4.9. Inlet &Outlet Controls

Inlet &Outlet Controls are the structures or landscape features that manage the flow into and out of a storm water management facility. Flow splitters, level spreaders, curb openings, energy dissipaters, traditional inlets, and curbless design are all examples and elements of inlet controls. Outlet controls regulate the release of storm water from a management facility. Examples of outlet controls include risers and orifices, underdrains, permeable weirs, positive overflows, sub-thermocline basin release, and impervious liners. Outlet control structures limit flow quantity and velocity to meet release rate requirements, reduce discharge flow energy and bypass flows in excess of designed storm water quality volume to prevent re-suspension of sediment, hydraulic overload, or erosion of management practices.

Key elements:

INLET and OUTLET controls must be designed within parameters required by the Fort Wayne's Development Standards/Criteria Manual.

INLET CONTROLS:

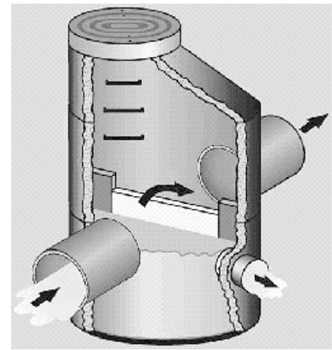
- Flow splitters divert the design water quality volume portion of the storm hydrograph to a management facility or series of facilities, while allowing the flow of larger storms to bypass the facility.
- Curbless roads, streets, and parking lots allow storm water to sheet flow into a BMP.
- Curb openings allow water to flow through a curb that would otherwise block the flow.
- Level spreaders spread out concentrated flow and release it as low velocity, non-erosive diffuse flow.
- Energy dissipaters slow down and spread flow from culverts and steeper slopes.

OUTLET CONTROLS

- Risers and orifices release ponded water at a reduced rate and reduced energy.
- Positive overflows allow storm water to safely flow out of a BMP.
- Underdrains collect water that has filtered through a porous medium and convey it to an outlet.
- Impervious liners prevent water from infiltrating the soil where infiltration is not desirable, such as in designated "hot spot" land uses and/or wellfield protection areas.
- Permeable weirs allow water to flow slowly through smaller openings and more quickly over the top of the weir.
- Level Spreaders spread out concentrated flow and release it as low velocity, non erosive diffuse flow.
- Energy dissipaters slow down and spread flow from culverts and steeper slopes.
- Sub-thermocline basin outlet provides direct discharge from the
- lower area of the water quality and/or quantity storage basin, reducing thermal impacts from heat island land use conditions.

Inlet Controls

Flow Splitter



Flow splitting devices are used to direct a designed water quality storm event into a storm water management facility, while bypassing excess flows from larger events around the facility into a bypass pipe or channel. The bypass typically connects to another storm water management facility or to the receiving drainage system, depending on the design and management requirements. This type of inlet control can also serve as the positive overflow for the BMP. Flow splitters can be constructed by installing diversion weirs in storm water control structures such as inlets and manholes. On a larger scale, they can be constructed using concrete baffles in manholes. Depending on design intent, the flow splitter can also function as a pretreatment facility for other BMP's. Pretreatment facilities can provide a greater level of protection for the BMP as well as decreasing short and long term maintenance.

Design Criteria

There are two basic components involved in the design of flow splitters: the elevation of the bypass structure, which is based on the designed maximum ponding elevation in the BMP, and capacity of the inlet and outlet control structures of the BMP, which control the maximum flow the BMP can receive and discharge.

Bypass Elevation:

The elevation of the bypass baffle or weir dictates the maximum elevation of the water in the BMP. The bypass elevation can be selected by setting it equal to the design storage elevation in the BMP. Flow will only start to bypass the BMP once it exceeds the design storage level of the BMP. The water level in the BMP may exceed the design level for large infrequent storms that utilize the bypass, so the BMP should provide adequate freeboard to prevent overflow.

Pipe Capacity:

The capacity of the influent and effluent pipes can also limit flow into and out of the BMP. Controlling flows in this fashion can help to minimize erosion and scour in the BMP and at the outlet structure. Adequate bypass capacity should be provided for conveyance of storm flow in excess of BMP design.

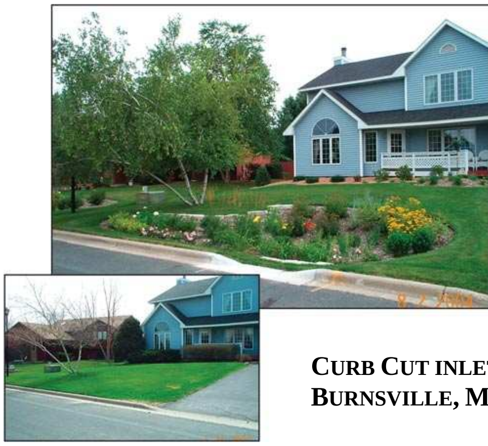
CURBLESS INLET TO BIORETENTION – INDIANAPOLIS, IN

Curbless Design

Curbless designs allow storm water to flow directly from the impervious source to the BMP. This type of design discourages concentration of flow and reduces the energy of storm water entering a management facility. Curbless designs are often used with parking bioretention islands or roadside swales.

