Test 7 – River and floodplain linking

1. Modelling performance tested

The objective of the test is to assess a package's ability to simulate fluvial flooding in a relatively large river, with floodplain flooding taking place as the result of river bank overtopping. The following capabilities are also tested: 1) the ability to link a river model component and a 2D floodplain model component, with volume transfer occurring by embankment/bank overtopping and through culverts and other pathways; 2) the ability to build the river component using 1D cross-sections; 3) the ability to process floodplain topography features supplied as 3D breaklines to complement the DEM[1].

2. Description

The site to be modelled is approximately 7 km long by 0.75 to 1.75 km wide, see Map 1, and consists of a set of three distinct floodplains (Maps 2, 3, 4) in the vicinity of the English village of Upton-upon-Severn, although the river Severn that flows through the site is modelled for a total distance of ~20km. Boundary conditions are a hypothetical inflow hydrograph for the Severn (a single flood event with a rising and a falling limb, resulting in below bankfull initial and final levels in the river (table provided), and a downstream rating curve (table provided). This poses a relatively challenging test through the need for the model to adequately identify and simulate flooding along separate floodplain flow paths, and predict correct bank/embankment overtopping volumes. The volume exchange takes place over natural river banks and/or embankments along which flood depths are expected to be small.

The site has been subjected to flooding on a number of occasions but it is not the intention to replicate an observed flood for this exercise, hence the boundary conditions have been designed to provide a suitable benchmarking case.

River channel geometry

The channel geometry is provided in the form of a text file with cross-sections labelled M013 to M054 (a separate csv file containing cross-section locations and spacing is provided). A uniform channel roughness value is used. Any head losses due to the plan geometry of the river (meanders) are ignored. Along some sections the channel is adjacent to floodplains on just one or on both sides. 3D "breaklines" are provided which define a) the boundary between the river channel and the area expected to be modelled in 2D, and b) elevations along these boundaries (these are consistent with the DEM elevations). These elevations are to be used in the prediction of bank/embankment overtopping. Wherever no floodplain is modelled along the river channel (more than 50% of the total length of river banks), a "**glass wall**" approach (or equivalent) should be applied if water levels exceed the bank elevation in the cross-section (i.e. the water level rises above the bank without spilling out of the 1D model).

[1] The breaklines provided were derived from the 1m DEM and are a 'vector' representation of important crest lines in the topography (including embankments). The ability to recognise these important crest lines and apply the right elevations is tested, rather than the ability to process the 3D breaklines themselves.

A bridge at the North end of Upton (between cross-sections M033 and M034), for which no data are provided, is ignored. No other structure is known to affect the flow along the modelled reach of the river.

Floodplains

The extents of the three modelled floodplains are defined as follows (See Maps 2, 3, 4):

Floodplain 1: on West bank of the River, from upstream from Cross-Section M024, to upstream from M030 (floodplain breakline number 2, see below).

Floodplain 2: on East bank of the river, from upstream from Cross-Section M029, to upstream from M036.

Floodplain 3: on West bank of the river, from half-way between cross-sections M031 and M032 to half-way between cross-sections M043 and M044. This includes the "island" on which the village of Upton lies.

The floodplains are otherwise bounded by the river bank breaklines provided, see above in "River channel geometry". Away from the river, for consistency in model extent, it is suggested to draw the boundaries of the 2D models approximately along the 16m contour line.

Floodplain 3 has a physical opening below the 16m altitude along the Pool Brook stream to the North-West of Upton. The model should extent to the edge of the DEM in this location. (however this boundary is to be treated as closed, i.e. no flow)

Note that the narrow strip of floodplain (between FP 1 and FP 3) on the West bank of the river in the vicinity of cross-sections M030 and M031 does not need modelling in 2D. Cross-sections M030 and M031 have been extended as far as the hillside to the West.

A shapefile containing polylines defining the outer boundaries of the floodplains is provided.

A number of features in the floodplains are expected to impact on results significantly and will be modelled. This includes:

- embankments and elevated roads, for which **3D breaklines** are provided as part of the dataset. These can be used to adjust nodes elevations in the computational grid. They should be distinguished from the river/floodplain boundary breaklines mentioned in the previous section.

