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MEMORANDUM

Date: May 30, 2017

To: Holly Piza, UDFCD
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From: Derek N. Rapp, PSE

Re: Summary of Known UD-Sewer 2009 Issues and Troubleshooting Techniques

Introduction

This memorandum serves to provide documentation of the known problems with the UD-Sewer 2009 Model v1.4 and to provide troubleshooting techniques to future model users. Peak Stormwater Engineering, LLC (PSE) was retained by the Urban Drainage and Flood Control District (UDFCD) in 2012 to review the UD-Sewer math engine code and to make the necessary changes to eliminate error messages that were reported by various consultants. In April 2014, an updated version of UD-Sewer 2009 version 1.4 was released that addressed all known math engine problems at that time.

Since 2014, additional problems have been reported by consultants but they have not resulted in any new version releases. Most of these new problems were either related to corrupted files caused by the Graphical User Interface (GUI) for UD-Sewer or were attributed to user inputs that could be corrected through troubleshooting. The biggest problem with troubleshooting the program though is that when an error occurs, the GUI lets the user know which code routine threw the error, but not the location in the sewer network where the error occurred. Therefore, it is necessary to work through each sewer manhole/pipe element in the model to isolate the problem and address it.

UDFCD has considered several options on what to do with the UD-Sewer model including: 1) making minor edits to address new errors as they come up, 2) making a major overhaul to the model code to address the GUI corruption errors and improve error trapping to identify where problems occur , 3) completely changing the user interface and code to an Excel-based model, and 4) eliminating support for the model and leaving it as it currently is. Regardless of what future decisions UDFCD makes on how to handle UD-Sewer, this memorandum serves to document the known problems and to provide troubleshooting techniques.

Known UD-Sewer Problems

The list below outlines the known problems with UD-Sewer and provides recommendations on what to do if this particular problem is encountered. Variations of the problems outlined below may occur that don't specifically match the descriptions provided here but may likely be resolved using a similar approach.

- File corruption issues have been reported by users in the past. It is not clear exactly when or how the files became corrupted since it is not possible to debug them once they are corrupted. It is believed that the problem is located within the Open/Save/Close routines of the GUI. Most examples have occurred when a user has a working .BSD file that they copy using Windows Explorer and rename. Then when they edit the new file and try to save it they see errors such as *"Invalid File Length, found 1332 expected 4"* or *"Object reference not set to an instance of an object"*. Once a file has been corrupted there is no known method to fix it. The preferred approach in this situation is to go back to a previous version of the model that works and start from that point. Rather than copying and saving using Windows Explorer, consider using the Save As option provided in the model. When using the Save As feature, be sure to navigate to the appropriate directory before clicking Save since sometimes the file path will be shown in the file name but the directory does not match. It is also recommended that the user save frequently and save with a new name so that you can go back to the last working version when necessary. The worst-case scenario is when there is no previously working version and the user must recreate the model from scratch.

- The UDFCD criteria manuals and equations are constantly evolving in an attempt to keep pace with new research. Currently, the only equation in the UD-Sewer model that is not consistent with the current Criteria Manual is the *Regional Time of Concentration* equation used in the Rational Method calculations. The model still uses the old empirical equation based solely on catchment length whereas the current UDFCD equation is based on catchment length, slope, and imperviousness. The UD-Sewer model does not have a user input for imperviousness so the new equation can't be incorporated into the math engine without modifying the GUI to allow for a user input of imperviousness. The user should be aware of these differences when selecting design constraints. The user has the ability to turn on and off the *"Use UDFCD Tc Checking"* option. It is recommended that it just be turned off since the check is not consistent with current criteria anyway. It should also be noted that if the user provides known flows then this Tc check is not even used.

- One of the most commonly seen error codes is *"Model Run Failed: Backwater solver failed (3455): Solver failed while calculating subcritical backwater conditions"*. Similar error codes may occur for supercritical conditions. These types of errors are reported in the various solver routines for hydraulic and energy grade lines but the actual problem may arise from a number of different scenarios. This type of error is returned because at this point in the model run the solver can't find a valid solution to the pipe hydraulics. Several attempts were made in the 2014 update to identify situations that could result in these failures (negative slopes, pressurized conditions, tailwater effects, etc.) and to apply assumptions that would allow the model to continue to run. It is now apparent that there are other scenarios causing this error that were not identified at that time. Also, since the error message doesn't tell the user which pipe/manhole element is causing the solver failure it is difficult to tell exactly where or what is causing the error. The two most recently reported examples of this error and how they were addressed are provided below.

