

Bridgend County Borough Council

Porthcawl Waterfront Masterplanning

Coastal Flood Inundation Modelling Report

Reference: 309314-ARP-XX-XX-RP-MO-001

P01 | 7 November 2025



This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 309314-00

Ove Arup & Partners Limited EQ 2nd Floor 111 Victoria Street Bristol BS1 6AX United Kingdom arup.com

Contents

1.	Introduction	1
1.1	Study background	1
1.2	Study scope	1
1.3	Study area	1
1.4	Description of proposals	2
2.	Previous modelling	4
3.	Modelled scenarios	5
3.1	Overview of scenarios	5
3.2	Overview of return periods and epochs	5
3.3	Climate change assumptions	5
3.4	File naming convention and event/scenario switches	6
4.	Baseline Model Updates	7
4.1	Software	7
4.2	Topography	7
4.3	Eastern Promenade defence levels	8
4.4	Buildings	9
4.5	Surface roughness	9
4.6	Boundary conditions	9
5.	With Scheme Model Development	22
5.1	Proposed scheme	22
5.2	Representation in flood inundation model	22
6.	Model results	24
6.1	Model performance and stability	24
6.2	Baseline model results	24
6.3	With scheme model results	26
6.4	Impact on flood risk	28
7.	Assumptions and Limitations	32
8.	Conclusions	33
Table	1: Modelled scenarios	5
Table	2: Sea Level Rise (SLR) allowances based on 2017 base year	5
Table	3: BaU Peak Sea Water Levels	15
Table	4: Proposed 1 Peak Sea Water Levels	16
Table	5: BaU Peak Wave Overtopping Flows (L/m/s)	19
Table	6: Proposed 1 Peak Wave Overtopping Flows (L/m/s)	20
Figur		
_	1: Location of key features within Sandy Bay. Inset image shows extract for Flood Map for ng with red dashed line indicating Flood Defence.	2

Figure 2: Extract from sketch of proposed coastal defences with key features annotated (SK-003, Arup, 2024)	3
Figure 3: Double precision solver sensitivity test results	7
Figure 4: Topographic survey sensitivity test results	8
Figure 5: Extents of updated Eastern Promenade defence	9
Figure 6: Defence sections – Baseline and Proposed 1	11
Figure 7: Schematised defence profiles	14
Figure 8: BaU sea water level profiles	17
Figure 9: Proposed 1 sea water level profiles	18
Figure 10: BaU 2126 T1000UE - Sea water level hydrographs	19
Figure 11: BaU wave overtopping profiles	21
Figure 12: Proposed 1 wave overtopping profiles	21
Figure 13: Extract of Masterplan exhibition boards (https://porthcawlwaterfront.co.uk – earlier version which differs slightly from Proposed 1)	22
Figure 14: Proposed developments – Proposed 1	23
Figure 15: Cumulative mass balance error plot for the BaU 2026 T0200 event	24
Figure 16: BaU present day maximum flood extents	25
Figure 17: BaU future epoch (Higher Central allowance) maximum flood extents	26
Figure 18: Proposed 1 present day maximum flood extents	27
Figure 19: Proposed 1 future epoch (Higher Central allowance) maximum flood extents	28
Figure 20: 2026 T0200 Impact Map	29
Figure 21: 2026 T1000 Impact Map	29
Figure 22: 2126 T0200HC Impact Map	31
Figure 23: 2126 T1000HC Impact Map	31
Appendices	
Appendix A	A-1
2017 Flood Inundation Modelling Report	A-1
Appendix B Porthcawl Coney Beach Wave Modelling Report	B-1 B-1
Appendix C Business as Usual maximum flood depth and hazard maps	C-1 C-1
Appendix D Proposed Option 1 maximum flood depth and hazard maps	D-1 D-1
Appendix E Impact maps	E-1 E-1

1. Introduction

1.1 Study background

Ove Arup & Partners (Arup) were commissioned in May 2025 by Bridgend County Borough Council (BCBC) to provide coastal flood risk modelling at Sandy Bay, Porthcawl in South Wales to support an emerging regeneration masterplan.

To maximise the long-term benefits for residents and visitors, Bridgend County Borough Council and Welsh Government have formed a landowner's agreement to see the Waterfront progress as one, harmonious development. The masterplan¹ proposals provide a high-level plan for how the Waterfront could be developed with quality mixed-use redevelopment, enhancing the seafront amenity and thereby reinforcing the recreation value and tourism attraction of the area.

The final development at the Waterfront will be built out in stages and involve different developers. There would be a design code, agreed by the Council as part of the planning process and this would set the standards that future developers delivering any part of the Masterplan in the future must comply with. This would ensure that the Local Planning Authority and the Welsh Government secure development of the highest quality and greatest benefit for residents. As the Masterplan progresses the design will be subject to further design and engineering input and will be shaped by further survey and technical studies.

1.2 Study scope

As part of the delivery of the masterplan planning application, a Flood Consequences Assessment (FCA) and Environmental Statement (ES) are being by prepared by Others. The FCA will identify flood risk to and from the development. It will be used to demonstrate what mitigation measures will be required to reduce the risks and consequences to ensure the development itself is as safe as possible and that there is minimal impact on flood risk generally.²

The FCA requires flood risk modelling information to inform it. There is a previous Sandy Bay coastal flood risk model which is to be updated to reflect both the up-to-date baseline situation, the latest climate change allowances and to test the masterplan proposals. The FCA will be informed separately regarding other sources of flooding.

1.3 Study area

The modelling builds on Arup's coastal flood risk modelling undertaken in 2017 to support an Outline Business Case to Welsh Government to identify and justify investment in Sandy Bay coastal defence enhancements, and then in 2019 to support the detailed design of enhancements to the Western Breakwater, the Eastern Promenade, the Relic Dunes and Rhych Point (see Figure 1 for key features within Sandy Bay).

¹ https://porthcawlwaterfront.co.uk/ (accessed 23/10/2025)

 $^{^{2}}$ Modelling for Flood Consequence Assessments – GN 028, Natural Resources Wales, 2020



Figure 1: Location of key features within Sandy Bay. Inset image shows extract for Flood Map for Planning³ with red dashed line indicating Flood Defences.

1.4 Description of proposals

Currently the section of frontage in Sandy Bay, Porthcawl known as Coney Beach (fronting Coney Beach Pleasure Park) has a mixture of existing privately owned defence structures including revetments, rock armour, vertical walls and walls of kiosks and businesses.

The Proposed Development coastal defences are a concrete terraced revetment extending approximately 220 m from the Eastern Promenade to east of Mackworth Road, shown in Figure 2. The revetment will be constructed to a crest level of 10 mAOD (higher than the existing promenade). At the crest of the revetment there will be a new promenade and the Masterplan development behind will tie into this raised level. Access to the beach will be enhanced by integration of steps and ramps into the revetment, in comparison to the existing limited access points.

These proposed works are the second phase of coastal defence work in Sandy Bay. In Phase 1 works were undertaken to enhance the Western Breakwater, Eastern Promenade, Relic Dunes and Rhych Point.

The Proposed Development coastal defences and promenade will enable the masterplan to comply with *Technical Advice Note (TAN) 15: development, flooding and coastal erosion*⁴ for new development by managing the risk of coastal flooding up to a 0.5% (1 in 200 year) Annual Exceedance Probability (AEP) event in 2126.

At Mackworth Road and east of Mackworth Road, due to the requirement to tie-in to levels of existing development outside the Masterplan boundary, some raising will take place but to a lower crest level of 8.5 mAOD. The Proposed Development will not manage coastal flood risk in compliance with TAN15 in this localised area. Additional site mitigation measures would be necessary should development be proposed in this area.

³ https://flood-map-for-planning.naturalresources.wales/

⁴ https://www.gov.wales/technical-advice-note-tan-15-development-flooding-and-coastal-erosion (accessed 23/10/2025)

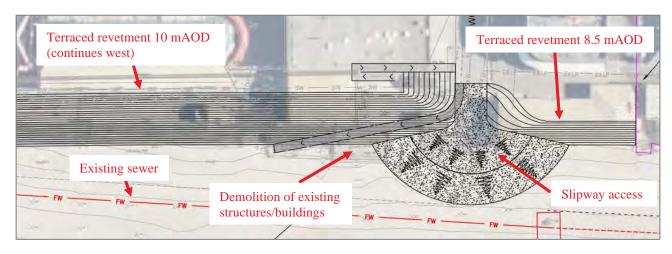


Figure 2: Extract from sketch of proposed coastal defences with key features annotated (SK-003, Arup, 2024)

2. Previous modelling

Arup undertook coastal flood modelling in 2017 for BCBC, to develop an Outline Business Case to justify flood and coastal erosion risk management investment at Sandy Bay, Porthcawl, South Wales. This led to the delivery of enhancements to the Western Breakwater, Eastern Promenade the Relic Dunes and Rhych Point. Flood modelling was undertaken for present day (corresponding at the time to year 2018) and future (2118) climate change conditions.

Several scenarios were modelled:

- A baseline 'Business as Usual' (BaU) scenario which assumes existing parapet walls forming the coastal flood defences along Eastern Promenade and at the southern end of Mackworth Road do not fail or breach during a coastal flood/tidal event and are maintained in their current condition to provide some degree of protection against tidal flooding. This scenario also assumed the Western Breakwater structure is continuing to be maintained.
- Two separate theoretical breach scenarios, based on the Business as Usual, which assessed the impact of
 breaching the parapet coastal flood defence wall at the southern end of Mackworth Road and the four
 short sections of parapet coastal flood defence wall along the Eastern Promenade.
- A theoretical scenario where the Western Breakwater structure is assumed to not be maintained and fail, and also the existing coastal flood defence walls fail/breach during a coastal/tidal flood event.

Wave overtopping hydrographs were calculated as part of the wave analysis exercise and applied to the TUFLOW 2D hydraulic model to determine flow routes and food depths. The model also included a sea water level boundary to represent any overtopping due to extreme sea water levels. The harbour gates are not explicitly represented, however the crest level of the gate is similar to the surrounding marina walls therefore is does not significantly impact overtopping in this location.

Model results for the Do Minimum scenario showed the primary flooding mechanism to be overtopping at Eastern Promenade and northerly flow to Griffin Park for present day conditions (2018) and additional overtopping at Mackworth Road for future conditions (2118).

The 2017 Flood Modelling Inundation Report is presented in Appendix A.

3. Modelled scenarios

3.1 Overview of scenarios

Two scenarios have been modelled, as detailed in Table 1.

Table 1: Modelled scenarios

Scenario	Details
Business as Usual	This scenario assumes that the coastal defences along Eastern Promenade will be maintained in their current condition and will not fail or breach during a coastal/tidal flood event, in both present day and future climate change conditions. The existing de-facto walls at the southern end of Mackworth Road are also assumed to be retained, but the slipway access opening (gate) is left open. This scenario also assumed the Western Breakwater structure is continuing to be maintained.
Proposed 1	This scenario uses the same assumptions as the Business as Usual scenario with regards to the Eastern Promenade and Western Breakwater defences being maintained. This scenario also includes the proposed developments for Proposed 1, both new features to be built (i.e. coastal defences, buildings) and reprofiling of existing ground levels. For more details, refer to Section 5.

3.2 Overview of return periods and epochs

The model will be run for only two return periods, the 0.5% (1 in 200 year) and the 0.1% (1 in 1,000 year) AEP event to inform the Flood Consequence Assessment.

Two future epochs are considered, present day (2026) and future (2126). The 100 year future scenario is based on TAN15 guidance⁴ "it is appropriate to think of new dwellings as having a lifetime of 100 years".

Two climate change assumptions are used to inform the future scenarios as detailed in the following section.

3.3 Climate change assumptions

Climate change assumptions for the coastal conditions are detailed in the Coastal Modelling Report presented in Appendix B.

Sea level rise was applied to the Coastal Flood Boundary Dataset 2018⁵ extreme water levels (base year 2017) following Welsh Government climate change guidance⁶. The guidance specifies the approach for deriving both Higher Central and Upper End allowances; these are based on the 70th and 95th percentiles, respectively, of the UK Climate Projections 2018 RCP8.5 data⁷. The allowances derived for Porthcawl are presented in Table 2.

The Welsh Government climate change guidance states development Proposals should be assessed against the relevant regional 70th percentile inform design levels. An assessment should also be made against the 95th percentile to inform mitigation measures, access and egress routes and emergency evacuation plans.

Table 2: Sea Level Rise (SLR) allowances based on 2017 base year

Madelladinas	Sea level ris	se value (m)
Modelled year	Higher Central (70 th percentile)	Upper End (95 th percentile)
2026	0.05	0.06
2126	1.10	1.49

⁵ Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels 2018, Environment Agency, 2019

⁶ Flood Consequences Assessments: Climate change allowances, Welsh Government, 2021

⁷ UK Climate Projections (UKCP18), Met Office, 2018

3.4 File naming convention and event/scenario switches

The TUFLOW control file (.tcf) is named as follows: PorthcawlCoastal_16_~e1~_~s1~.tcf.

The name of the TUFLOW control file includes the model version number as well as one event switch (e1) and one scenario switch (s1). The event switch e1 combines the scenario, climate change epoch, return period of the tidal flood event and climate change allowance (for instance 'BaU_2126_0200HC'). This simplified approach was selected due to the reduced number of tidal flood event return periods, climate change epochs and allowances to be simulated.

The scenario switch s1 is used for sensitivity testing.

4. Baseline Model Updates

4.1 Software

The version of TUFLOW was updated to the 2025.0.3 build, the latest available version at the time the modelling work started.

The TUFLOW Classic solver was run in single precision mode. A sensitivity test was conducted running the TUFLOW Classic solver in double precision mode for the 2126 Business as Usual 0.5% AEP tidal event with Higher Central climate change allowance.

As shown in Figure 3, the difference in modelled maximum flood depths and extents was found to be negligible therefore all simulations were run using the single precision TUFLOW solver.

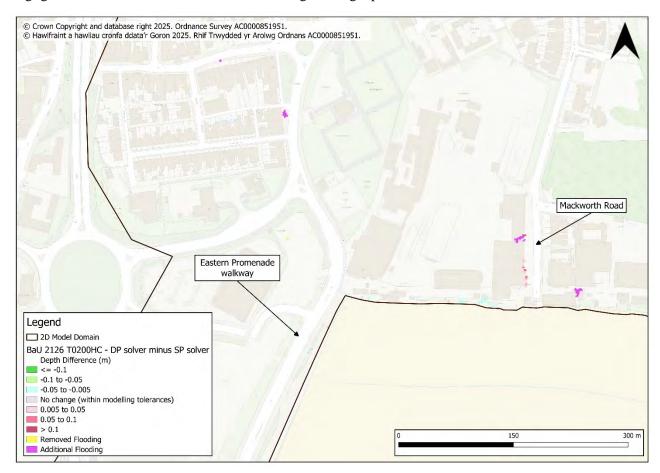


Figure 3: Double precision solver sensitivity test results

4.2 Topography

The existing model used Natural Resources Wales (NRW) 1m resolution LiDAR DEM covering the entire area and downloaded in 2016. LiDAR levels were locally overwritten by two sets of topographic survey data: a topographic survey commissioned as part of the existing project and completed by Azimuth Land Surveys Limited in November 2016 (drawing number AR3150-01A) which covered the Sandy Bay and Eastern Promenade frontage and an older topographic survey from April 1999 provided by BCBC (drawing number 4472/200A0/1.1) which covered the harbour and breakwater to the south of the Eastern Promenade.

As part of the Baseline model updates, latest 1m resolution LiDAR DEM flown in January 2023 was downloaded from the DataMapWales⁸ portal in July 2025. The data was reviewed, and the ground levels were found to be sensible therefore it was enforced into the 2D hydraulic model.

It was necessary to understand whether the two topographic datasets (November 2016 and April 1999) enforced in the existing hydraulic model are to be used after updating ground levels to the latest LiDAR DEM. Therefore, a sensitivity test was conducted running the model with and without those topographic survey levels for the 2126 Business as Usual 0.5% AEP tidal event with Higher Central climate change allowance. The results (see Figure 4) showed a limited impact overall and a small increase in maximum flood depths and extents along Mackworth Road and near the harbour. It was decided to remove ground levels from the two topographic survey datasets from the updated hydraulic model and rely on the more upto-date LIDAR levels. Wall crest levels at the end of Mackworth Road from the 2016 survey were retained in the model.

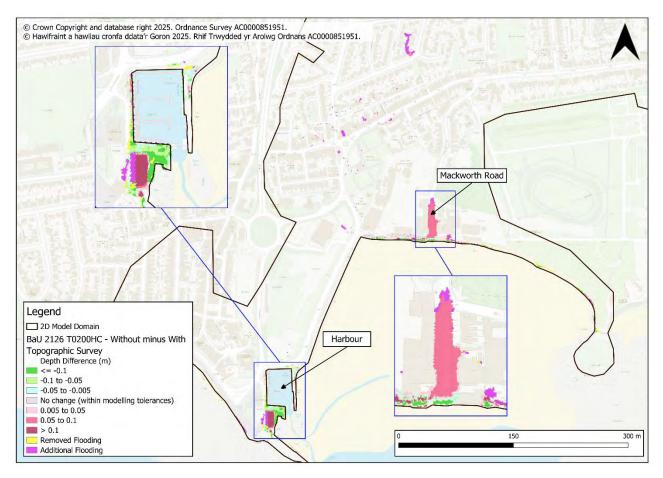


Figure 4: Topographic survey sensitivity test results

4.3 Eastern Promenade defence levels

In the existing hydraulic model, the Eastern Promenade defence levels were enforced based on the November 2016 topographic survey which collected the crest levels of the de-facto defence.

The Eastern Promenade defence levels have been updated following the scheme designed by Arup in 2019 for BCBC. Therefore, as part of the Baseline model updates, the As-Built drawing (drawing number 264874-ARP-XX-EP-DR-CD-1203) of the Eastern Promenade strengthening works was used to update the crest levels of the Eastern Promenade defence in the hydraulic model.

The extents of the updated Eastern Promenade defence levels are shown in Figure 5. The southernmost 50m long section of defence was not included in the As-Built drawing therefore, existing levels from the

-

⁸ LiDAR viewer | DataMapWales

November 2016 topographic survey were retained for that section, however this area was not redeveloped as part of the scheme, as such the 2016 levels should still be appropriate.

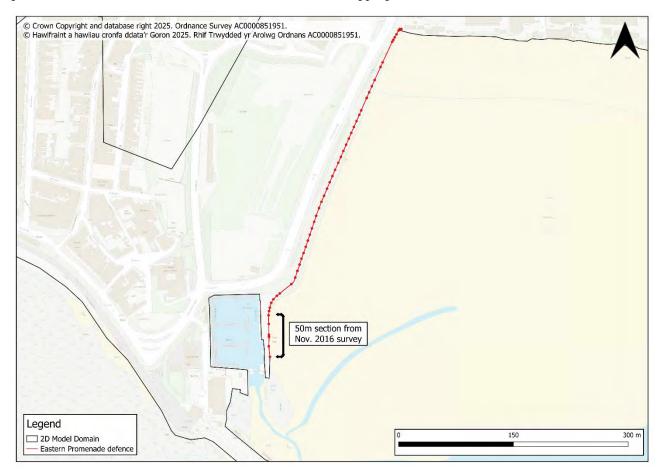


Figure 5: Extents of updated Eastern Promenade defence

4.4 Buildings

The Ordnance Survey (OS) Master Map used to define the buildings in the existing model was obtained in January 2017. There have been newly developed buildings in the study area since that date as well as buildings no longer existing.

Therefore, as part of the Baseline model updates, the TUFLOW 2D Z-shape defining the buildings in the hydraulic model was updated based on the latest OS Master Map provided by BCBC in September 2025. The assumed threshold level for each building in the study area is based on the average LiDAR level plus a nominal threshold level of 0.15m (this is the same assumption as in the existing hydraulic model).

4.5 Surface roughness

Similarly, in the existing model, the TUFLOW 2D material layer which defines the 2D surface roughness was based on OS Master Map from January 2017.

This was updated to be based on the latest OS Master Map provided by BCBC in September 2025.

4.6 Boundary conditions

4.6.1 Coastal modelling

Partners Limited

Our subconsultant ABPmer provided coastal modelling services for the previous coastal flood risk modelling in 2017 and 2019 and have updated this to provide water and wave conditions along the frontage. Reporting of this study can be found in Appendix B.

Key activities to update the previous work are summarised below:

- Update of extreme water levels to be consistent with the latest Coastal Flood Boundary Dataset 2018 guidance.⁹
- Update climate change allowances to use the latest Welsh Government guidance for a project base year of 2026 and design horizon of 2126. 10
- Update the Joint Probability Assessment.
- Re-run the spectral wave model for joint probability pairing events and extract wave data at key locations.
- To extract wave data along the Coney Beach frontage the model was run including reflection off the eastern promenade wall, to then extract wave data along the eastern promenade wall this reflection was removed in the model.

4.6.2 Overtopping assessment

Calculations of overtopping along the frontage have applied empirical formulae from EurOtop¹¹ and are based on the numerical modelling joint probability wave and water level conditions described in Section 4.6.1.

The defence sections were divided so key changes in levels and profiles were captured. Where a defence section spans across multiple extraction points the worst case was selected, noting that typically defence sections were small enough that there was little difference in extraction point conditions across the section. How the frontage has been divided into defence sections is shown in Figure 6 below. The Relic Dune frontage to the east of Defence Section 9 and frontage west of Defence Section 1 are of sufficient level that wave overtopping rates are negligible for the scenarios tested in the context of flood risk to the Proposed Development.

Bridgend County Borough Council

_

⁹ https://www.gov.uk/government/publications/coastal-flood-boundary-conditions-for-uk-mainland-and-islands-design-sea-levels

¹⁰ https://www.gov.wales/sites/default/files/publications/2022-11/guidance-for-flood-and-coastal-erosion-risk-management-authorities-in-wales_0.pdf

¹¹ https://www.overtopping-manual.com/eurotop/downloads/

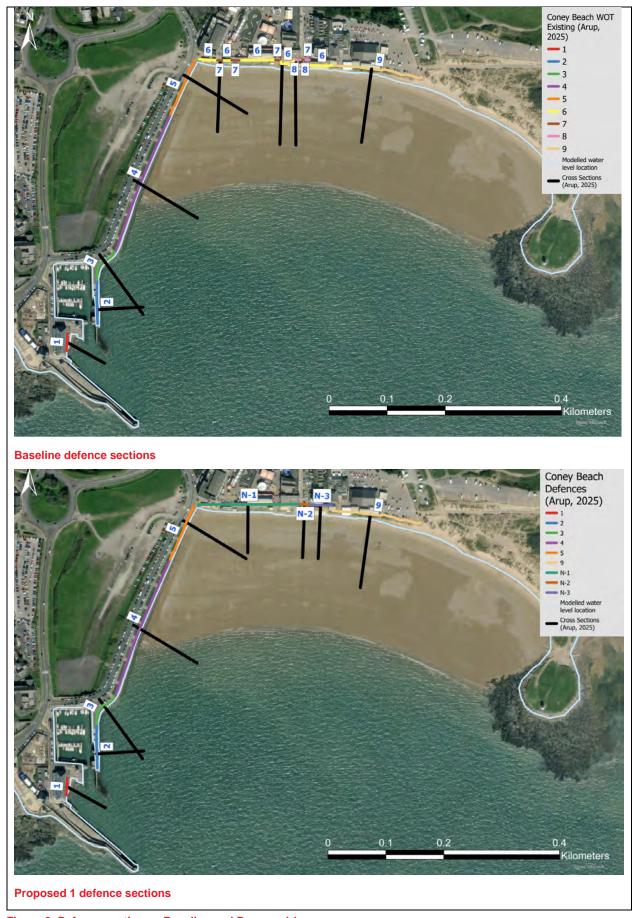


Figure 6: Defence sections – Baseline and Proposed 1

For the purposes of the overtopping assessment schematised profiles of each section of defence have been prepared to identify key inputs to the EurOtop formula. The defence profiles assessed are presented in Figure 7 below.

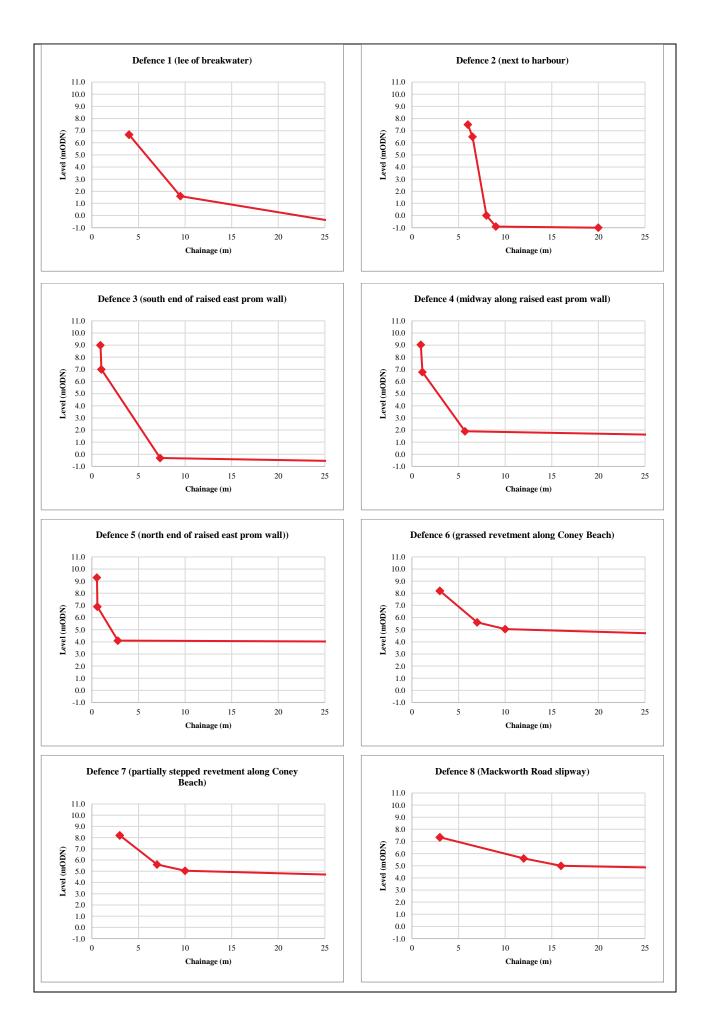
The existing profiles are based on what was used for the existing previous inundation model¹² and have been checked against available topographical survey information¹³, apart from profiles along the eastern promenade which have been updated using as-built survey data for the parapet wall.¹⁴ The eastern most defence profile from the previous model was split into two to better capture the higher ground level relative across the Hi-Tide land compared to Mackworth Road.

Profiles for proposed defences are based on a 1:2 slope terraced revetment with crest height 10mAOD extending across the Coney Beach frontage, from the west tie-in to eastern promenade to Mackworth Road. At Mackworth Road and to the east of the road the crest level is 8.5mAOD, raising the existing levels of Mackworth Road (shown in Figure 2).

¹² Porthcawl Overtopping Assessment - Porthcawl PAR, ABPmer, 2017

¹³ Topographical Survey Sandy Beach Porthcawl, Azimuth Land Surveys Limited, 2017

¹⁴ As-built survey information provided by Knights Brown, August 2025.