- a set of low bridges of total width ~40m under the elevated causeway (**A4104 road**) immediately west of Upton. This can be modelled as a single 40m opening through the A4104 causeway (elevations provided as floodplain breakline number 7). A photograph and a datafile containing various parameters (including X Y coordinates and dimensions) are provided as part of the dataset.

The modelled flood is not expected to inundate roads and built-up areas to any significant extent. Therefore a uniform roughness value is applied across the floodplains, with a specified value. The floodplain land use in this reach is predominately pasture with a lesser amount of arable crops. Any effect of buildings are ignored (for example in the town of Upton).

Any feature of the floodplain not mentioned above, including any perceived “false blockages” should be ignored. 2 “marinas” within floodplain 1 (near North end) and floodplain 2 (near South end) should simply be modelled as ground, with elevations as given by the DEM.

1D-2D volume transfer

No parameter value or modelling approach is specified for the prediction of river/floodplain volume transfer (except the elevations specified by the breaklines).

At the real site volume exchange between the channel and the floodplains also occur through a number of flapped outfalls. These are ignored.

A masonry **culvert** immediately upstream from the village of Upton (“Pool Brook”) is however modelled, see Map 4. It is assumed circular in cross-section. A photograph and a spreadsheet containing various parameters (including X Y coordinates and dimensions) are provided as part of the dataset.

An opening in the embankment (floodplain breakline number 2) at location X=384606 Y=242489 (see Map 2) at the southern end of Floodplain 1 (blocked by a **sluice** in reality) is assumed to remain opened during the duration of the flood. This should be understood as a 10m wide opening (invert level 10m) offering a pathway from Floodplain 1 to the river at cross-section M030.

Misc

The DEM is a 1.0m resolution LiDAR Digital Terrain Model (no vegetation or buildings) provided by the Environment Agency (http://www.geomatics-group.co.uk). Due to the very large size of the 1m DEM file, a coarsened 10m DEM is also provided, but it is emphasised that this is unlikely to provide the right elevations along embankments, river banks and other features, for which 3D breaklines are provided.

Minor processing of the original EA LiDAR DEM was done, consisting in merging tiles and filling small areas of missing data in the modelled floodplains. Areas of missing data (-9999) may remain in the DEM, but only outside the modelled 2D domain described previously.

The model is run until time T = 72 hours to allow the flood to settle in the lower parts of the modelled area.

3. Boundary and initial conditions

River channel:

Upstream: inflow versus time applied at the northernmost cross-section, cross-section M013.

Downstream: rating curve (flow versus head), applied at the southernmost cross-section, cross-section M054.

Initial condition: a uniform water level of 9.8m.

Floodplains:

Linked to the river channel along the river bank breaklines provided, and through the Pool Brook culvert (Floodplain 3) and the opening (sluice) at the South end of Floodplain 1.

All other boundaries are closed (no flow).

Initial condition: A uniform water level of 9.8m.

Pool Brook culvert: Initial water level 9.8m.

4. Misc. parameter values

Manning's n: 0.028 uniformly in river

0.04 uniformly in floodplains

Model grid resolution: 20m

(or ~16700 nodes in the model extent defined in Section 2 under "Floodplains")

Time of end: the model is to be run until time t = 72 hours (if an alternative end time is used run times must be reported for t=72 hours)

5. Required output

Software package used: version and numerical scheme.

Specification of hardware used to undertake the simulation: processor type and speed, RAM.

Minimum recommended hardware specification for a simulation of this type.

Time increment used, grid resolution (or number of nodes in area modelled) and total simulation time to specified time of end.

Raster grids (or TIN) at the model resolution consisting of:

a. **Peak water level elevations**
b. **Peak water depths**
c. **Peak velocities**
d. **Water level elevations at T=72hours.**
e. **Water depths at T=72hours.**

The above concerns the *floodplains* only

Water level elevation and **Velocity** versus time (output frequency 60s), at locations shown in Maps 2, 3, 4. Coordinates provided as part of the dataset.

