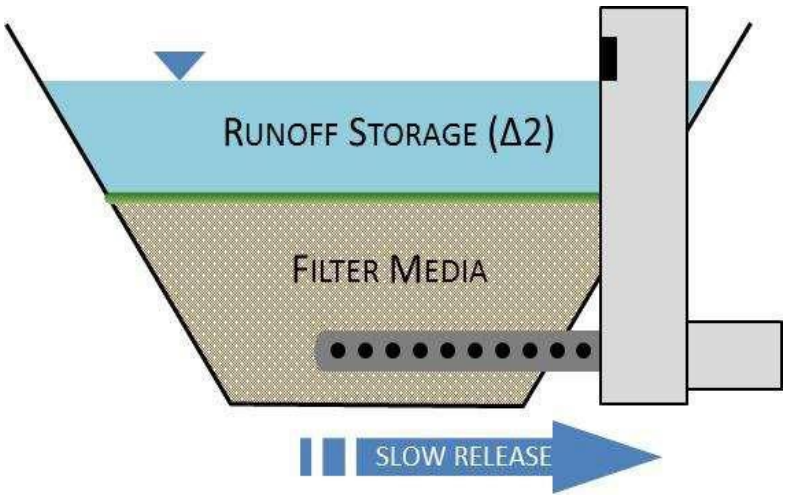
# BMP 6.4.11: Slow Release Concept




The Slow Release Concept (SRC) is a stormwater strategy used to manage the increase in the pre vs. post development runoff volume through attenuation and discharge of storm events up to and including the 2-year 24-hour storm (Δ2 volume). The goal of the SRC is to mimic the normal baseflow hydrology in the receiving stream. The SRC can be used in tandem with volume management measures such as infiltration and evapotranspiration. This concept can be used in either above-ground or underground storage systems – though underground systems will be more challenging and costly.

- This BMP follows Title 25, Chapter 102.11(b) for Alternative BMP and design standards.
- Maintain a minimum 1-foot separation to the seasonally high water table which should be verified by bore pit analysis. Minimum thickness for amended soil/ filter media is 2 feet (24") to ensure adequate pollutant removal.
- Infiltration Guidelines and Soil Testing Protocols apply to show that standard infiltration is not viable or not fully achievable. Justification and documentation is required including an analysis of which volume reducing BMPs were considered as not feasible and why.
- Design to hold and slowly release the difference in the pre vs post development runoff volume of the 2-yr 24-hour storm (Δ2)
- Maximize non-structural BMPs on-site. The BMP manual allows volume credit up to 25% of the Δ2.
- Must utilize soil amendments and restoration (per BMP 6.7.3) on all disturbed areas to be revegetated – as feasible.
- Provide positive stormwater overflow through engineered outlet structure. (as depicted)
- Above ground storage systems will typically utilize an underdrain system. (as depicted)

Commercial: Yes
Ultra Urban: Yes
Industrial: Yes
Retrofit: Yes
Highway/Road: Yes

**Stormwater Functions**

Volume Mgmt: High
Recharge: Low
Peak Rate Control: Low-High
Water Quality: High

**Water Quality Functions**

TSS: 85%
TP: 85%
NO3: 30%

**Other Considerations**

- **The Slow Release Concept (SRC) can be used when a volume increase still remains only after all other volume management BMPs have been utilized and/or exhausted including structural and non-structural BMPs. Justification and documentation are required including an analysis of which volume reducing BMPs were considered as not feasible and the reasons why.**

- **Protocol 1. Site Evaluation and Soil Infiltration Testing** and **Protocol 2. Infiltration Systems Guidelines** should be followed to clearly demonstrate a lack of infiltration capability on site, see Appendix C.

