2D Modelling

In this guide, we introduce 2D modelling. You will build all necessary 2D modelling components, setup and run a 2D simulation, and visualise the results from this, all in just ten simple steps!

Introduction

In this guide, we will load a DEM (Digital Elevation Model) into Flood Modeller to provide the underlying ground elevation data. From there we will build from scratch all the required 2D modelling components to run a 2D only simulation. We will view animated results from this showing the behaviour of the flow over the floodplain and the flood extent.

We assume (and highly recommend!) readers of this guide have previously completed either ‘Getting Started – River Modelling’ or ‘Getting Started – Urban Modelling’. Completion of the former would be particularly advised, as this guide considers the example of flood flows entering the 2D domain by overtopping the river.

Please note that there are a variety of ways to undertake different tasks in Flood Modeller. Throughout this guide, we provide details of selected methods only.

We will use data contained in the 2DModelling folder for this tutorial, which can be found within the GettingStartedData folder. Access this here if needed.

Tip: We recommend reading the entirety of each instruction, including the labels on the images provided, before carrying out each step.

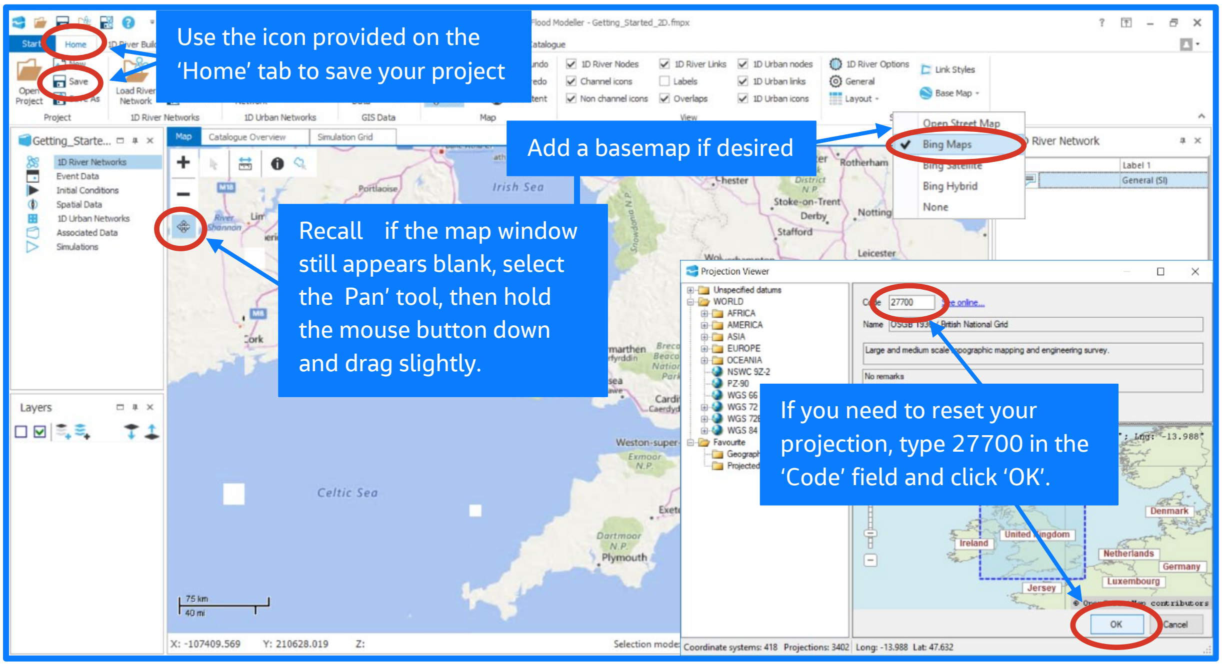
Let’s get going!

Step 1

Initially open Flood Modeller (or start a new project if already open).

Add a background map and save the project before progressing.

Recall Flood Modeller will automatically select the default projection specified in the ‘Application Settings’ window, which will be set at OSGB 1936 as needed (unless you have changed your default projection, in which case you will want to adjust the projection for this tutorial).