Water level elevation and **Velocity** versus time (output frequency 60s) at the following river cross-sections (1D model):

M015

M025

M035

M045

6. Dataset content

Description	File Name
Georeferenced Raster ASCII DEM at resolution 1m	Test7DEM.asc
Georeferenced Raster ASCII DEM at resolution 10m	Test7DEM_10m.asc
1D Model Cross-sections	Test7-1DXS.txt
1D Model Cross-section locations and spacing	Test7-1DLoc-Spacing.csv
Location of output points	Test7-Output.csv
River bank breaklines	Test7-bank-bklines.csv
Floodplain breaklines	Test7-FP-bklines.csv
Photograph showing Pool Brook culvert	Test7-PoolBrookCulvert.jpg
Pool Brook culvert parameters	Test7-PoolBrookCulvert.xls
Photograph showing A4104 bridge	Test7-A4104bridge.jpg
A4104 bridge parameters	Test7-A4104bridge.xls
Dowstream rating curve (flow versus water level)	Test7-DSRatingCurve.csv
Upstream inflow (flow versus time)	Test7-USInflow.csv

Notes:

1D Model Cross-sections file (Test7-1DXS.txt): this contains 1 table of 6 columns for each cross-section. The first (chainage in m) and second (elevation in m) columns only should be used. All other data can be disregarded. The location and spacing of cross-sections are contained in file Test7-1DLoc-Spacing.csv

All coordinates in the British coordinates system.

7. Additional comments

Modelling instructions for this test have been provided as clearly as possible. Participants may contact Heriot-Watt University for more specific instructions. However it is intended that any aspect of the modelling not considered in this specification is left to the modeller's own initiative.

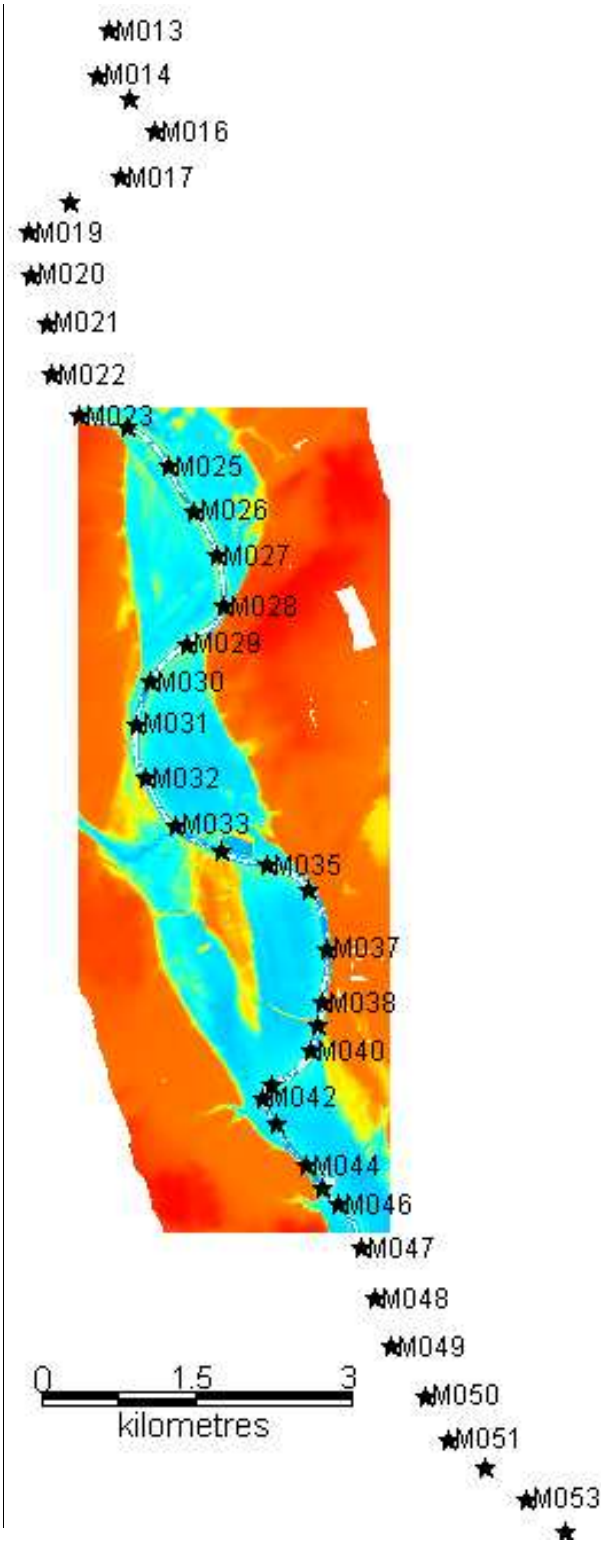
Linear interpolation should be used to interpolate inflow values.

