Castle Point Strategic Flood Risk Assessment

Tidal and Breach Modelling Technical Note

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Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position
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1. Introduction

AECOM has been commissioned to update the Strategic Flood Risk Assessment (SFRA) for Castle Point Borough Council (CPBC). As part of the SFRA, tidal and breach modelling was undertaken. This technical note provides an overview of the methodology and results for the tidal and breach modelling.

Tidal sources of flooding to the Castle Point administrative area are a dominant source of flood risk, but due to the presence of substantial tidal defences, under normal circumstances, in the present day, a pathway of flooding is prevented. Therefore, the risk from tidal sources is a 'residual' risk of a defence failure and needs to be considered when determining whether a site can be made 'safe'.

The Thames Estuary 2100 (TE2100)1 plan sets out the policy for the defences in the future. Within the Castle Point administrative area, Canvey Island and Hadleigh Marshes policy units are at risk of flooding from tidal sources. The policy units are shown in Figure 1-1.

For the Canvey Island policy unit, the preferred policy is 'P4' ('we will take further action to keep up with climate and land use change so that flood risk does not increase'). Therefore, tidal flooding in the future to Canvey Island can only occur through a breach of the defences and no assessment of overtopping of the flood defences is required.

For the Hadleigh Marsh Policy Unit, the preferred policy is 'P3' ('take action to maintain flood defences at their current level, accepting that the flood risk will increase'). Therefore, a tidal flood map has been produced which maps actual tidal flood risk in the future through still water overtopping across the whole frontage of the Hadleigh Marshes flood cell. Residual risk of defence failure has also been considered.

AECOM has consulted with the Environment Agency regarding the modelling approach and specific details of the methodology (Meeting date: 11/03/2024). The approach documented in this technical note has been confirmed to be acceptable by the Environment Agency on 5th June 20242.

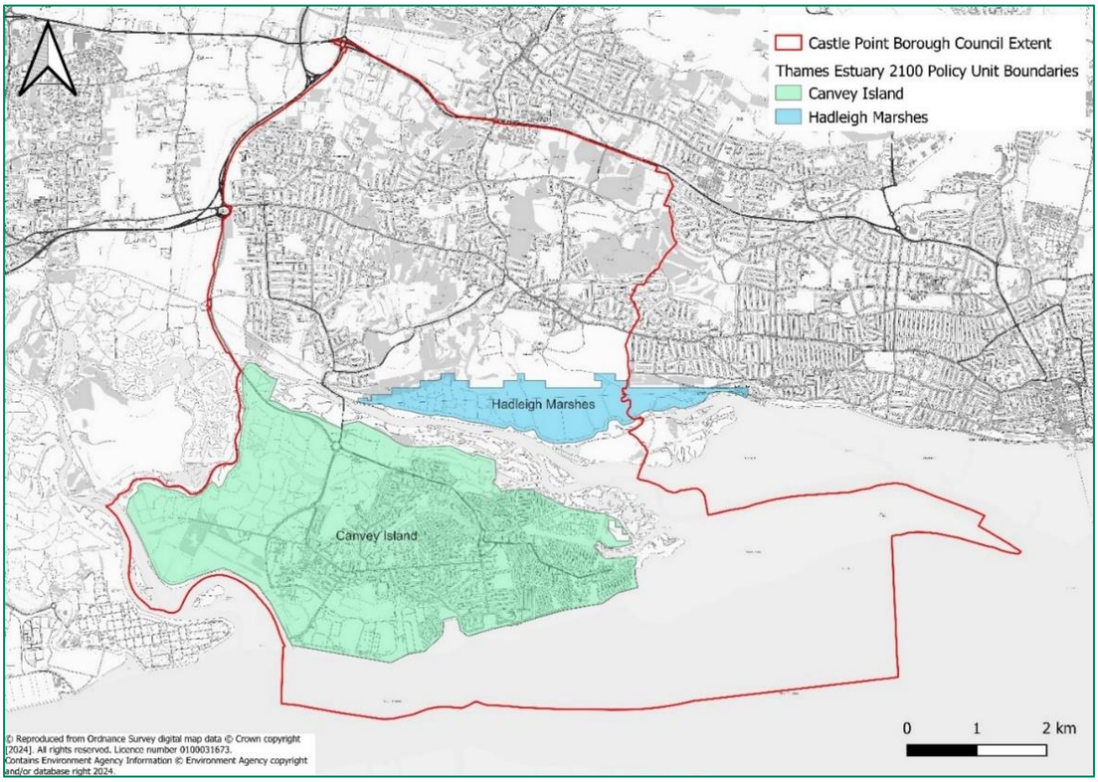

Figure 1-1: Canvey Island and Hadleigh Marshes Policy Unit Boundaries

[1] EA, 2023, Thames Estuary 2100 (TE2100), available at: https://www.gov.uk/government/collections/thames-estuary-2100-te2100
[2] Pat Abbott, EA, email to Richard Moore, Subject: Castlepoint model methodology (05 June 2024)

2. Tidal and Breach Modelling Methodology

2.1 Overview

This breach modelling methodology was developed based on the latest Environment Agency guidance, LIT 56413 Breach of defences guidance (June 2021).