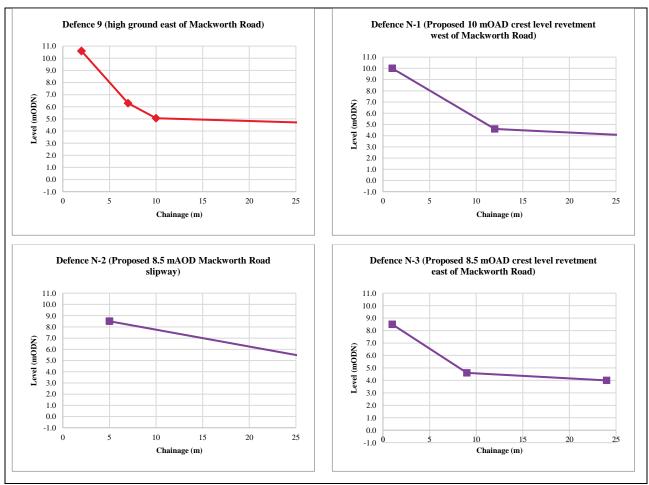


Figure 7: Schematised defence profiles

During the overtopping work for the detailed design of the eastern promenade¹⁵ it was investigated if the EurOtop empirical formulae approach or neural network approach should be adopted. The empirical formulae approach was found to be preferred. This was due to the neural network approach found to not well represent incident wave obliquity following diffraction around the western due to a lack of oblique wave tests in the database which the neural network tool is based on.

EurOtop generally provides two sets of equations corresponding to the 'mean value approach' and 'design or assessment approach'. The latter is equivalent to the mean value + 1 standard deviation and is recommended for design, therefore implemented in the current analysis. This is consistent with the approach adopted in the Eastern Promenade wave overtopping assessment and previous work to define the required crest level of the terraced revetment.

The seabed (beach) levels at the structure toe have been taken survey data from 2017, conducted by Azimuth Land Surveys Limited and it is assumed that they are unchanged. The overtopping assessment is based on the assumption that beach draw-down is limited in the longer term and therefore any level variations at the frontage which could affect wave overtopping around the Bay are likely to only be a function of the change in tidal events with SLR. Lowering of the foreshore may results in increased wave height where the water depth can be a limiting factor and it is recommended sensitivity testing take place in the detailed design stage of the proposed terraced revetment.

¹⁵ Porthcawl Sandy Bay Coastal Scheme - Eastern Promenade Wave Overtopping Technical, Arup 2019

¹⁶ Porthcawl Conceptual Understanding - Porthcawl PAR, ABPmer, 2017

Roughness factor for the terraced revetment of 0.6 has been adopted from the previous overtopping crest level assessment¹⁷. It should be noted that this assessment identified that during further design stages physical modelling could be used to investigate uncertainty with the roughness factor and potentially could lead to a slightly lower crest level to continue to meet the required wave overtopping performance. For the existing partially stepped revetement along Coney Beach (defence profile 7) a roughness factor of 0.8 was applied.

4.6.3 Overtopping hydrographs

All wave and water level pairs provided from the joint probability assessment have been assessed, the overtopping volumes for each defence profile have been calculated to identify the worst-case pairing at each profile for each scenario. Whilst this is a conservative approach, the alternative approach, of selecting the worst-case overtopping volume across the whole frontage for each scenario, creates high uncertainty due to it being unknown where the volume ends up, i.e. there could be a dominating volume at one defence profile which returns to the sea rather than causing flood risk.

Overtopping volumes were based on a total of still water level overtopping volume (or 'overflow') and wave overtopping volume. To calculate the overtopping volumes where still water level exceeds the crest the weir formula for a broad crested weir has been applied from EurOtop.

Where frontages exist that have not been assessed for wave overtopping, i.e. the harbour, which is sheltered from wave action, maximum extreme still water levels have been applied.

To estimate overtopping volumes during a storm event, idealised overtopping hydrographs have been generated for each scenario at each defence. The hydrographs were prepared using Environment Agency guidance.¹⁸

A design tide hydrograph was constructed using a base astronomical tide extracted from Admiralty Total Tide software for Porthcawl. This was combined with a scaled Mumbles design surge shape profile taken from Environment Agency Coastal Flood Boundary Conditions 2018 so the water level of the overtopping event matches the peak water level of the tide hydrograph.

The wave overtopping component is only considered to occur for a 12hr period over the main surge peak. This avoids a situation where a large wave height from a storm is assumed to occur for the whole duration of the hydrograph, which is an unrealistic representation of storm duration.

4.6.4 Application of boundary conditions in the hydraulic model

4.6.4.1 Sea Water Level

The sea water levels are applied for each of the frontage sections defined during the overtopping calculations using a TUFLOW 2D BC layer. The sea water level profiles in the Business as Usual and Proposed 1 scenarios are shown in Figure 8 and Figure 9.

The peak sea water levels along each frontage section for the Business as Usual and Proposed 1 scenarios are shown in Table 3 and Table 4.

Table 3: BaU Peak Sea Water Levels

Frontage Section	2026 T0200 (mAOD)	2026 T1000 (mAOD)	2126 T0200HC (mAOD)	2126 T1000HC (mAOD)	2126 T0200UE (mAOD)	2126 T1000UE (mAOD)
SWL_Defence_1	5.70	6.00	7.30	7.63	7.69	8.02
SWL_Defence_2	5.70	5.10	7.30	7.63	7.69	8.02

¹⁷ Overtopping Calculations - Coney Beach Proposed Revetment, Arup, 2022.

¹⁸ Coastal flood boundary conditions for the UK: update 2018 - User guide, Environment Agency, 2019

Frontage Section	2026 T0200 (mAOD)	2026 T1000 (mAOD)	2126 T0200HC (mAOD)	2126 T1000HC (mAOD)	2126 T0200UE (mAOD)	2126 T1000UE (mAOD)
SWL_Defence_3	5.70	5.10	6.65	6.15	7.04	7.39
SWL_Defence_4	5.70	5.10	6.65	6.15	7.04	7.39
SWL_Defence_5	6.15	6.34	7.05	7.00	7.04	7.39
SWL_Defence_6_1, SWL_Defence_6_2, SWL_Defence_6_3, SWL_Defence_6_4, SWL_Defence_6_5	6.40	6.53	7.30	7.34	7.44	7.73
SWL_Defence_7_1, SWL_Defence_7_2, SWL_Defence_7_3, SWL_Defence_7_4	6.15	6.34	7.30	7.34	7.44	7.73
SWL_Defence_8_1, SWL_Defence_8_2	6.40	6.72	7.30	7.34	7.69	8.02
SWL_Defence_9	6.40	6.53	7.05	7.63	7.69	8.02
SWL_Other_1, SWL_Other_2, SWL_Other_3	6.55	6.96	7.60	8.01	7.99	8.40

Table 4: Proposed 1 Peak Sea Water Levels

Frontage Section	2026 T0200 (mAOD)	2026 T1000 (mAOD)	2126 T0200HC (mAOD)	2126 T1000HC (mAOD)	2126 T0200UE (mAOD)	2126 T1000UE (mAOD)
SWL_Defence_1	5.70	6.00	7.30	7.63	7.69	8.02
SWL_Defence_2	5.70	5.10	7.30	7.63	7.69	8.02
SWL_Defence_3	5.70	5.10	6.65	6.15	7.04	7.39
SWL_Defence_4	5.70	5.10	6.65	6.15	7.04	7.39
SWL_Defence_5	6.15	6.34	7.05	7.00	7.04	7.39
SWL_Defence_N1	6.15	6.34	7.05	7.00	7.04	7.39
SWL_Defence_N2	6.15	6.53	7.05	7.34	7.44	7.73
SWL_Defence_N3	6.15	6.53	7.05	7.34	7.44	7.73
SWL_Defence_9	6.40	6.53	7.05	7.63	7.69	8.02
SWL_Other_1, SWL_Other_2, SWL_Other_3	6.55	6.96	7.60	8.01	7.99	8.40

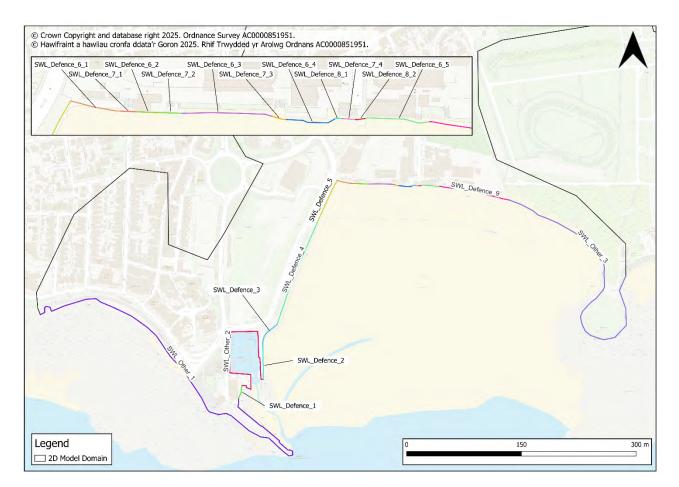


Figure 8: BaU sea water level profiles

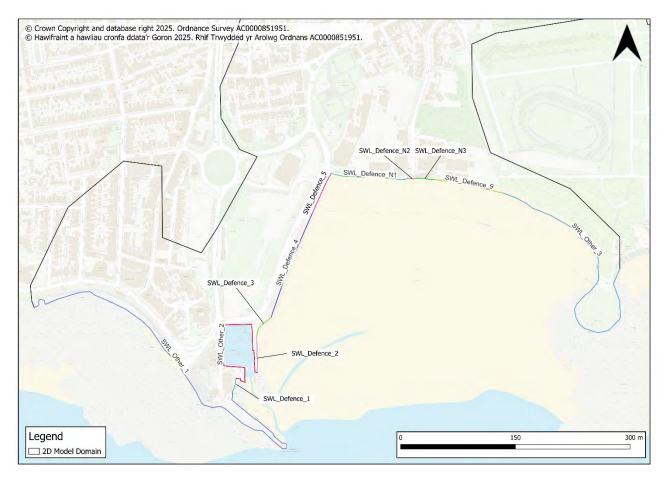


Figure 9: Proposed 1 sea water level profiles

In the model, applying the full tidal cycle resulted in large mass balance error values due to the large and rapid changes in volume in the model associated with the transitions from low tide to high tide. This issue was resolved by setting a minimum water level of 6.37mAOD which corresponds to the extreme water level in 2026 for a 1.3% AEP event (including sea level rise to the 70th percentile), as calculated by ABPmer as part of the wave modelling exercise. This does not have an impact on flooding as this level is still approximately 0.3m below the lowest ground level around the harbour.

The sea water level hydrographs have a total duration of 36 hours to include one tidal peak on each side of the main tidal peak (three tidal peaks in total). An example of sea water level hydrograph for the 2126 Business as Usual 0.1% AEP tidal event with Upper End climate change allowance is shown in Figure 10.

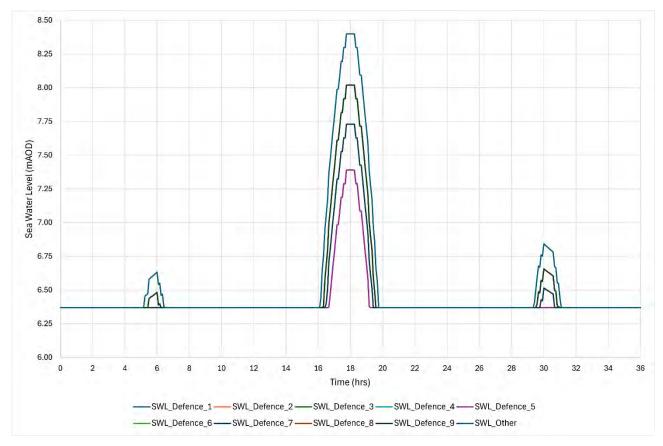


Figure 10: BaU 2126 T1000UE - Sea water level hydrographs

4.6.4.2 Wave Overtopping Flows

The wave overtopping flows are applied for each of the frontage sections defined during the overtopping calculations using a TUFLOW 2D SA layer. The wave overtopping profiles are located landward of the existing defences or proposed developments in order to ensure the overtopping flows propagate landwards as intended. The wave overtopping profiles in the Business as Usual and Proposed 1 scenarios are shown in Figure 11 and Figure 12.

The peak wave overtopping flows along each frontage section for the Business as Usual and Proposed 1 scenarios are shown in Table 5 and Table 6.

The wave overtopping flows have been calculated in L/m/s therefore, for each frontage section, they are multiplied by the length of the section and divided by a factor of 1000 in order to convert them to m³/s. This is achieved using commands within the TUFLOW 2D BC database.

Table 5: BaU Peak Wave Overtopping Flows (L/m/s)

Frontage Section	2026 T0200 (mAOD)	2026 T1000 (mAOD)	2126 T0200HC (mAOD)	2126 T1000HC (mAOD)	2126 T0200UE (mAOD)	2126 T1000UE (mAOD)
SWL_Defence_1	12.99	36.65	57.53	57.53	57.53	57.53
SWL_Defence_2	0.11	0.46	18.83	110.48	110.48	110.48
SWL_Defence_3	0.03	0.34	0.59	1.08	1.29	4.81
SWL_Defence_4	0.02	0.02	0.10	0.32	0.47	2.36
SWL_Defence_5	0.00	0.00	0.06	0.42	0.50	3.40
SWL_Defence_6_1, SWL_Defence_6_2, SWL_Defence_6_3, SWL_Defence_6_4, SWL_Defence_6_5	0.31	2.43	117.90	224.75	290.15	484.35

Frontage Section	2026 T0200 (mAOD)	2026 T1000 (mAOD)	2126 T0200HC (mAOD)	2126 T1000HC (mAOD)	2126 T0200UE (mAOD)	2126 T1000UE (mAOD)
SWL_Defence_7_1, SWL_Defence_7_2, SWL_Defence_7_3, SWL_Defence_7_4	0.00	0.00	16.48	49.94	76.71	182.55
SWL_Defence_8_1, SWL_Defence_8_2	1.62	27.22	330.32	363.31	340.99	302.26
SWL_Defence_9	0.00	0.00	0.00	0.89	1.54	14.19

Table 6: Proposed 1 Peak Wave Overtopping Flows (L/m/s)

Frontage Section	2026 T0200 (mAOD)	2026 T1000 (mAOD)	2126 T0200HC (mAOD)	2126 T1000HC (mAOD)	2126 T0200UE (mAOD)	2126 T1000UE (mAOD)
SWL_Defence_1	12.99	36.65	57.53	57.53	57.53	57.53
SWL_Defence_2	0.11	0.46	18.83	110.48	110.48	110.48
SWL_Defence_3	0.03	0.34	0.59	1.08	1.29	4.81
SWL_Defence_4	0.02	0.02	0.10	0.32	0.47	2.36
SWL_Defence_5	0.00	0.00	0.06	0.42	0.50	3.40
SWL_Defence_N1	0.00	0.01	1.04	3.94	4.89	15.25
SWL_Defence_N2	0.07	0.82	26.54	68.30	85.37	180.95
SWL_Defence_N3	0.47	3.48	69.40	153.88	185.06	349.22
SWL_Defence_9	0.00	0.00	0.00	0.89	1.54	14.19

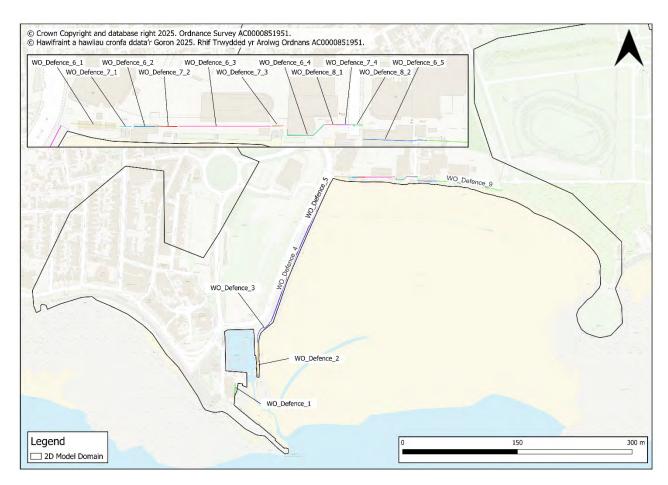


Figure 11: BaU wave overtopping profiles

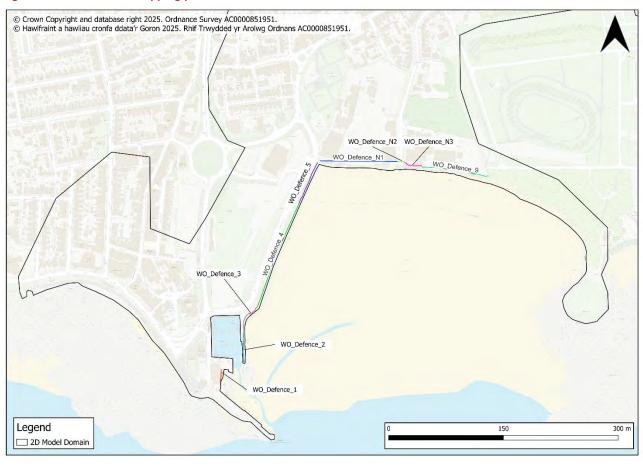


Figure 12: Proposed 1 wave overtopping profiles

5. With Scheme Model Development

5.1 Proposed scheme

5.1.1 Proposed 1

The proposed development comprises of new homes, businesses and leisure facilities and is supported by infrastructures such as the coastal defences, new access roads, car parks and provision of public open spaces, as shown in Figure 13.



Figure 13: Extract of Masterplan exhibition boards (https://porthcawlwaterfront.co.uk – earlier version which differs slightly from Proposed 1)

5.2 Representation in flood inundation model

5.2.1 Proposed 1

Partners Limited

The proposed developments included in Proposed 1 are shown in Figure 14. Proposed 1 includes newly developed features (buildings, car parks, a park and a road) and reprofiled ground levels.

Stantec on behalf of BCBC provided a drawing containing the proposed developments for Option 1 (PR-HYD-XX-XX-M3-C-0820_Proposed Surface) as well as a CSV file containing level data to inform the elevation of the proposed developments.

A DEM raster of the proposed road was generated based on the provided elevation points and using Triangulated Irregular Network (TIN) interpolation.

The buildings, car parks, park and reprofiled ground level areas were enforced in the 2D TUFLOW hydraulic model using 2D Z Shapes. The Z attribute was set to a constant value in case the proposed level was constant across the footprint of the development (flat profile), otherwise for developments with sloping profiles, the Z attribute was set to -99999 and points with the proposed elevations were snapped around the boundary of the

polygon representing the development, allowing TUFLOW to interpolate levels within the polygon boundary. The Shape_Option attribute was set to 'NO MERGE' to avoid proposed levels being merged with existing terrain levels (based on LiDAR).

The two southernmost buildings have underground car parks accessible via a 6m-wide ramped entrance. For the purposes of the FCA it was deemed necessary to represent the basements in the model. A tailored approach was adopted to enforce the levels of those buildings: the internal level of each building was set to the basement level, but a thick line set to the ground floor level was digitised around the boundary of the building with a 6m-wide gap representing the car park entrance. With this approach, when the flood water level is lower than the ground floor level, flood water can only enter the building via the car park entrance and flood the basement. When the flood water level is higher than the ground floor level, flood water can enter the building from any direction.

Finally, a separate TUFLOW 2D Material layer containing the Manning's n roughness values to be applied to the newly proposed developments was created and read by the model, locally overwriting the Manning's n roughness values applied in the Business as Usual scenario.

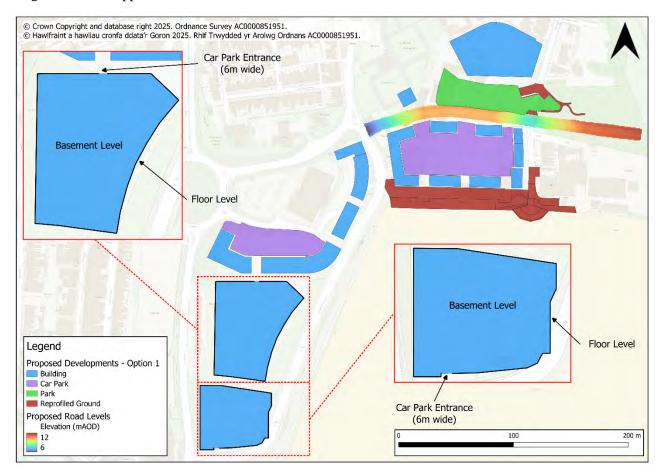


Figure 14: Proposed developments - Proposed 1

6. Model results

6.1 Model performance and stability

Default TUFLOW simulation parameters were used and a timestep of 1 second was applied; this is appropriate for a 2m resolution model. Timeseries model results were saved at 15 minute intervals and maximums were tracked for every timestep.

The cumulative mass balance error gives an indication of the computational performance of the model, with values within \pm 1% considered acceptable. The cumulative mass balance error for Business as Usual simulations ranges from -0.47% and 0.41% and the cumulative mass balance error for Proposed simulations ranges from -0.41% and 0.31%, therefore the model performance is considered acceptable, and the model is considered stable.

An example of cumulative mass balance error for the 2026 Business as Usual 0.5% AEP tidal event is shown in Figure 15. At the beginning of the simulation, when tidal water first wets the 2D model cells, the mass balance error is slightly larger than 1% in absolute value but it quickly stabilises within \pm 1% and stays in that interval until the end of the simulation.

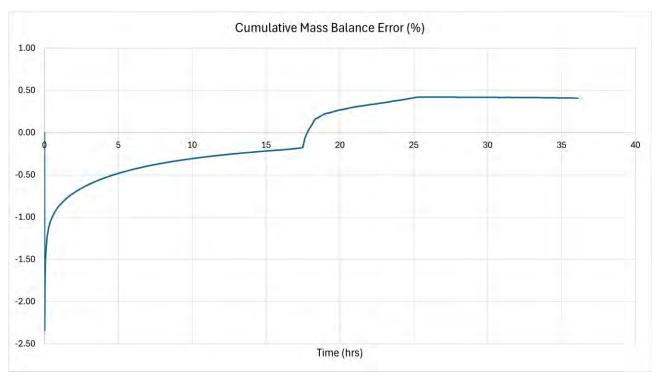


Figure 15: Cumulative mass balance error plot for the BaU 2026 T0200 event

6.2 Baseline model results

Model results for present day climate change conditions (2026) are shown in Figure 16 below. This shows flooding along the Eastern Breakwater south of the harbour, for the northern portion of Eastern Promenade near Griffin Park and at Sandy Bay, along the frontage near Mackworth Road. For the area south of the harbour, the maximum flood depths are shallow and typically below 5cm for both the 0.5% AEP and 0.1% AEP flood events. The maximum flood depths along the Sandy Bay frontage are also shallow (less than 5cm) and the maximum flood extents are limited to the area immediately near the frontage although some flood water runs down to the West of the frontage and floods a small portion of the Eastern Promenade and Griffin Park. In the 0.1% AEP event, the maximum flood extents go as far as 60m landwards along Mackworth Road. There is also limited flooding on the Eastern Promenade pedestrian walkway, which is due to a limited amount of wave overtopping ponding behind the Eastern Promenade flood defence (there is drainage here introduced in the Eastern Promenade scheme not represented in the model).

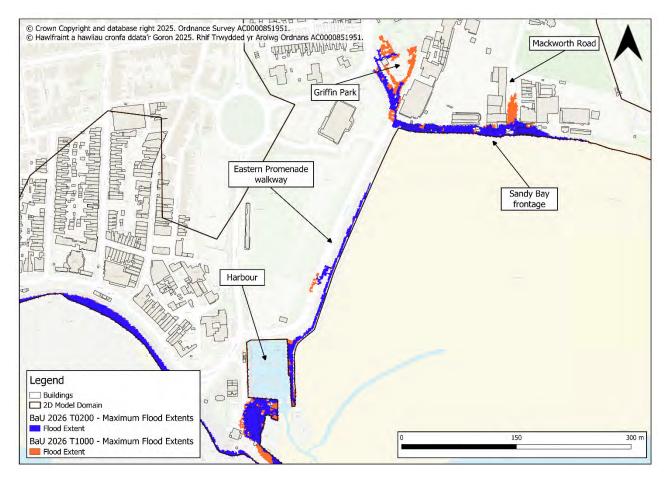


Figure 16: BaU present day maximum flood extents

Model results for the future epoch climate change conditions (2126 with Higher Central allowance) are shown in Figure 17 below. This shows larger flood extents than in the present day epoch. There is extended flooding along the Eastern Promenade walkway, with maximum flood depths of approximately 20cm for the 0.5% AEP event and 70cm for the 0.1% AEP event. For the low-lying areas North of the harbour, the maximum flood depths are of approximately 60cm for the 0.5% AEP event and 190cm for the 1% AEP event. The flooding also extends further North of Sandy Bay following two main flow paths, one running down the Eastern Promenade and New Road with flooding extending as far as Nicholls Avenue for the 0.5% AEP event and beyond Woodland Avenue for the 0.1% AEP event, and the other running down Mackworth Road. The maximum flood depths along Eastern Promenade / New Road are of approximately 45cm in the 0.5% AEP event and 50cm in the 0.1% AEP event whereas the maximum flood depths along Mackworth Road are of approximately 80cm in the 0.5% AEP event and 90cm in the 0.1% AEP event.

Maximum flood depth and flood hazard maps for all simulated flood events are included in Appendix C.

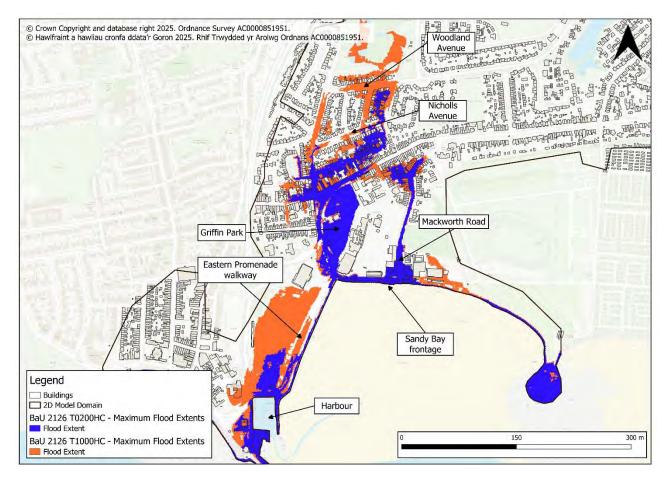


Figure 17: BaU future epoch (Higher Central allowance) maximum flood extents

6.3 With scheme model results

6.3.1 Proposed 1

Model results for present day climate change conditions (2026) are shown in Figure 18 below. This shows that when comparing to the Business as Usual, overall, the maximum flood extents are reduced due to reduced overtopping at Sandy Bay. There is some flooding along Mackworth Road and new flooding to the Buccaneers public house to a maximum depth of 0.08m in the 0.5% AEP flood event and 0.25m in the 0.1% AEP flood event.

The new flooding to the Buccaneers public house is mainly due to the updated ground profile at the Sandy Bay frontage and southern end of Mackworth Road which results in more flooding for events in which wave overtopping is the main driver. In the Business as Usual, the profile between the Sandy Bay frontage and the Buccaneers public house is sloped seaward so the injected wave overtopping flows have to overcome the adverse slope to get to the building. However, in the Proposed 1, the Sandy Bay frontage and southern end of Mackworth Road are raised to a level higher than the floor level of the Bucanners public house therefore, injected wave overtopping flows, although smaller than in the Business as Usual, can run down the landward slope to reach the building. It should be noted that the model includes no subsurface drainage which could mitigate this.