- **Hydraulic Loading is an important consideration. Sizing Criteria for these BMPs are discussed in the Design Considerations below.**

- **Pollutant Loading is also an important consideration. Water Quality Treatment, including pretreatment, is vital to the success of this BMP.**

## Description

The Slow Release Concept (SRC) is a volume management strategy that collects, stores, and filters captured runoff through a water quality media/device, and slowly releases the treated volume to an on-site or off-site surface water. The SRC utilizes a storage area, either above-ground or underground, that temporarily impounds the captured runoff from storm events up to and including the 2-year 24-hour storm. The runoff is then filtered through a water quality media or equivalent water quality treatment device prior to slowly discharging the treated volume. As previously noted, the storage area can either be an above ground basin or an underground storage area, i.e., stone trench, vaults, chambers, etc. For above ground storage, shading is highly recommended to reduce thermal impacts.

SRC may be confused with extended detention, however it differs for the following reasons:

- The slow release concept manages the volume for all storms up to and including the 2-year/24-hour storm when the collected rain drains through the 2 feet of amended soils. This follows 102.8(g)(2). After draining through the amended soils, the runoff is discharged through an underdrain and dewatered between 24 to 72 hours. (Equivalent Water Quality BMP(s) and drain set up would be needed for underground systems using SRC and documented using Worksheets 12 and 13) The size (stream order) and the physical condition of the stream needs to be taken into account when determining the appropriate drain time. Low order streams which may be more susceptible to erosion should maximize drain time to 72 hours. Research supports that this approach is acceptable and helps "mimic" baseflow. (or rather the interflow portion of the stream hydrograph) The objective of slow release is provide volume management for the "stream bank protection" stage of the basin **and** to provide water quality treatment.

- The extended detention (ED) volume is for storms events greater than the 2-year (up to the 100 year) which is much greater in magnitude and is discharged though higher orifice(s) on a multi-stage outlet structure. The objective of ED is to provide peak rate control and to hold the "flood protection" stage of the basin for as long as possible and to safely convey the discharge to the receiving stream.

The system can incorporate infiltration and evapotranspiration as site conditions allow. The outflow

should be designed to mimic normal baseflow conditions in the receiving waters and help support aquatic habitat. The quality of the runoff is treated by the natural cleansing processes of soil media (including any infiltration that may occur). Additional water quality is treated through the vegetation planted in the above ground systems. The keys to this slow release process are to minimize the height of the water stored and discharge in a manner to minimize its duration so that the captured volume do not lead to plant mortality or stagnant water issues in the basin; and not lead to any erosion issues after being discharged out of the basin. The designer shall demonstrate through their design and plant selection that ponding time will not adversely affect vegetation.

Slow release is typically incorporated into a multi-stage detention facility with the upper portions of the facility providing flow attenuation for storm events greater than a 2-year 24-hour storm – up to an including the 100-year 24-hour storm. In the absence of a multi-stage system, an engineered overflow structure should be provided to provide safe conveyance for the 100-year storm. As previously noted the drain time is project-specific and receiving-stream dependent and hence can vary – but will typically be between 24 and 72 hours after the 2-year/24-hour storm event in accordance with Chapter 3 of this manual. Stream channel protection may also be a design consideration.

## Applications

- This concept can be utilized with various BMPs. The designer would need to determine proper suitability and can adapt various elements to achieve project goals.
- This concept can be used for both new construction and retrofit projects.
- Other applications of SRC may be determined by the Design Professional, as appropriate, with DEP approval.

