NOTE TO FILE

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Contract	Gwent Europark, Magor - FCA and PEA
Client	CMF UK
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Subject	Gwent Europark, Magor - FCA Flood Modelling

1 Introduction

The following Technical Note details the updates and amendments made to NRW's 2016 'Caldicot and Wentlooge Coastal Modelling Study' to support the Flood Consequences Assessment (FCA) for Gwent Europark, Magor (the Site).

The Caldicot and Wentlooge Coastal Modelling Study was undertaken by JBA Consulting on behalf of NRW. The 2016 study generated detailed and comprehensive coastal flood risk modelling of the Caldicot and Wentlooge Levels. Specifically, the Caldicot model covers the Gwent Europark site. Since 2016 a range of datasets have changed, including LiDAR, climate change predictions and Coastal Boundary Conditions. Furthermore, the resolution of the model was inherently limited by the size of the model, introducing key modelling and flood risk definition limitations at the site of interest.

To facilitate a detailed assessment of flood risk the 2016 NRW flood model has been comprehensively updated as detailed in this Technical Note.

2 Flood Model Updates

The following updates were made to the model from the 2016 Caldicot and Wentlooge Coastal Modelling Study:

2.1 Tidal Boundary Conditions

The model's tidal boundary was updated using the latest version of the Coastal Flood Boundary Dataset (CFBD) and Welsh Government climate change guidance.

The tidal boundary calculated assumes a 50 year lifetime of development. Given the period in which JBA has advised on the site, 2023 is set as the present-day year and 2073 for 50 years from now.

Full details of this work are provided in Section 3 of this report.

2.2 Wave Overtopping

Wave overtopping has been recalculated for the assumed 50 year lifetime of development. Details of the associated wave emulation and wave overtopping calculations are contained in Sections 4 and 5 respectively.

2.3 Multiple Domain Model Setup

The model was divided split into two lined 2D domains, to allow for greater resolution and accuracy around the Site. These two domains are shown in Figure 2.1. A larger domain, with a resolution of 10m, covers most of the original model area and preserves the original grid size and timestep. A smaller, high-resolution domain, focused on the site and surrounding reens. The high-resolution domain uses a grid resolution of 2.5m. The 2.5m 2D domain uses a computational timestep of 1.25s.

Previous model results, shown in Figure 2-3, show that no water passes over the road embankment, only underneath it through the culverts. Therefore, the two 2D domains are linked 1D-to-1D linkages applied across the A4810 road boundary, as shown in Figure 2-2. The A4810 provides high ground separation between the two domains and therefore avoids the need for potentially troublesome 2D-to-2D linkages.

The smaller domain incorporates Natural Resources Wales (2022) 1m LiDAR DTM and drone acquired LiDAR survey data for the site. Where available the drone data was used as this captured more recent topographical changes in the area.

