CHAPTER 6
STORMWATER MANAGEMENT

6.1 Introduction

Urban and suburban development typically increases impervious surfaces (i.e. pavement and rooftops) which in turn increases the volume and velocity of stormwater discharges. These changes can influence the integrity of the natural stream corridor, which can degrade water quality through the discharge of eroded bank material. Additionally, stormwater runoff from development typically carries a higher load of nutrients and pollutants that can degrade the water quality of receiving lakes and streams.

A nested approach to capturing and treating stormwater runoff will alleviate many of the impacts of development on downstream water quality in addition to providing flood protection. This approach includes; runoff reduction, the treatment of the water quality volume, channel protection, reduction in downstream flooding by detention/retention, and routing of the overflow condition for extreme flood events. Each step in this nested stormwater management strategy provides varying levels of runoff quality and quantity control.

6.2 Runoff Reduction

The idea behind runoff reduction is the removal of a portion of the runoff volume as opposed to capturing that runoff and delaying its release. Runoff reduction can be accomplished through any one or a combination of the following: infiltration, interception and evapotranspiration or capture/reuse. These alternatives allow the post-developed hydrograph to mimic the pre-developed condition and increases groundwater recharge. Per the Stormwater Ordinance, at least 10% of the water quality volume must be addressed through runoff reduction.

To reduce runoff on new development sites the following options are available:

a. Retain 10% of the total site in trees, grassland or deep-rooted vegetation (shallow-rooted turf grass is not allowed). This 10% of the site must be outside of the Streamside buffer, if applicable.

b. Re-establish 12% of the total site in trees or deep-rooted vegetation.
   1) If planting trees, the density requirement is 6 trees per acre, with a minimum size of 1.5 caliper.
   2) If re-establishing native vegetation, the requirement is 80% coverage after two years.

c. Capture and reuse 10% of the water quality volume

d. Engineered infiltration

e. Any combination of the above.
1. **Runoff Reduction with deep-rooted vegetation to aid in infiltration.**

   Historic prairies, wetlands and savannas once occupied millions of acres in North America. Annual plants like corn, or shallow rooted species like bluegrass, have primarily replaced historic communities of deep-rooted, long-lived species (Apfelbaum, 1993). These changes to plant ecosystems have compacted and modified the soil capability to hold water and absorb nutrients.

   The native prairie vegetation once contained up to 70% of its biomass below ground. This extensive root system was efficient at carbon fixation, increasing soil organic matter content and infiltration. The soils under the deep roots are able to absorb and hold water in pore spaces throughout the entire rooting depth. Bharati et al., 2002, found that the re-establishment of deep-rooted vegetation improved soil quality and water infiltration after only six years.

   Trees also provide numerous water quality benefits, including reductions in stormwater runoff. The tree canopy can capture rainfall, and during hot summer months, much of that water evaporates before it reaches the ground. The duff or leaf layer also stores water like a sponge and works to decompose the vegetation. The root system uses the remaining rainwater that enters the soil, which is then transpired back to the atmosphere.

2. **Runoff Reduction with Interception/Evapotranspiration**

   Although smaller landscaping plants and bushes can provide some interception and evapotranspiration, substantial runoff reduction will come from retaining existing trees and planting new ones. Trees provide runoff reduction via interception, transpiration, and increased infiltration. Additional environmental benefits include improved air quality, reduced heat island effects, pollutant removal and habitat preservation or formation. The degree of runoff reduction provided by trees depends mainly on the tree type (i.e., evergreen or deciduous), canopy area, and the maturity/size of the tree. For an estimate of the amount of interception per tree species, see [http://www.treebenefits.com/calculator/](http://www.treebenefits.com/calculator/)

3. **Runoff Reduction with Capture/Reuse**

   As many sites look for additional ways to address sustainability, capture and reuse of stormwater – also known as stormwater harvesting – has become an increasingly popular method of runoff reduction. Storage and reuse techniques range from small-scale systems such as rain barrels to cisterns (underground or otherwise) that may hold large volumes of water.

   The water captured from a roof tends to be relatively clean (depending on atmospheric conditions, roof material and condition) and often can be used to reduce the potable water used for fire suppression, toilet/urinal flushing or custodial uses with minimal treatment (some facilities rely on a simple swimming pool filter and
chlorine injector). This does require a parallel water system (gray water lines) as this water should not be combined with the potable water source.

