Norwich Western Link

Environment Statement

Chapter 12: Road Drainage and the Water Environment

Appendix 12.2: Flood Risk Assessment

Sub Appendix C River Wensum Technical Modelling Log

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Glossary of Abbreviations and Defined Terms

The definition of key terms used in this report are provided below. These definitions have been developed by reference to the definitions used in EU and UK legislation and guidance relevant to the water environment as well as professional judgement based on knowledge and experience of similar schemes in the context of the Proposed Scheme.

Term	Definition
1D model	A hydraulic model used for watercourses that calculates flow in the direction of the channel only. It does not calculate movement vertically or horizontally in the channel.
2D model	A hydraulic model used for watercourses and floodplains that calculates flow along a plane in two directions, often at 90 degrees to each other. It does not calculate movement in the vertical direction.
Digital Terrain Model	A surface produced from LIDAR data where surface features such as buildings and vegetation have been removed so that is represents ground level.
Flood Estimation Handbook	A manual consisting 5 volumes that sets out the techniques to be used within the UK to derive flood flows, which are used to support Flood Risk Assessments.
Flood Modeller Pro	A hydraulic modelling software package
Fluvial Flood Risk	Flooding resulting from a flows within a watercourse exceeding the capacity of that watercourse.
Hydraulic Model	A software tool used to estimate water levels during a flood event based on topographical data of watercourse channels and the floodplain and flood event flows or rainfall data.
Hydrology	The study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks.
Left Bank	Left bank is defined by the direction of flow of the watercourse, looking downstream in the direction of flow. For the purposes of this FRA both the River Wensum and Foxburrow Stream run in a south-easterly direction in the vicinity of the Proposed Scheme. The left bank is therefore on the north-east side of these watercourses.

Term	Definition
LIDAR	Light Detection and Ranging, a method used to collect ground level data from an aircraft allowing large areas to be collected. The data in its unfiltered form will pick up vegetation and properties. A filtered form is generated to represent the ground surface and is used in assessments.
Manning's Roughness Value or Coefficient	A coefficient to represent different surface rougnesses and used in the Manning equation to understand the relationship between flow and water depth.
Model cell size	The resolution that LIDAR data is sampled at for use in the model. Smaller cell sizes increase the length of time it takes for a model to run.
QMED	The median flow extracted from an AMAX series. This is considered to represent the 1 in 2 annual probability event flood.
ReFH	The Revitalised Flood Hydrograph rainfall runoff method. One of the Flood Estimation Handbook methods for determining peak flows and hydrographs.
Right Bank	Right bank is defined by the direction of flow of the watercourse, looking downstream in the direction of flow. For the purposes of this FRA both the River Wensum and Foxburrow Stream run in a south-easterly direction in the vicinity of the Proposed Scheme. The right bank is therefore on the south-west side of these watercourses
TUFLOW	A hydraulic modelling software package

1 Overview

1.1.1 This model log forms an Appendix of the **Flood Risk Assessment** (Document Reference: 3.12.02) and should be read in conjunction with the **River Wensum Hydraulic Modelling Report** (Document Reference: 3.12.02b).

1.1.2 A linked 1D-2D FMP-TUFLOW hydraulic model has been produced for use within the Proposed Scheme assessment. The model has been used to inform both the baseline fluvial flood risk, and the potential impacts of the Proposed Scheme to both the road itself and to third parties during construction and operation of the development.

1.1.3 The model has been trimmed and updated from a previous Environment Agency model that was produced by JacksonHyder in 2017.

1.2 Topographic data consistency

1.2.1 The topographic survey data used for the modelling is summarised in **Table 1-1.**

Table 1-1 Topographic survey data

Data	Details
National Rivers Authority Anglian Region river and structure survey from 1993	Survey used within previous model has been retained.
Taverham Mill survey	Survey obtained in 2010 and incorporated in 2017 CH2M study.
Environment Agency 2019 Composite 1m LIDAR Dataset	Replaced previous 2014 LIDAR dataset that had been used to populate DTM within the model.

2 Model Schematisation

2.1 Modelling approach and choice of software

2.1.1 The model domain comprises the stretch of the River Wensum between Fakenham Road at Attlebridge and Costessey Mill. The watercourse and floodplain are generally well connected, and there are numerous field drains and ponds throughout the floodplain. There are a number of complex hydraulic structures which relate to Taverham Mill and Costessey Mill where the watercourse bifurcates before re-combining further downstream.

2.1.2 A hydraulically linked 1D Flood Modeller Pro (FMP) and 2D TUFLOW model has been used for the purpose of this study. The choice of software reflects the requirement to represent both the River Wensum watercourse and floodplain features in sufficient accuracy.

2.2 Model schematisation

2.2.1 The 1D model has been retained from the previous modelling study, but it has been trimmed to comprise only the sections between Fakenham Road near Attlebridge and Costessey Mill. Similarly, the 2D domains have been reduced to comprise only the Wensum and Costessey domains from the previous modelling study. The trimming was undertaken to both reduce run times and prevent instabilities from other parts of the model from propagating to the area of interest.

2.2.2 The 1D domain has been dynamically linked to the 2D domain via the use of HX and CN boundary lines according to modelling best practice.

2.2.3 Further information regarding the updates that have been made to improve the performance, stability and accuracy of the hydraulic model is provided in Section 1 of the associated Hydraulic Modelling Report.

3 1D Baseline Model Representation

3.1 Labelling Convention

3.1.1 In the 1D domain, the naming convention comprises a watercourse section label, for example WENF2 to denote the main Wensum channel, followed by a chainage value. The chainage represents the distance from the downstream model limit of each channel.

3.1.2 Additional suffixes have been assigned to the watercourse chainage label to describe non river channel units as follows:

- su/sd for spills
- bu for bridges (upstream), bd for bridges (downstream)
- u for upstream face
- d for downstream face
- i for interpolate.

3.1.3 For complex areas with multiple channels, further labels have been added to denote the different channels and parallel structures present.

3.1.4 Model cross sections have been populated from the channel survey. The model cross section chainage correlates to the chainage of the surveyed section.

3.2 Channel Roughness

3.2.1 **Table 3-1** summarises the Manning's n values applied to the river channel. Broadly, channel roughness values represent the lower side slopes and the bed of the channel, bank roughness values represent the upper side slopes and top of bank of the channel. Beyond the top of the bank, roughness values are represented in the 2D domain.

3.2.2 Photographs were not provided with the available survey data that was used to construct the model. Checks of the roughness values retained from the

previous modelling have been made using available satellite imagery. Further, thorough sensitivity testing to determine the impacts of varying roughness parameters on the model results has been undertaken.

Table 3-1 Manning's n values for the 1D channel

Watercourse	Model Nodes	Manning's 'n' Roughness	Description of typical reach cover
River Wensum	WENF2_23782u – WENF2_8500	Bank: 0.05 Channel: 0.035 Channel: 0.04	Sparse trees and scrub, high grass Silted channel with varying levels of vegetation
River Wensum (Costessey restoration features)	WENS05_2388 – WENS05_0000	Brushwood berm: 0.075 Woody material: 0.075 Composite berm: 0.05 Glide: 0.03 Cattle drink: 0.03 Pinch point: 0.03	Various restoration features

3.3 Hydraulic Structures

3.3.1 **Table 3-2** to **Table 3-4** summarise the representation of the hydraulic structures in the 1D model.

