HEC-RAS Modelling Assignment

Module 8 WSE - HI River Flood Analysis and Modelling

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Contents

1. Model evaluation for current 1D available data

1.1 Choose geometry data

These four geometries design cross sections differently. We need to run each geometries respectively and check whether the model successes. In the model, we set the maximum distance between XS's to 10, and computation interval to 1 minute. For boundary conditions, the Upper River and Main Tributary apply flow hydrograph provided by raw data. The Lower River utilizes normal depth, which can be calculated by the slope of two adjacent cross sections. For the initial conditions, the Upper River and Main Tributary apply 98.2 and 5 m^3/s respectively. After simulation, only G3 can run without error.

$$\text{normal depth} = \frac{228.468 - 228.43}{9.15} = 0.00415 \tag{1}$$

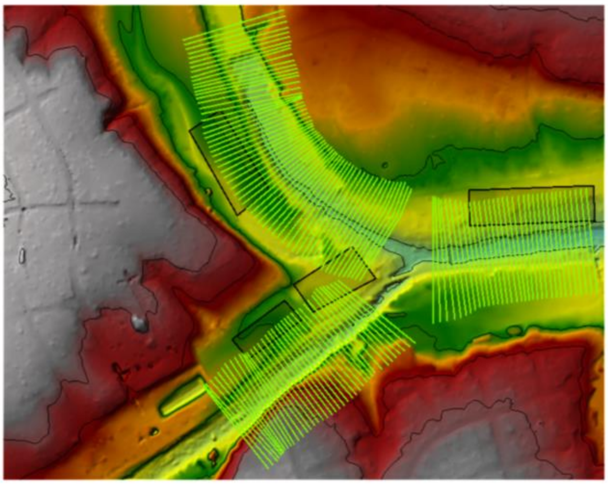

Figure 1. 1D modelling design

1.2 Evaluate the 1D model's accuracy

This catchment is the river combined with simply-connected floodplains. The flow in main channel is well connected to flow in the overbank, and that flow in both is primarily unidirectional in natural.

Observing the final result, the upstream river appears overflow phenomenon. That means the main channel cannot satisfy the flow requirements, which should have flowed into floodplain areas. Then we select the image with the highest water level at the 865.63 cross section, and find there is no boundary beside the flow.

