate determined using the rational formula with C = 0.20 and I as shown in Table IV-2 of the *Elkhart County Highway Street Standards*.

All runoff entering a Legal Drainage System is subject to approval by the Elkhart County Drainage Board. The approved permit must be included with the Construction SWPPP submittal and Post Construction Plan submittal.

Retention basins are determined using the rational formula Q(ft^3/s) = CIA. See *Elkhart County Highway Street Standards* for appropriate values of C and I. This method is used for drainage areas less than 200 acres. For areas larger than 200 acres, the County must approve the method for calculating drainage. For retention basins that will encroach the water table, the storage must be two (2) times the required calculated storage requirement. Riprap and end sections are required at all exposed stormwater pipe outlets and inlets.

Soil Borings

Soil borings in proposed areas of water detention or retention are required for all projects. Soil borings must be done at a frequency of 1 boring per 5,000 square feet of proposed storage area rounded up to the next 5,000 SFT increment. Each area must have a minimum of one (1) soil boring test.

Examples:

Proposed Site A has one (1) proposed 3,000 SFT detention pond. One soil boring in this proposed area is required.

Proposed Site B has two (2) proposed detention ponds: Pond 1 is 4,000 SFT and Pond 2 is 6,000 SFT. One soil boring is required for Pond 1 and two soil borings are required for Pond 2.

Soil Borings must be reviewed and recommendations made by a registered Soil Scientist and/or licensed Geotechnical Engineer. For detention/retention areas and basins proposed to be dry, the seasonal high-water table elevation must be a minimum of one (1) foot below the proposed ground elevation of the basin. If the seasonal high-water table elevation does not meet the one (1) foot minimum requirement, the area must be designed as a wet basin. See Elkhart County Highway Street Standards for more detailed design requirements.

Plan Development

Plans, at a minimum, must include the following:

1. Project narrative and supporting documents, including:
    a. Index indicating the location, in the construction plans, of all information required.
    b. Description of the nature and purpose of the project.
    c. Legal description of the project site. Description to the ¼ section, township, and range, is adequate for approval purposes.
    d. Soil properties, characteristics, limitations, and hazards associated with the project site and the measures that will be integrated into the project to overcome or minimize adverse soil conditions. Submit soil map, size 11x17, from United State Department of Agriculture's Natural Resources Conservation Service.
    e. General construction sequence of how the project will be built including phases of construction.
    f. Hydraulic Unit Code (14 Digit) available from the United States Geological Survey (USGS).
    g. A reduced plat or project site map (11x17) showing lot boundaries, road layout and names.
    h. Identification of any other state or federal water quality permits required for construction associated with the project site.
2. Vicinity Map
3. Existing project site layout
4. Final project site layout
5. Grading Plan
6. Drainage Plan
7. Stormwater Pollution Prevention Plan (SWPPP) associated with construction including:
    a. Location, sizes and dimensions of all pipes and swales, detailsed specifications, and construction details of all temporary and permanent best management practices.
    b. Temporary stabilization plan and sequence of implementation

c. Permanent stabilization plan and sequence of implementation
d. Construction sequence describing the relationship between implementation of BMP's and stages of construction activities.
e. Self-Monitoring program including plan and procedures. PermiTrack software must be utilized for reporting inspections for all Elkhart County projects.
f. A description of potential pollutant sources associated with construction activities that may be expected to add a significant amount of pollutants to stormwater discharge.
g. Material handling and storage associate with construction activity.

8. Post Construction Stormwater Pollution Prevention Plan including:
   a. A description of potential pollutant sources from proposed land use that may be expected to add a significant amount of pollutants to stormwater discharge.
   b. Location, dimensions, detailed specifications, and construction details of all post construction stormwater quality measures.
   c. A description of measures that will be installed to control pollutants in stormwater discharges that will occur after construction activities have been completed. Asequence describing when each post construction storm water quality measures will be installed.
   d. A sequence describing when each post construction stormwater quality measures will be installed.
   e. BMPs that will remove or minimize pollutants from stormwater run-off.
   f. BMPs that will be implemented to prevent or minimize adverse impacts to stream and riparian habitat.
   g. A narrative description of the maintenance guidelines for all post construction BMPs to facilitate their proper long-term function.

Refer to 327 IAC 15-5-6.5 for more detail, which requirements are incorporated into this Technical Manual.

Preconstruction Process

The following describes the individual steps for the Elkhart County Preconstruction Process. These steps correspond to the steps of the flowchart on the next page.

Step 1: Plan Development

Step 2: Development of Stormwater Pollution Prevention Plan (SWPPP) and Post Construction Plan

Step 3: Submit SWPPP Package to

Jim Hess
Elkhart County Soil and Water Conservation District
17746-B County Road 34
Goshen, IN 46528

Submit Post Construction Plan to

John Heiliger
Elkhart County Surveyor's Office
4230 Elkhart Road
Goshen, IN 46526

The reviewers will review the documents and provide comments. If comments are made, they must be addressed. Documents must be resubmitted to obtain approval.

