MEMORANDUM

To:	P. N Guin
From:	P. Olar Bear
Date:	04MAR2024
Subject:	CE 3372 – Water Systems Design, Exercise Set 21.

Purpose

The purpose of the exercise(the problem statement is repeated below) is to develop expertise in application of gradually varied flow equation in open channel flow, and practice SWMM skills for simple geometries. The exercise is a repeat of an earlier exercise using SWMM instead of hand-built tools.

Discussion

The solution is presented below after re-statement of the problem. Relevant discussion components appear imbedded within the solution.

Problem Statement

1. Water flows at a steady rate of $192 ft^3/s$ through a concrete-lined rectangular channel 16 ft wide as depicted in Figure 1. The water enters the 0.35% sloped channel ($S_0 = 0.0035$) at location 1 and is flowing at 110% normal depth ($1.1 \times y_n$). The water exits over a 3-foot tall weir (assume sharp-crest weir) at location 2.

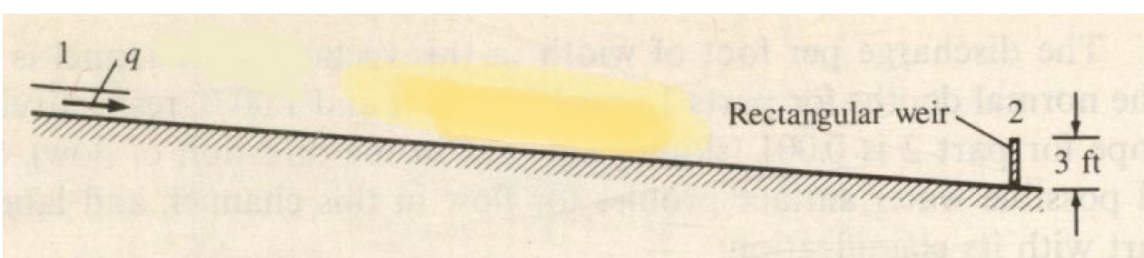

Figure 1: Profile of concrete-lined rectangular channel.

Use SWMM to repeat the exercise in ES-19. The problem set-up is repeated above. Use the average Δx from your ES-19 solution as the spatial step in SWMM to use.

a) Make your SWMM model have conduits that are the average Δx from ES-19.

b) Set the `FIXED` outfall boundary condition as the pool elevation you determined in ES-19.

c) Run the SWMM model using `DYNAMIC WAVE` routing.

d) Include a screen capture of your SWMM model showing the computed water-surface-profile.

e) Export the water surface profile from SWMM and demonstrate that the computed profile in SWMM and in ES-19 (by-hand) are essentially the same.

Solution

To address the specific questions in ES-19 the following steps were required:

(a) Build a tool to take Q, n, Width as input. Figure 2 is such a tool with these inputs along the left side of the spreadsheet.

(b) Compute normal and critical depth for the channel. Normal depth is computed using Manning's equation for a rectangular channel, then apply goal seek until the computed flow rate agrees with the prescribed flow rate. For the supplied problem values the normal depth is about 1.509 feet. Critical depth is computed settinf the Froude number for the rectangular channel to unity (one) and solving for the required flow depth. For the supplied problem values the critical depth is about 1.648 feet.

(c) Assume depth at weir is weir height+critical depth – use that as starting value for the numerical method. For the supplied problem values, the pool depth just upstream of the weir is about 4.648 feet.

(d) Use variable step method as outlined in class an compute spacing as depth is changed. For the supplied values, we start at the weir and compute upstream, using depth increments of 0.1 feet until the depth is at 110% of normal depth, which for this problem is about 1.66 feet.

(e) Plot the results.

Implementing these steps was shown in Figure 2.

The average spacing can be estimated as the total distance $\approx 768 ft.$ divided by the

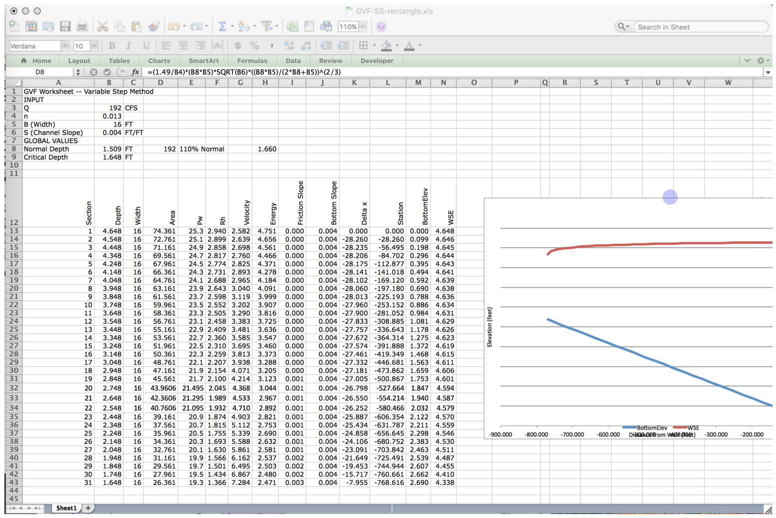

Figure 2: GVF Spreadsheet for channel in Figure1

number of reaches (in this solution 30), which is $\approx 25.6ft.$. Use this value in the next exercise where the same problem is examined using SWMM.

