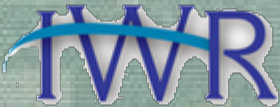


# UK Benchmarking Models – HEC-RAS

Gary Brunner, P.E., D. WRE,  
M.ASCE



US Army Corps  
of Engineers



# Benchmarking HEC-RAS against the UK 2D Modeling test data sets

## ■ Purpose

- To demonstrate that the HEC-RAS two-dimensional modeling capabilities can produce similar results to the two-dimensional models documented by the United Kingdom Environmental Agency Benchmarking report
- To show that HEC-RAS can produce similar results with larger grid cell sizes, due to the use of subgrid bathymetry
- To demonstrate that HEC-RAS can convergence for a wide range of computational time steps

# Research Document 51

- Available from the HEC-RAS webpages
- <https://www.hec.usace.army.mil/software/hec-ras/documentation.aspx>



US Army Corps  
of Engineers  
Hydrologic Engineering Center

## Benchmarking of the HEC-RAS Two-Dimensional Hydraulic Modeling Capabilities

April 2018

Approved for Public Release. Distribution Unlimited.

RD-51



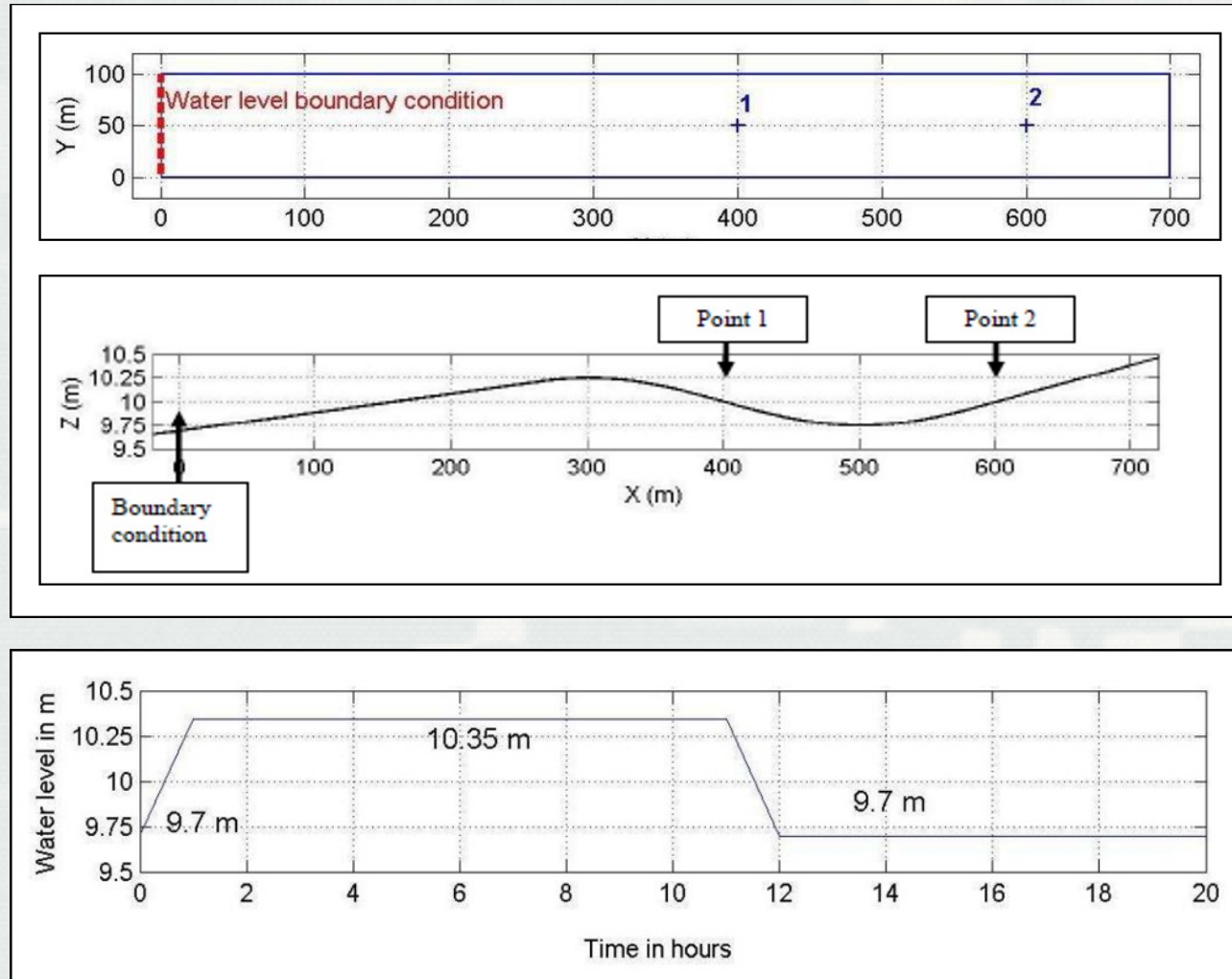
# Benchmarking HEC-RAS

## UK Benchmarking Tests

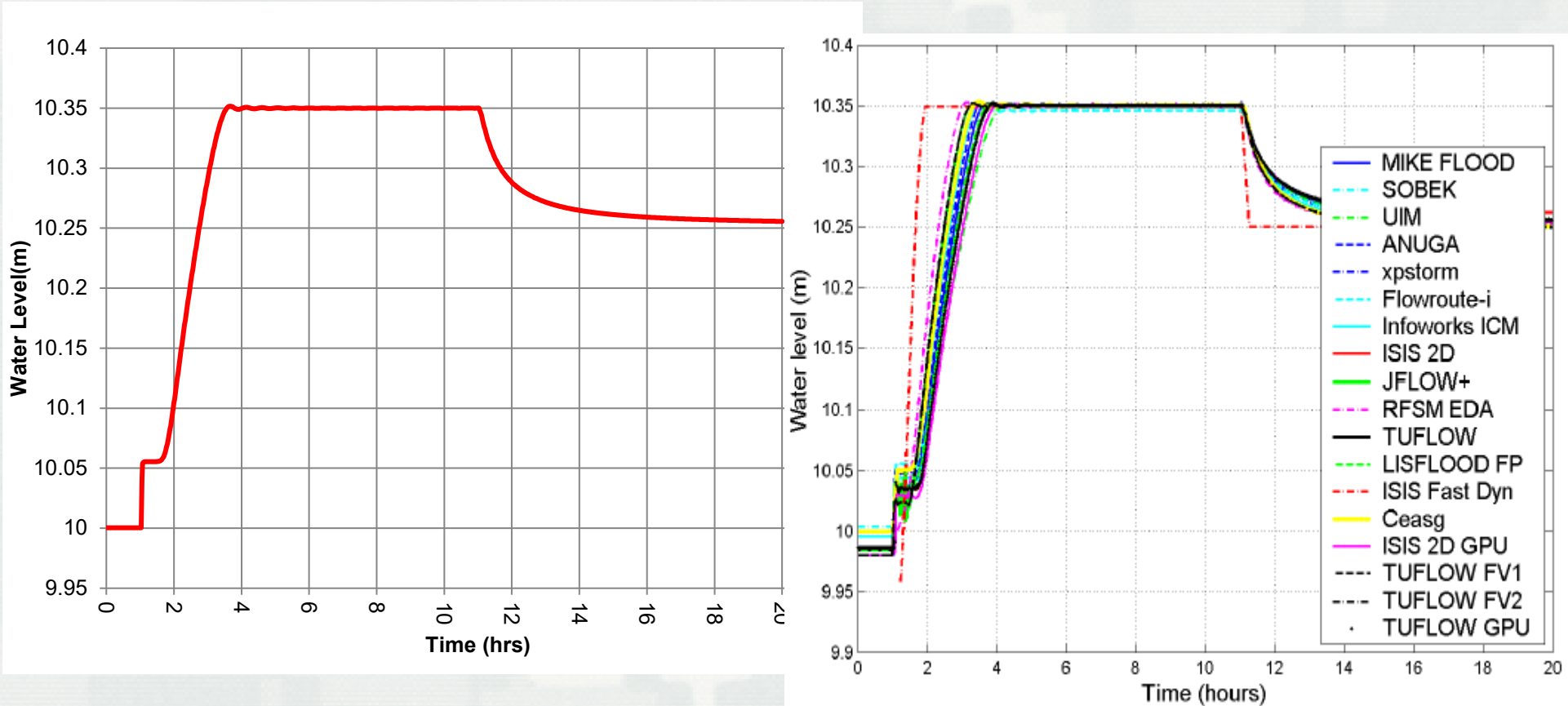
Test	Description	Test Completed/reason for not completing
1	Flooding a disconnected water body	yes
2	Filling of floodplain depressions	yes
3	Momentum conservation over a small obstruction	yes
4	Speed of flood propagation over an extended floodplain	yes
5	Valley flooding	yes
6A	Flume Scale Dambreak	yes
6B	Full Scale Dambreak	yes
7	River and floodplain linking	yes
8A	Rainfall and point source surface flow in urban areas	yes
8B	Surface flow from a surcharging sewer in urban areas	No; HEC-RAS does not currently have the option to perform combined 2D surface flow connected to subsurface pipe flow

# Benchmark Test 1

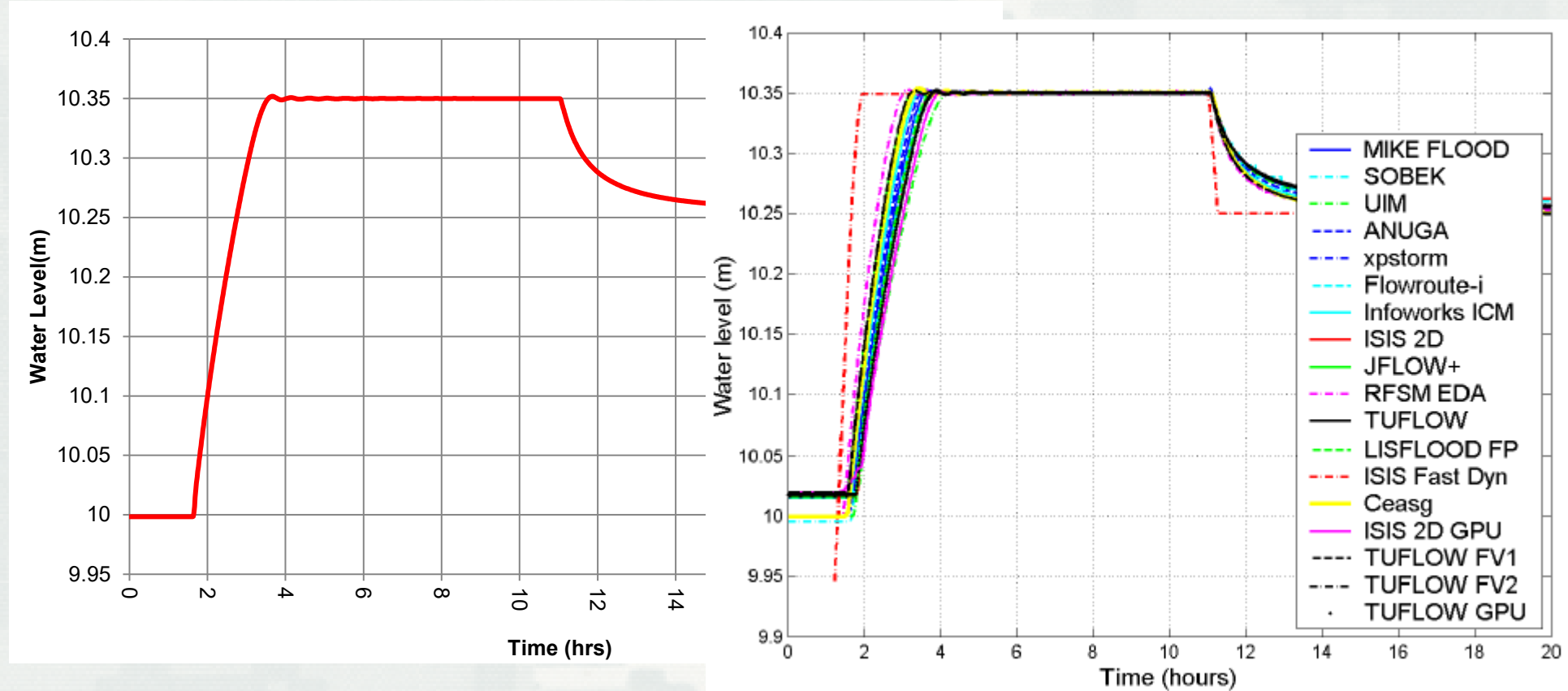
## Flooding a Disconnected Water Body



# Test 1 Results – Location 1

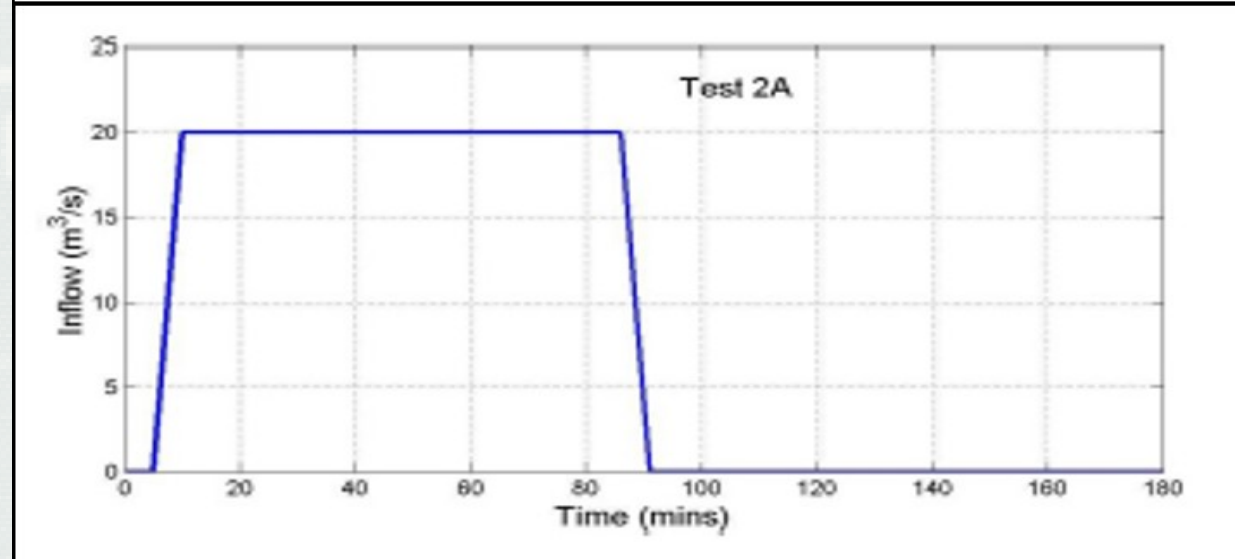
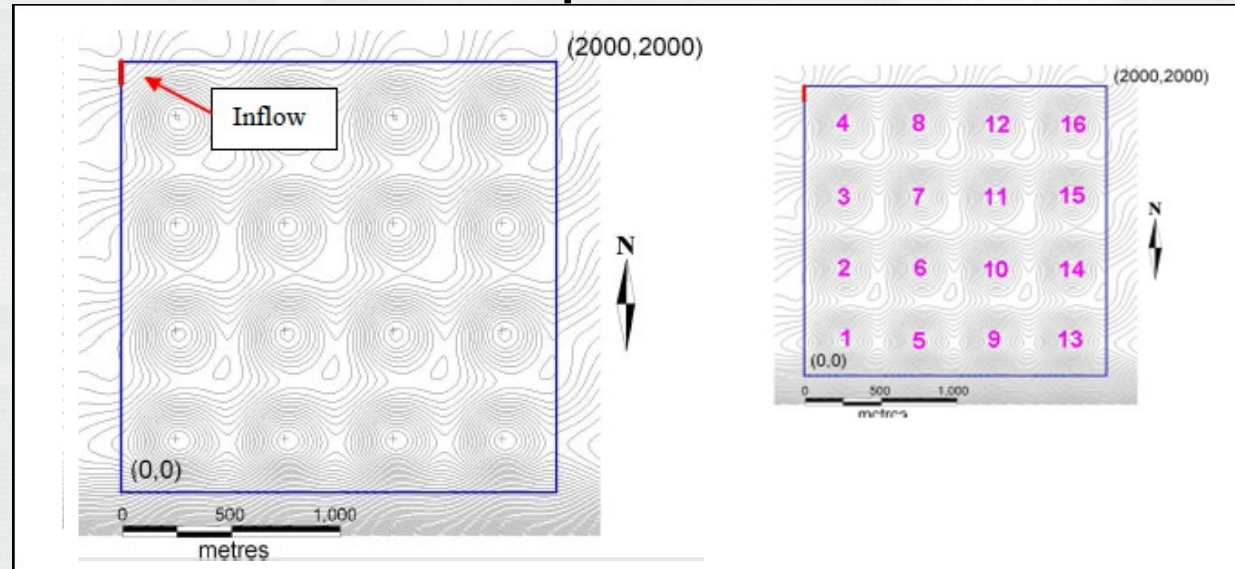