Table 3-2 Details of hydraulic structures in the 1D model along the River Wensum

Structure	US and DS channel sections	Representation	Dimensions/ Parameters
New Fakenham Road Bridge	WENF2_22445u, WENF2_22445d	USBPR Bridge, no spill as does not surcharge for all events	Soffit: 12mAOD, width: 19.2m
Ringland Road Bridge	WENF2_17740u, WENF2_17740d	USBPR Bridge, spill unit	Soffit: 9.94mAOD, springing level: 9.7mAOD, width: 30.3m
Access Bridge by Three Corner Plantation	WENF2_15976u, WENF2_15976d	USBPR Bridge, spill unit	Soffit: 9.34mAOD, width: 17.2m
Taverham Road Bridge	WENF213450u, WENF213450d	Arch bridge with three arches, no spill unit as does not surcharge	Arch 1: 6m wide, soffit 7.44mAOD, springing level 6.49mAOD. Arch 2: 7.85m wide, soffit 7.69mAOD, springing level 6.38mAOD Arch 3: 6m wide, soffit level 7.44mAOD, springing level 6.4mAOD

Structure	US and DS channel sections	Representation	Dimensions/ Parameters
Mariott's way disused railway bridge	WENF2_8695u, WENF2_8695d	USBPR bridge, no spill unit as does not surcharge	Width 21.3m, soffit level 11.510mAOD

Table 3-3 Details of hydraulic structures in the 1D model along at Taverham Mill

Structure	US and DS channel sections	Representation	Dimensions/Parameters
Mill outfall	TAVs1_0350	Outfall unit	Sill level: 7.24mAOD, bore area: 0.049m^2, downstream sill level: 4.6mAOD
Sluice D	TAVERND_191u	Vertical sluice unit	Crest elevation: 6.62mAOD, length: 1m, breadth: 1.15m
Sluice C	WENS13666_1u, WENS13666_2u, WENS13666_3u,	Three vertical sluice units in parallel	The three sluices are identical. Crest elevation: 6.61mAOD, length 5.4m, breadth 0.72m
Sluice B	WEN2_13638Su, WE_13638_2Su	Two vertical sluice units in parallel	Sluice 1: Crest elevation: 7.15mAOD, length 19m, breadth 1.54m Sluice 2: Crest elevation: 7.15m, length 3.66m, breadth 4.49m
Main weir	WENF_13623u	Spill unit Footbridge not included	Variable geometry spill, left opening width: 2.61m, right opening width 2.45m

Table 3-4 Details of hydraulic structures in the 1D model at Costessey Mill

Structure	US and DS channel sections	Representation	Dimensions/Parameters
Costessey Lane road crossing	WENF2_9500u, WENF2_9485u	Three culverts in parallel, represented using conduit units	Culvert 1: 1.8m x 1.55m rectangular Culvert 2: Arch culvert, 1.95m wide 0.3m high Culvert 3: Arch culvert, 1.86m wide, 0.31m high
Crump weir	WENF2_9457u	Crump weir	Crest elevation 5.3m, breadth 29.5m
Road bridge	COSTESB_27u	Arch bridge	3.7m wide, soffit level 5.3mAOD, springing level 4.75mAOD
Mill compound entrance	COSTESAb243u	USBPR bridge with two openings	Opening 1: Width 2.2, soffit: 5.8mAOD Opening 2: Width 2.2m, soffit 5.8mAOD
Gate under mill	COSTESA_Gu	Tilted weir	Gate height: 1.550, breadth of weir: 5.25, pivot elevation 4.65mAOD
Exit from mill compound	COSTESA_230u	USBPR bridge with two arch openings	Arch 1: Width 2.3m, springing level 4.55mAOD, soffit level 5.61mAOD Arch 2: Width 2.3m, springing level 4.55mAOD, soffit level 5.59mAOD

3.4 1D Model Boundaries

3.4.1 The model was cut at node WENF2_23782u, which is the most upstream node in the Wensum domain and where the River Wensum passes beneath a railway embankment.

3.4.2 Inflows for this study have been derived by extracting flow hydrographs from the original 2017 1D only flood model of the River Wensum produced by CH2M. Where necessary, the model has been re-run with scaled hydrographs to derive model results for the latest climate change scenarios.

3.4.3 A QTBDY has been used to apply the inflow hydrographs at the upstream extent of the model.

3.4.4 There is a lateral flow boundary to distribute flows between Trout Stream, a tributary of the Wensum which joins immediately upstream of the railway embankment at the upper extent of the Wensum domain, and Costessey pits. For the purposes of the study, it was deemed appropriate to apply this inflow downstream of the railway embankment so the updated model contained all contributing flows from W9int. The lateral inflow was not applied immediately downstream of the railway embankment to prevent stability issues with the application of the upstream QTBDY.

3.4.5 A lateral flow boundary has been used to apply the W9int REFHBDY to the following nodes:

- WENF2_23783L
- WENF2_20500L
- WENF2_16500L
- WENF2_14250L
- WENS05_1571L

3.4.6 The downstream boundary comprises a rating curve based on modelling results extracted from the updated 2016 Norwich model. This boundary has

been retained from the previous modelling study undertaken by JacksonHyder and has not been altered.

4 2D Baseline Model Representation

4.1 Labelling Convention

4.1.1 The standard labelling convention and folder structure for TUFLOW models has been applied. Control files (.tcf, .tgc, .tbc, .tmf) have been prefixed with WEN_TRIM and a 2 digit version number. GIS files are saved in the Model/GIS folder and prefixed with the TUFLOW ascribed codes and suffixed with a letter denoting the shapefile geometry type (point, line or region) and a 2 digit version number.

4.2 Model Grid Resolution and Modifications

4.2.1 The LIDAR data has been sampled at 8m in the Wensum domain and 5m in the Costessey domain to represent the floodplain.

4.2.2 Bank top levels have been applied separately and are based on the available topographic survey data. Bank top levels are applied at surveyed cross sections and linearly interpolated between these points.

4.2.3 The following modifications have been made to the LIDAR to better represent features within the floodplain:

- Shapefile regions have been used to set the Costessey pits to constant elevations
- A shapefile region has been applied at the railway embankment at the upstream extent of the model with a constant elevation of 15mAOD to prevent unrealistic backflow from the channel against the upstream boundary
- A shapefile region has been applied at Fakenham Road near Attlebridge to enforce the road levels here as they form an important barrier to flow
- A line shapefile has been applied to Ringland Road to enforce the road levels.

4.3 Floodplain structures

4.3.1 There are a number of floodplain structures that convey flow through railway and road embankments in the model domain. **Table 4-1** summarises these structures and their representation in the model.

Table 4-1 Summary of floodplain structures

Structure	Representation	Dimensions/ Parameters	Comments
Fakenham Road bypass	Shapefile region used to stamp through embankment to allow water to flow through, a shapefile line has also been used to carve through the existing field drain	Clear span of 9.78m, length of 13.33m	Simplified representation considered appropriate due to lack of detailed information
Ringland Road culvert	ESTRY rectangular culvert	0.8m x 0.8m	Lack of detailed geometry information therefore modelling as rectangular as a conservative estimate of flow area
Three Corner Plantation embankment	Embankment has been represented using a line shapefile, a gap has been purposefully left to allow water to flow through.	Approx. span width of 17m, length approx. 17m.	Representation retained from previous study as no additional information obtained.

4.3.2 Unfortunately, a photograph was only available for the Fakenham Road Bypass structure, shown in **Figure 4-1** below.

Figure 4-1 Fakenham Road Bypass

4.4 Floodplain Roughness

4.4.1 OS Mastermap data has been used to determine floodplain surface types. A spatially varying roughness has been applied across the 2D domain using this data and the roughness values linked to the different surface types as shown below.