The breach modelling covers the 10 breach locations for Castle Point from the 2018 South Essex Level 1 SFRA3. The breach locations cover two flood cells (Canvey Island and Hadleigh Marshes) as shown in Figure 2-1. All of the breach locations are at walls, embankments or barriers. There are no breaches at structures (i.e. gates, sluices etc.). In total, 9 breach locations are located around Canvey Island and 1 breach location at Hadleigh Marsh. The breach locations and breach parameters (toe level, crest level, embankment height, breach invert level, breach width and time to close) were discussed and confirmed with the Environment Agency[2].

As the defences are planned to be raised around Canvey Island it has been assumed that in the future no overtopping should occur, up to and including the 0.1% Annual Exceedance Probability (AEP) event. This means that only breach scenarios have been assessed for the Canvey Island flood cell.

There are no plans to raise the defences along the Hadleigh Marsh Policy unit therefore, both breach and still water overtopping may occur. The breach scenario has been simulated with still water overtopping allowed across the whole frontage of the Hadleigh Marshes flood cell (Section 2.9). A separate still water overtopping scenario assessment with no breach has been undertaken also (Section 2.10). The Hadleigh Marshes Policy unit is protected from wave action by Two Tree Island, Leigh Marsh and Hadleigh Estuary. Therefore, no wave action has been assessed in the overtopping of the defences. This approach was confirmed with the Environment Agency.