# Test 1 Results – Location 2



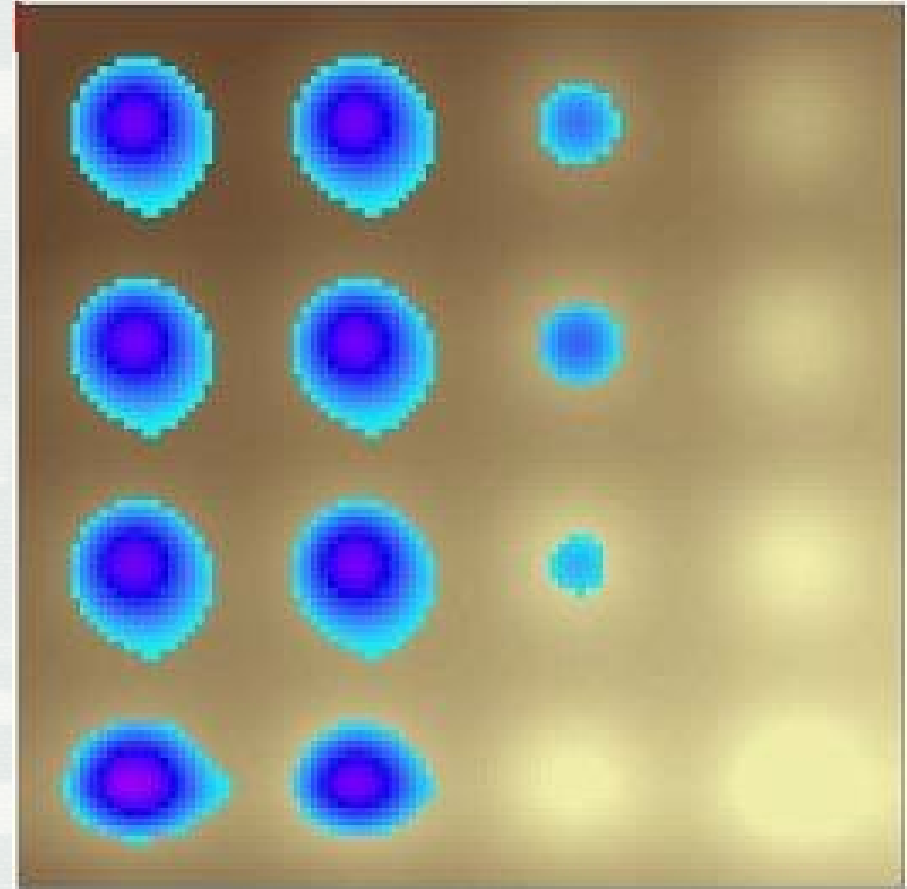
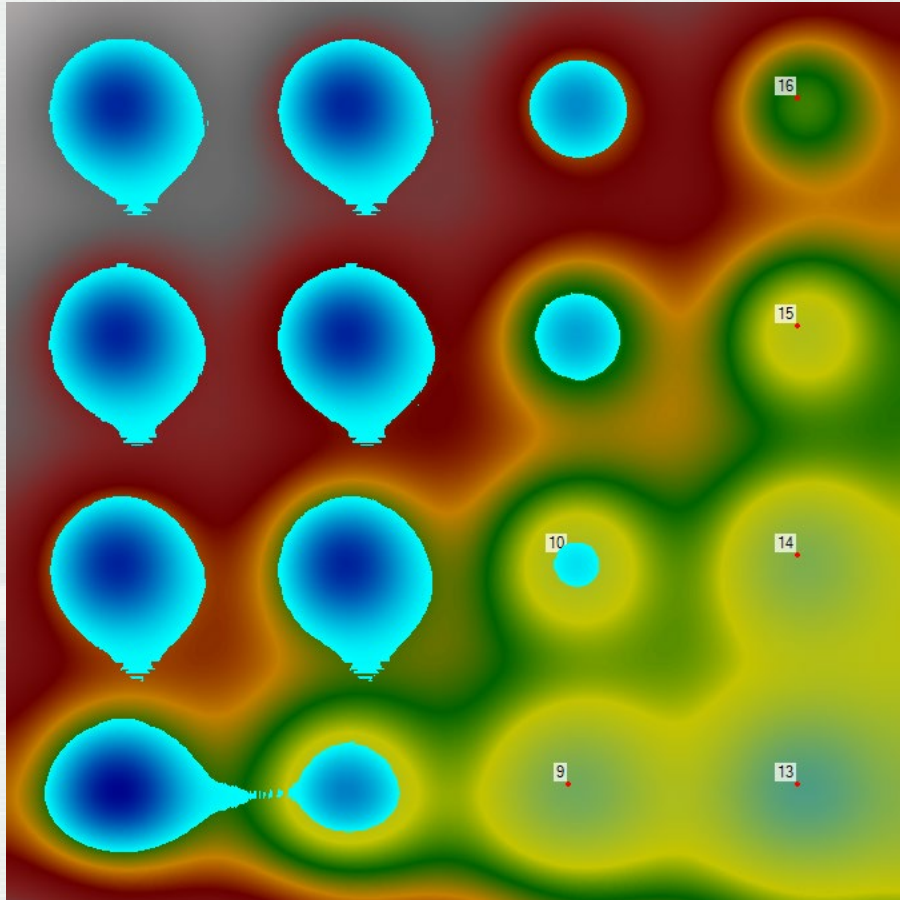


# Benchmark Test 2 Filling of Floodplain Depressions





# Test 2 Results – Final water depths



# Test 2 Results – Location 1

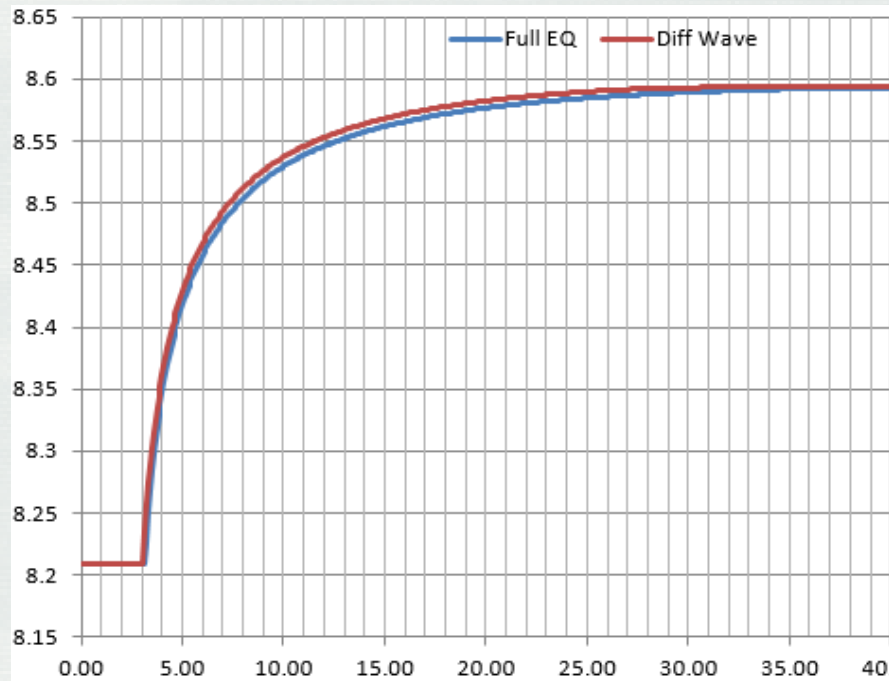
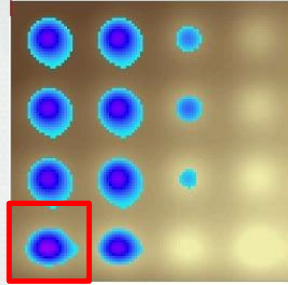
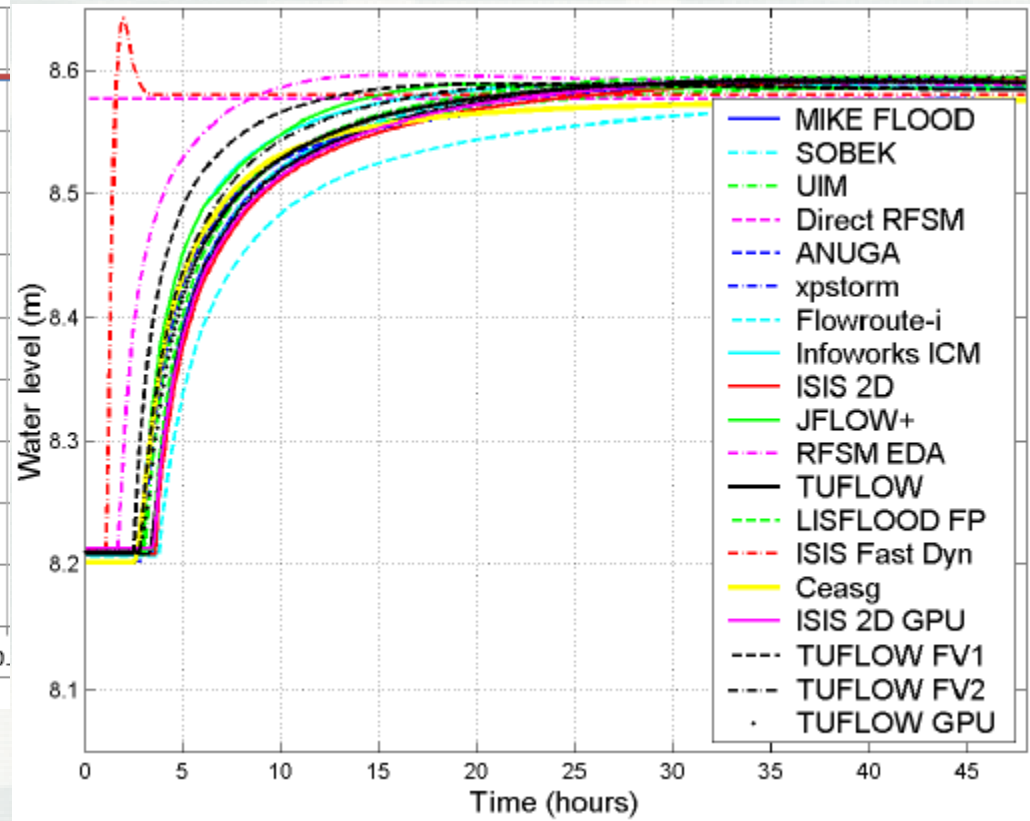
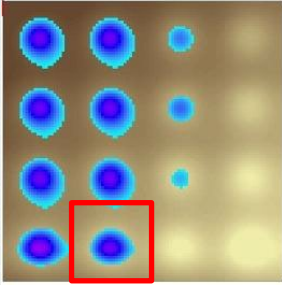


Figure 10. Test Point 1 - Water Level (m) versus Time (hrs).





# Test 2 Results – Location 5

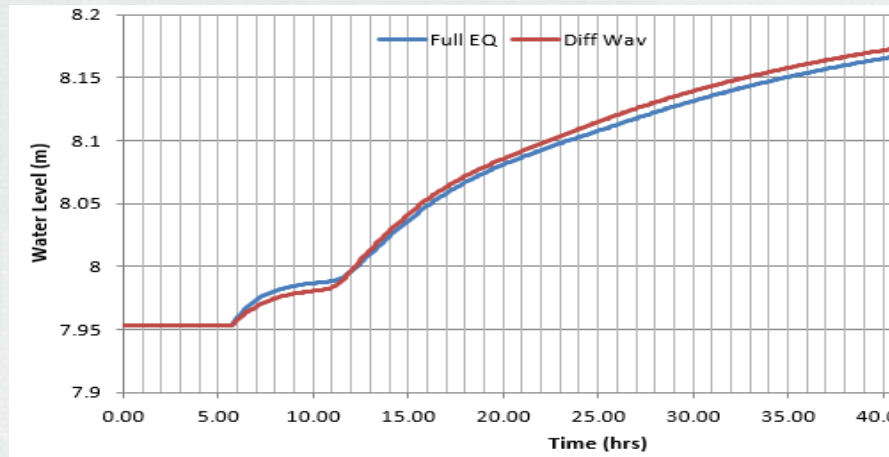
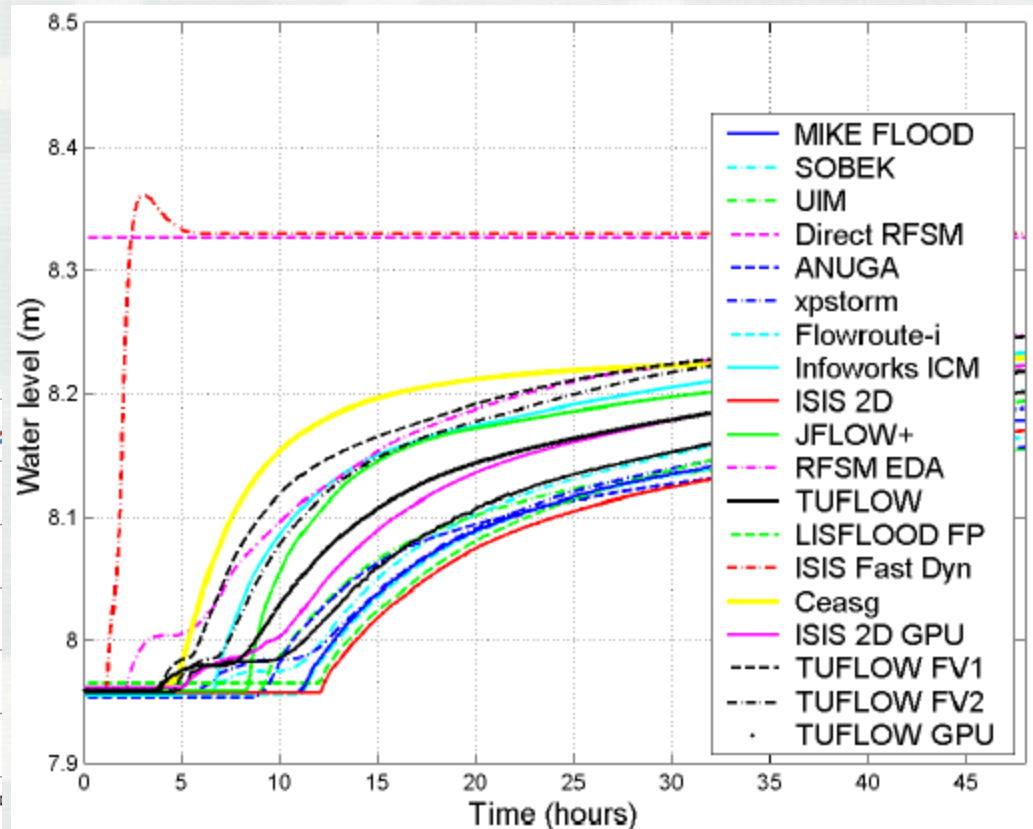
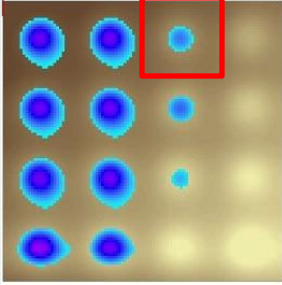
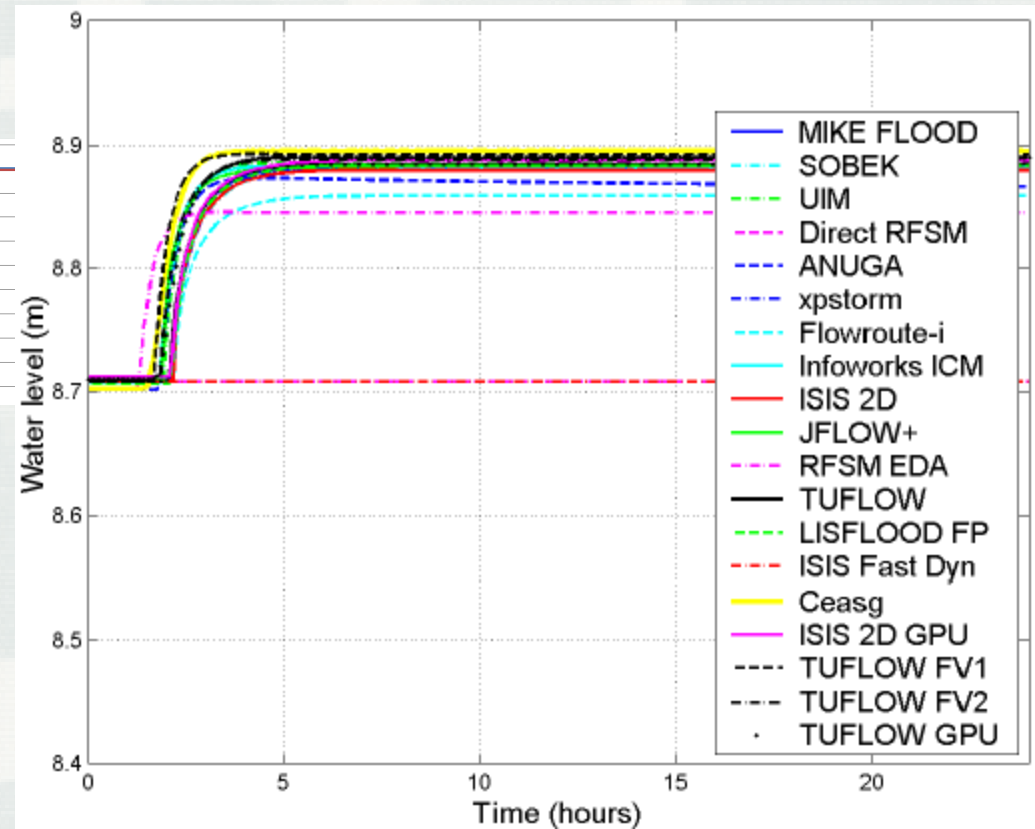
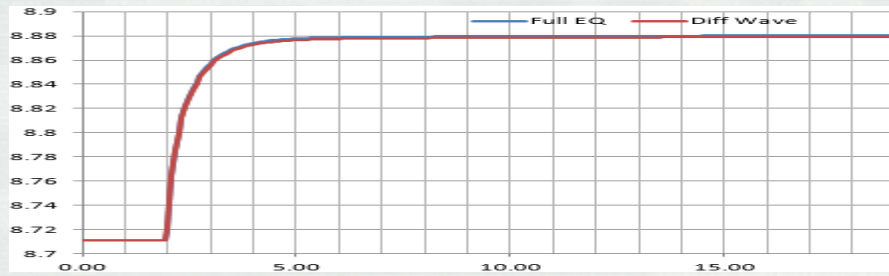


Figure 14. Test Point 5 - Water Level (m) versus Time (hrs).