Table 4-2 Manning's n values for the 2D domain

Description / Mastermap Feature Code	Manning's 'n' value
Building (10021)	0.300
General surface – multi surface (10053)	0.017
General surface – step (10054)	0.017
General surface - manmade (10056)	0.017
General surface - natural (10056)	0.040
Glasshouse (10062)	0.200

Description / Mastermap Feature Code	Manning's 'n' value
Inland water (10089)	0.035
Landform - slope (10096)	0.040
Landform - cliff (10099)	0.030
Coniferous trees (10111)	0.100
Coniferous trees – scattered (10111)	0.060
Coppice Or Osiers (10111)	0.070
Marsh Reeds or Saltmarsh (10111)	0.048
Non coniferous trees (10111)	0.070
Non-coniferous trees – scattered (10111	0.040
Orchard (10111)	0.065
Rough grassland (10111)	0.040
Scrub (10111)	0.050
Path (10123)	0.030
Rail (10167)	0.025
Road or Track (10172)	0.015
Roadside - pavement (10183)	0.025
Roadside - verge (10183)	0.030
Structure (10185)	0.030
Structure – pylon (10193)	0.035

4.5 2D Model Boundaries

4.5.1 In the 2D domain, the downstream boundary comprises a series of HQ boundaries perpendicular to the channel with a ‘b’ gradient value of 0.001.

4.5.2 The TUFLOW 2D domain is linked to the FMP 1D channels using a HX boundary along the left and right bank top of the channels. This boundary coincides with the bank top levels stamped into the 2D domains based on the cross section survey.

4.5.3 The ESTRY structure beneath Ringland Road is linked into the 2D domain using SX boundaries.

5 Proposed Model Representation

5.1.1 The elements of the Proposed Scheme and associated Temporary Works in the vicinity of the River Wensum and relevant to the hydraulic modelling work are described in Section 4.2 and Section 4.2.6 of the **River Wensum Hydraulic Modelling Report** (Document Reference: 3.12.02b) respectively.

5.2 1D Model

5.2.1 There have been no changes to the River Wensum representation in the FMP 1D model as a result of the Proposed Scheme.

5.2.2 The bailey bridge has been included in the FMP 1D model for the Temporary Works.

5.3 2D Model

5.3.1 The Proposed Scheme has been represented in the TUFLOW 2D model using ASCII files generated from the 3D design drawings for the viaduct embankments and maintenance tracks. The piers are represented as thin z shape lines along cell edges for the full width of each set of 3 piers.

5.3.2 The Temporary Works have been represented in the TUFLOW 2D model as z shape file for the working platform set to a typical level of 10.8mAOD with increases above this in the vicinity of the bailey bridge. The bailey bridge is represented as a layered flow constriction for those parts of the structure located outside of the FMP 1D channel. The culverts beneath the working platform have been inserted as ESTRY 1D structures embedded within the 2D domain.

5.3.3 Details of the representation of the Proposed Scheme and Temporary Works structures within the 2D domain are summarised in **Table 5-1** and **Table 5-2** respectively.

Table 5-1 2D Model Proposed Scheme model elements

Scheme Feature	Model layers	Description
Viaduct piers	2d_zsh_viaduct_piers_WSM_WEN_TRIM_DEV1_01_L.shp	Thin break line typically 40m in length along cell sides set to 30m high so that levels sit above maximum water levels
Left bank viaduct abutment	Embankment_Group1_Interpolated_Masked.asc	Raster layer with the elevations of the proposed road surface, read in on top of the LIDAR DTM
Right bank viaduct abutment	Embankment_Group3_Interpolated_Masked.asc	Raster layer with the elevations of the proposed road surface, read in on top of the LIDAR DTM

Scheme Feature	Model layers	Description
Left bank maintenance track	Accesstrack_group1_interpolated_masked.asc	Raster layer with the elevations of the proposed road surface, read in on top of the LIDAR DTM
Right bank maintenance track	Accesstrack_group2_interpolated_masked.asc	Raster layer with the elevations of the proposed road surface, read in on top of the LIDAR DTM

Table 5-2 2D Model Temporary Works model elements

Scheme Feature	Model layers	Description
Working platform	2d_zsh_C_Road_Stan_005_R.shp 2d_zsh_C_Road_Stan_006_R.shp	Z shape. Levels 10.8m AOD.
Bailey Bridge	2d_lfcsh_BaileyBridge.shp	Soffit level of the structure set to 11.076m AOD. 100% blockage applied for 2m deck height to 13.076m AOD. 0% blockage applied above this level.
Working platform culverts	1d_nwk_culverts_temp_003_L.shp 2d_bc_culverts_temp_003_P.shp	12x900mm diameter circular culverts situated within the floodplain and a 3m wide by 1m high box culvert situated in a drain. Connected to the 2D domain with SX point link.

6 Model Schematisation

6.1.1 The baseline, proposed and temporary works model schematisations are shown in **Figure 6-1**, **Figure 6-2** and **Figure 6-3** respectively.

Figure 6-1 Baseline model schematic

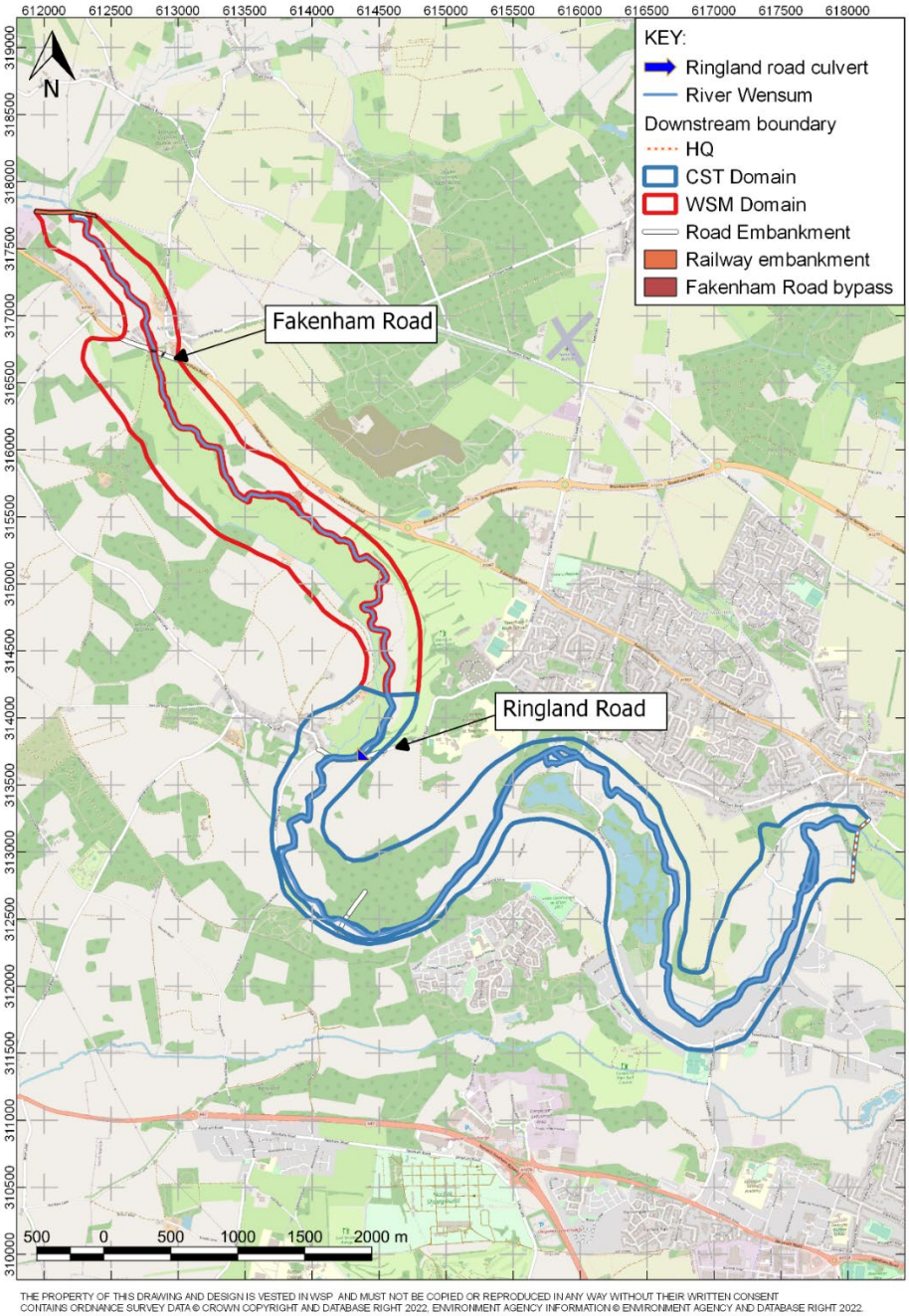


Figure 6-2 Proposed Scheme model schematic.