Similarly to the Business as Usual, there is also a very limited amount of flooding on the Eastern Promenade pedestrian walkway, which is due to a limited amount of wave overtopping ponding behind the Eastern Promenade flood defence (there is drainage here introduced in the Eastern Promenade scheme not represented in the model).

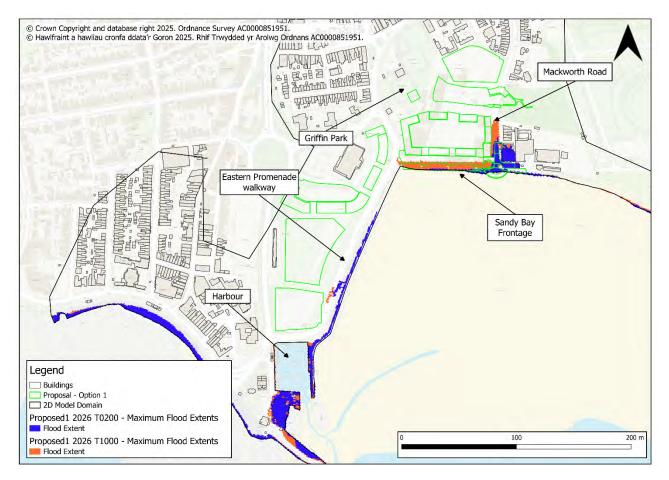


Figure 18: Proposed 1 present day maximum flood extents

Model results for the future epoch climate change conditions (2126 with Higher Central allowance) are shown in Figure 19 below. This shows that when comparing to the Business as Usual, overall, the maximum flood extents are significantly reduced due to reduced overtopping at Sandy Bay. None of the proposed developments will be flooded, except from the new building located immediately North of the harbour. Flooding enters this building from the 6m-wide car park entrance and floods the basement to a maximum depth of 0.25m for the 0.5% AEP flood event and 3.01m for the 0.1% AEP flood event. The proposed scheme also causes increased flooding to the Buccaneers public house (for the same reason as in the present day conditions), near Mackworth Road, to a maximum depth of 0.53m for the 0.5% AEP flood event and 0.64m for the 0.1% AEP flood event.

Maximum flood depth and flood hazard maps for all simulated flood events are included in Appendix D.

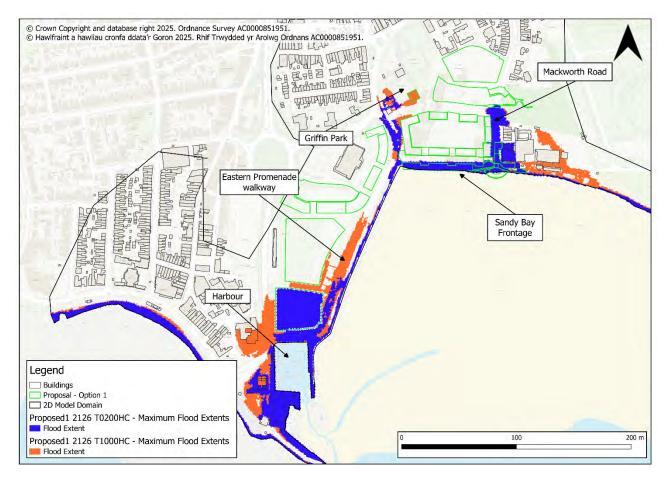


Figure 19: Proposed 1 future epoch (Higher Central allowance) maximum flood extents

6.4 Impact on flood risk

6.4.1 Proposed 1

For the present day climate change conditions (2026), a comparison of maximum flood depths between Proposed 1 and Business as Usual is shown in Figure 20 and Figure 21. For the 0.5% AEP flood event, flooding is removed from the northern end of the Eastern Promenade and Griffin Park. Near Mackworth Road, there is additional flooding to the Buccaneers public house which is now flooded by depths of up to 0.08m where previously there was no flooding.

For the 0.1% AEP flood event, flooding is removed from the northern end of the Eastern Promenade and Griffin Park. Near Mackworth Road, there is additional flooding to the Buccaneers public house which is now flooded by depths of up to 0.25m.

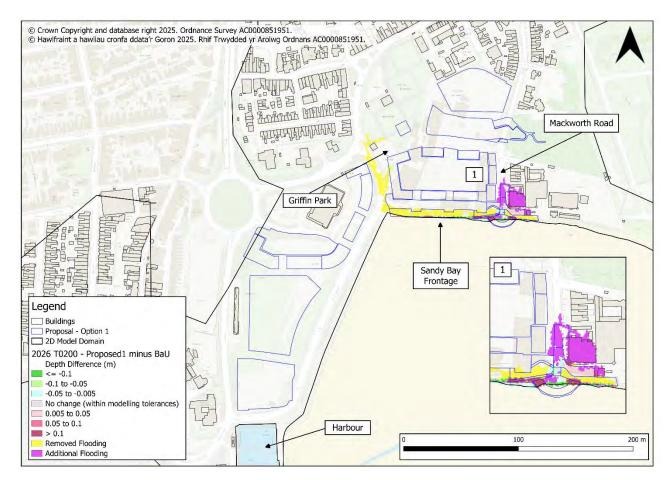


Figure 20: 2026 T0200 Impact Map

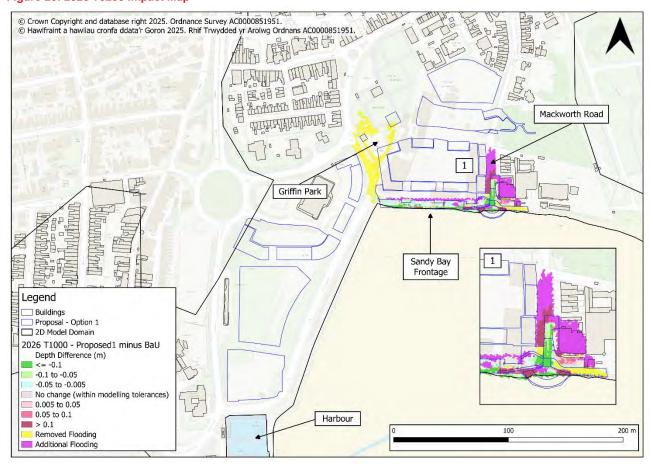


Figure 21: 2026 T1000 Impact Map

For the future epoch climate change conditions (2126 with Higher Central allowance), a comparison of maximum flood depths between the Proposed Option 1 and Business as Usual is shown in Figure 22 and Figure 23. For the 0.5% AEP flood event, flooding is removed for Griffin Park and areas located further North and for the northern part of Mackworth Road. Near Mackworth Road, there is an increase in maximum flood depths to the Buccaneers public house by up to 0.54m. There is also an increase in maximum flood depths for the newly proposed building immediately North of the harbour and for the portion of Eastern Promenade located between the harbour and that building. In this area, maximum flood depths increase by up to 0.03m. This is due to the floor level of the newly proposed building being higher than the existing ground levels in this area and therefore, some of the tidal flooding is retained between the harbour and the building.

For the 0.1% AEP flood event, flooding is removed for Griffin Park and areas located further North and for the northern part of Mackworth Road. Near Mackworth Road, there is an increase in maximum flood depths to the Buccaneers public house by up to 0.61m. There is also an increase in maximum flood depths for the newly proposed building immediately North of the harbour, for the portion of Eastern Promenade located between the harbour and that building and for the Glamorgan Holiday Home at the southern end of the Eastern Promenade. In those areas, maximum flood depths increase by up to 0.06m. This is due to the floor level of the newly proposed building being higher than the existing ground levels in this area and therefore, some of the tidal flooding is retained between the harbour and the building.

Impact maps for all simulated flood events are included in Appendix E.

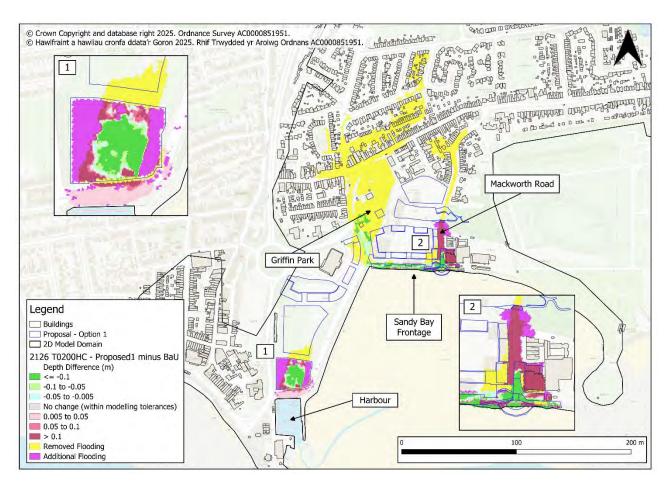


Figure 22: 2126 T0200HC Impact Map

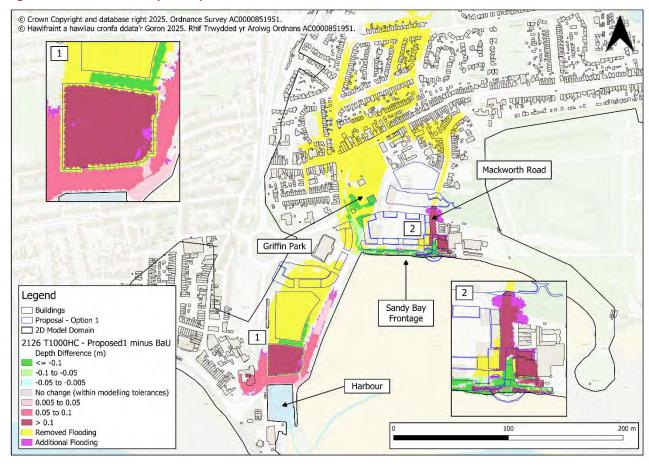


Figure 23: 2126 T1000HC Impact Map

7. Assumptions and Limitations

A two-dimensional (2D) hydraulic model was selected as being the most appropriate type of model for representing flood inundation caused by overtopping of the frontage. This type of model is able to represent overland flow routes and determine the spatial variation in flood depths and velocities across the study area. However, this model does not have the ability to replicate the complex hydrodynamic interactions associated with wave overtopping (such as splashes), the wave overtopping flows are simply injected along the frontage.

There is little information with which to validate the model. Therefore, given the lack of validation information, there is a certain level of uncertainty associated with the model results.

The hydraulic model developed represents inundation from overtopping of the frontage; it does not include any representation of surface water flooding due to rainfall. The hydraulic model does not include any representation of the subsurface drainage/sewerage infrastructure or drainage holes through the Eastern Promenade parapet walls. This infrastructure could reduce flood extents and flood depths; this effect would be significant where flood volumes are relatively small. As such, the hydraulic model represents a conservative situation where no spare capacity in the drainage network is assumed.

It is noted that the Flood Map for Planning³ suggests there is a flow route extending west from Newton, to the east of Sandy Bay, towards the Proposed Development. The flood modelling does not consider explicitly coastal/tidal flood risk from around Newton. The Flood Map for Planning suggests that there is a narrow potential flow route at a low spot on a public footpath between 24 Beach Road and Bryneglwys Avenue. However, based on the available lidar data, the narrow flow pathway crest level is approximately 7.9 mAOD, compared against a 7.6 mAOD predicted water level for a 0.5% AEP event in 2126 (Higher Central climate change allowance). And so, the flood cell at Newton is considered a separate issue.

8. Conclusions

Flood modelling has been undertaken to assess flood risk from tidal / coastal overtopping along Sandy Bay and Eastern Promenade both now and in the future. Business as Usual and Proposed 1 options have been simulated for two return period events (0.5% AEP and 0.1% AEP). Proposed 1 includes various new developments landward of Sandy Bay and the Eastern Promenade.

The existing 2D hydraulic model was updated to include latest available data:

- Latest 1m resolution LiDAR DEM covering the study area was used to inform ground elevations;
- As-built levels corresponding to the strengthening works of the Eastern Promenade defences were enforced in the model:
- Latest OS Master Map provided by BCBC was used to inform the location of buildings and the 2D surface roughness;
- Updated sea water level and wave overtopping hydrographs were derived for two climate change epochs, present day (2026) and future (2126).

For Proposed 1, the proposed developments were enforced in the 2D hydraulic model using a combination of 2D Z Shapes and DEM raster data. The 2D hydraulic model was run using the latest version of the TUFLOW software.

Model results for the Business as Usual option show that the main flooding mechanisms are overtopping of the Sandy Bay frontage with flooding running down two main flood routes, one running down the end of Eastern Promenade and New Road and the other running down Mackworth Road and overtopping of the Eastern Promenade immediately North of the harbour, which causes flooding of the low-lying area North of the harbour.

With the proposed scheme in place, model results show a reduction in maximum flood depths and extents North of Sandy Bay due to the reduced overtopping of the Sandy Bay frontage. There is basement flooding for one of the new buildings in the future climate change epoch (higher central allowance) and additional flooding to the Buccaneers public house along Mackworth Road.

Appendix A

2017 Flood Inundation Modelling Report

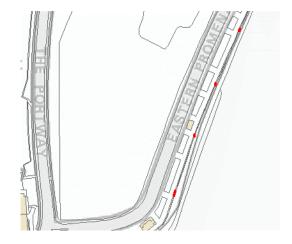
ARUP

		D. Ven Der Lour	Il Cuphell	But Ruln
		D. Von Der Lour	Pl Call	Pl Cyll
				✓

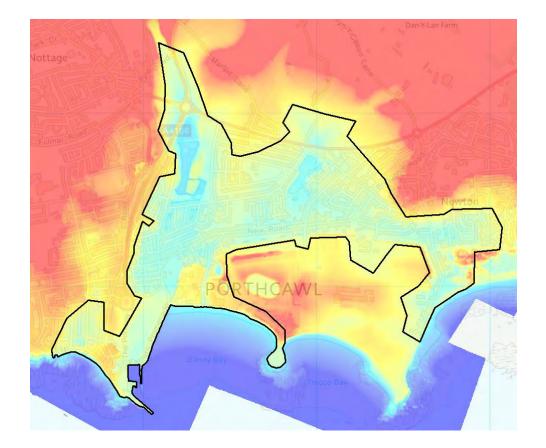








might be





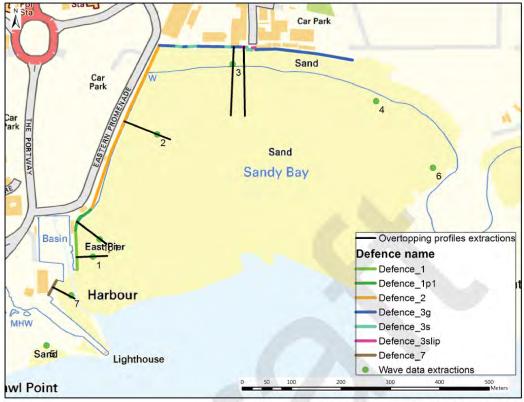
 0

0

0

n



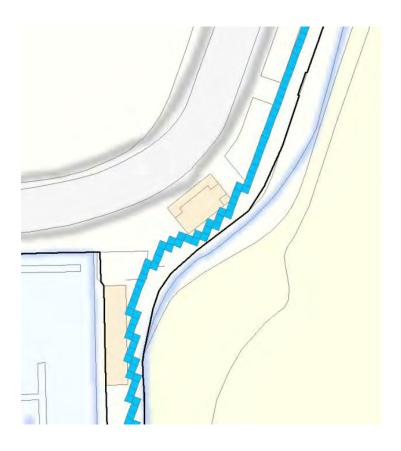


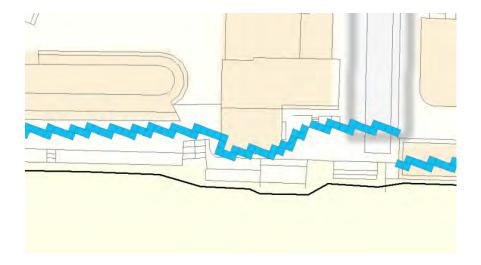
Contains Ordnance Survey data © Crown copyright and database right 2016)

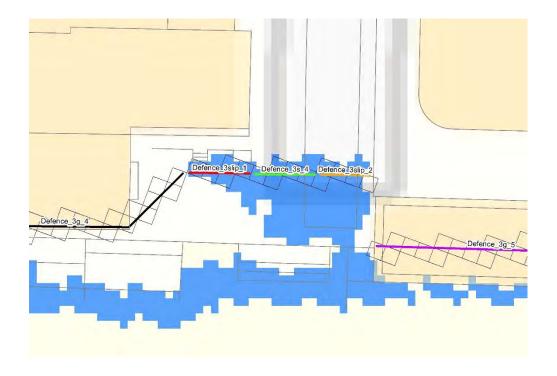
1,668	1,043	2,037	15,840	37	9,695	50
3,984	3,502	5,575	32,038	196	18,350	144
4,569	4,589	7,149	36,465	239	20,553	176
4,984	5,537	8,523	39,696	270	22,121	201
5,985	8,610	12,990	47,798	347	25,918	271
8,316	23,196	34,344	68,476	538	34,837	503

8,221	125,269	268,138	0	0	0	60,931	
18,474	194,394	460,884	0	0	4	90,730	
21,057	213,146	515,449	0	0	5	98,943	
22,889	226,796	555,766	0	0	7	104,954	
27,305	260,903	658,673	0	0	10	120,095	
37,557	347,183	932,442	0	0	26	159,115	

10,066	286,215	795,976	18,479	133	6,107	101,966	
24,732	404,594	1,453,003	32,414	594	11,477	143,805	
31,031	435,096	1,674,915	36,817	811	13,206	156,313	
36,455	456,906	1,849,561	40,200	1,003	14,544	165,734	
53,749	510,037	2,337,782	49,330	1,649	18,191	190,455	
132,486	636,628	3,951,741	77,087	4,973	29,546	260,676	









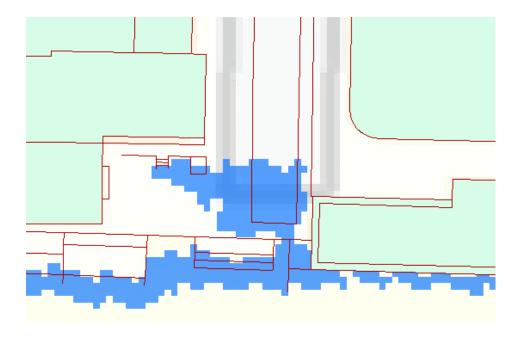


















| Issue | 15 March 2017

Page 26

Page 27





| Issue | 15 March 2017

Page B1

4-50 | Draft 1 | 1 February 2017

Appendix B

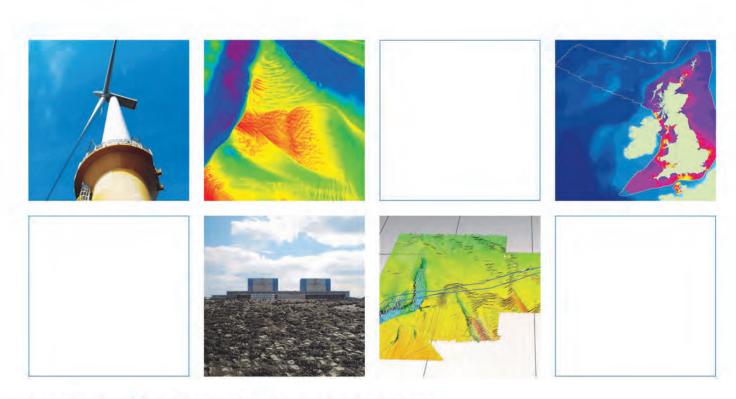
Porthcawl Coney Beach Wave Modelling Report

Arup

Porthcawl Coney Beach

Wave Modelling

September 2025



Innovative Thinking - Sustainable Solutions

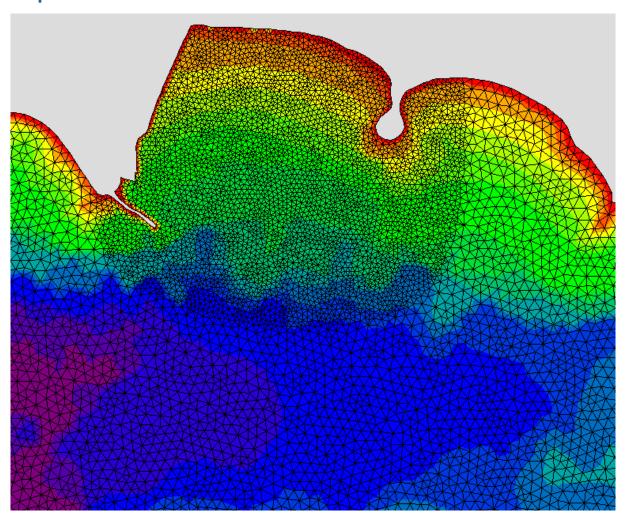


Page intentionally left blank

Porthcawl Coney Beach

Wave Modelling

September 2025



Document Information

Document History	y and Autho	risation		
Title	Porthcawl Co	ney Beach		
	Wave Modell	ing		
Commissioned by	Arup			
Issue date	September 2	025		
Document ref	R.4937			
Project no	R/5632/02	R/5632/02		
Date	Version	Revision Details		
25/07/25	1	Issued for client review		
21/08/25	2	Issued for client review Results for additional output locations provided in Addendum		
12/09/25	3 Issued for client review. Updated to correct minor typos in Addendum			

Prepared	Approved	Authorised
Helen Godwin	Adam Fulford	Heidi Roberts
Handwi	Hotel	ellotate

Suggested Citation

ABPmer, (2025). Porthcawl Coney Beach, Wave Modelling, ABPmer Report No. R.4937. A report produced by ABPmer for Arup, September 2025.

Notice

ABP Marine Environmental Research Ltd ("ABPmer") has prepared this document in accordance with the client's instructions, for the client's sole purpose and use. No third party may rely upon this document without the prior and express written agreement of ABPmer. ABPmer does not accept liability to any person other than the client. If the client discloses this document to a third party, it shall make them aware that ABPmer shall not be liable to them in relation to this document. The client shall indemnify ABPmer in the event that ABPmer suffers any loss or damage as a result of the client's failure to comply with this requirement.

Sections of this document may rely on information supplied by or drawn from third party sources. Unless otherwise expressly stated in this document, ABPmer has not independently checked or verified such information. ABPmer does not accept liability for any loss or damage suffered by any person, including the client, as a result of any error or inaccuracy in any third party information or for any conclusions drawn by ABPmer which are based on such information.

All content in this document should be considered provisional and should not be relied upon until a final version marked 'issued for client use' is issued.

All images on front cover copyright ABPmer.

ABPmer

Quayside Suite, Medina Chambers, Town Quay, Southampton, Hampshire SO14 2AQ T: +44 (0) 2380 711844 W: http://www.abpmer.co.uk/

Contents

1	Introduction		1
2		Sources	
	2.1	Coastal Flood Boundary Dataset	
	2.2	UK Climate Projections	
	2.3	ABPmer Regional Wave Hindcast	2
3	Meth	odology	4
	3.1	Extreme Water Levels	4
	3.2	Joint Probability Analysis	
	3.3	Local Wave Modelling	10
4	Sumr	nary and Conclusions	15
5	Refer	ences	16
Adde	endum		
Α	Addit	ional Modelling	18
Table	es		
Table	1.	Summary of SW Hindcast Setup	3
Table	2.	Comparison of CFBD 2008 and CFBD 2018 values	
Table	3.	Sea Level Rise guidance values based on UKCP18 RCP8.5	
Table	4.	Extreme water levels, including sea level rise*	6
Table	5.	Extreme Wave Conditions at Nearshore JPA point	7
Table	6.	2026 Joint Probability Pairs with Associated Peak Period (Tp) - RCP8.5 70th	
		Percentile	9
Table	7.	2126* Joint Probability Pairs and Associated Peak Period (Tp) - RCP8.5 70th	
		Percentile	9
Table	8.	2126* Joint Probability Pairs and Associated Peak Period (Tp) – RCP8.5 95 th	
		Percentile	9
Table		Key Model Parameters for Local SW Model	
Table		Location of Coney Beach extraction points	
Table		Inshore wave conditions for 2026	
Table		Inshore Wave Conditions for 2126, RCP8.5 70 th Percentile SLR	
Table		Inshore Wave Conditions for 2126, RCP8.5 95 th Percentile SLR	
Table		Location of quay wall extraction points	
Table		Inshore wave conditions for 2026	
Table		Inshore Wave Conditions for 2126, RCP8.5 70 th Percentile SLR	
Table	A4.	Inshore Wave Conditions for 2126, RCP8.5 95th Percentile SLR	21

Figures

Figure 1.	CFBD Chainage Location 462	4
Figure 2.	UKCP18 Tile 51.50°N, 3.75°W for Porthcawl	
Figure 3.	2026 JPA Contours (Sector 225° to 255°)	
Figure 4.	2126 JPA Contours (Sector 225° to 255°)	8
Figure 5.	Local SW Model Mesh, Showing Extent of Model	
Figure 6.	Local SW model extraction locations	
Figure A1.	Additional local SW model extraction locations	18

1 Introduction

ABPmer was previously commissioned by Ove Arup and Partners Ltd. ('Arup') to undertake detailed wave modelling, Joint Probability Analysis (JPA) and provide dune management coastal process support for Sandy Bay, Porthcawl. The work was undertaken to support detailed design of the Eastern Promenade, Sandy Bay and improvement works to the Western breakwater, on behalf of Bridgend County Borough Council (BCBC). The work undertaken previously is described in ABPmer (2019).

This present report describes additional work undertaken for Coney Beach, Sandy Bay. This new study updates the JPA and local modelling undertaken previously to bring it into line with the latest Welsh Government recommendations (Welsh Government, 2022). The specific changes from Welsh Government (2022) are as follows:

- Previous water levels were taken from Environment Agency's (EA's) Coastal Flood Boundary Dataset 2008 (CFBD08); this has since been updated and replaced by CFBD 2018 (CFBD18) and these extreme levels have been used in the JPA for this new study instead.
- Sea level rise (SLR) was accounted for in the previous work by using UK Climate Projections 2009 (UKCP09) medium emissions case. This was noted in ABPmer (2019) to differ from the (current, at the time) recommendations in Welsh Government (2017). Since the report was produced, updated recommendations have been published in Welsh Government (2022) and SLR has been applied in this new study following these latest recommendations.
- In ABPmer (2019) two epochs were defined: the base year, 2020, and the design horizon, 2120. In this latest work, these epochs are updated to a base year of 2026 and a design horizon of 2126.

These changes have been implemented at the nearshore JPA points utilised in the previous study, and new JP pairing events with Annual Exceedance Probabilities (AEP) of 0.5% (200-year return period) and 0.1% (1000-year return period) have been transformed inshore using the detailed local wave model used in the previously study, for epochs 2026 and 2126.

The structure of this report is as follows:

Section 2: Provides an overview of the data sources used in the study.

Section 3: Outlines the employed methodologies in the work.

Section 4: Presents the output of this new work, which is then compared against the results from

ABPmer (2019).

Addendum A: Presents resultant wave conditions at three additional locations in Sandy Bay.