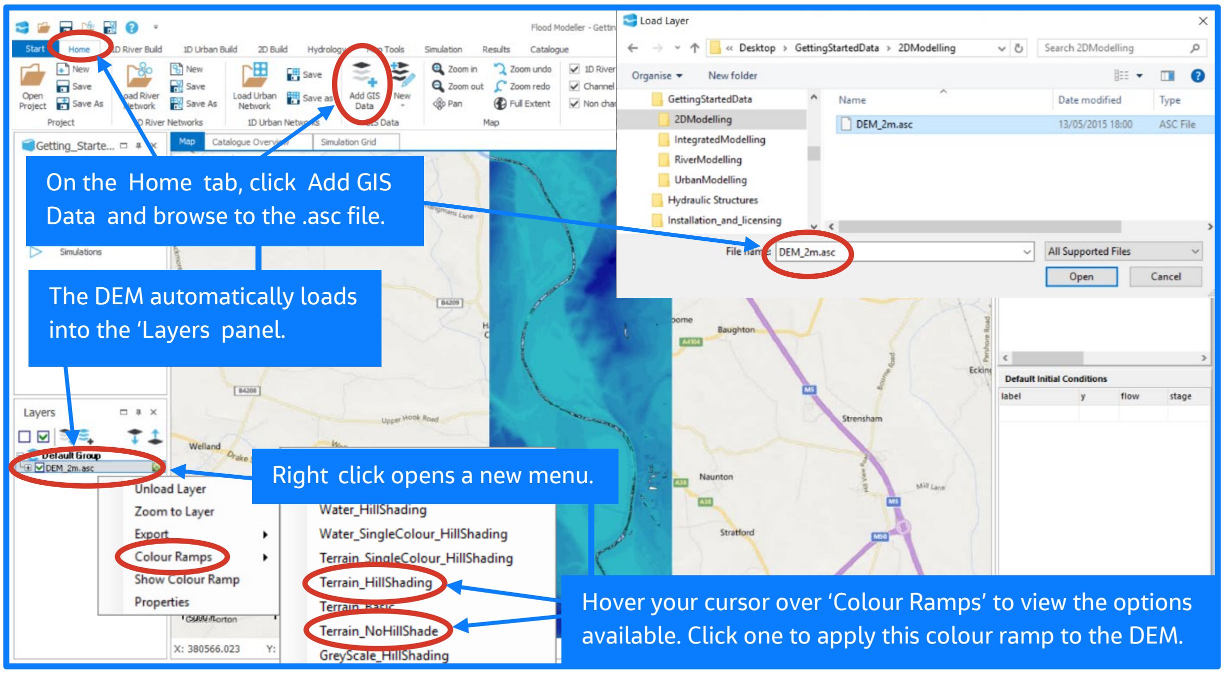
Tip: Save your project in the folder 2DModelling containing your DEM file. The results from your simulations will, by default, attempt to save in this folder.

Note: If you are having issues with your basemap not displaying, the article here may help.

Step 2

Load the ground data DEM_2m.asc (in the 2DModelling folder). This will appear in the map view (with a default blue colour ramp applied) and in the layers panel. Adjust the colour ramp to one of the ‘Terrain’ options provided; these are appropriately coloured as to be easily distinguishable from water.

The DEM is a raster grid providing the underlying ground elevation data. The tile provided covers an area around the river. Notice that certain locations (in particular, in the river itself!) have no data provided. We will need to take particular care when modelling near these locations, more on this later on.



Tip: In the ‘Layers’ panel, right-click on the DEM and select ‘Show Colour Ramp’ to see a key of elevations for each shade used.

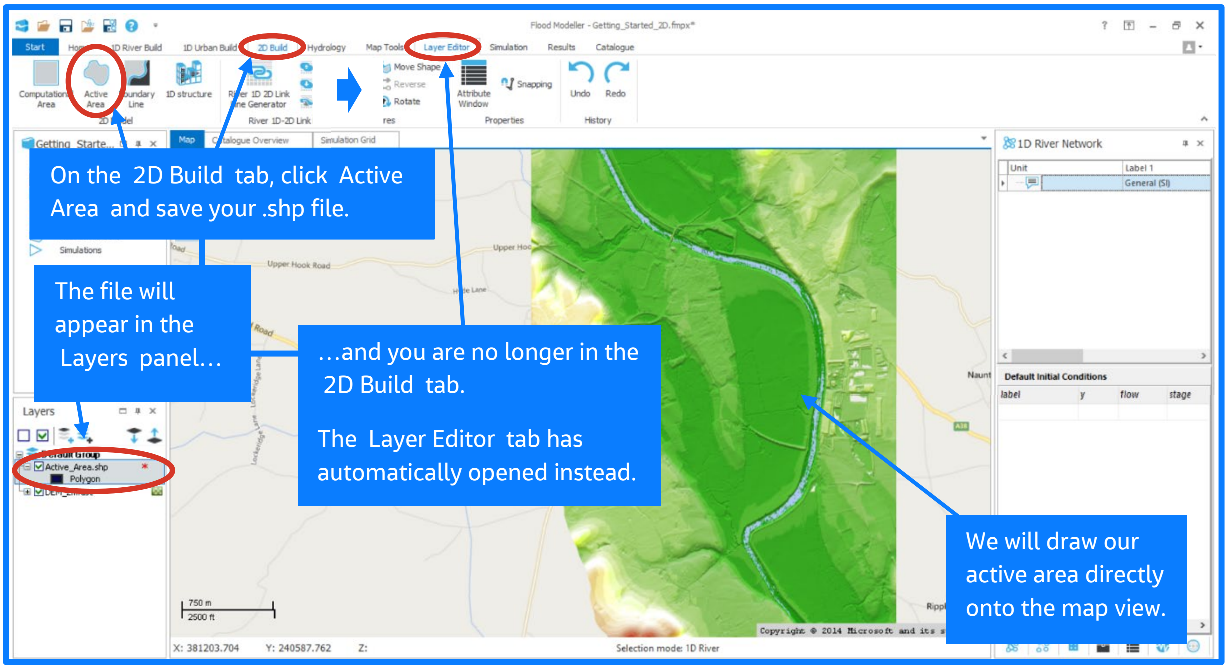
Step 3

We will create an active area. This is a polygon that we will draw directly onto the map view.