## Design Considerations

1. Follow design considerations for BMP and associated volume management approach. This strategy would need to be affirmatively analyzed by a person trained in PCSM design. This strategy should only be considered after all other volume management BMPs have been utilized and/or exhausted[1] including structural and non-structural BMPs. **Justification and documentation is required including an analysis of which volume reducing BMPs were considered as not feasible and the reasons why**. This analysis is even more crucial in special protection watersheds and need to be incorporated into the Antidegradation Analysis.
2. Soil testing and evaluation is one of the important steps in this process. Adequate soils testing and evaluation must be performed to demonstrate to the satisfaction of DEP or other reviewing authority that infiltration is not feasible on the entire project site and that at least one foot of separation distance exists between seasonal high water table and bottom of BMP.
    a. The designer should go through each BMP in Chapters 5 and 6 of this Manual (or other acceptable reference), and incorporate each BMP into their design to manage the proposed increase in volume. Chapter 3 of the BMP Manual is also a good reference for sites with limited infiltration capacity.
    b. The designer should maximize Infiltration BMPs strategies.
3. When there is a deficit between the amount of infiltration achievable and the amount required (i.e. through Worksheets #4 and 5), the designer can incorporate this slow release volume mitigation strategy.
    a. After determining the deficit runoff volume to be managed, BMP(s) should be designed to manage this runoff volume through a slow release device. Slow release devices can

have various design elements. (e.g. above-ground, subsurface, etc.) Samples are included in this document. These samples show a minimum 2-foot depth of amended soils/filter media for Water Quality (WQ) with an underdrain system.

b. The volume is managed by setting the invert of the lowest orifice or weir at the maximum elevation of the $\Delta 2$ Volume – which should be clearly shown on the outlet detail. This low orifice would be in addition to any other orifice(s) or control structures for managing larger storm events.

c. Another option (not shown) for a subsurface basin would be to utilize a smaller orifice to manage this volume for storms up to and including the 2-year/24-hour storm event with a non-clogging device and then incorporate adequate WQ BMP(s)[2]. This strategy would need to be consistent with Chapter 3 of the PA BMP Manual which states "retention and detention facilities should be designed to completely drain water quality volumes including both the permanently removed volume and the extended detention volume over a period of time not less than 24 hours and not more than 72 hours from the end of the design storm." Subsurface systems that incorporate other WQ BMPs and do not utilize the minimum 2 feet of soil media will need to complete Worksheets 12 and 13 to demonstrate water quality compliance.

4. Ultimately, the designer's analysis should clearly demonstrate what BMPs are being proposed for **each point of discharge**, and how much volume is being managed by each BMP (when comparing the pre- and post-construction runoff volume from a 2-year/24-hour storm event). **As noted in Design Considerations Item No. 1, the analysis should also include which BMPs were considered as not feasible and the reasons why.**

5. <u>Specifications for the amended soil or filter media</u> – The soil mix or filter media should be site-specific depending on the anticipated pollutants (gradation) at the proposed site. The maximum soil texture is course sand. The minimum depth is 2 feet (24 inches) which is consistent with Appendix C Protocol 2 of the PA BMP Manual to assure adequate pollutant removal. Please reference BMP 6.4.7 Constructed Filter in the PA BMP Manual for more information.

[1] Exhausting all options for infiltration would include looking at all infiltration BMP options and conducting soil

evaluations/testing at multiple locations and multiple depths at each location.

[2] In this case, preference for "WQ BMP" would be a constructed filter (BMP 6.4.7) or other BMP(s) with similar WQ functions. Pretreatment BMPs at all major inflow points should be designed as well – similar to an infiltration basin.

6. Sizing Criteria. Similar to the loading ratio concept for infiltration BMPs, sizing consideration also needs to be given to this BMP strategy to avoid either hydraulic or pollutant overloading[1]. Sizing of this BMP can be achieved in different ways. The simplest way is to follow the table below which was adapted from PWD's Manual version 3.0 (Table 4.1-4) which is based on a maximum loading ratio of 16:1 and a release rate of 0.05 cfs/acre.