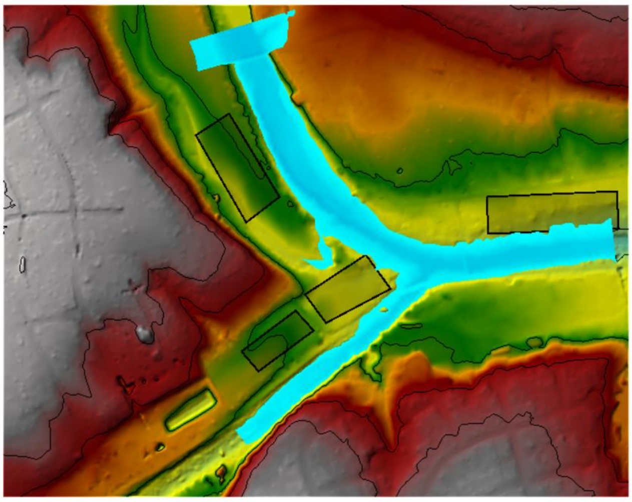

Figure 2. The depth map with 1D model

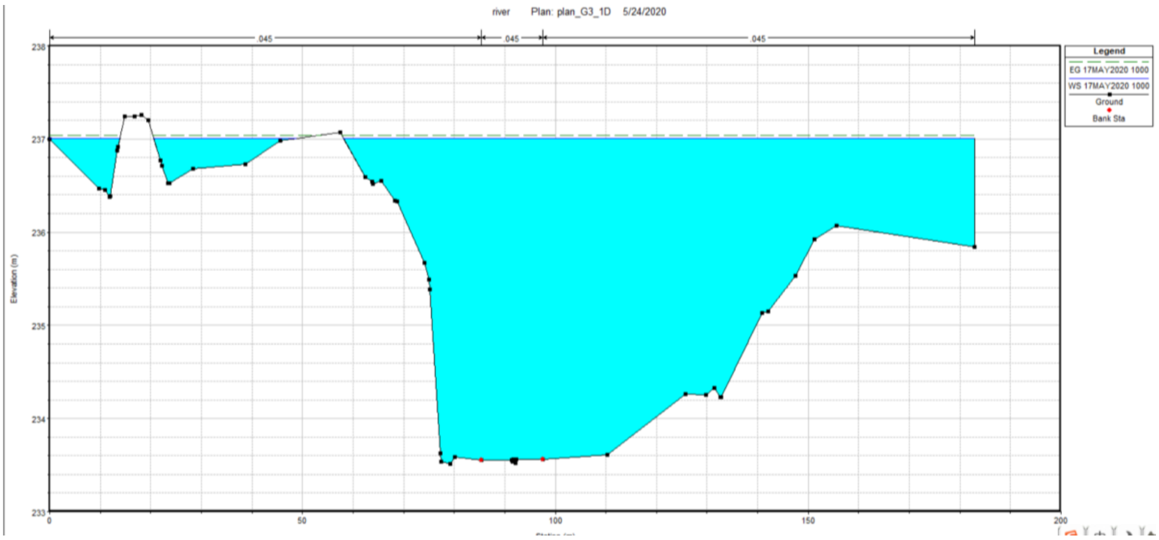

Figure 3. Water level at 865.63 cross section

In terms of modelling practice, this 1D model works well. In most areas, flow does not appear to overflow. Considering about the applicability to the case study, it does not meet the requirements. Since four areas for housing developments locates at the floodplain part, and this model cannot simulate this process.

2. Implement the 1D/2D solution

2.1 build the 1D/2D solution

The upstream is expected to spread, so it's better to implement the 2D model flow. There, we may apply lateral structure to connect a 2D flow area to a 1D river reach. The modelling process is as follows:

First, change the given Xsections and replace this area with a 2D area. We choose 865.63 cross section as an example to explain it. The profile on the left side has a high elevation, which does not need to be converted into a 2D area. However, the right part is floodplain, whose watershed is at the local highest point. Repeating this methods, we trim the cross section in the Upper River and Main Tributary.

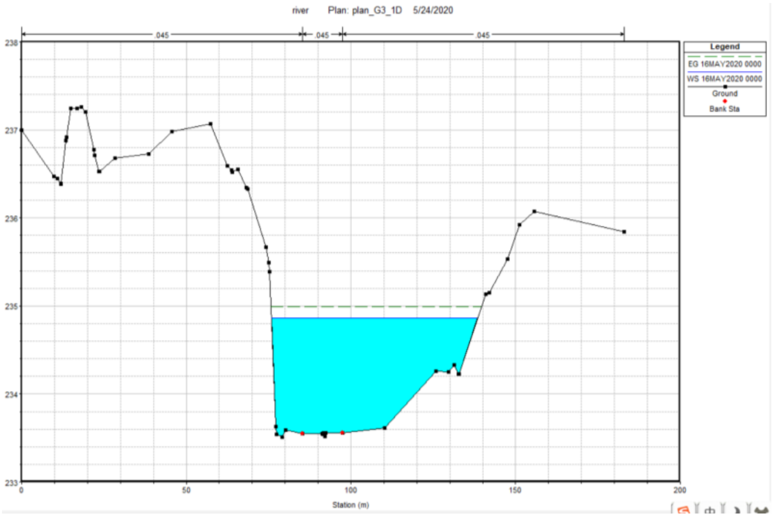

Figure 4. The profile at 865.63 cross section

Second, draw a polygon boundary for the 2D area. We should create a 2D Flow Area polygon to represent the boundary of the 2D area using the 2D Flow Area drawing tool in the Geometric Data Editor. One thing should take care is that the boundary between a 1D river reach and a 2D Flow Area should be high ground that separates the two. In this case, we only draw the area wrapped in the Upper River and Main Tributary. There is a hill at the top of the Upper River, which can be selected as the 2D boundary.

Third, design the lateral structure to connect the 1D/2D area. When using a lateral structure to connect a main river to the floodplain, try to find the high ground that separates the main river from the floodplain. The natural high ground barrier is normally 0.3 to 1 m high. Also the range of Weir coefficients should between 0.28 and 0.55 in SI units. We initially design the right overbank of the Upper River as the lateral structure. Then use the particle tracking to observe the simulated results. The place for the flow to transfer is where the lateral structure needs be built. After that, we can delete the useless structure and make the model concise.