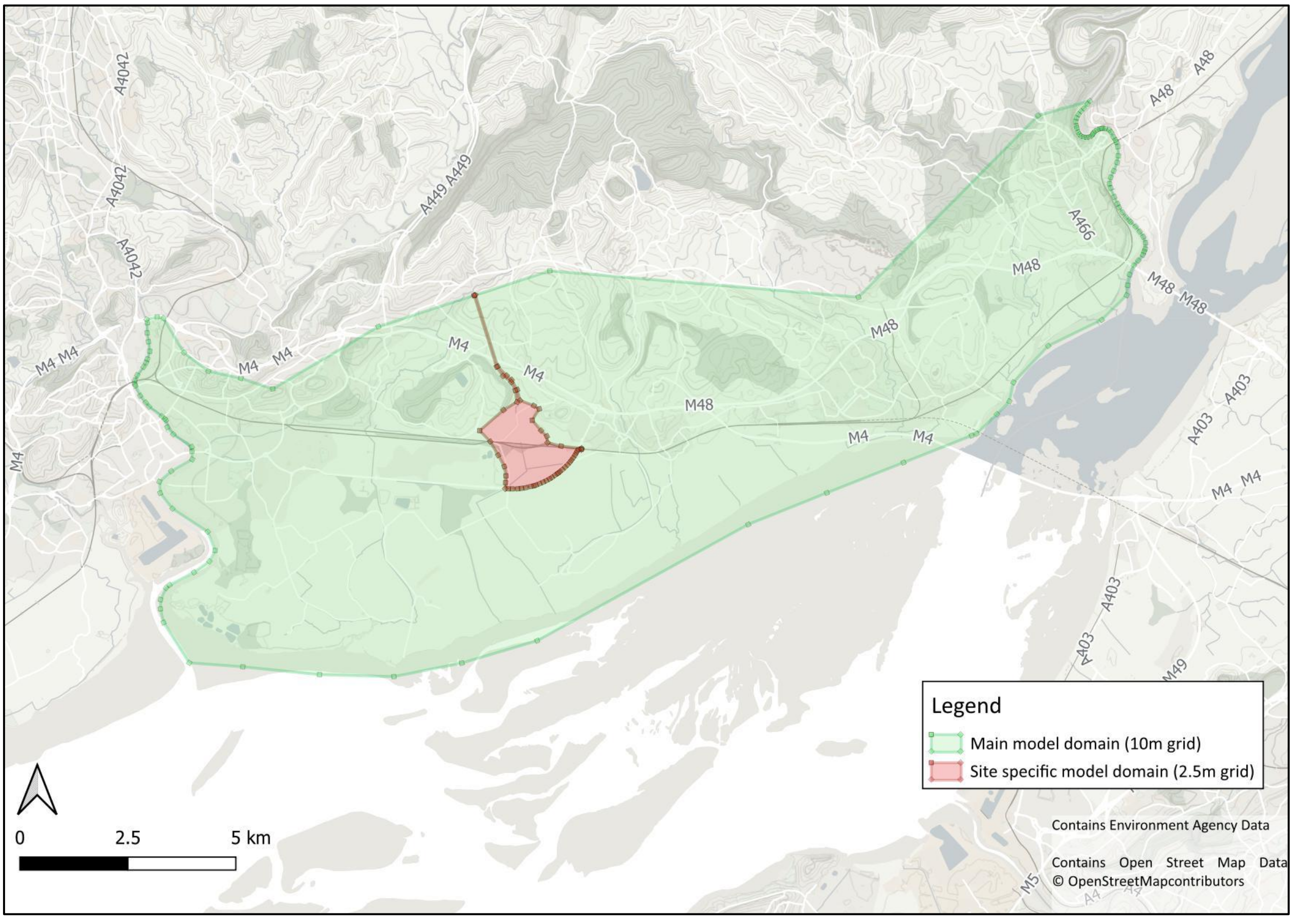

Figure 2-1: Domains for 2.5m and 10m grids

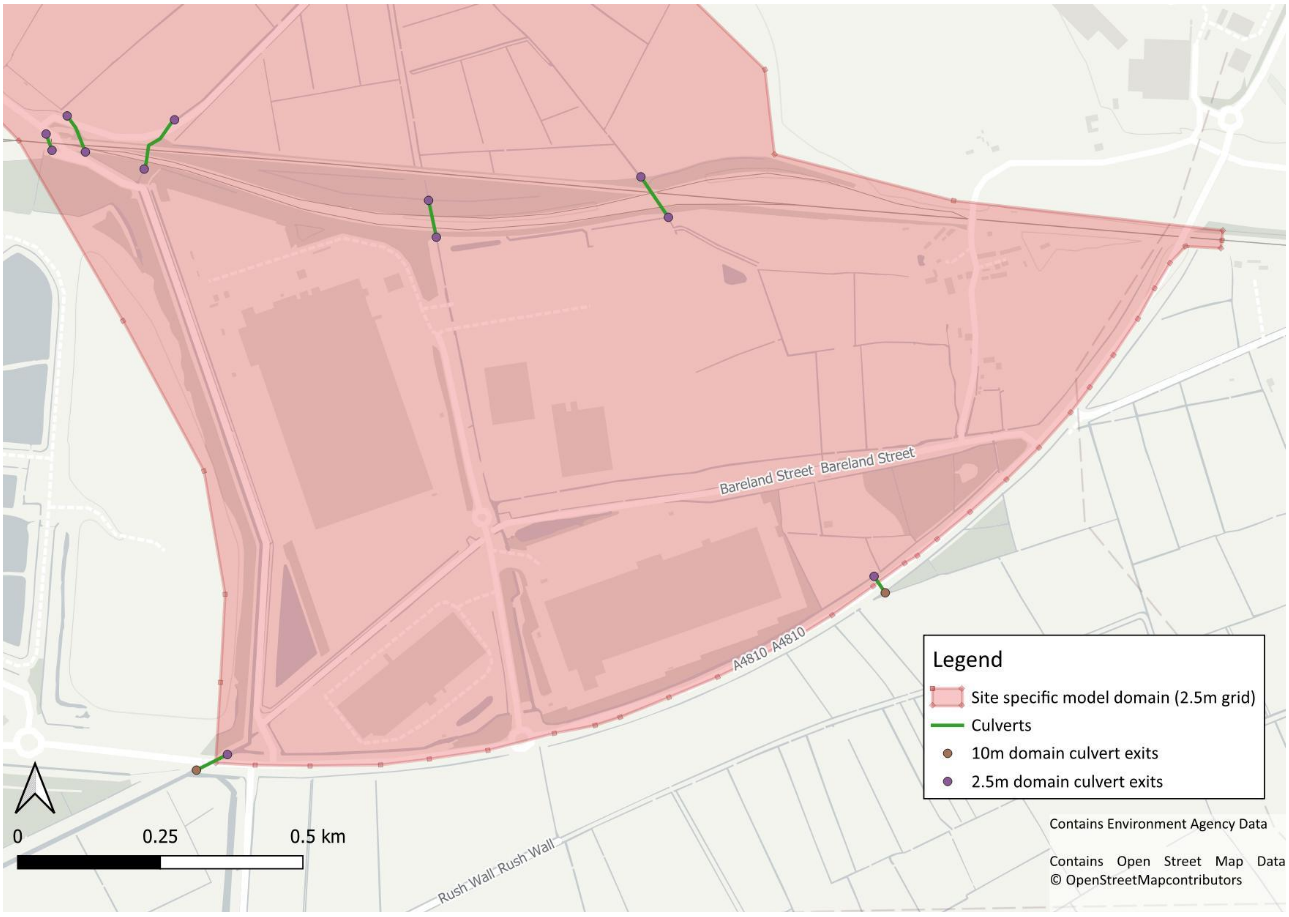

Figure 2-2: Close up of border between the domains and the connecting culverts

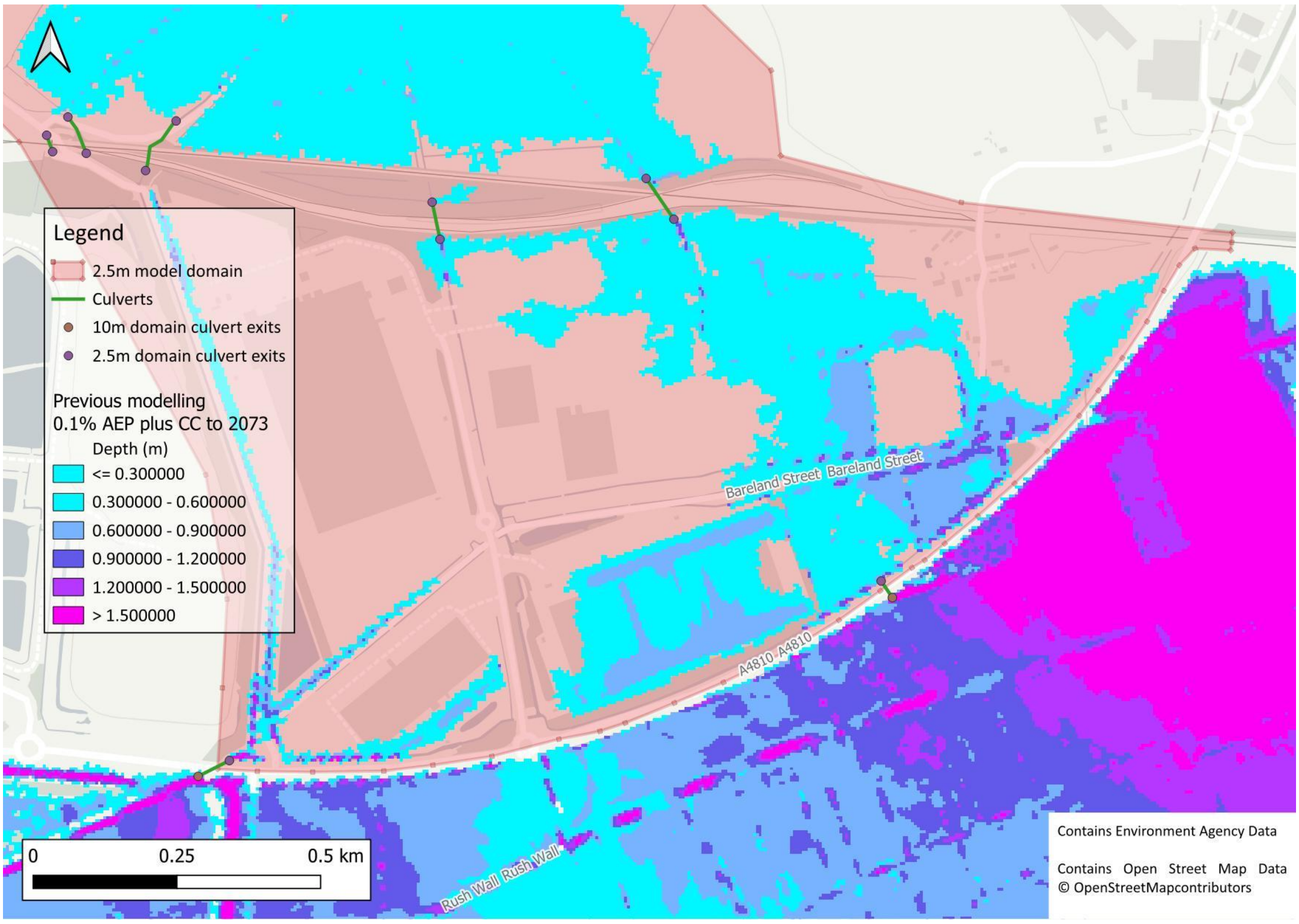

Figure 2-3: Previous baseline model results

2.4 Model Run Time

The model runtime was extended from 49.75 to 66 hours, as this greater duration allowed tidal flooding to reach its maximum extent and depth in the area of interest.

2.5 Channel improvements

Many of the reens near the site had blockages caused by LiDAR filtration issues, caused by small bridges or vegetation. To better model the flow of water around the area these blockages were removed from the model's Digital Terrain Model (DEM) based on adjacent reen bed levels and imagery where available.

Figures 2-4 and 2-5 illustrate the modifications made to the model's DEM to remove these blockage features. Figure 2-6 shows the locations of the DEM edits.