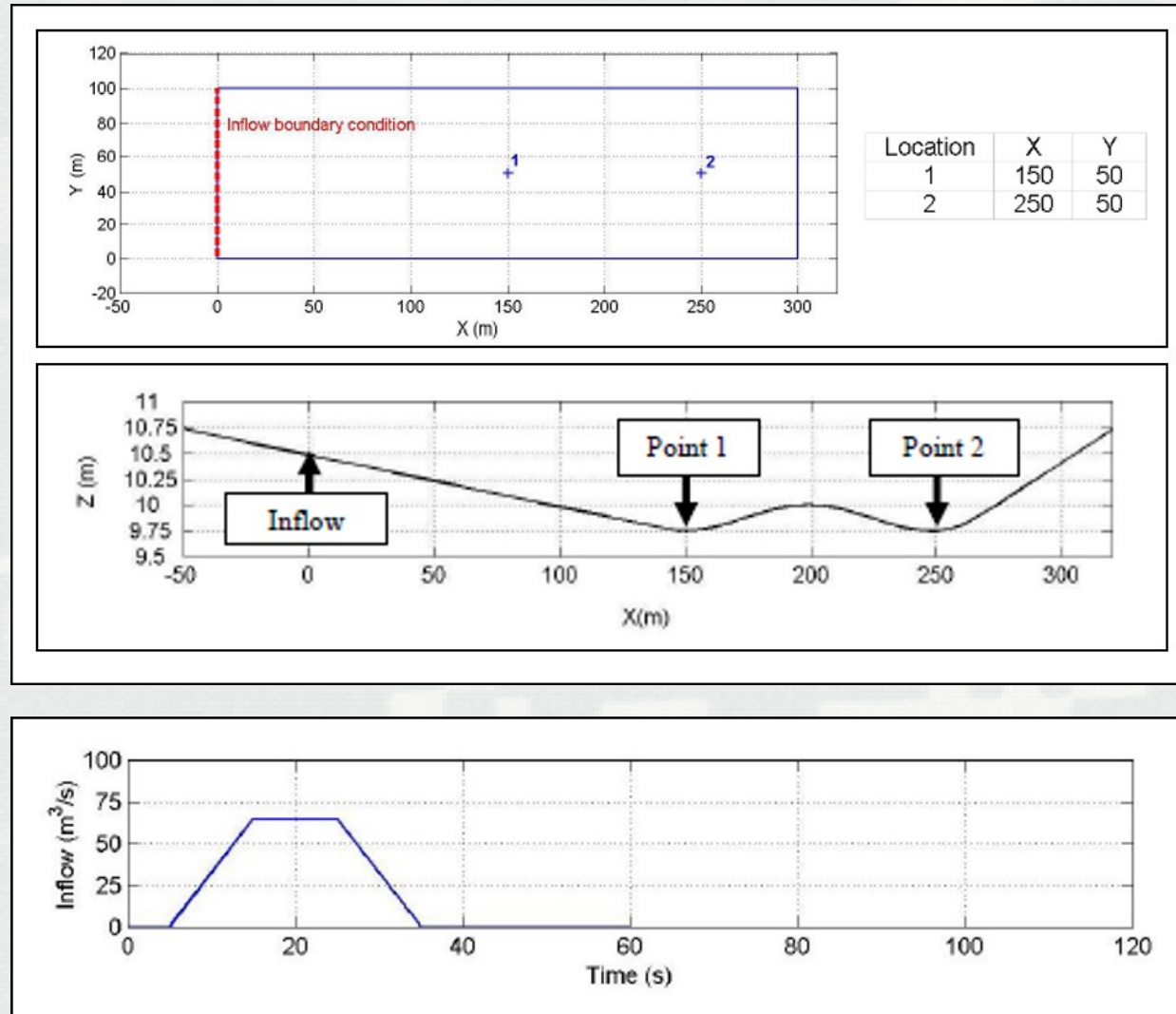
# Test 2 Results – Location 12



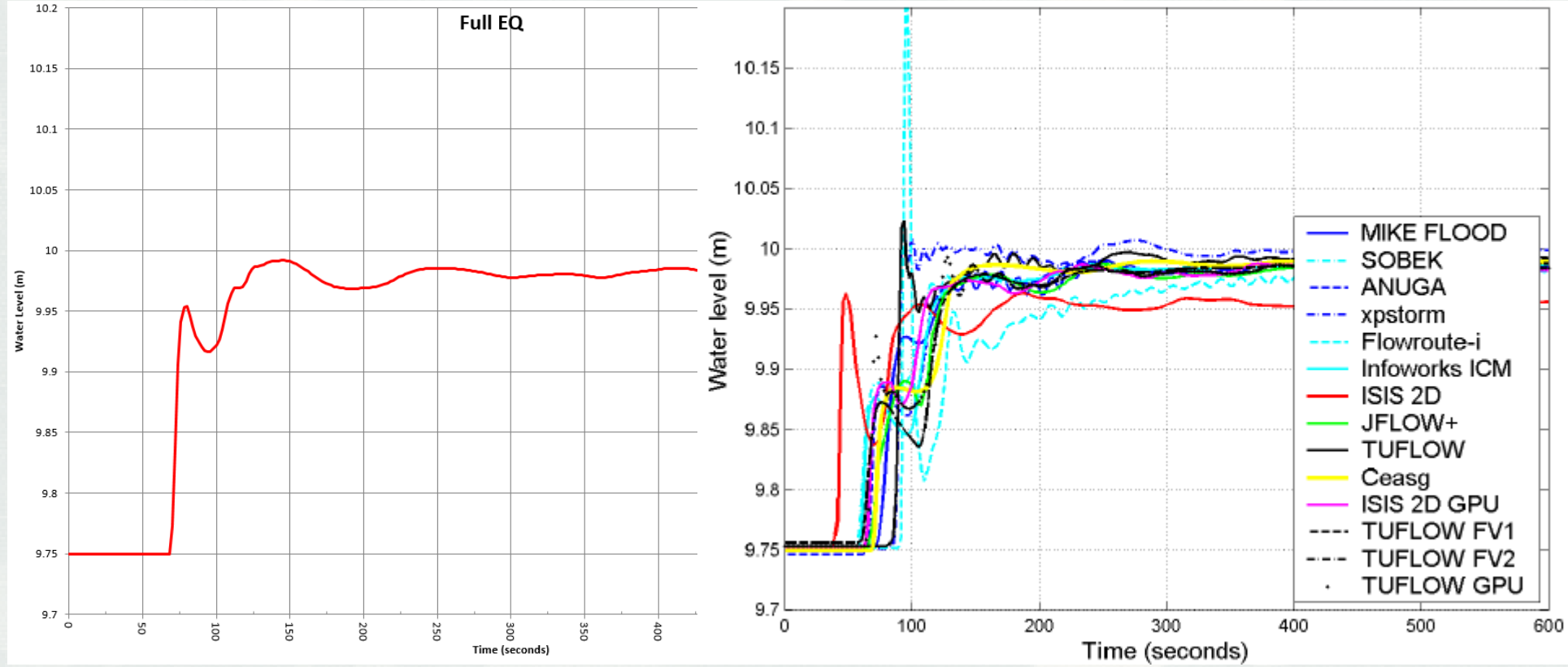


# Benchmark Test 3

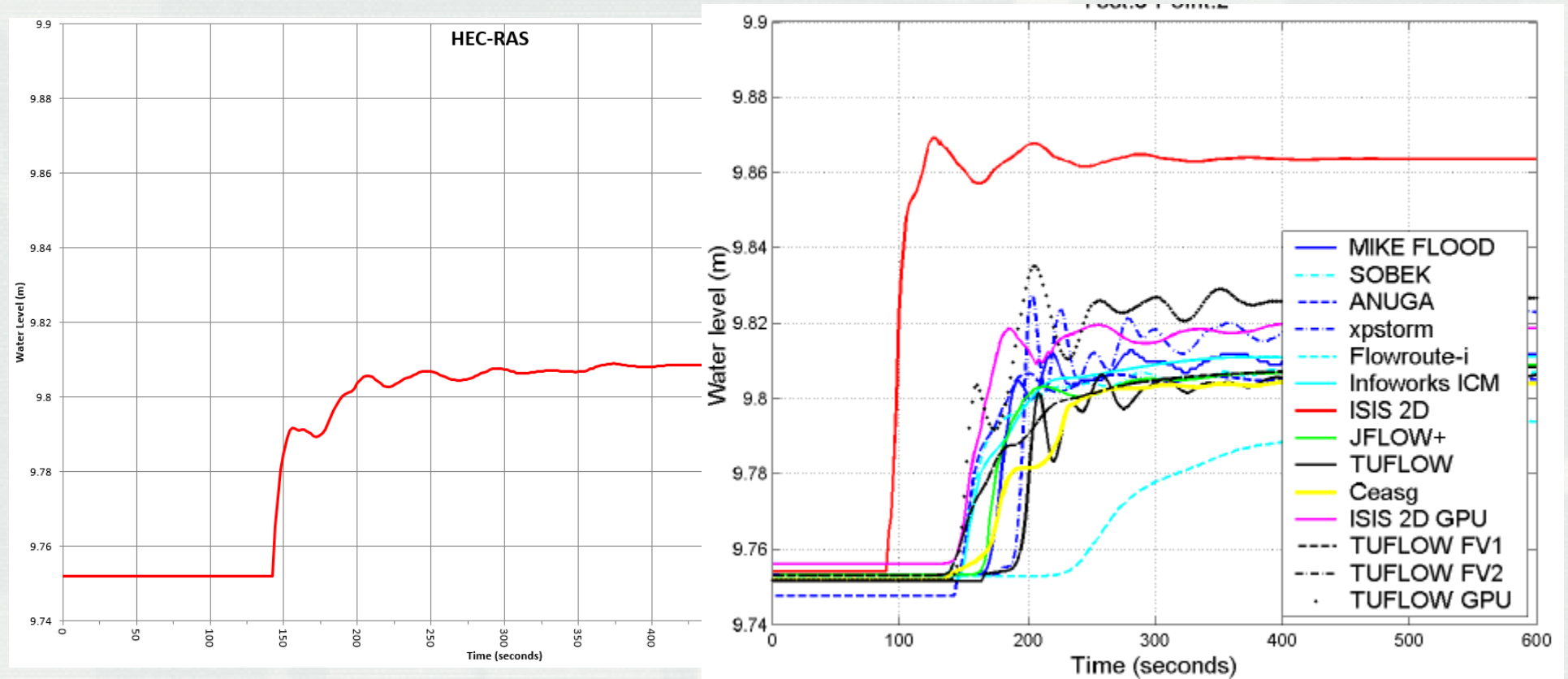
## Momentum Conservation over a Small Obstruction



# Test 3 Results – Location 1

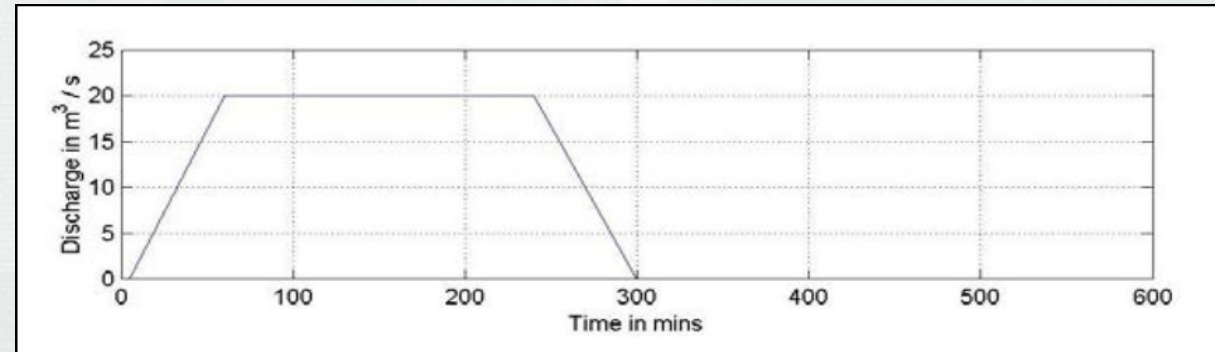
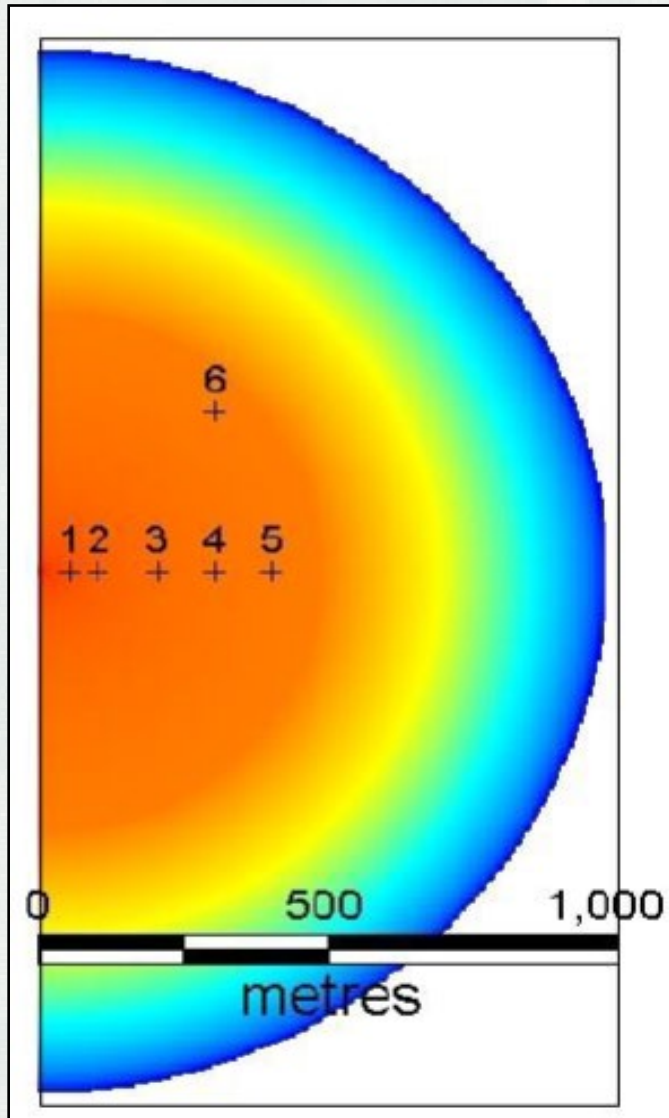


# Test 3 Results – Location 2



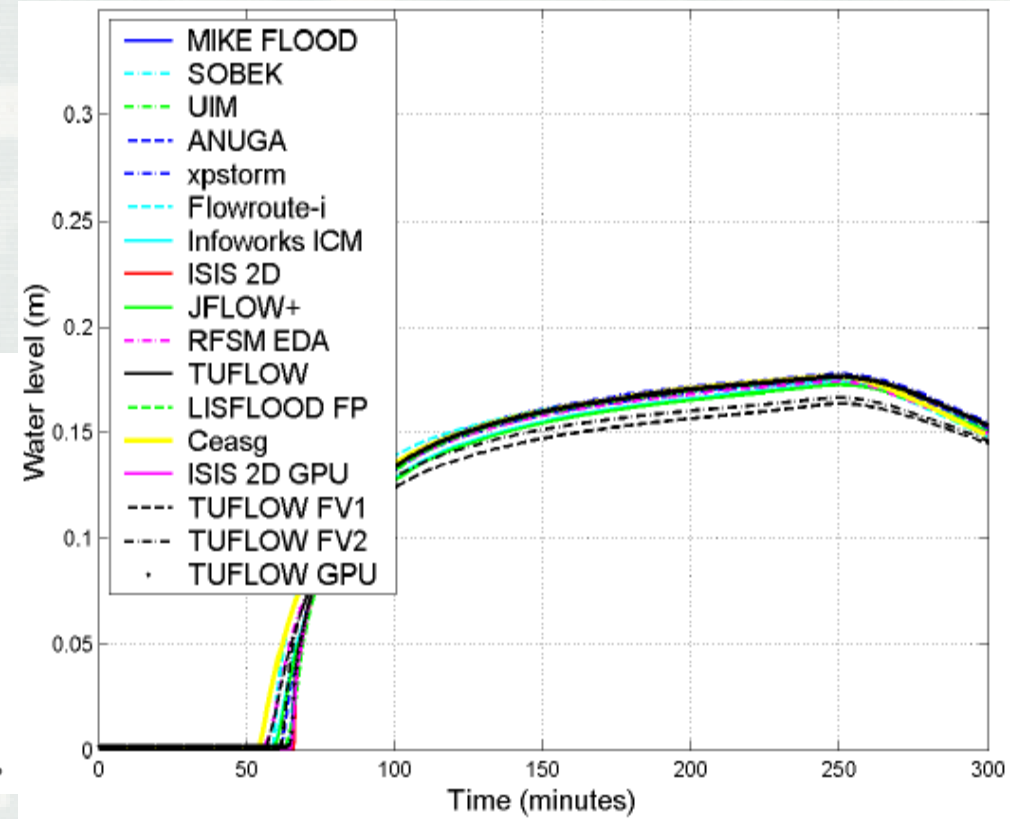
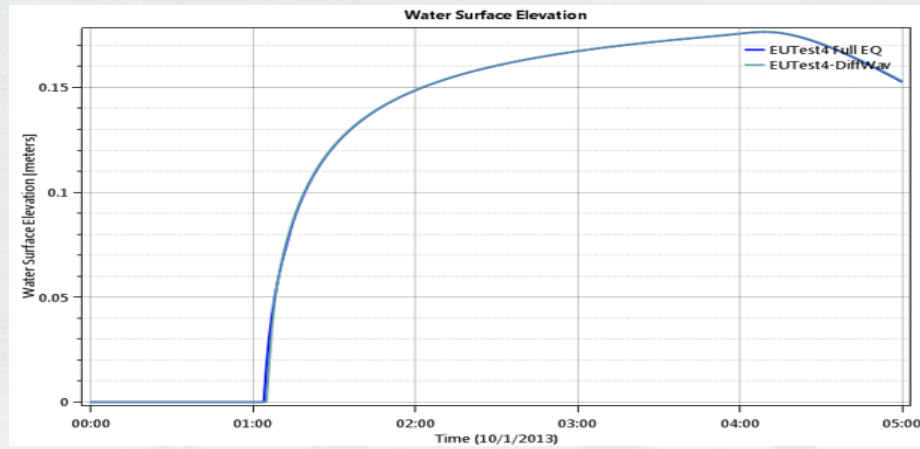
# Benchmark Test 4