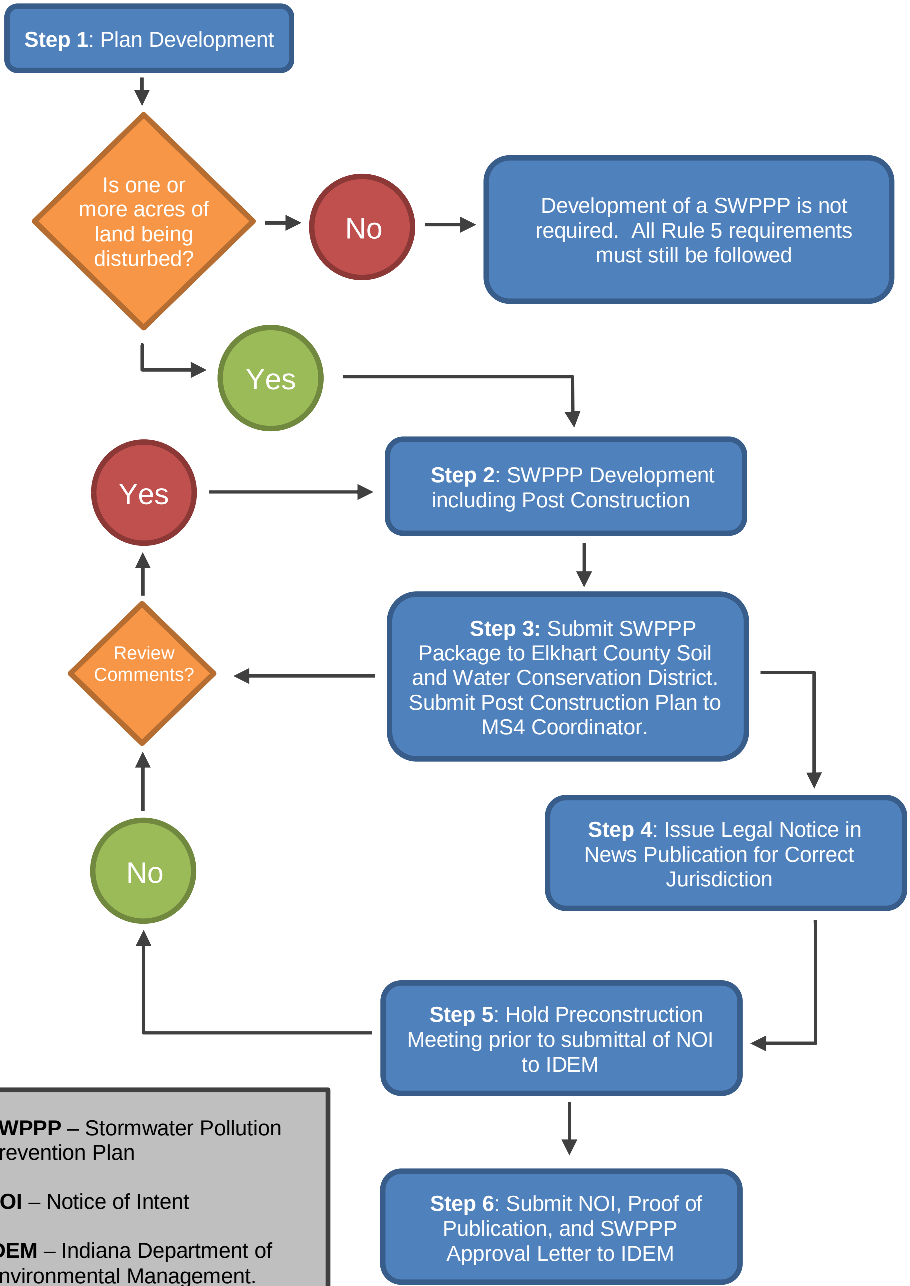
Step 4: Issue Legal Notice in News Publication for Correct Jurisdiction

Step 5: Hold Preconstruction Meeting prior to submittal of Notice of Intent to IDEM.

Step 6: Submit Notice of Intent (NOI), Proof of Publication, and SWPPP Approval Letter to

Indiana Department of Environmental Management
Stormwater Program, IGCN, Room 1255
100 North Senate Avenue
Indianapolis., IN 46204-2251

Elkhart County Preconstruction Process



SWPPP – Stormwater Pollution Prevention Plan

NOI – Notice of Intent

IDEM – Indiana Department of Environmental Management.

NOT – Notice of Termination

Construction Process

The following describes the individual steps for the Elkhart County Construction Process. These steps correspond to the steps of the flowchart on the next page.

Step 1: Preconstruction Meeting help prior to construction beginning.

Step 2: Confirm designated erosion and sediment control site inspector is setup in PermiTrack

Step 3: Construction may begin on site 48 hours after submittal of Notice of Intent (NOI) package to Indiana Department of Environmental Management (IDEM).

Step 4: Conduct Erosion and Sediment Control Inspections once per week and after every rain event of at least ½". Inspections due to rain events must be conducted no later than one business day after the event.

Step 5: If needed, file a renewal NOI with IDEM every five (5) years.

Step 6: The initial Stormwater Clearance expires at the end of the second year after issuance. If a Notice of Termination (NOT) has not been properly submitted to the SWCD before the end of the second year after issuance, a renewal request for Stormwater Clearance must be submitted to the Soil and Water Conservation District. The Stormwater Clearance must be renewed every subsequent year thereafter until a NOT is properly submitted to the SWCD.