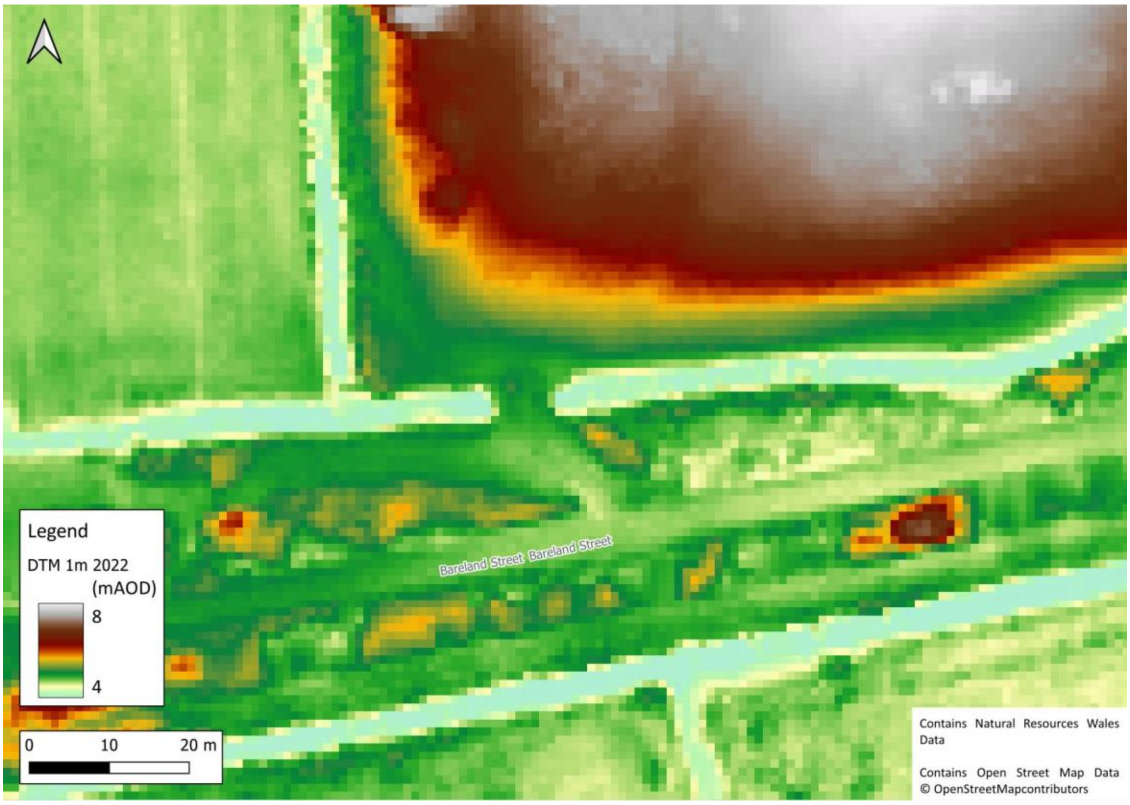

Figure 2-4: Reen blockage in NRW 2022 1m LiDAR dataset

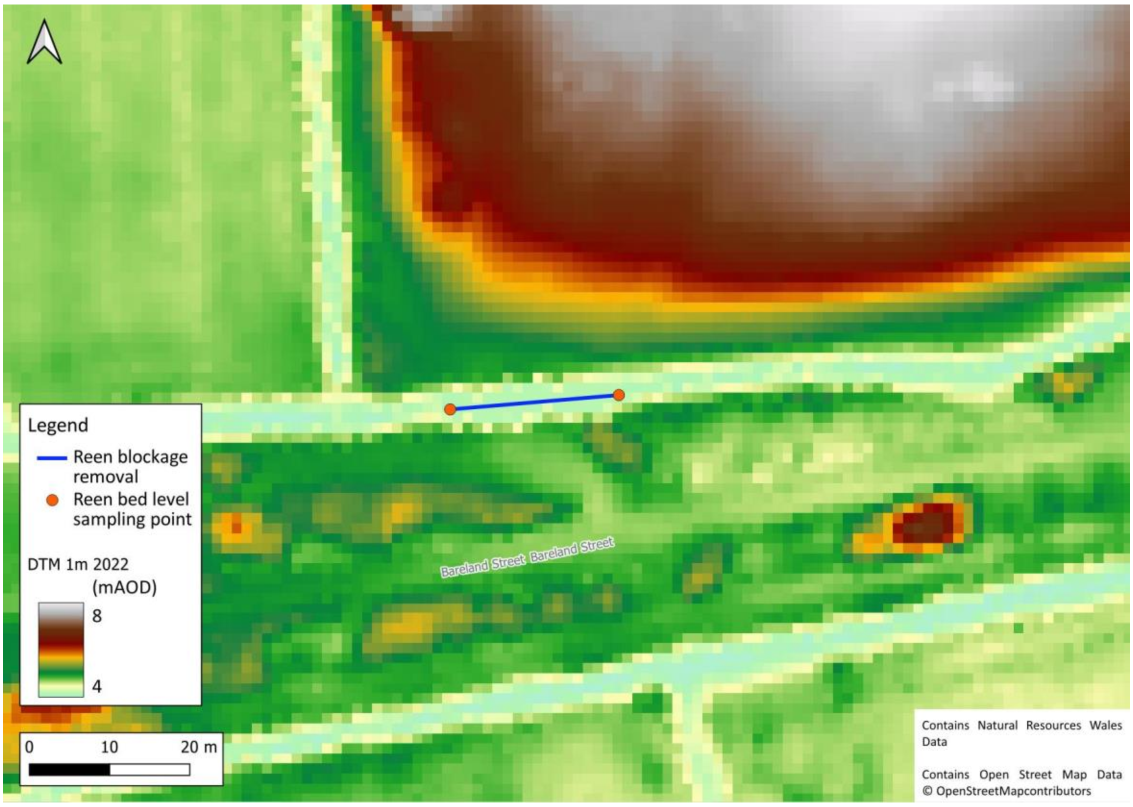

Figure 2-5: Reen with blockage removed in updated model

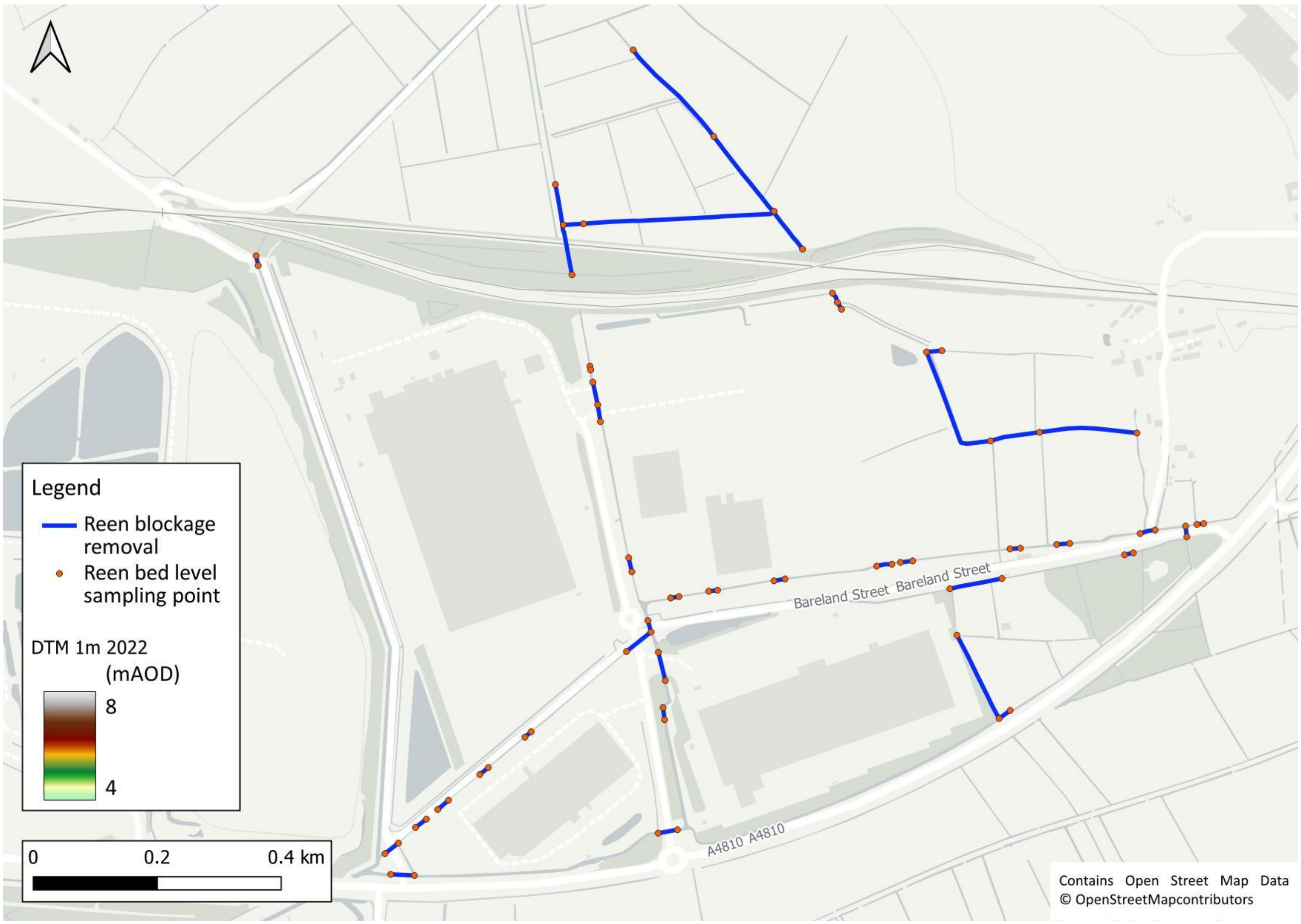

Figure 2-6: Map of reen cut-through locations

2.6 Culvert updates

Some culverts and other file types were updated to shapefile format for ease of editing.

2.7 Post-development modelling

The project engineers, Shear Design Ltd, created and supplied a 3D CAD model of the proposed site levels. This 3D CAD model was converted to an ASCII grid and applied to the model to configure the post-development scenario.

A feature of the design was to link the existing and proposed swales around the site perimeter with a 1050mm culvert. This culvert was added to the model, with invert levels corresponding with the actual and proposed swale invert levels.

2.8 Run information

Run reference	Baseline - Caldicot_~e1~_~s1~_036.tcf
Purpose of runs:	To model 0.1% AEP event plus climate change for 2073 epoch (50-year design life as non-residential site)
TUFLOW file names:	Caldicot_~e1~_~s1~_036.tcf Caldicot_~e1~_~s1~_036.ecf Caldicot_WD_036.tgc | Caldicot_WD_S036.tgc Caldicot_WD_031.tbc | Caldicot_WD_S031.tbc
Run time:	Simulation time: 66 hours
AEP events:	0.1% AEP plus climate change (2073)
Boundary conditions:	bc_dbase_Caldicot_011.csv
Run settings:	TUFLOW version: 2023-03-AE-iSP-w64

Run reference	Post development- Caldicot_~e1~_~s1~_050.tcf
Purpose of runs:	To model post development run for the 0.1% AEP event plus climate change for 2073 epoch (50-year design life as non-residential site)
TUFLOW file names:	Caldicot_~e1~_~s1~_050.tcf Caldicot_~e1~_~s1~_050.ecf Caldicot_WD_036.tgc | Caldicot_WD_S049.tgc Caldicot_WD_031.tbc | Caldicot_WD_S050.tbc