Captured rainwater can also be used for landscape irrigation during dry periods. This water would not need to be treated to the same degree as that used for the toilet flushing, but care may need to be taken to remove any solids of a size that could clog the irrigation system. This is especially important if parking lot runoff is used.

Some of these systems can rely on gravity to convey the water while others require some kind of pressurization. This issue should be considered in the design. Cost and frequency of maintenance should also be considered.

The County will allow the designer to assume that the facility will be completely drained between storms. However, an overflow system should be provided when the capacity of the facility is exceeded.

4. Engineered Infiltration
Engineered infiltration is the use of a highly pervious media underlain by an aggregate bed for temporary storage and infiltration of stormwater runoff. Subsurface infiltration is well suited for expansive, generally flat open spaces, such as lawns, meadows, and ball fields, which are located downhill from nearby impervious areas. Stormwater runoff from impervious areas (including rooftops, parking lots, roads, walkways, etc.) is conveyed to the subsurface storage media, and distributed via a network of perforated piping. The storage media typically consists of clean washed, uniformly graded aggregate. However, other proprietary alternatives are available. These alternatives are generally variations on plastic cells that more than double the storage capacity of aggregate beds. Storage media alternatives are suited for sites where potential infiltration area is limited. If designed, constructed, and maintained these features can stand-alone as stormwater runoff volume, rate and quality control practices. If connected to shallow groundwater, then these systems can also maintain aquifer recharge, while preserving valuable open space.

6.3 Treatment of the Water Quality Volume
In order to reduce nonpoint source pollution from a development, the engineer should review the types of pollutants expected from the various surfaces and work to address the pollutant load in the “first flush”, typically defined as the water quality volume (defined in Chapter 3) less any volume subtracted through runoff reduction. In order to do this, the engineer should look for ways to reduce runoff (system disconnection and infiltration, evapotranspiration and/or capture-reuse) to the maximum extent practicable. Then, the remainder of the water quality volume should be treated in BMPs appropriate to the types of pollutants expected. At this time, specific numeric discharge limits and/or pollutant removal rates are not being prescribed. However, as state and federal laws change, the County may re-evaluate the need to set pollutant limits.
1. Design Guidance for Water Quality BMPs

Design criteria for the sizing of the more common stormwater quality BMPs appear in the Mid-America Regional Council (MARC) Manual of Best Management Practices for Stormwater Quality dated March 2008. BMP design criteria are rapidly developing and regularly being refined. If the Engineer prefers to use another source for design guidance, the source should be cited within the design calculations. Sizing information for proprietary BMPs is usually available from the manufacturer and should also be cited as such.

Various land uses and cover types produce different types of pollutants and impact stormwater volumes and velocities in different, but predictable, ways. This section provides general information related to stormwater quality BMPs in addition to a discussion of how each land use type can be addressed.

a. Treatment of Discharge from Buffer Areas and Forests

Natural vegetation provides filtration, infiltration and evapotranspiration of most of the rainfall in these areas and therefore no specific treatment is required for runoff from these areas. Protection of these areas and guidelines for maintenance should be included in the overall post-construction stormwater management operation and maintenance plan. These areas should still be included in the overall runoff calculations for stormwater quantity management.

b. Treatment of Discharge from Rooftops

The runoff discharged from rooftops is relatively clean. The biggest concerns are the temperature of the runoff, any pollutants picked up from the atmosphere and the overall quantity of the water. This water can be reused as a no potable source which is addressed above in Runoff Reduction. When rooftop water is captured and reused, this can serve as both the water quantity and quality BMP. The only additional treatment necessary will be dictated on the type of reuse. For instance, if roof runoff is used for toilet flushing, the water may need additional treatment (filter, chlorination, uv, etc) to be suitable for this purpose. Likewise, if the runoff is used for irrigation, treatment may be needed to prevent clogging of the irrigation system.