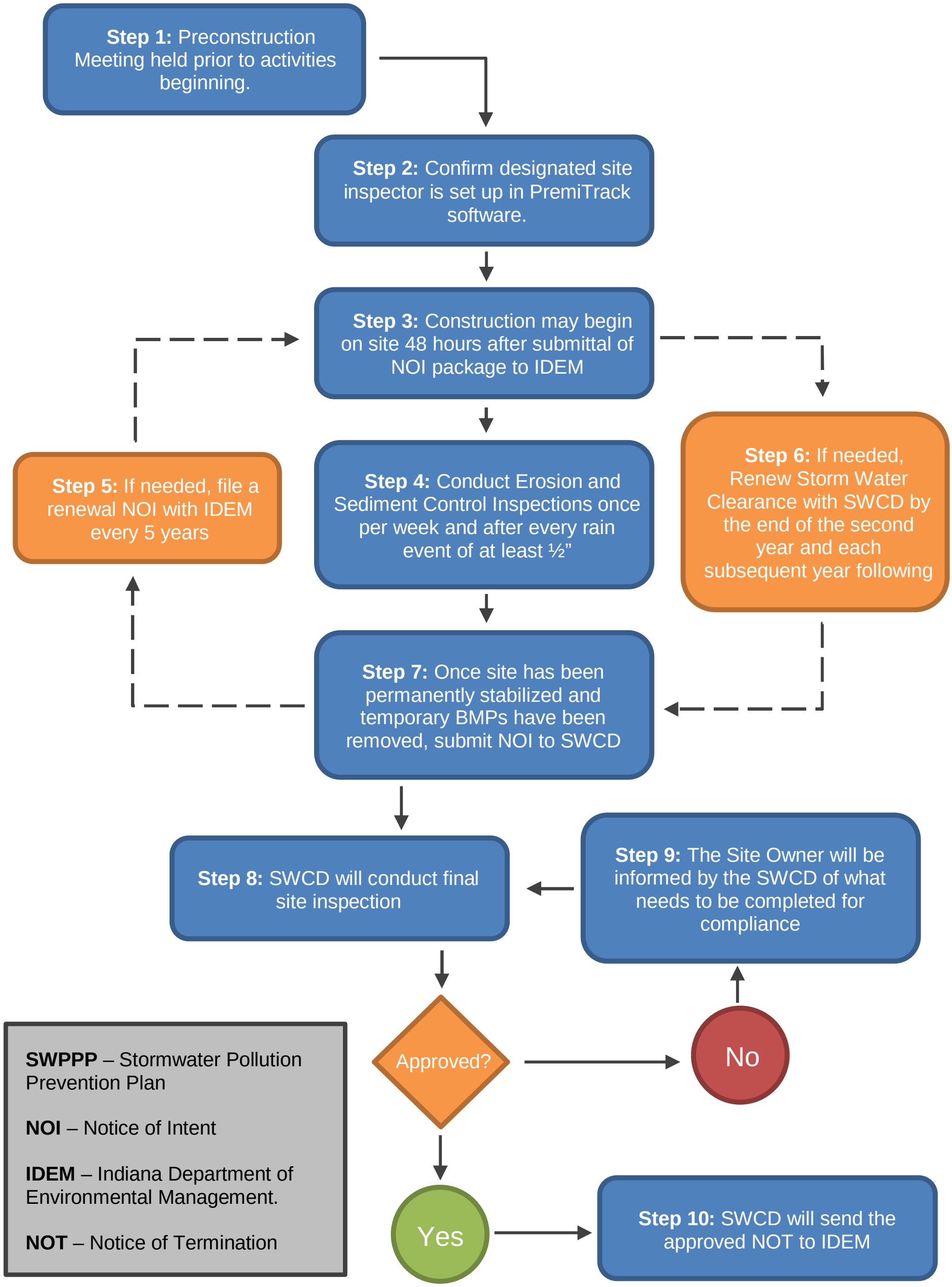
Step 7: Once construction has completed, the site has been permanently stabilized, and temporary Best Management Practices (BMPs) have been removed, submit NOT to SWCD.

Step 8: SWCD and Elkhart County MS4 Coordinator will conduct final site inspection.

Step 9: The site Owner will be informed of what needs to be completed for compliance

Step 10: SWCD will send the approved NOT to IDEM.

Elkhart County Preconstruction Process



CONSTRUCTION BMP
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TEMPORARY GRAVEL CONSTRUCTION ENTRANCE

Significantly Targeted Pollutants: None

Partially Targeted Pollutants: Sediment, Nutrients, Toxic Materials, 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 must be placed to avoid steep slopes, blind spots, or curves on public roads.

Gravel entrances for real estate under 2 acres must be 20 feet wide by 50 feet long. Gravel entrances for real estate over 2 acres must be 20 feet wide by 150 feet long.

The entrance must be a minimum of 6 inches thick.

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

Utilize INDOT CA No. 53 washed aggregate for a 2-inch-thick top-dress.

Geotextile fabric must be used as a separation layer between the underlying soil materials and the added aggregate to prevent intermixing of aggregate and the underlying soil material.

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 a 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 exceeding half an inch 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 can only be used if the water is conveyed to a sediment trap or basin or vacuumed up.

Insufficient stone on construction entrance, above. Insufficient stone can cause tracking of sediment and mud onto roadways.

Construction entrance installed correctly, above.

PORTABLE TOILETS

Portable toilets must be used on any project site when access to permanent restrooms is not practical or feasible. All Occupational Safety and Health Administration (OSHA) guidelines including, but not limited to, the guidelines establishing the number of facilities and the sanitation schedule, must be followed at each project site.

Portable toilets cannot be installed in (1) areas of concentrated flow or (2) areas where stormwater may be present.

SILT FENCE

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 must 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 within six months.

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

If the fence is supported by wire mesh fencing, then the support posts must not be spaced more than 8 feet apart. If the fence has extra-strength fabric without wire backing, then the support posts must not be spaced more than 6 feet apart.

Spacing between rows of silt fence must 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

Materials: Fabric must 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 must be 2-by-2-inch hardwood or steel posts.

Installation: The location of the silt fence must 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 must 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.

A silt fence must be installed per the manufacturer's instructions and recommendations. At a minimum, a silt fence must 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 must be inspected every 7 days and after every rain event exceeding half an inch of rainfall.

Any fabric tears, decomposition, or inefficiencies in the silt fence must be replaced immediately.

Deposited sediment must be removed every time it reaches half the height of the silt fence at the silt fence's lowest point and every time it causes 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.

Silt fence above has not been properly maintained and overwhelmed with sediment.

Silt fence properly installed with a ‘J’ hook at the end of the run to prevent water from bypassing fence.

FILTER TUBE/FILTER SOCK

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.

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

Specifications for permeable materials are as follows:

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 must be produced using an aerobic composting process meeting 40 CFR 503 regulations, including time and temperature data indicating effective weed seed, pathogen, and insect larvae kill.

Compost must 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 must 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.

