Technical Procedure Document

Subject: Computer Modeling for Hydraulic Grade Line and Velocity Computations

Introduction

The City of Charleston Design Manual section 3.4.4.2 requires all pipe calculations to incorporate the Saint-Venant equations if backwater, tailwater, and/or tidal conditions are present, and the pipe run has five or more connections. If these conditions are not present, Manning's Equation may be used. The City of Charleston has performed an analysis of the HEC-22 program, and others, to determine if they are generally accepted approaches.

The critical piece of this review was the City's requirement in section 3.4.6.1 #2 of the 2020 SWDSM which states "*The minimum slope for storm drainage pipe shall be three tenths of 1 percent [0.003 ft/ft] where possible. The minimum flow velocity shall be 2 fps for pipes flowing full or half full. Often the controlling factor is velocity rather than grade. Pipes that have the purpose of equalization between two or more ponds do not have to meet this requirement. Maximum allowable flow velocity shall be 10 fps under any flow condition.*" The intent of this requirement is to provide adequate flushing velocities for all pipe runs to reduce sediment buildup within the piped system.

Design Requirements

1. HEC-22, as well as other hydraulic modeling programs which incorporate the Saint-Venant equations, are appropriate for pipe capacity analysis / design (i.e. Hydraulic Grade Line Determination). While programs differ from one another, they each provide adequate pipe sizing capabilities that meet the current SWDSM if applied correctly. These computations are to be performed using the 4% AEP storm event and can use either a constant or dynamic tailwater condition as long as it is representative of the downstream conditions.

2. The City has determined that if the proposed design can show that the minimum 2 fps flow velocity is met for the 4% AEP storm event or any storm event that will have a more frequent occurrence (i.e. 50%, 25%, 10%), then the intent of the SWDSM is considered to have been met for the proposed design.

3. For evaluating minimum pipe velocities, HEC-22 is not acceptable as the reported values are not correct for partially submerged pipes when the downstream depth is below the top of the pipe but above normal depth conditions within a pipe. Therefore, an alternate program will be required that provides more accurate results. These computations can use either a constant or dynamic tailwater condition as long as it is representative of the downstream conditions.

4. For situations where a hydraulic modeling program does not provide a minimum velocity at the pipe terminal, the City will require that a velocity of 2.5 fps be shown to ensure that the intent of the manual is still being met. Below is a quick summary of how some of the allowable hydraulic modeling programs currently report velocity:

a. HEC-22 is not suitable for reporting minimum velocity as described in item #3 above.
b. ICPR reports a velocity at both the upstream and downstream ends of the pipe based on the representative pipe flow area for the depth.
    i. Designer to show that the lower of the two velocity values be at or above 2 fps.
c. EPA SWMM calculates a velocity at the upstream, downstream, and middle of the pipe, however only the velocity at the middle of the pipe is reported with the output. The middle velocity is determined by the pipe's area based on an average depth from the upstream and downstream ends.
    i. Design to show that the middle velocity is at or above 2.5 fps.
d. Civil3D's Storm Sewer Analysis (SSA) is a modified version of EPA SWMM and also only reports the pipe velocity related to the middle of the pipe.
    i. Design to show that the middle velocity is at or above 2.5 fps.
    ii. If it can be shown that the program is able to provide velocities at the upstream and downstream ends of the pipe, then the design can show that the lower of the two velocity values are at or above 2 fps to satisfy this requirement.

5. A design exception request will be required if the proposed design is unable to meet the minimum flow velocity of the current SWDSM. The designer would need to show that the intent of the manual is still being met by the proposed design. This can be accomplished by providing pretreatment to all stormwater runoff prior to it entering the proposed closed storm drain system. Pretreatment practices can include, but are not limited to, the following:
    a. Open Channel Systems
    b. Green Infrastructure Practices
        i. Stormwater filtration Systems
        ii. Vegetated Filter Strips / Sheet Flow to Outfall Location
        iii. Pocket Rain Gardens