## Speed of Flood Propagation over an Extended Floodplain

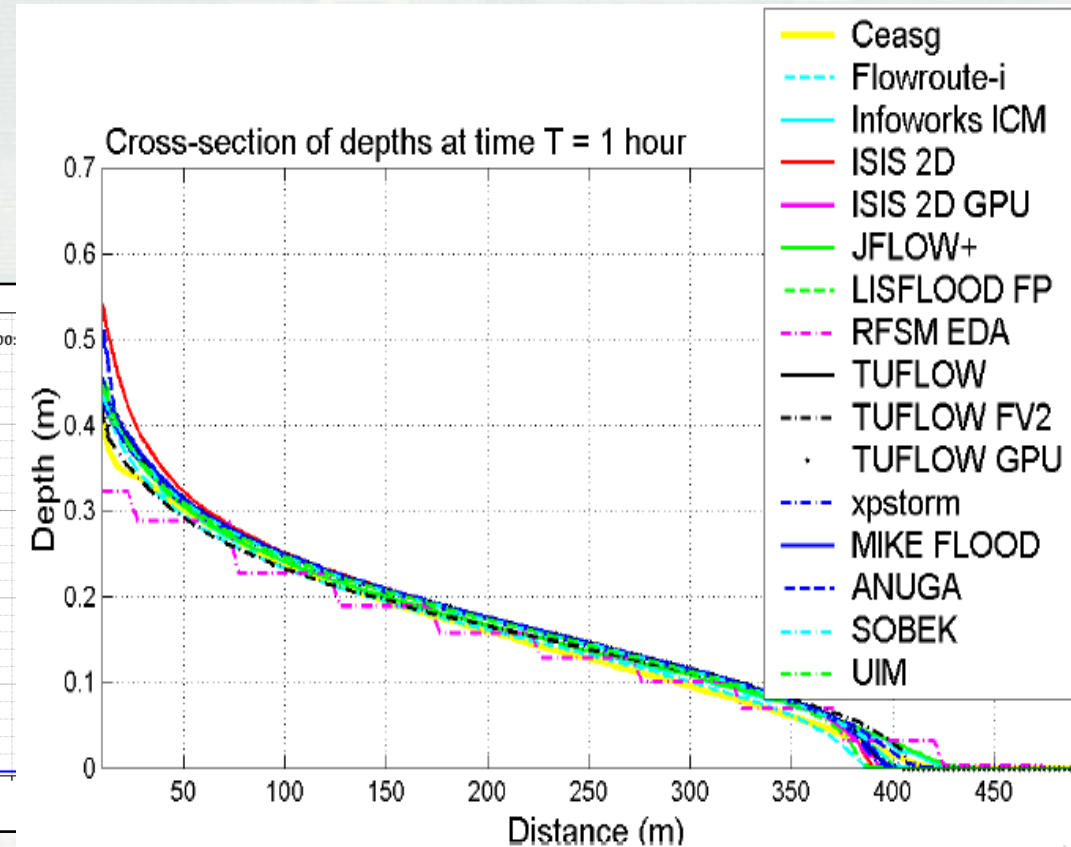
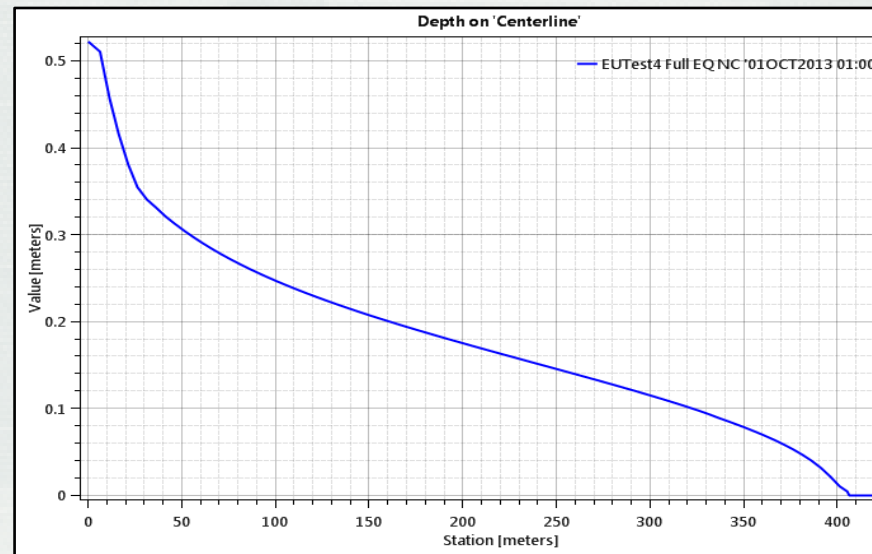




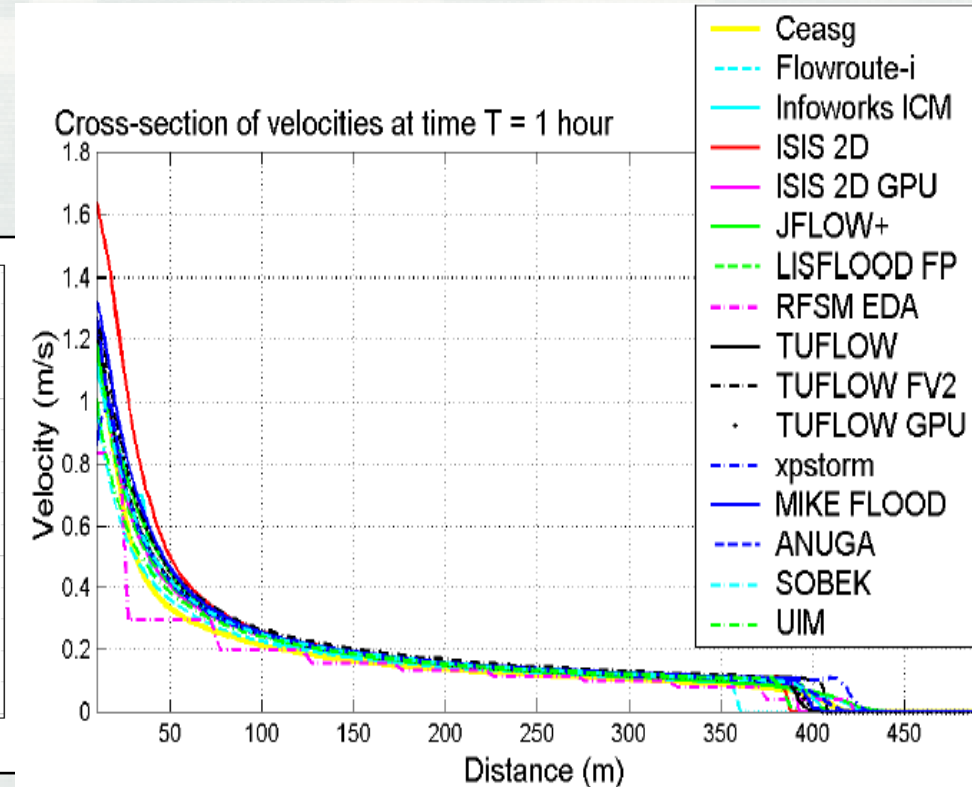
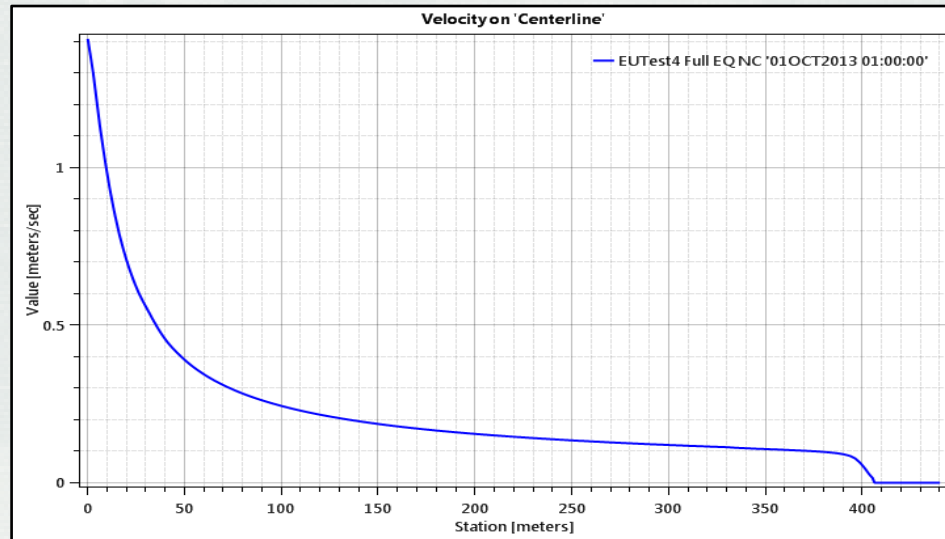
# Test 4 Results – Location 6



# Test 4 Results – Centerline Profile at time = 1 hour

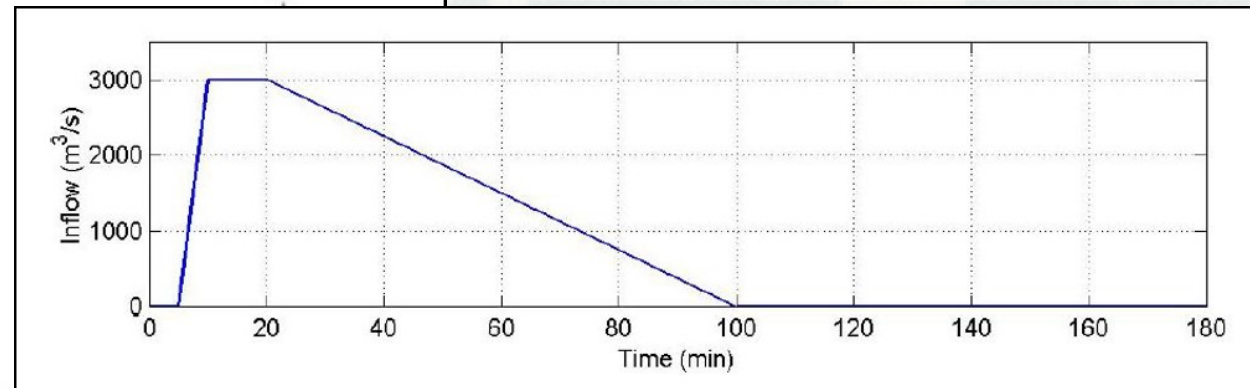
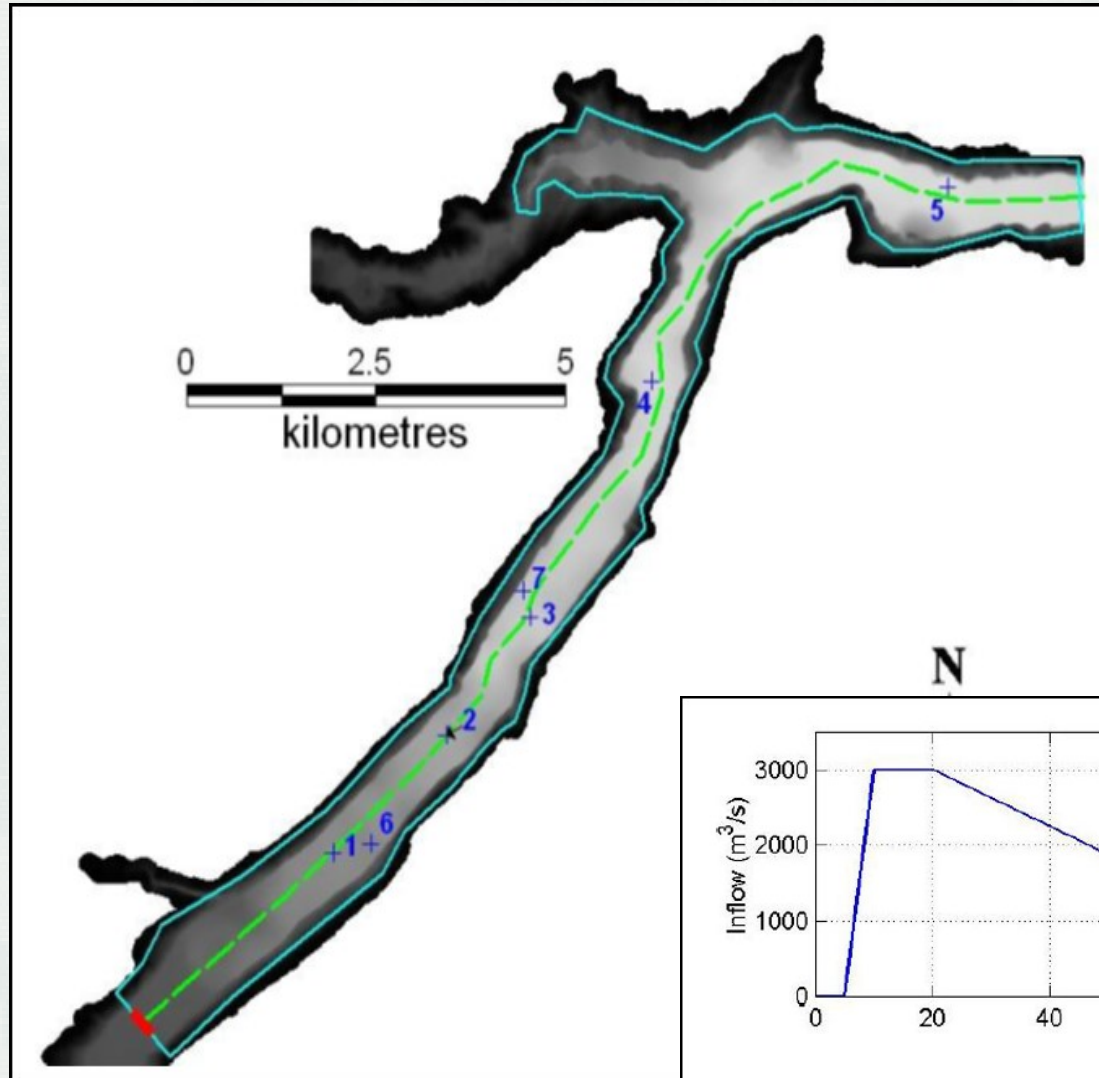