Aggregate Specifications:

INDOT CA No. 5 or No. 8 aggregate. 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 must 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 must be overlapped; not abutted.

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 must be spaced no more than five feet apart and driven a minimum of 18 inches deep into the soil.

The stake must be flush with the top of the tube.

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 must be removed and either reconstructed or new product installed.

Traffic must 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.

Filter tube above can be placed horizontally across a slope to shorten a slope’s length and prevent rill and gully erosion.

ROCK CHECK DAM

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 must have a maximum dam height of 2 feet 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

Refer to INDOT Standard Drawings E-205-TECD for Construction Details.

Materials: Utilize an 8-ounce or heavier nonwoven geotextile fabric. INDOT revetment riprap must be used for the dam and well-graded INDOT CA No. 5 aggregate must 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 must 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 must 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

This rock check dam was not built to specification, was not shaped correctly, no filter stone is present, and no geotextile is present. The check dam must be rebuilt.

This check dam is shaped correctly with a low weir in the middle and it is tied into the slopes.

TEMPORARY SEDIMENT TRAP

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.

The pool area must 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 sediment trap pond must completely drain within 48 hours to 72 hours of a rain event.

The outlet must have a capacity designed for a 2-year frequency, 24-hour rain event.

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

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

Materials: Temporary sediment traps must 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 must be inspected weekly and following each rain event. Sediment traps must be repaired immediately if damaged. Check and repair embankment for any erosion and holes.

Remove sediment when it has accumulated to one half the design depth. Check and repair sediment trap pool area side slopes for any erosion.

Replace spillway gravel facing if clogged with INDOT CA No. 5 Aggregate.

Inspect vegetation and, if necessary, seed again.

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.

Sediment trap above does not have filter stone causing sediment to flow through riprap and into waterway.

Sediment trap above placed in appropriate location and constructed correctly to filer sediment.

TEMPORARY DIVERSION

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

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

Installation: Lay out the diversion by setting grade and alignment to fit site needs and topography while 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 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.

DEWATERING

Construction projects occasionally require some form of dewatering operation to allow for construction of building foundations, installation of utility lines, or isolation of work areas in and around waterbodies or stream channels. This usually involves the use of a pumping system which siphons water from a pit or trench. When the dewatering operation draws water from the bottom of the pit or trench, it often agitates the soil material on the bottom and results in a slurry which is pumped outside of the pit or trench. This generally results in the discharge of sediment-laden water.

Operators performing dewatering activities must take into consideration the quality of the water that will be discharged. Typically, sediment will be the primary pollutant associated with the discharge water and can be addressed through a variety of sediment control measures. However, it is not uncommon for groundwater or even surface water to contain other pollutants that can potentially be discharged through dewatering. The presence of other pollutants will typically be associated with the former land use of the project site. Several former land uses of concern might be those sites that are considered stormwater hotspots. If pollutants of concern other than sediment are associated with the discharge water it may be necessary to provide additional treatment and in some situations obtain additional permits to authorize the discharge.

It is extremely important to note that dewatering measures require intensive maintenance and require frequent monitoring, cleanout, repair and/or replacement.

Designs for dewatering operations can be complex and may require site investigation and, depending on the measure selected, the application of sound engineering principles. Flow rates associated with the pumping operation are critical to the overall design and must be considered when selecting a sediment control measure. Measures must also be selected based on their performance during high flow events associated with rainfall. A professional knowledgeable in these applications and experienced in design must be consulted when selecting measures associated with dewatering. Discussions must occur with County officials and IDEM prior to use of dewatering measures.

Installation: Locate the desired outflow location for the dewatering system and coordinate the filter and stabilization method to be used with the installer. Discuss the pump capacity and piping components to be used with the installer. Construct a secondary containment BMP such as a sediment trap near the waterway. Place filter bag on a flat stable surface outside of the waterway behind secondary containment. A filter bag must be placed in a location that it can be removed efficiently without causing damage or losing sediment.

Inspection: Every filter bag must be inspected daily during dewatering operations to see if it is laden with sediment or has become damaged. Piping system must be inspected daily for leaks, kinks, and other conditions for needed repair.

Maintenance: Repair any pumps damaged or not operating properly. Repair or replace filters that exhibit leaks or failure. Filters may need to be replaced when they become laden with sediment. Repair or replace leaking or damaged piping. Repair eroded areas and stabilize.

Filter bags must not be placed in waterways. Bags often break or become dislodged sending sediment downstream.

Filter bags should not be placed in waterways. Bags often break or become dislodged sending sediment downstream.

TEMPORARY SLOPE DRAIN

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.

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

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

Fill must be used and compacted over the pipe to a minimum of a depth of 1 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 must 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

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

A flared-end or “T” type end section must be utilized for the inlet.

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

Installation: Temporary slope drains must be placed on undisturbed soil or well compacted fill. The slope drain inlet must 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 must be 6 inches higher than the adjoining diversion.

All pipe connections must 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 and clean the outlet for erosion or sedimentation. Repair or extend the outlet 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.

Above, a slope drain would have prevented erosion from the underdrain.

Above, slope drain properly constructed with a stable outlet.

INLET PROTECTION

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: Floatable Materials

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

Specifications: Inlet protection must be limited to a one quarter of an acre maximum contributing drainage area.

Inlet protection must be designed to handle the runoff from a 2-year frequency, 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 must be onsite during any storm in excess of the 2-year 24-hour duration rain event.

Materials: Inlet protection must be constructed of a metal frame or basket with a top width and length such that the frame fits into the inlet. Geotextile fabric must 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 on sediment from the street, without flushing with water, to reduce the sediment load on the curb inlet.

GRAVEL DONUT DROP INLET PROTECTION

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

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

Gravel donut drop inlet protection must 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-inch wide 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.