If rooftop water is not going to be captured and reused, measures must be taken to address the impacts of the runoff. However, if this water is allowed to discharge across a driving surface, it could pick up significantly more contaminants. Therefore, this should be avoided whenever possible. Additionally, remove direct connection of rooftop water from the storm sewer system whenever feasible.
c. **Treatment of Discharge from Managed Lawns/Landscaped Areas**
   The runoff discharged from managed lawns and landscaped areas can contain a variety of pollutants from pesticides, herbicides, fertilizers and animal sources. Poorly maintained areas that are actively eroding can also be a source of sediment discharge. Where these areas are near pedestrian or vehicle traffic, litter may be an additional issue. Runoff resulting from the water quality volume that has not been removed through runoff reduction will need to address these issues. Additionally, non-structural measures should be included in the overall post-construction stormwater management operation and maintenance plan. This may include standard operating procedures for care of these areas related to agrochemical application, mowing height, litter removal, etc.

d. **Treatment of Discharge from Parking Lots/Driveways/Roads**
   The runoff discharged from parking lots, driveways and roads can contain a wide variety of pollutants including particulates, nitrogen, phosphorus, lead, zinc, iron, copper, cadmium, chromium, nickel, manganese, cyanide, sodium chloride, calcium chloride and sulphates, and phenols. Additionally, litter from these areas is a primary source of floatables in the receiving water bodies. Water temperature from parking lots can reach levels that are toxic to fish in the receiving waterbody. Runoff resulting from the water quality volume that has not been removed through runoff reduction will need to address these issues. Up to 25% of a site’s total impervious surfaces may discharge in a sheet flow condition through existing established vegetation such as may exist in a stream buffer without otherwise being treated. However, this quantity should still be considered in the overall stormwater quantity management.

e. **Treatment of Off-Site Stormwater:** Off-site stormwater conveyed through a land development shall be placed within an easement and conveyed in a manner that does not increase upstream or downstream flooding. Off-site stormwater shall be conveyed around on-site stormwater BMPs, unless the facilities are designed to manage the off-site stormwater. The Director may allow the treatment of off-site stormwater in lieu of the treatment of the entire site’s water quality volume.

f. **Additional Criteria for Stormwater Hotspots:** In addition, stormwater discharges from stormwater hotspots may require the use of specific structural, non-structural, and/or pollution prevention practices, including enhanced pre-treatment. Discharges from a stormwater hotspot shall not be infiltrated without enhanced pre-treatment, as approved by the Director.
g. **Landscape Plan:** The design of vegetative stormwater BMPs shall include a landscape plan detailing both the vegetation in the BMP and the maintenance requirements, and who will manage and maintain the vegetation.

2. **Pre-treatment for Water Quality BMPs**

Even after site stabilization, BMPs may need adequate pre-treatment to filter coarse pollutants such as sediment and grit to promote long-term functionality. Some fine media filter systems such as sand filters and some proprietary products may also need pre-treatment in order to minimize operation and maintenance costs and activity intervals. A coarse stone diaphragm, settling forebay, vegetative swale/buffer or hydrodynamic separator could serve this purpose.

Pre-treatment may also be needed for BMPs that detain/retain runoff to reduce the operation and maintenance requirements. Detention/retention ponds do very little to address water quality, therefore a forebay or similar pre-treatment method should be used to reduce sediment, trash and nutrients from entering downstream water and reduce the need for expensive dredging or cleaning of the basin.

3. **Protection of Water Quality BMPs from Construction Site Runoff**

BMPs that rely on infiltration such as bioretention, rain gardens and infiltration basins or trenches, will clog if exposed to excessive sediment. Most permanent stormwater treatment BMPs will need to be installed only after the construction site has been stabilized. BMPs that rely on settling and filtration could likewise require extensive maintenance to preserve functionality.

6.4 **Channel Protection**

As urbanizing areas are converted from fields to impervious surfaces, the volume of runoff and the frequency of "channel-forming" events increases substantially. Research suggests that this change in hydrology can cause channels to expand to two to five times their original size (Hammer, 1972, Moriwasa and LaFlure, 1979, Allen and Narramore, 1985 and Booth, 1990). Channel erosion, on average, is estimated to account for 66% to 75% of the sediment load in urban watersheds (Trimble, 1997 and Dartinguenave *et al.*, 1997).

To reduce channel erosion on downstream properties and protect in-stream habitats, the stormwater system shall be designed so that post-development discharges will not erode natural channels or steep slopes. The following Tier 1 and/or Tier 2 Performance Criteria are required for all developed sites.

