TECHNICAL NOTE

JBA Project Code	2021s1074
Contract	Dorset Level 1 SFRA
Client	Dorset Councils Partnership
Day, Date and Time	June 2022
Author	Tom Singleton
Reviewer / Sign-off	Jose Sabatini
Subject	Climate Change Modelling

1 Introduction

JBA Consulting was commissioned by Dorset Councils Partnership to prepare updated climate change flood risk modelling and mapping for five fluvial models as part of the Dorset Level 1 Strategic Flood Risk Assessment. The work included updating the flood flows to each model to reflect the latest peak river flow allowances presented within the Environment Agency's climate change projections for the Strategic Flood Risk Assessments. Climate change uplifts can be seen in Table 1-1.

Table 1-1: Environment Agency's climate change projections

Climate Change allowance	Uplift applied to model
Central	+47%
Higher Central	+63%
Upper End	+103%

It should be noted that this Technical Note does not discuss model outputs in the form of floodplain flood extent, flood depths, water levels, and velocities. This document is a verification and review of the methodology applied to each model for updating the flood flows for the latest climate change projections. Analysis of model mass balance is undertaken to determine suitability of each model. Discussion of floodplain flooding will be included in the main SFRA report.

1.1 Model details

The details of the fluvial models as part this study are outlined in Table 1-2.

Table 1-2: Model details

Model name	Year	Type
Britport model	2020	ESTRY-TUFLOW, 1D-2D, Fluvial
Crane and Moors model	2020	Flood Modeller-TUFLOW, 1D-2D, Fluvial
Lower Stour model	2020	Flood Modeller-TUFLOW, 1D-2D, Fluvial
River Frome model	2014	ISIS-TUFLOW, 1D-2D, Fluvial
Gillingham model	2006	TUFLOW, 2D, Fluvial

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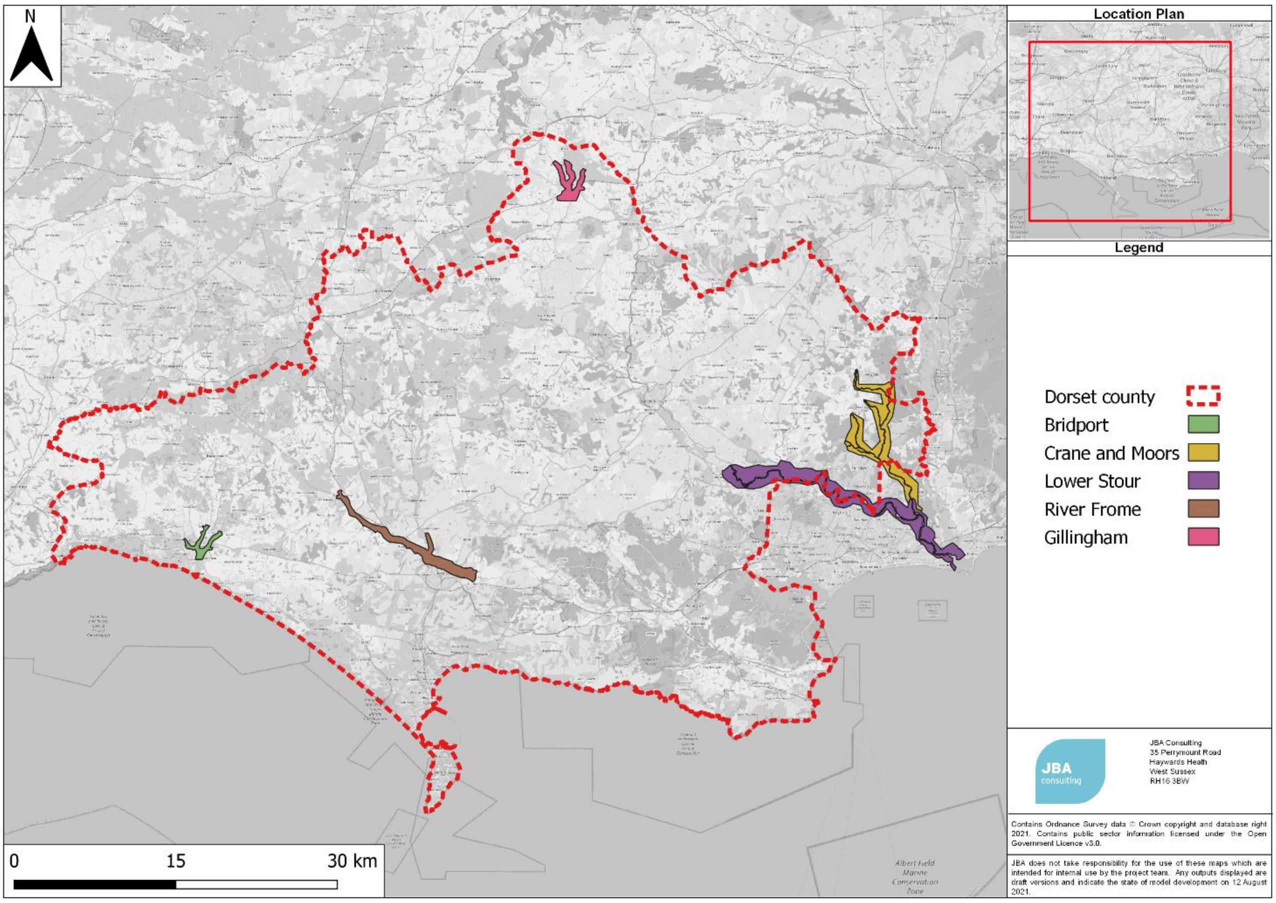
1.2 General approach

In order to assess climate change flood risk. The models were re-run for the 100-year (1% AEP) plus 47%, 63%, and 103% (Central, Higher Central, and Upper End respectively) fluvial flood events.