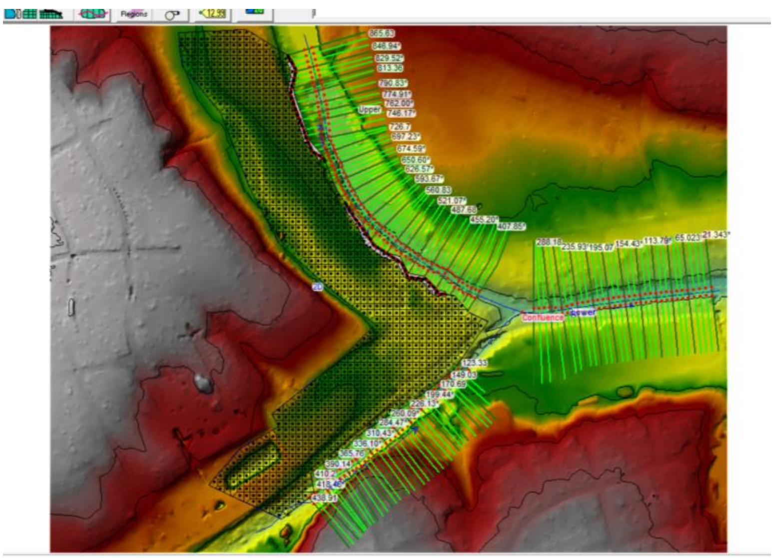

Figure 5. 1D/2D modelling design

2.1 Analysis the result

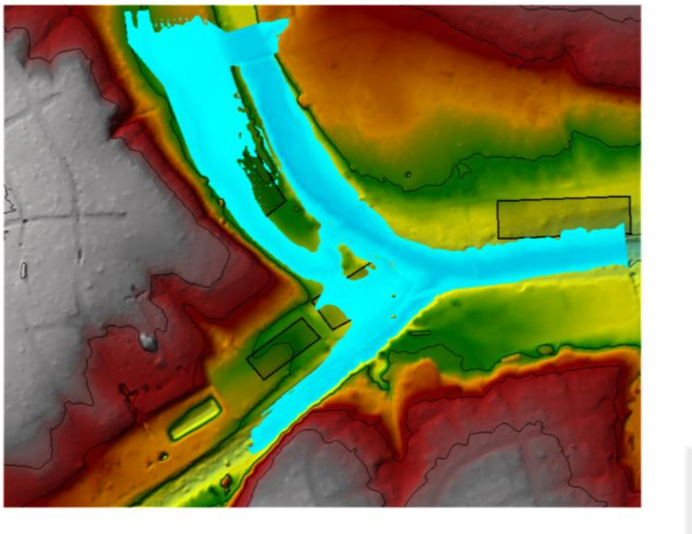

Figure 6. The depth map with 1D/2D model

At the right overbank of the Upper River, the area was covered by the flood, whose submerged depth is from 0 to 1.0m. It is measured by drawing several straight lines to cut the floodplain area. Overall, the flood involves a wide range and a deep depth.

Next, we plot the discharge on the outlet of 1D and 1D/2D model, and compare the difference. Actually, the two curves almost overlap. This also shows the final simulation results of 1D and 1D/2D model are close, but the middle process has a bit of difference. The baseflow combined with the inflow from the upstream form peak flow. In this case, peak flood = baseflow (130) + inflow from the upstream (110) = 240cms.