# Test 4 Results – Centerline Velocity Profile at time = 1 hour



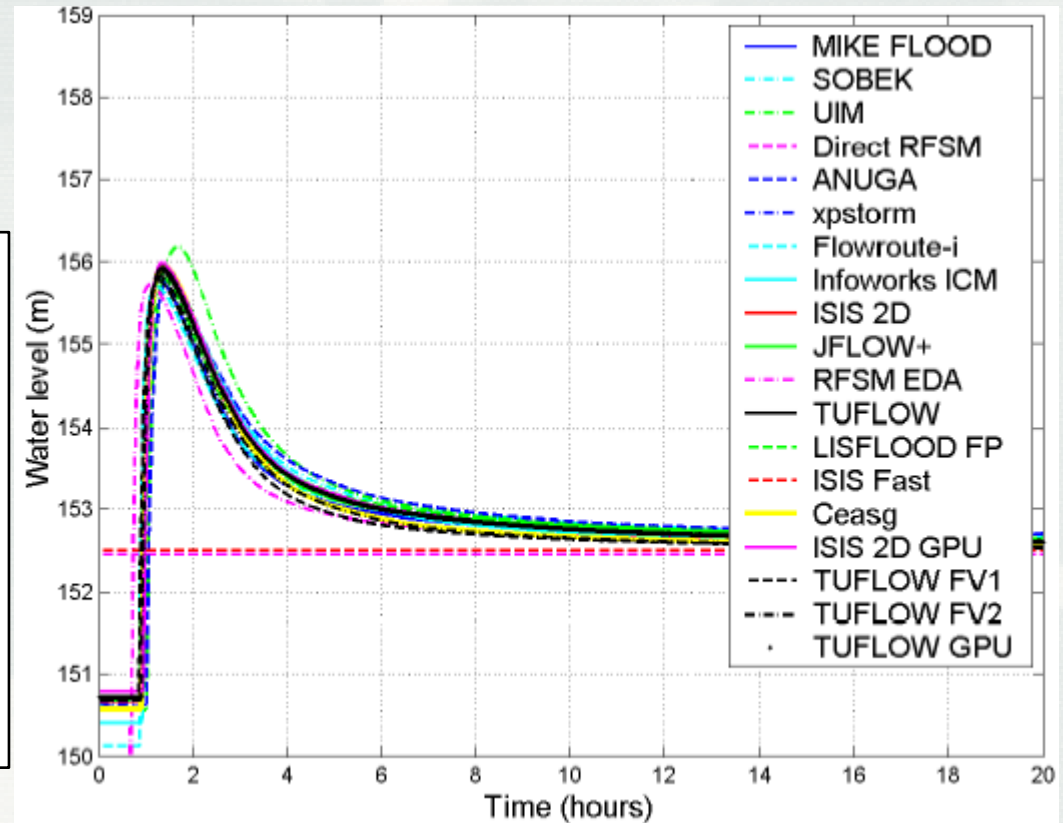
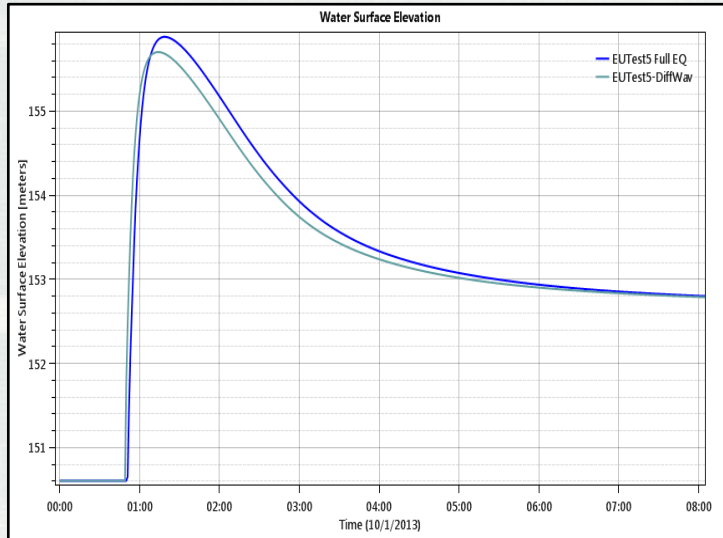
# Benchmark Test 5

## Valley Flooding

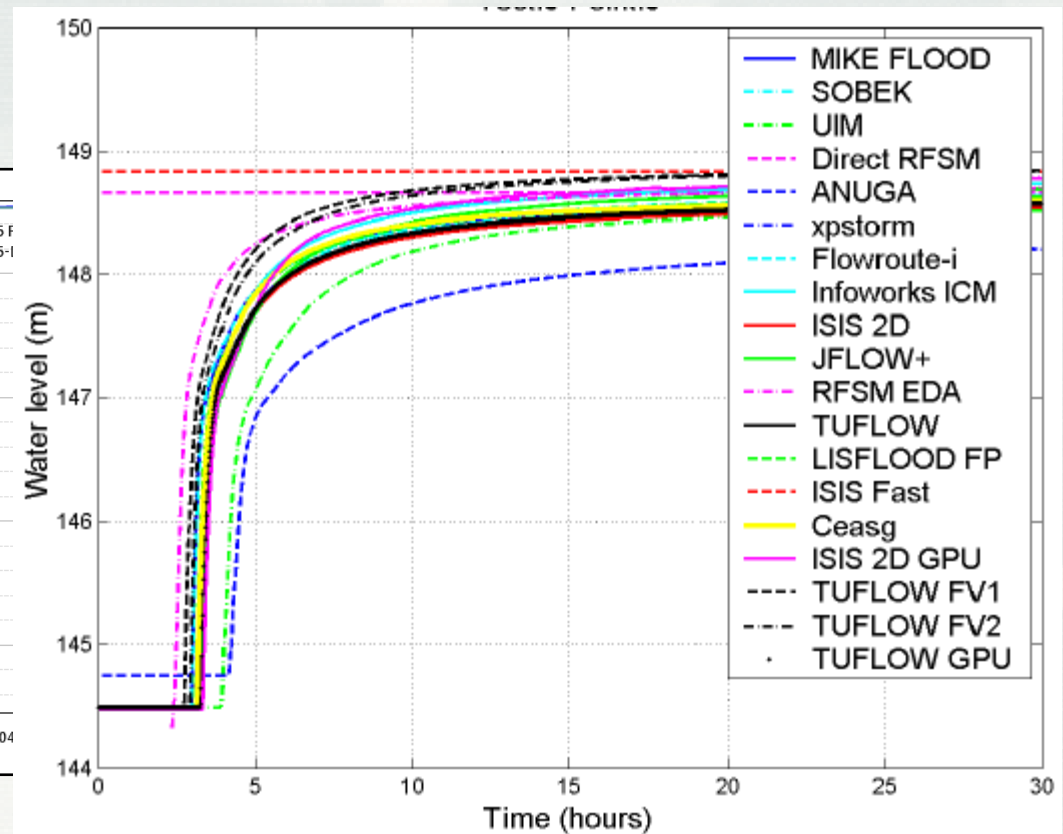
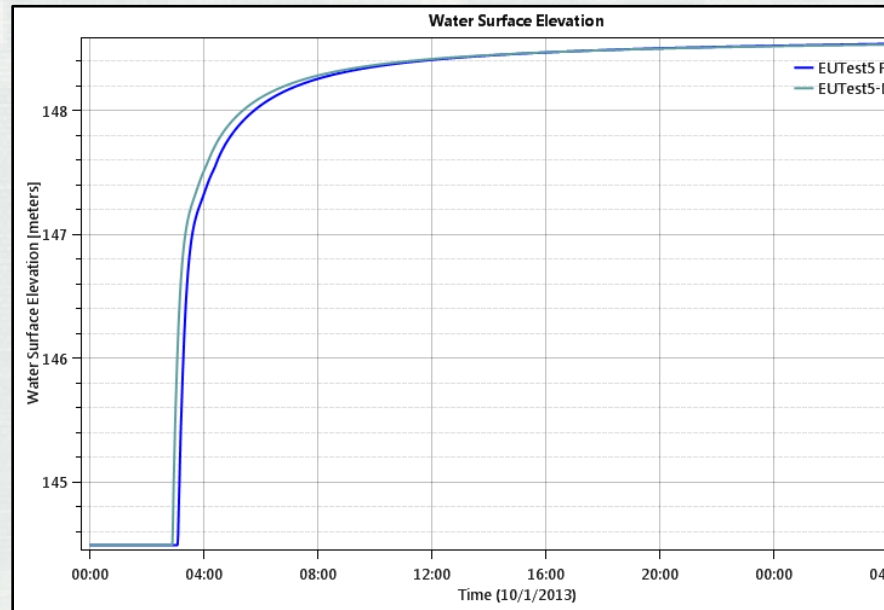




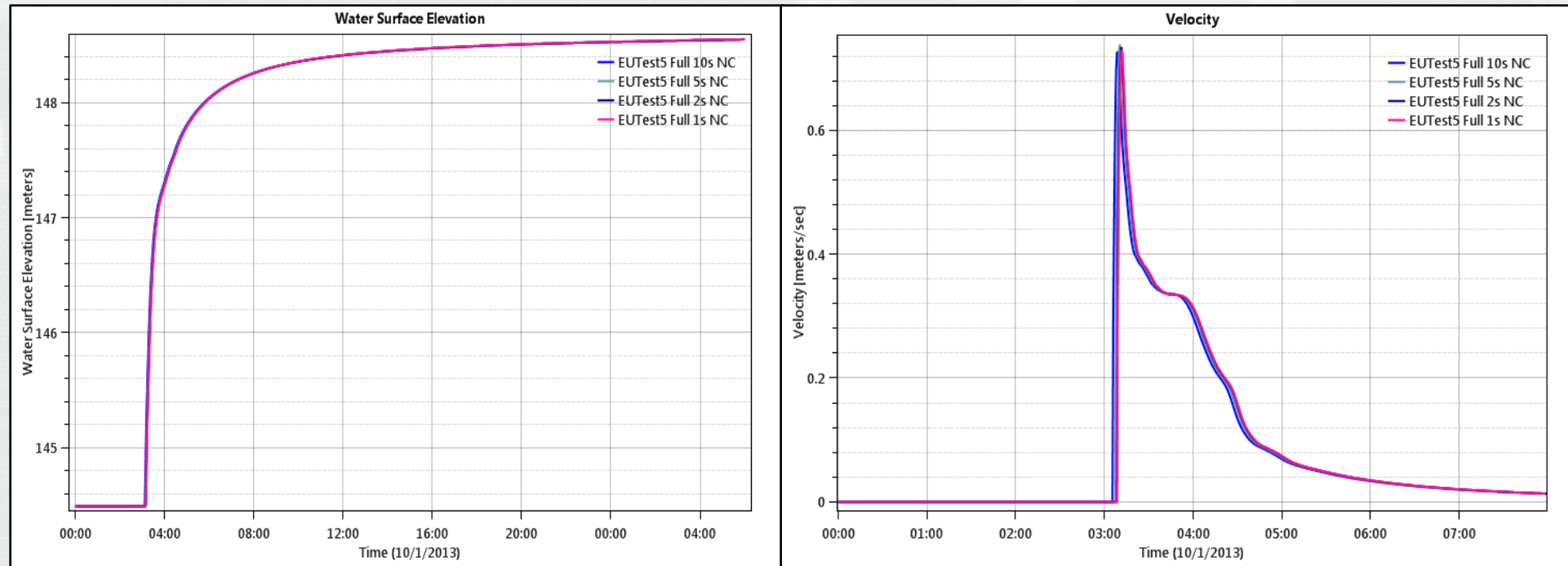
# Test 5 Results – Location 3



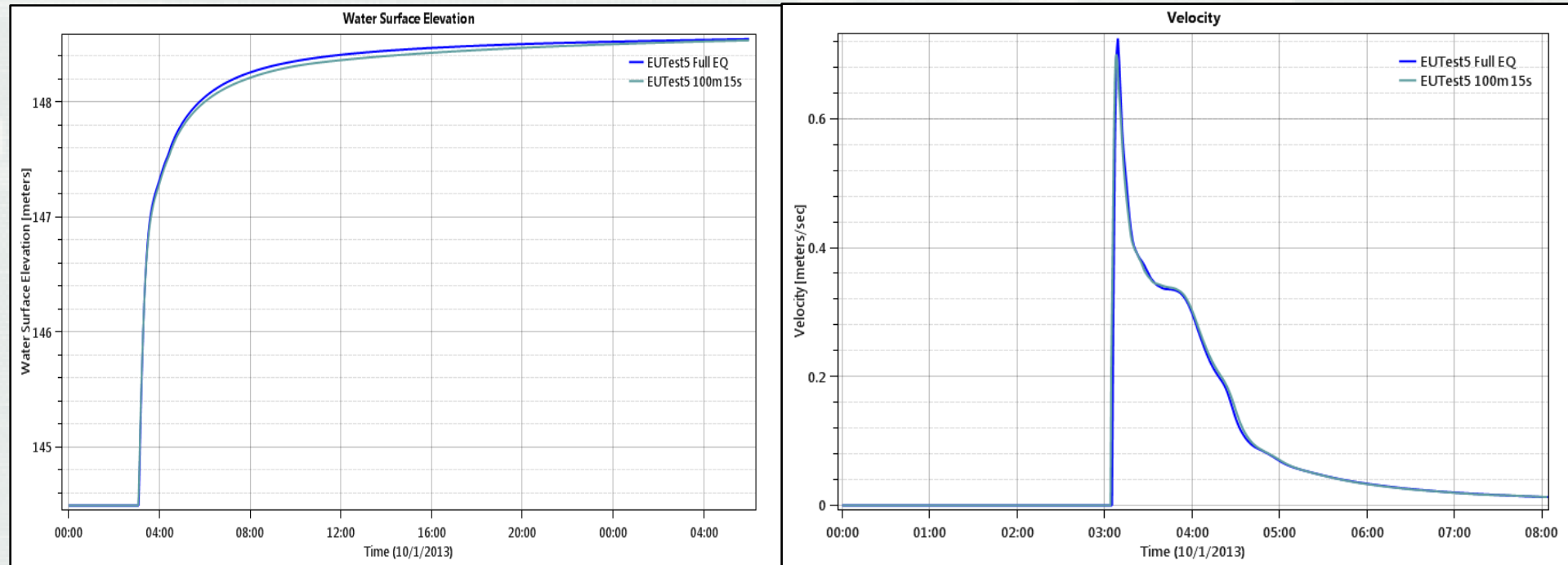
# Test 5 Results – Location 5



# Test 5 – FEQ Sensitivity to Computation Interval, $\Delta T = 1, 2, 5, 10$ seconds – Location 5



# Test 5 – FEQ Sensitivity to Grid Resolution, $\Delta X = 50$ m and 100 m – Location 5



## Run Times:

**50 m Grid and 10s time step = 100 seconds**

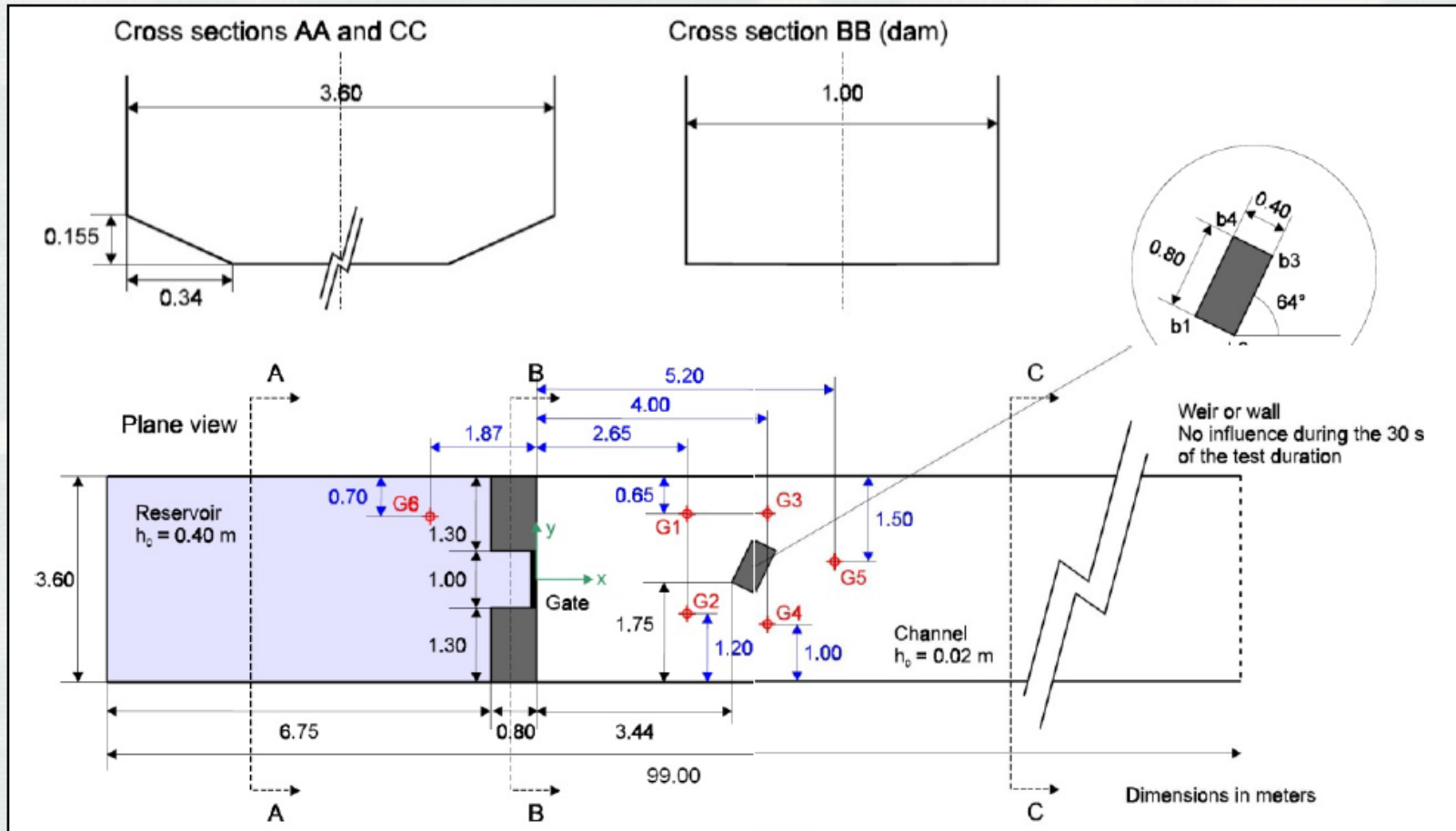
**100 m Grid and 15s time step = 24 seconds**