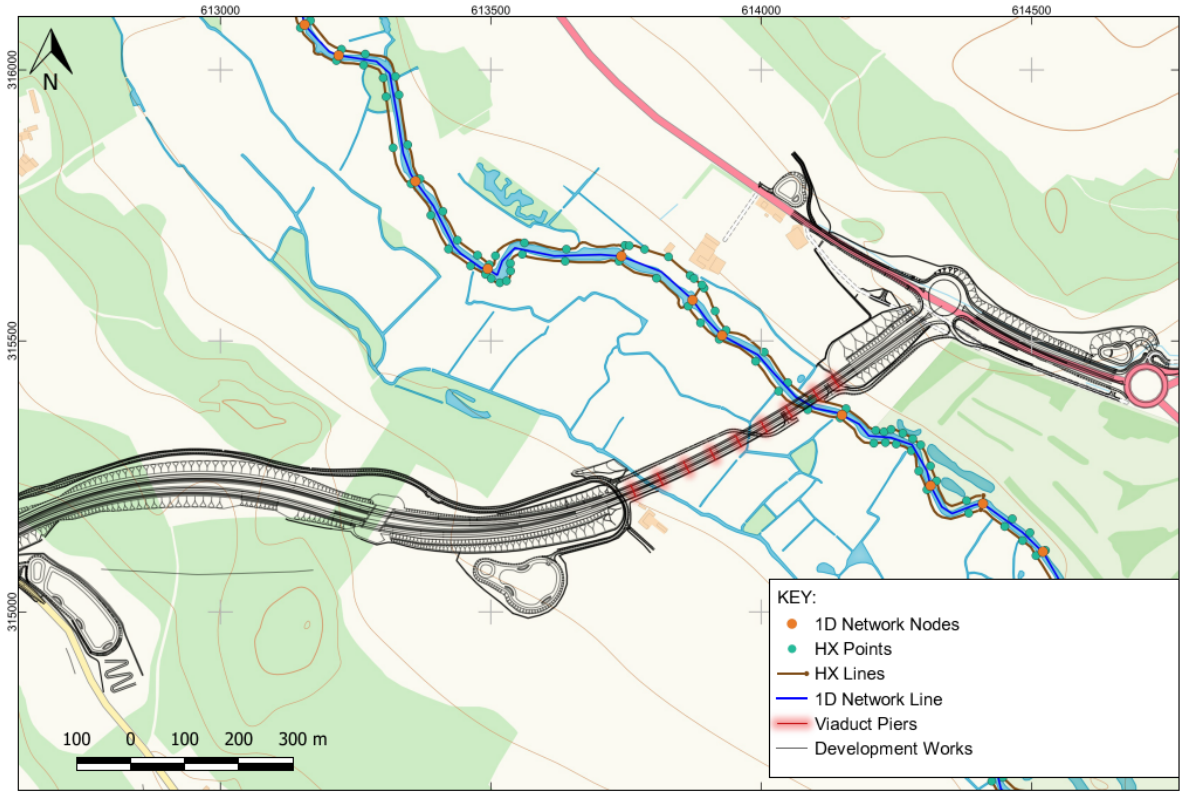
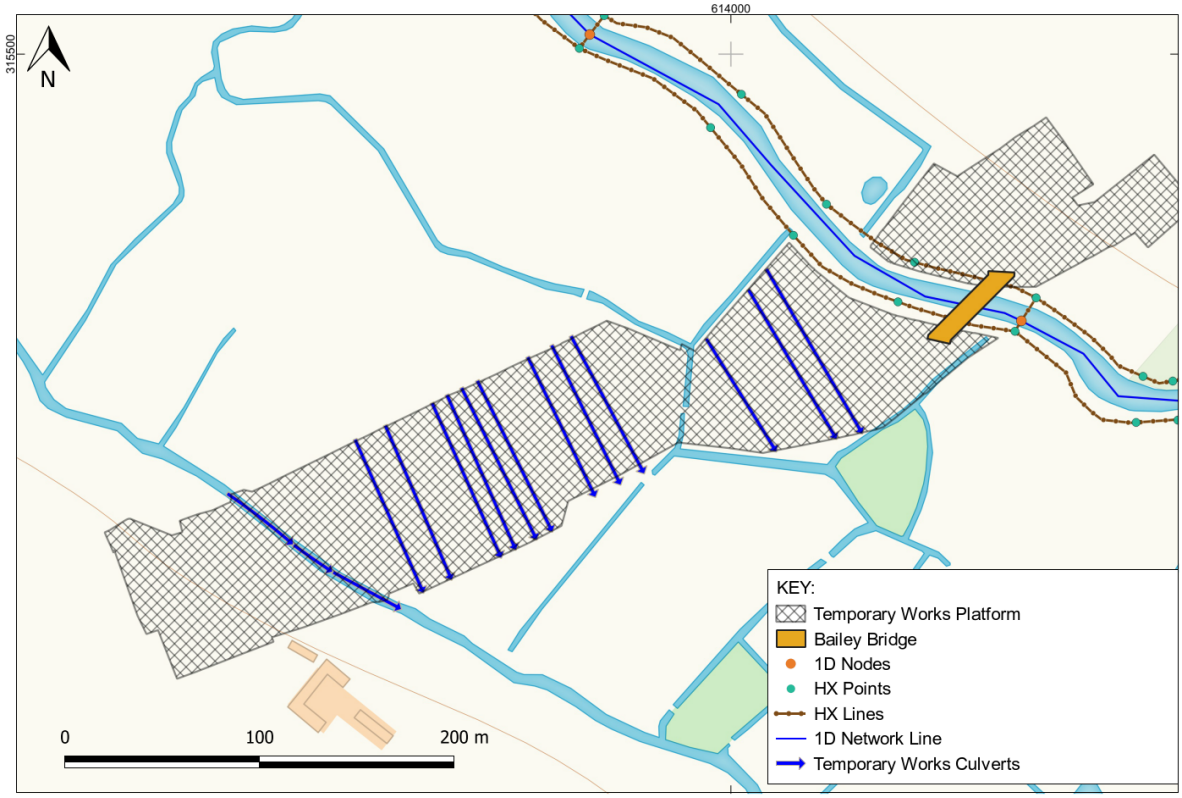


Figure 6-3 Temporary Works model schematic



7 Model Run Summary

7.1 Model Run Parameters

7.1.1 **Table 7-1** summarises the model run parameters used for the baseline, proposed and temporary works model run scenarios.