1. **Tier 1 Performance Criteria:** sites having less than 5 acres of land disturbance and less than 20% imperviousness on the entire tract shall apply the following performance standards:
a. Wherever practical, maintain sheet flow to riparian buffers or vegetated filter strips. Vegetation in buffers or filter strips must be preserved or restored where existing conditions do not include dense vegetation.
b. Energy dissipaters and/or level spreaders must be used to spread flow at outfalls.
c. On-site conveyances must be designed to reduce velocity through a combination of sizing, vegetation, check dams, and filtering media (e.g., sand) in the channel bottom and sides.
d. If flows cannot be converted to sheet flow, they must be discharged at an elevation that will not cause erosion or require discharge across any constructed slope or natural steep slopes.
e. Outfall velocities must be non-erosive from the point of discharge to the receiving channel or waterbody where the discharge point is calculated.

2. **Additional Performance Criteria for Tier 2 sites**: Sites greater than 5 acres of land disturbance OR greater than 20% imperviousness on the entire tract shall apply the performance standards in subsection (1), in addition to the following performance standards:

   a. Site design techniques that decrease runoff volumes and peak flows. This shall be accomplished by controlling the post-development peak discharge rate to the pre-development rate.

      This criterion shall be met for the 2-year, 24-hour storm event, (or equivalent storm runoff volume using other methodologies). The release rate shall be equal to or less than the 1-year, 24-hour storm event. Boone County will give credit for the application Runoff Reduction and WQv measures towards meeting the storage requirements.

      OR

   b. In an effort to encourage micro-detention and utilize stormwater BMPs to detain stormwater, the difference (increase) in the runoff volume that is predicted due to the development during the 2-year event will be stored and released at no more than 0.1 cfs/acre; providing that 75% of the water leaving the site drains through at least one of storage basin, and that the volume stored accounts for the added runoff from the entire disturbed site. See Chapter 3 for calculation procedures.

### 6.5 Flood Control

Stormwater detention facilities are designed specifically to receive and temporarily hold stormwater runoff to provide channel protection and prevent downstream flooding. Detention facilities can delay the discharge of peak flows and reduce velocities to minimize stream bank erosion in downstream waterbodies. Retention facilities are
established for permanent storage of water; only releasing water during the design storm or through evaporation and groundwater recharge. Stormwater storage BMPs that rely primarily on infiltration and evapotranspiration can more closely mimic the pre-development hydrology of the site.

Extensive consideration should be given to Low Impact Development techniques that allow dispersed micro detention to better mimic the site’s original hydrology. Swales, rain gardens, Bioretention and constructed wetlands, infiltration basins/trenches, etc can achieve both water quantity and water quality control goals. Many of these systems may not be sufficient to control peak flood control volumes. Overflow systems and additional storage may be necessary to fully control peak discharges.

**Flood Control Criteria:** Downstream overbank flood and property protection shall be provided by controlling the post-development peak discharge rate to the pre-development rate. This criterion shall be met for the 25-year, 24 hour storm event on property zoned REC, REC-P, C-O, C-N, C-G, C-GP, M-L, M-LP, M-G, M-GP.

Stormwater BMPs that impound water shall demonstrate that the 100-year storm can safely pass through the structure without overtopping or creating damaging conditions downstream.

1. **Discharge to Large Waterbody:** The land development discharges directly to a flood plain, major river or waterbody and the Director determines that waiving the flooding criteria will not harm public health and safety. The applicant shall secure drainage easements from any downstream property owners across whose property the runoff must flow to reach the flood plain, major river or waterbody. The applicant shall also demonstrate that any piped or open-channel system in which the runoff will flow has adequate capacity and stability to receive the project’s runoff plus any off-site runoff also passing through the system.

2. **Insignificant Increases in Peak Flow:** The land development results in insignificant increases in peak flow rates, as determined by the Director.

3. **Alternative Criteria Provided:** The land development is subject to a floodplain study that recommends alternative criteria for flood control.

4. **Increases in Downstream Peak Flows or Flood Elevations:** The Director determines that complying with the requirements of this section will result increases in peak flows or downstream flooding conditions due to coincident peaks from the site and the contributing watershed or another factor.

5. **Documentation for Waiver:** When seeking a waiver in accordance with either (1), (2), (3) or (4) above, the applicant shall demonstrate that stormwater discharges will not unreasonably increase the extent, frequency, or duration of flooding at downstream properties and structures or have an unreasonable adverse effect on
streams, aquatic habitats, and channel stability. In making its determination to allow full or partial waivers, the Director shall consider cumulative impacts and the land development’s adherence to the land use plans and policies of Boone County, including the promotion of infill and redevelopment in particular areas.