**Table 1. Slow Release Concept – Sizing Table**

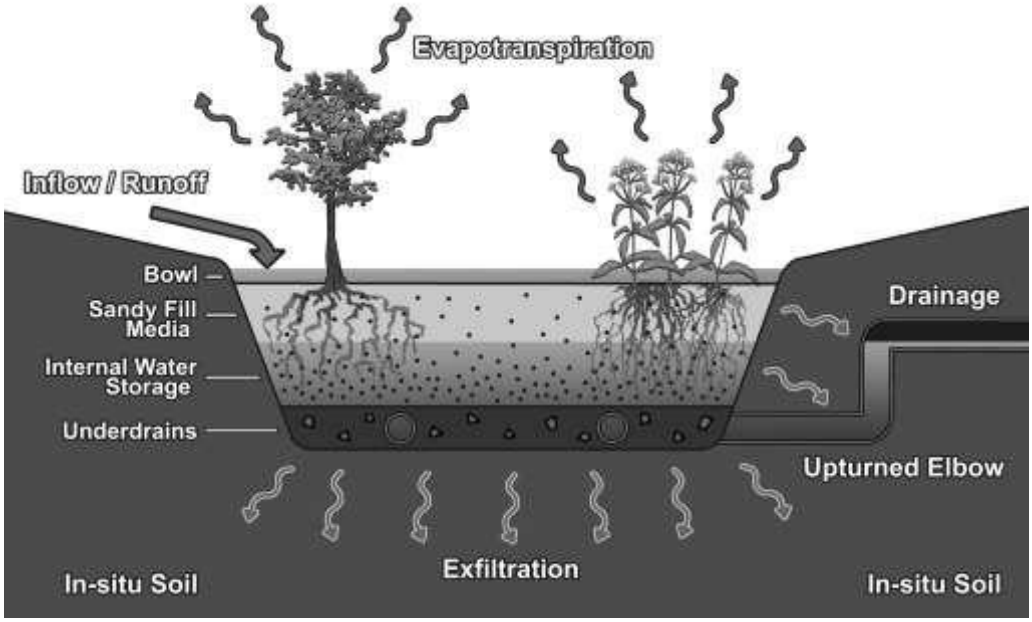
| Drainage Area (sq. ft.) | Minimum BMP Area (sq. ft.) | Orifice Diameter (inches) |
|---|---|---|
| 0-17,000 | 1,063 | 1/2" |
| 17,000-24,000 | 1,500 | 5/8" |
| 24,000-33,000 | 2,063 | 3/4" |
| 33,000-43,560 | 2,723 | 7/8" |
| 43,460-68,000 | 4,250 | 1" |
| 68,000-96,000 | 6,000 | 1 ¼" |
| 96,000-132,000 | 8,250 | 1 ½" |
| 132,000-174,240 | 10,890 | 1 ¾" |

In lieu of this simplified approach, the designer may perform their own analysis which would need to be reviewed and approved by the reviewing entity. This may be necessary for a number of reasons – for instance, to prolong the drain time as long as possible due to the size/condition of the receiving stream. (e.g. headwater streams warrant max. drain time of 72 hours). It should be noted that undersizing of these BMPs are a significant concern of the Department –especially if these BMPs promote any level of infiltration.

7. Drainage characteristics of Soil Media. Please note that the designer will have to exercise caution when selecting a soil media. As noted in Appendix C Protocol 2 of the PA BMP Manual, soil infiltration rate can be between 0.1 inches per hour and 10 inches per hour per. **The designer will need to select a soil media that possesses the proper characteristics that address infiltration rate and water quality.** To maximize water quality treatment and achieve the listed water quality functions (85%/85%/30%) – the residence time within the soil should be maximized within the established parameters. For this reason, the maximum soil texture is course sand. In addition per Appendix C, "Soils with rates in excess of 6.0 inches per hour may require an additional soil buffer (such as an organic layer over the bed bottom) if the Cation Exchange Capacity (CEC) is less than 5 and pollutant loading is expected to be significant."
8. Calculating flows through the perforated underdrains – Please reference PennDOT Publication 408 Section 610 for specifications of underdrains. This section specifies a minimum rate of 10 gallons (1.34 cubic feet) per minute per linear foot of pipe. There may need to be multiple underdrains or longer underdrains to provide adequate design capacity to drain within 72 hours after the storm. In addition, the section BMP 6.4.7 Constructed Filter in the PA BMP Manual has recommended specifications for lateral spacing of multiple underdrains.