Participants are asked to provide model results **at least** for the grid resolution specified above.

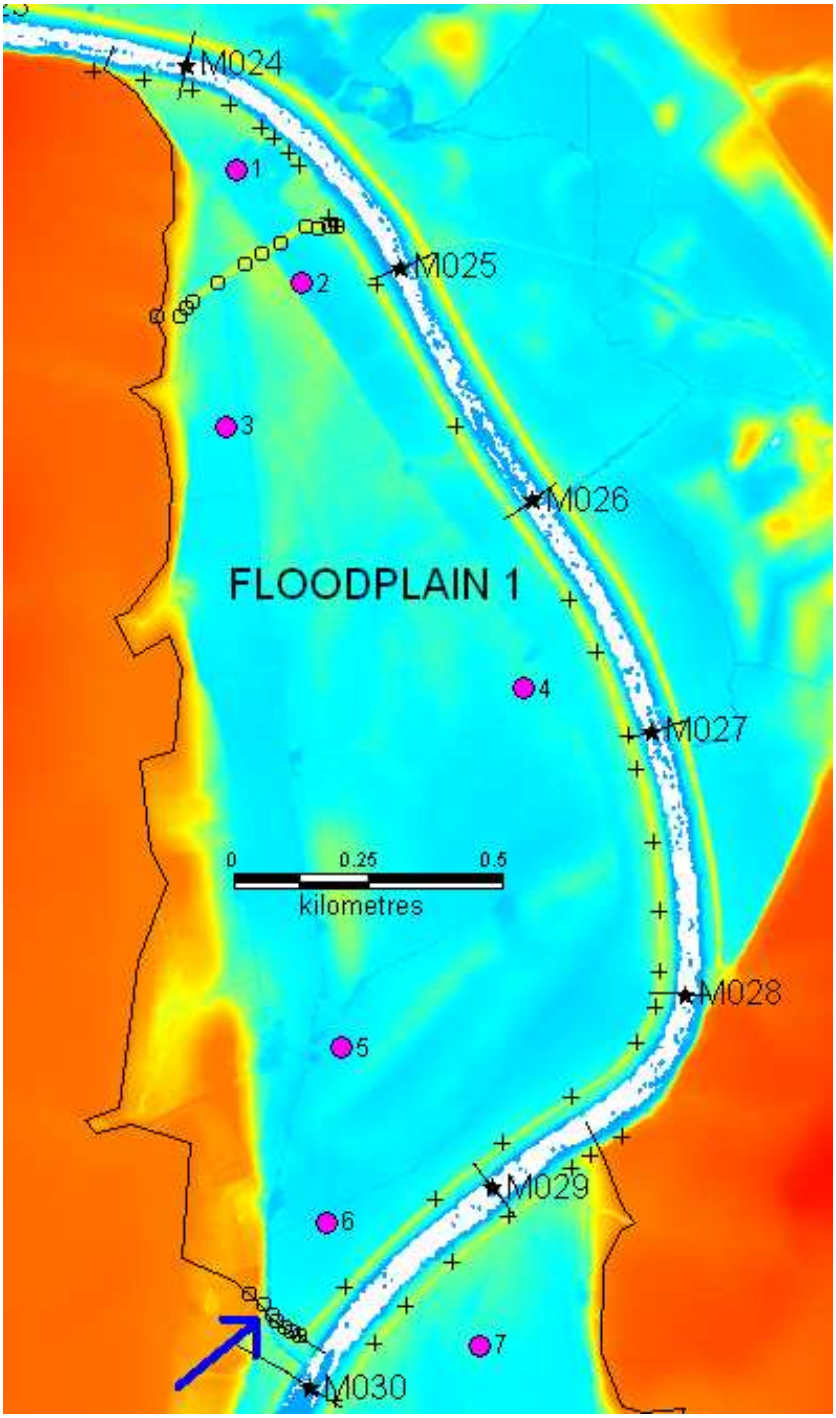
Model results for one alternative resolution or mesh may also be provided.

Participants are asked to justify their reasons for not carrying out the test, or for carrying out the test using an alternative resolution.

