CITY OF CHARLOTTESVILLE PUBLIC WORKS DEPARMENT, ENGINEERING DIVISION- VSMP TECHNICAL - GUIDANCE DOCUMENT-DRAFT 1.0 (Jack Dawson 7-2-2020)

SWM QUANTITY AND OUTFALL COMPLIANCE: HYDROLOGY, DRAINAGE AREAS, AND OUTFALL ACCOUNTING

1. OUTFALL ACCOUNTING

A. SHEET FLOW AND CONCENTRATED OUTFALLS

The Virginia Administrative Code only provides parameters for the compliant discharge of post development flows in one of two flow regimes and conditions; sheet flow and concentrated flows to a stormwater conveyance system:

Va. Admin. Code 9VAC25-870-66-B reads in part:

> "Channel protection. *Concentrated stormwater* flow shall be released into a stormwater conveyance system and shall meet the criteria in subdivision 1, 2, or 3 of this subsection, where applicable, from the point of discharge to a point to the limits of analysis in subdivision 4 of this subsection."

Va. Admin. Code 9VAC25-870-66-D reads:

> "Increased volumes of *sheet flow* resulting from pervious or disconnected impervious areas, or from physical spreading of concentrated flow through level spreaders, must be identified and evaluated for potential impacts on down-gradient properties or resources. Increased volumes of sheet flow that will cause or contribute to erosion, sedimentation, or flooding of down gradient properties or resources shall be diverted to a stormwater management facility or a stormwater conveyance system that conveys the runoff without causing down-gradient erosion, sedimentation, or flooding. If all runoff from the site is sheet flow and the conditions of this subsection are met, no further water quantity controls are required."

There are important design implications worth explicitly stating as a result of the limited provisions for outfalls within the Admin. Code or Virginia Stormwater Management Program publications or guidelines:

1) All discharges, in proposed conditions, must either be discharged as "concentrated stormwater (B), or "sheet flow" (D).

2) All concentrated stormwater flows, must be discharged ("released") directly into a conveyance system of one of the following types:

1) Manmade stormwater conveyance system

2) Restored stormwater conveyance system

3) Natural stormwater conveyance systems.

3) Any discharges other than concentrated discharges, must be demonstrated to discharge as sheet flow and must be "evaluated for potential impacts on down-gradient properties".

(NOTE: Application of the Energy Balance (EB) does not negate the applicability of the above referenced code sections or the associated design implications stated here. The Energy Balance can only be applied to concentrated outfalls discharging to one of the three eligible outfall conveyances. EB application only limits the scope of the downstream analysis for compliance with the channel protection criteria.)

B. OUTFALLS-'OTHER'

There are no provisions within VSMP guidance for any outfalls, or any runoff leaving a site, to be in compliance with the VSMP if it is of any flow regime or condition, other than contributing concentrated runoff directly to a stormwater conveyance, or, can be demonstrated to be in sheet flow condition *and* generated from either pervious area, or, impervious areas with appropriately designed disconnection schemes (i.e. level spreaders). The City of Charlottesville Public Works Engineering Division acknowledges that complete control of onsite drainage areas for strict conformance with the above regulations can be burdensome, especially in an urban environment. In order to provide consistent review and enforcement of VSMP regulations within the City of Charlottesville, the following measures should be taken when any site runoff in the proposed conditions are intended to, or otherwise will, leave the site in a condition other than to one of the 3 eligible concentrated conveyances, or in strict conformance with the sheet flow requirements. These areas of discharge type 'Other', if demonstrated to meet the conditions stated below, shall be considered for approval of a variance to the VSMP for strict outfall conformance. In order to secure a variance/exception to allow for such a discharge, is required that the Limits Of Analysis (LOA) for all Outfalls on the project, be determined and designated on the plans to demonstrate adequate compliance with the necessary conditions.