Unless a computational area has otherwise been defined, the software will initially consider this to be the entire DEM by default. Ultimately the 2D solver will reduce this to the smallest possible rectangular grid of cells enclosing your active area, if specified.

Calculations are then performed on all the cells in the computational area within (or partly within) the active area polygon. These are the cells that are able to get wet! Your licence must accommodate for these cells. Using an active area therefore makes our simulation more efficient; calculations will be performed over the entire computational area otherwise.

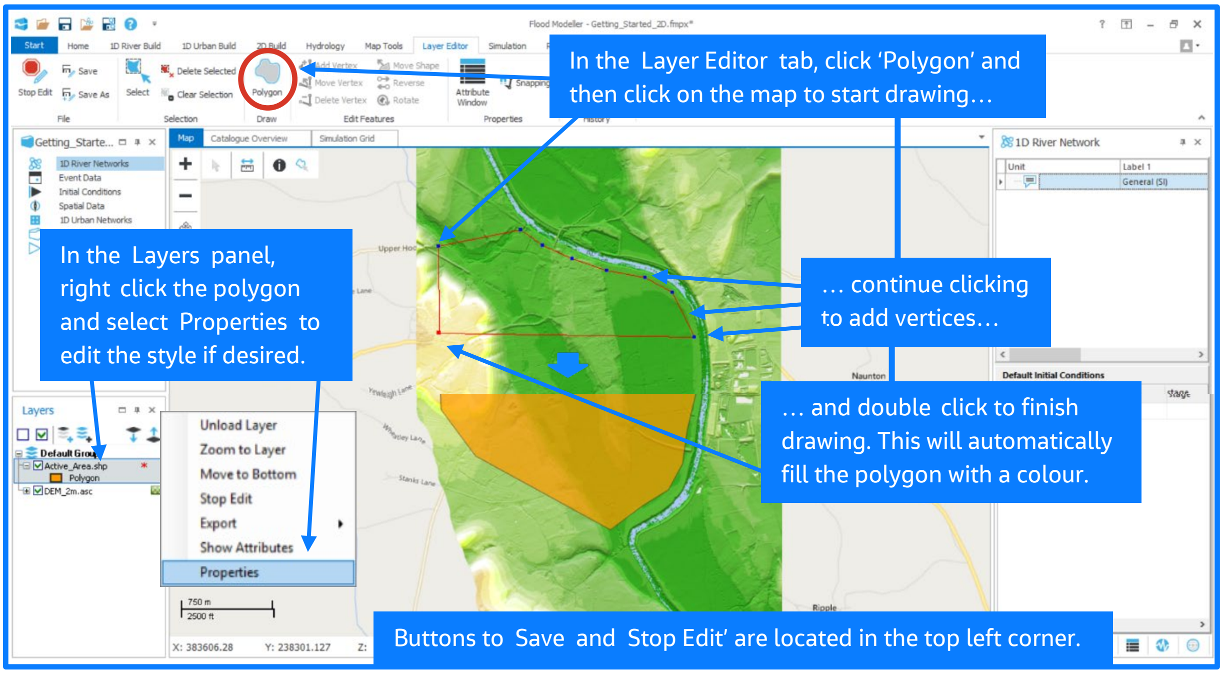
We are going to draw our active area to the west of the river, south of Upton bridge – you may wish to load in your river network from 'Getting Started – River Modelling' to identify this area more easily.



Step 4

Draw an 'Active Area' polygon to the West of the river, from Upton_Bridge to Upton_05310. Save your .shp file and exit the layer editor.

Don't forget to save the project too!