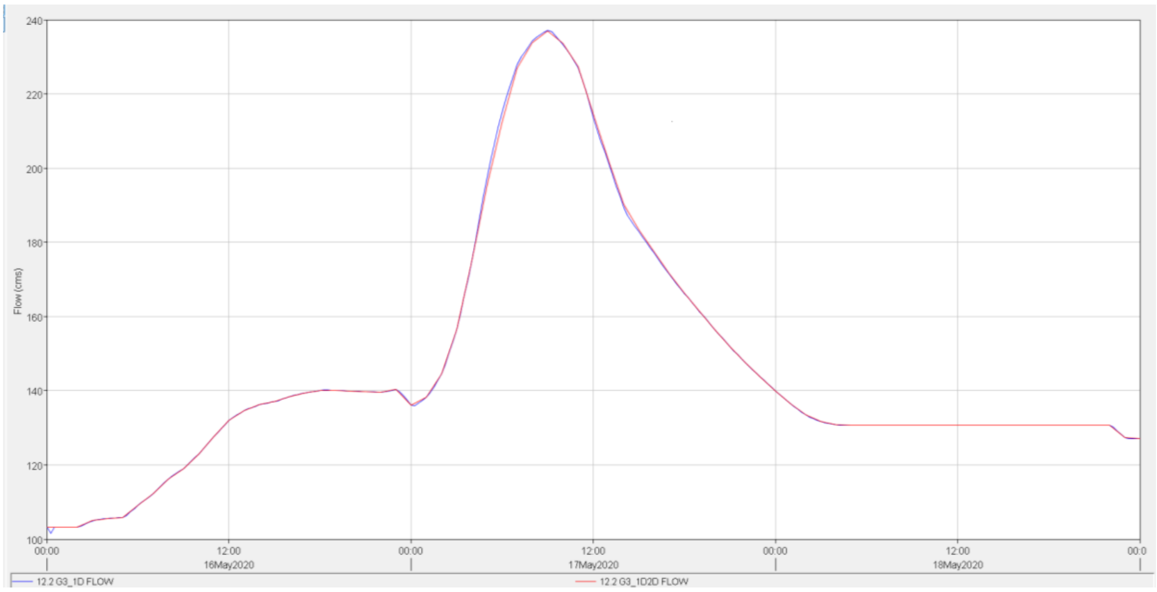

Figure 7. Comparison of peak flood between 1D and 1D/2D model

3. Scenario testing for future conditions

3.1 Choose one area for housing development

We finally choose the area in the upstream of the main tributary. Even in the case of the largest flood coverage, there is no flooding in this case. Also it is close to main tributary and mountains. Other three are easily submerged during flooding process, causing unstable foundation.

3.2 Alleviate flooding conditions

First, we can heighten a weir in the upstream, where the 1D model connects to the 2D area. Since this is the main entrance for 2D model, if water wants to flow in, it needs more energy.