1.3 Model extents

The location of each model domain is highlighted in Figure 1-1.

Figure 1-1: Model domain locations



1.4 Model runs

Each model was run for the following scenario:

- 100-year (1% AEP) baseline fluvial flood event
- 100-year (1% AEP) plus 47% climate change (Central Allowance) fluvial flood event
- 100-year (1% AEP) plus 63% climate change (Higher Central allowance) fluvial flood event
- 100-year (1% AEP) plus 103% climate change (Upper End allowance) fluvial flood event

2 Risk of Flooding from Surface Water - Updated climate change mapping

2.1 Aim of the project

JBA Consulting prepared an update the Risk of Flooding from Surface Water (RoFSW) mapping, based on the latest national climate change allowances available at the time (December 2021) the update was prepared.

JBA Consulting applied rainfall intensity uplifts in line with the Environment Agency (EA) guidance to the EA's Risk of Flooding from Surface Water Mapping. From this, JBA Consulting produced surface water depth, hazard and velocity outputs for the 1% Annual Exceedance Probability (AEP) return period.

2.2 Scope of the project

Separate allowances have been published based on the return periods, with a different set of allowances provided for the 3.3% and 1% AEP events. No allowances have been published for the 0.1% AEP events.

At the time of updating the RoFSW mapping, the climate change allowances were available on a national level. In May 2022, the Environment Agency rolled out changes to peak rainfall intensity allowances, making them specific to Management Catchments in England. The following table (Table 5-1) displays the peak rainfall intensity climate change allowances for the 1% AEP return period, indicating the outdated national allowances and updated Dorset Management Catchment allowances.

Table 5-1 - Peak rainfall intensity climate change allowances for the 1% AEP return period, past and present guidance

Epoch	Climate change allowance	National (outdated)	Dorset Management Catchment (updated)
2050s	Central	10%	20%
	Upper End	20%	25%
2070s	Central	20%	25%
	Upper End	40%	40%

2.3 Approach

At the time of modelling, a range of allowances were provided nationally. The peak rainfall intensity allowances are sub-divided by epoch (time period) and percentile. Two different epochs are defined - the 2050s (2022-2060) and 2070s (2061-2125) - representing how surface water flood risk will change over time. Climate change allowances are based on percentiles which indicate the proportion of possible scenarios which fall below an allowance level. The central allowance is based on the 50th percentile (median) and the upper end allowance is based on the 95th percentile.

JBA Consulting has applied only the 1% AEP return period allowances for this updated RoFSW mapping, as outlined below:

- 1% AEP - 20% (central) and 40% (upper end) climate change uplift, for the 2070s epoch (based on climate change allowance guidance available at the time)

3 Fluvial Model Updates - Methodology

This section of the technical note outlines the approach used during the application of updating the flood flows to each model to reflect the latest peak river flow allowances presented within the Environment Agency's climate change projections for the Strategic Flood Risk Assessments.

3.1 Bridport

The Bridport model is a 1D-2D, ESTRY-TUFLOW model that includes five 1D inflow locations representing the various modelled watercourses (River Brit [4.65km], River Asker [3.70km] River Simene [1.35km], and the Walditch Stream [0.7km]), as well as a number of distributed 2D inflow regions across the model domain. This study has not altered the representation of model inflows from the 2018 Bridport Model Enhancement study[1]. A multiplication factor has been applied to derive the inflow hydrographs within the boundary condition database to represent the increased climate change flows.

3.2 Crane and Moors

The Crane and Moors model is a 1D-2D, Flood Modeller-TUFLOW model. The hydrological inflows were derived by scaling ReFH2 hydrographs to the FEH statistical peak flows as outlined in the Moors River Catchment Modelling Report[2]. This study has not altered the representation of model inflows from the original study and a multiplication factor has been applied to the inflow boundary nodes within the Flood Modeller to represent the increased climate change flows.

3.3 Lower Stour

The Lower Stour model is a 1D-2D, Flood Modeller-TUFLOW model. The fluvial flood response in the Lower Stour is dominated by the large upstream catchment ($839km^2$). This inflow is represented using a normalised Wimborne hydrograph scaled to match statistical estimates. Remaining inflows are represented using distributed ReFH boundaries. This study has not altered the representation of model inflows from the 2019 JACOBS Lower Stour Model Update[3]. A multiplication factor has been applied to the inflow boundary nodes within the Flood Modeller to represent the increased climate change flows.

The Christchurch tri-probability assessment study[4], as referred to in the 2019 JACOBS report, concluded there is little correlation between the Stour fluvial flows and surge levels. Hence, for the 2019 JACOBS Lower Stour Model Update[3] considered appropriate to apply a 50% AEP tidal condition (that was based on representative observed events) for all fluvial design events. Therefore, this study has adopted the same approach and use the 50% AEP tidal curve as the downstream boundary condition.