Table 7-1 River Wensum model run parameters

Parameter	Approach
Model cell size	WSM domain: 8m CST domain: 5m
Model run times	Start: 0 hours Finish: 90 hours
Timestep	1D FMP: 1 second 2D TUFLOW: 4 seconds
Time series output interval	Map output interval: 600s Time Series Output Interval: 300s 1d Save Interval: 300s
1D run parameters	Default parameters Double precision

Parameter	Approach
2D run parameters	Default with the following changes: Double precision Map Output Format == XMDF Map Output Data Types == d h MB1 MB2 V ZUK0 Store Maximums and Minimums == ON MAXIMUMS ONLY Mass Balance Output == ON Reveal 1D Nodes == ON

7.2 Baseline Model Scenarios

7.2.1 **Table 7-2** summarises the model files used to run the model and the model check outputs for the baseline model scenario. **Figure 7-1** to **Figure 7-3** provide the plots showing the stability of the model.

Table 7-2 Model files and model check outputs for the baseline scenario

Reporting output	Model run files and model check outputs
Scenario	RST (This represents the baseline scenario, with restoration features included) This scenario has been run for the 1 in 2, 5, 20, 50, 100, 100 + 11%, 100 + 20%, 100 + 44% and 1 in 1000 year flood events.
FMP Files	IEF: WEN_TRIM_18_RST_Q0100+CC44 DAT: WEN_TRIM_v13-RST IED: WEN_TRIM_Q0100+CC44_01 RESULTS:
FMP Messages	Datafile line 4930: *** warning W2229 *** at label: WENF2_9485ua Value of trash screen height is set to 0; areas will be calculated using piezometric head. Datafile line 4953: *** warning W2229 *** at label: WENF2_9485ul Value of trash screen height is set to 0; areas will be calculated using piezometric head. Datafile line 4976: *** warning W2229 *** at label: WENF2_9485ur Value of trash screen height is set to 0; areas will be calculated using piezometric head. Datafile line 5971: *** warning W2044 *** at label: COSTESB_35d Warning: different values (+/- 20 %) for Mannings n encountered within one panel at line 5980. Verify input data Datafile line 5981: *** warning W2044 *** at label: COSTESB_27u Warning: different values (+/- 20 %) for Mannings n encountered within one panel at line 5990. Verify input data Datafile line 5991: *** warning W2044 *** at label: COSTESB_27u above line 6003: different values (+/- 20 %) for Mannings n encountered within one panel

Reporting output	Model run files and model check outputs
TUFLOW Files	TCF: WEN_TRIM_18_~s1~_~e1~ ECF: WEN_TRIM_18_~s1~_~e1~ TGC: WEN_TRIM_CST_RST_11\ WEN_TRIM_WSM_RST_14 TBC: WEN_TRIM_CST_RST_11\ WEN_TRIM_WSM_RST_14 TMF: WEN_001 RESULTS: WEN_TRIM_18_RST_Q100+CC44
TUFLOW Messages	WARNING 2073 – Object ignored. Only Points, Lines, Polylines, Regions & Region Centers used. WARNING 2073 – Object ignored. Only Points, Lines, Polylines & Region Centers used. CHECK 2370 – Ignoring coincident point found in HX 2D BC layer. WARNING 2073 – Null Shape object ignored. Only Regions, Lines, Polylines & Multiple Polylines used. CHECK 2370 – Ignoring coincident point found in HX 2D BC layer. CHECK 2078 – End of 3D HX breakline is dangling. WARNING 2073 – Null Shape object ignored. Only Regions, Lines, Polylines & Multiple WARNING 2073 – Object ignored. Only Points, Lines, Polylines & Region Centers used. CHECK 2118 – Lowered SX ZC Zpt by 0.00m to 1D node bed level. WARNING 2073 – Object ignored. Only Points, Lines, Polylines, Regions & Region Centers used. WARNING 2073 – Object ignored. Only Points, Lines, Polylines & Region Centers used. CHECK 2108 – 2D HX link applied more than once at cell. WARNING 2073 - Object ignored. Only Points, Lines, Polylines, Regions & Region Centers used. WARNING 2073 - Object ignored. Only Points, Lines, Polylines & Region Centers used. WARNING 2400 - Hidden node not allocated as a primary node to a 2D2D link cell in 2D Domain WSM. Review 2D2D link line shape and check vertex spacing is not too close. Majority of warnings/checks relate to null objects within shapefiles which do not impact model results. Dangling breakline does not significantly alter interpolation of bankline and therefore does not impact results.

Figure 7-1 FMP Convergence Plot for the baseline 1 in 100 plus 44% annual probability event

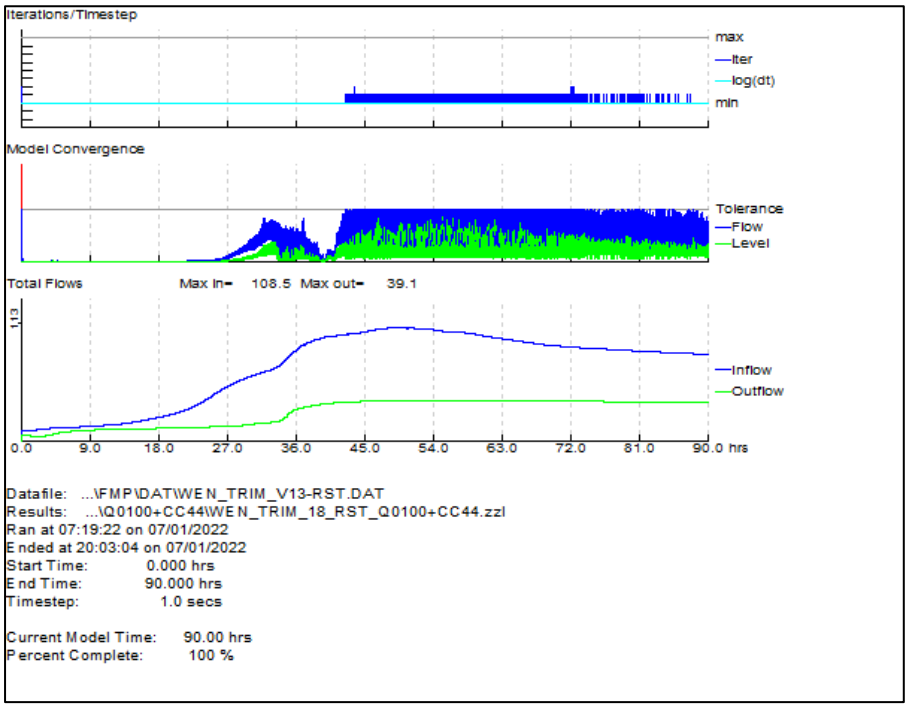


Figure 7-2 TUFLOW dv plot for the baseline 1 in 100 plus 44% annual probability event