Curb Openings

Curb openings provide an alternative inlet control when a curbless design is not possible. Bioretention and landscaped islands in curbed parking lots or roadways often use curb openings as inlet controls. If flow is to be introduced through curb openings, the pavement edge should be slightly higher than the elevation of the vegetated areas. Curb openings should be at least 12 -18 inches wide to prevent clogging (CA Storm Water Manual). Inlet design of the curb openings need to address energy reduction, erosion protection and flow dispersion.



CURB CUT INLET – BURNSVILLE, MN

CURB CUT OUTLET TO FILTER STRIP – RICHMOND VILLAGE SHOPS, RICHMOND, IN

Level Spreaders

Level spreaders are controls that are designed to uniformly distribute concentrated flow into a BMP. There are many types of level spreaders that can be selected based on the peak rate of inflow, the duration of use, and the site conditions. Level spreaders help reduce concentrated flow, thereby reducing energy, erosion and increasing the design life of many storm water facilities. All level spreader designs follow the same principles:

- Concentrated flow enters the spreader via pipes, swales, or curb openings.
- The flow is slowed and energy is dissipated.
- The flow is distributed throughout a long linear shallow trench, behind a low berm, through a channel drain or through a perforated pipe.
- Water then flows over the berm or edge of trench/channel drain uniformly along the entire length.

SEQUENTIAL INFILTRATING LEVEL SPREADERS AND FILTER STRIPS – COFFEE CREEK, CHESTERTON, IN

The following considerations are important when designing and constructing level spreaders:

STABILIZED UPSTREAM AND DOWNSTREAM OF LEVEL SPREADER

- It is critical that the edge over which flow is distributed is level. If there are small variations in height on the downstream lip small rivulets will form. Experience suggests that design variations on the downstream side of the discharge can stop water from re-concentrating and potentially causing erosion downstream of the level spreader. Typically the design includes porous media such as a gravel seam around the discharge area on the downstream side.

- The downslope side of the level spreader should be clear of debris. After construction, debris such as soil, wood, and other organic matter might accumulate immediately upstream and/or downstream of the level spreader. This effectively blocks the level spreader's capability to discharge a diffused flow, forcing it to reconcentrate.

- The downstream side of the level spreader should be fully stabilized before the level spreader is activated. If a level spreader is installed above a disturbed area without sufficient established vegetative cover or other adequate ground cover such as construction matting (straw-coconut blanket), erosion rills will quickly form. Even sheet flow can cause significant downstream erosion on disturbed areas.

- Do not construct level spreaders in newly deposited fill without adequate compaction. Undisturbed and/or compacted earth is much more resistant to erosion than fill. Erosion is even likely to occur over a well-established young stand of grass planted on fill.

- Typical level spreaders are not generally designed for large diameter sediment removal facilities and may require pretreatment of flow prior to entering BMP. Significant sediment and debris deposition in the spreader can render it ineffective.

Types of Level Spreaders

Rock lined or vegetated Channel

Rock-lined and vegetated channels function as level spreaders when the lower (downslope) lip of the channel is level. The channel works best when it is placed along an elevation contour. Channel depths and widths vary greatly upon design need. The depth of the channel depends on the flow and pretreatment design considerations. Smaller rock-lined or vegetated channels do not typically serve as detention devices.

Concrete Troughs and Half Pipes

Concrete troughs 4-12 inches deep can be used as level spreaders. Half sections of pipe can also be used for the same function. The depths of the trough or pipe will depend on the flow. Concrete troughs are a more expensive level spreader alternative; however, they are easy to maintain and have a longer design life. If sediment or debris accumulates in the trough or pipe, it can be easily removed. Concrete level spreaders have design lives of up to 20 years while other level spreader designs may be able to effectively function for a period of 5-20 years. Accordingly, long term maintenance and replacement costs should be lower if installed properly.

Treated and Untreated Lumber
Treated and untreated lumber is not recommended as a level spreading device due to issues with deformation and decomposition.

Composite or plastic lumber
Composite and/or plastic lumber can be beneficial components of a level spreader design.