2 Data Sources

2.1 Coastal Flood Boundary Dataset

The 'Coastal Flood Boundary Conditions for UK Mainland and Islands' is a dataset published by the Environment Agency (2019). The dataset provides a set of extreme peak sea levels with annual exceedance probability ranging from 1:1-year to 1:10,000-years. Extreme values are provided at points around the UK coastline with a spacing of about 2 km on the open coast, less in estuarine areas.

The dataset is derived through extreme value analysis of 53 tide gauge datasets around the UK coast. The extreme levels calculated at these gauges were interpolated along the coastline using numerical surge tide models. Further information on both numerical modelling for spatial interpolation and extreme value analysis is provided by Environment Agency (2011).

The version of the coastal flood boundary dataset used in this work is the 2018 update, described by Environment Agency (2019).

2.2 UK Climate Projections

The UK Climate Projections (UKCP) is a set of tools and datasets that illustrate how the UK climate may change in the future. The latest iteration of UKCP is UKCP 2018 (UKCP18). The 'sea level anomalies for marine projections around UK coastline, 2007-2100' for Representative Concentration Pathway (RCP) 8.5 (for information see van Vuuren, *et al.* (2011)), henceforth referred to as UKCP18 for brevity. These data were obtained from the Met Office UKCP data portal¹. The dataset contains annual sea level rise (SLR) anomaly for the years 2007 to 2100 at 5th, 10th, 30th, 33rd, 50th, 67th, 70th, 90th and 95th percentiles.

2.3 ABPmer Regional Wave Hindcast

Regional wave modelling was undertaken to derive a long-term 37-year wave climate at a nearshore location offshore of Sandy Bay, Porthcawl. This hindcast is a refinement of ABPmer's existing MIKE21 Bristol Channel SW model. The refinement was to the mesh where resolution was increased in the vicinity Sandy Bay. Additional detail on the modelling approach is provided by ABPmer (2019), a summary of the model setup is presented in Table 1.

Hindcasts were setup for epochs 2020 and 2120 in the original work, the epoch 2020 case included no sea level rise (SLR) as was representative of present-day conditions. The 2120 epoch hindcast had a +0.76 m adjustment added to water levels to account for SLR. This adjustment was derived from a previous iteration of UK Climate Projections (2009), which was superseded shortly after the study was completed. In an addendum to ABPmer (2019) it was noted that the applied uplift for the 2120 epoch was now 0.35 m below the recommended SLR value from the latest Welsh Government guidance at the time (Welsh Government, 2017). A sensitivity study was therefore undertaken, and it was identified the additional +0.35 m uplift in water levels only resulted in a 0.9% increase in significant wave height (Hs) at the nearshore JPA point. As the 70th percentile SLR in this latest work (Section 3.1.1) is approximately the same as the previous Welsh Government recommendation for 2120, the previous 2120 epoch hindcast has again be used with a 0.9% uplift applied to Hs outputs. Henceforth the two hindcasts are referred to as epoch 2026 and 2126.

_

https://ukclimateprojections-ui.metoffice.gov.uk/ui/home

Table 1. Summary of SW Hindcast Setup

Model Element / Parameter	Detail / Values Used		
Element Mesh	From 7.7 km at boundary to 160 m in study area		
Bathymetry	 GEBCO 		
	 Digitised Admiralty charts 		
	 UKHO INSPIRE data: 		
	LiDAR surveys		
	 Project specific topographic survey 		
Wave Boundary Forcing	ABPmer's SEASTATES hindcast ²		
Water Level Forcing	 Epoch 2020: SEASTATES Tide and Surge 		
	 Epoch 2120: SEASTATES Tide and Surge + SLR from UKCP09 		
Wind Forcing	NCEP CFSR/CFSv2		
Spectral Formulation	Fully spectral, instationary formulation		
Spectral Discretisation	 Logarithmic frequency discretisation; 24 frequency bands 		
	 Directional sector discretisation; 12 sectors 		
Diffraction	Not included		
Wind Formulation	Velocity components varying in time and domain		
Wave Breaking	Specified gamma; 0.8 (default)		
Bed Friction	Constant Nikuradse = 0.04 (default)		
White Capping	Included (defaults)		

https://seastates.net/

3 Methodology

3.1 Extreme Water Levels

Extreme water levels have been taken from the Coastal Flood Boundary Dataset 2018 (CFBD18). These data were accessed via the gov.uk website³. Data from the same location (Point 462; Figure 1) as used in ABPmer (2019) has been applied to this study. The CFBD18 values have a base date of 2008 and are presented in Table 2 alongside the CFBD08 values used in ABPmer (2019) for comparison.

3.1.1 Sea Level Rise Allowance

To take into account sea level rise (SLR) at the site, the latest Welsh Government (2022) recommendations were followed. The guidelines provide a table of SLR value for each local authority area in Wales based on UKCP18, 70th and 95th percentiles. Projections are given for epochs 2100 and 2120. For epochs beyond 2100 the guidelines recommend using allowances from UKCP18, 2007 - 2101 RCP 8.5 dataset, with the average increment for last 5 years (2094 to 2099) being used to extrapolate level beyond 2100. In this work two epochs will be used for design, a base year of 2026 representing present day conditions, and a design horizon year of 2126. Therefore, it was necessary to obtain SLR allowances from the UKCP18, 2007 - 2100 RCP 8.5 dataset, rather than tabulated data in Welsh Government (2022)



Figure 1. CFBD Chainage Location 462

^{3.} https://www.data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018

The UKCP18, 2007 - 2100 RCP 8.5 dataset (Cell 51.50°N, 3.75°W, Figure 2) was used to calculate the SLR from the CFBD18 base year of 2017 to the 2026 and 2126 epochs. The results of these calculations are presented in Table 3 for the 70^{th} and 95^{th} percentile RCP8.5 cases.

Table 2. Comparison of CFBD 2008 and CFBD 2018 values

AEP [%]	Return Period [years]	CFBD (2008) [mODN]	CFBD (2018) [mODN]	Difference [m]
100.00	1	5.59	5.66	+0.07
50.00	2	5.67	5.76	+0.09
20.00	5	5.77	5.90	+0.13
10.00	10	5.86	6.01	+0.15
5.00	20	5.95	6.11	+0.16
4.00	25	5.98	6.14	+0.16
2.00	50	6.07	6.25	+0.18
1.33	75	6.14	6.32	+0.18
1.00	100	6.18	6.37	+0.19
0.67	150	6.25	6.44	+0.19
0.50	200	6.31	6.50	+0.19
0.40	250	6.34	6.54	+0.20
0.33	300	6.38	6.58	+0.20
0.20	500	6.49	6.70	+0.21
0.10	1,000	6.66	6.91	+0.25
0.01	10,000	7.48	8.01	+0.53



Figure 2. UKCP18 Tile 51.50°N, 3.75°W for Porthcawl

Table 3. Sea Level Rise guidance values based on UKCP18 RCP8.5

Period	70 th Percentile	95 th Percentile
2017 to 2026	0.05	0.06
2017 to 2126	1.10	1.49

3.1.2 Final Extreme Water Levels

The final extreme water levels were derived by combining the SLR values from Table 3 with the CFBD18 values (Table 2). The combined values are provided in Table 4. In this table the 70th percentile and 95th percentile SLR values are presented. Welsh Government (2022) advises (in their worked example) that 70th percentile RCP8.5 SLR values represent the design allowance, and 95th percentile values represent sensitivity planning values. As such, for the 2026 present-day epoch, only the 70th percentile SLR from CFBD18 2017 base year are considered in the subsequent analysis and modelling; however, for the 2126 design horizon, both the 70th percentile and 95th percentile values are considered.

Table 4. Extreme water levels, including sea level rise*

AEP [%]	Return	Extreme Water Levels [mODN]				
	Period			%ile	Incl. SLR 95 th %ile	%ile
	[years]	(base year 2017)	2026	2126	2026	2126
100.00	1	5.66	5.71	6.76	5.72	7.15
50.00	2	5.76	5.81	6.86	5.82	7.25
20.00	5	5.90	5.95	7.00	5.96	7.39
10.00	10	6.01	6.06	7.11	6.07	7.50
5.00	20	6.11	6.16	7.21	6.17	7.60
4.00	25	6.14	6.19	7.24	6.20	7.63
2.00	50	6.25	6.30	7.35	6.31	7.74
1.33	75	6.32	6.37	7.42	6.38	7.81
1.00	100	6.37	6.42	7.47	6.43	7.86
0.67	150	6.44	6.49	7.54	6.50	7.93
0.50	200	6.50	6.55	7.60	6.56	7.99
0.40	250	6.54	6.59	7.64	6.60	8.03
0.33	300	6.58	6.63	7.68	6.64	8.07
0.20	500	6.70	6.75	7.80	6.76	8.19
0.10	1,000	6.91	6.96	8.01	6.97	8.40
0.01	10,000	8.01	8.06	9.11	8.07	9.50

Water levels are only considered accurate to one d.p. but are provided to two d.p. to allow differences between pairs to be examined

^{*} SLR allowance based on UKCP18 RCP8.5 70th and 95th percentile projections, following Welsh Government (2022) recommendations

3.2 Joint Probability Analysis

As in the previous work (ABPmer, 2019), Joint Probability Analysis (JPA) has been undertaken using the JOIN-SEA (HR Wallingford, 1998) method. This analysis was conducted using the 37-year hindcast output from the regional SW hindcasts for the 2026 and 2126 epochs. To develop the dependence relationship between waves and water levels the 37-year hindcast water level output from the SEASTATES Tide and Surge model were used.

The independent extreme conditions used in the JOIN-SEA analysis were the extreme levels described in Section 3.1.2 and Table 4. The independent extreme wave heights used were the same as those used in the previous work (ABPmer, 2019), since the regional hindcasts remain unchanged. These extreme wave heights are presented in Table 5. These extreme values are associated with a south-westerly direction (225°-255°), which is the direction associated with most extreme wave conditions in Sandy Bay (see ABPmer (2019), Section 4.2).

AEP [%]	Return Period [years]	Hs [m] – 2026	Hs [m] – 2126
200.00	0.5	3.55	3.62
100.00	1	4.00	4.09
50.00	2	4.39	4.49
20.00	5	4.81	4.93
10.00	10	5.09	5.20
5.00	20	5.32	5.43
2.00	50	5.59	5.68
1.00	100	5.75	5.84
0.5	200	5.90	5.97
0.2	500	6.06	6.12
0.1	1,000	6.16	6.21
0.05	2,000	6.25	6.28
0.02	5,000	6.35	6.37
0.01	10,000	6.41	6.42

Table 5. Extreme Wave Conditions at Nearshore JPA point

In the previous work, a dependence correlation coefficient of 0.24 was used in the JOIN-SEA analysis as this value was found to produce extreme contours which better fit the hindcast data. The same correlation coefficient values were used again in this re-run of the analysis.

In the JPA, JOIN-SEA undertakes its own univariate analysis of the parameters being examined but allows the univariate extremes of the JPA to be adjusted to extreme values determined from a separate assessment. Hence, within the JPA, the extreme water levels are 'forced' to replicate the CFBD extreme water levels (Table 4). In turn, the marginal wave extremes were also 'forced' to reproduce those derived in ABPmer (2019), and shown in Table 5. This method replicates that applied in the original study.

The resultant JPA curves are provided in Figure 3 and Figure 4 for the 2026 and 2126 70th percentile cases respectively. Tabulated wave and water level pairs for annual exceedance probabilities (AEPs) of 0.5% and 0.1% are provided in Table 6 and Table 7. For the 2126 95th percentile case, an uplift of +0.39 m is applied to the water levels from the 2126 70th percentile case. The wave and water level pairs for the 2126 95th percentile case are provided in Table 8. Note that the Hs values given in these tables have the 0.9% markup applied to account for additional SLR, see Section 2.3 and ABPmer (2019), Addendum. The peak period, Tp, associated with Hs are derived through the same steepness relationships presented in ABPmer (2019).

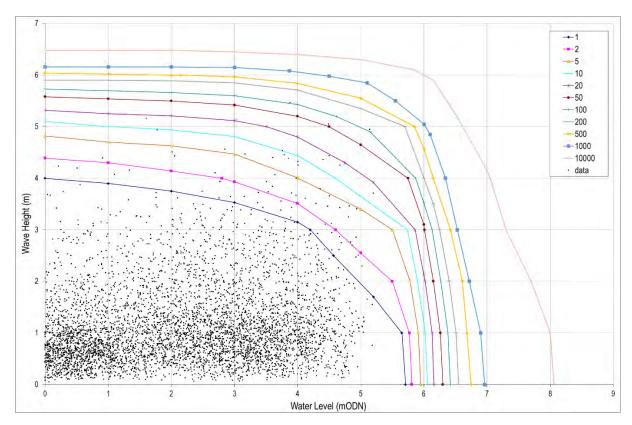


Figure 3. 2026 JPA Contours (Sector 225° to 255°)

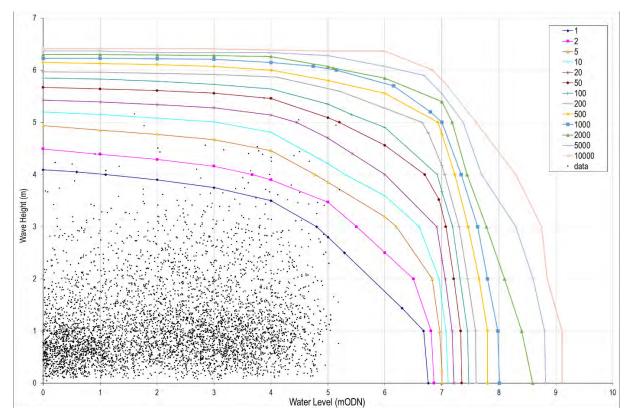


Figure 4. 2126 JPA Contours (Sector 225° to 255°)

Table 6. 2026 Joint Probability Pairs with Associated Peak Period (Tp) – RCP8.5 70th Percentile

AEP [%]	Return Period [years]	WL [mODN]	Hs [m]	Tp [s]
0.5	200	4.00	5.71	13.5
0.5	200	5.00	5.35	13.0
0.5	200	5.70	5.00	12.7
0.5	200	6.15	3.50	10.5
0.5	200	6.40	2.00	8.0
0.1	1000	5.10	5.85	13.7
0.1	1000	6.00	5.05	12.7
0.1	1000	6.34	4.00	11.3
0.1	1000	6.53	3.00	9.8
0.1	1000	6.72	2.00	8.8

Water levels are only considered accurate to one d.p., but are provided to two d.p to allow differences between pairs to be examined.

Hs values include 0.9% markup to account for additional SLR in 2020 epoch hindcast, see (ABPmer, 2019) Addendum

Table 7. 2126* Joint Probability Pairs and Associated Peak Period (Tp) – RCP8.5 70th Percentile

AEP [%]	Return Period [years]	WL [mODN]	Hs [m]	Tp [s]
0.5	200	4.10	5.92	13.7
0.5	200	5.20	5.65	13.4
0.5	200	6.65	5.05	12.7
0.5	200	7.05	4.04	11.3
0.5	200	7.30	3.03	9.8
0.1	1000	5.15	6.05	13.9
0.1	1000	6.15	5.75	13.5
0.1	1000	7.00	5.05	12.7
0.1	1000	7.34	4.04	11.3
0.1	1000	7.63	3.03	9.8

Water levels are only considered accurate to one d.p., but are provided to two d.p. to allow differences between pairs to be examined

Table 8. 2126* Joint Probability Pairs and Associated Peak Period (Tp) – RCP8.5 95th Percentile

AEP [%]	Return Period [years]	WL [mODN]	Hs [m]	Tp [s]
0.5	200	4.49	5.92	13.7
0.5	200	5.59	5.65	13.4
0.5	200	7.04	5.05	12.7
0.5	200	7.44	4.04	11.3
0.5	200	7.69	3.03	9.8
0.1	1000	5.54	6.05	13.9
0.1	1000	6.54	5.75	13.5
0.1	1000	7.39	5.05	12.7
0.1	1000	7.73	4.04	11.3
0.1	1000	8.02	3.03	9.8

Water levels are only considered accurate to one d.p., but are provided to two d.p. to allow differences between pairs to be examined

^{*} SLR allowance based on UKCP18 RCP8.5 70th, following Welsh Government (2022) recommendations Hs values include 0.9% markup to account for additional SLR in 2120 epoch hindcast, see (ABPmer, 2019) Addendum

^{*} SLR allowance based on UKCP18 RCP8.5 95th, following Welsh Government (2022) recommendations Hs values include 0.9% markup to account for additional SLR in 2120 epoch hindcast, see (ABPmer, 2019) Addendum

3.3 Local Wave Modelling

The model set up and mesh used in the nearshore transformation of wave level wave height pairs from Table 6 to Table 8 is the same as the set up described in ABPmer (2019). The local SW model mesh is shown in Figure 5. The model configuration is outlined in Table 9. For further information, refer to ABPmer (2019).

The only difference in the model setup to the previous study was the representation of the Eastern Promenade. As the primary aim of the present study is the Coney Beach frontage (and accounting for the recent improvement works), the new vertical wall eastern promenade frontage has been treated as a reflective structure with a 0.9 reflection coefficient. Previously, this coastal boundary (rock revetment structure) was represented by a standard land boundary (fully absorbing boundary condition).

3.3.1 SW Model Simulations

The 30 wave water level pairs from Table 6 to Table 8 were simulated for a wave direction of 240°. Model outputs were extracted at the locations provided in Table 10 and Figure 6. Locations 3 to 6 in Table 10 are the same extraction locations as points 3 to 6 from ABPmer (2019), locations 3b to 6b are new locations added in for this work to provide an extra level of granularity in the modelled conditions along the beach frontage.

Extracted inshore wave conditions from the SW model are provided in Table 11 for the 2026 epoch and Table 12 and Table 13 for the 2126 epoch 70th percentile and 95th percentile cases, respectively.

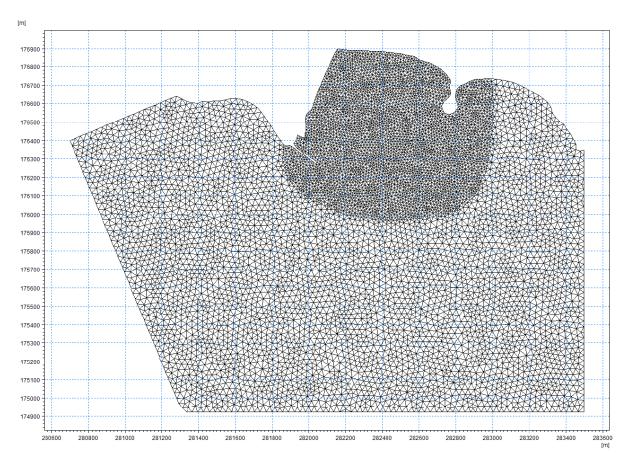


Figure 5. Local SW Model Mesh, Showing Extent of Model

Table 9. Key Model Parameters for Local SW Model

Parameter	Values Used
Spectral Formulation	Fully spectra, quasi-stationary formulation.
Spectral Discretisation	Logarithmic frequency discretisation; 24 frequencies, minimum frequency of 0.036 and frequency factor of 1.14
	Directional sector discretisation; 21 sectors, minimum of 90°, maximum of 300°.
Diffraction	Included (default parameters)
	Smoothing factor of 1; number of smoothing steps 1
Wind Formulation	Not included
Wave Breaking	Specified gamma, constant 0.8 (default)
Bed Friction	Constant Nikuradse value of 0.001 (default)
White Capping	Included (default parameters)
Structures	Included, see Section 3.3

Table 10. Location of Coney Beach extraction points

Point	Easting [m OSGB]	Northing [m OSGB]	Bed Depth [mODN]
3	282660	176770	4.9
4	282530	176834	4.6
5	282336	176858	4.6
6	282165	176863	4.1
3b	282712.7	176717.8	4.3
4b	282599.3	176805.2	4.9
5b	282442.5	176852.1	4.8
6b	282254.7	176861.1	4.6



Figure 6. Local SW model extraction locations

Table 11. Inshore wave conditions for 2026

	Event	Wave	Resulting Wave Parameters at Extraction Point (east to west)							
	JPA Input	Parameter	3b	3	4b	4	5b	5	6b	6
	574 7 42.5	Hs [m]	-	-	-	=	=	-	-	=
	Hs = 5.71 m, Tp = 13.5 s, WL = 4.00 mODN,	Tp [s]	-	-	-	-	-	-	-	-
	WE = 4.00 MODN,	Mdir [°]	-	-	-	-	-	-	-	-
9	Hs = 5.35 m, Tp = 13.0 s,	Hs [m]	0.8	0.1	0.3	0.5	0.2	0.5	0.6	0.8
2026	WL = 5.00 mODN	Tp [s]	12.6	12.6	12.7	12.7	12.8	12.9	13.0	13.2
RP)	WL = 3.00 IIIODN	Mdir [°]	220	201	207	200	195	184	186	196
- R	Ha - F 00 - Tr - 12.7 a	Hs [m]	1.3	1.1	1.0	1.1	0.9	1.1	1.2	1.3
yea	Hs = 5.00 m, Tp = 12.7 s, WL = 5.70 mODN	Tp [s]	12.5	12.5	12.6	12.6	12.6	12.7	12.7	12.8
(200-year	WL = 3.70 IIIODN	Mdir [°]	218	205	204	201	194	186	187	195
(2)	Ha = 3 F0 = Tn = 10 F a	Hs [m]	1.5	1.3	1.3	1.3	1.2	1.3	1.3	1.3
0.5%	Hs = 3.50 m, Tp = 10.5 s, WL = 6.15 mODN	Tp [s]	10.6	10.6	10.3	10.6	10.7	10.7	10.7	10.7
0	WL = 6.13 MODN	Mdir [°]	218	208	206	203	198	190	192	197
	Hs = 2.00 m, Tp = 8.0 s, WL = 6.40 mODN	Hs [m]	1.3	1.2	1.1	1.1	0.9	0.8	0.7	0.6
		Tp [s]	8.0	8.1	8.1	8.1	8.1	8.2	8.2	8.2
		Mdir [°]	219	210	207	204	199	193	197	197
	He - F 9F ma Tm - 12 7 a	Hs [m]	0.9	0.3	0.4	0.6	0.3	0.7	0.7	0.9
	Hs = 5.85 m, Tp = 13.7 s, WL = 5.10 mODN,		13.4	13.7	13.8	13.9	13.9	14.1	14.1	14.2
	WL = 3.10 MODIN,	Mdir [°]	219	201	206	200	194	183	185	196
56	Us = 5.05 m Tn = 12.7 s	Hs [m]	1.5	1.3	1.3	1.3	1.2	1.3	1.4	1.4
2026	Hs = 5.05 m, Tp = 12.7 s, WL = 6.00 mODN	Tp [s]	12.5	12.5	12.6	12.6	12.6	12.7	12.7	12.7
RP)	WE = 6.00 IIIODN	Mdir [°]	218	206	204	201	195	187	188	196
ar	Hs = 4.00 m, Tp = 11.3 s,	Hs [m]	1.7	1.5	1.4	1.5	1.3	1.4	1.5	1.4
-ye	WL = 6.34 mODN	Tp [s]	10.0	11.1	10.3	11.1	10.5	11.2	10.7	11.2
000	WL = 0.34 IIIODN	Mdir [°]	218	208	206	202	197	190	192	197
(1,0	Ha = 2.00 m Tn = 0.8 a	Hs [m]	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.1
0.1% (1,000-year	Hs = 3.00 m, Tp = 9.8 s, WL = 6.53 mODN	Tp [s]	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
0	WL - 0.33 IIIODN	Mdir [°]	218	209	207	203	199	193	195	197
	Hs = 2.00 m, Tp = 8.0 s,	Hs [m]	1.3	1.3	1.1	1.0	0.9	0.8	0.7	0.6
	WL = 6.72 mODN	Tp [s]	8.0	8.1	8.1	8.1	8.1	8.2	8.2	8.2
	WE - U.IZ IIIODIN	Mdir [°]	219	211	208	205	199	194	197	198

ABPmer, September 2025, R.4937

Table 12. Inshore Wave Conditions for 2126, RCP8.5 70th Percentile SLR

	Event	Wave	Resulting Wave Parameters at Extraction Point							
	JPA Input	Parameter	3b	3	4b	4	5b	5	6b	6
		Hs [m]	-	-	-	-	-	-	-	0.0
	Hs = 5.92 m, Tp = 13.7 s, WL = 4.10 mODN,	Tp [s]	-	-	-	-	-	-	-	14.2
	WL = 4.10 MODIN,	Mdir [°]	-	-	-	-	-	-	-	195
9	Ha F.CF To 12.4 a	Hs [m]	0.9	0.4	0.5	0.8	0.5	0.8	0.8	1.0
2126	Hs = 5.65 m, Tp = 13.4 s, WL = 5.2 mODN	Tp [s]	12.8	12.9	13.0	13.1	13.2	13.6	13.8	13.9
<u>a</u>	WL = 3.2 MODIN	Mdir [°]	219	202	205	200	193	184	186	196
(200-year RP)	Ha F OF To 12.7 a	Hs [m]	1.9	1.8	1.7	1.7	1.6	1.7	1.8	1.7
yea	Hs = 5.05 m, Tp = 12.7 s, WL = 6.65 mODN	Tp [s]	12.5	12.5	12.6	12.6	12.6	12.7	12.7	12.7
6	WL = 6.63 MODN	Mdir [°]	217	208	205	201	196	189	190	197
(2	Ha 404 m To 113 a	Hs [m]	2.1	1.9	1.9	1.8	1.7	1.7	1.7	1.6
0.5%	Hs = 4.04 m, Tp = 11.3 s, WL = 7.05 mODN	Tp [s]	11.1	11.1	11.4	11.1	11.2	11.2	11.3	11.3
0	WL = 7.03 IIIODN	Mdir [°]	218	209	205	203	198	192	194	198
	Hs = 3.03 m, Tp = 9.8 s, WL = 7.30 mODN	Hs [m]	1.9	1.9	1.7	1.6	1.5	1.3	1.2	1.1
		Tp [s]	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
		Mdir [°]	218	210	208	204	200	195	197	198
	He = 6.05 m Tn = 12.0 c	Hs [m]	0.9	0.4	0.5	0.7	0.4	0.7	0.8	1.0
	Hs = 6.05 m, Tp = 13.9 s,	Tp [s]	13.8	13.9	14.0	14.1	14.1	14.2	14.3	14.3
	WL = 5.15 mODN,	Mdir [°]	219	201	206	200	193	184	185	196
56	Ho - F 75 m Tn - 12 F a	Hs [m]	1.6	1.4	1.4	1.4	1.3	1.4	1.5	1.6
2126	Hs = 5.75 m, Tp = 13.5 s, WL = 6.15 mODN	Tp [s]	12.9	12.9	13.1	13.1	13.3	13.7	13.9	14.0
RP)	WL = 6.13 MODN	Mdir [°]	217	206	204	200	195	187	187	196
ar	Hs = 5.05 m, Tp = 12.7 s,	Hs [m]	2.1	2.0	1.9	1.9	1.8	1.9	2.0	1.9
-ye	WL = 7.00 mODN	Tp [s]	11.0	12.5	11.4	12.6	11.7	12.7	12.2	12.7
000	WE = 7.00 HIODN	Mdir [°]	217	208	205	201	197	190	191	197
(1,000-year	Hs = 4.04 m, Tp = 11.3 s,	Hs [m]	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.6
0.1%	WL = 7.34 mODN	Tp [s]	11.1	11.1	11.1	11.1	11.2	11.3	11.3	11.3
0.	VVL = 7.54 IIIODIN	Mdir [°]	218	210	207	203	199	193	195	197
	Uc = 2.02 m Tn = 0.0 c	Hs [m]	2.0	1.9	1.8	1.7	1.5	1.3	1.2	1.0
	Hs = 3.03 m, Tp = 9.8 s, WL = 7.63 mODN	Tp [s]	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
	VVL - 7.03 IIIODIN	Mdir [°]	218	211	208	205	200	195	197	198