The following conditions are required to be adequately demonstrated in the plans and computation booklet during the review process in order to secure an exception to allow for an otherwise nonconforming outfall. Conditions requiring an exception must also be the minimum necessary to afford relief and may require further, reasonable and appropriate conditions, imposed as necessary to ensure the intent of the VSMP regulations are preserved:

1) It is impractical, or overly burdensome, to grade or otherwise capture and convey all onsite water to a concentrated outfall or to discharge through the sheet flow condition.
2) The proposed volumes and discharges for each relevant design storm leaving the property through an outfall identified as 'Other', shall be added to/accounted for in the energy balance/Qpeak analysis of a concentrated outfall contributing to the same LOA as the 'Other' discharge in question, when demonstrating quantity compliance for those outfalls.
3) The engineer provides a statement and supporting exhibits or data, that the discharge has been evaluated for potential impacts on down-gradient properties and that the outfall will not cause or contribute to erosion, sedimentation, or flooding of down gradient properties, to the satisfaction of the City Engineer.

2. SITE HYDROLOGY

A. EXISTING AND PROPOSED; REPLICATION

The Code of Virginia § 62.1-44.15:28 (10/13), requires that:

> "…VSMPs (/VESMPs) maintain after-development runoff rate of flow and characteristics that replicate, as nearly as practicable, the existing predevelopment runoff characteristics and site hydrology, or improve upon the contributing share of the existing predevelopment runoff characteristics and site hydrology if stream channel erosion or localized flooding is an existing predevelopment condition."

In an effort to replicate "as nearly as practicable, the existing predevelopment runoff characteristics and site hydrology", the following guidance is being provided to applicants seeking VSMP approval in the City of Charlottesville.

Maintenance of existing drainage patterns is an important tool for localities to manage both water quality and quantity/flooding considerations and protect property rights within the City. Largely maintaining drainage characteristics, to, through, and beyond a site, is critical to protect downstream properties, ensures the continued functioning of SWM and drainage facilities proximate to the project, and helps localities anticipate future drainage patterns, to plan remedial work, and improve drainage and SWM facilities. Generally, strict conformance with Section 1 of this guidance document will ensure that compliance with this section is met. However, this code section can be easily overlooked during the concept phase of design. There are important ramifications of maintaining site hydrology on the design progression and not anticipating these problems soon, can mean much time is required redesigning and computing SWM facilities later in the process. To assist the designer/applicant, a few notes about how this code section impacts other areas of VSMP compliance are stated below:

1-Where existing 'concentrated' outfalls leave the property line, there generally exist 'storm water conveyance' channels of one type or another. Establishing a proposed outfall in the exact location of an existing outfall, typically allows the designer to seek outfall compliance through the Energy Balance (9VAC25-870-66-3-a). Shifting these outfalls even slightly, generally negates the existence of an acceptable channel and may require work offsite (downstream property) to establish a Stormwater Conveyance Channel to an acceptable existing channel.

2-Large manipulation of onsite drainage areas ('bucking grade'), even when outfall locations are maintained, so that one existing outfall receives a large portion of what previously flowed to another, may yield the storage quantity requirement in the DA for the increased outfall impractical to achieve compliance under 9VAC25-870-66.

3-Utilizing either the sheet flow or 'Other' discharge type, where previous discharges may not have existed, may make satisfying the condition that discharges: "will not cause or contribute to erosion, sedimentation, or flooding of down gradient properties"

B. OFFSITE DRAINAGE AREAS

It is the goal of this section to outline the City's interpretation of some crucial terms within the energy balance and how those interpretations in conjunction with the other hydrologic compliance guidance provided here, may affect the modeling of offsite drainage areas.

(NOTE: The guidance herein addresses Offsite Drainage Areas only as it applies to demonstrating VSMP quantity compliance. Further fundamental requirements of storm drain and BMP design (HGL's, 100 yr paths, tail water's, etc) are still required to be analyzed appropriately, with hydrologic and hydraulic methods suitable to demonstrate compliance with any applicable regulations.)*

The Energy Balance equation per 9VAC25-870-66-B-3-a reads:

$$Q_{Developed} \leq I.F.*(Q_{Pre\text{-}developed}* RV_{Pre\text{-}Developed})/RV_{Developed}$$

Under no condition shall QDeveloped be greater than QPre-Developed nor shall QDeveloped be required to be less than that calculated in the equation (QForest * RVForest)/RVDeveloped; where

I.F. (Improvement Factor) equals 0.8 for sites > 1 acre or 0.9 for sites ≤ 1 acre.