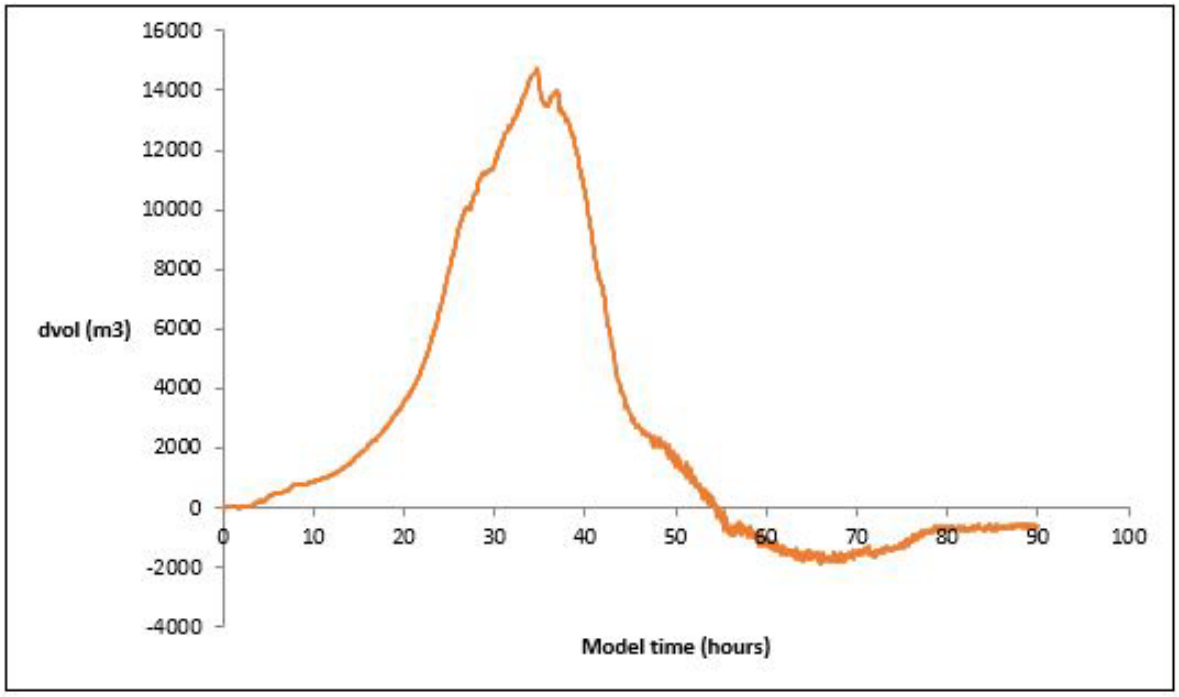
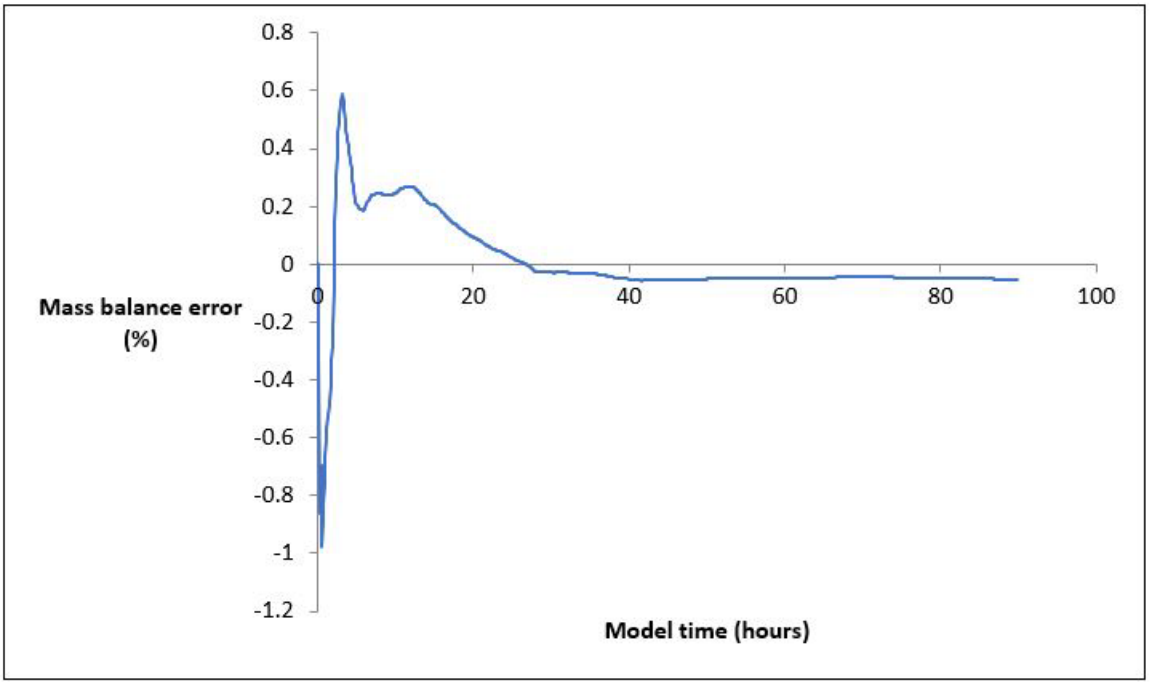


Figure 7-3 TUFLOW ME plot for the baseline 1 in 100 plus 44% annual probability event



7.3 Temporary works

7.3.1 **Table 7-3** summarises the model files used to run the model and the model check outputs for the temporary works model scenario. **Table 7-4** to **Figure 7-6** provide the plots showing the stability of the model.

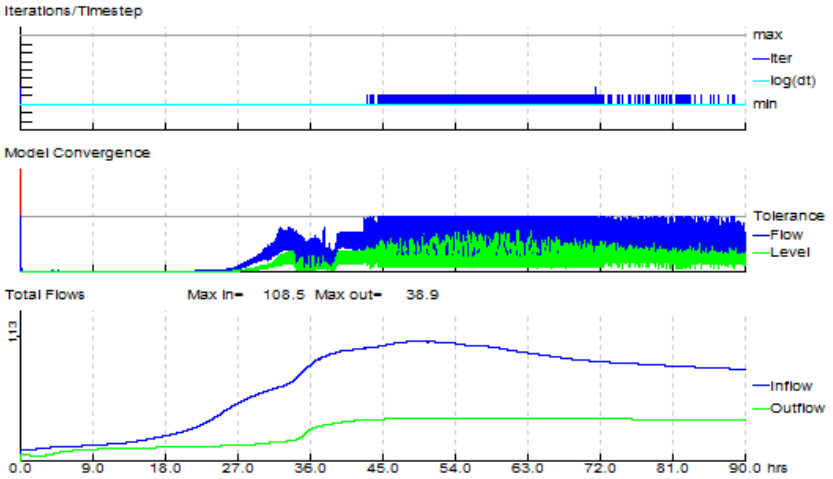
Table 7-3 Model files and model check outputs for the temporary works scenario

Reporting output	Model run files and model check outputs
Scenario	TEMP (This represents the temporary works scenario, with temporary works platform and bailey bridge included) This scenario has been run for the 1 in 2, 5, 20, 50, 100, 100 + 11%, 100 + 20%, 100 + 44% and 1 in 1000 year flood events.
FMP Files	IEF: WEN_TRIM_19_TEMP_Q0100+CC44 DAT: WEN_TRIM_v13-TEMP IED: WEN_TRIM_Q0100+CC44_01 RESULTS: WEN_TRIM_19_TEMP_Q0100+CC44

Reporting output	Model run files and model check outputs
FMP Messages	Datafile line 4997: *** warning W2229 *** at label: WENF2_9485ua Value of trash screen height is set to 0; areas will be calculated using piezometric head. Datafile line 5020: *** warning W2229 *** at label: WENF2_9485ul Value of trash screen height is set to 0; areas will be calculated using piezometric head. Datafile line 5043: *** warning W2229 *** at label: WENF2_9485ur Value of trash screen height is set to 0; areas will be calculated using piezometric head. Datafile line 6038: *** warning W2044 *** at label: COSTESB_35d Warning: different values (+/- 20 %) for Mannings n encountered within one panel at line 6047. Verify input data Datafile line 6048: *** warning W2044 *** at label: COSTESB_27u Warning: different values (+/- 20 %) for Mannings n encountered within one panel at line 6057. Verify input data Datafile line 6058: *** warning W2044 *** at label: COSTESB_27u above line 6070: different values (+/- 20 %) for Mannings n encountered within one panel