ABPmer, September 2025, R.4937

Table 13. Inshore Wave Conditions for 2126, RCP8.5 95th Percentile SLR

	Event	Wave	Resulting Wav	e Parameters	at Extraction Po	oint				
	JPA Input	Parameter	3b	3	4b	4	5b	5	6b	6
	H- 502 - T- 12.7	Hs [m]	0.5	-	-	-	-	-	0.1	0.5
	Hs = 5.92 m, Tp = 13.7 s, WL = 4.49 mODN,	Tp [s]	13.5	-	-	-	-	-	14.2	14.3
	WL = 4.49 MODIN,	Mdir [°]	223	-	-	-	-	-	186	196
9	He - F 65 m Tn - 12 4 c	Hs [m]	1.2	1.0	1.0	1.0	0.9	1.0	1.1	1.2
2126	Hs = 5.65 m, Tp = 13.4 s, WL = 5.59 mODN	Tp [s]	12.8	12.8	13.0	13.0	13.1	13.4	13.7	13.9
RP)	WE = 3.39 IIIODN	Mdir [°]	218	205	204	200	194	185	186	195
ar F	Hs = 5.05 m, Tp = 12.7 s,	Hs [m]	2.1	2.0	2.0	2.0	1.9	1.9	2.0	1.9
-ye	WL = 7.04 mODN	Tp [s]	12.5	12.5	12.6	12.6	12.6	12.7	12.7	12.7
(200-year	WL = 7.04 IIIODN	Mdir [°]	217	208	205	201	197	190	191	197
2) (2	Hs = 4.04 m, Tp = 11.3 s,	Hs [m]	2.2	2.1	2.1	2.0	1.9	1.8	1.8	1.6
0.5%	WL = 7.44 mODN	Tp [s]	11.1	11.1	11.4	11.2	11.2	11.3	11.4	11.4
0	WE = 7.44 MODN	Mdir [°]	217	210	205	203	199	193	195	197
	Hs = 3.03 m, Tp = 9.8 s, WL = 7.69 mODN	Hs [m]	2.0	1.9	1.8	1.7	1.5	1.3	1.2	1.0
		Tp [s]	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
		Mdir [°]	218	211	208	205	200	195	197	198
	Hs = 6.05 m, Tp = 13.9 s,	Hs [m]	1.2	0.9	1.0	1.0	0.9	1.0	1.1	1.2
	WL = 5.54 mODN,	Tp [s]	13.8	13.9	14.0	14.0	14.1	14.2	14.3	14.3
	WE = 3.34 MODIN,	Mdir [°]	218	205	204	200	194	184	185	194
2126	Hs = 5.75 m, Tp = 13.5 s,	Hs [m]	1.9	1.7	1.7	1.7	1.6	1.7	1.8	1.7
21	WL = 6.54 mODN	Tp [s]	12.8	12.9	13.1	13.2	13.4	13.7	13.9	13.9
RP)	VVE = 0.54 MODIV	Mdir [°]	217	207	204	201	195	188	189	196
ar	Hs = 5.05 m, Tp = 12.7 s,	Hs [m]	2.3	2.2	2.2	2.2	2.1	2.1	2.2	2.0
-ye	WL = 7.39 mODN	Tp [s]	10.9	12.5	11.4	12.6	11.7	12.7	12.2	12.7
000	VVE = 7.55 MODIV	Mdir [°]	217	208	205	202	197	191	192	197
Ę,	Hs = 4.04 m, Tp = 11.3 s,	Hs [m]	2.4	2.3	2.2	2.1	2.0	1.9	1.8	1.6
0.1% (1,000-year	WL = 7.73 mODN	Tp [s]	11.1	11.1	11.1	11.2	11.2	11.3	11.4	11.4
0	77L - 7.75 IIIODN	Mdir [°]	217	210	207	204	199	194	196	197
	Hs = 3.03 m, Tp = 9.8 s,	Hs [m]	2.0	2.0	1.8	1.7	1.5	1.2	1.2	1.0
	WL = 8.02 mODN	Tp [s]	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
	17E - 0.0E 1110D14	Mdir [°]	218	211	208	206	201	196	198	198

ABPmer, September 2025, R.4937

4 Summary and Conclusions

In the work presented, nearshore wave and water level pairs from Joint Probability Analysis (JPA) for present day case and design horizon case have been transformed inshore. The present-day epoch has shifted in this new work to 2026 from 2020 and likewise the design horizon epoch has shifted to 2126 from 2120. This update to the design conditions has also been brought into line with the latest Welsh Government (2022) recommendations.

Where the local SW model results were extracted at the same locations as used in ABPmer (2019), outputs were compared. These comparisons showed that:

- All Hs values in updated local modelling were within 0.2 m of equivalent values from ABPmer (2019) for 2026 vs 2020, within 0.3 m for 2126 70th percentile case vs 2120, and generally within 0.5 m for 2126 95th percentile case vs 2120.
- All Tp values were within 0.3 s of previous modelling across all cases
- All wave direction values are generally within +/- 5° of the previous model output. Slightly larger direction differences (up to 15°) are predicted at the far western end of the beach, accounting for the influence of the newly renovated Eastern Promenade.

Generally, there is a small increase in wave height, and minor change in wave direction as a result of the larger sea level rise recommended by Welsh Government (2022).

In the previous work, ABPmer also undertook sensitivity tests to explore the impact of changes to wind and wave conditions under climate change (ABPmer, 2019, Section 3.5). The tests showed that a 10% increase to forcing winds and a 10% increase to forcing waves in the design horizon hindcast (epoch 2126) resulted in around a 10% increase in nearshore wave height. The results of this sensitivity test are applicable to the present study too.

5 References

ABPmer, 2019. Porthcawl Detailed Design Support, Western Breakwater and Eastern Promenade, Sandy Bay, ABPmer Report No.: R.3147.

Environment Agency, 2011. Coastal Flood Boundary Conditions for UK Mainland and Islands. Design Sea Levels., Environment Agency: SC060064/TR2.

Environment Agency, 2019. *Coastal Flood Boundary Conditions for the UK: Update 2018,* Environment Agency: SC060064/TR6.

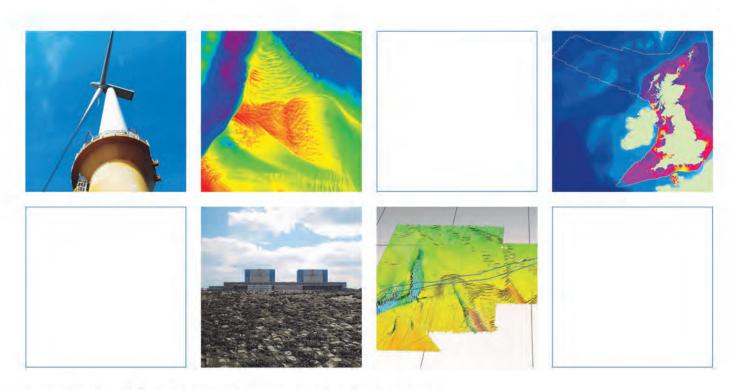
HR Wallingford, 1998. The Joint Probability of Waves and Water Levels: JOIN-SEA, Report: SR 537.

van Vuuren, D. et al., 2011. The representative concentration pathways: An overview. *Climatic Change*, 109(5).

Welsh Government, 2017. Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales, Welsh Government: Withdrawn.

Welsh Government, 2022. Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales, Welsh Government: WG46400.

Addendum



Innovative Thinking - Sustainable Solutions



A Additional Modelling

Following completion of the modelling and delivery of the results outlined in the main body of this report, additional outputs were required for three locations (Point 7, 8 and 9) along the eastern promenade frontage to the west of Coney Beach. This required all events to be re-run with the wave reflection removed from this defence so that the extracted wave conditions represent incident waves conditions. As identified in the previous assessment (ABPmer, 2019), the oblique nature of the incident waves along the eastern promenade may develop a stem wave along the promenade. The SW model used to develop the results presented here are not able to reproduce this. For further information on this please see ABPmer (2019).

Other than removing the reflection coefficient applied to the eastern promenade, the model set up and model scenarios examined are the same as that presented in the main body of this Technical Note.

The three locations at which the results have been extracted are provided in Table A1 and Figure A1 below. The outputs are provided in Table A2, Table A3 and Table A4.

Table A1.	Location of	quay wall	extraction points
-----------	-------------	-----------	-------------------

Point	Easting [m OSGB]	Northing [m OSGB]	Depth mODN
7	282102	176704	1.9
8	282066	176623	0.7
9	282012	176529	-0.3

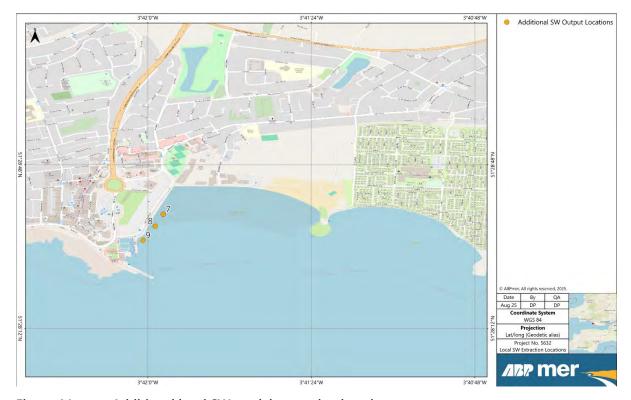


Figure A1. Additional local SW model extraction locations

Table A2. Inshore wave conditions for 2026

	Event	Wave	Resulting Wave Parameters at Extraction Point				
	JPA Input	Parameter	7	8	9		
		Hs [m]	1.6	1.7	1.1		
Hs	Hs = 5.71 m, Tp = 13.5 s, WL = 4.00 mODN,	Tp [s]	14.1	14.1	14.2		
	= 4.00 MODN,	Mdir [°]	173	164	153		
9	Hs = 5.35 m, Tp = 13.0 s, WL	Hs [m]	1.7	1.5	1.1		
2026	= 5.00 mODN	Tp [s]	13.3	13.5	13.9		
<u>a</u>	= 3.00 IIIODN	Mdir [°]	172	165	157		
<u>ہ</u>	Hs = 5.00 m, Tp = 12.7 s, WL	Hs [m]	1.8	1.5	1.1		
yea	= 5.70 mODN	Tp [s]	12.8	12.9	13.0		
0.5% (200-year RP)	= 3.70 IIIODN	Mdir [°]	174	170	155		
(2)	Hs = 3.50 m, Tp = 10.5 s, WL	Hs [m]	1.0	0.8	0.6		
.5%	= 6.15 mODN	Tp [s]	10.7	10.7	10.7		
0	- 0.13 1110011	Mdir [°]	176	169	159		
	Hs = 2.00 m, Tp = 8.0 s, WL = 6.40 mODN	Hs [m]	0.4	0.3	0.3		
		Tp [s]	8.2	8.2	8.2		
	- 0.40 MODIV	Mdir [°]	177	171	161		
	Hs = 5.85 m, Tp = 13.7 s, WL	Hs [m]	2.0	1.9	1.5		
	= 5.10 mODN,	Tp [s]	14.2	14.3	14.4		
	- 3.10 IIIODIN,	Mdir [°]	171	165	155		
56	Hs = 5.05 m, Tp = 12.7 s, WL	Hs [m]	1.7	1.5	1.1		
203	= 6.00 mODN	Tp [s]	12.8	12.9	13.0		
(A)	= 0.00 mobit	Mdir [°]	173	167	155		
arl	Hs = 4.00 m, Tp = 11.3 s, WL	Hs [m]	1.2	1.0	0.7		
-ye	= 6.34 mODN	Tp [s]	11.2	11.2	11.2		
000	= 0.54 MODIV	Mdir [°]	177	168	158		
(1,0	Hs = 3.00 m, Tp = 9.8 s, WL	Hs [m]	0.7	0.6	0.5		
0.1% (1,000-year RP) 2026	= 6.53 mODN	Tp [s]	9.7	9.7	9.7		
0	- 0.55 1110014	Mdir [°]	176	170	160		
	Hs = 2.00 m, Tp = 8.0 s, WL	Hs [m]	0.4	0.3	0.3		
	= 6.72 mODN	Tp [s]	8.2	8.2	8.2		
	- 0.72 IIIODIN	Mdir [°]	177	172	162		

Table A3. Inshore Wave Conditions for 2126, RCP8.5 70th Percentile SLR

	Event	Wave	Resulting Wave Parameters at Extraction Point			
	JPA Input	Parameter	7	8	9	
	Hs = 5.92 m, Tp = 13.7 s, WL	Hs [m]	1.7	1.8	1.2	
	= 4.10 mODN,	Tp [s]	14.2	14.3	14.3	
	= 4:10 IIIODN,	Mdir [°]	174	165	153	
بو	Hs = 5.65 m, Tp = 13.4 s, WL	Hs [m]	1.9	1.7	1.3	
2126	= 5.2 mODN	Tp [s]	13.9	14.0	14.3	
<u>@</u>	- 5.2 mobin	Mdir [°]	171	165	155	
0.5% (200-year RP)	Hs = 5.05 m, Tp = 12.7 s, WL	Hs [m]	1.7	1.5	1.2	
Š	= 6.65 mODN	Tp [s]	12.8	12.9	12.9	
8	= 0.03 IIIODIN	Mdir [°]	174	164	154	
6 (2	Hs = 4.04 m, Tp = 11.3 s, WL	Hs [m]	1.1	1.0	0.8	
.5%	= 7.05 mODN	Tp [s]	11.3	11.3	11.2	
0	= 7:03 IIIODIN	Mdir [°]	174	168	158	
	Hs = 3.03 m, Tp = 9.8 s, WL = 7.30 mODN	Hs [m]	0.7	0.6	0.5	
		Tp [s]	9.7	9.7	9.7	
	= 7:30 IIIODIN	Mdir [°]	176	171	160	
	Hs = 6.05 m Tn = 12.0 s W/I	Hs [m]	2.1	2.0	1.5	
	Hs = 6.05 m, Tp = 13.9 s, WL = 5.15 mODN,	Tp [s]	14.3	14.4	14.4	
		Mdir [°]	171	165	155	
56	Hs = 5.75 m, Tp = 13.5 s, WL = 6.15 mODN	Hs [m]	2.1	1.9	1.4	
2126		Tp [s]	14.1	14.2	14.3	
P)		Mdir [°]	174	166	153	
0.1% (1,000-year RP)	Hs = 5.05 m, Tp = 12.7 s, WL	Hs [m]	1.7	1.5	1.2	
-ye	= 7.00 mODN	Tp [s]	12.8	12.8	13.0	
	= 7:00 IIIODIV	Mdir [°]	172	164	154	
(1,	Hs = 4.04 m, Tp = 11.3 s, WL	Hs [m]	1.1	1.0	0.8	
1%	= 7.34 mODN	Tp [s]	11.3	11.3	11.4	
0.	- 1.54 IIIOUN	Mdir [°]	174	168	158	
	Hs = 3.03 m, Tp = 9.8 s, WL	Hs [m]	0.7	0.6	0.5	
	= 7.63 mODN	Tp [s]	9.7	9.7	9.7	
	- 1.03 IIIODN	Mdir [°]	177	171	161	

Table A4. Inshore Wave Conditions for 2126, RCP8.5 95th Percentile SLR

	Event	Wave	Resulting Wave Parameters at Extraction Point				
	JPA Input	Parameter	7	8	9		
	H- 502 - T- 12.7 - WI	Hs [m]	1.9	1.8	1.2		
	Hs = 5.92 m, Tp = 13.7 s, WL = 4.49 mODN,	Tp [s]	14.3	14.3	14.3		
	- 4.49 MODN,	Mdir [°]	174	164	155		
بو	He = E 6E m Tn = 12.4 c \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Hs [m]	2.0	1.9	1.4		
2126	Hs = 5.65 m, Tp = 13.4 s, WL = 5.59 mODN	Tp [s]	14.0	14.1	14.2		
<u>@</u>	- 3.39 IIIODN	Mdir [°]	173	170	153		
ar R	Hs = 5.05 m, Tp = 12.7 s, WL	Hs [m]	1.7	1.5	1.2		
Š	= 7.04 mODN	Tp [s]	12.8	12.8	13.0		
8	= 7:04 IIIODN	Mdir [°]	172	164	154		
0.5% (200-year RP)	Hs = 4.04 m, Tp = 11.3 s, WL	Hs [m]	1.1	1.0	0.8		
.5%	= 7.44 mODN	Tp [s]	11.3	11.4	11.4		
0	= 7:44 IIIODN	Mdir [°]	174	168	158		
	Hs = 3.03 m, Tp = 9.8 s, WL	Hs [m]	0.7	0.6	0.5		
	= 7.69 mODN	Tp [s]	9.7	9.7	9.7		
	= 7:09 IIIODIN	Mdir [°]	177	171	161		
	Hc = 6.05 m Tn = 12.0 c W/l	Hs [m]	2.2	2.1	1.6		
	Hs = 6.05 m, Tp = 13.9 s, WL = 5.54 mODN,	Tp [s]	14.3	14.4	14.4		
		Mdir [°]	172	170	152		
56	Hs = 5.75 m, Tp = 13.5 s, WL = 6.54 mODN	Hs [m]	2.1	1.8	1.4		
2126		Tp [s]	14.1	14.2	14.2		
P)		Mdir [°]	174	163	153		
ar	Hs = 5.05 m, Tp = 12.7 s, WL	Hs [m]	1.7	1.5	1.2		
- Ā	= 7.39 mODN	Tp [s]	12.8	12.9	12.9		
0.1% (1,000-year RP)	- 1.39 IIIODN	Mdir [°]	170	164	153		
(1,0	Hs = 4.04 m, Tp = 11.3 s, WL	Hs [m]	1.1	1.0	0.8		
1%	= 7.73 mODN	Tp [s]	11.3	11.3	11.5		
0.	- 1.13 IIIODN	Mdir [°]	174	168	158		
	Hs = 3.03 m, Tp = 9.8 s, WL	Hs [m]	0.7	0.6	0.5		
	= 8.02 mODN	Tp [s]	9.7	9.7	9.7		
	- 0.02 IIIODIN	Mdir [°]	177	172	161		