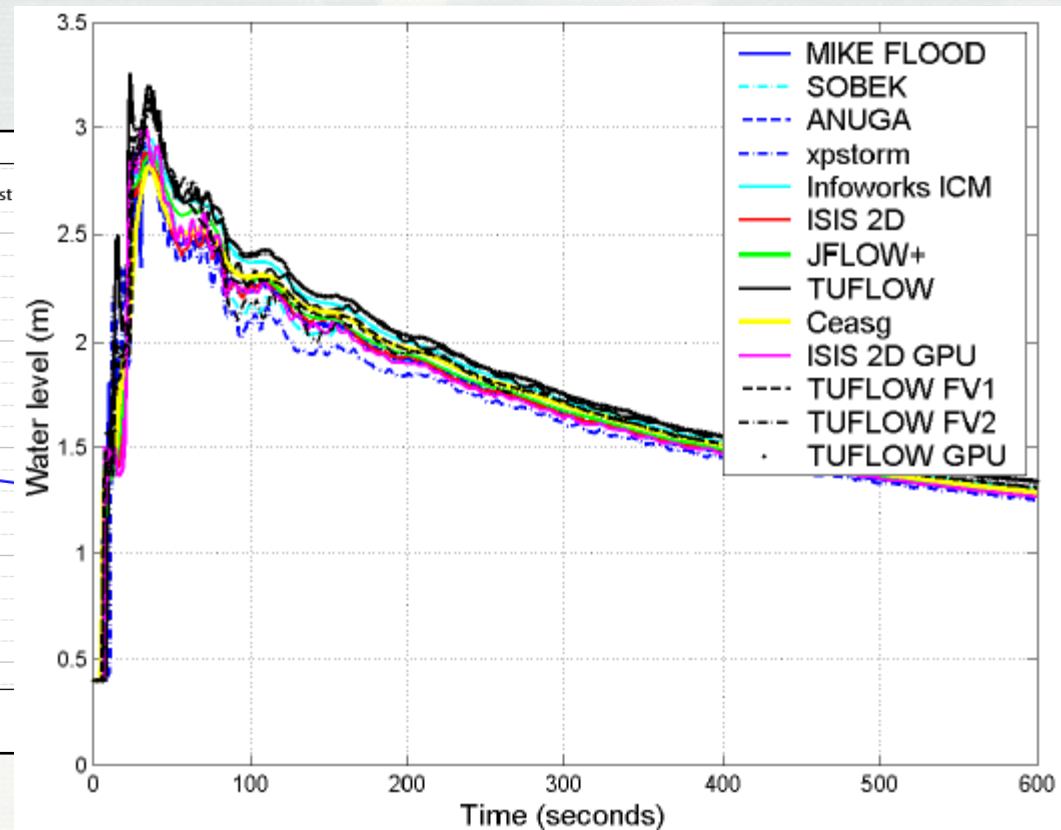
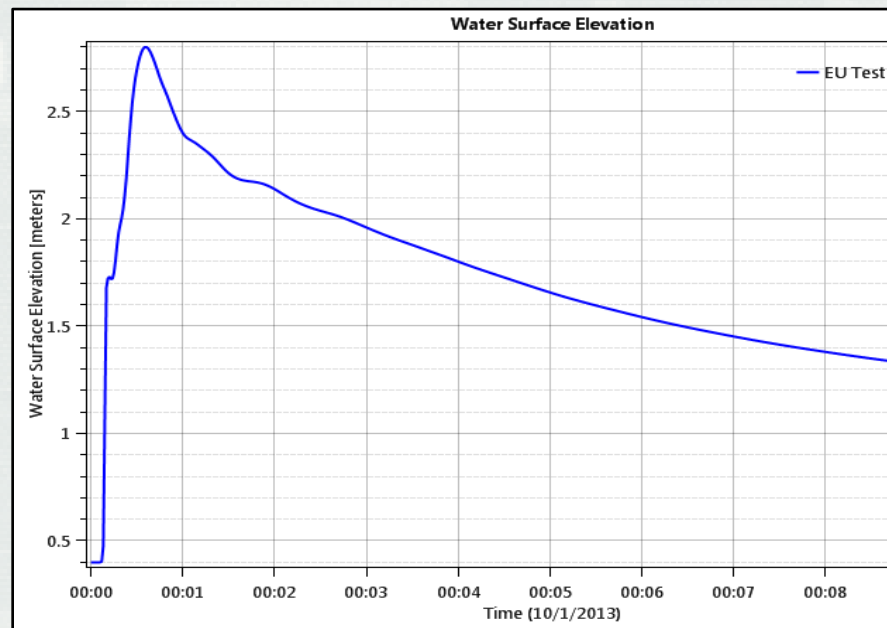
# Benchmark Test 6B

## Dam Break

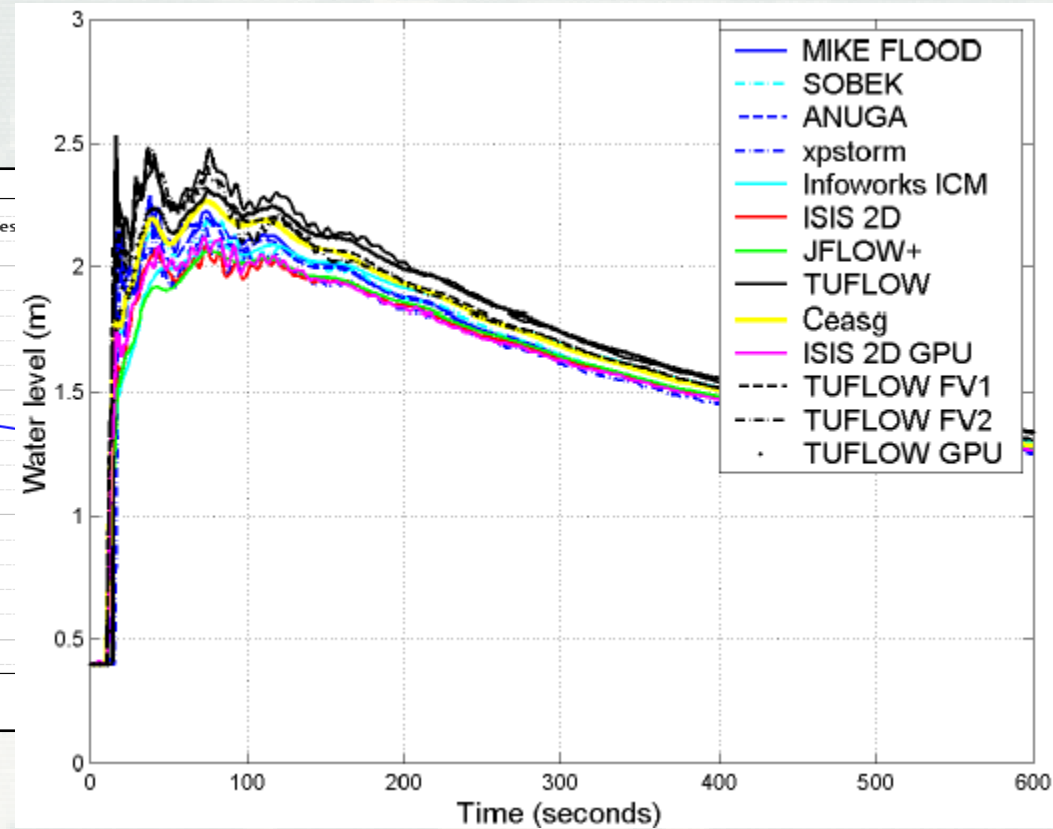
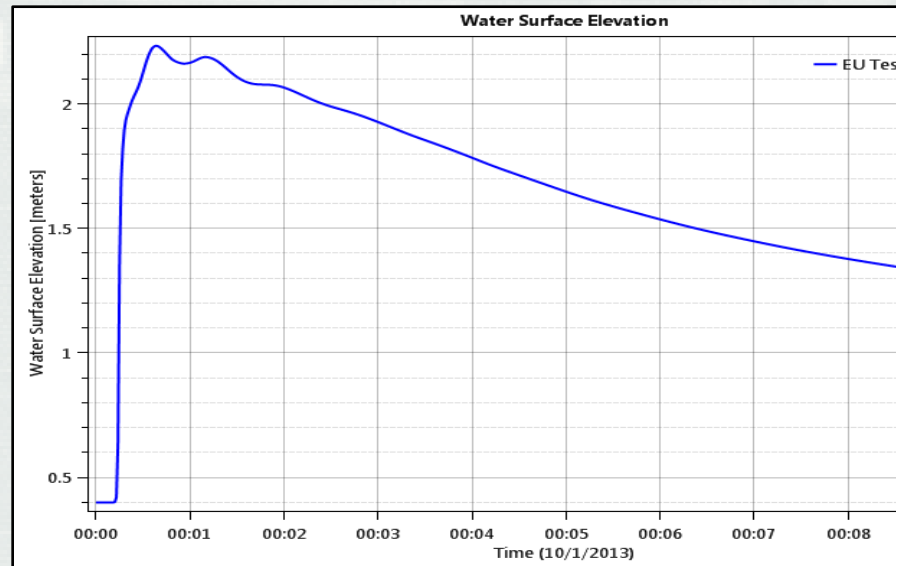
Note: Flume dimensions were multiplied by 20 for full scale model runs



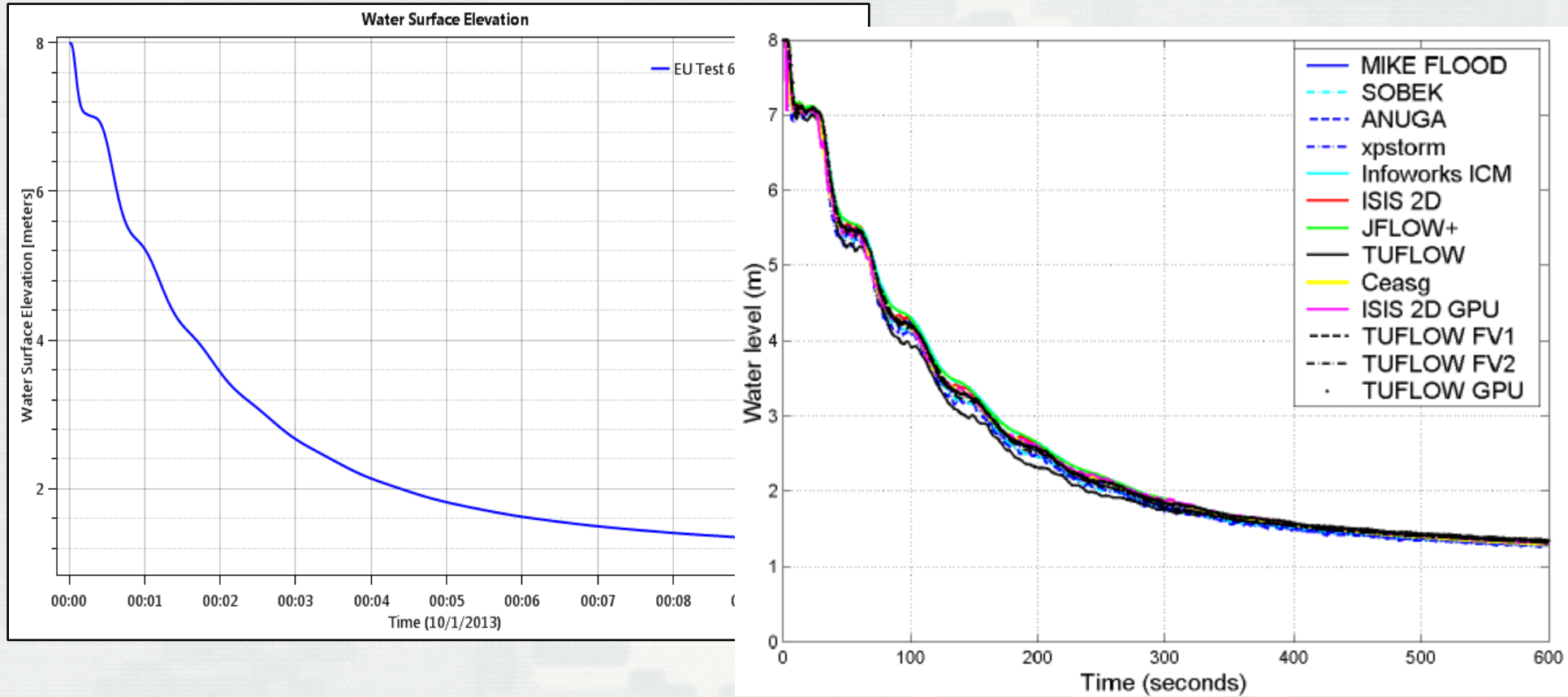
# Test 6B Results – Location G2



# Test 6B Results – Location G4

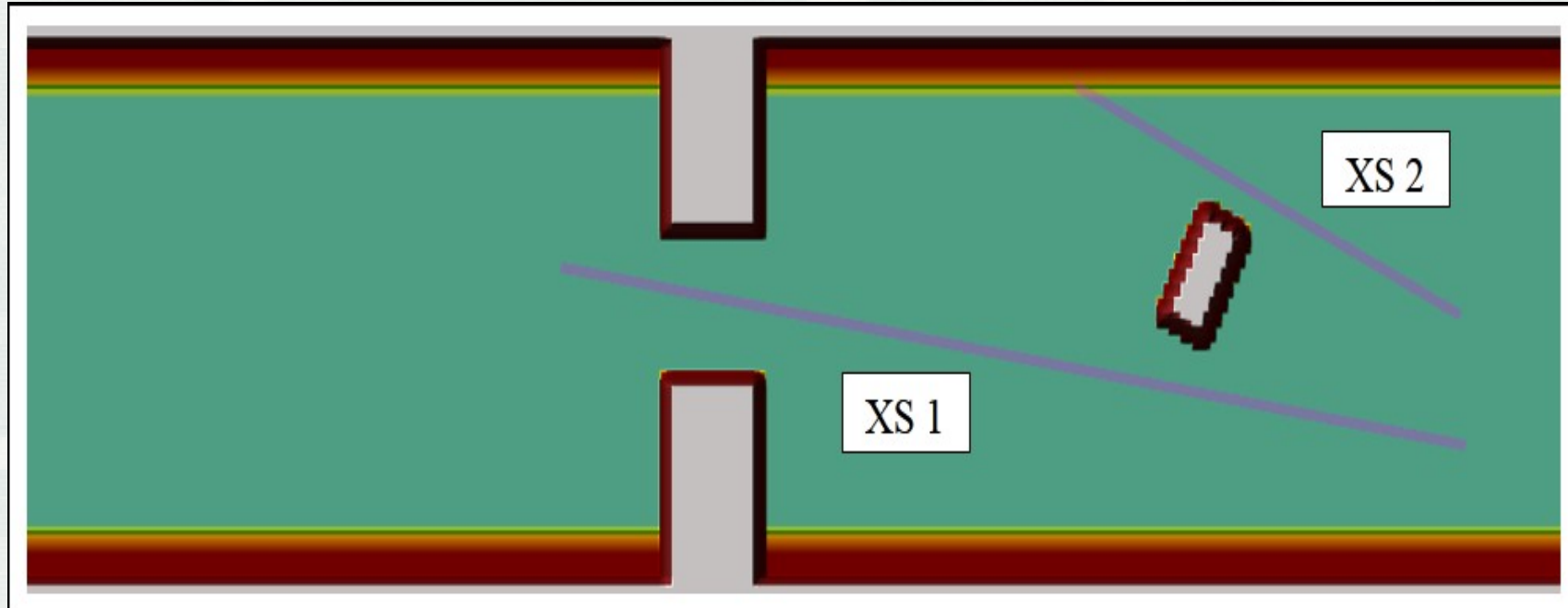


# Test 6B Results – Location G6

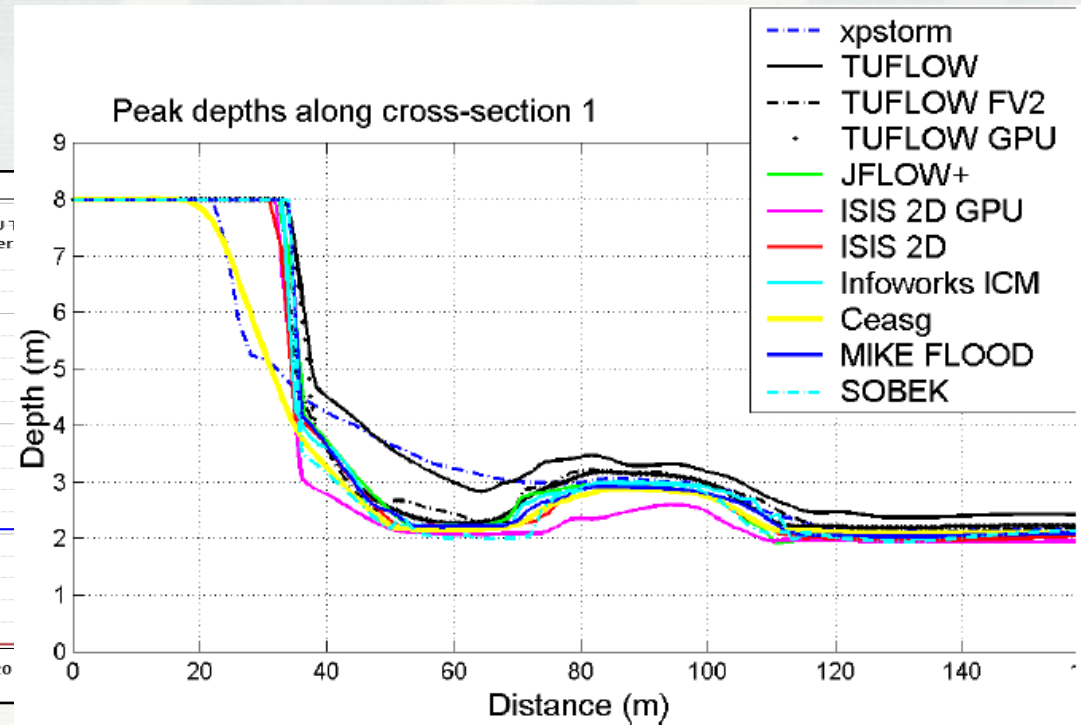
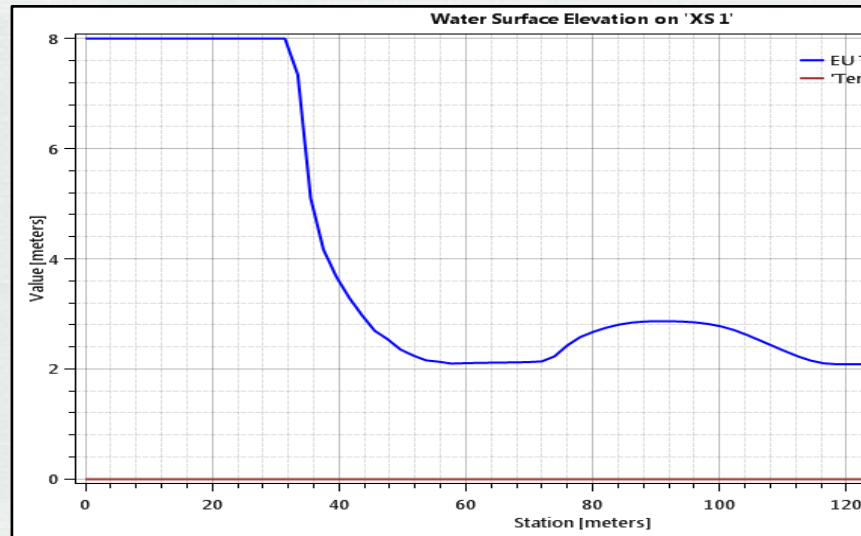