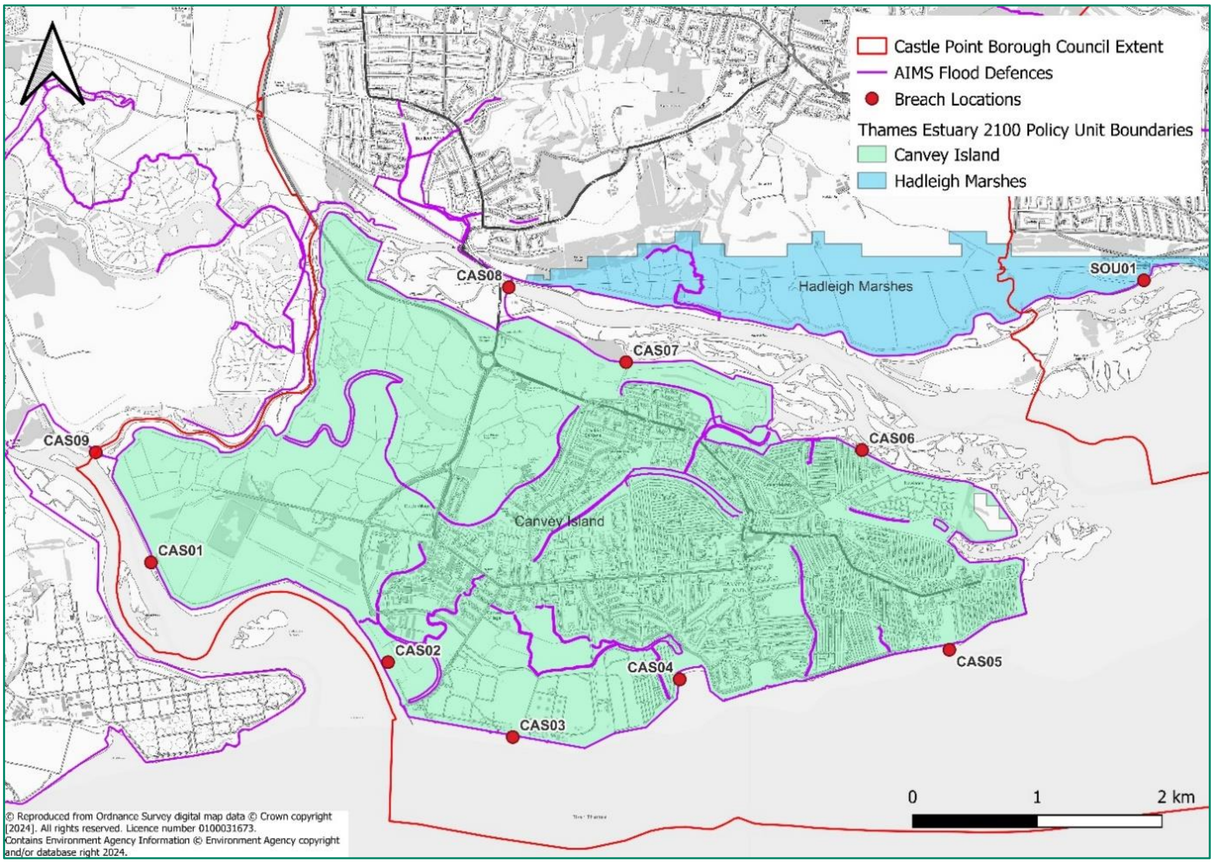

Figure 2-1: Canvey Island and Hadleigh Marshes Breach Locations with AIMS Flood Defence

[3] AECOM, 2018, *South Essex Level 1 Strategic Flood Risk Assessment*, available at: https://localplan.southend.gov.uk/sites/localplan.southend/files/201902/South%20Essex%20Strategic%20Flood%20Risk%20Assessment%20Level%201.pdf

2.2 Software

The breach models have been built using TUFLOW classic 2D fixed grid solver, version 2023-03-AC-iDP-w64.

2.3 Grid Size

A fixed 5 metre (m) grid cell size has been used in the model to represent the terrain. This was confirmed after initial test runs to be detailed enough to represent flow paths, whilst still achieving manageable run times (<8 hours).

2.4 Topography

The latest ground level data, 1m 2022 Light Detection and Ranging (LiDAR) Composite Digital Terrain Model (DTM) obtained from Department for Environment Food & Rural Services (DEFRA) Data Services Platform[4] has been used to represent the existing ground levels in Canvey Island and Hadleigh Marshes.

The 2022 LiDAR composite data contains survey undertaken between March 2012 and May 2022. Where repeat surveys have been undertaken the newest, best resolution data is used.

There has been no major construction works in the area since the survey was undertaken that is likely to impact the topographical data. It is assumed that the 2022 LiDAR is representative of the current ground levels within the Castle Point administrative area.

2.5 Defence Elevations

AIMS Spatial Flood Defences data[5] supplied by the Environment Agency were used to determine the flood defence elevations in both flood cells using the 'effective' crest elevation for embankments and hard defences, as agreed with the Environment Agency.

AECOM received confirmation from the Environment Agency on 6th March 2024 that there are no proposed changes to defence crest levels as part of the Canvey Island shoreline revetment works. Therefore, AIMS defences information was used for all crest levels.

Table 2-1 details the AIMS asset data for the 10 breach locations, including the effective crest elevation. The crest elevations in Table 2-1 were confirmed to be acceptable by the Environment Agency on 5th June 2024[2] for use in the Level 1 SFRA study.

In the northern part of Canvey Island, LiDAR DTM was preferred over the AIMS dataset at the Tewkes Creek FSA embankments (AIMS ID 479579) as it provided a more accurate representation of the defences. The AIMS effective crest elevation represents the lowest elevation within it, which in this case included a "gap" in the flood defences. This meant that by using the effective crest elevation the whole defence was predominately removed. The LiDAR DTM, which captures both the gap and the defence crest elevation, was therefore deemed more suitable to represent this defence.

The AIMS dataset shows that there are inland defences within Canvey Island. These are specified as 'Higher Ground' and have been represented by the LiDAR DTM only.

[4] DEFRA, 2024, *Data Survey Data Download,* accessed February 2024, available at: https://environment.data.gov.uk/survey
[5] DEFRA, 2024, *AIMS Spatial Flood Defence (inc. standardised attributes Data Download*, accessed March 2024, available at: https://environment.data.gov.uk/dataset/8e5be50f-d465-11e4-ba9a-f0def148f590

Table 2-1: Breach locations AIMS asset data

Breach Location	AIMS Asset ID	Defence Type	AIMS Asset Name	Effective elevation (m AOD)	Actual Upstream Crest Level (m AOD)	Actual Downstream Crest Level (m AOD)
CAS01	167220	Hard defence with earth embankment	Wall – Holehaven Creek to Upper Horse	6.49	6.49	6.58
CAS02	167054	Hard defence with earth embankment	Entrance to Holehaven Creek to Jetty	6.53	6.53	6.89
CAS03	167053	Hard defence with earth embankment	Canvey Refineries Wall	6.82	6.86	6.82
CAS04	167052	Hard defence with earth embankment	Thorney Bay to Refineries	6.84	6.86	6.86
CAS05	165839	Hard defence with earth embankment	N/A	6.39	6.67	6.53
CAS06	165831	Hard defence with earth embankment	Kellington Rd to Newland / Kings Park Village	6.52	6.59	6.55
CAS07	148655	Hard defence with earth embankment	Canvey Island Seawall. Benfleet Barrier to Tewkes Creek.	6.50	6.51	6.59
CAS08	148654	Hard defence – barrier	Wall – Benfleet Barrier to Canvey Northern Walls	6.39	6.65	6.55
CAS09	165688	Hard defence – barrier	Easthaven Steel Piling Wall	6.63	6.93	6.68
SOU1	6176	Earth embankment	East/West of Leigh Station	5.5	5.84	6.15