Contact Us

ABPmer

Quayside Suite, Medina Chambers Town Quay, Southampton SO14 2AQ

T +44 (0) 23 8071 1840

F+44 (0) 23 8071 1841

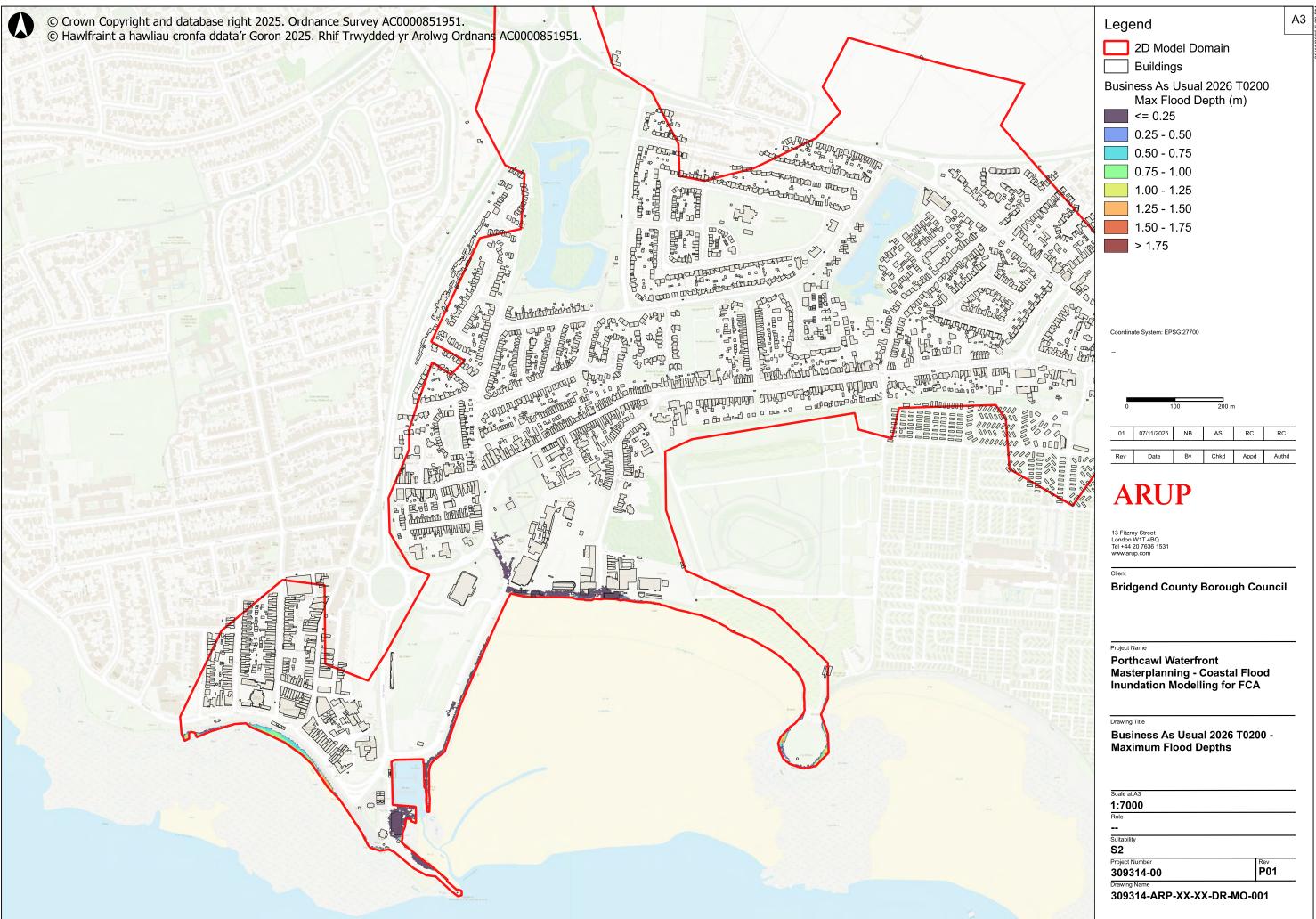
E enquiries@abpmer.co.uk

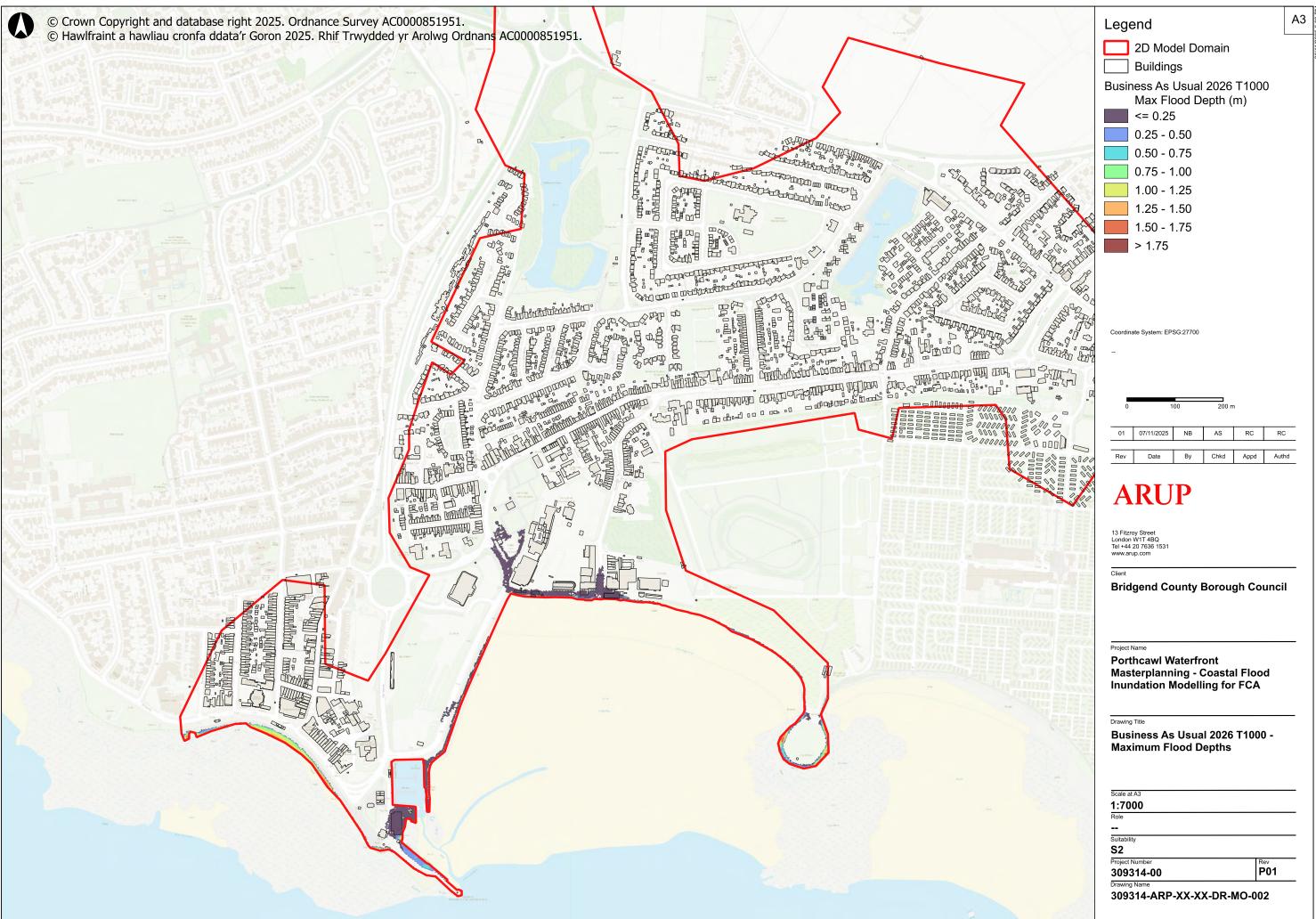
www.abpmer.co.uk

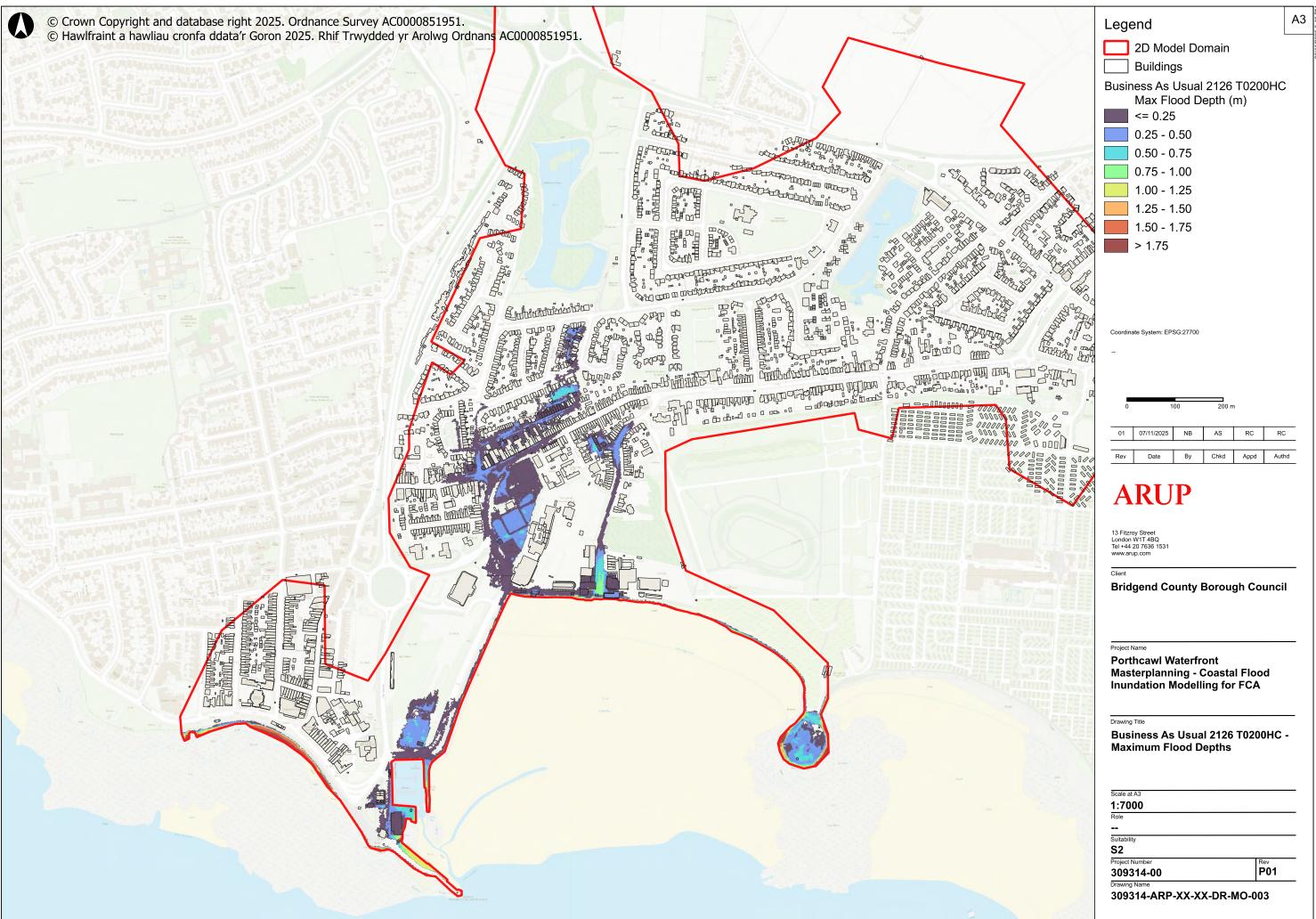


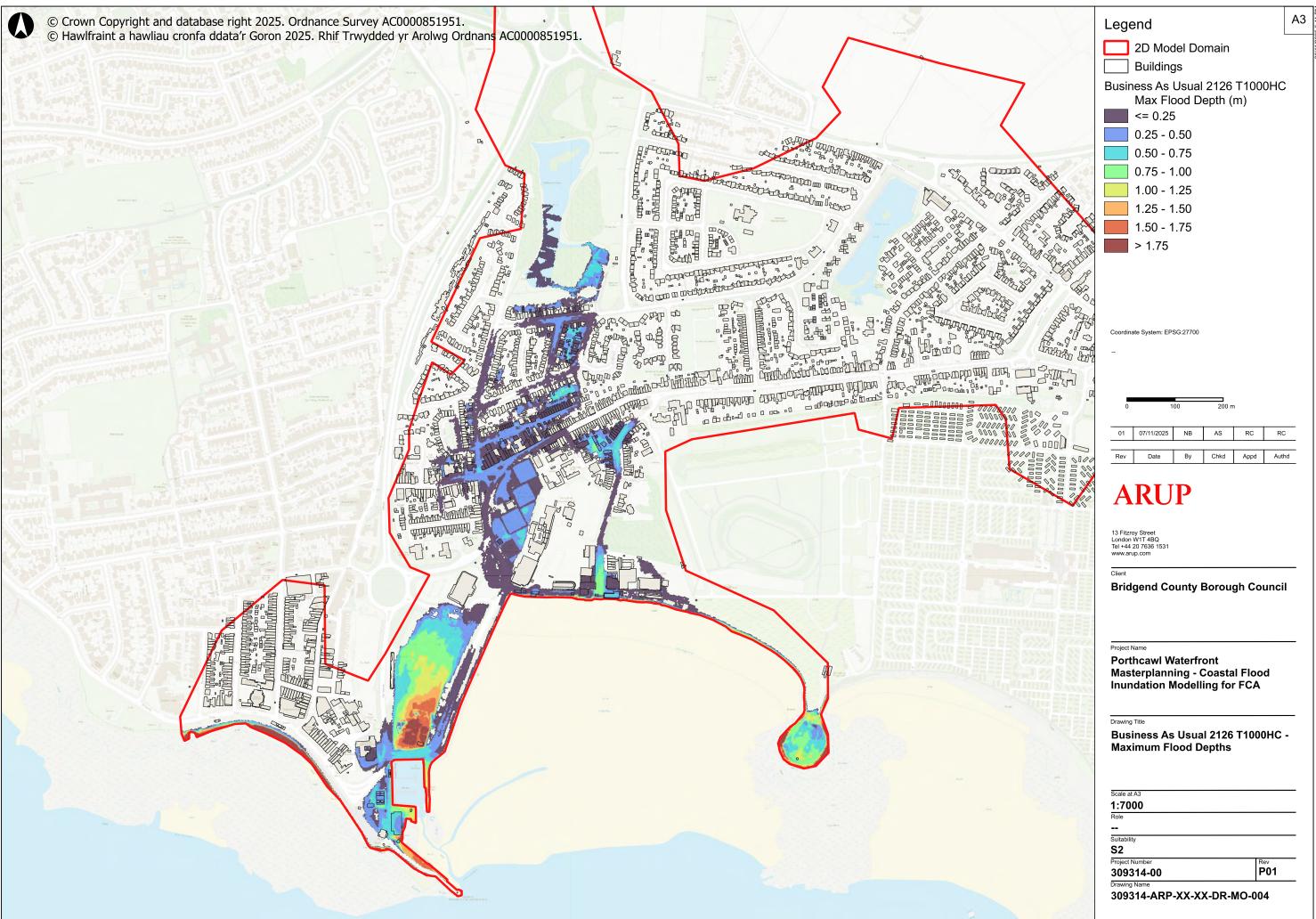
Appendix C

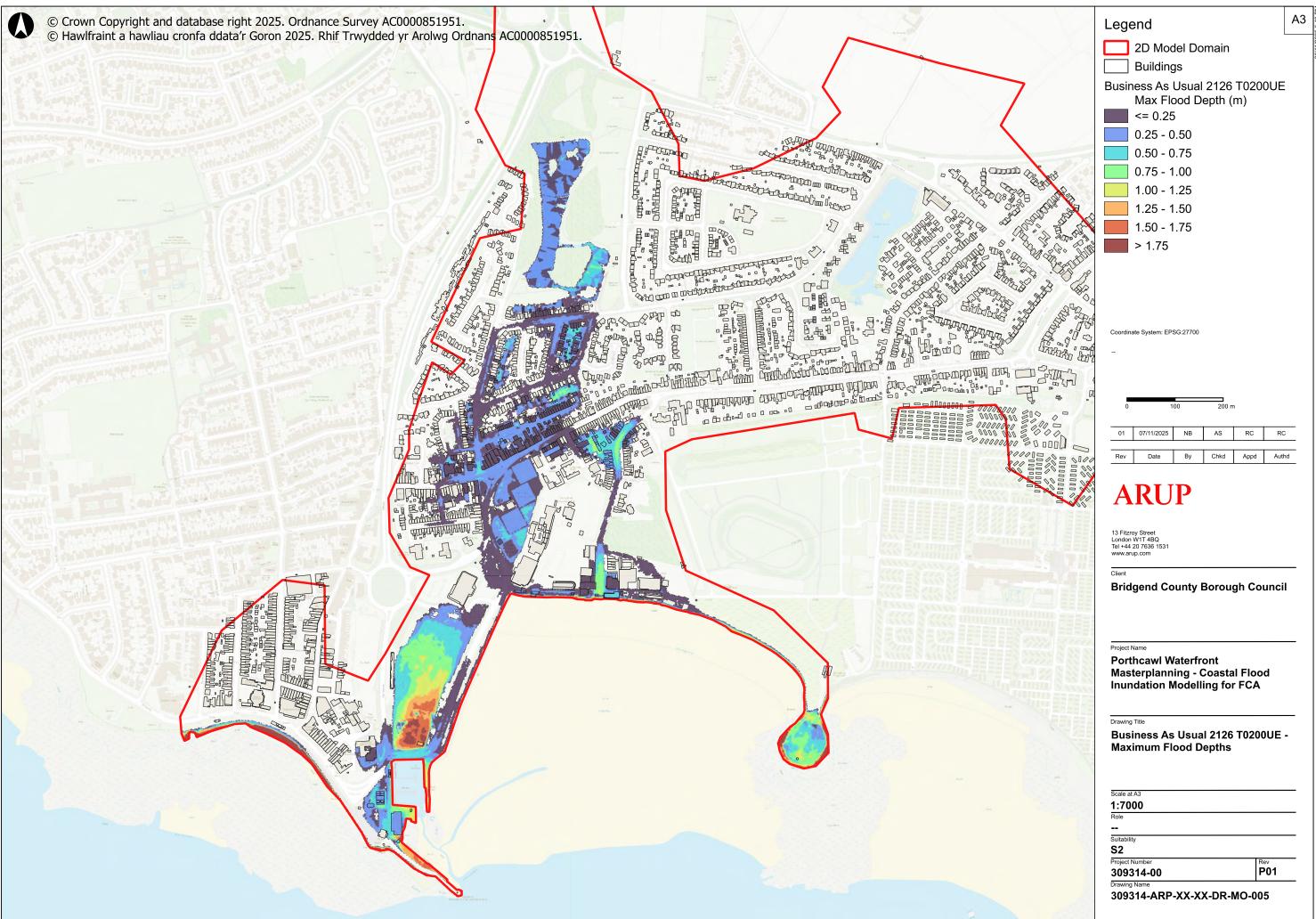
Business as Usual maximum flood depth and hazard maps