[1] This BMP incorporates water quality treatment – typically an amended soil layer designed to provide pollutant reduction.

9. Underdrain aggregate envelope – Please reference PennDOT Roadway Construction details RC-30M for underdrain bedding and aggregate envelope options. The aggregate selected for the underdrain bedding and envelope should be clean washed stone for water quality reasons.
10. Cleanout for underdrain – The underdrain(s) should be equipped with a cleanout for future maintenance. Caution should be used so that a riser pipe from the u-drain is not allowed to take in surface waters. The u-drain maintenance could be done from inside the riser instead of stand pipes that all too frequently do not specify a water tight top cap or at least the pipe extended up past any standing water elevations.
11. Capped Underdrain and/or Control Valve – Underdrains should be capped within the outlet structure. The cap should be drilled for an appropriately sized orifice to manage release rates. (See Table 1 for orifice sizes) Also see Underdrain Connection Standard Detail in Philadelphia Water Department (PWD) Guidance Manual. (Fig. 4.1-5) Control valve may also be included for maintenance reasons and to better manage the discharge rate if the other design components are not functioning as planned (turn the valve to slow the discharge to the desired release rate). Due to issues with control valves being misused and/or inappropriately maintained and/or freezing during winter months, the reviewing entity has the discretion to prohibit their use.
12. Vegetation - The native vegetation for the above ground concept should be selected so that the vegetation can grow and sustain under the design conditions. The vegetation should be able to grow and sustain based on the depth of stored water in the slow release storage basin and the length of time that the depth is sustained prior to the slow release.
13. Design Variations – The underdrain can include an upturned elbow towards its outlet and is **highly recommended**. Future iterations of this BMP may make this a requirement. The upturned elbow creates a zone within the amended soils or filter media named the "internal water storage (IWS)". This zone has been researched and studied to show that this IWS can improve runoff volume reduction and water quality treatment. (Davis et al, 2009) (Davis, Hunt & Traver, 2011) The upturned elbow can also aid if site conditions present daylighting issues with the underdrain's discharge elevation. Please see figure below with upturned elbow.




(Image by Shawn Kennedy, NC State University)

## Detailed Stormwater Functions

**Volume Management Calculations**
Full volume management credit up to the $\Delta 2$ volume for dead or static storage that is slow released. (Keeping in mind that all attempts must be exhausted to maximize volume reductions with non-structural BMPS (up to 25%of $\Delta 2$) and other structural BMPs such as capture & reuse; and soil restoration.) The Department reserves the right to deny the use of the slow release concept for projects that threaten the integrity of the receiving stream by producing excessive amounts of volume runoff not implementing the above-mentioned volume reduction practices. Additional BMPs may be necessary.

**Peak Rate Mitigation Calculations:** See Chapter 8 for Peak Rate Mitigation methodology which addresses link between volume reduction and peak rate control.

**Water Quality Improvement:** Based on type and depth (min. 24") of amended soil/filter media or other water quality BMP placed in series with slow release concept. The designer may utilize Worksheet #10 or Worksheets 12 & 13 to demonstrate nitrate compliance as currently shown in Chapter 8 of BMP Manual, Flow Chart D – Water Quality Process.

The Department reserves the right to deny the use of the slow release concept for projects that threaten the water quality of the receiving stream. Additional BMPs may be necessary.

## Construction Sequence

1. Follow sequencing for BMP. This will be project specific per the design engineer's recommendation.

## Maintenance and Inspection Issues

1. Follow recommended maintenance and inspection schedule for BMP. This will be project specific per the design engineer's recommendation.