6.6 Redevelopment Criteria

Redevelopment is any development that creates or adds three thousand (3,000) square feet or more of impervious cover by modifying a previously existing improved property. This includes the building of structures, filling, grading, paving; (including the conversion of gravel areas to pavement), or excavating.

Redevelopment excludes ordinary maintenance activities such as remodeling of buildings on the existing footprint, resurfacing and/or repaving of existing paved areas, and exterior changes or improvements that do not materially increase or concentrate stormwater runoff or cause additional nonpoint source pollution.

Land development that qualifies as redevelopment shall meet one of the following criteria:

1. **Reduce Impervious Cover:** Reduce existing site impervious cover by at least 20%.

2. **Provide Treatment:** Provide water quality treatment for at least 20% of the site’s pre-development impervious cover and 100% of any new impervious cover, not to exceed 150% of the total new impervious.
   
   a. This can be accomplished through stormwater BMPs designed in accordance with the criteria in Ordinance Sections 4.2 through 4.3 and the Boone County Stormwater Design Manual.
   b. Runoff reduction may be used instead of water quality treatment on land zoned Residential, Transition or Agriculture where the lot size is at least 2.5 acres and impervious cover is less than 10%.

3. **Apply Innovative Approaches:** Utilize innovative approaches to reduce stormwater impacts across the site. Examples include green roofs and pervious parking materials.

4. **Provide Off-Site Treatment:** Provide equivalent stormwater treatment at an off-site facility within the same watershed and as immediately downstream of the site as feasible.

5. **Address Downstream Issues:** Address downstream channel and flooding issues through channel restoration, increase in existing system capacity and/or other off-site remedies.
6. Combining of Measures: Any combination of (1) through (5) above that is acceptable to Boone County Public Works.

6.7 Detention and Infiltration Basin Requirements

Stormwater detention facilities are designed to receive and temporarily hold stormwater runoff to protect downstream areas from flooding. Detention facilities can delay the discharge of peak flows and reduce velocities to minimize streambank erosion in downstream waterbodies. On the other hand, retention facilities are for the permanent storage of water; only releasing water during the design storm or through evaporation and groundwater recharge.

1. General Provisions:
   a. Dams which are greater than 10 feet in height but do not fall into State or Federal requirement categories shall be designed in accordance with the latest edition of NRCS (SCS) Technical Release No. 60, “Earth Dams and Reservoirs”, as highest hazard rated structures.

   b. All lake and pond development must conform to local, state, and federal regulations. Legal definitions and regulations for dams and reservoirs can be found in the Missouri Code of State Regulations, Division 22.

   c. The water surface of the design storage pool shall be a minimum of 20 feet from building structures. A greater distance may be necessary when the detention facility might compromise foundations or if slope stability is a consideration. The vertical separation between the maximum ponding elevation and the lowest floor of applicable surrounding structures shall be a minimum of 2.0 feet.

   d. In developments where a public street is proposed across the dam of a permanent lake, a right-of-use agreement shall be executed between Boone County and the developer/owner. This right-of-use agreement shall specify that Boone County will maintain the street pavement, sidewalk, street curb inlets and the accompanying piping. The ownership, maintenance of the dam, outlet structures and overflow spillway shall be the responsibility of the developer/owner, homeowners association or other identified responsible party.
2. **Primary Outlet Works**
   The primary outlet shall be designed to meet the following requirements:

   a. The outlet shall be designed to function without requiring attendance or operation of any kind or requiring use of equipment or tools, or any mechanical devices.

   b. All discharge from the detention facility when inflow is equal to or less than the 25-year inflow shall be via the Primary outlet.

   c. The design discharge rate via the outlet shall continuously increase with increasing head and shall have hydraulic characteristics similar to weirs, orifices or pipes.

   d. For dry detention basins, the design shall allow for discharge of at least 80 percent of the detention storage volume within 24 hours after the peak or center of mass of the inflow has entered the detention basin.

   e. Retention basins (Ponds) shall be designed with a non-clogging outlet such as a reverse-slope pipe, or a weir outlet with a trash rack. A reverse-slope pipe draws from below the permanent pool extending in a reverse angle up to the riser and establishes the water elevation of the permanent pool. Because these outlets draw water from below the level of the permanent pool, they are less likely to be clogged by floating debris.

   f. The Director may require openings be protected by trash racks, grates, stone filters, or other approved devices to insure that the outlet works will remain functional.