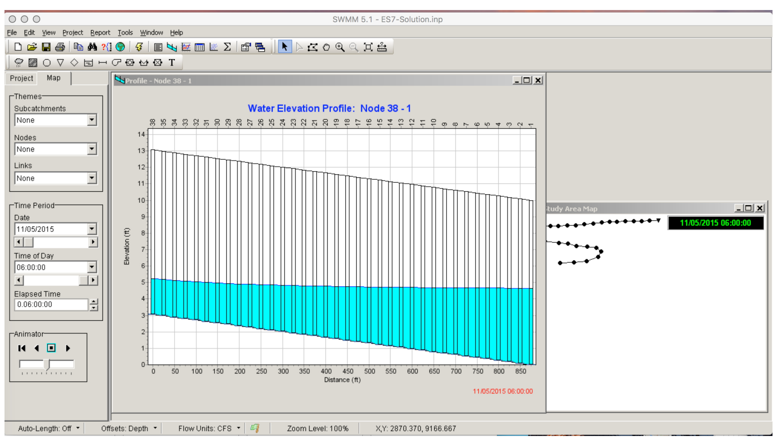

Figure 3: GVF Spreadsheet for channel in Figure1

Figure 3 is a screen capture of a SWMM model to replicate the problem conditions. At first glance the profiles look identical (they are not, but they are close).

Figure 4 is a plot that displays both profiles on the same axes. The profiles are similar close to the downstream pool, but depart at the upstream end — but not by much; either would be meaningful for engineering decisions. The result indicates that the gradually varied flow equation is conceptually simple (as evidenced by the step-backwater method in Excel), but in practice one would choose to use the professional

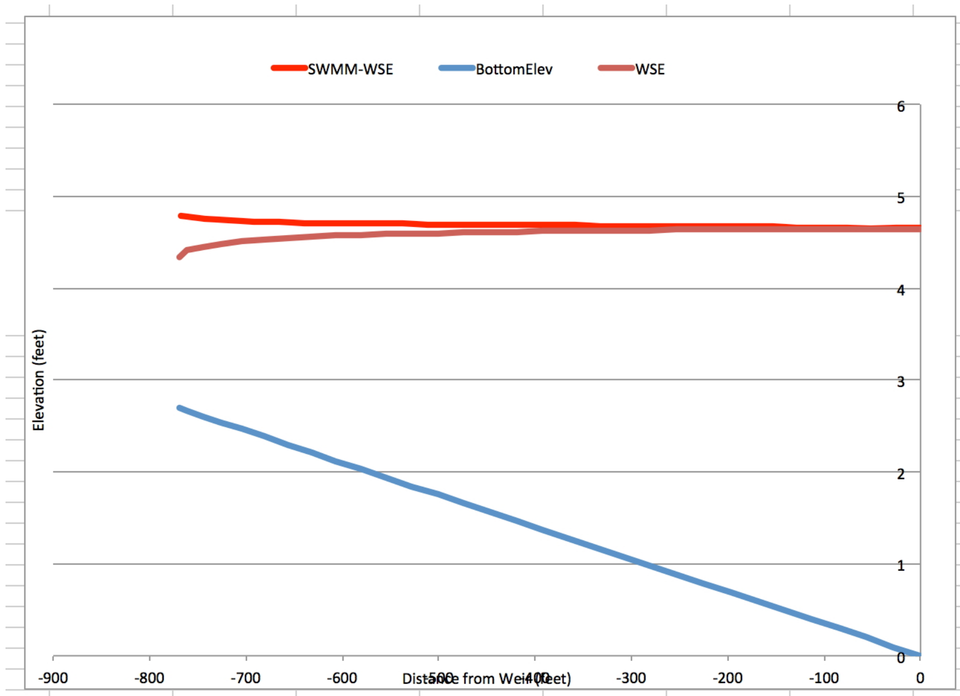

Figure 4: Comparison of SWMM and by-hand solutions

program (as much for acceptance of results as other inherent error checking that is completely omitted from our by-hand technique).