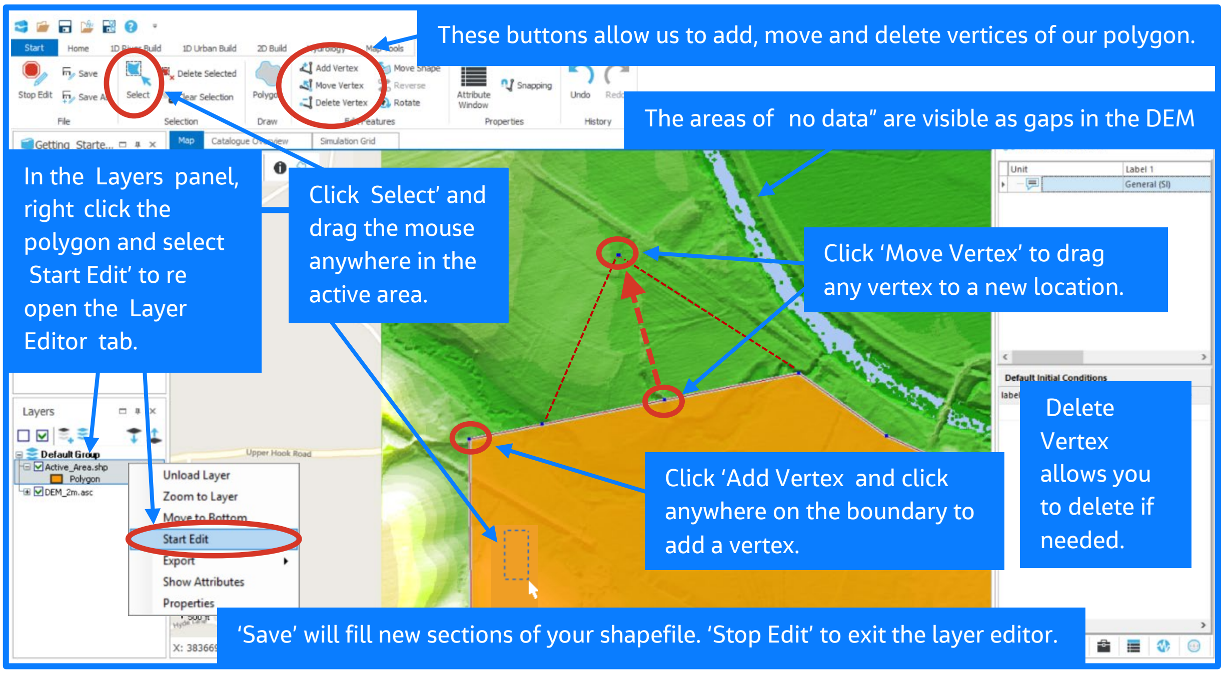


Tip: In the 'Layers' panel, right-click the active area .shp file and select 'Properties' to change the colour. Here you can also change the transparency, allowing you to see the DEM underneath.

Tip: We recommend you draw your polygons in a clockwise direction.

Step 5

Your simulation will likely crash (or give inaccurate results) should any of the points where your DEM displays “no data” end up in the active area. Due to nature of way of recording lidar, the in-bank part of the river is often this sort of data. If needed, edit your shapefile and move the vertices so your active area is clearly away from the “no data” areas along the river itself.



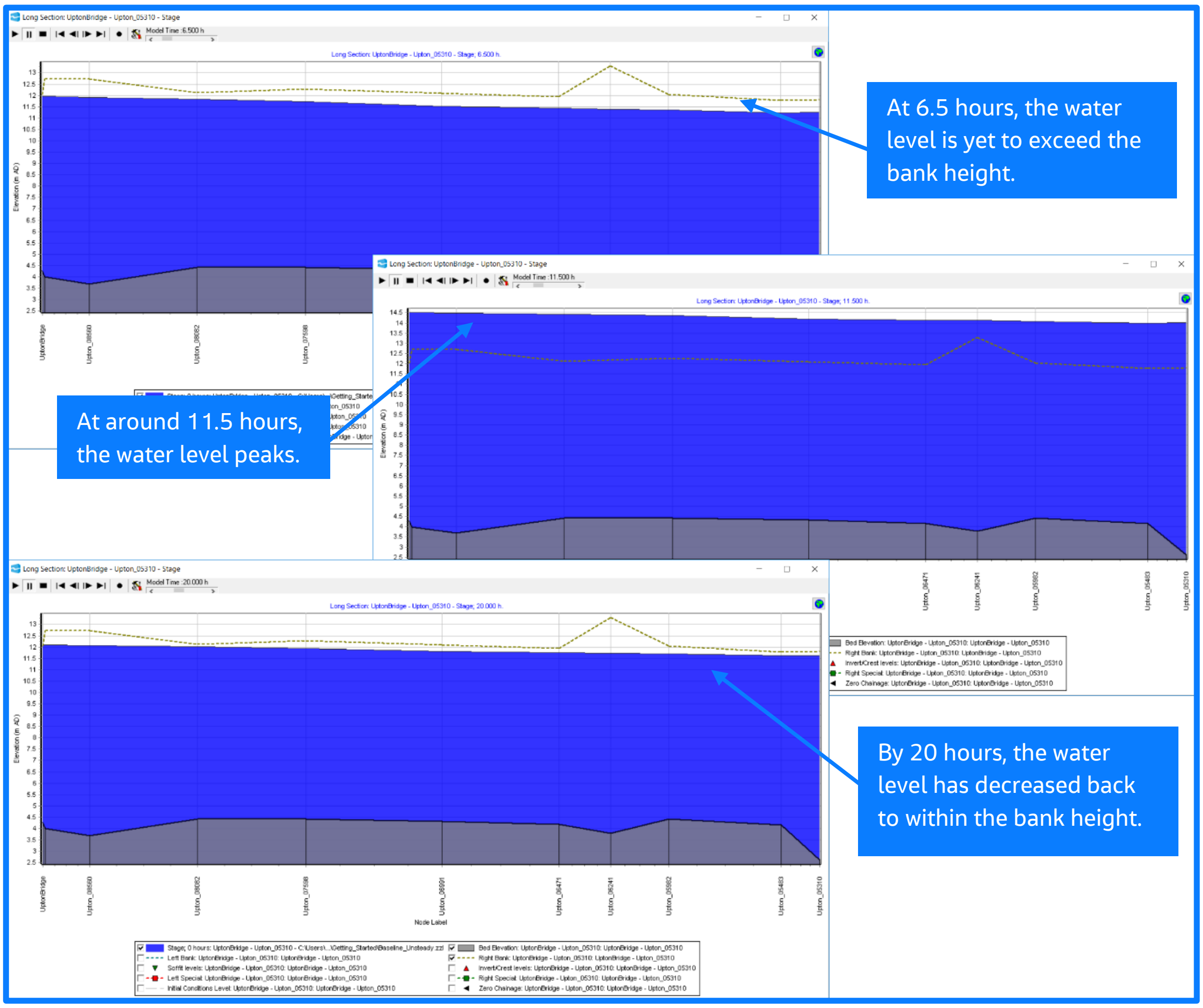
Tip: Don’t forget to save your project too! This will mean your shapefiles automatically load into the ‘Layers’ panel and map view when you next open your project.