- In July 2016, a user reported the subcritical backwater solver error above and then subsequently found a solution by iteratively manipulating pipe sizes until the error disappeared. In this example, increasing the size of *Pipe A* from 30" to 36" allowed the model to run successfully. Increasing the size of *Pipe A* to 33" was the threshold at which the model would run, anything less than 33" would cause the error. Although the increase in the size of *Pipe A* allowed the model to run, *Pipe A* was not actually the pipe causing the error. The error was caused by an 18" lateral pipe (*Pipe B*) flowing into *Manhole A* at the upstream end of *Pipe A*. *Pipe A* was flowing under supercritical conditions and therefore could not directly cause the subcritical error. However, the 18" *Pipe B* lateral flowing into *Manhole A* was flowing right below critical depth and causing the error. An increase of *Pipe B* by only 0.5" to 18.5" allowed the model to run with a Froude number of 1.0. Therefore, at 18" the *Pipe B* flow was hovering just below critical depth but the model could not find a subcritical solution within the tolerance of the model accuracy. This scenario is just one example of how the model can produce errors and how the user can identify the problem pipe through trial and error.

- In April 2017, a user reported an error of this same type but it turned out that it was not directly related to the manhole/pipe sizing but instead to local contributing flow rates provided by the user not being consistent with the associated Rational Method input parameters (runoff coefficient, C and catchment area, A) needed to calculate the combined time of concentration and flow rates in downstream pipes. As outlined on pages 7 and 8 of the User's Manual, if the user decides to provide local flow rates then these values will be used in the immediate manhole. But downstream, the model requires the catchment area and runoff coefficient for all upstream manhole/pipe elements in order to estimate the overall watershed time of concentration and resulting combined peak flow at downstream locations. The explanation of this process is more fully explained in the "*UDSEWER 2009 Model Overview*" document accompanying the model. The section titled "*Rational Method Calculation*" includes a subsection titled "*Known Local Contribution*" which explains how the Rational Equation (Q = CIA) is rearranged to solve for Intensity based on the user provided Q, C, and A values. In the user's model, the Q, C, and A values resulted in intensities that ranged from 0.035 in/hr (very low) all the way up to 27.8 in/hr (extremely high). These were well outside of the range of the user-entered IDF table in the model which ranged from 0.64 in/hr for 120 minutes up to 5.66 in/hr for 5 minutes. The model then proceeded to estimate a Tc value for each catchment by interpolating the user-entered IDF table for each calculated intensity. These Tc values ended up being constrained to either 5 minutes or 120 minutes in the model. The model then attempted to determine the combined peak flows at downstream locations by evaluating the combined time of concentration of upstream flow paths, determining the overall intensity, and multiplying by the area-weighted runoff coefficient for all upstream catchments. In the user's model, the program attempted to calculate the downstream combined Tc values which resulted in extremely long durations (over 400 minutes) which then resulted in very low intensities and essentially zero flow rate in the pipe. These zero flows then resulted in the solver error when attempting to calculate the HGL/EGL for the downstream pipe. Unfortunately, the model routine to back-calculate the combined flow rates is not setup to flag the calculated zero flows. Instead the zero flows were being evaluated in the backwater solver and a solution could not be found. In order to fix this type of error and get it to run properly, the user needs to provide Area and Runoff Coefficient inputs that correspond to the local Q values. If there are reasons why the values don't match, such as inflows from a source other than precipitation, the user may need to enter known design flows to evaluate the sewer hydraulics rather than rely on the program to calculate the combined flows from known local contributing flows.

General Troubleshooting Techniques

As outlined in the known problems above, the current version of UD-Sewer may produce error messages that are not explicitly clear on what or where a problem is occurring. The steps below are intended to help the user to troubleshoot these problems and hopefully find and fix the issue to create a working model. It is recommended that the user save the model frequently and that the model name be changed often. This allows the user to go back to a previous version if they encounter a file corruption issue resulting from the GUI. It also allows the user to track model changes which may be useful if they encounter a math engine solver error. If the user encounters a math engine error such as a backwater solver error, they will need to identify the pipe/manhole element that is causing the error. Although this process is tedious and time consuming, it is currently the only option available and is best accomplished by following the procedure outlined below:

1. Save the working file with a new name that helps identify what is being changed in each test iteration. Make sure to keep the original model so that you can go back and check the original inputs or start the process over.

2. Start at the upstream end of the model and delete the uppermost pipe/manhole element. Then save the model with a new name and try to rerun the model.

3. If the same error message is returned, then try removing the next downstream pipe/manhole element, saving with a new name, and running the model again. Continue this process by iteratively removing the uppermost pipes until the error goes away.

4. If the error message goes away or a different error message is returned, then you have most likely identified the pipe/manhole element causing the error.

5. Once the pipe/manhole element causing the error is identified, go back to the previously saved version that included the error causing element. Then closely review the input parameters for this pipe/manhole element including known flows, Rational Method parameters, cross-section dimensions and elevations. If all input parameters appear valid, then try changing the pipe size or flow rates iteratively until the model runs.

6. Once a user-input change is identified that eliminates the error, try going back to the original model and making the same change to see if the original model will run. If it does run then the problem has been identified and further evaluations can be made.

7. If the error message persists in the original model or a new error message is returned, it is possible that there is more than one pipe/manhole element causing problems. Try repeating all of the steps above but keeping the change identified in #5 as part of the new test model.