2.6 Further Modifications

Further modifications were applied to capture key overland flow paths and to improve stability, these were:

- Topographic patches – these have been applied at the activated 2D HT boundary cells for each breach scenario to lower the LiDAR DTM to the elevation of the breach invert This was necessary to promote the propagation of water entering the 2D domain at the correct breach elevation.
- 2d_zsh - used to lower several areas of land across the model domain to represent flow paths not captured by LiDAR, such as culverts. Initial results were reviewed to identify obstructed flow paths. Satellite imagery was then reviewed to locate potential culverts. Where culverts were identified, they were added; otherwise, they were not included. This method captured the main flow routes, though some smaller ones may be missing. Assumed invert levels and sufficient width were applied, ensuring culverts were at least one cell thick to allow water flow, even if this exceeded actual culvert widths (again this was determined through reviewing satellite imagery as exact culvert dimensions are unknown) due to grid size constraints including chosen grid size and orientation.
- Initial water levels (IWL) for features in the floodplain – The IWLs were assigned to features such as lakes and ponds in the floodplain as a conservative assumption reflecting they are not available to store water. The LiDAR DTM captures the surface of existing water bodies and the IWL has been set ~100mm above this as a conservative buffer of 0.1m.

2.7 Roughness

New Ordnance Survey Master Map (OSMM) (2024) data supplied by CPBC was used to specify varying Manning's n roughness coefficients throughout the model extent. The OSMM polygons were grouped according to land use, and Manning's n roughness coefficients were applied accordingly.

Roughness parameters were not varied with water depth, based on the assumption that, due to the large volumes of water in tidal modelling, depth-varying roughness would have minimal impact on the model results.

The roughness layer is representative of the land use at the time of the assessment. There are no known significant changes of land use proposed within the borough in the near future.

Table 2-2 presents the coefficients applied for common OSMM land use descriptors. The values used were based on engineering judgement and Environment Agency guidance.

Table 2-2: Proposed roughness values for OSMM features

OSMM Land Use Description	Manning's n
Building	0.3
General Surface (multi-surface)	0.04
General Surface (man-made / natural)	0.04
Water	0.03
Landform (slope)	0.03
Natural environment (non-coniferous trees)	0.1
Path (man-made)	0.025
Roadside (natural)	0.035
Road or track (structure)	0.025
Road or track (man-made)	0.025
Land (unclassified)	0.04

2.8 Boundary Conditions

A boundary condition 2D water level versus time (HT) shapefile was applied across the breach width for each breach location (i.e. 9 breach locations in the Canvey Island policy unit and 1 breach location in the Hadleigh Marshes policy unit). The boundary conditions used were the tidal curves derived from the nearest water level in the TE2100 extreme water level dataset for each breach, detailed in Section 3.

In the Hadleigh Marshes policy unit, a 2D HT boundary was applied along the entire defence frontage as well as at breach location (SOU1) to allow overtopping of the defence.

2.9 Breach Parameters

All breaches have been applied using the "Read GIS Variable Z Shape" command in TUFLOW which enables the breach to open at a set time and then close again. Grid cells have been lowered to the breach invert level where the 2D HT boundary cells have been applied to ensure that water enters the 2D domain at the intended elevation. The 2D variable z-shape (2d_vzsh) is setup to lower (fail) when the water level in the estuary reaches the breach trigger elevation. The determination of the breach trigger elevation is detailed in Section 2.9.3.

2.9.1 Breach Width

The breach width for each location is stated in Table 2-3 and were determined by the defence type (as shown in Table 2-1) and the latest Environment Agency guidance for Estuary/Tidal River sources[6]. For all hard defences this equates to a breach width of 20m and for the earth embankment at SOU01 this is 50m.

2.9.2 Time to Close

The time to close the breach represents the estimated response time that a breach can be repaired. It was agreed with the Environment Agency (15 May 2024) that 30 hours should be used as the time to close for all breach

[6] Environment Agency, LIT 56413 *Breach of defences guidance*, (2021)

locations. All models were simulated for 30 hours plus an additional 12 hours (c. one tide cycle) following the closure of the breach to allow the peak water level to be resolved at the extents of the flood cell.