Reporting output	Model run files and model check outputs
TUFLOW Files	TCF: WEN_TRIM_20_~s1~_~s2~_~e1~ ECF: WEN_TRIM_20_~s1~_~s2~_~e1~ TGC: WEN_TRIM_CST_RST_11\ WEN_TRIM_WSM_RST_15 TBC: WEN_TRIM_CST_RST_11\ WEN_TRIM_WSM_RST_15 TMF: WEN_001 RESULTS: WEN_TRIM_20_TEMP_Q100+CC44
TUFLOW Messages	WARNING 0305 – Projection of .shp file is different to that specified by the SHP Projection == command. WARNING 2073 – Object ignored. Only Points, Lines, Polylines & Region Centers used. CHECK 2470 – Neither LFC default approach nor Shape_Option is set. Using PORTION approach CHECK 2370 – Ignoring coincident point found in HX 2D BC layer. WARNING 2073 – Null Shape object ignored. Only Regions, Lines, Polylines & Multiple Polylines used. WARNING 2073 – Object ignored. Only Points, Lines, Polylines, Regions & Region Centers used. CHECK 2078 – End of 3D HX breakline is dangling. WARNING 1317 – WLL does not cross (2 point WLL only) or snap to 1D channel CHECK 2118 – Lowered SX ZC Zpt by 0.00m to 1D node bed level. WARNING 2118 - Lowered SX ZC Zpt by 1.8m to 1D node bed level. CHECK 2108 - 2D HX link applied more than once at cell. CHECK 2210 - Top of first FC Layer is below ground level. WARNING 2400 - Hidden node not allocated as a primary node to a 2D2D link cell in 2D Domain WSM. Review 2D2D link line shape and check vertex spacing is not too close. Majority of warnings/checks relate to null objects within shapefiles which do not impact model results. Dangling breakline does not significantly alter interpolation of bankline and therefore does not impact results. Checks and warnings for loweing SX levels are associated with the temporary works culverts inlets and are appropriate.

Figure 7-4 FMP Convergence Plot for the temporary works 1 in 100 plus 44% annual probability event



Datafile: ...\FMP\DAT\WEN_TRIM_V13-TEMP.DAT
Results: ...\Q0100+CC44\WEN_TRIM_19_TEMP_Q0100+CC44.zzl
Ran at 03:49:26 on 20/11/2023
Ended at 17:00:42 on 20/11/2023
Start Time: 0.000 hrs
End Time: 90.000 hrs
Timestep: 1.0 secs

Current Model Time: 90.00 hrs
Percent Complete: 100 %

Figure 7-5 TUFLOW dv plot for the temporary works 1 in 100 plus 44% annual probability event

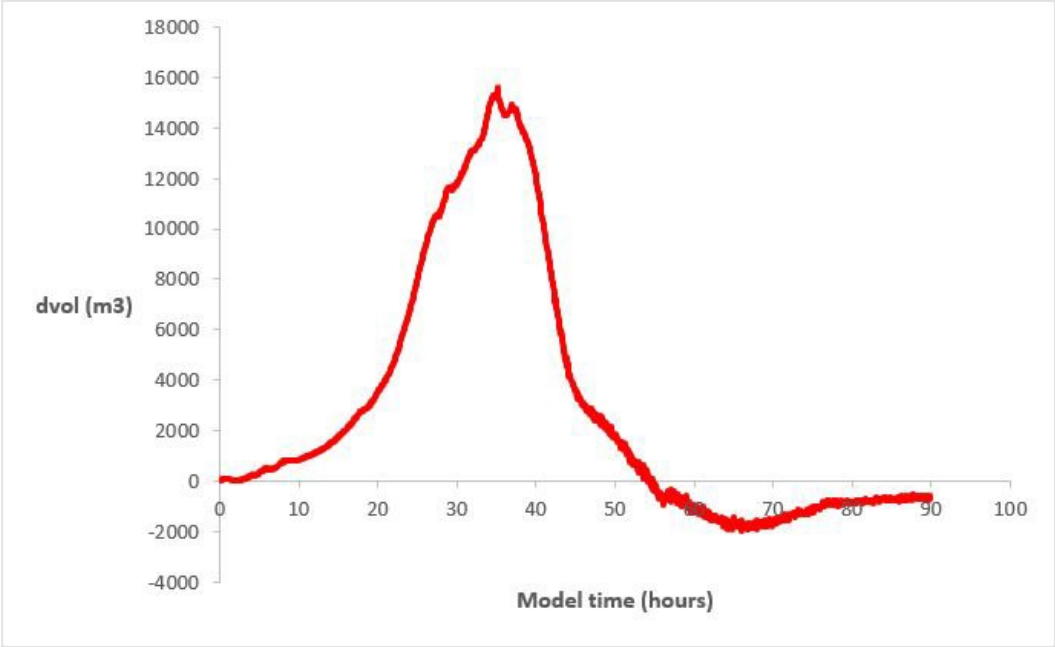
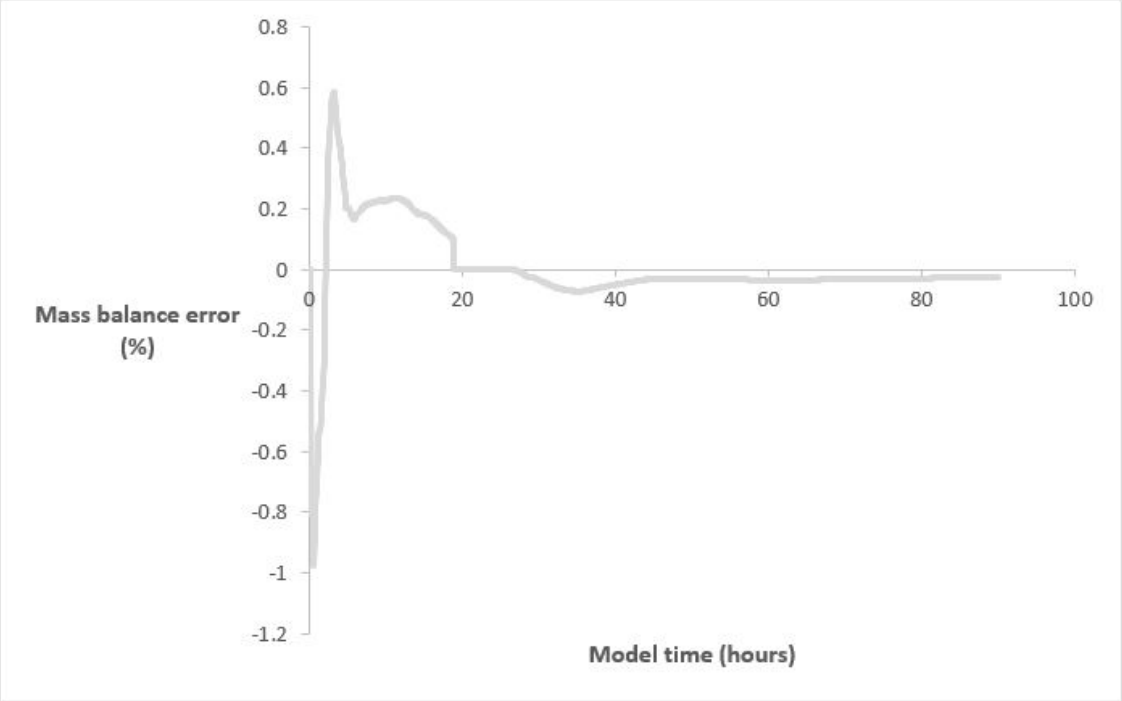


Figure 7-6 TUFLOW ME plot for the temporary works 1 in 100 plus 44% annual probability event



7.4 Proposed scheme

7.4.1 **Table 7-4** summarises the model files used to run the model and the model check outputs for the proposed model scenario. **Figure 7-7** to **Figure 7-9** provide the plots showing the stability of the model.