$Q_{Developed}$ = The allowable peak flow rate of runoff from the developed site.
$RV_{Developed}$ = The volume of runoff from the site in the developed condition.
$Q_{Pre\text{-}Developed}$ = The peak flow rate of runoff from the site in the pre-developed condition.
$RV_{Pre\text{-}Developed}$ = The volume of runoff from the site in pre-developed condition.
Q_{Forest} = The peak flow rate of runoff from the site in a forested condition.
RV_{Forest} = The volume of runoff from the site in a forested condition

A very important technicality to understand is that calculation of the RV, is dependent only on intrinsic properties of the onsite DA (CN, rainfall (P)) and is otherwise independent of the upstream DA or flow paths (CN, rainfall (P)).

However, determination of the values of the peak flow rates (Q's) are dependent not only on the specific onsite parameters, but also extrinsic properties of the any contributing drainage areas. For example, If offsite water is conveyed through the site in the existing condition, and that conveyance is proposed to be altered in any way that would affect its hydraulic characteristics, the actual post development Q (peak flow rate of runoff from the developed site) may be altered whether or not there was any other manipulation of the onsite portion of the site itself, by virtue of an altered time of concentration path if nothing else.

The ramifications of this are that when taken in conjunction with item 2-A above, demonstrating quantity compliance becomes much more burdensome when onsite conveyances of offsite water are adjusted.

A simplified example:

Existing conditions: 1 Acres site is bisected by 30" SD line which carries runoff from an upstream contributing DA of 4 Acres, and discharges just after crossing beyond the midpoint of the property. All of the subject site drains to the inlet in the center of the property, with no offsite overland contribution.

Proposed Condition 1: The site is developed into a building and parking pad. The old inlet is removed, though the line stays as is. A new two inlet system will drain the entirety of the site to a detention facility, which then ties into the 30" SD in the proximity of the old inlet via an 18" SD.

To demonstrate Channel Protection compliance for Proposed Condition 1:

Since the 30" pipe crosses the property line, the pipe itself can be designated as the outfall, thereby satisfying one of the appropriate Stormwater Conveyance Channel requirements described in 1)-A-2 above. Let us assume the designer elects to use the energy balance. Since the improvement factor is only applied to the onsite DA, and there is no change whatsoever to the contributing DA or its path through the site, no further accounting of the offsite is required (for quantity compliance*, designers should not forget to consider any possible tail water effects on detentions systems). The outfall in existing and proposed conditions can be functionally assigned to the location in the pipe where the inlet was, the same place the proposed new 18" ties in to the 30". Both RVdev and RVpre can be calculated based on the coverage of the 1 AC site in existing and proposed conditions. The Qpre can be calculated based on the existing Tc path of the site, as well as the other required inputs. This allows the "right hand of the equation" (or Qallowable) to be calculated using the EB. Finally, through a routing analysis of the detention facility, the Qdev can be demonstrated to be <Qallowable and Channel Protection compliance for the outfall demonstrated.

Proposed Condition 2: The site is developed into a building and parking pad. The old inlet is removed, and the 30" inch line is extended in length, and reduced in slope, and realigned to take a longer path around the perimeter of the site, before retying into the last several feet of pipe before it leaves the property. A new two inlet system will drain the entirety of the site to a detention facility, which then ties into the 30" SD immediately before leaving the site.

To demonstrate Channel Protection compliance for Proposed Condition 2:

This is a very similar situation to the above, in that there is only one onsite DA and one offsite DA. However, the Tc path for the offsite DA has been manipulated. This means the Energy Balance Equation needs to be tabulated with a perspective towards the total Q leaving the pipe. It cannot be simplified to remove the offsite component from the EB. The EB must become:

$$Q_{Developed} \leq (I.F.*(Q_{Pre\text{-}developed(onsite)} * RV_{Pre\text{-}Developed(onsite)})/RV_{Developed})) + (Q_{Pre\text{-}developed(offsite)} * RV_{Pre\text{-}Developed(offsite)})/RV_{Developed(offsite)}$$

Once the "right hand of the equation" (or Qallowable) is calculated, the Q for the entire drainage area must be calculated, with appropriate routing of onsite detention, to determine Qdeveloped and compare for Channel Protection adequacy.