Exercise 5 - Simulating and evaluating flood prevention measures

This exercise is part of series designed to teach students how floodplain inundation can be simulated by numerical models and how flood risk maps can be produced from simulation results within the KULTURisk methodology framework. In this case the flood inundation model is LISFLOOD-FP (hereafter lisflood) however most two-dimensional hydraulic models can be used in much the same way. This exercise follows on to look at how prevention measures can be used to reduce the risk of flooding. A number of simple indicative engineering options are suggested to reduce flooding in the River Flood Valley (the fictional river valley introduced in Exercise 2). Alternative input files for the lisflood model will be created to allow simulation of the effects of these indicative engineering options on the predicted area of flooding. Results should then be inspected and analysed to evaluate the various prevention measures. It should be noted that this is **not** an exercise designed to teach students about the technical details of flood engineering, but rather to familiarise them with the input files to lisflood and how to modify them, how the simulation reacts to variations in the domain topography, and to begin to think about what factors should be discussed when planning flood engineering.

Introduction

Structural schemes implemented to reduce the degree of flooding in an area generally act either to increase the speed at which water can travel through an area, or increase the volume of water which can be stored in an area. The increased storage capacity could be in the river channel to reduce the likelihood of water overflowing the banks, or it could be in the form of a separate storage reservoir designed to release the excess water over a long period. In this exercise we look at increasing river capacity by either widening or deepening the river channel and by creating an extra channel which acts to increase storage and decrease the time taken for water to exit the domain by straightening one of the channel meanders. This exercise also looks at the use of flood walls to defend specific areas of the towns. Any flood prevention measure is also likely to have impacts on nearby areas of the river catchment which must be taken into consideration. Non-structural prevention measures for flood risk prevention are also common (though they will not be discussed in this exercise). These include flood-risk targeted land-use and urban planning policies, improvements to building codes and risk-transfer schemes such as encouraging the purchase of insurance policies.

Data provided

No extra data files for the simulation are provided for this exercise, but you will need to use the water depths files from Exercise 2 to compare new results with (those produced using the subgrid solver). A MatLab script (compare_scenarios.m) has been provided to aid analysis and to run this you will also need the ascii_reader.m file provided with Exercise 3. The document “Exercise 5 answers.pdf” has been provided to give an indication of the simulation results which should be expected if the exercise is carried out correctly. Instructions have been given for file modification in Excel; however other software could be used instead by following a similar methodology if you do not have access to these programs.

Flood prevention scenario A: Flood walls

Large areas of Riverton and Waterville have been highlighted as being at risk of flooding under certain circumstances (see Exercise 2 and 3). Due to the topography of the valley, areas to the North of Riverton and Waterville are relatively simple to protect using strategically placed flood walls. Funds have been provided ($5000)[1] which will cover the cost of approximately 280 m of flood wall, equivalent to four cells of the model domain located diagonally next to each other. Two options have been suggested for flood wall placement (Figure 1). To protect North Waterville a wall could be located between locations 424250 198502 and 424450 198702 meters. Alternatively, to protect North Riverton a wall could be located between 425551 199101 and 425751 198901 meters. As the local expert, you have been asked to model the effect of each of the two scenarios and to evaluate effectiveness of the defences.

Create two modified dem files by increasing the elevation values by 1.0 m in the appropriate cells

To modify in excel first make a copy of the original dem file, rename as appropriate and open in excel using :

- **`File > Open >"All files (*.*)">Delimited> Choose an appropriate delimiter`**

choosing an appropriate delimiter. Then simply navigate to the required cells (see below), modify the contents and save the file again ensuring the file type is not changed. This could also be carried out using other programs such as MatLab or ArcMap if you are familiar with these.

- Wall 1 = cells AA36; AB35; AC34 AD33
- Wall 2 = cells BA25; BB24; BC23; BD22

Run lisflood using these alternative dem files and evaluate the effects of the prevention measures. Remember the `.par` file must be modified to specify the new demfile and also to change the `dirroot` to avoid over-writing results

Compare the final water depth files (`res-0010.wd`) produced using these modified files with those run using the original dem file in Exercise 2. Also compare with the `landuse`, `population`, `buildings` and `buildings_cost` data files from Exercise 3 to evaluate the two scenarios and decide which site should be chosen. For simplicity you should simply consider whether buildings are inundated or not rather than to what depth. We have provided a short MatLab function[2] (compare_scenarios.m) which will compare two water depth files for you and combine them with the socio-economic data from exercise 3. It will guide the user through uploading the data and then produce a graph showing which areas are inundated under each

[1] Note prices/costs suggested in this exercise are purely illustrative and are not expected to represent real-world costs.

[2] To run the function "compare_scenarios" open MatLab and first ensure MatLab can "see" the function by either following `File> Set path... > Add folder` and navigating to the folder containing the function, or putting the function in a folder which MatLab can already see (i.e. one already listed under the MatLab search path in the Set path... pop up window. Note – if you have not already done so, for the compare_scenarios function to work you must also ensure that MatLab can "see" the function ascii_reader.m provided in the Exercise 3 folder. Next, type compare_scenarios in the MatLab command window, press enter and follow the instructions on screen. If all else fails, simply open the function by double clicking it, then copy the whole section from "`ButtonName`" to the end, pasting it into the command window and press `enter`!

scenario and some tables showing the relative costs of the two scenarios. If you are more confident in using MatLab or wish to take this further, this function could be used as a starting point and modified for more complex analysis. Alternatively files could be viewed in other software and evaluated qualitatively. Below are some questions to consider:

- *Which flood wall will save the most people from being flooded?*
- *Which flood wall prevents the most monetary losses?*
- *Are there any negative impacts of either of the walls?*
- *Which site represents the best value for money?*
- *What might the impacts of these measures be on areas downstream?*