Table 7-4 Model files and model check outputs for the proposed scenario

Reporting output	Model run files and model check outputs
Scenario	DEV1 (This represents the proposed scenario, with the viaduct piers and access track included) This scenario has been run for the 1 in 2, 5, 20, 50, 100, 100 + 11%, 100 + 20%, 100 + 44% and 1 in 1000 year flood events.
FMP Files	IEF: WEN_TRIM_18_DEV1_Q0100+CC44 DAT: WEN_TRIM_v13-RST IED: WEN_TRIM_Q0100+CC44_01 RESULTS: WEN_TRIM_18_DEV1_Q0100+CC44

Reporting output	Model run files and model check outputs
FMP Messages	Datafile line 4930: *** warning W2229 *** at label: WENF2_9485ua Value of trash screen height is set to 0; areas will be calculated using piezometric head. Datafile line 4953: *** warning W2229 *** at label: WENF2_9485ul Value of trash screen height is set to 0; areas will be calculated using piezometric head. Datafile line 4976: *** warning W2229 *** at label: WENF2_9485ur Value of trash screen height is set to 0; areas will be calculated using piezometric head. Datafile line 5971: *** warning W2044 *** at label: COSTESB_35d Warning: different values (+/- 20 %) for Mannings n encountered within one panel at line 5980. Verify input data Datafile line 5981: *** warning W2044 *** at label: COSTESB_27u Warning: different values (+/- 20 %) for Mannings n encountered within one panel at line 5990. Verify input data
TUFLOW Files	TCF: WEN_TRIM_18_~s1~_~e1~ ECF: WEN_TRIM_18_~s1~_~e1~ TGC: WEN_TRIM_CST_RST_11\ WEN_TRIM_WSM_RST_14 TBC: WEN_TRIM_CST_RST_11\ WEN_TRIM_WSM_RST_14 TMF: WEN_001 RESULTS: WEN_TRIM_18_DEV1_Q100+CC44

Reporting output	Model run files and model check outputs
TUFLOW Messages	WARNING 2073 – Object ignored. Only Points, Lines, Polylines, Regions & Region Centers used. WARNING 2073 – Object ignored. Only Points, Lines, Polylines & Region Centers used. CHECK 2370 – Ignoring coincident point found in HX 2D BC layer. WARNING 2073 – Null Shape object ignored. Only Regions, Lines, Polylines & Multiple Polylines used. CHECK 2078 – End of 3D HX breakline is dangling. CHECK 2118 - Lowered SX ZC Zpt by 0.00m to 1D node bed level. CHECK 2108 – 2D HX link applied more than once at cell. WARNING 2400 - Hidden node not allocated as a primary node to a 2D2D link cell in 2D Domain WSM. Review 2D2D link line shape and check vertex spacing is not too close. Majority of warnings/checks relate to null objects within shapefiles which do not impact model results. Dangling breakline does not significantly alter interpolation of bankline and therefore does not impact results.

Figure 7-7 FMP Convergence Plot for the proposed 1 in 100 plus 44% annual probability event

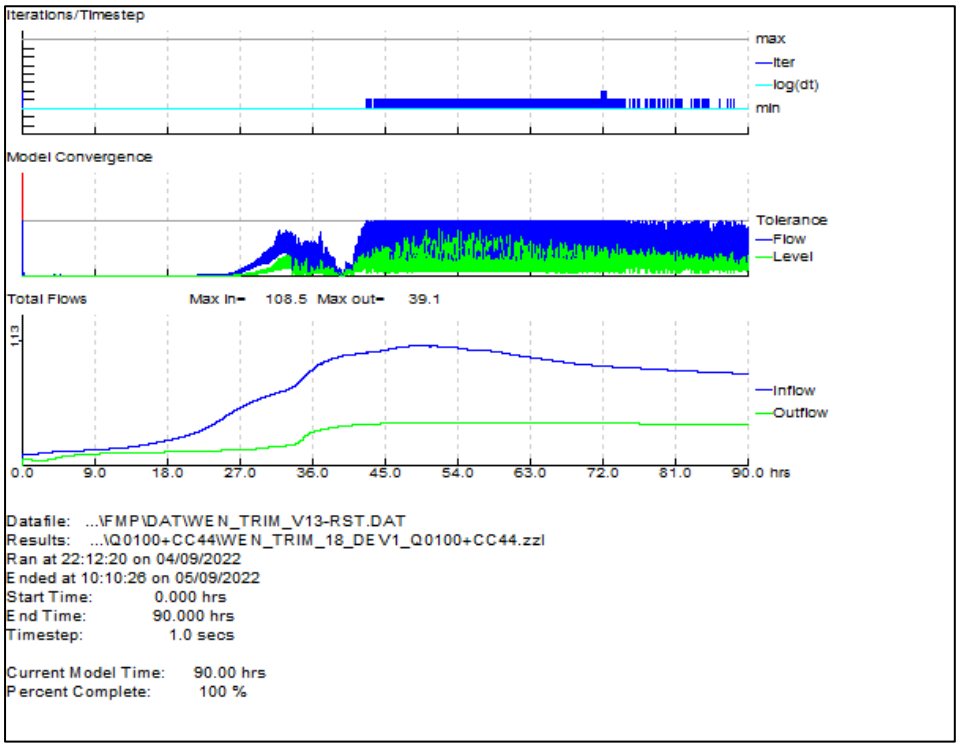


Figure 7-8TUFLOW dv plot for the proposed 1 in 100 plus 44% annual probability event

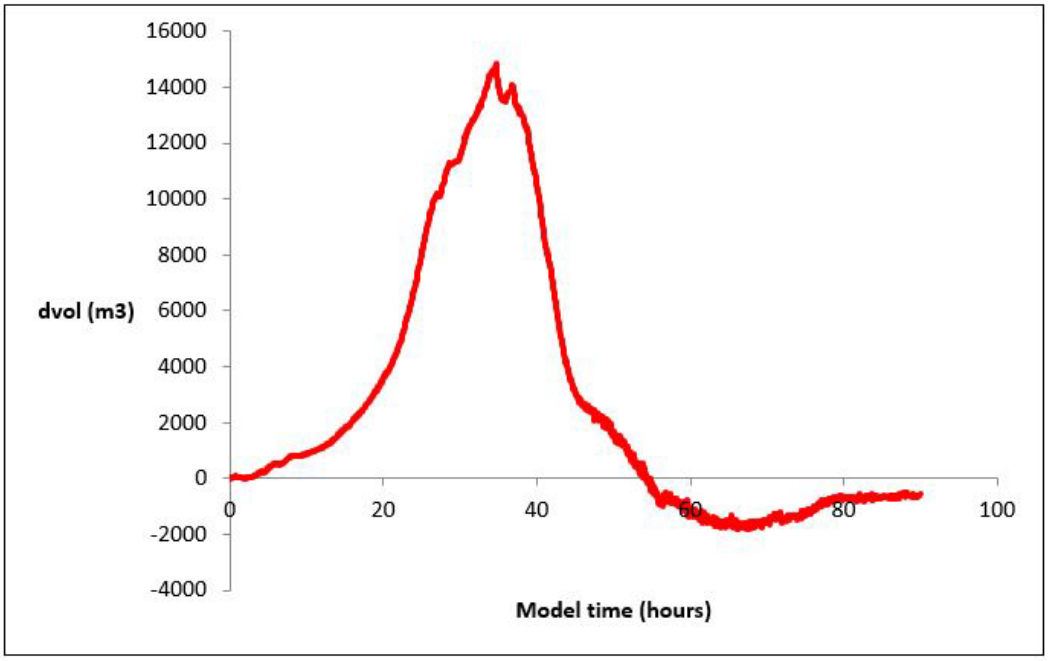


Figure 7-9 TUFLOW ME plot for the proposed 1 in 100 plus 44% annual probability event