Run time:	Simulation time: 66 hours
AEP events:	0.1% AEP plus climate change (2073)
Boundary conditions:	bc_dbase_Caldicot_011.csv
Run settings:	TUFLOW version: 2023-03-AE-iSP-w64

3 Still Water Boundary Conditions

3.1 Extreme sea levels

In 2018, a new extreme sea level dataset was released as part of the Coastal Flood Boundary Dataset (CFBD). This provides extreme sea levels for a series of return periods (RP) with a base year of 2017. The previous 2016 modelling used the previous CFBD with a 2014 base year. Extreme sea levels were therefore extracted for the following design events:

- 0.5% AEP (return period of 200 years)
- 0.1% AEP (return period of 1000 years)

3.2 Sea level rise uplifts

Extreme sea levels were uplifted from a 2017 base year to present-day 2023 and the following future epoch:

- 2073 (50 year lifetime of development)

This enabled model simulations to account for the estimated effects of climate change over the lifetime of development, as required by TAN15.

Climate change uplifts for sea-level rise were calculated based on the latest projections from the UK Climate Projections 2018 (UKCP18) using the representative concentration pathway (RCP) 8.5 and the 70th percentile uplifts Table 3-1, in accordance with Welsh Government's climate change guidance[1].

Table 3-1: CFB extreme sea levels and sea level uplifts

Location	Chainage	ESL (mAOD) (2017)		Sea level rise uplifts (m) (base year 2017)	
		T200	T1000	2023	2073
Estuary Severn	380_9	9.27	9.66	+0.03	+0.45
UK mainland	396	8.33	8.67		
UK mainland	382	9.07	9.43		
Estuary Usk	398_10	8.51	8.87		
Estuary Severn	380_5	9.17	9.53		
Estuary Severn	380_15	9.33	9.70		