Step 6

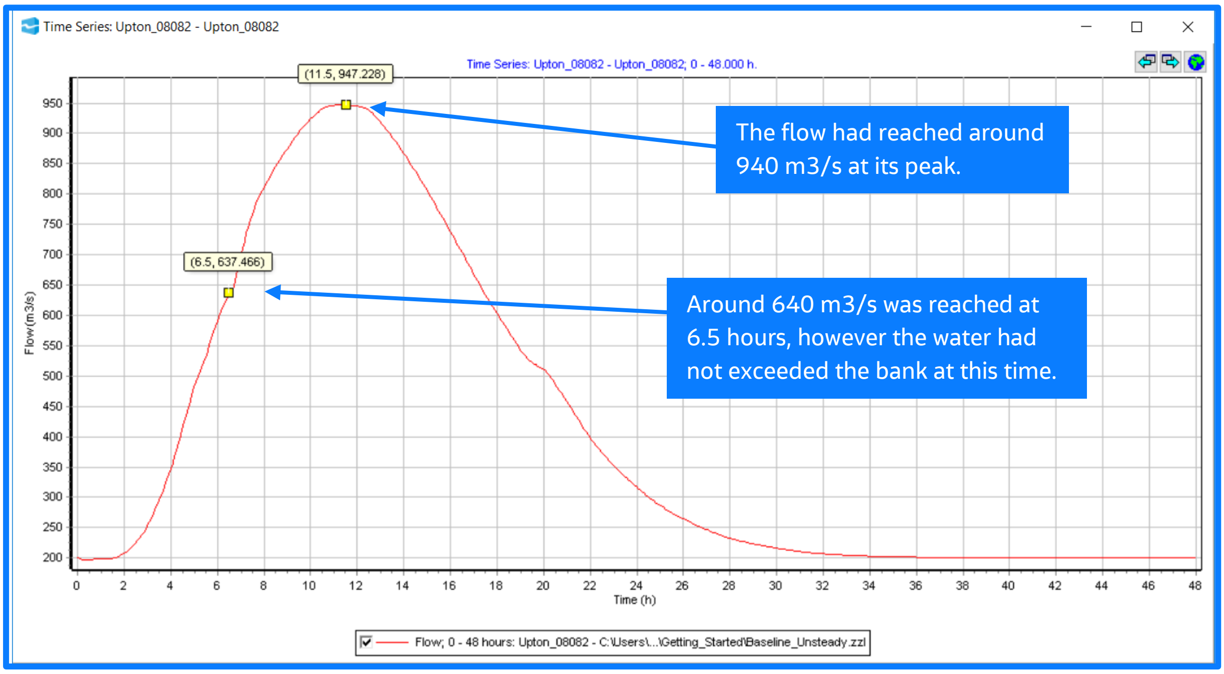
Boundary data is required. We need to indicate where and how much flow is entering our active area. In this instance, we are interested in making some initial investigations into flooding downstream of Upton bridge.

We refer to the guide ‘Getting Started – River Modelling’ and recall our 1D river simulation showed the water exceeding the bank height; we will use these results further to create an approximate flow vs time relationship. We estimate the times at which the water level exceeds the (right) bank height, and time of peak, from the ‘Long Section’ plots showing the stage across the entire area of interest. Right or left bank is determined looking downstream the river network.

We notice that at 6.5 hours, the water level is yet to exceed the bank height. At around 11.5 hours, the water level and flow peaks (note this time will vary slightly along the reach, we only require a rough approximation for the purposes of this guide.) By 20 hours, the water level has decreased back to within the bank height.



To estimate the peak flow at 11.5 hours, we consider the flow at a node in the area of interest, just prior to exceeding the bank height, and at its peak.



Around 640 m^3/s was reached at 6.5 hours, however the water had not exceeded the bank at this time. The flow had reached around 940 m^3/s at its peak. Although there are many other factors to take into consideration, we approximate this difference of 300 m^3/s as the peak flow exceeding the bank and leaving the river at this location. We further estimate that half of the water will flow over the left side of the bank (which we are not modelling) leaving 150 m^3/s as the peak flow exceeding the right bank and entering our active area. We therefore create the following table approximating flow over time.