3. **Emergency Spillways and Draw Down**
   The emergency spillway may either be combined with the outlet works or be a separate structure or channel meeting the following criteria:

   In cases where the impoundment/emergency spillway is not regulated by either State or Federal agencies, the emergency spillway shall be designed to pass the 100 year (1% annual chance) storm with 1 foot of freeboard from the design stage to the top of dam, assuming zero available storage in the basin and zero flow through the primary outlet. This design provides an added level of protection in the event of a clogged primary outlet or a subsequent 100 year (1% annual chance) storm event that occurs before the flood pool from the initial storm event recedes to the principal outlet elevation.

   Drain works consisting of valves, grates, pipes, and other devices as necessary to completely drain the facility in 72 hours or less when required for maintenance or inspection shall be provided. Pumping will be considered an alternative if the design engineer can show this is a readily available, viable solution.
4. **Erosion Control**
Primary outlet works, emergency spillways, and dams, as well as conveyance system entrances to detention basins, shall be equipped with energy dissipating devices as necessary to limit shear stresses on receiving channels.

5. **Retention Facility or Wet Pond**
For basins designed with permanent pools a sediment forebay shall be provided to trap coarse particles. The minimum normal depth of water before the introduction of excess stormwater shall be four feet. If the pond is to contain fish, at least one-quarter of the area of the permanent pool must have a minimum depth of 10 feet. The side slopes shall conform as closely as possible to regraded or natural land contours, and should not exceed three horizontal to one vertical. Slopes exceeding this limit require erosion control, reasonable safety measures and a geotechnical analysis.

6. **Detention Facility or Dry Pond**
For facilities designed to be normally dry, a sediment forebay shall be provided to trap coarse particles. Provisions must be incorporated to facilitate interior drainage to outlet structures. Grades for drainage facilities shall not be less than 1½ percent. Paved trickle channels are prohibited. Earth bottoms shall be sodded or vegetated with appropriate native, non-invasive vegetation. A turf-type tall fescue blend is an acceptable alternative. The side slopes of dry ponds should be relatively flat to reduce safety risks and help to lengthen the effective flow path. Slopes shall not be steeper than three horizontal to one vertical.

7. **Multipurpose Feature**
When possible, dry detention facilities can be designed to serve secondary purposes for recreation, open space, or other types of use which will not be adversely affected by occasional or intermittent flooding.

8. **Rooftop Storage**
Detention storage may be met in total or in part by detention on roofs. Details of such designs shall include the depth and volume of storage, details of outlet devices and downdrains, elevations and details of overflow scuppers, and emergency overflow provisions. Consideration shall also be given to wave action on structural loading conditions. Connections of roof drains to sanitary sewers are prohibited. Design loadings and special building and structural details shall be subject to approval by the **Director of Resource Management**.

Additionally, “green” roof technology that utilizes plant material to provide storage, treatment and evapotranspiration of the stormwater can be utilized to achieve quantity control requirements as well as water quality objectives. The green roof industry has a resource portal at [www.greenroofs.com](http://www.greenroofs.com)

9. **Parking Lot Storage**
Parking lots paved with traditional impervious pavements may be designed to provide temporary detention storage of stormwater on a portion of their surfaces. Generally,
such detention areas shall be in the more remote portions of such parking lots. Depths of storage shall be limited to a maximum depth of six inches, and such areas shall be located so that access to and from parking areas is not impaired.

Parking lots paved with pervious pavements or that are designed with innovative turf reinforcement techniques may be designed to provide temporary detention storage of stormwater below their surface in the pore spaces of granular media. The designer should consider the infiltration rate of the soil beneath the media and provide underdrains as necessary to allow for discharge of at least 80 percent of the detention storage volume within 24 hours after the peak or center of mass of the inflow has entered the detention system through either infiltration to the soil or through the underdrains or a combination thereof.

10. Underground Storage
All or a portion of the detention storage may also be provided in underground detention areas, including, but not limited to, oversized storm sewers, vaults, tanks, etc.

Design underground detention facilities with adequate access for maintenance (cleaning and sediment removal). Provide such facilities with positive gravity outlets. Venting shall be sufficient to prevent accumulation of toxic or explosive gases.

11. Other Storage
Extensive consideration should be given to Low Impact Development techniques that allow for dispersed microdetention to better mimic the site’s original hydrology. Swales, rain gardens, bioretention and constructed wetlands infiltration basins/trenches, etc can achieve both water quantity and water quality control goals. Additionally, storage and reuse of stormwater for irrigation or toilet flushing is highly encouraged. Many of these systems may not be sufficient to control peak flood control volumes. Overflow systems and additional storage may be necessary to fully control these peak discharges.