1 2018s1503-C-N001-3.pdf, JBA, March, 2019

2 WEM Lot 1 Pk5 Moors Catchment Flood Risk Modelling Report_P3.pdf, Capita AECOM, November, 2020

3 LOWER STOUR MODEL REPORT.pdf, JACOBS, OCTOBER, 2019

4 2014s1743 Christchurch tri-probability study v2.0.pdf, JBA, March, 2015

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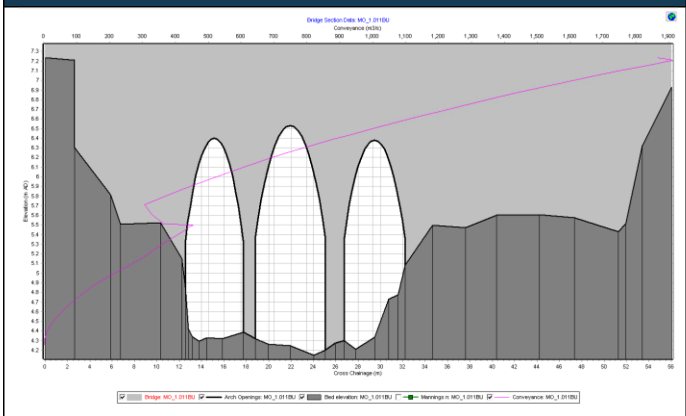
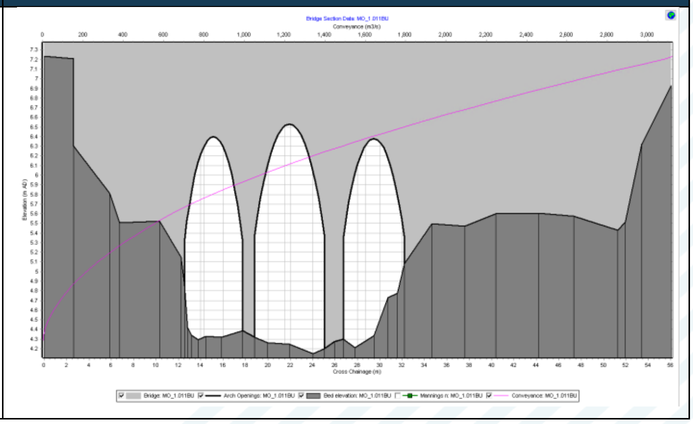
Convergence instabilities were observed at model node MO_1.1.011 which resulted in the simulations failing. Conveyance through the bridge at model node MO_1.1011BU was improved through adding embankment markers to the bridge section data. Conveyance plots are outlined in Table 1-2.

However, instabilities were still occurring after these conveyance adjustments resulting in the model crashing. Test runs of increasing the 'Alpha' parameter to 0.8 and 0.85 (default = 0.7) were completed in an effort to improve 1D model stability. 'Alpha' is an relaxation parameter. It defines the weighting of the results towards the previous iteration. Unfortunately, the model simulations did not successfully complete. More detailed investigations into model stability are required, which is not part of this project scope. Therefore, the results from this model cannot be displayed in subsequent sections.

Table 3-1: Conveyance improvement at MO_1.011BU

Original conveyance at MO_1.011BU	Improved conveyance at MO_1.011BU
	

**Conveyance = pink line*

3.4 River Frome

The River Frome model is a 1D-2D, ISIS-TUFLOW model. The River Frome model area encompasses 16km of the River Frome from upstream of Maiden Newton to Lower Bockhampton Bridge. The following tributaries are also included within the model domain:

- River Hooke (0.5km),
- Sydling Water (0.5km), and
- River Cerne (2.5km).

This study has not altered the representation of model inflows from the 2014 River Frome Model Improvement Study[5]. A multiplication factor has been applied to the inflow boundary nodes within the Flood Modeller to represent the increased climate change flows.

3.5 Gillingham

The Gillingham model is a 2D only, TUFLOW model which incorporates three watercourses; the River Stour, Shreen Water, and the River Lodden. This study has not altered the representation of model inflows from the 2006 Gillingham ABD report[6]. A multiplication factor has been applied to derive the inflow hydrographs within the boundary condition database to represent the increased climate change flows.

5 River Frome_Report_RevB.pdf, Mott Macdonald, June, 2014

6 SW708 Gillingham Final Report.pdf, Capita Symonds, November, 2006

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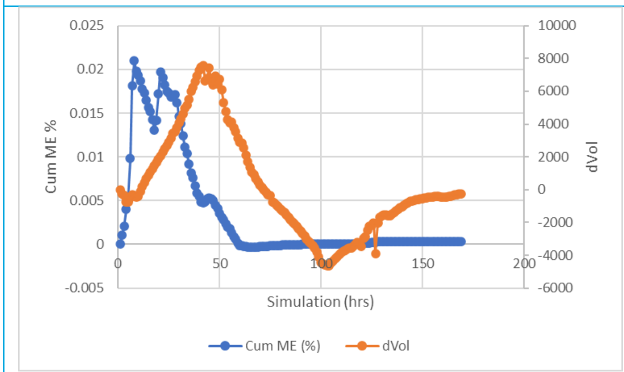
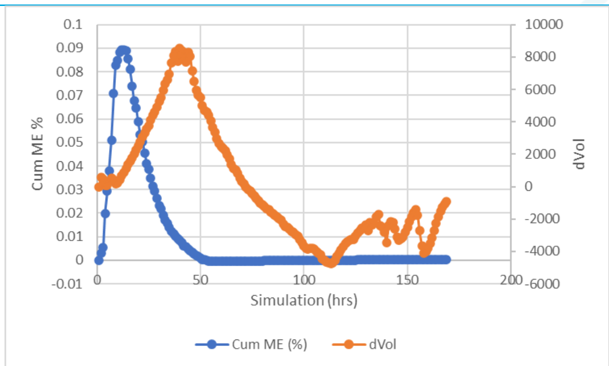
4 Model performance and verification