Time (hours)	Flow (m^3/s)
0	0
6.5	0
11.5	150
20	0
48	0

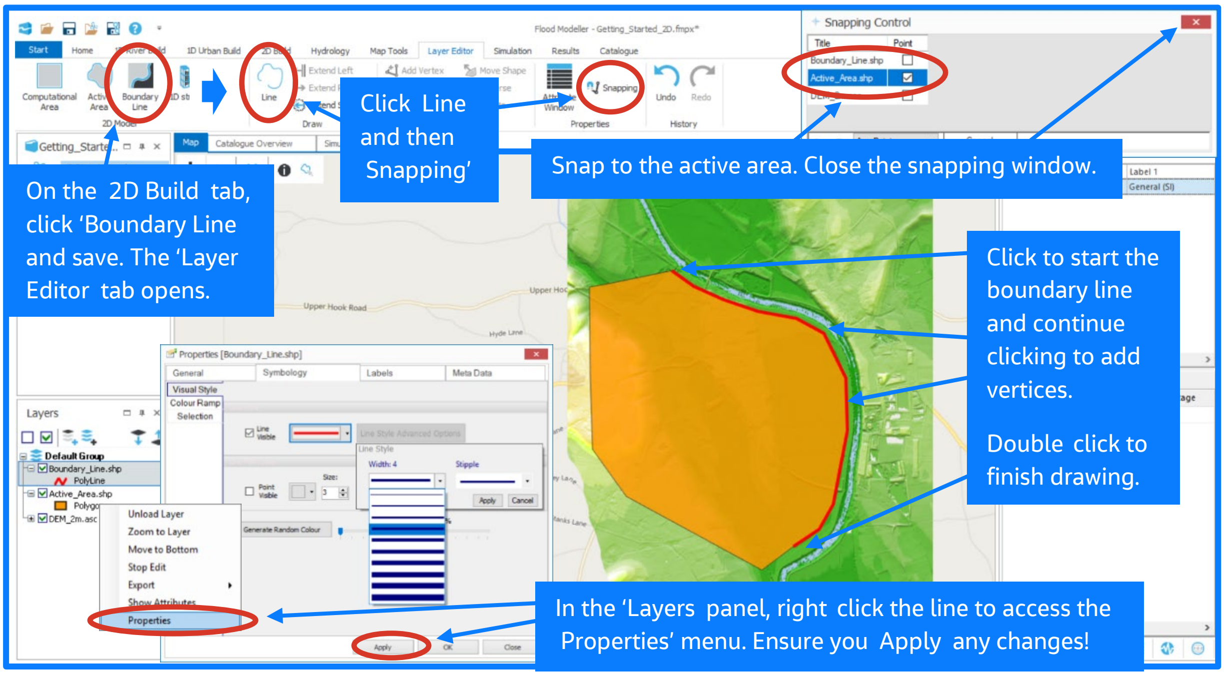
We note that many approximations have been made in creating this data, and certain factors have been ignored altogether (such as water exceeding the bank height further upstream, or water re-entering the river at any locations). For the purposes of this guide, we will consider the above assumptions provide sufficient accuracy levels for our simple 2D model.

Step 7

Draw a ‘Boundary Line’. Let’s snap this to the edge of the active area. Don’t forget to save!

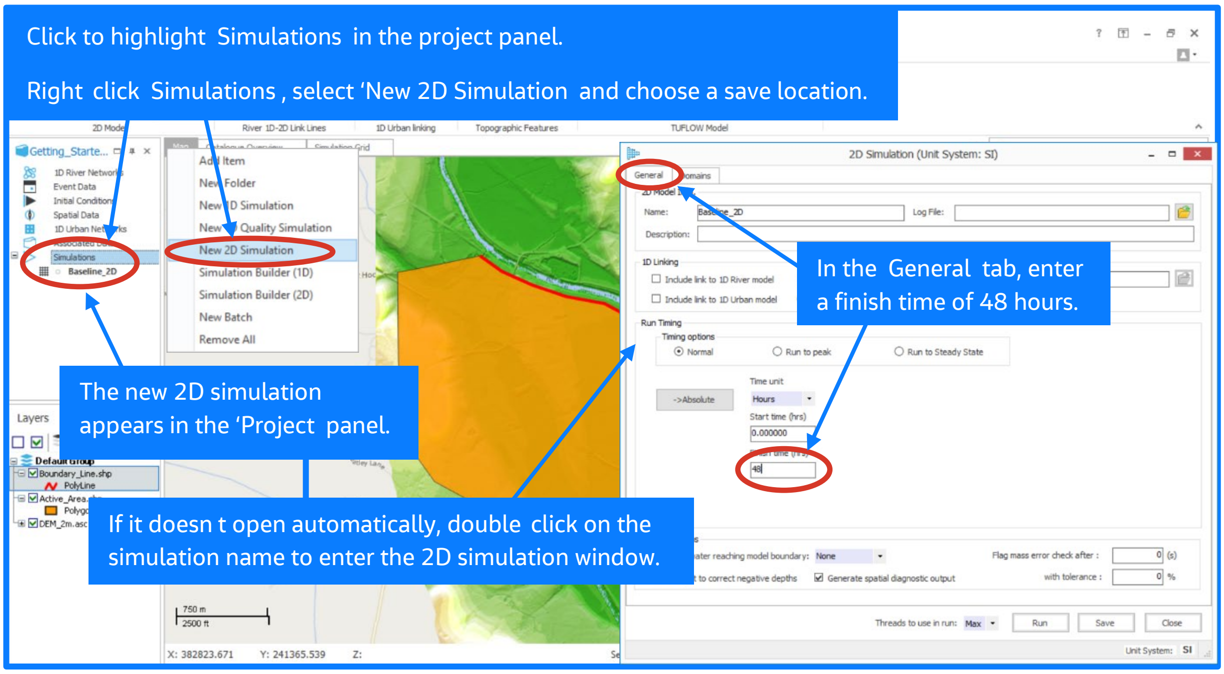
We recommend also changing the colour and increasing the thickness to ensure this is easily visible.