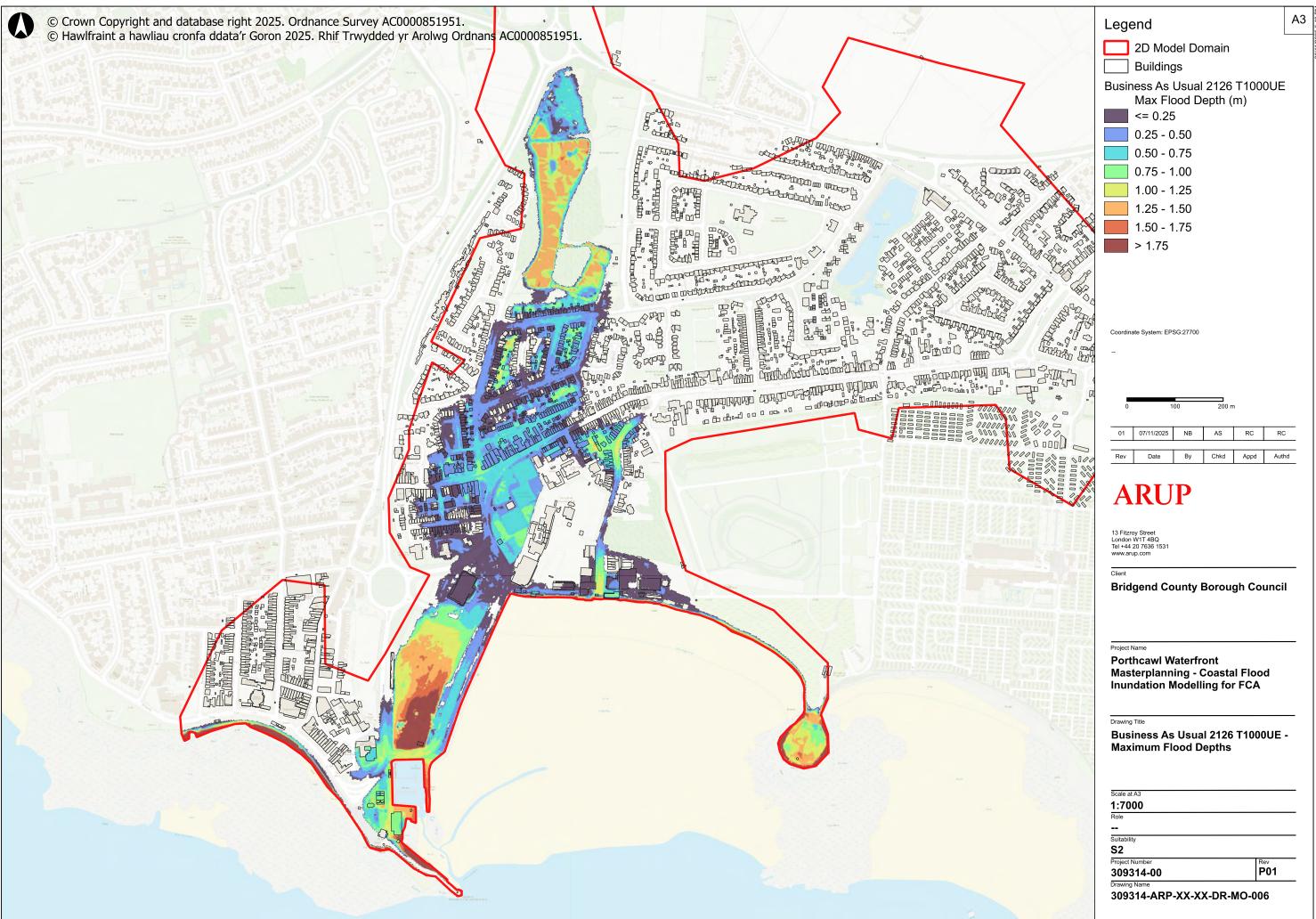


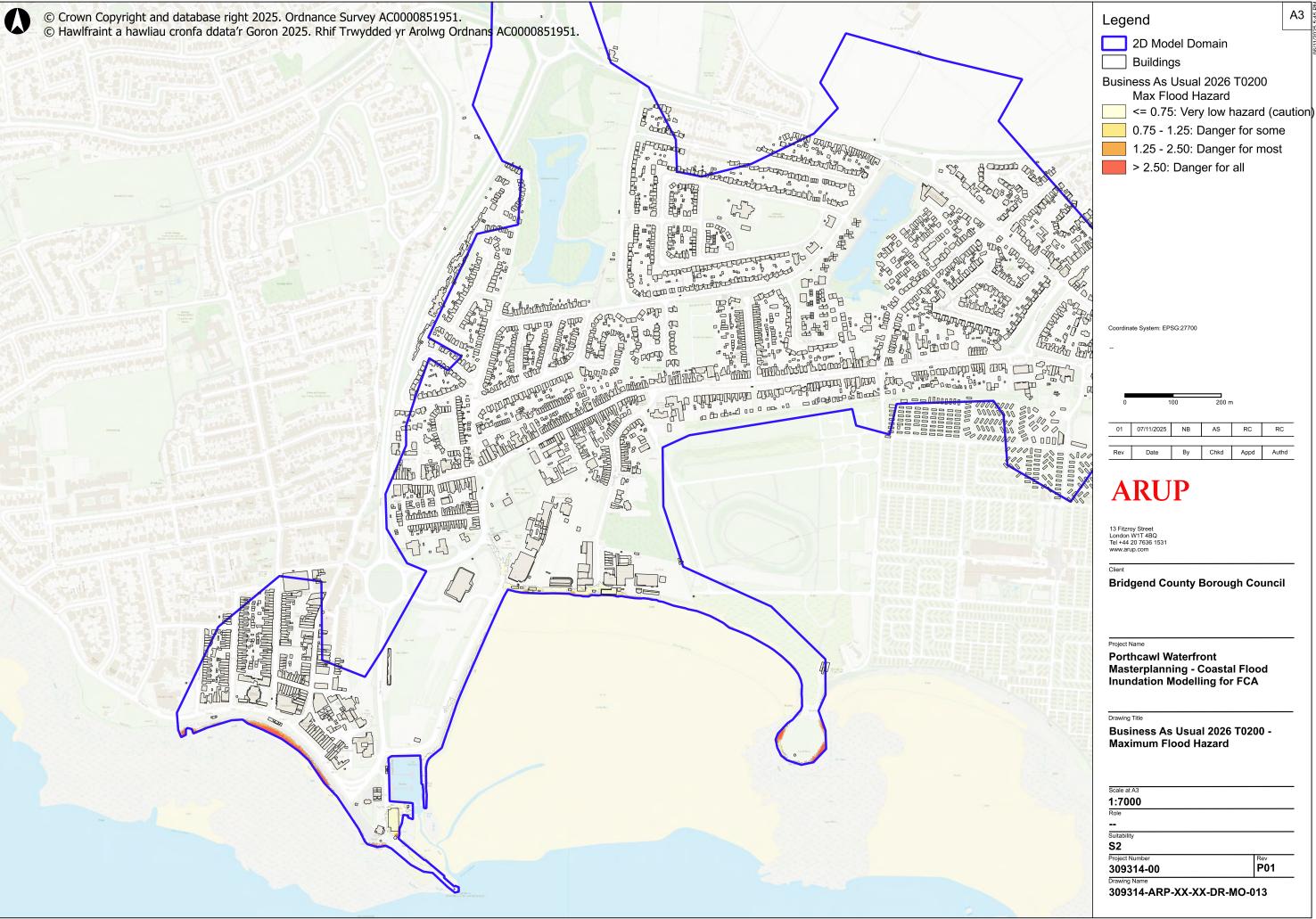


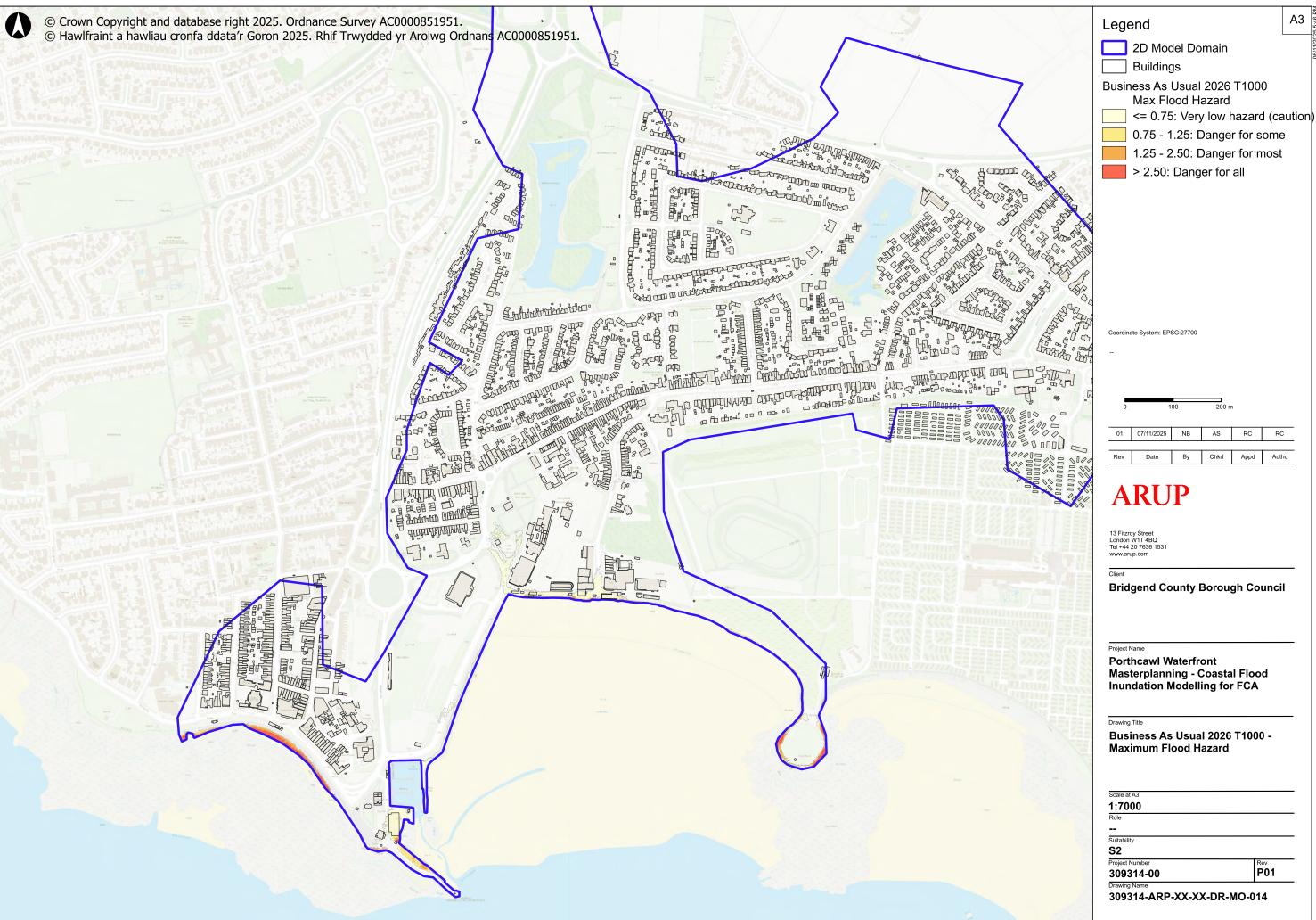


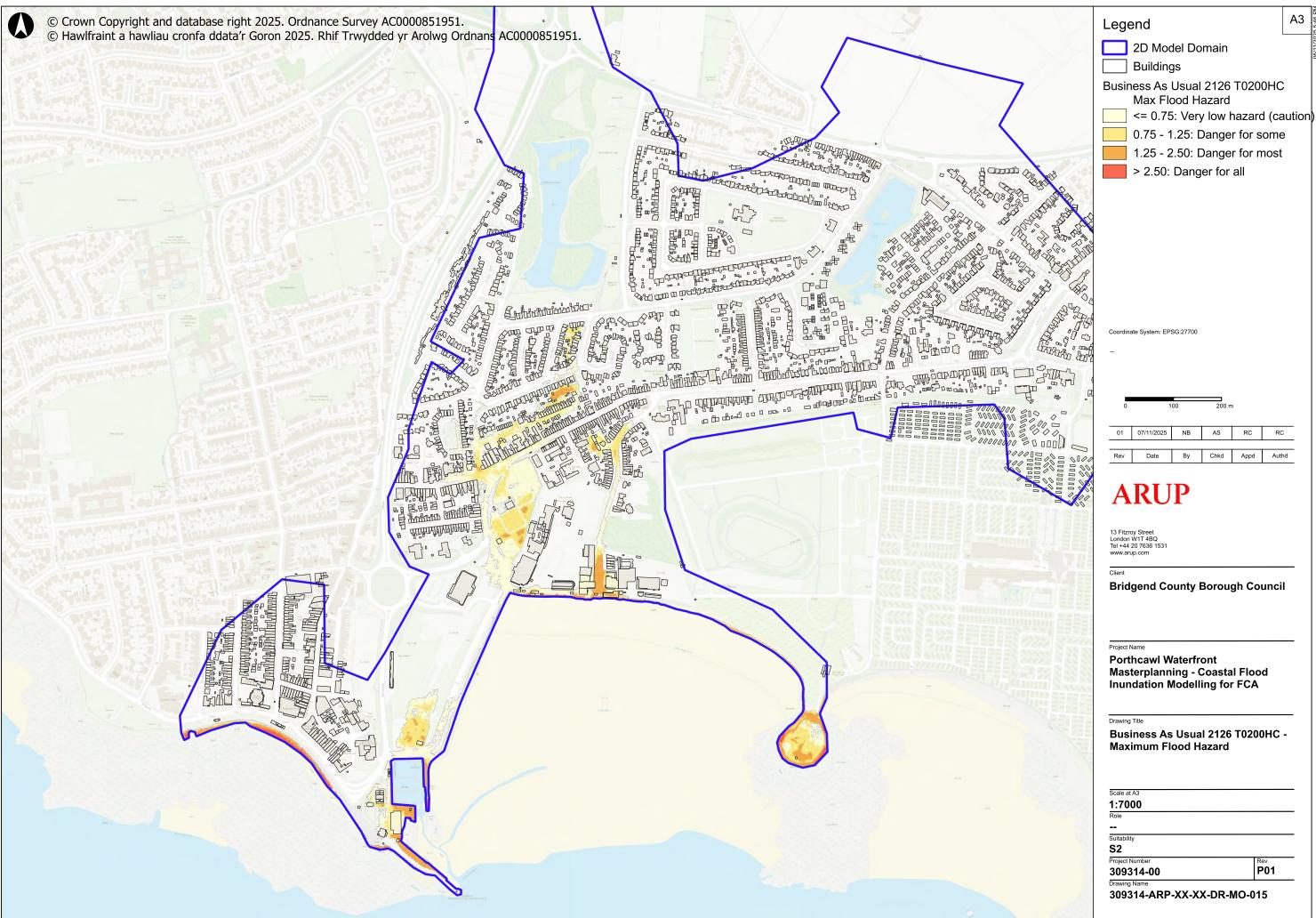


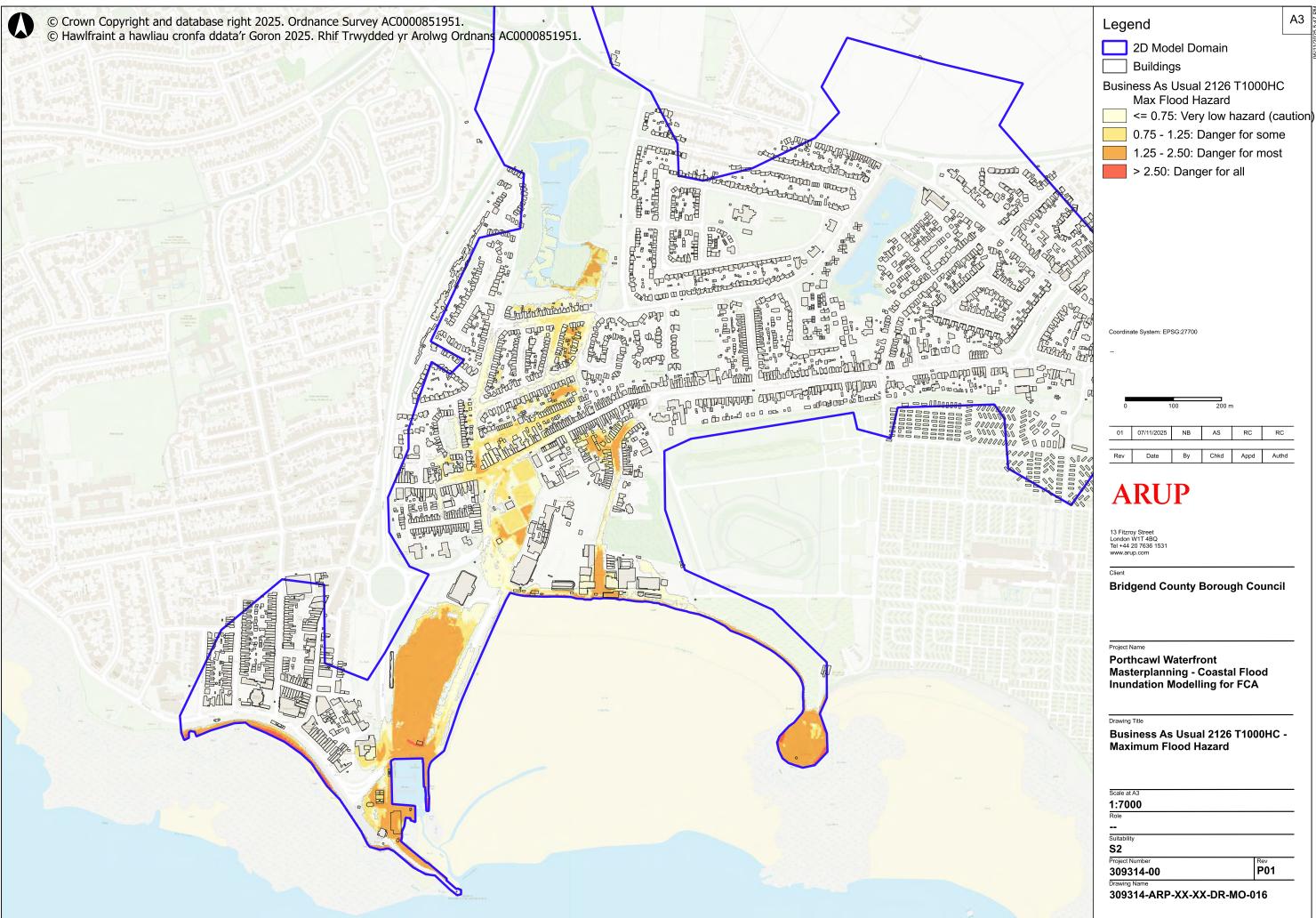


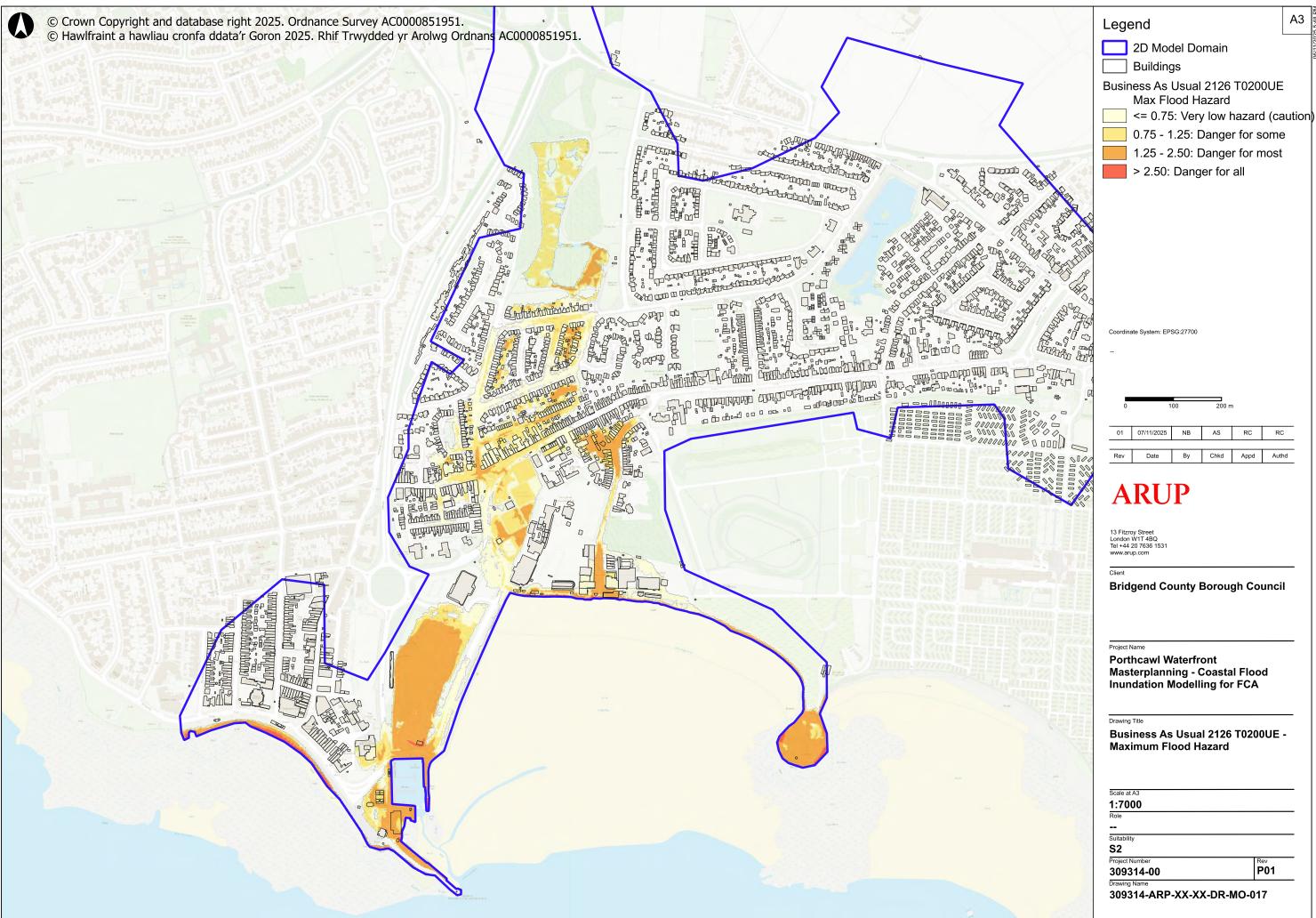


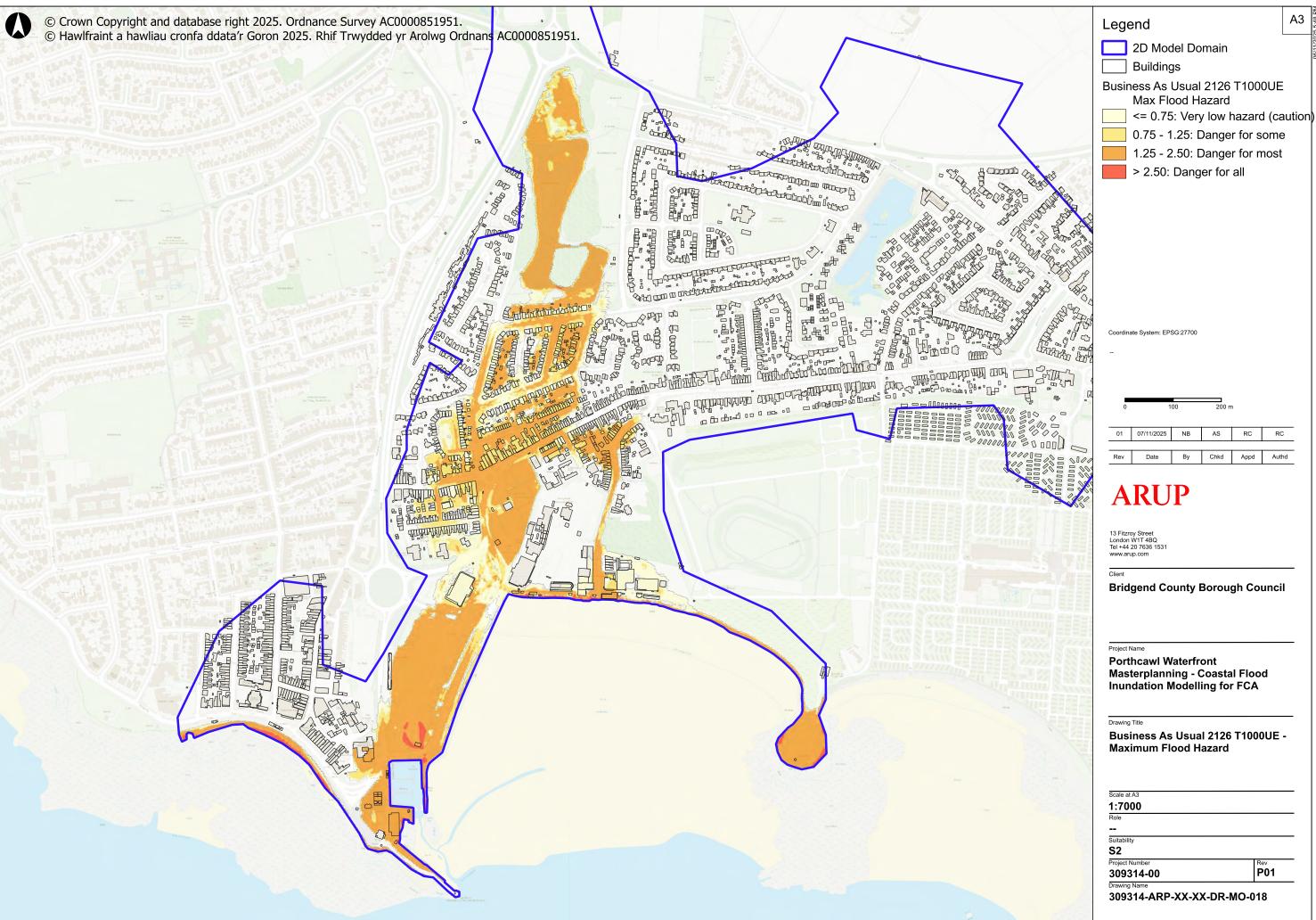






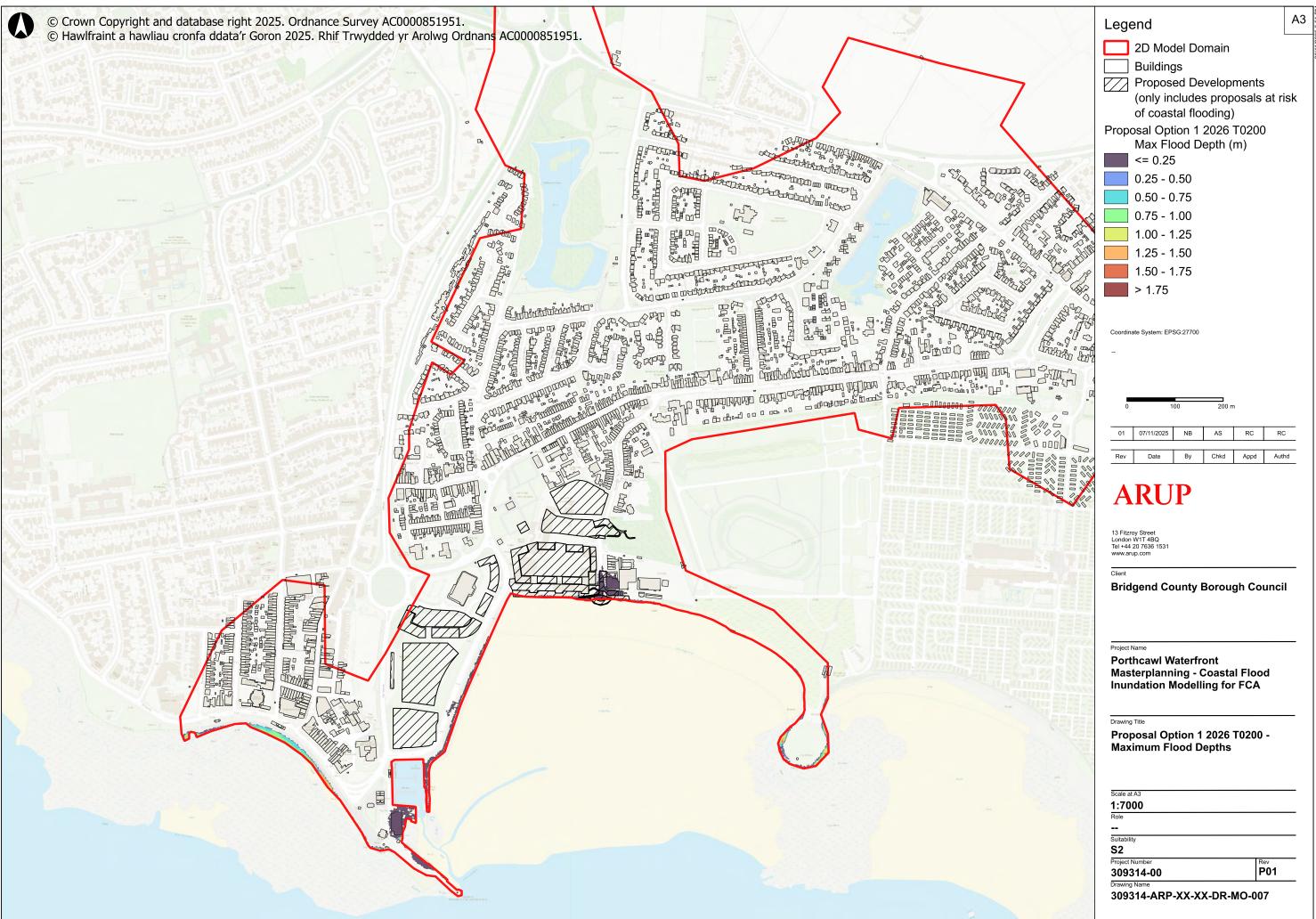


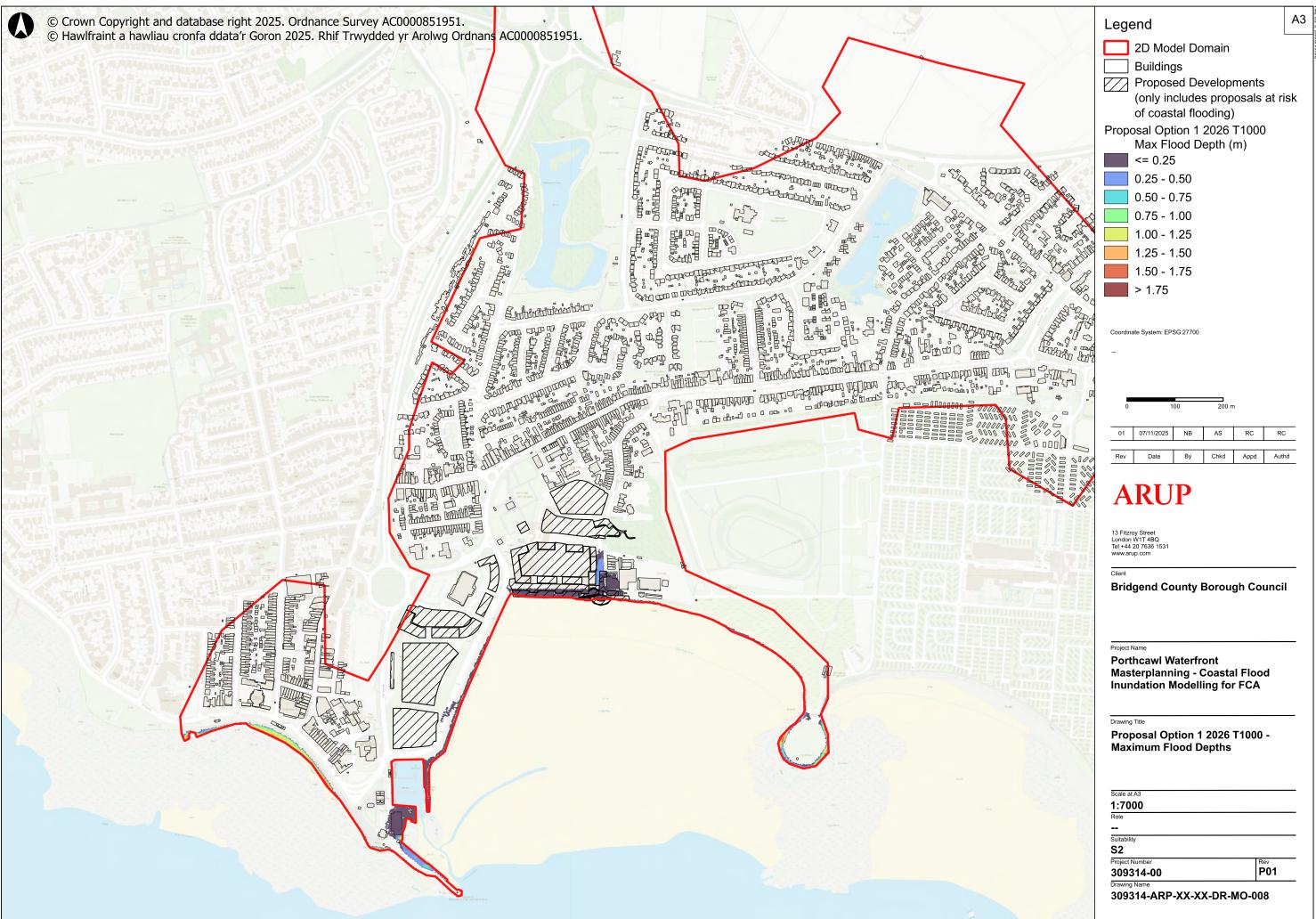


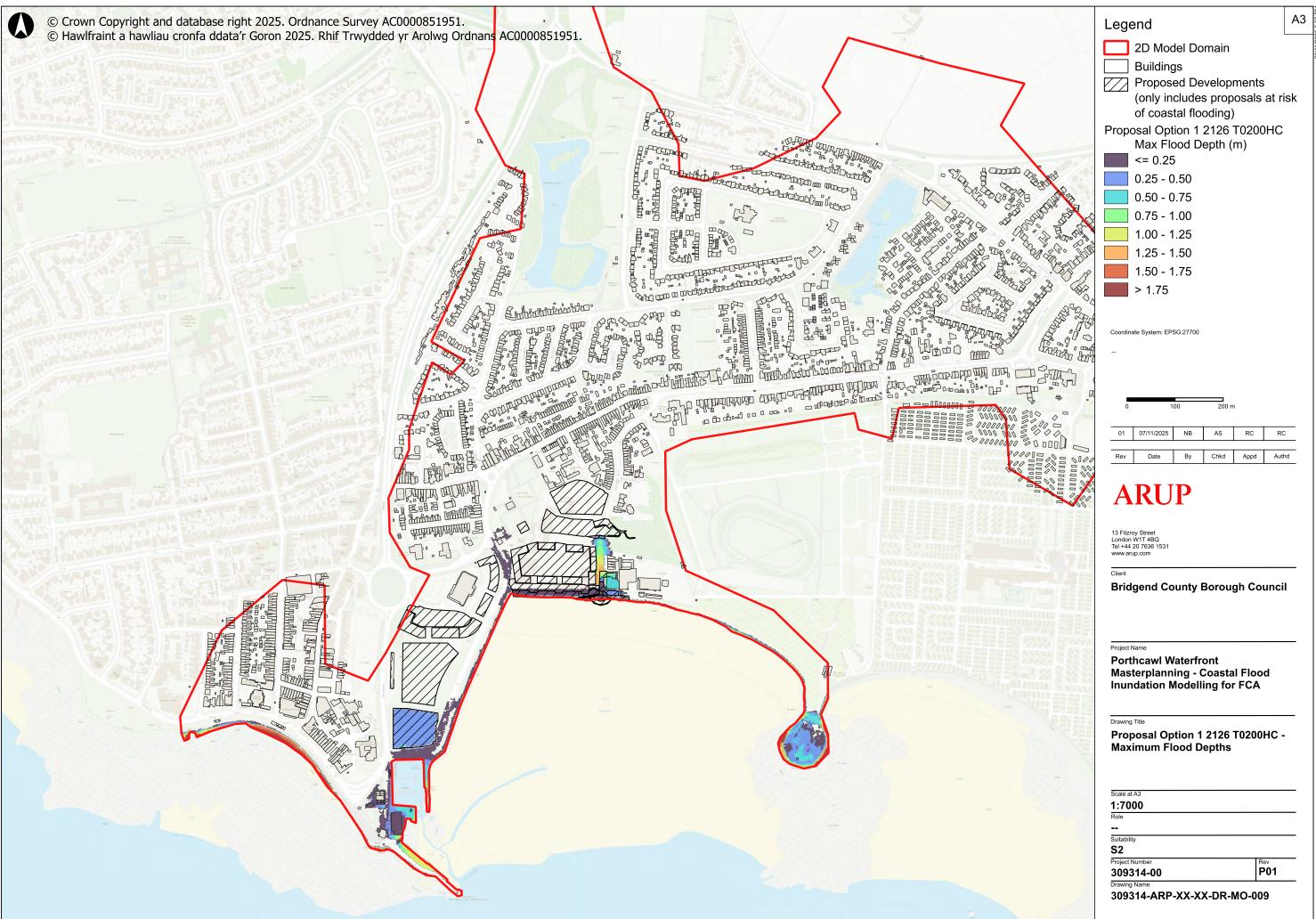


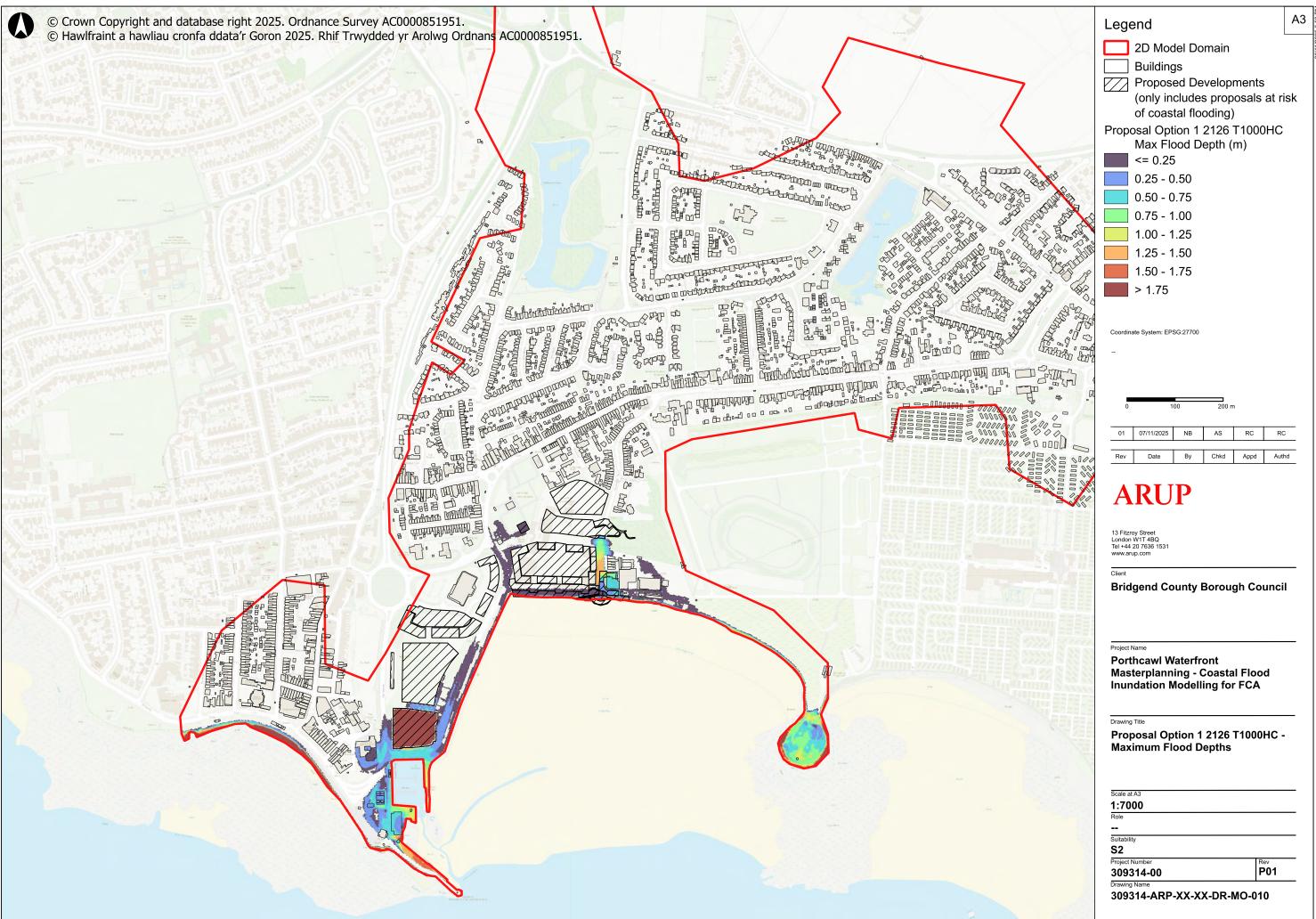
Appendix D

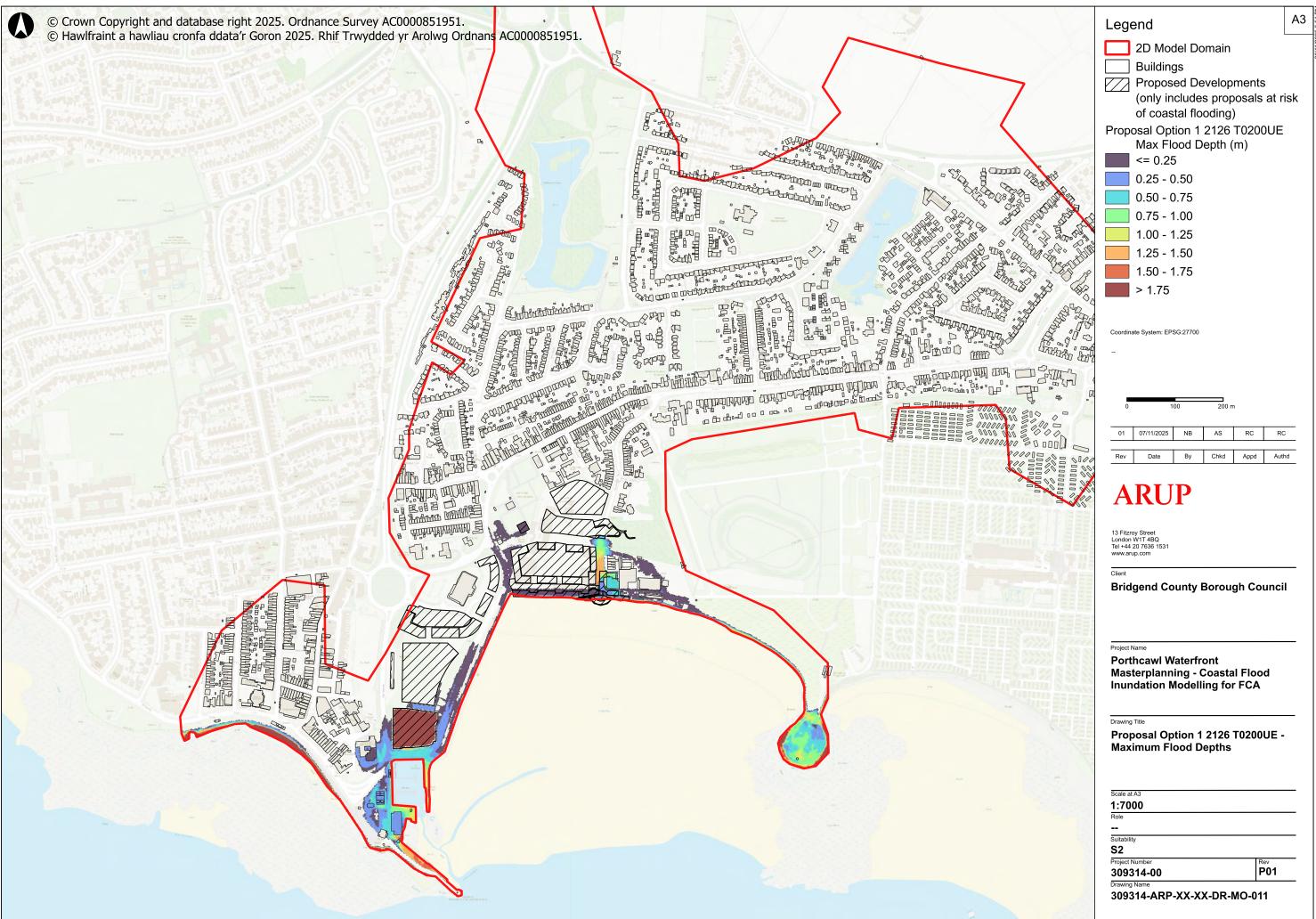
Proposed Option 1 maximum flood depth and hazard maps