4.1 Britport model

1D MB and dVol - Mass Balance and dVol results for the 1D domain are within modelling standards bounds for all scenarios modelled. Plots can be observed in Table 4-1.

2D MB and dVol - Mass Balance results for the 2D domain during the 100-year baseline are just beyond modelling standards bounds (±1%). Although the baseline 100-year event shows that the 2D mass balance is greater than the standard tolerance, the model was approved to be used in this study. The climate change outputs display the same patterns, increasing mass balance error due to the increase flows. However, as JBA has inherited the model as part of this study, and it is not within the scope to troubleshoot, this is deemed acceptable. However, this is a limitation of the study and outputs. Plots can be observed in Table 4-2.

Table 4-1: 1D model mass balance and model convergence

<table>
<tr><td>100-year baseline</td><td>100-year +47% climate change</td></tr>
<tr><td>
</td><td>
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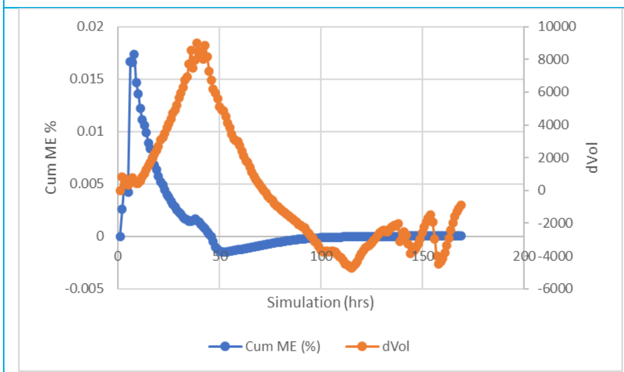
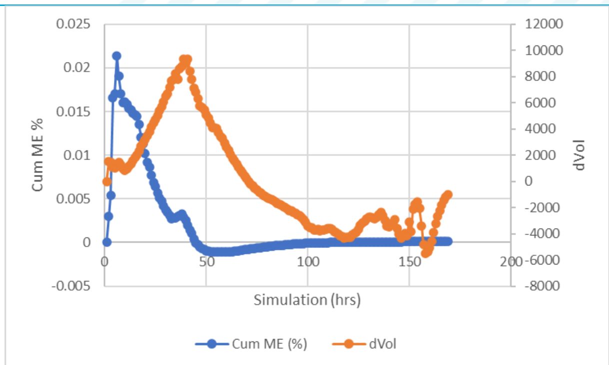
<tr><td>100-year +63% climate change</td><td>100-year +103% climate change</td></tr>
<tr><td>
</td><td>
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Table 4-2: 2D model mass balance and model convergence

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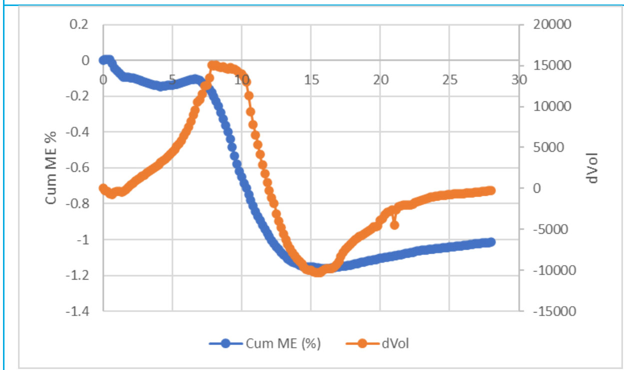
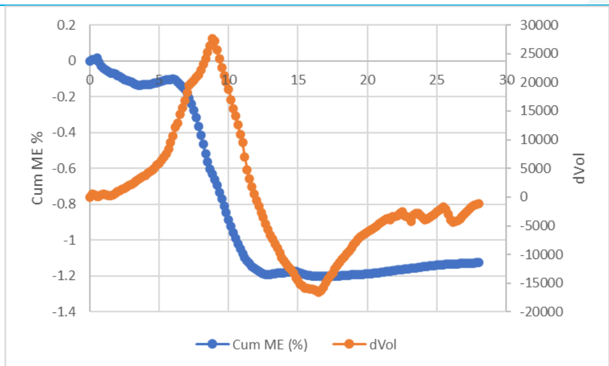
<tr><td>
</td><td>
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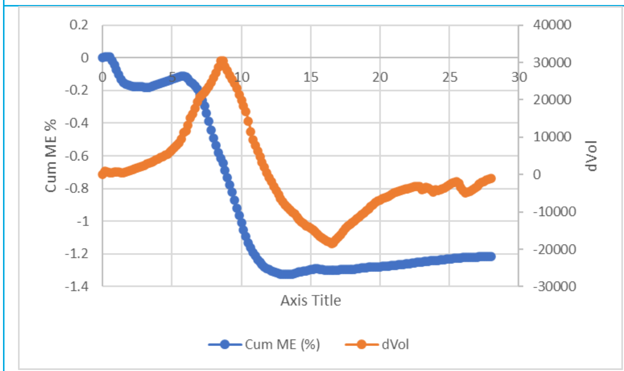
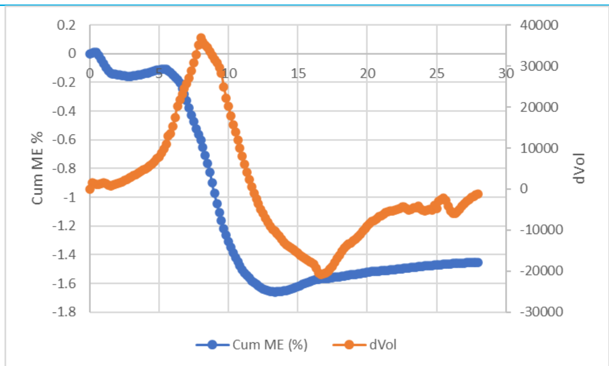
<tr><td>100-year +63% climate change</td><td>100-year +103% climate change</td></tr>
<tr><td>
</td><td>
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</table>