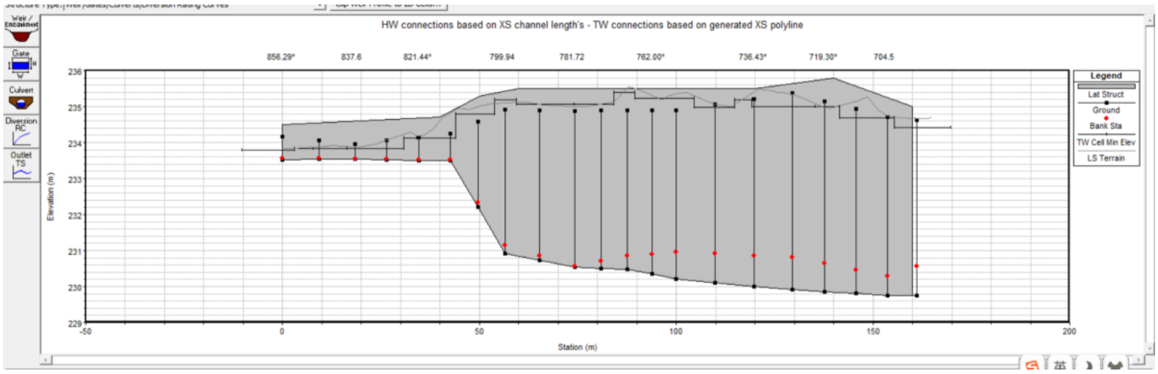

Figure 8. Original lateral structure

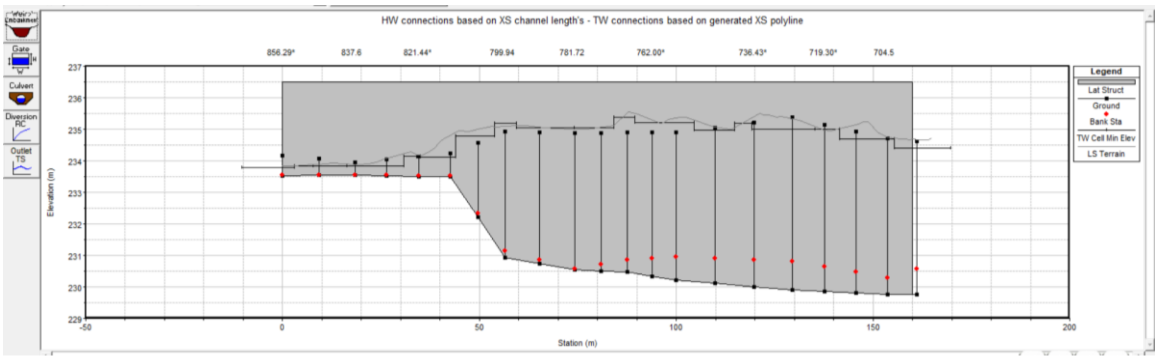

Figure 9. Building a weir

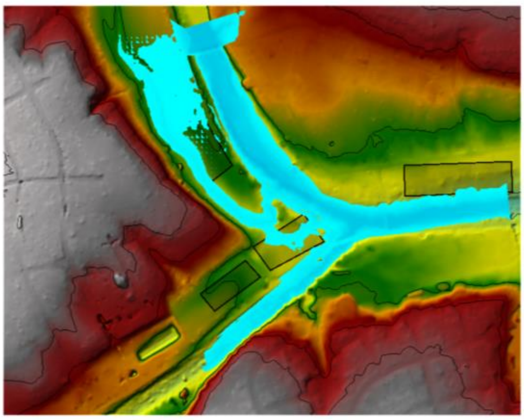

Figure 10. The depth map when building a weir at the upstream

Second, we can create a breach along the second lateral structure. The actual physical meaning is that we have built a diversion port here, and the water on the platform will automatically flow into the river.

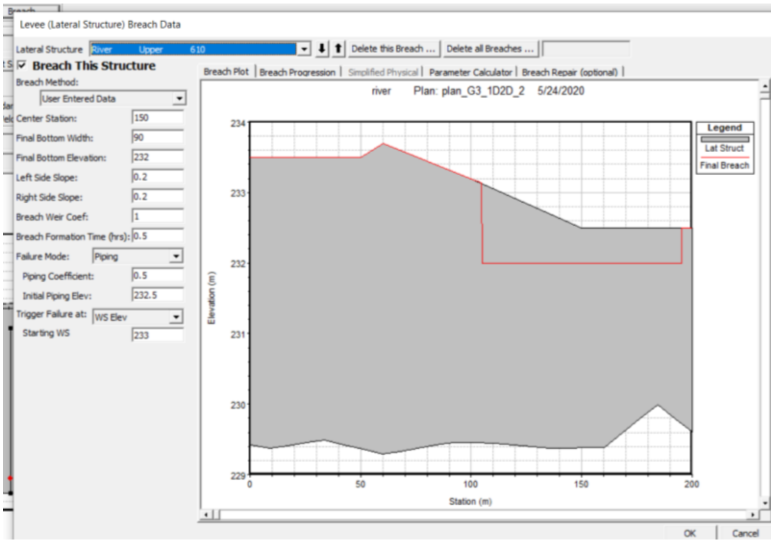

Figure 11. Create a diversion at the middle lateral structure

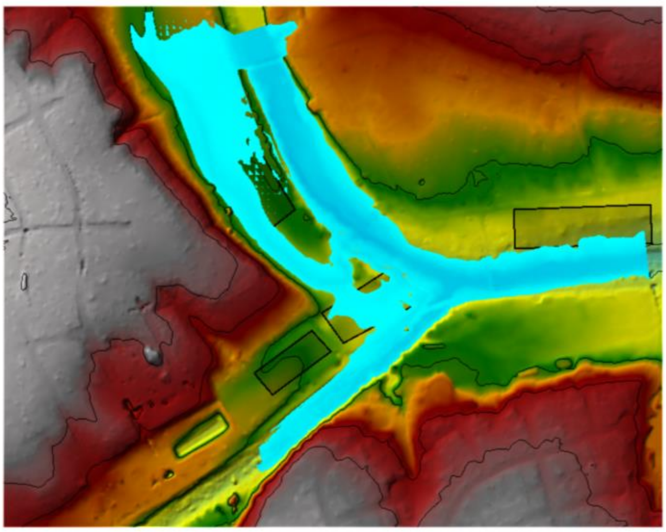

Figure 12. The depth map when creating a diversion port

One is to hinder the inflow of water, and the other is to encourage the water to flow out of the floodplain. Both of them can make the house away from the submerged area, while reducing the submerged depth of the area. Overall, the weir is more effective than diversion port to reduce the flood risk.