WELDED WIRE INLET PROTECTION

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

Materials: Welded wire inlet protection must 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 must be wrapped 3 inches over the top member of the 6 inch by 6 inch welded wire mesh and must be secured with fastening rings through both geotextile layers and close around a steel member at 6 inches on center.

Geotextile must 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 must extend past the welded wire and be left unsecured for entrenchment.

Welded wire assembly must 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 must 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.

CONCRETE WASHOUT

Significantly Targeted Pollutants: None

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.

Locate concrete washout systems at least 50 feet away from bodies of water or conveyance systems.

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

The washout system must be constructed of straw bales, sandbags, soil material, or other appropriate materials.

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

Installation: Construct a washout base or excavate an earthen pit that is free of rocks and other debris that may cause tears or punctures in the polyethylene lining.

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.

Excess concrete must be removed when the washout system reaches 50% of its capacity.

Dispose of all concrete in a legal manner.

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 must be closed. All hardened concrete and other materials must be properly disposed of and holes, depressions, and other land disturbances associated with the system must be backfilled, graded, and stabilized.

RIPRAP

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: None

Purpose: Riprap is utilized to protect slopes or similar areas subject to erosion by water.

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

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

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

Riprap must be of a size and gradation that will withstand velocities of stormwater discharge flow design.

Riprap must 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 can be less than 3 inches

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 must be one and a half times the design thickness of the riprap (minimum 2 feet) and must extend a horizontal distance equal to the design thickness (minimum 1 feet 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. For permanent installations, inspect riprap every 6 months.

ENERGY DISSIPATOR (OUTLET PROTECTION)

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 storm water flow and dissipating its energy.

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

The maximum velocity through the outlet protection must not exceed 10 feet per second.

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

Outlet protection must 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 may be necessary with higher velocities.

Outlet protection thickness must 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 (inches)	Average Riprap Diameter (inches)	Apron Width (feet)	Apron Length (feet)
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

Materials: Riprap that is hard 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 must 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.

Concrete, gabion baskets, grouted riprap, interlocking concrete blocks, cabled concrete, and turf reinforcement products 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.

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.

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.

This outlet protection is not shaped correctly. Water should flow down the middle of the riprap.

This outlet protection slows the velocity of water exiting the pipe to help prevent soil erosion.

TEMPORARY SEED

Purpose: To provide temporary stabilization for areas for bare soil surfaces.

Specifications: Temporary Seed must follow current *Elkhart County Highway Street Standards*. Temporary Seed must be used on areas that will be untouched for seven (7) or more days.

Installation: Prepare slopes by roughening the soil surface prior to laying seed. If soil is compacted, loosen soil to a depth of 2-3” prior to temporary seeding.

Apply temporary seed mix uniformly over the disturbed, bare soil areas expected to be inactive.

Do not cover the seed with more than one-half inch of soil. Mulching

must take place within 24 hours after the seeding operation.

Inspection: Inspect weekly and within 24 hours after a ½” or more rain event. Look for eroded areas, rills, and gullies. Adequate temporary stabilization is approximately 80 percent vegetation density.

Maintenance: Repair eroded areas by reworking the area and reseeding promptly. Apply mulch to reseeded areas within 24 hours. Fertilize if needed during the active growing season (March through November).

Weeds seen above indicate slow has not been protected for an extended amount of time.

The temporary vegetation and slope drains above provide slope stability.

Post Construction Requirements

Post Construction Stormwater Pollution Prevention Plan (PCSWPPP)

Sites that are not exempt from Elkhart County Ordinance 06-284 must have an approved PCSWPPP. The PCSWPPP must include:

Detailed information on each Post Construction Best Management Practice (BMP).

Operation, maintenance, and repair of all BMPs identified in the construction plan that are remaining in place after construction activities have completed.

Implementation plan for operation and maintenance of provisions set forth on the landscaping plan.

Included with the PCSWPPP, the following requirements must also be met:

A narrative description of the maintenance guidelines for all Post Construction BMPs to facilitate their proper long-term function.

Execution of an enforceable maintenance agreement that designates the parties responsible for the operation, maintenance, and repair of all Post Construction BMPs.

Maintenance records kept for at least five (5) years for all repairs and maintenance done to all Post Construction BMPs. These records must be made available to County officials promptly upon request.

The PCSWPPP must be presented in recordable format. Upon final approval, the executed PCSWPPP will be recorded with the Elkhart County Recorder's Office and will be binding on all future owners, as it will run with the land.

Post Construction Best Management Practices (BMPs) and Low Impact Development (LID)

Planning must be done in the pre-construction phase for adequate site stormwater development after construction has completed. The following pages detail Post Construction BMPs and provisions for Low Impact Development that can be used for varying site conditions. Other BMPs and provisions not included in this manual need to be approved by the plan reviewers prior to implementation.

POST CONSTRUCTION
BMP TABLE OF CONTENTS

EROSION CONTROL BLANKET

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.

Staples, pins or stakes must be used to prevent movement or displacement of the blanket.

Materials: Erosion control blankets must 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 must 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 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.

Adjacent blankets must 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 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 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 must 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 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.

Ditches without blankets will wash the mulch away, disabling grass from growing, and lead to or cause erosion.

Erosion control blanket being used for permanent vegetation establishment and slope protection.

VEGETATED SWALE

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 must be designed by a professional proficient in hydrology and stormwater design and in accordance with the Indiana Storm Water Quality Manual.

Typical storm intensities must be calculated for each specific site location. Swale design must be based on flow rate, not volume. Runoff must pass from the upstream end to the downstream end of the swale in ten minutes.

Swale must 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 required.

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

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

Impermeable soils facilitate ponding and must be avoided.

The bottom of the swale must 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 must be limited to perennial grasses, grass-legume mixes, and prairie mixes.

Species of vegetation chosen must 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 must be maintained at a minimum height of three to four inches.