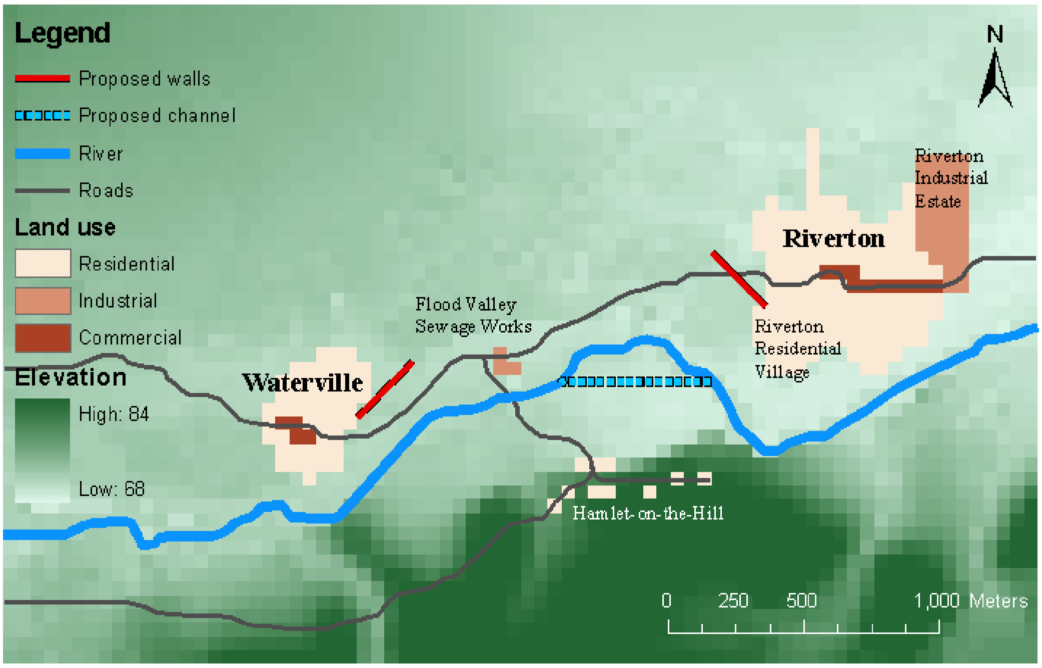

Figure 1 Location of urban areas and proposed flood defences within the River Flood Valley.

Flood prevention scenarios part B: Channel modification

The people of the Flood River Valley have voted against the use of defence walls to prevent flooding in their area due to fears it will ruin the aesthetic quality of the valley (!). Three further prevention measures have been suggested, all of which will be more costly than the proposed flood walls. They are all designed to speed the flow of flood water through the valley as opposed to preventing flow to a particular area:

- Deepen the whole river channel through the valley by 1 m – estimated costs $9000

- Widen the whole river channel through the valley by 20 m (doubling the width) – estimated costs $8000
- Create an extra channel to straighten the meander between Waterville and Riverton – estimated costs $6500

Once again, as the local expert you have been asked by the council to model the effect of each of the scenarios and evaluate the effectiveness of the defences.

Create modified input files for lisflood for each scenario. This will involve modification of the `.bed` and `.width` files

1) **Deepening the channel**

Make a copy of the `Flood_valley.bed` file, rename it and open in excel as above. Create a new worksheet within this file and move it to the furthest <u>left</u> position. Populate this new worksheet with a copy of the original work sheet which is identical except that cells with channel bed elevations should be decreased in value by 1 m. This could be done manually, or by typing the following equation into cell A7 and copying across/down to the other cells (note – copy the first 6 header rows across manually)

- **`=IF(deepen.bed!A7>0,deepen.bed!A7-1,deepen.bed!A7)`**

where "`deepen.bed`" is the name of the worksheet containing the original data. Once the file is modified, save it ensuring the file type is not changed.

2) **Widening the channel**

Make a copy of the `Flood_valley.width` file, rename it and open in excel as above. Populate a new worksheet (method as above) with a copy of the original work sheet which is identical except that cells with channel widths are increased from 20 to 40 m.

- **`=IF(widen.width!A7>0,40,widen.width!A7)`**

where "`widen.width`" is the name of the worksheet containing the original data. Once the file is modified, save it ensuring the file type is not changed.

3) **Creating an extra channel**

Make copies of both the `Flood_valley.bed` and the `Flood_valley.width` file, and rename appropriately. The following cells will need modification:

- **AQ34 to AY34 (representing row 28 and columns 43 to 51 of the dem raster, excluding the header).**

Open the new `.bed` file and also open the original `demfile` in Excel. In the original `demfile` navigate to the specified cells, highlight and copy (`ctrl-c`) the values. In the new `.bed` file navigate to the specified cells, highlight and paste (`ctrl-v`) the values. Then, still in the new `.bed` file manually re-type the value in each of the modified cells, decreasing the elevation value in each cell by 2 m. Save the new `.bed` file ensuring the file type is not changed.

Open the new `.width` file in Excel. Navigate to the appropriate cells and change the values from zero to 20 m. Save the new `.width` file ensuring the file type is not changed

Run lisflood using the alternative .bed file and .width file for each scenario. Evaluate the effects of the prevention measures.

Again, use the compare_scenarions.m function to compare the final water depth files (`res-0010.wd`) produced using these and the original dem file with the `landuse, population`, `buildings` and `buildings_cost` data files to evaluate the scenarios. Consider the same questions as suggested above. This time you could also consider the projected costs of each scheme and even the different stakeholders involved. Finally: are there any other prevention schemes which you think may work effectively to reduce inundation? Overall, which prevention scenario do you think you would recommend to the council?

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