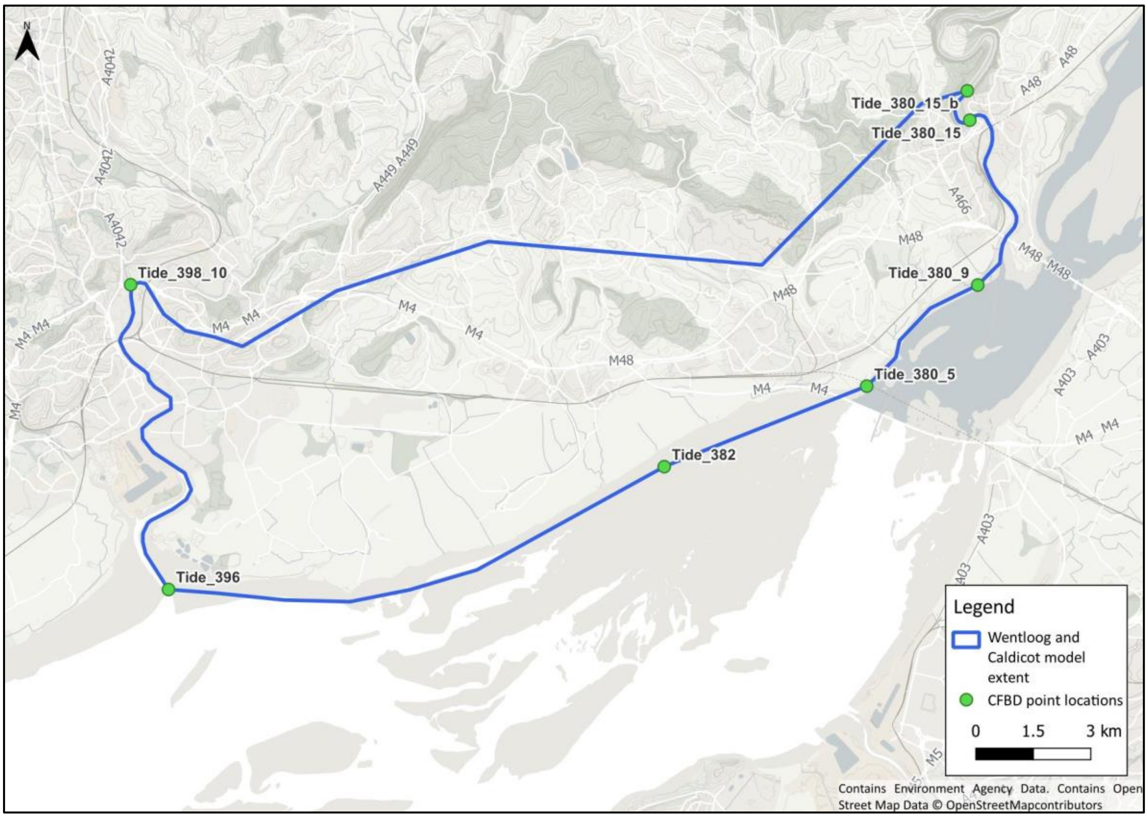

Figure 3-1: CFBD point locations applied in the model

1 Climate change allowances and flood consequence assessments, 2021 https://www.gov.wales/climate-change-allowances-and-flood-consequence-assessments

3.3 Design Tide Curves

Design tide curves were generated to provide the model boundary conditions following Environment Agency guidance. This process used information from three principal sources:

- Extreme still water sea-level estimates - Updated CFB dataset
- Design astronomical tide - Class A Tide Gauge Network
- Design surge shape - Class A Tide Gauge Network, with surge shape from the CFB data

To generate the tidal profile, the peak of the design surge profile was aligned to coincide with the low tide level before the maximum tidal peak. The tidal profile was then scaled to peak at the extreme sea-level for each of the modelled return periods, as shown in Figure 3-2. Finally, the tidal time series were uplifted to the different epochs by adding the sea level rise values determined in Section 3.2.