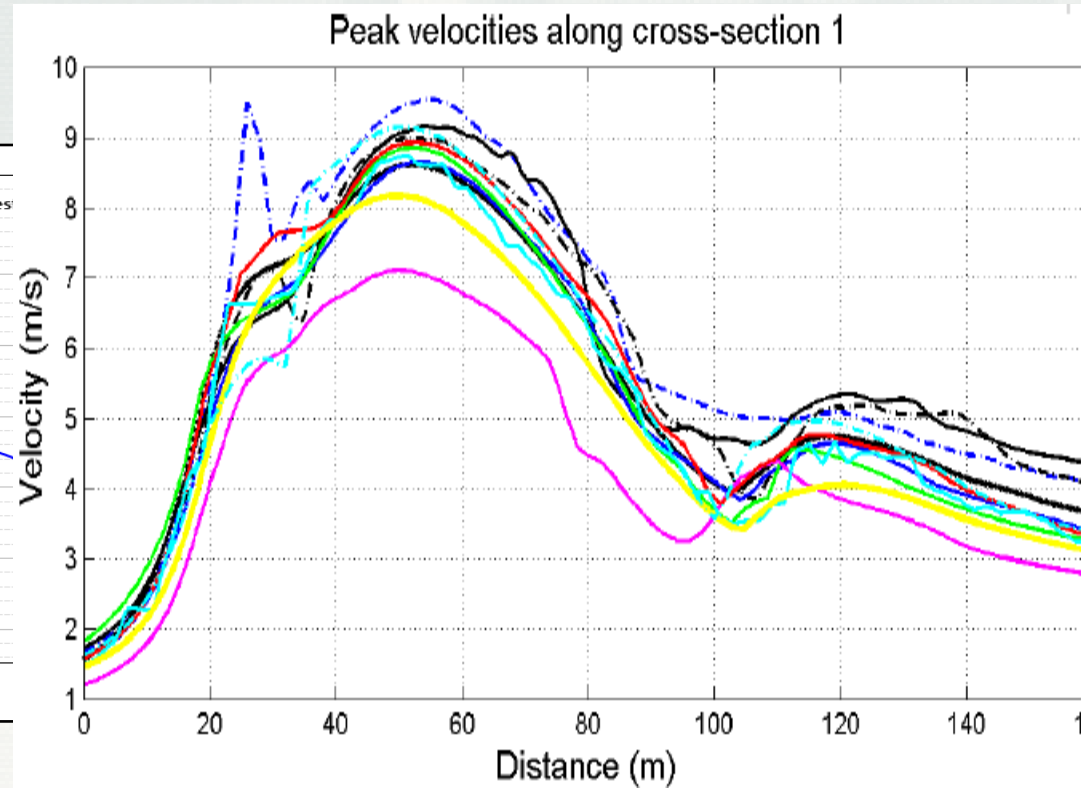
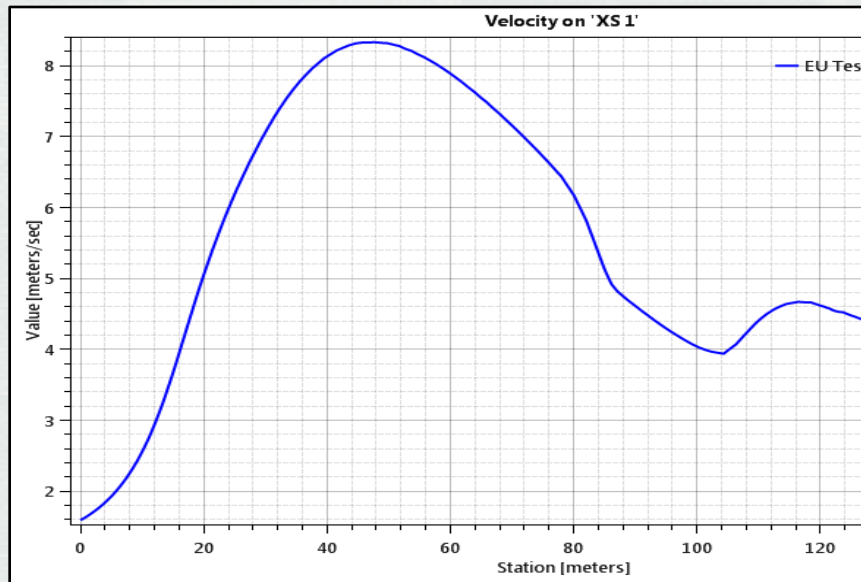
# Test 6B – Cross Section Locations



# Test 6B – XS 1 Max Water Surface

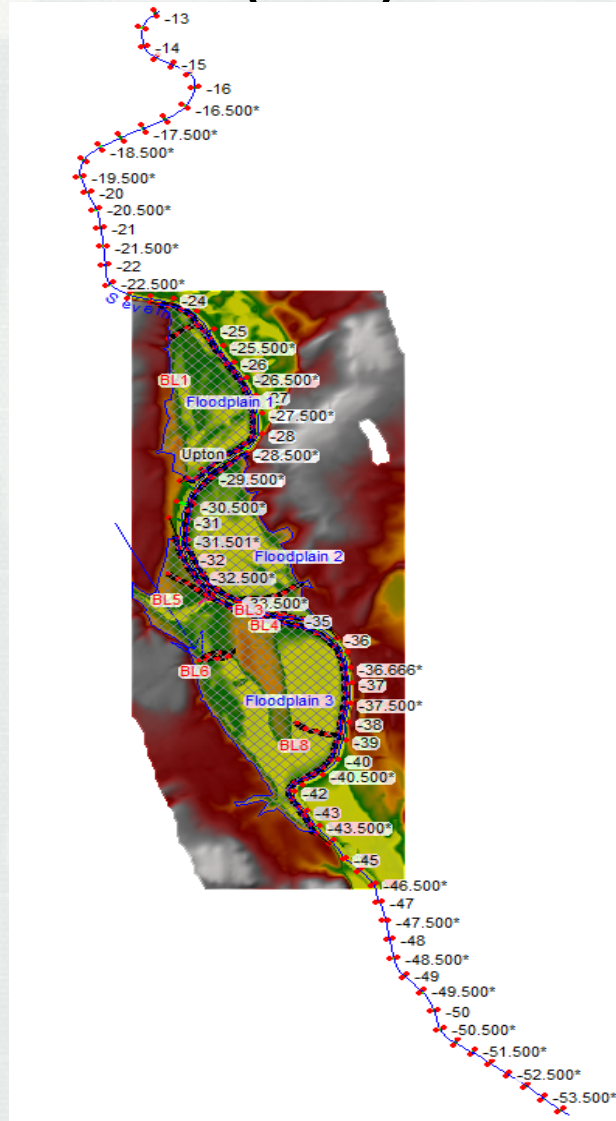


# Test 6B – XS 1 Max Velocity



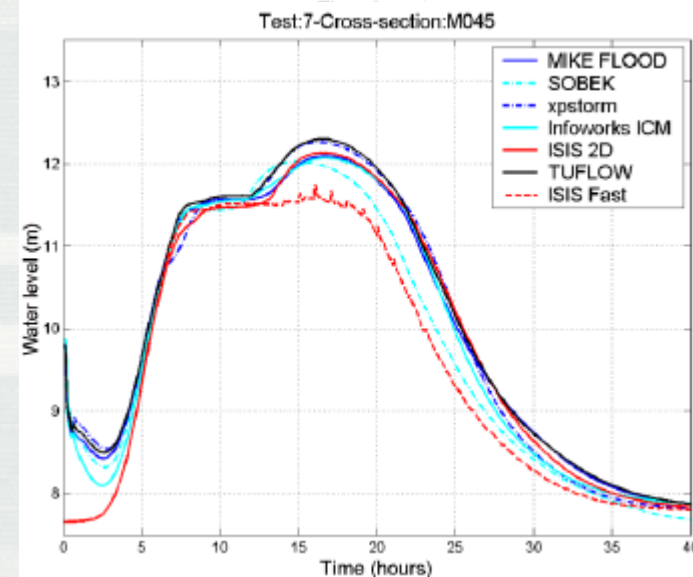
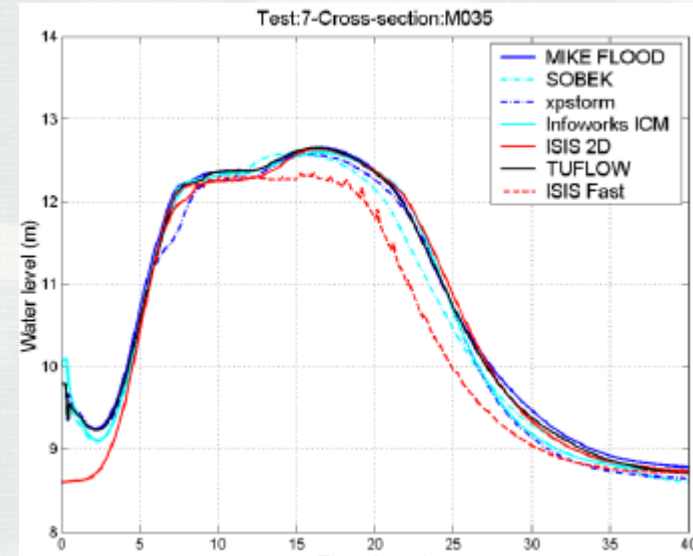
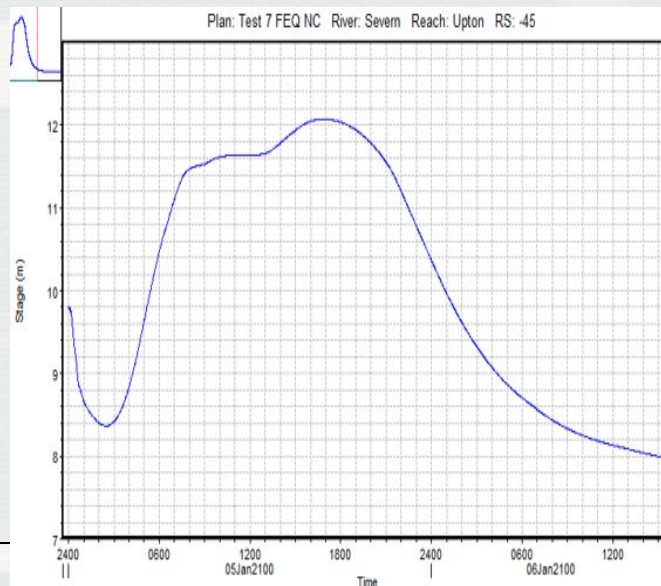
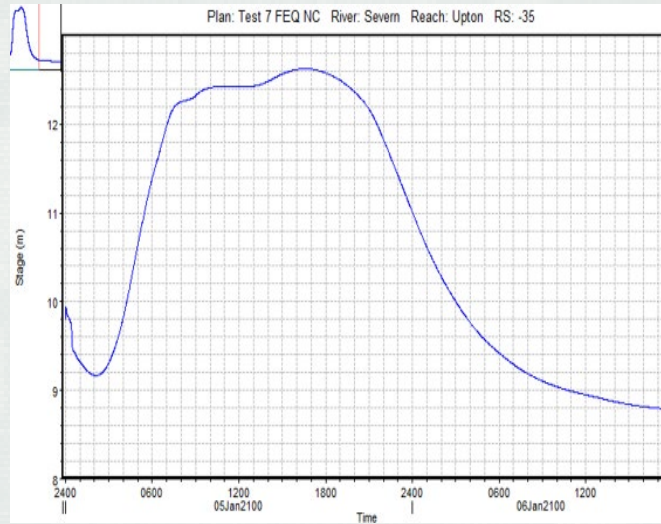
# Benchmark Test 7

## (1D) River and (2D) Floodplain Linking

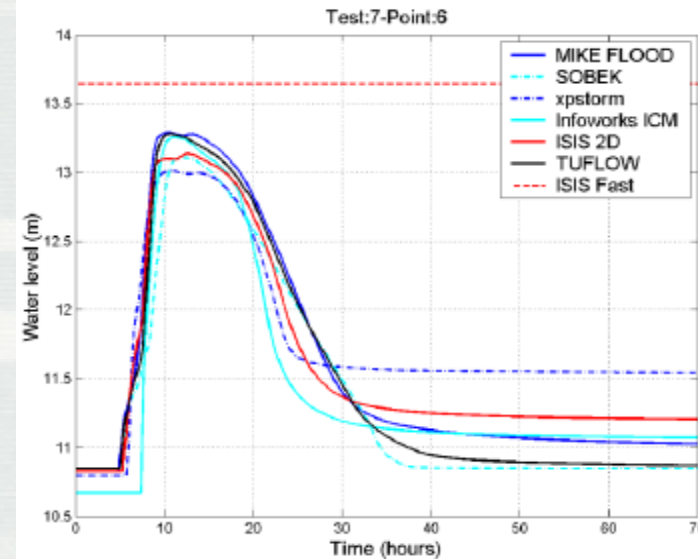
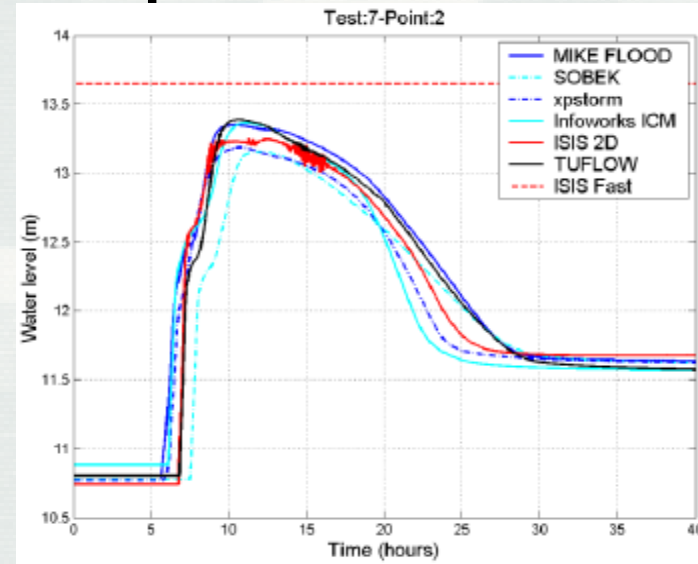
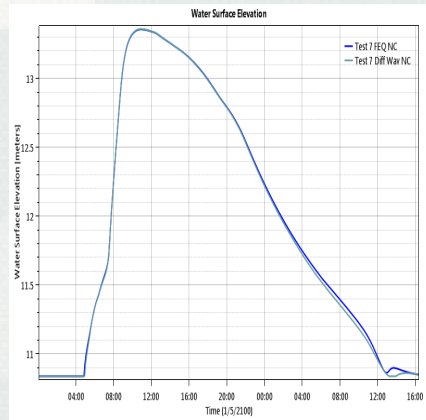
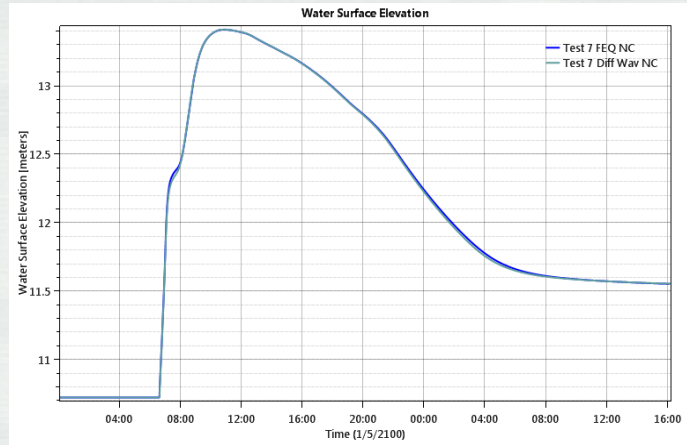