This is going to represent the area along which the water will enter the 2D active area. A boundary line is not required to be on the edge of an active area. Areas of high elevation (such as the top of buildings) near the boundary location could be a reason to move the boundary line, to ensure inflows can propagate onto the floodplain.



Step 8

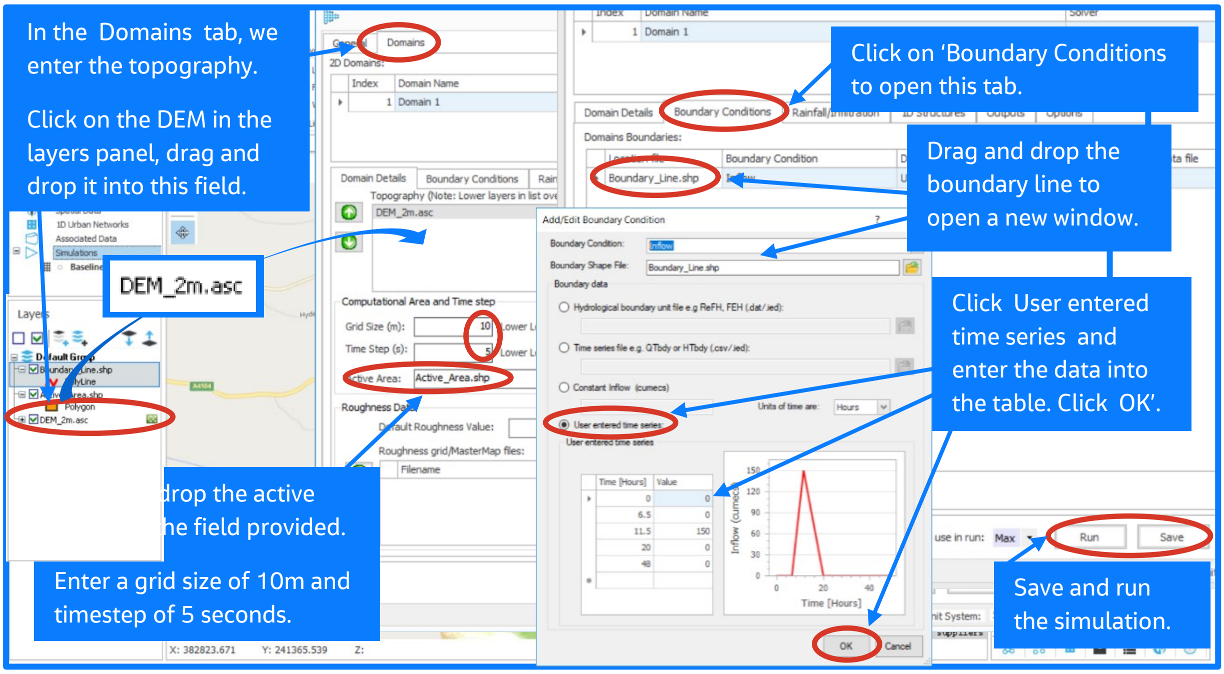
Now we have the underlying elevations, an active area and a boundary (both location and data), we're ready to setup our 2D simulation. This will simulate the flow entering the active area from the boundary and calculate the water depth (alongside other parameters) in all grid cells within the active area at each timestep. Start a new 2D simulation and set the finish time to cover the whole storm event.



Step 9

Enter the DEM as the topography data and specify your active area. Select an appropriate cell size and timestep. Add the boundary line and the table of values determined in part 6 of this guide as a user entered time series. Save and run the simulation.