Level Spreader System Configuration

A typical level spreader system consists of pre-treatment (e.g., a forebay), principal treatment (e.g., a level spreader with grassed buffer), and emergency treatment (e.g., a reinforced grassy swale downslope of spreader). A stilling area such as a forebay is particularly useful upstream of a level spreader, because low energy should be dissipated before the flow enters a level spreader. The forebay will periodically fill with sediment, which must be removed.

Energy Dissipaters

Energy dissipaters are typically engineered devices such as rip-rap aprons or concrete baffles designed to reduce the velocity, energy, and turbulence of the flow. Where applicable, more aesthetically available landscape boulders can also be used. These structures can be employed when highly erosive velocities are encountered at the end of culverts or at the bottom of steep slopes where aesthetics are not a concern. A standard reference for design of these structures is U.S. Army Corps of Engineers, Hydraulic Engineering Center Circular 14 (HEC-14).

Riprap Aprons

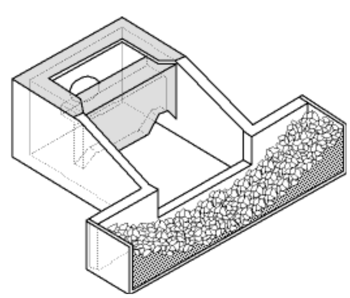
Riprap aprons are commonly used for energy dissipation, due to their relatively low cost and ease of installation. A flat riprap apron can be used to prevent erosion at the transition from a pipe or box culvert outlet to a natural channel. Riprap aprons will provide adequate protection if there is sufficient length and flare to dissipate energy by expanding the flow. City of Fort Wayne Transportation and/or Indiana Department of Transportation (INDOT) typical riprap design standards provide a sound approach for riprap apron design.

Riprap Basins

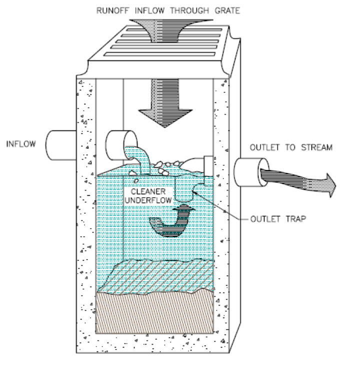
A riprap outlet basin is a pre-shaped scour hole lined with riprap that functions as an energy dissipater. It is recommended that temporary or if necessary permanent upstream sediment pretreatment controls are required to protect the riprap basin.

Baffled Outlets

A baffled outlet is a boxlike structure with a vertical hanging baffle and an end sill. Energy is dissipated primarily through the impact of the water striking the baffle and through the resulting turbulence.



ISOMETRIC VIEW OF BAFFLED OUTLET



CATCH BASIN – ISOMETRIC VIEW
NOT TO SCALE

Inlets and Catch Basins

Traditional inlets and catch basins, although not recommended, may be used as an inflow device for storm water facilities where curb and gutter design is desired or required. The disadvantage of traditional inlets is that the inverts of the outlet pipes are relatively deep, and excavation of storm water facilities may need to be deeper than with curb openings or a curbless design. A standard reference for designing traditional drainage systems is U.S. Army Corps of Engineers, Hydraulic Engineering Center Circular 22 (HEC-22). Any inlet or catch basin that connects to a BMP must have at least a one (1) foot sump.

Maintenance Concerns for Inlet Controls

Table 4.9.1: Inlet Maintenance Guidelines

	Activity	Schedule
	Inlet control devices should be inspected after several storms to ensure that they are functioning properly and that there are no erosion or debris problems developing. Source of sediment contamination should be identified and controlled when native soil is exposed or erosion channels are present.	As needed from monthly (minimum) inspection
	Inspected for sediment and debris buildup. Sediment buildup exceeding 2 inches in depth or that begins to constrict the flow path should be removed. Clean out leaves, trash, debris, etc.	As needed from monthly (minimum) inspection
	Maintain records of all inspections and maintenance activity. Include estimate of sediment and/or debris removed Indicate sediment and/or debris disposal methods	Ongoing, with documentation of each monthly inspection report

Outlet Controls

Risers and Orifices

An orifice is a circular or rectangular opening of a prescribed shape and size that allows a controlled rate of outflow when the orifice is submerged. When it is not submerged, the opening acts as a weir. The flow rate depends on the height of the water above the opening and the size and edge treatment of the orifice. A riser is a vertical structure with one or more orifices that provide the controlled release in combination.

Control structures may consist of several orifices and weirs at different elevations to meet storm water management requirements. Multiple orifices may be necessary to meet the water quality volume and/or flood protection performance requirements for a detention system. Orifices may be located at the same elevation if necessary to meet performance requirements. Small orifices are sometimes needed when a storm water management system must meet low flow rate requirements.