Installation: Parabolic or trapezoidal cross sections maximize infiltration.

Triangular cross sections must be avoided as they concentrate flow and promote channel erosion.

Side slopes must be maintained at a 3:1 or flatter ratio

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

Swale gradients (slopes) of one to two percent are required.

Swale length must be a minimum of 200 feet to encourage deposition.

Maintenance: Mowing (minimum height of 3 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 swale 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.

DRY DETENTION BASIN

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 must be designed by a professional proficient in hydrology and stormwater design.

Refer to the current edition of the *Elkhart County Highway Street Standards (Elkhart County Roads Guidelines and Standards for Design and Public Improvement)* 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 must 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 must be permeable.

Extended dry basins must be limited to drainage areas of ten acres or more in order to maintain an 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. The basin must be sited on soils 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 must remain below the base of the pond at all times to allow the pond to dry out. Site selection must be chosen to maximize flow path length between the inlet and outlet and allow for maximum stormwater detention and release capability of the basin.

Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting. This can be accomplished with the installation of a sediment forebay pond, or other upstream pretreatment measure. A sediment forebay is an inlet structure separated from the rest of the basin. Sediment forebay ponds are designed to capture sediment before it enters the main body of the detention basin. Sediment forebay ponds are usually separated from the main basin by a wall or berm. Sediment forebay structures act to concentrate sediment in a single area of the basin, making cleaning more efficient and less costly.

Dry extended detention basins must 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 must be limited to a ratio of 3:1. The side slopes of vegetated embankments must be designed at 3:1 (horizontal to vertical). Riprap protected embankments must be no steeper than 2:1. A minimum of one foot of freeboard is recommended above the 100-year storm volume. A geotechnical engineer must evaluate slope stability on sites where the embankment berm is in excess of ten feet. Slopes must 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 need to 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 must be regulated by a standpipe, gate valve, orifice plate, or notched weir. Outlet structures must be designed to allow the controlled release of detained stormwater runoff and must include measures to deter clogging by debris (e.g., trash racks, skimmers, etc.). Outlet structures must be designed with stability in mind and must 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 must incorporate an emergency spillway capable of safely passing a minimum of a 100-year flow event efficiently through the basin. These spillways must be reinforced and capable of withstanding significant flood conditions. Measures must 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.

In much the same way as sediment forebay ponds trap sediment coming into the basin, a similar feature called a micropool can provide additional pollutant removal before water exits the basin. Micropools are relatively shallow, permanent pools or a series of pools. These micropools can be planted with wetland species or include a shelf with wetland species. Micropools are usually constructed at or very near the outlet of the basin and incorporate easy maintenance access into their design.

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

Annually inspect for embankment damage, monitor sediment accumulation in the basin, sediment forebay pond, and micropool.

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

Remove sediment from sediment forebay pond and micropool as needed or when stormwater storage volume is reduced by 25 percent or more.

Remove litter and debris from basin inlet and outlet monthly.

WET DETENTION POND

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 must be designed by a professional proficient in hydrology and stormwater design.

Site must be selected with adequate base-flow to maintain a permanent pool. Underlying soils within hydrologic soil groups C and D can be used as they are typically adequate to maintain a permanent pool.

The contributing drainage area must 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. The final size of the drainage area must be submitted to Elkhart County for review and approval.

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 must be no steeper than 4:1 and must 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 must provide access areas to conduct maintenance.

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

Sediment forebay ponds are recommended.

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.

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 sediment forebay pond annually and after large storm events.

Repair undercut and eroded areas as needed.

As necessary, but at least monthly, clear debris from the inlet and outlet structures and ensure they are operational.

Remove sediment from the forebay the earlier of (1) every 5 to 7 years or (2) when water capacity is reduced by 25 percent.

Remove sediment from the permanent pool every time the volumes are reduced by 25 percent or the pond becomes eutrophic. Sediment removal from the permanent pool must be performed at least every 20 to 25 years.

SEDIMENT FOREBAY POND

Significantly Targeted Pollutants: Sediment

Partially Targeted Pollutants: Floatables

Purpose: Sediment forebay ponds are small structures placed in front of infiltration stormwater quality measures and larger structures such as wet detention ponds, dry extended detention ponds, or constructed wetlands. The purpose of the forebay is to intercept, concentrate, and settle out a majority of the sediment that is coming into the system before it reaches the larger pond or basin. This creates a convenient collection place for sediment cleanout as opposed to performing frequent maintenance on the larger downstream stormwater quality measure.

Specifications: Sediment forebay ponds must be positioned upstream of the larger pond or stormwater management structure and located in an area with easy access for maintenance equipment. A forebay must be located at each inlet that contributes ten percent or more of the design storm inflow.

The size of the sediment forebay pond will vary based on the downstream structure. Approximately 10 to 25 percent of the surface area of the downstream pond must be devoted to the forebay.

Typical depths associated with a forebay are 4 to 6 feet.

If possible, the shape must be long and narrow to facilitate settling of suspended particles. Design to avoid resuspension of previously settled material. Typical length to width ratios are 3:1 to facilitate retention time and removal efficiency.

A barrier to separate the forebay from the permanent structure must be included as part of the design. The barrier may be constructed of permeable soils or materials such as INDOT CA #8 crushed stone. Other options may include a weir, pipe structure, gabion baskets, riprap, pavers, or other nonerosive materials.

The overflow must be able to efficiently pass flows exceeding design specifications; velocities must not be erosive.

Maintenance: Inspect the sediment forebay pond twice per year or more frequently depending upon the amount of sediment that is present in the system.

Cleanout of the sediment forebay pond must occur when sediment buildup reaches 25 percent of the storage capacity of the forebay pond.

SUBSURFACE DETENTION

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, must be designed by a professional proficient in hydrology and stormwater design.

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 and grit separator, hydrodynamic separator, grass swales, wetland/pond system, or other measures into the design of the storage system.