6.8 Required Submittals for Detention and Infiltration Basins
The Owner shall submit the following information and data to the Director.
1. Elevation-area-volume curves for the storage facility including notation of the storage volumes allocated to runoff, sediment, and permanent residual water storage for other uses (wet basins only).
2. Inflow hydrographs for all design storms.
3. Stage-discharge rating curves for the emergency spillway, primary outlet works and combined outlets and overflows.
4. Routing curves for all design storms with time plotted as the abscissa and the following plotted as ordinates:
   a. Cumulative inflow volume.
   b. Cumulative discharge volume.
   c. Cumulative storage.
   d. Stage elevation
5. Operation and maintenance plan

6.9 Ongoing Maintenance for Stormwater BMPs

All stormwater facilities and BMPs shall be maintained in accordance with the approved and recorded stormwater maintenance agreement and stormwater maintenance plan. If no maintenance agreement or plan is in place, the owner shall maintain the facility as designed in order to continue the mitigation of stormwater quantity and quality impacts. This maintenance shall include removal of overgrown vegetation, repair of erosion, repairs to any inlet/outlet structures, and removal of excess silt or any other maintenance deemed necessary to provide said mitigation. The design of stormwater facilities shall incorporate maintenance accommodation and long-term maintenance reduction features.

1. Maintenance Responsibility

The responsible party named in the recorded stormwater maintenance agreement (Section 3.7) shall maintain in good condition and promptly repair and restore all structural and non-structural stormwater facilities and BMPs. The responsible party shall maintain all necessary access routes and appurtenances (grade surfaces, walls, drains, dams and structures, vegetation, erosion and sedimentation controls, and other protective devices) in order to maintain the mitigation of stormwater quantity and quality impacts. Such repairs or restoration and maintenance shall be in accordance with the approved stormwater management construction plan, the stormwater maintenance agreement and the stormwater maintenance plan.

2. Inspection by Boone County Public Works

The County may enter and inspect facilities subject to regulation often as necessary to determine compliance with the stormwater ordinance. If the site has security measures in force that require proper identification and clearance before entry, the responsible party shall make the necessary arrangements to allow access to representatives of the County.

3. Records of Maintenance Activities

The responsible party shall make records of the installation and of all maintenance and repairs, and shall retain the records for at least five (5) years. These records shall be made available to the Director during inspection of the facility and at other reasonable times upon request.

4. Failure to Provide Adequate Maintenance

In the event that the stormwater BMP has not been maintained and/or becomes a danger to public safety or public health, the Director shall notify the responsible party by registered or certified mail. The notice shall specify the measures needed to comply with the maintenance agreement and the maintenance plan and shall specify that the responsible party has thirty (30) days or other time frame mutually agreed to between the Director and the responsible party, within which such measures shall be completed. If such measures are not completed, then the Director shall pursue enforcement procedures pursuant to Section 9 of this Ordinance.
If a responsible person fails or refuses to meet the requirements of an inspection report, maintenance agreement, or maintenance plan; the Director, may correct a violation of the design standards or maintenance requirements by performing the necessary work to place the practice in proper working condition. The Director may assess the responsible party of the practice for the cost of repair.

5. **Required Easements**

Easements for the stormwater management facilities including structural facilities, engineered channels and overflow paths, are required. Drainage easements shall include access from a convenient public street or parking lot. Minimum dimensions are as follows:

   a. Where a storm drain consists of a closed conduit, the width shall be the greater of fifteen (15) feet or the sum of the conduit diameter and twice the cover depth over the conduit.

   b. The stormwater drainage system easements shall contain the overflow from the 100-year (1% annual chance) storm event and shall indicate the highest expected water surface elevation of said event.

   c. Access easements to and around detention/retention facilities shall be a minimum of fifteen (15) feet wide with cross slopes to be safely accessible by a vehicle unless otherwise approved by the Director.
EXAMPLE:
TRIBUTARY AREA = 20 ACRES
RATIONAL METHOD RUNOFF COEFFICIENT "C" = 0.6
SEDIMENT STORAGE = 120 CU. FT. PER ACRE PER YEAR
TOTAL SEDIMENT STORAGE = 120 x 20 = 2400 CU. FT. PER YEAR.