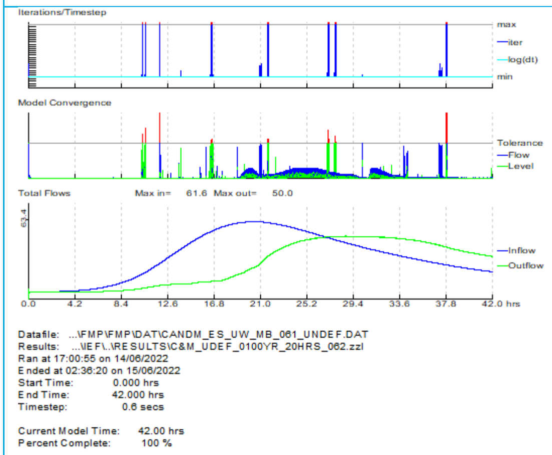
4.2 Crane and Moors model

Whilst mass balance outputs are within standard boundaries, for both 1D and 2D model outputs, there are instances of non-convergence found within the 1D as illustrated below in Table 4-3.

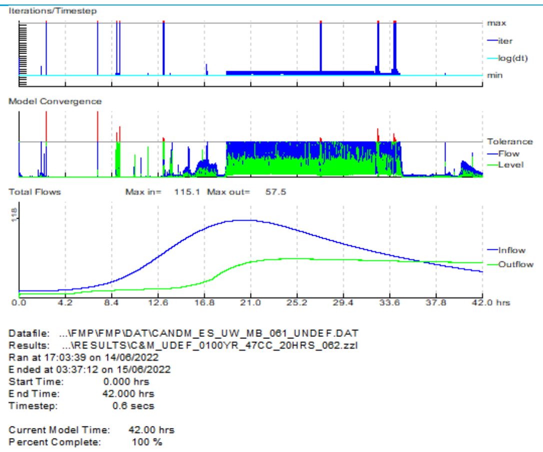
Floodplain flow is predicted earlier in the simulation and fluctuation of flows are due to instances of recirculation encountered between the 1D and 2D domains.