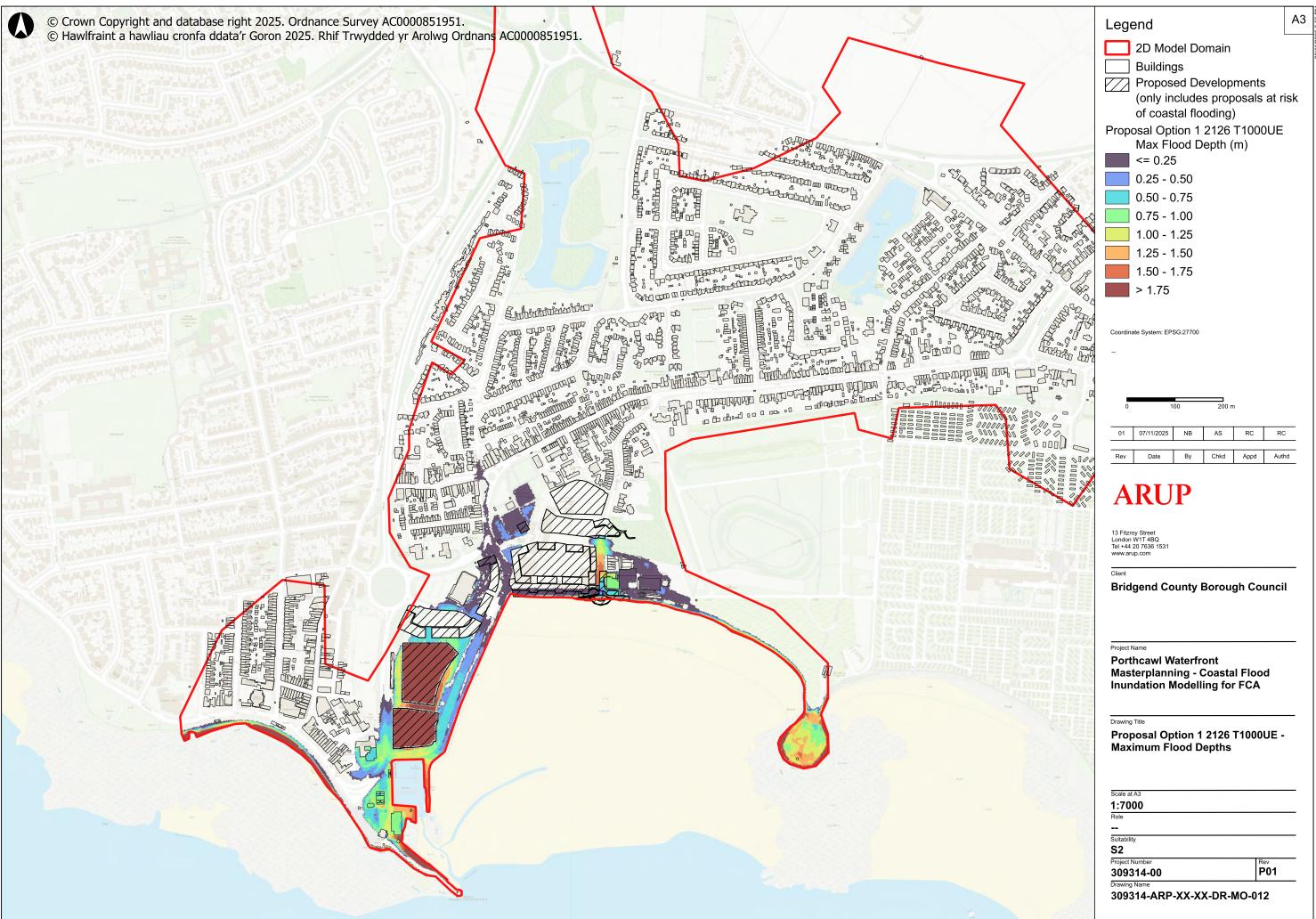


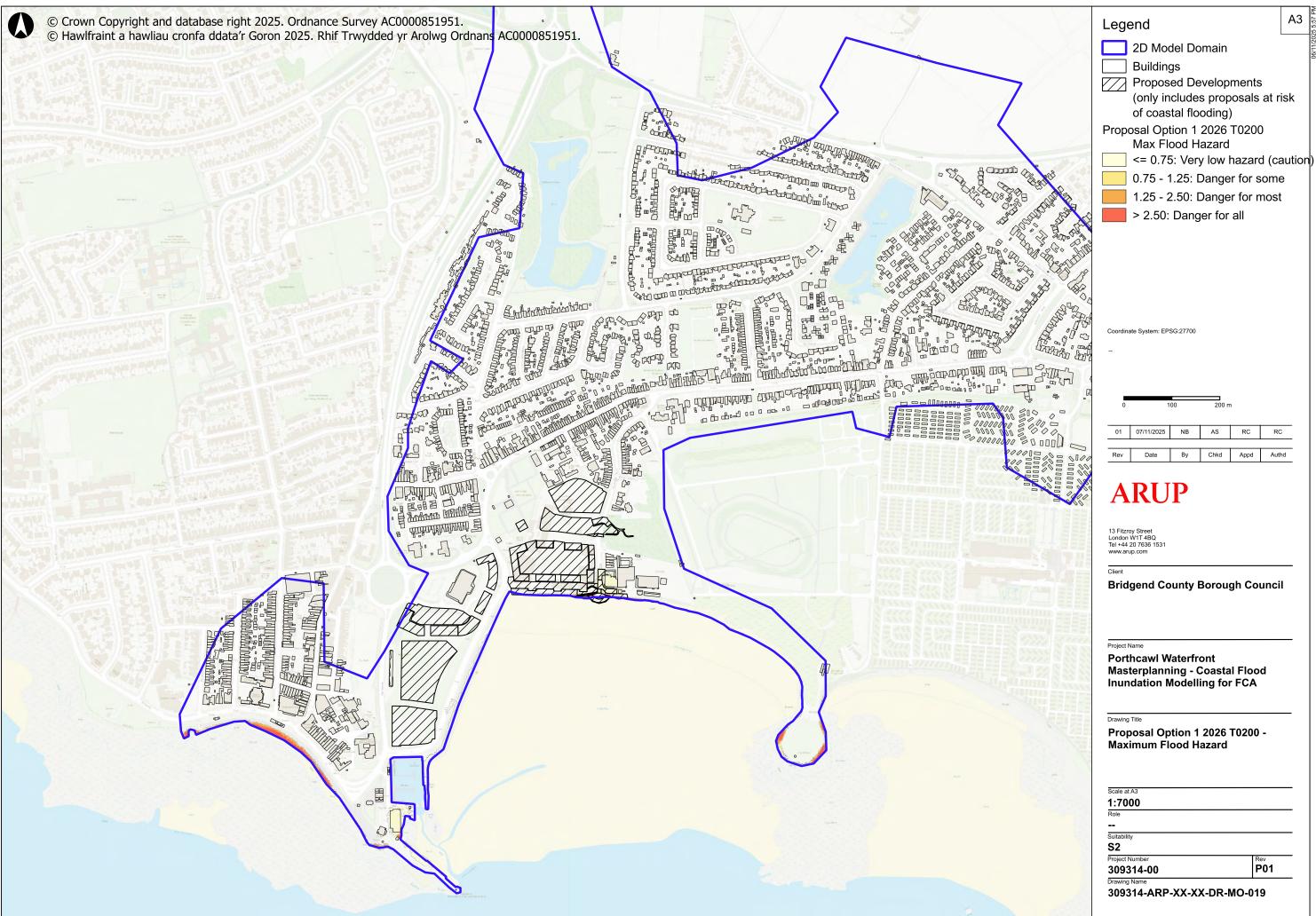


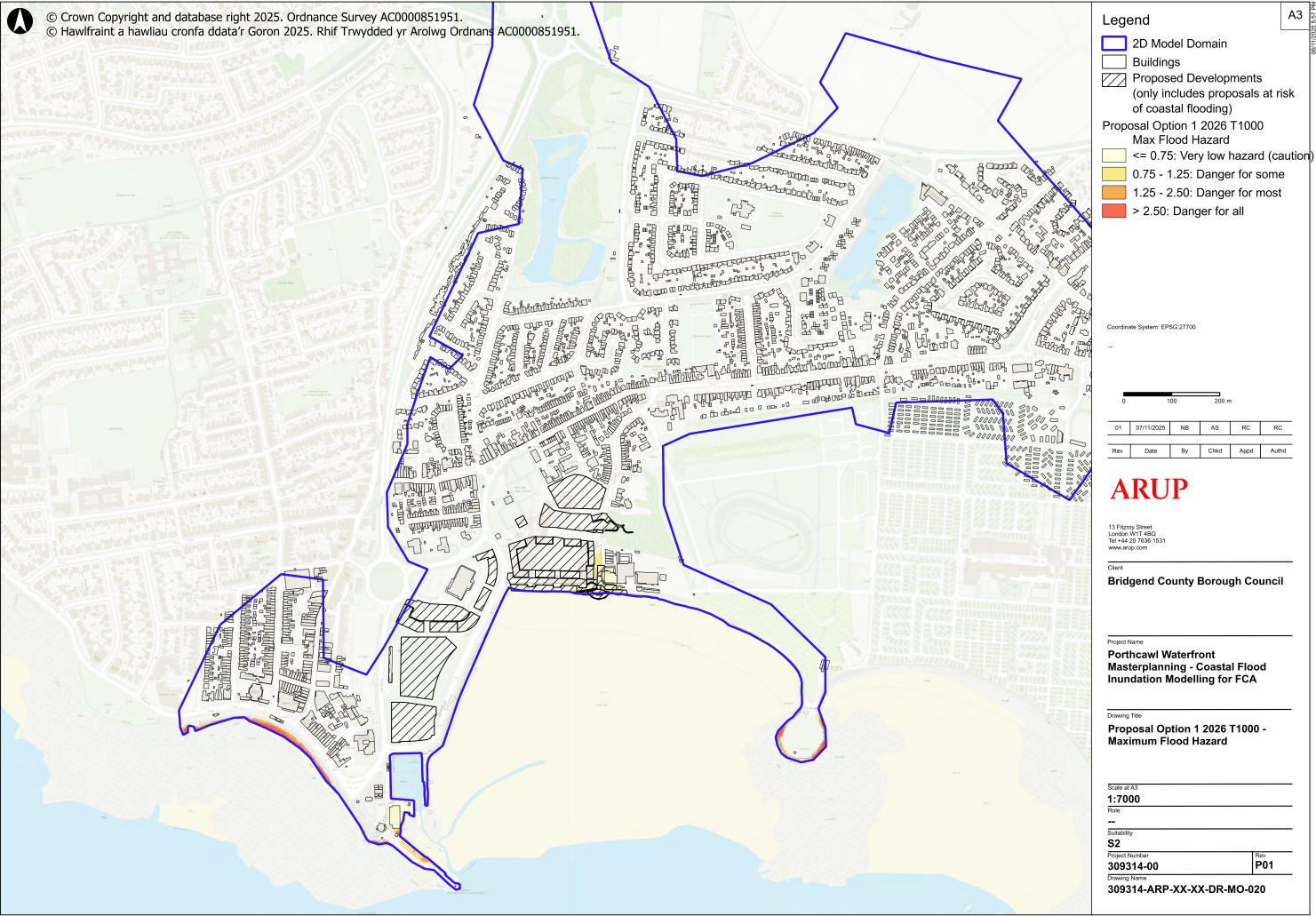


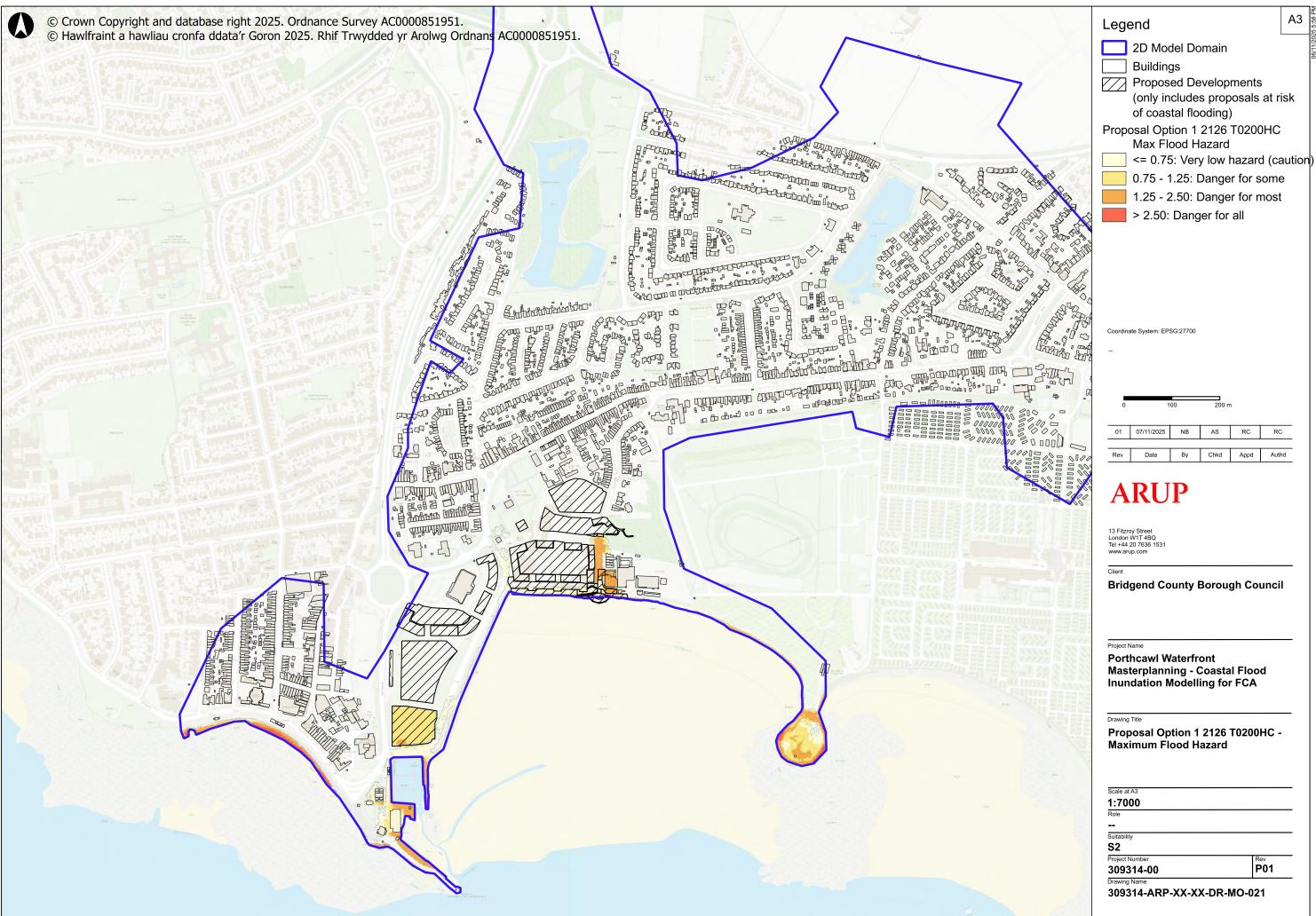


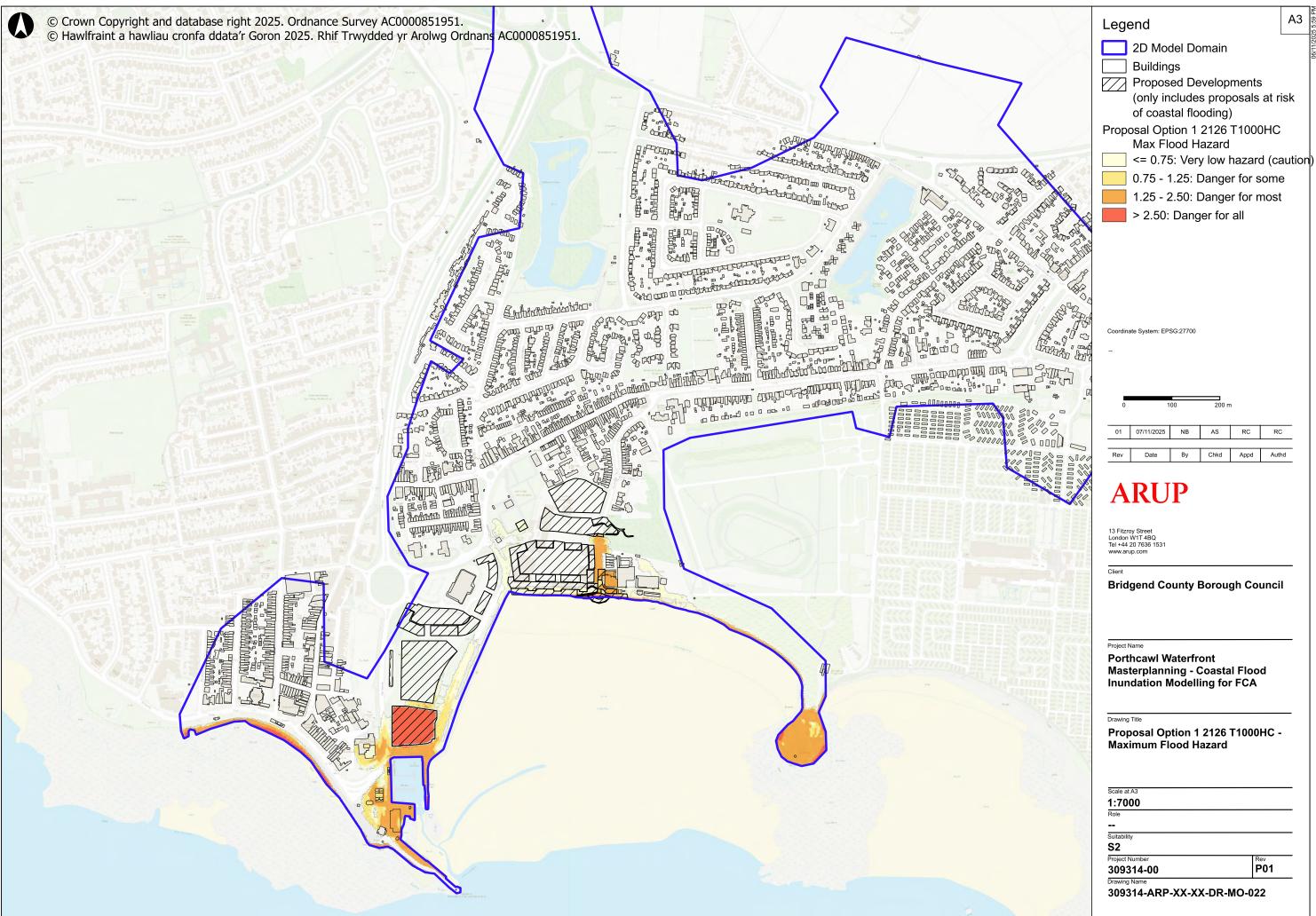


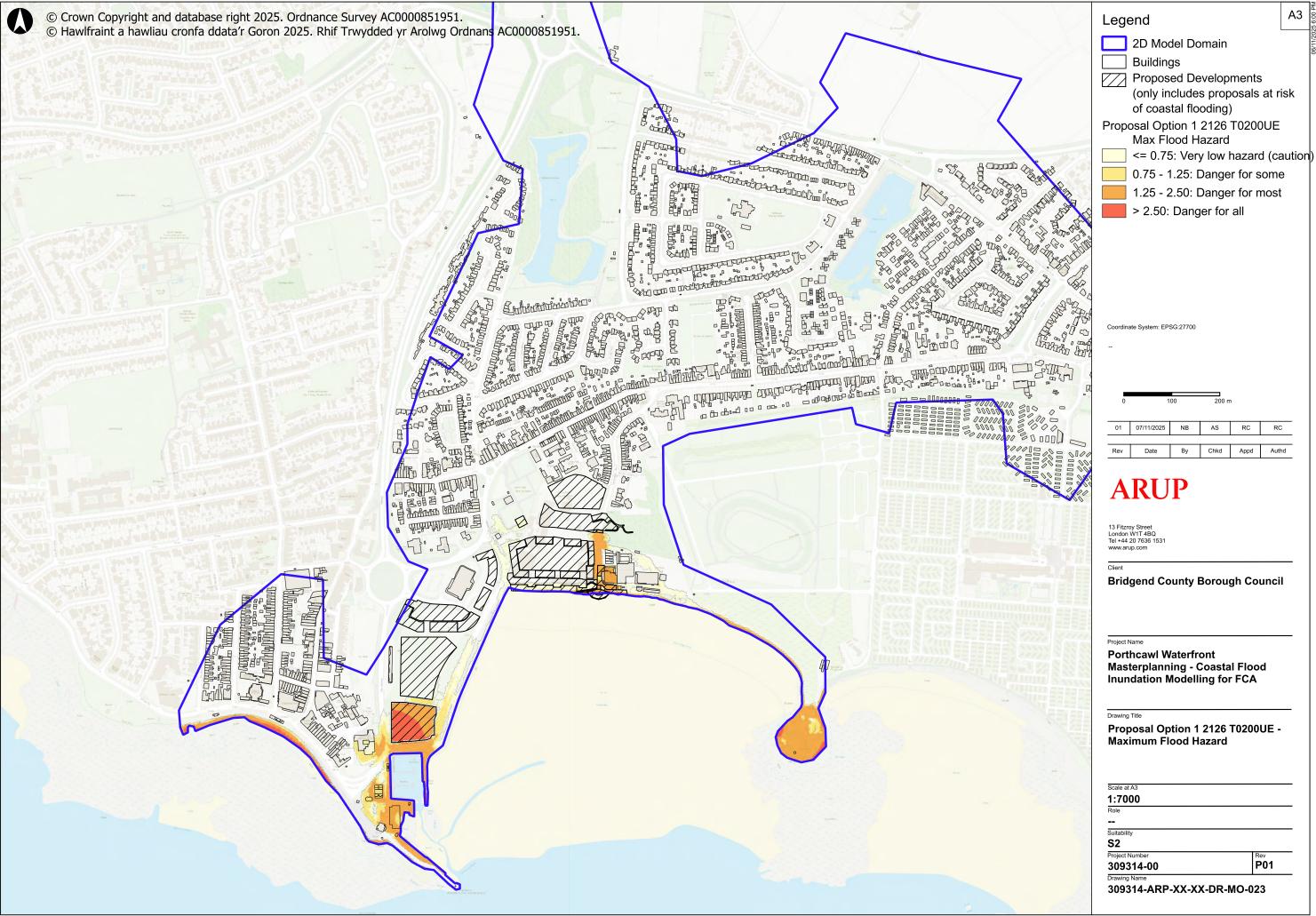


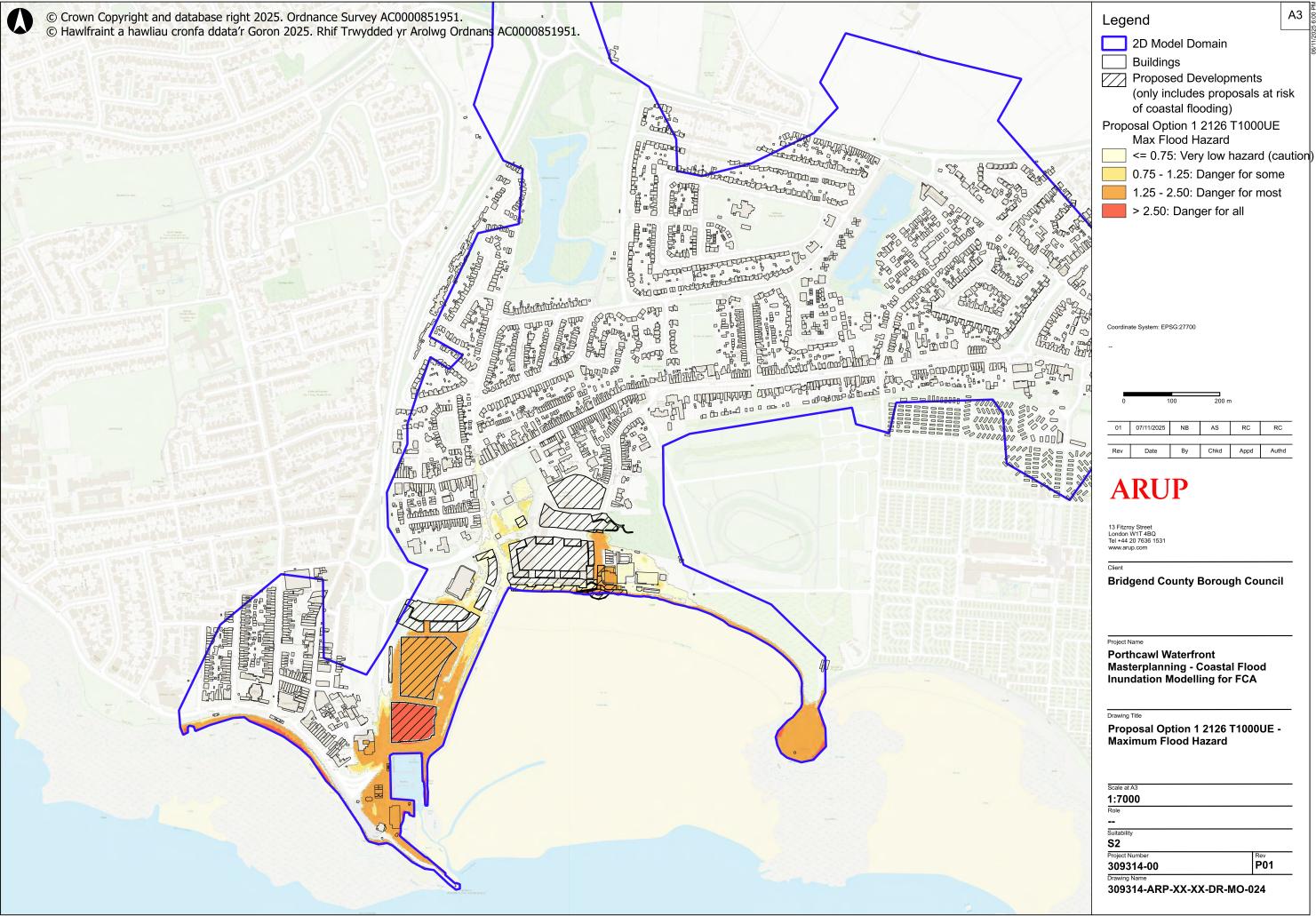












Appendix E

Impact maps