Time (hours)	Flow (m^3/s)
0	0
6.5	0
11.5	150
20	0
48	0



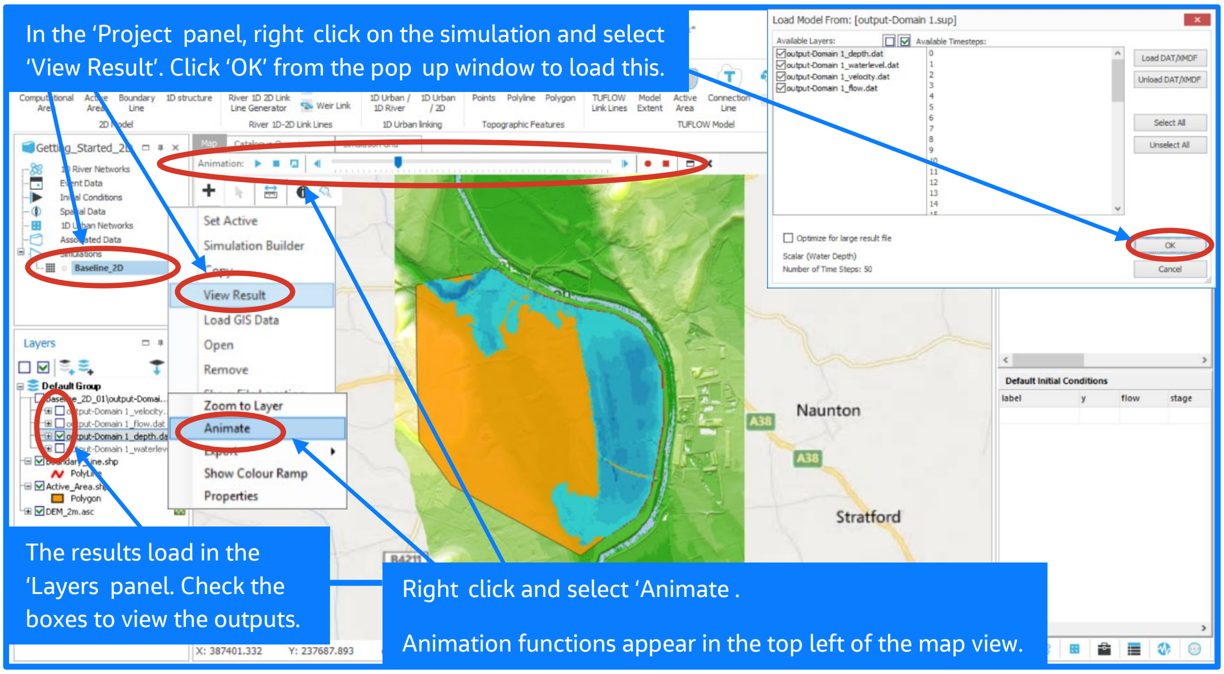
Note: When you drag and drop your DEM into the 'Topography' field, the 'Grid Size' field will automatically fill with the value 2. This is because the DEM provide is at a 2m resolution. We recommend you increase the grid size to 10m, or 20m if you find the simulation is running slowly.

A 2D simulation will be noticeably slower to run that your 1D simulations as there are many more calculations taking place. Increasing the grid size reduces the number of calculations, however a coarse grid reduces the detail provided in the final result, and may have other ramifications (for example, recall from step 5 that the grid cells should not contain areas of "no data").

Step 10

View the results from the simulation. Animate the water depth and investigate how much of your active area floods.

Is your active area big enough? Turn on the ‘flow’ output – are there any areas where the flow appears to reflect from the boundary of the defined active area? Increase your active area, ensuring it remains clear of grid cells with “no data” defined. Save and re-run the simulation – can you create an active area to contain all the water throughout the simulation time?



Tip: Remember to close the animation toolbar when you have finished viewing the animated sequence (leaving this open can cause unexpected things to happen when you continue working!)

Note: That there are numerous other ways to view the results from your 2D simulations, please refer to the user manual for further details.

Summary

You have now had an initial introduction to 2D modelling.

We loaded a DEM that provided the underlying ground elevations in a 2m grid. This could have been any raster grid of elevation data, at any grid size. We notice that aspects such as accuracy and simulation time will not only depend on the size of this grid, but also the grid used for the active area.

We defined an 'Active Area' and used simple-to-access menus and buttons provided in Flood Modeller to edit this. We noticed this was a subset of the computational area; we could have chosen to specify this too. Other options provided include specifying a rotated grid - rotating the grid to align with the predominant direction of floodplain flow is sometimes considered advantageous in 2D modelling.

We saw how the active area cannot cover areas of the DEM containing "no data" values. This includes after it has been adjusted to an alternative grid size (and/or rotation), if specified. Flood Modeller also provides multiple options for defining topographic features, including specifying deactivation areas (subsets of the active area to be computationally 'ignored'), areas of higher ground and roughness patches.

We defined a polyline shapefile to indicate the boundary location using the specific 'Boundary Line' functionality provided, and specified the flow entering the 2D domain based on the results from our 1D river simulation in 'Getting Started – River Modelling'. We noted the flaws in this approximation; however, the rough estimation was suitably accurate for the purposes of this tutorial.

Finally, we setup and ran our 2D only simulation, animating the results from this to see the water flow from the boundary and across the active area. We used a timestep of 5 seconds, following the guidance that the timestep (in seconds) is half the cell size (in metres).

We saw that, alongside other outputs, the direction of flow could be visualised; we used this to ensure our active area was large enough to not induce reflections from the flow at its boundary. Alternatively, we could have used a 1D boundary unit to allow the water to "escape" the 2D domain at this location.

We discussed that a significant downfall of the approximation of flow entering the domain, and equally of the simulation outputs, is not allowing for any flow to re-enter the river. To allow the 1D and 2D components to dynamically exchange data at runtime, a fully integrated modelling approach should be taken. We will discuss the advantages of this further in the guide 'Getting Started – Integrated Modelling'.

What's next?

If you would like to find out more about the 2D solvers, check out our YouTube channel, user manual or get in touch with our support team.

You also may be interested in the other 'Getting Started' guides in this series.