Table 4-3: 1D model mass balance and model convergence

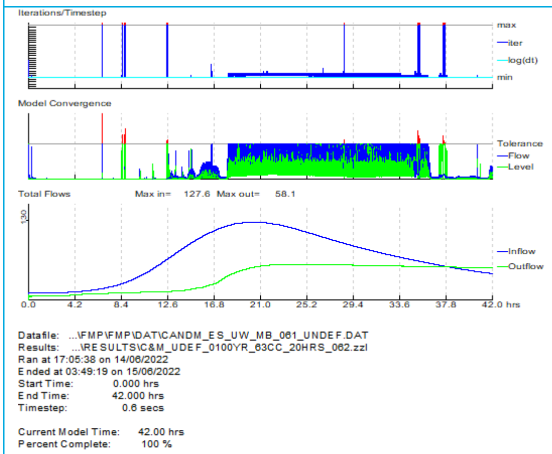
100-year baseline



100-year +47% climate change



100-year +63% climate change



100-year +103% climate change

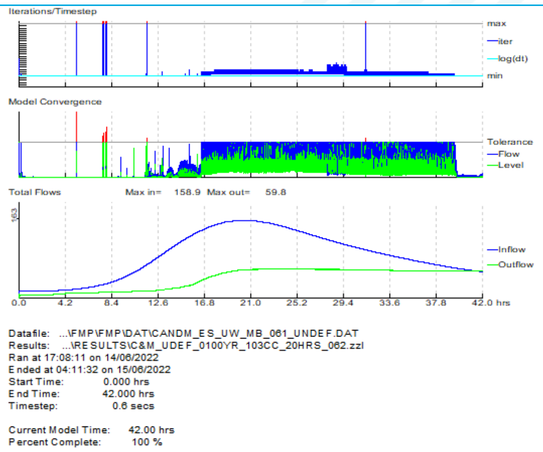


Table 4-4: 2D model mass balance and model convergence

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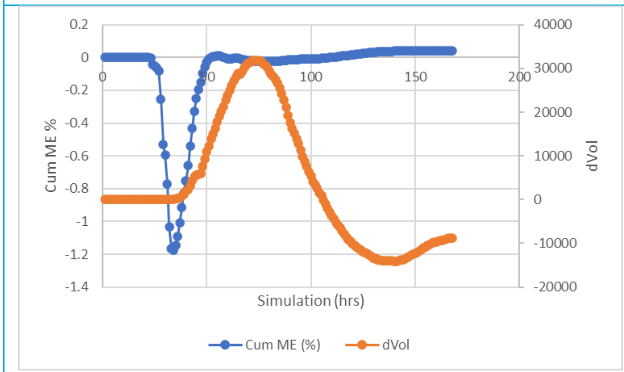
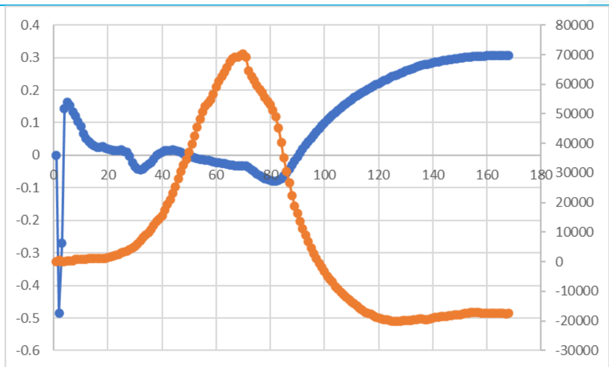
<tr><td>
</td><td>
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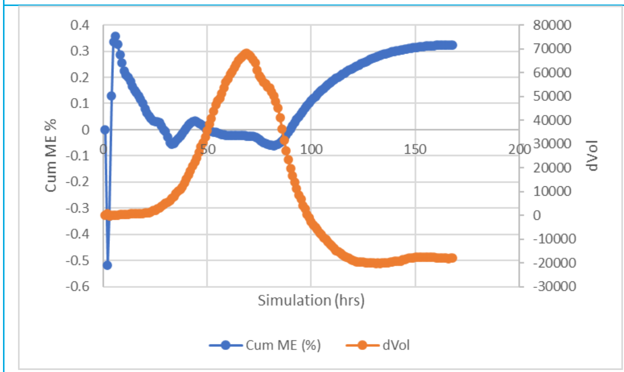
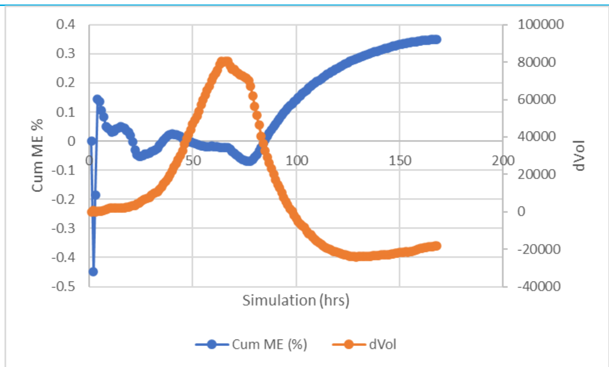
<tr><td>100-year +63% climate change</td><td>100-year +103% climate change</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

4.3 Lower Stour model

Model results are not available. Please refer to Section 3.3 for further information.

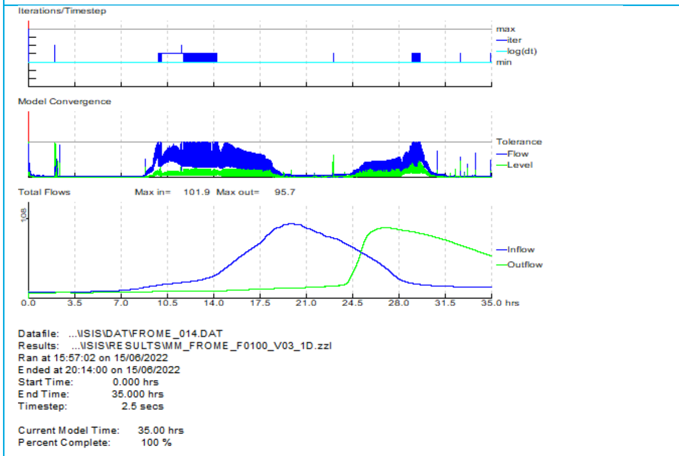
4.4 River Frome model

Whilst mass balance outputs are within standard boundaries for 1D outputs, there are instances of non-convergence found within the 1D, as illustrated below in Table 4-5.