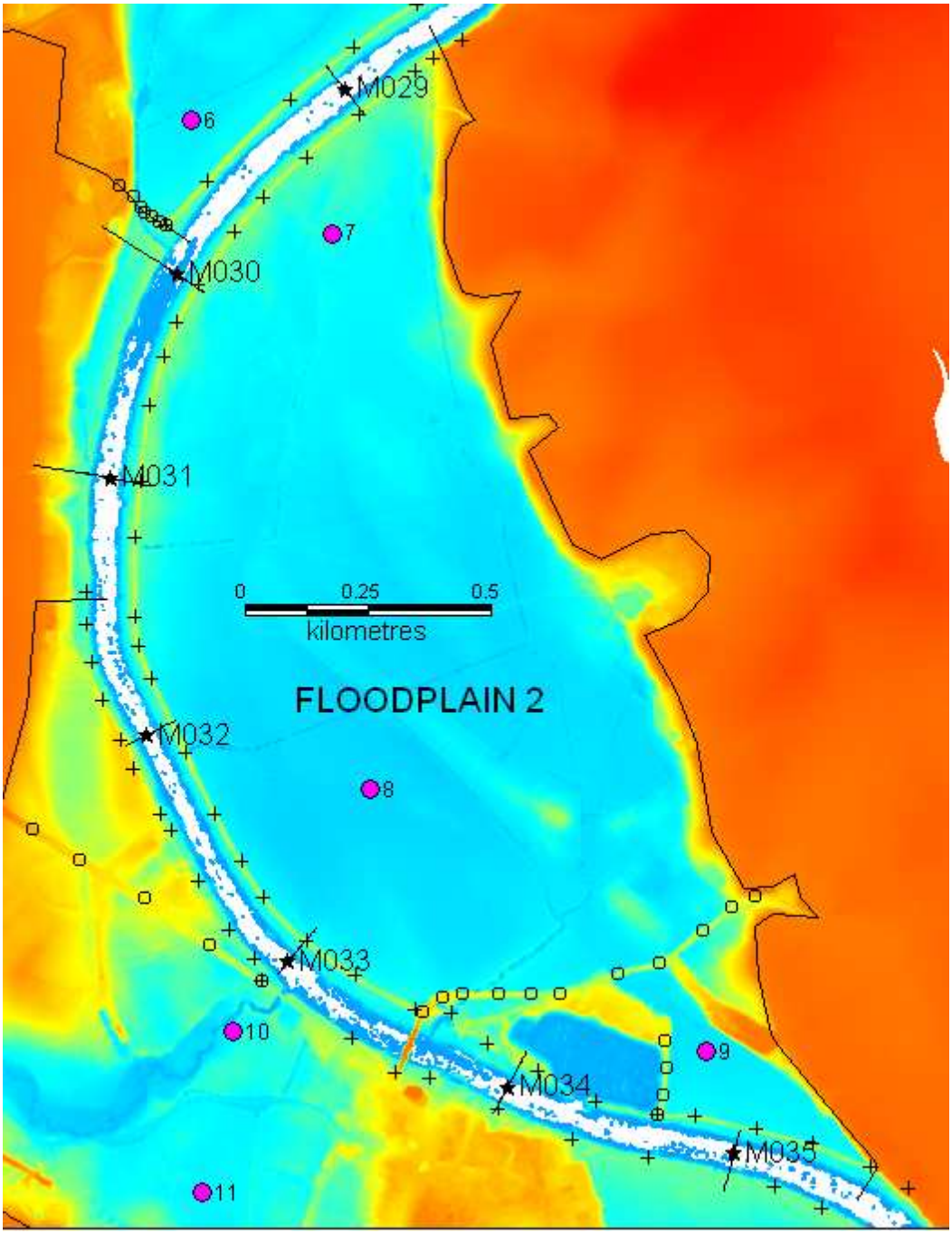
8. Maps



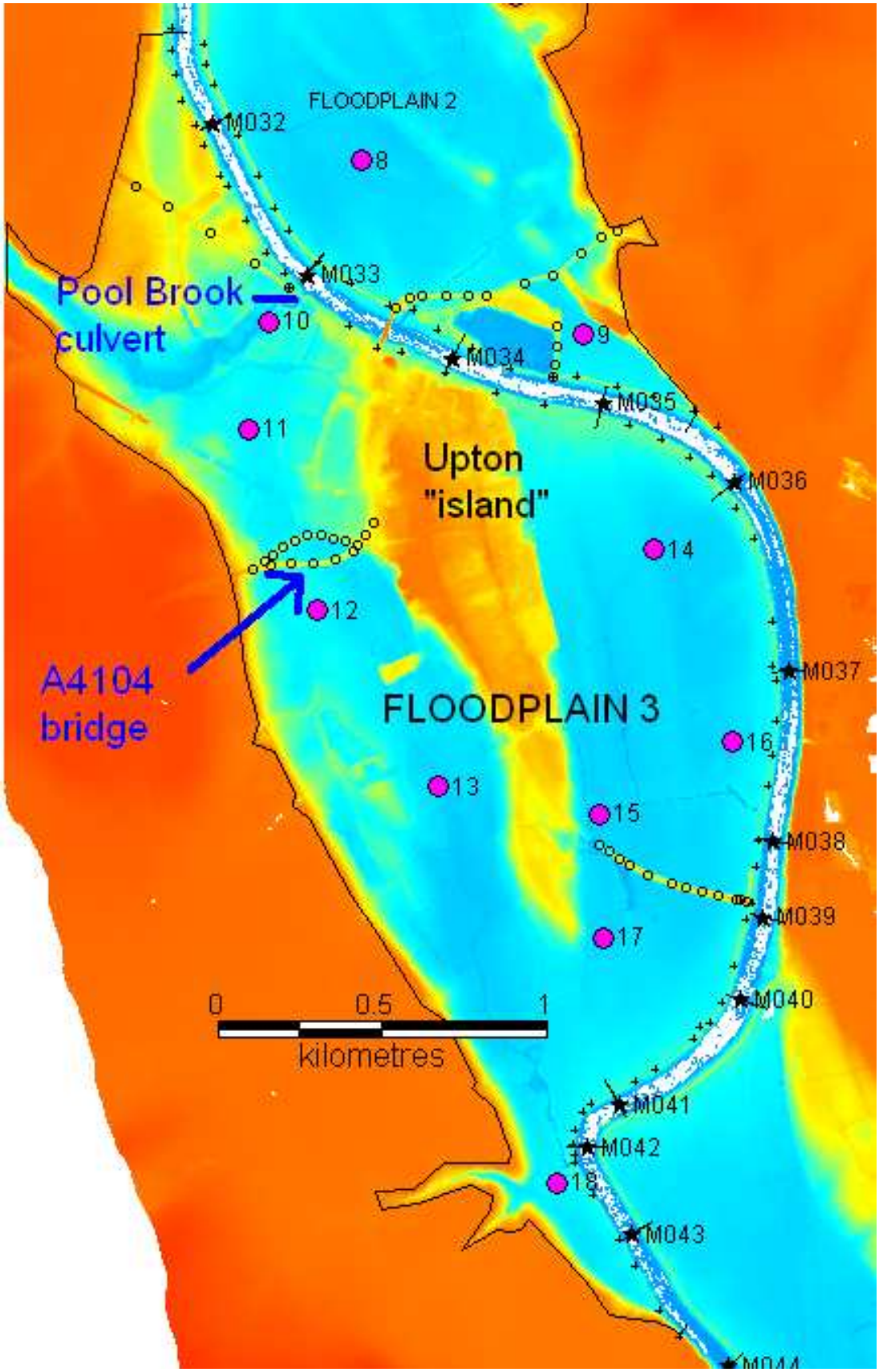
Map 1: Map of the modelled reach of the River Severn and floodplain system around Upton-upon-Severn. *The river flows from North to South.*



Map 2: Map of floodplain 1. Blue arrow: opening in embankment (sluice). Crosses: bank breaklines vertices. Circles: floodplain breakline vertices. Purple dots: output points. Black line: outer extent of model.



Map 3: Map of floodplain 2. Crosses: bank breaklines vertices. Circles: floodplain breakline vertices. Purple dots: output points. Black line: outer extent of model.



Map 4: Map of floodplain 3. Crosses: bank breaklines vertices. Circles: floodplain breakline vertices. Purple dots: output points. Black line: outer extent of model.