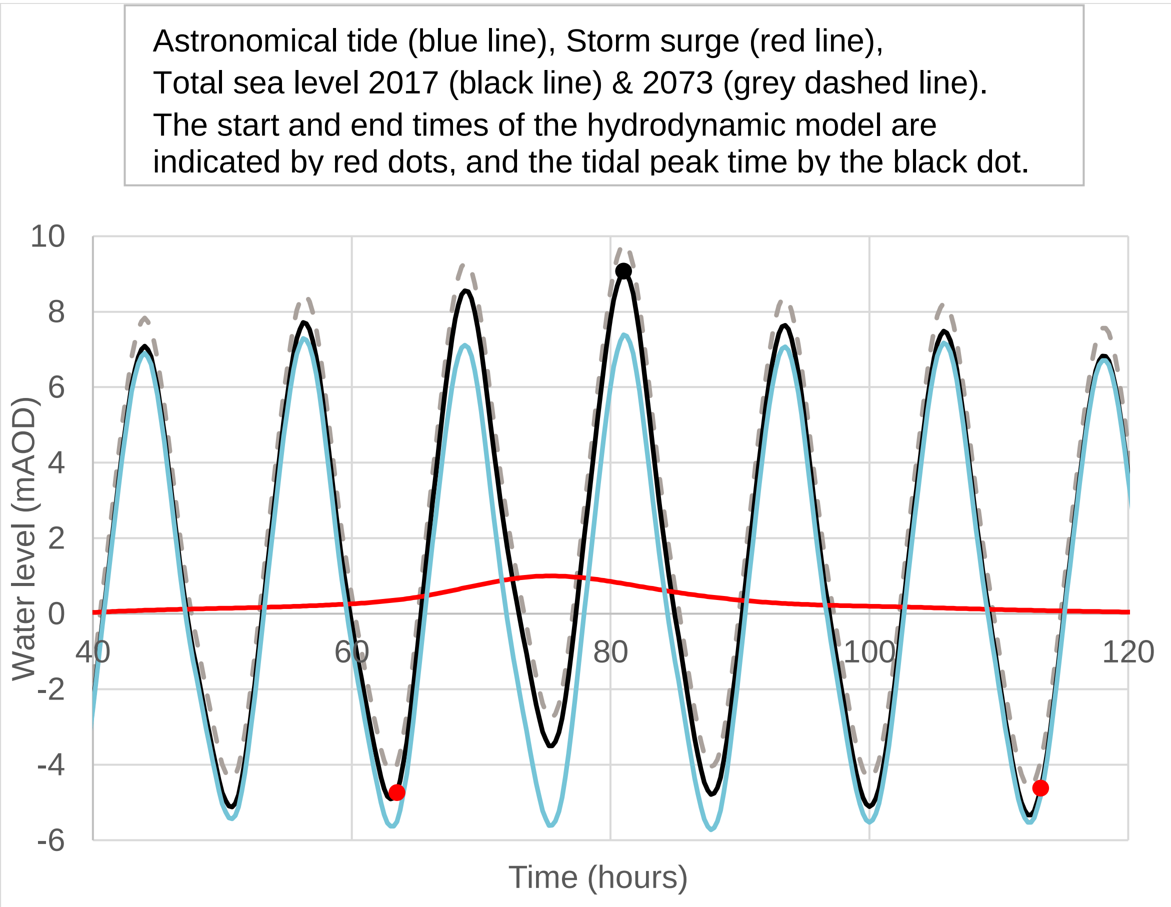

Figure 3-2: Tidal time series - CFB point's chainage 382

4 Wave Emulation

4.1 Background

In the 2016 'Caldicot and Wentlooge Coastal Modelling Study', a Maximum Dissimilarity Algorithm (MDA) was used to select 1,000 representative events from the Monte Carlo dataset. The selection of representative events was simulated in the wave transformation model to characterise the full range of multivariate conditions. From this selection of wave model runs, emulators were trained to reproduce the relationships between the offshore and nearshore waves. The trained emulators were then used to rapidly predict the nearshore conditions using the offshore Monte Carlo sample.

4.2 Wind speed and wave height uplifts

Wind speeds and wave height were increased by 10% for the future epoch - 2073 - from that of the present-day base year in-line with UKCP18 sensitivity guidance.

4.3 Updated nearshore wave climate

The emulators that were created as part of the 2016 study were used to transpose the adjusted 2023 and 2073 offshore Monte Carlo event set to the nearshore.

Before doing so, the ability of the existing emulator functions used to predict the nearshore conditions was assessed. The result, and closeness to the modelled epochs and data, showed the emulators performance as suitable for use within this model update.

5 Wave Overtopping

5.1 Background

Once the nearshore wave and water level climate was updated for the new climate change epochs (Chapters 3 & 4), it was necessary to simulate these conditions in a wave overtopping model to determine wave overtopping discharges. The overtopping model required the nearshore wave and water level climate along with a defence schematisation that would define the defence geometry for specified lengths of defence. The overtopping model was the same as that previous used in the 2016 study - the European Overtopping Manual (EurOtop) Neural Network 1 tool. This tool uses a database of lab and field tests of different defence geometries and wave and water level combinations to return a mean overtopping discharge.

5.2 Defence schematisation

The defence schematisations provided by HR Wallingford in the original 2016 study were reused as part of the 2023 project, as defences were not being updated. The locations of the defence schematisations and corresponding wave overtopping profiles can be found in Figure 5-1 and Figure 5-2.

The 23 discrete overtopping profiles modelled along the coastline are detailed in Table 5-1.

5.3 Wave overtopping modelling

The wave overtopping model was simulated for the 23 defence sections using the updated wave and water level combinations for present-day (2023) and the future epoch (2073). Wave overtopping discharges were generated for the 0.5 and 0.1% AEP events that were suitable for inclusion in the existing TUFLOW flood inundation model.