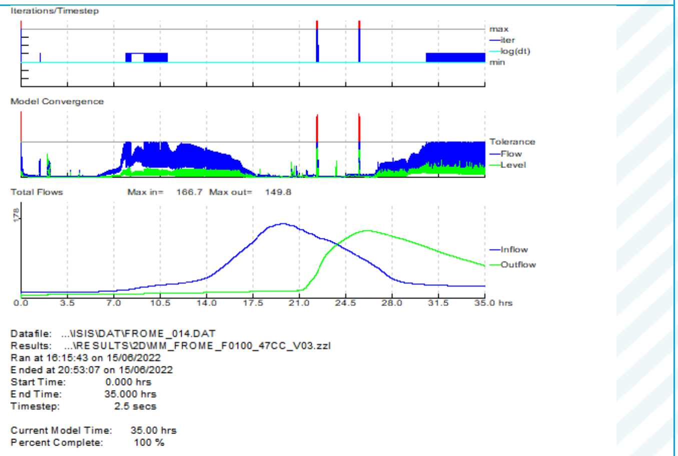
2D MB and dVol - Mass Balance results for climate change simulations behaves similar to that of the baseline with a large mass balance error being reported at the beginning of the simulation. However, it then recovers to within acceptable limits. This is deemed acceptable as the scope of the study does not include investigations into resolving the mass balance errors in the baseline. Plots can be observed in Table 4-6.

Table 4-5: 1D model mass balance and model convergence

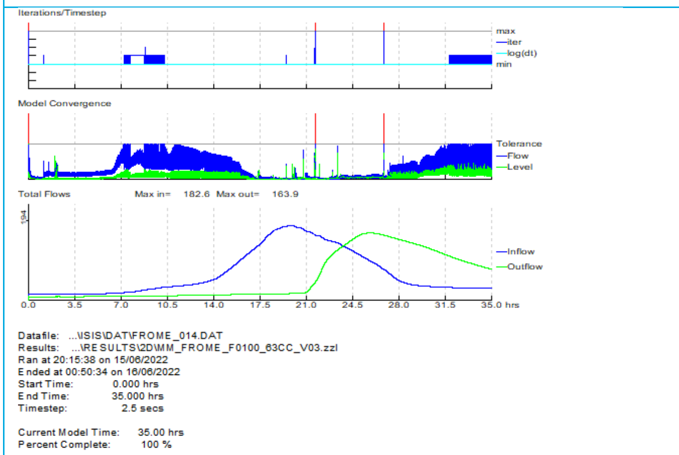
100-year baseline



100-year +47% climate change



100-year +63% climate change



100-year +103% climate change

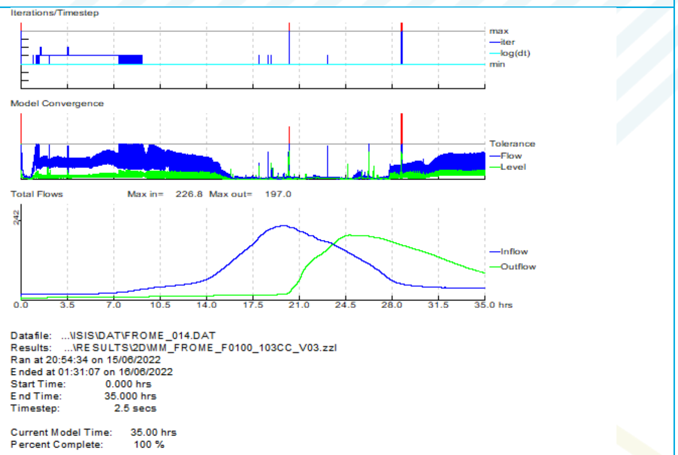


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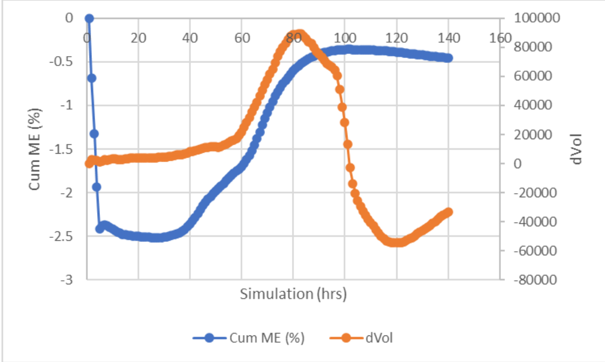
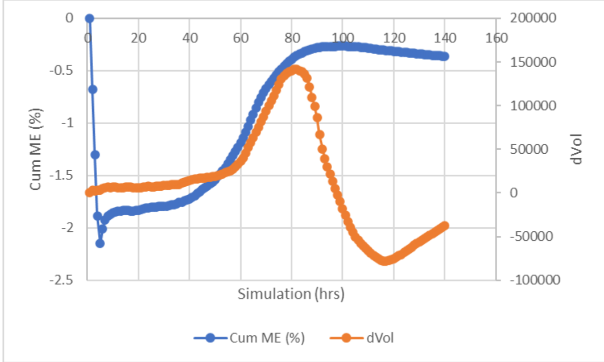
Table 4-6: 2D model mass balance and model convergence