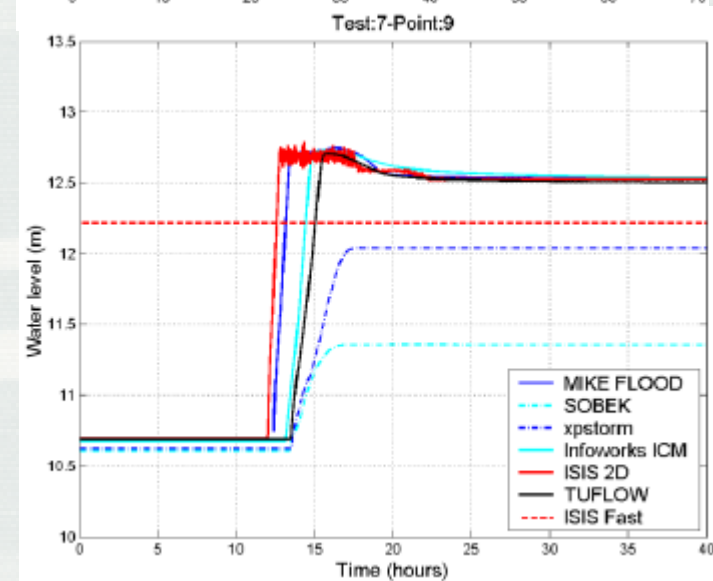
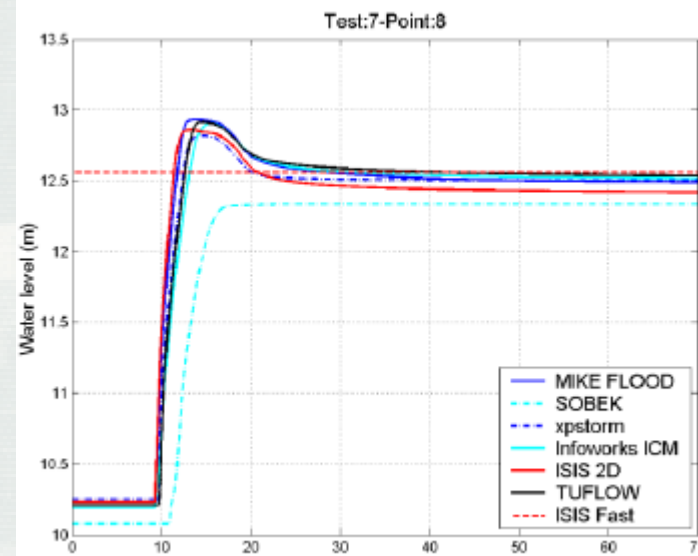
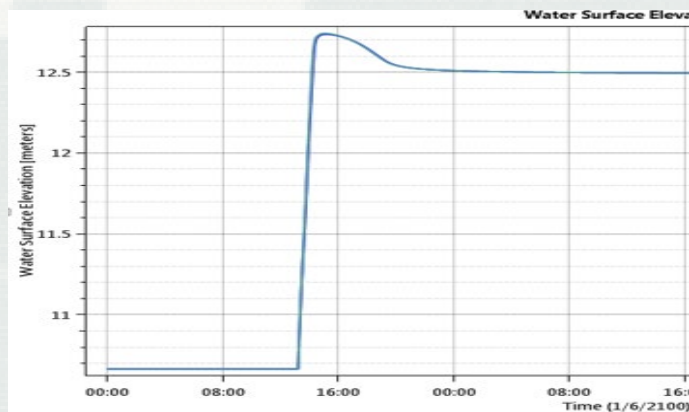
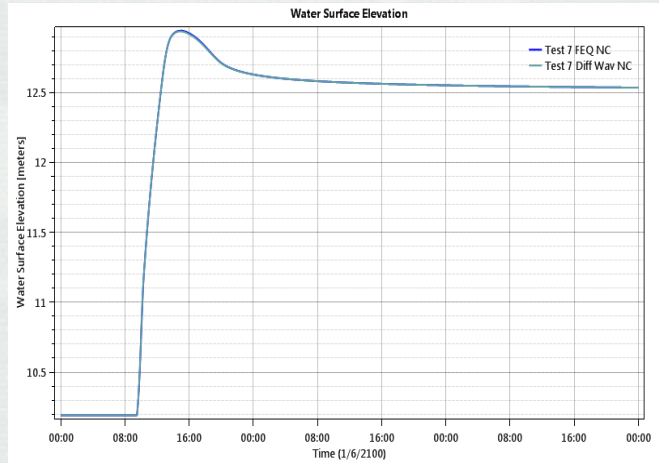
# Test 7 Results – XS M035 and M045



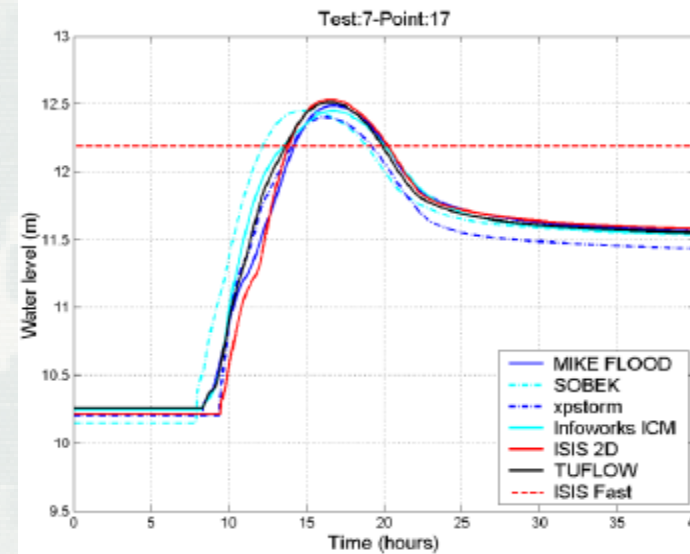
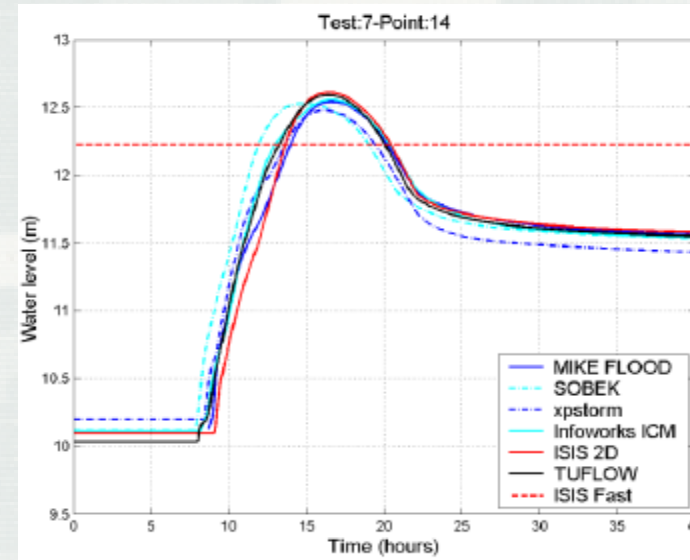
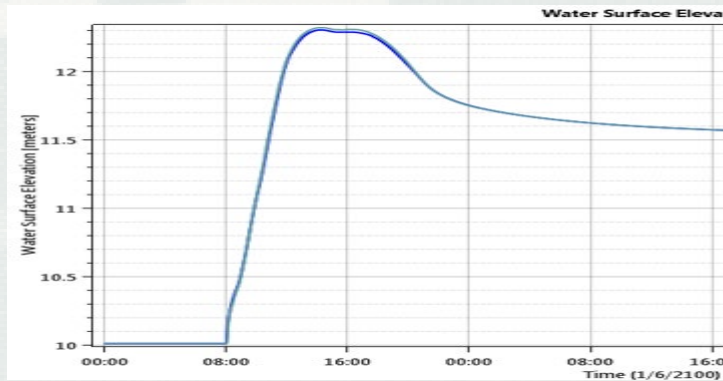
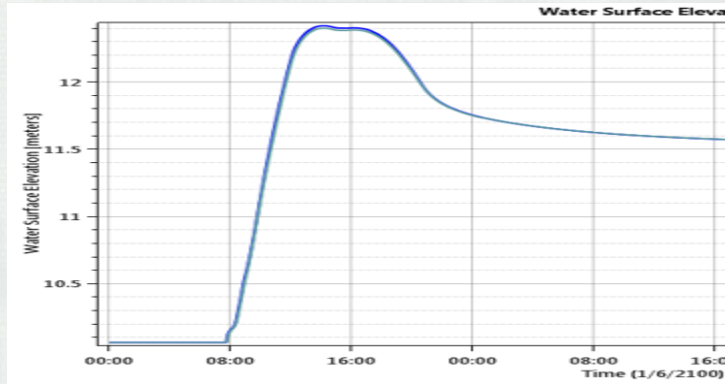
# Test 7 Results – floodplain 1: loc 2 & 6



# Test 7 Results – floodplain 2: loc 8 & 9

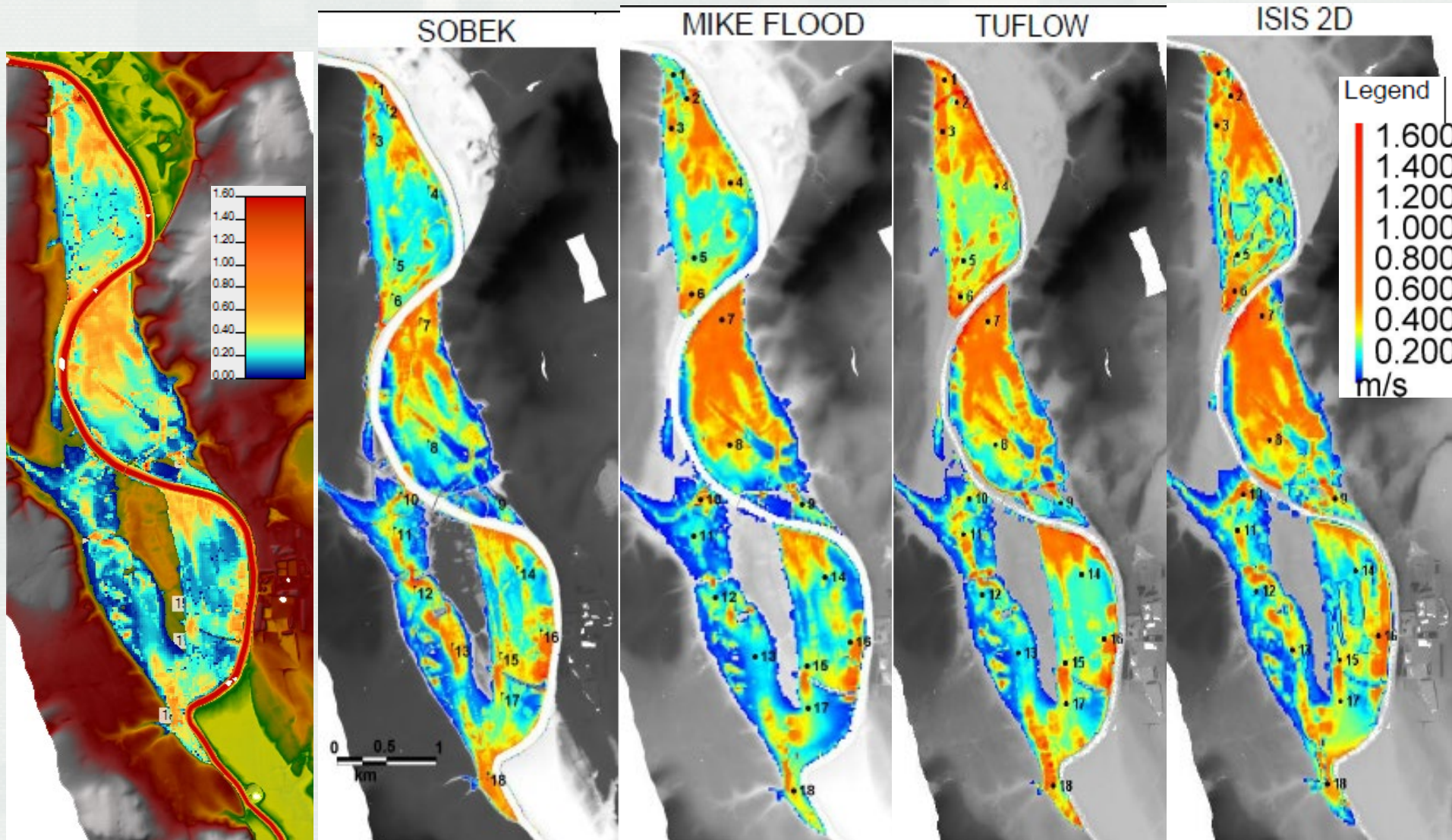


# Test 7 Results – floodplain 3: loc 14 & 17



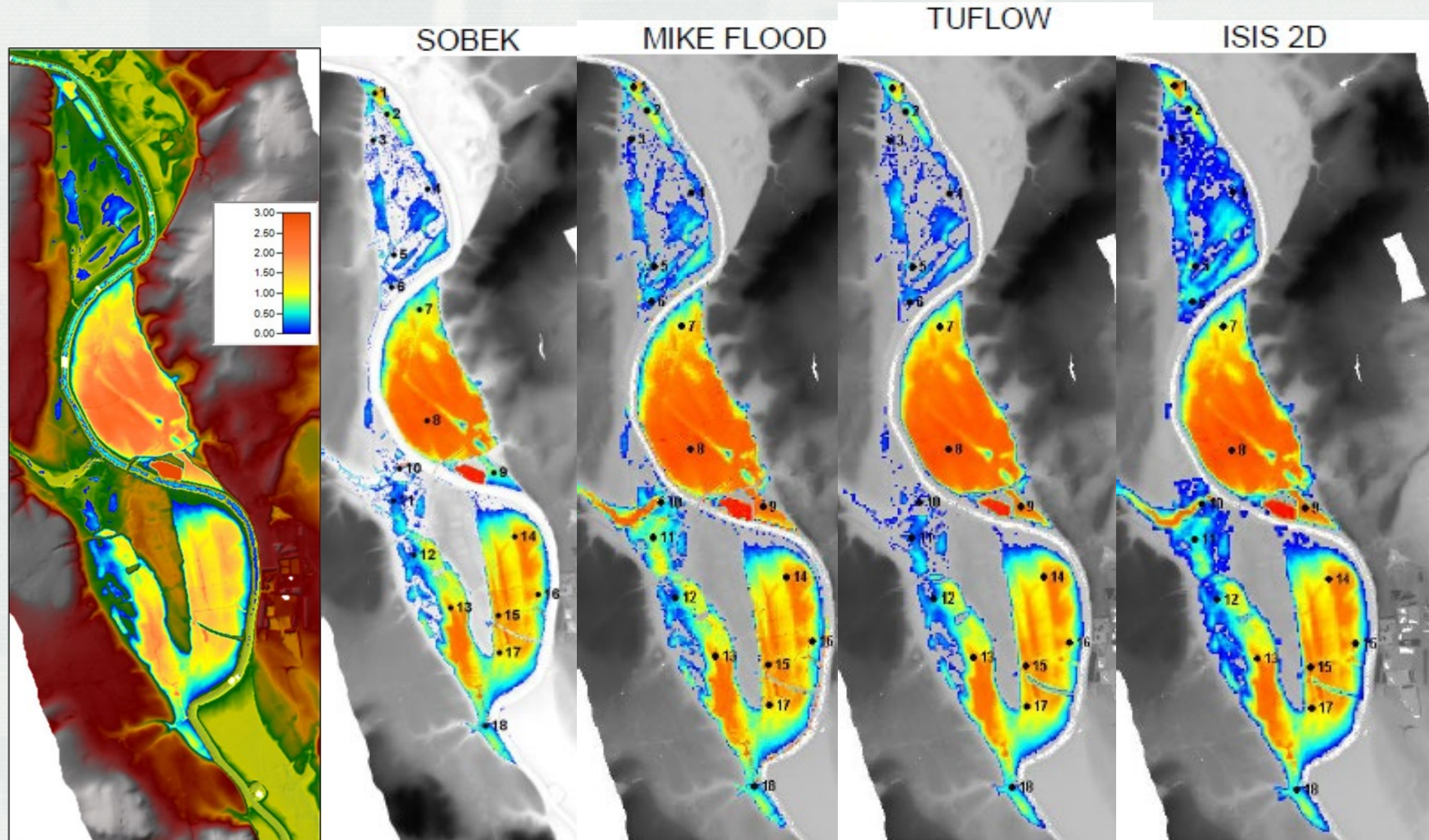


# Test 7 Results – Max Velocities





# Test 7 Results – Final Depths



# Computational Time

2D Test Name	Number Cells	HEC-RAS	MIKE21	TUFLOW	ISIS 2D	SOBEK
EU Test No 1	700	2s	1.9s	2.1s	1.7s	17s
EU Test No 2	10,000	13s	9.6s	7.3s	22s	1min 40s
EU Test No 2	1,600	4s				
EU Test No 3	1200	1s	1s	2s	3.6s	20s
EU Test No 4	80,000	24s	32s	47s	1min 22s	16min 54s
EU Test No 4	20,000	6s				
EU Test No 5	7,460	24s	28.3s	26s	58.5s	2 min 48s
EU Test No 5	1,809	5s				
EU Test No 6	36,492	37s	55s	1min 49s	9 min 19s	16 min 50s
EU Test No 6	8,871	14s				
EU Test No 7 20m grid	16,590	6 min 47s	3 min 49s	3 min 20s	6 min 48s	195 min
EU Test No 7 40m grid	4,195	2 min 27s				
EU Test 8A 2m grid	97,000	15 min 2s	6 min 7s	7 min 57s	9 min 20s	24 min 53s
EU Test 8A 4m grid	23,760	2 min 2s				

# Questions?