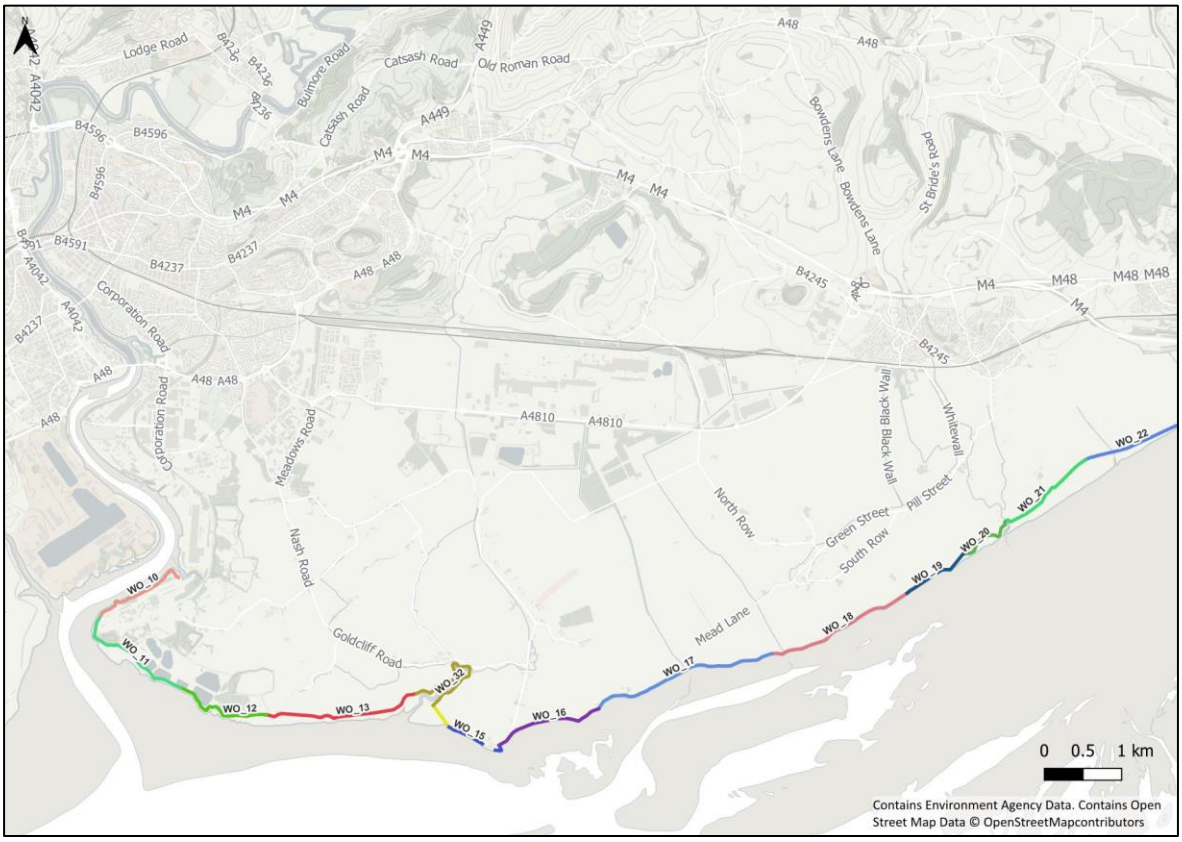

Figure 5-1: Caldicot defence schematisation locations (West)

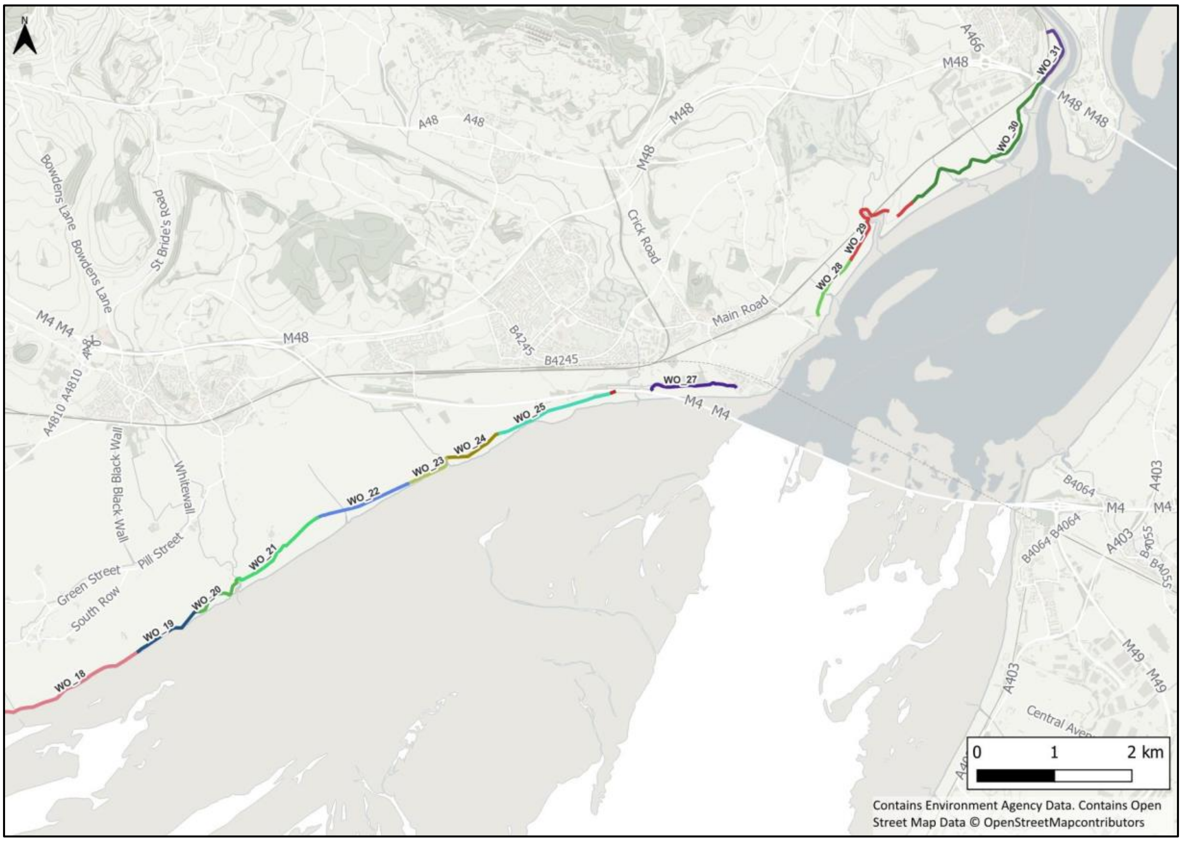

Figure 5-2: Caldicot defence schematisation locations (East)

Table 5-1: Wave overtopping profile information

Section	Toe level (mAOD)	Crest level (mAOD)	Section description
10	-2.79	8.42	Grass embankment
11	6.03	11.34	Grass embankment
12	3.80	11.85	Grass embankment
13	5.90	11.10	Rock armoured revetment fronting a wave return wall
14	6.30	9.47	Blockstone fronting a wave return wall
15	3.12	9.90	Blockstone fronting a wave return wall
16	2.68	9.83	Blockstone fronting a wave return wall
17	3.30	9.72	Blockstone fronting a wave return wall
18	3.74	9.70	Blockstone fronting a wave return wall
19	4.97	9.77	Blockstone fronting a wave return wall
20	6.40	9.78	Blockstone fronting a wave return wall
21	6.71	9.41	Grass embankment
22	6.31	9.06	Grass embankment with berm
23	5.43	9.13	Grass embankment
24	6.91	8.99	Rock armoured revetment fronting a wave

Section	Toe level (mAOD)	Crest level (mAOD)	Section description
			return wall with berm
25	6.85	9.13	Grass embankment
26	7.98	9.30	Rock armoured revetment fronting a wave return wall
27	7.71	9.30	Grass embankment
28	7.75	8.96	Grass embankment
29	7.28	8.97	Grass embankment with berm
30	7.38	9.29	Grass embankment
31	6.01	9.05	Grass embankment with berm
32	6.32	9.11	Grass embankment