CURB CUT INLET AND OVERFLOW OUTLET, BIORETENTION, INDIANAPOLIS, IN

Protection from Clogging

Protection from clogging is required for any orifice size. Small orifices used for slow release applications can be susceptible to clogging, which prevents the structural control from performing its function and potentially causing adverse impacts. Design measures can be taken to prevent clogging. These measures are most effective when used in combination with periodic inspection and maintenance.

BIORETENTION POSITIVE OVERFLOW OUTLET – DILLON PARK, HAMILTON COUNTY, IN

Positive Overflows

A positive overflow permits storm water to flow out of the BMP when the water level reaches a maximum design elevation in a subsurface feature or a maximum ponding depth in a surface feature. Flow through the positive overflow can either connect to another BMP or an approved point of discharge. A multi-stage outlet control may include a number of orifices for controlled flow and a positive overflow to quickly pass flow during extreme events. Overflow structures should be sized to safely convey larger storms from the BMP. If flow reaches the BMP via a flow splitter, this structure can provide the positive overflow.

Underdrains

Underdrains are conduits, such as perforated pipes, horizontal gravel seams, and/or gravel filled trenches that intercept, collect, and convey storm water that has percolated through soil, and engineered media, a suitable aggregate, and/or geotextile. Perforated underdrains are an outlet control when the collected water contributes to storm discharges as regulated under the Fort Wayne's Development Standards/Criteria Manual. Underdrains may be used in combination with other techniques such as bioretention to regulate outflow. Design of underdrains should consider the following criteria based on site specific conditions and the Fort Wayne's Development Standards/Criteria Manual:

- A permeable filter fabric is placed between the gravel layer and surrounding soil to prevent sediment contamination.
- Clean out access must be provided for all underdrain systems. Clean outs shall be placed, at a minimum, at each underdrain turn fitting.

Impervious Liners

Impervious liners are considered an outlet control because they prevent water from infiltrating and thus crossing a system boundary. Impervious liners may be selected from the following four types: compacted till liners, clay liners, geomembrane liners, and concrete liners. Underdrains can be used in conjunction with impervious liner design as long as the underdrain outlet does not conflict with the impervious liner function.

Permeable Weirs

Permeable weirs are typically constructed from composite or plastic lumber stacked with spaces between each timber to provide long, narrow openings that slowly pass storm water. They have the appearance of a wooden fence. Under low flow conditions, water ponds behind the permeable weir and slowly seeps through the openings between the timbers, functioning like a dry extended storage pond. Under high flow conditions, water flows both over and through the weir.

Permeable weirs are generally used in wetland areas, constructed water quality treatment ponds, water quality swales, and/or pretreatment forebays. They promote sedimentation by slowing flow velocities as water ponds behind the weir. They also provide a means of spreading runoff as it is discharged, helping to decrease concentrated flow and reduce velocities as the water travels downstream.

Maintenance Concerns for Outlet Controls

Table 4.9.2: Outlet Maintenance Guidelines

	Activity	Schedule
	Outlet control devices should be inspected after several storms to ensure that they are functioning properly and that there are no erosion or debris problems developing. Source of sediment contamination should be identified and controlled when native soil is exposed or erosion channels are present.	As needed from monthly (minimum) inspection
	Inspected for sediment and debris buildup. Sediment buildup exceeding 2 inches in depth or that begins to constrict the flow path should be removed. Clean out leaves, trash, debris, etc.	As needed from monthly (minimum) inspection
	Maintain records of all inspections and maintenance activity. • Include estimate of sediment and/or debris removed • Indicate sediment and/or debris disposal methods	Ongoing, with documentation of each monthly inspection report

Note:

Design of inlet and outlet controls are not limited to the examples shown within this text. Successful storm water management plans will combine appropriate materials and designs specific to each site.

4.9.1. Inlet and Outlet Controls Designer/Reviewer Checklist

Type of inlet control proposed____

Type of outlet control proposed ____

Item	Yes	No	N/A	Notes
Rate of inflow/outflow calculated?				
Properly sized for drainage area, flow, pollutant capture?				
Adequate freeboard to prevent overflow?				
Proper bypass elevation?				
Manufacturer's recommendations followed?				
Details provided for device and connections?				
Erosion control provided, if necessary?				
Easy access/visibility for maintenance?				
Orifice protected from clogging?				
Avoidance of stormwater concentration as much as practical?				
Slope considered and appropriate?				
Receiving vegetation considered?				
Located in undisturbed virgin soil?				
If not, will soil be properly compacted and stabilized?				
Acceptable minimum flow path length below BMP?				
Appropriate vegetation selected for stabilization?				
Feasible construction process and sequence?				
Erosion and sedimentation control provided to protect spreader?				
Maintenance accounted for and plan provided?				
If used during construction, are accumulated soils removed?				

THIS PAGE LEFT BLANK INTENTIONALLY