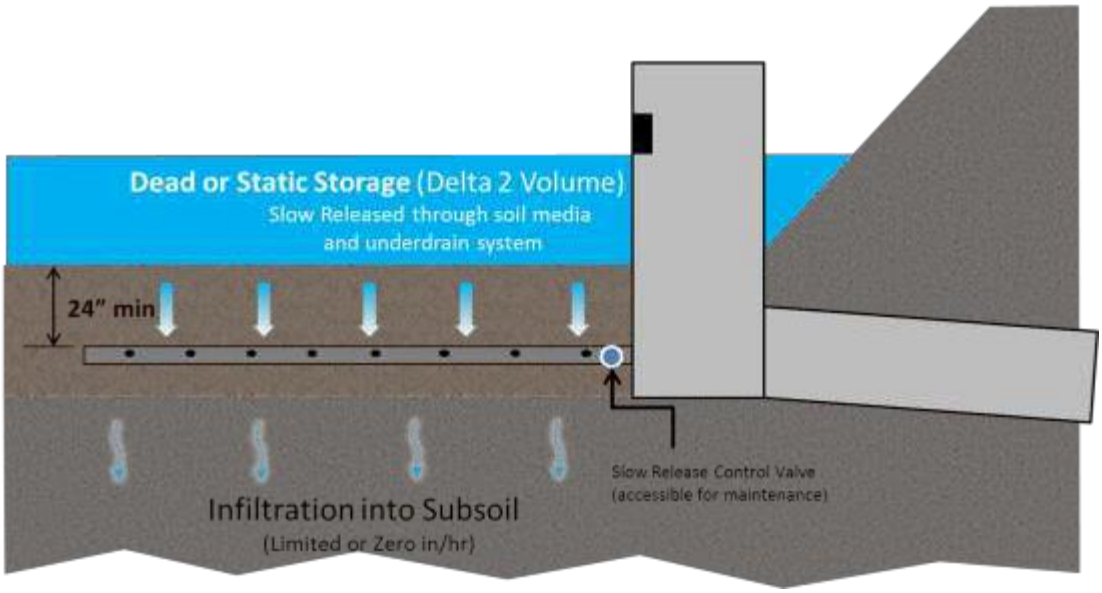
## References

PWD Stormwater Management Guidance Manual v3.0, 4.1 Bioinfiltration/Bioretention

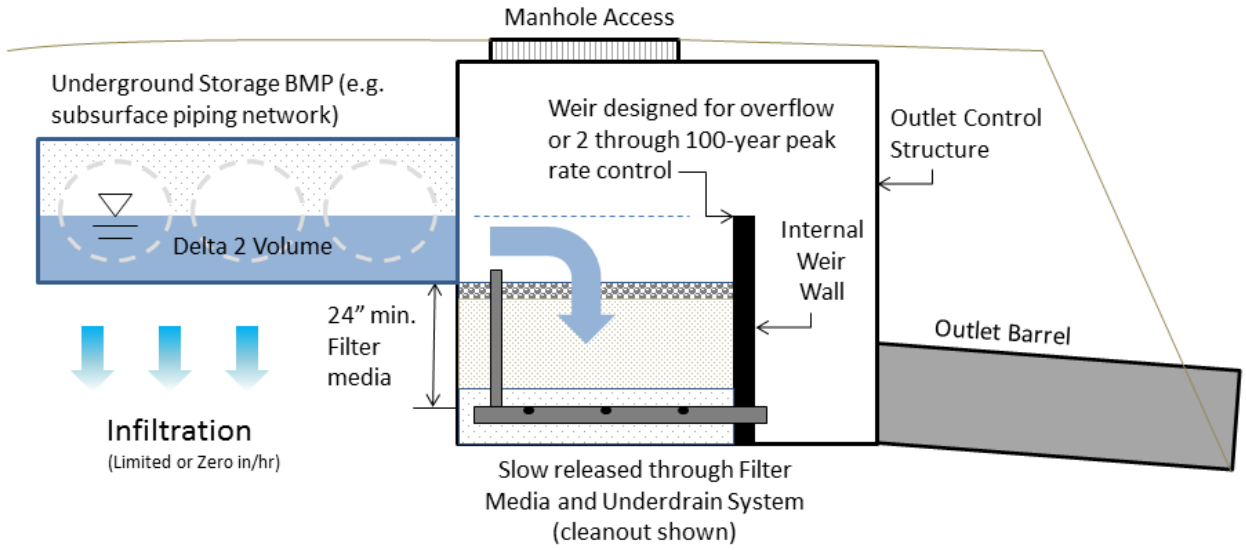
PennDOT Publication 408 Section 610 for specifications of underdrains