Areas must 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” must 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.

GRAVITY OIL-GRIT SEPARATOR

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 must be determined based on manufacturer's recommendations. Total wet storage area must 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 must be per manufacturer's recommendations.

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

HYDRODYNAMIC SEPARATOR

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 reentrainment. Testing to establish the TSS removal rate of a BMP must be conducted by an independent testing facility.

Floatable controls must 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 are required to be certified by a professional engineer licensed in the State of Indiana.

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

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

BIORETENTION (RAIN GARDEN)

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 must 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 required to provide adequate storage.

Slopes must be 5 percent or flatter.

The bottom of the bioretention system must 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.

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.

CONSTRUCTED WETLANDS

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 must 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 must be provided by incorporating a sediment forebay pond or equivalent 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, but at least 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.

LOW IMPACT DEVELOPMENT TABLE OF CONTENTS

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.

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. It is recommended for the installation of a rain garden to be a minimum of 10 feet away from buildings 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, forebay, or other method to reduce the amount of sediments entering into (or clogging) the rain garden.

Plants must 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 must 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 must 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 cannot be used or considered for a rain garden.

A minimum of 18 inches of uncompacted, engineered and permeable soil must be placed in, at least, the base of the rain garden. The engineered soil must 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, an underdrain or other overflow structure must also be included. 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 must 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 must be by low contact pressure equipment, excavators and/or backhoes and must operate from adjacent ground.

If there is existing desirable vegetation, measures must be taken to have the least amount of impact/removal of this vegetation.

A licensed landscape architect and/or licensed engineer should handle specific design of the rain garden as well as specific types of plants, which would be unique for each site.

Maintenance: Quarterly inspection must occur to (1) confirm the rain garden system is working correctly and (2) properly dispose of any sediment that is 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 must 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 every storm event that creates sitting water. Water must drain within 48 hours, and if it doesn't, some modifications to the system is 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 visit www.inpaws.org (Indiana Native Plant and Wildlife Society) 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, more grasses/sedges could be used. Industrial sites would benefit from a rain garden providing more function than visual appeal.

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 of an obligate wetland status (almost always wet, rarely found in uplands)
    b. Two of a facultative wetland status (usually wet, but occasionally found in uplands)
    c. One of a facultative status (either wet or dry)

2. Two rushes
    a. One of an obligate wetland status (almost always wet, rarely found in uplands)
    b. One of a facultative wetland status (usually wet, but occasionally found in uplands)

3. Four grasses
    a. One of a facultative status (either wet or dry)
    b. Two of an obligate wetland status (almost always wet, rarely found in uplands)
    c. One of an obligate upland status (rarely wet, almost always found in uplands)

4. Twelve Wildflowers/Shrubs
    a. Five of an obligate wetland status (almost always wet, rarely found in uplands)
    b. Four of a facultative wetland status (usually wet, but occasionally found in uplands)
    c. Three of a facultative or facultative upland status (occasionally wet, but usually found in uplands). Please visit plants.usda.gov for more information on wetlands.

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.

Applications: Native plants must 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 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.

Reference Indiana Native Plant and Wildflower Society (INPAWS) at www.inpaws.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.

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.

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 must be taken in choosing the correct rain barrel size to properly hold and discharge stormwater after rain events.

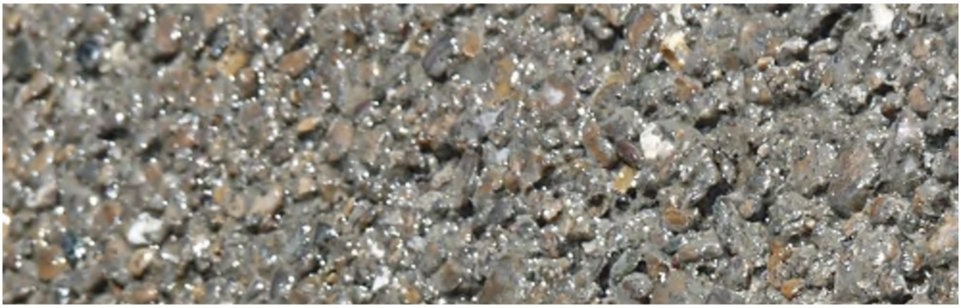
Place a screen at the bottom of the downspout to minimize the amount of leaves and other debris entering the rain barrel.

The rain barrel must 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 must 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.

Inspect, clean, and dispose of any particles or debris in the rain barrel and downspout as needed.



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.

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.

Care must 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 is considered for stormwater overflow from the permeable pavement, the plant selection must 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.

If possible, lawn areas must not drain into a permeable pavement site because of the extra sediment running off from the lawn. This can cause problems with the sediment soaking 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 off of the lawn area.

Design and installation must follow the concrete industry standards and specifications.

Pavement design must allow for water to completely drain, from 12 hours minimum to 72 hours maximum. Soil must be uncompacted, engineered, and permeable for quick percolation. If it seems that water does not infiltrate quickly, an underdrain may be required 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 must 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 must 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 must 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 must be a geotextile fabric on top of existing subgrade.