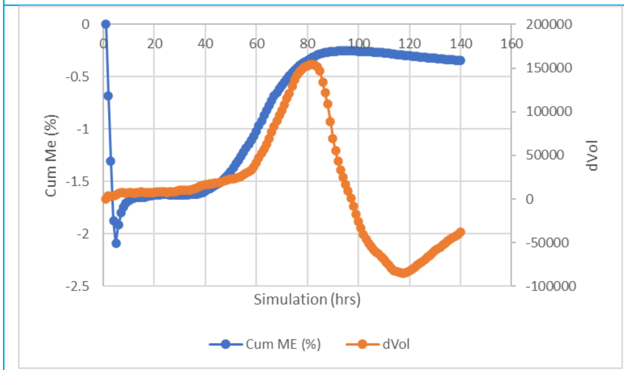
100-year baseline



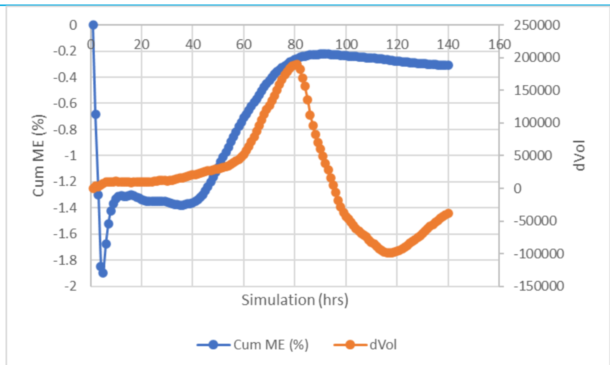
100-year +47% climate change



100-year +63% climate change



100-year +103% climate change



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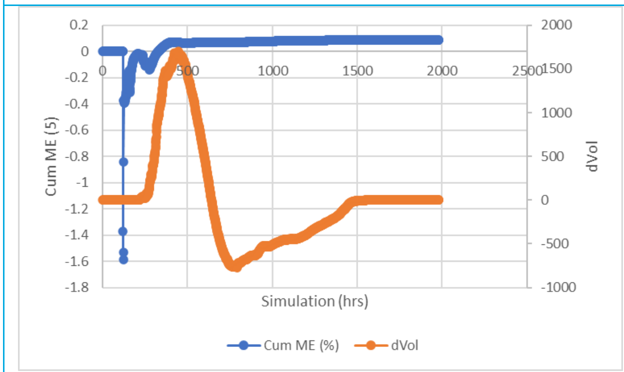
4.5 Gillingham model

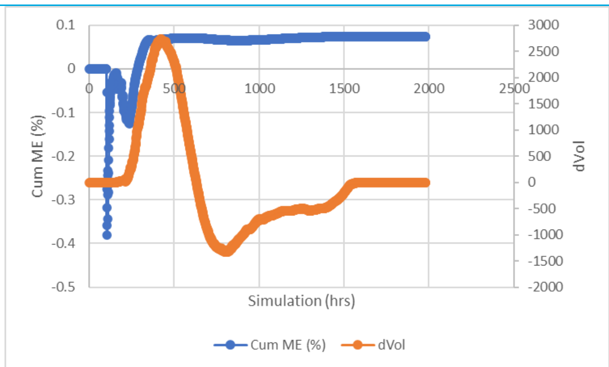
Mass balance outputs are within standard boundaries for 2D model outputs. Although, a sharp trough in cumulative mass error can be observed at the beginning of each simulation, this is deemed to be acceptable as levels return to within modelling standards for the remainder of the simulations.

Table 4-7: 2D model mass balance and model convergence

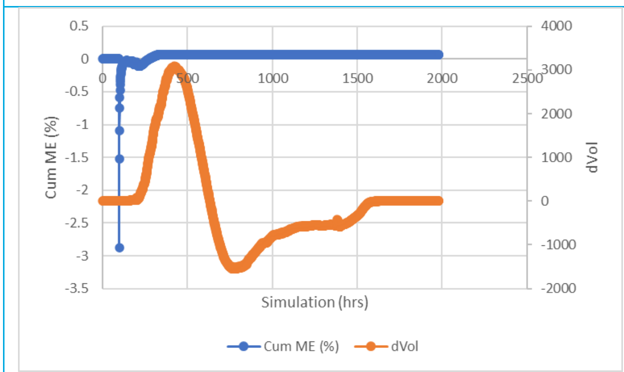
100-year baseline



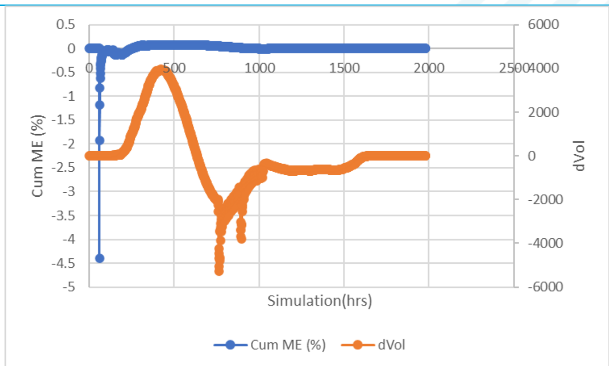
100-year +47% climate change



100-year +63% climate change



100-year +103% climate change



5 Limitations and recommendations

- The 100-year baseline for the Britport, River Frome and Gillingham models all shows 2D mass balance errors that are greater than the standard tolerance (±1%). The climate change events therefore follow the same patter, with increased mass balance errors with increasing flows. However, as these models were already approved models to be used within this study, and the scope does not allow for extensive troubleshooting, these errors are deemed acceptable but may have impacts on model outputs.
- The Lower Stour model failed to complete simulations for the updated climate change uplifts. Minor edits have been made to reduce the instabilities in the troubled parts of the model. However, more detailed investigations into model stability are required, which is not part of this project scope.