Journal Publications:
Bioretention Tech: Overview of Current Practice & Future Needs; (Davis et al, ASCE Journal of Environmental Engineering March 2009)
Bioretention Outflow: Does it Mimic Nonurban Watershed Shallow Interflow?; (DeBusk et al, Low Impact Development 2010 ASCE)
Hydrologic Performance of Bioretention Stormwater Control Measures (Davis et al, draft 2011)
Field Performance of Bioretention: Hydrology Impacts (Davis) Journal of Hydrologic Engineering February 2008
Meeting Hydrologic and Water Quality Goals through Targeted Bioretention Design (Hunt et al) Journal of Environmental Engineering June 2012

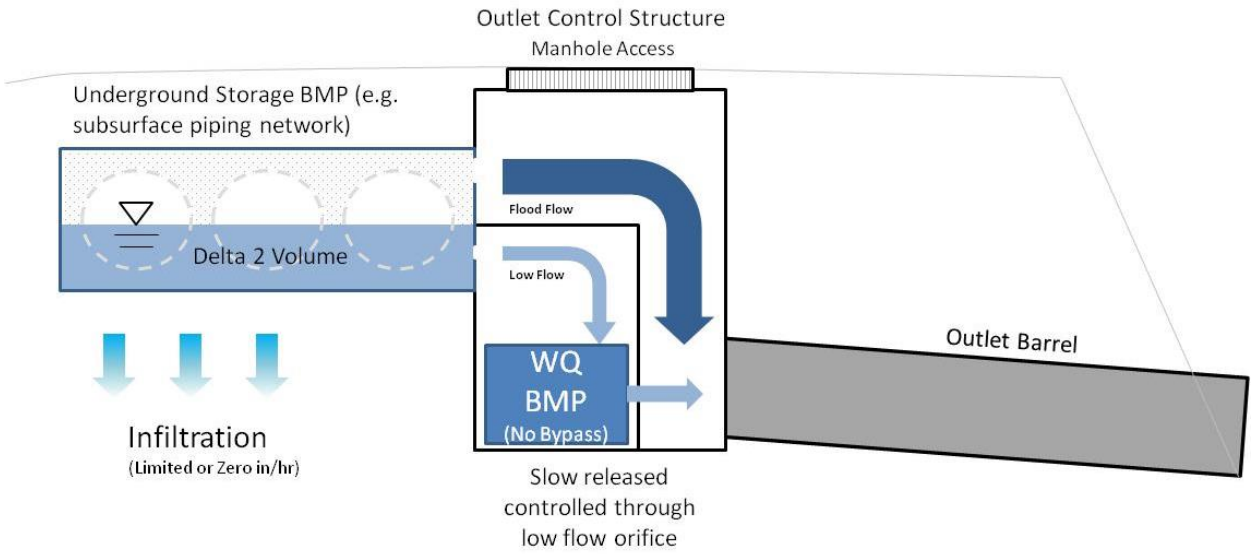
## Example 1: Slow Release Concept. Above Ground Storage (Preferred)




## Example 2: Slow Release Concept. Underground Storage w/ Filter Media:



## Example 3: Slow Release Concept. Underground Storage w/ WQ BMP:




## Example 4: Slow Release Concept. Underground Storage w/ WQ BMP: