6

Verification of DSM2-Hydro

DSM2-Hydro originated from FourPt Model written by Lew Delong, et al. Since 1993 the Delta Modeling Section has added many enhancements to the model, but the numerical formulation has been left intact. Given the magnitude of the changes that have been incorporated into DSM2-Hydro, it was felt that perhaps this would be a good time to check and make sure that the model is working as it was designed. This idea was brought up at one of the IEP-PWT meetings. During the discussions, the IEP-PWT agreed that since the FourPt Model has gone through rigorous evaluations and has been accepted as a valid tool for hydrodynamic simulations, then the same could be said about DSM2-Hydro, if it can duplicate the same results as FourPt. Three test problems were used in this evaluation. These test problems (with some modifications) were part of a series of test problems designed by Professor Sobey from UC Berkeley, as a part of the Bay-Delta Modeling Forum 'Peer-Review' process. The first test problem is one where an analytical solution exists, so DSM2-Hydro results were compared to the analytical solution. The second and third test problems involve a branched network, where no analytical solution is available. The DSM2-Hydro results were then compared to those of FourPt.

The following is the description of the three test problems used for the verification of DSM2-Hydro:

The cross-sections for all the test problems are assumed to be trapezoidal, with a side slope of 1:2, as shown in Figure 6-1. The bed width (B) and bottom elevation (D) are given for each problem. Δx = 500 feet and Δt = 1 minute for all the test problems.

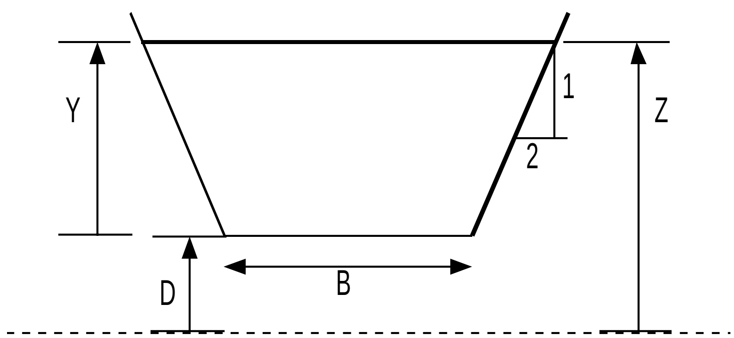

Figure 6-1: Cross-Section Used for All Test Problems

Test Problem 1

Uniform flow

Given: A 10,000-foot channel (FL), B = 10 feet, bottom elevations are shown in Figure 6-2. Flow boundary condition at upstream (F) Q = 200 cfs, stage boundary condition at downstream (L) Z = 5.74 feet.

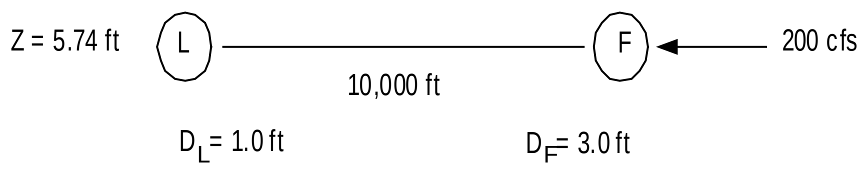

Figure 6-2: Comparison with Analytical Solution

Based on Manning's formula, and a flow of 200 cfs, the normal depth is computed to be 4.74 feet. With the bottom elevation at L being at 1.0 foot, the computed stage will be at 5.74 feet. So based on the above conditions, the steady-state solution will be a uniform flow, with a depth of 4.74 feet, regardless of the choice for initial conditions. The initial condition selected for this problem was:

$Z(x) = 9.74 – 0.0004\ x$
$Q(x) = 0.$

The analytical solution for this problem is:

$Z(x) = 7.74 –0.0002\ x$
$Q(x) = 200$ cfs

DSM2-Hydro was set up for a four-hour simulation. Model output indicated that it took about two and a half hours to reach steady-state solution, and it matched the analytical solution perfectly. Figure 6-3 shows the model output for stage at F (x = 0).

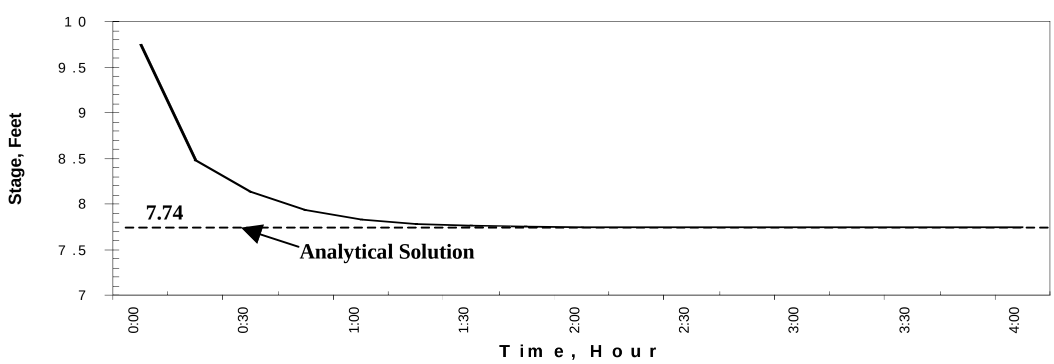

Figure 6-3: Stage at the Upstream End

Test Problem 2

A Branched network is shown in Figure 6-4. All the dimensions are shown in the Figure and the table below.

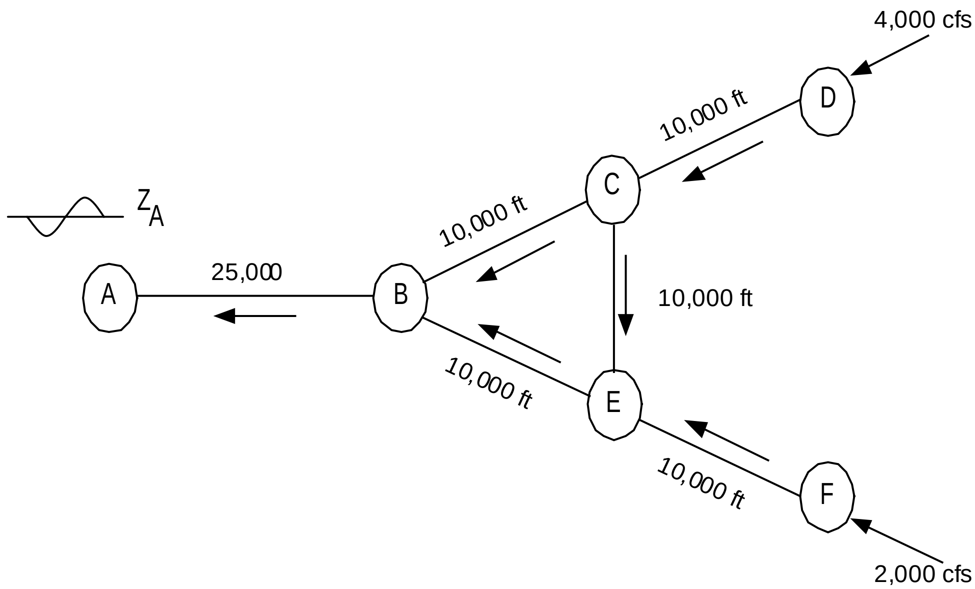

Figure 6-4: Branched Network

Reach	AB	BC	CD	BF	FE	CF
B (ft)	400	300	300	200	200	100
n	0.016	0.018	0.018	0.02	0.02	0.03

Node	A	B	C	D	E	F
D (ft)	-20	-15	-10	+0	-5	-10

Flow boundary conditions are used at D (Q = 4000 cfs) and F (Q = 2000 cfs), and a constant stage boundary condition is used at A (Z = 0 ft). Since there is no analytical solution available for this problem, it was decided to run both DSM2-Hydro and FourPt Model, and compare the output. Model output showed that the output from the two models matched exactly, thus proving that in fact DSM2-Hydro is duplicating the results of FourPt Model. Figure 6-5 shows the model output for flow at the downstream (A). The results clearly show that the steady-state solution for flow at A is 6000 cfs. This is further proof that there is no numerical leakage in DSM2-Hydro as found in DSM1. DSM1, a modified version of FDM7E, is an explicit model and is based on the method of characterization.

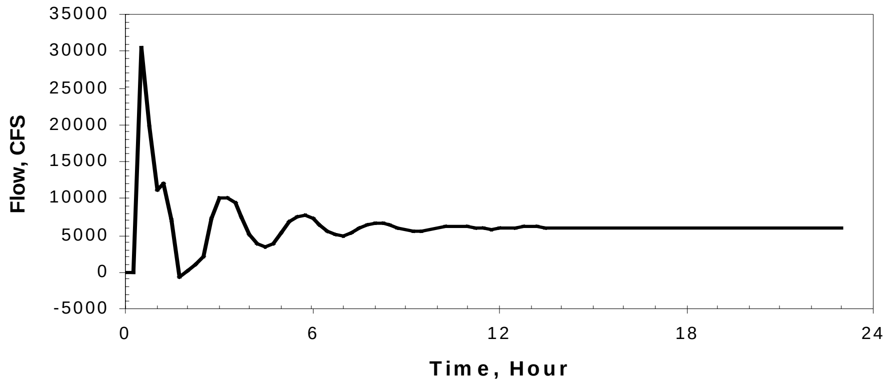

Figure 6-5: Flow at the Downstream (Fixed Stage at Boundary)

Test Problem 3

The configuration for this problem is exactly the same as the previous test problem, except that a tidal boundary condition is specified for the downstream (A):

$Z = 3 \sin(\omega t)$, where $\omega = 2\pi / T$, and the tidal period T = 12 hours.

In this case, the model is expected to reach a dynamic steady-state condition, where the flow and stage at all locations oscillate within a period of 12 hours. Again since no analytical solution is available, FourPt Model was used side by side with DSM2-Hydro, and the results were exactly identical. The output for flow and stage at all locations indicated a repeating pattern within a period of 12 hours. Figure 6-6 shows computed flows at the downstream (A). The computed 12-hour average flow at A is exactly 6000 cfs, which once again is proof that there is no numerical leakage associated with DSM2-Hydro, similar to that of DSM1.

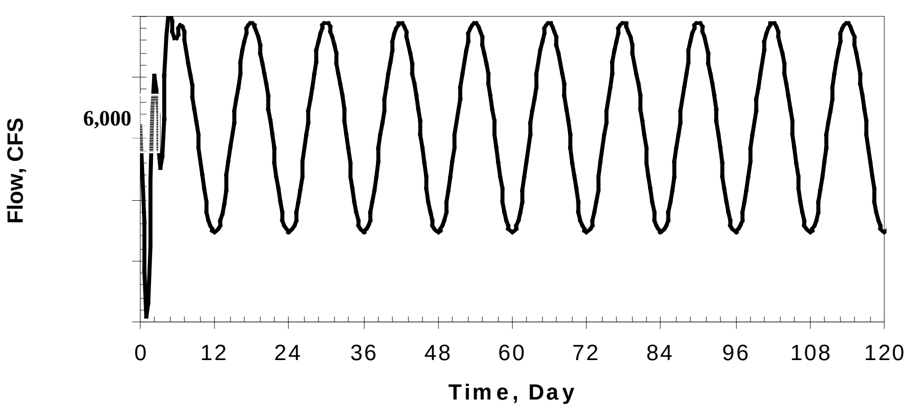

Figure 6-6: Flow at the Downstream (Tidal Boundary)