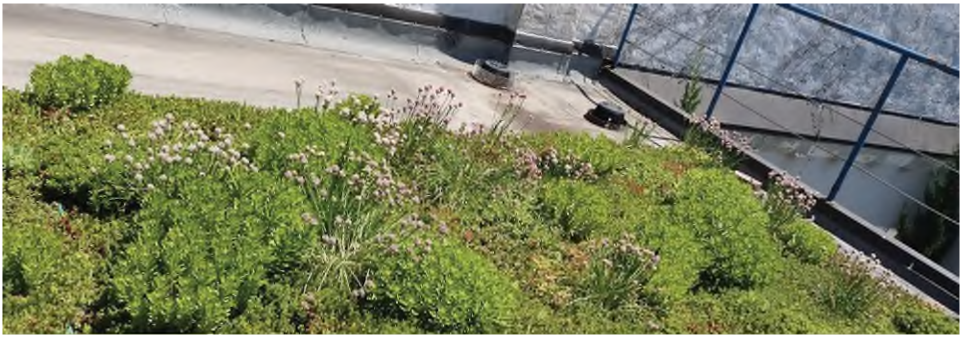
A typical cross section of a gravel grid system must include the grid or ring system with geotextile fabric attached, on top of compacted sandy gravel base to a depth determined by an engineer based on load requirements (typically anywhere from 6 to 12 inches). The base material would then be on top of compacted subgrade. This ring system must then be filled with 3/16” to 3/8” angular, uniform size and washed gravel.

A typical cross section of a grass grid system must include the grid or ring system on top of 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 must 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, must 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: Weekly 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 are not uprooted by the plow being too low and knocking the paver out of place. In addition to snowplows, a street sweeper or vacuum truck may be required, as a preventative measure, 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.



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.

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 must 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 engineer.

State or local standards must be followed in regards to wind resistance of rooftop elements. This is important because of uplift pressures on roofs, which would likely require no vegetation in these areas, but soil can remain intact with an erosion control blanket.

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 is drought tolerant with consideration given to root depths (based on media depth). If the area includes high wind velocities, measures must 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 must be done for water tightness before any additional layers are installed. This must 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 must 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 cannot be assumed. Typically 125 pounds/square foot between columns on the structure is needed to accommodate a roof garden, however a structural engineer must be consulted because every roof and building structure is unique.

Maintenance: Regular inspection of roof membrane system and drainage paths.

Vegetation management is needed to reduce weeds and reestablish any plants that do not survive.

If project engineer deems necessary, annually check on the waterproofing system, and verify that it is watertight below plant and soil cover.

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.

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 then, to the extent possible, the filter strip must be as close to the same width as the impervious surface.

Filter Strips must have a gentle to flat slope. However, 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 must be taken to make this as flat as possible. If possible, cross slope must be 1% or less.

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 must be placed in the filter strip. The engineered soil must have an infiltration rate of at least 1 inch per hour. 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 must be done after mixing the soil to ensure proper drainage before planting the filter strip.

If there is existing desirable vegetation, measures must be taken to have the least amount of impact/removal of this vegetation.

Ideally, only use native plants which can tolerate (1) salt, (2) long periods of wet weather, and (3) long periods of drought. There must be 80% vegetative cover. See “Native Plants” section for typical plant varieties.

A licensed engineer or landscape architect should handle specific design of the filter strip per NRCS Field Guide requirements.

Maintenance: Periodic inspection and proper disposal of any sediments, trash, or large debris is required. If the site allows for a trash receptacle or other container, it should be highly considered for proper disposal of trash or cigarette butts. No trash or cigarette butts should be disposed of by placement on the ground.

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.

Above, a narrow strip of vegetation on the bank is only partially protecting the stream.

Above, use of existing vegetated filter strip along and within the ditch.

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.

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 must be placed at the bottom of the bioswale, with a typical width of 2 feet to 6 feet. The engineered soil must 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 must 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 must 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 must be native and selected based on their tolerance to harsh conditions, including (1) long dry periods, (2) long wet periods, (3) winter snow storage, (4) salt, and (5) sand. See below as well as “Native Plants” section for typical plant varieties.

Longitudinal slope must not exceed 3%, preferable 1% or less, and side slopes must not exceed 2:1 (3:1 preferable, or whatever mower specifications require).

If there is desirable existing vegetation, measures must be taken to have the least amount of impact/removal of this vegetation.

A licensed Landscape Architect and/or an experienced individual supervised by a licensed Professional Engineer should handle specific design of the bioswale.

Maintenance: Weekly inspection and proper disposal of any sediment, trash or large debris is required.

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.inpaws.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 of an obligate wetland status (almost always wet, rarely found in uplands)
    b. One of a facultative wetland status (usually wet, but occasionally found in uplands)
2. Five grasses
    a. One of an obligate wetland status (almost always wet, rarely found in uplands)
    b. Two of a facultative wetland status (usually wet, but occasionally found in uplands)
    c. Two of a Facultative status (either wet or dry)
3. Fourteen Wildflowers/Shrubs
    a. Seven of an obligate wetland status (almost always wet, rarely found in uplands)
    b. Three of a facultative wetland status (usually wet, but occasionally found in uplands)
    c. Three of a facultative status (either wet or dry)
    d. One of a facultative upland status (occasionally wet, but usually found in uplands)

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.

Applications: Infiltration basins can be used in most developed or developable areas where there is open land for the holding basin.

Infiltration basins must 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 must 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 must be one or more 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 must 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 must be taken in order to cause minimal compacting.

A minimum of 18 inches of uncompacted, engineered, and permeable soil must be placed in the infiltration basin. The engineered soil must 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 must 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 must be taken to have the least amount of impact/removal of this vegetation.

A licensed landscape architect or licensed engineer should handle specific design of the infiltration basin.

Maintenance: Periodic inspection of all inlets and catch basins is required to confirm the system is working correctly and to properly dispose 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 must be taken to reduce and mitigate compaction, including limiting all traffic on and around the rain garden.

Inspect basins after large storm events. Water must drain within 48 hours, and if it doesn't, some modifications to the system is necessary (e.g. check compaction rates on soil, add an inlet, or add an underdrain). Water pooled over 48 hours could cause a mosquito problem.

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.

Applications: Hybrid ditches are able to be utilized 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 a hybrid ditch must 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 all inlets and catch basins is required to confirm the system is working correctly and to properly dispose of any sediment that is clogging the system.

Vegetation management is needed to reduce weeds and reestablish any plants that do not survive.

Sediment must be removed and properly disposed, as needed.