2.9.3 Breach Trigger Elevation

The breach trigger elevation is the water elevation at which the onset of the breach occurs and is determined by the defence height. The breach trigger elevation has been calculated to be ¾ of the defence height, as per Environment Agency guidance[6] and is stated in Table 2-3 for each breach location.

2.9.4 Breach Invert Level & Defence Height Determination

The defence height was determined by subtracting the AIMS defence crest elevation from the defence toe level. No as-built or design drawings of the defences were made available therefore, the toe level of the defence was determined by interrogating the LiDAR DTM on the landward side of the breach location, as per Environment Agency guidance[6]. The toe-level was then determined as the lowest ground level within a radius equal to the breach width.

Figure 2-2 demonstrates how the toe level was selected for CAS03. The defence location is shown by the green line. The toe level was determined to be 1.71m AOD after analysing a 20 metre (breach width) radius (shown in brown) on the landward side of the breach location. The lowest point in that 20 m radius was chosen.

The toe levels and defence heights for all breaches are stated in Table 2-3.

Figure 2-2: Defence Toe Level determination through CAS01 with 20 m diameter zone

2.9.5 Final Breach Parameters

The breach parameters set out in Section 2.9.1 to Section 2.9.5 were agreed with the Environment Agency and CPBC2. The final breach parameters are shown in Table 2-3.

Table 2-3: Breach Parameters

Breach	Breach Width (m)	Time to close (hours)	Crest Level (m AOD)	Defence Toe Level (m AOD)	Defence Height (m)	Breach Trigger Elevation (m AOD)
CAS01	20	30	6.49	2.65	3.84	5.53
CAS02	20	30	6.53	2.25	4.28	5.46
CAS03	20	30	6.82	1.71	5.11	5.54
CAS04	20	30	6.84	1.94	4.90	5.62
CAS05	20	30	6.39	1.53	4.86	5.18
CAS06	20	30	6.52	1.58	4.94	5.29
CAS07	20	30	6.50	3.44	3.06	5.74
CAS08	20	30	6.39	-0.28	6.67	4.72
CAS09	20	30	6.63	-1.63	8.26	4.57
SOU01	50	30	5.50	3.60	1.90	5.03

2.10 Still Water Overtopping

The Hadleigh Marsh Policy Unit Policy ‘P3’ means that the flood defence elevations will be maintained at the present-day level. For this reason, still water overtopping of the defences was represented in the breach scenario (SOU01), and also a separate overtopping assessment was undertaken. The overtopping only scenario helps to understand the flood risk impacts should defences not be raised in line with future climate change predictions.

Still water overtopping of the flood defences was represented by a 2D HT boundary along the entire defence frontage, allowing tidal inundation into the catchment. The flood defence elevation determined the elevation at which tidal inundation could begin within a flood cell.

3. Tidal Boundaries

3.1 Design Events

Tidal boundaries have been generated for the following annual exceedance probabilities (AEP) events:

- A tidal flood event with a return period of 1 in 200 years (0.5% AEP) for the year 2025,
- A tidal flood event with a return period of 1 in 200 years (0.5% AEP) for the year 2125 with higher central climate change allowances,
- A tidal flood event with a return period of 1 in 200 years (0.5% AEP) for the year 2125 with upper end climate change allowances,
- A tidal flood event with a return period of 1 in 1000 years (0.1% AEP) for the year 2025,
- A tidal flood event with a return period of 1 in 1000 years (0.1% AEP) for the year 2125 with higher central climate change allowances, and
- A tidal flood event with a return period of 1 in 1000 years (0.1% AEP) for the year 2125 with upper end climate change allowances.

3.2 Tidal Boundary Development

The tidal models required newly derived tidal curves based on the most recent extreme water level data and climate change predictions to be applied as the still water levels in the hydraulic model. Details around the methodology in producing the tidal boundaries is discussed within Appendix A.

As presented in Appendix A, the still extreme water level varies across the CPBC administrative area. Therefore, different tidal curves were required to represent the still water level at each breach location (Table 3-1). The tidal curve for each breach was determined by the following:

- Identification of the nearest TE2100[1] node (Figure 3-1 and Table 3-1).

- Modified tidal curve was generated using the extreme water levels for each location taking into account sea level rise from the baseline year (2025) to the scenario year (2125).
- For the overtopping scenario the defence frontage was split between nodes 3.36a (for the eastern side) & 3.34 (for the western side). The tidal curves were applied across the entire Hadleigh Marshes defences frontage.

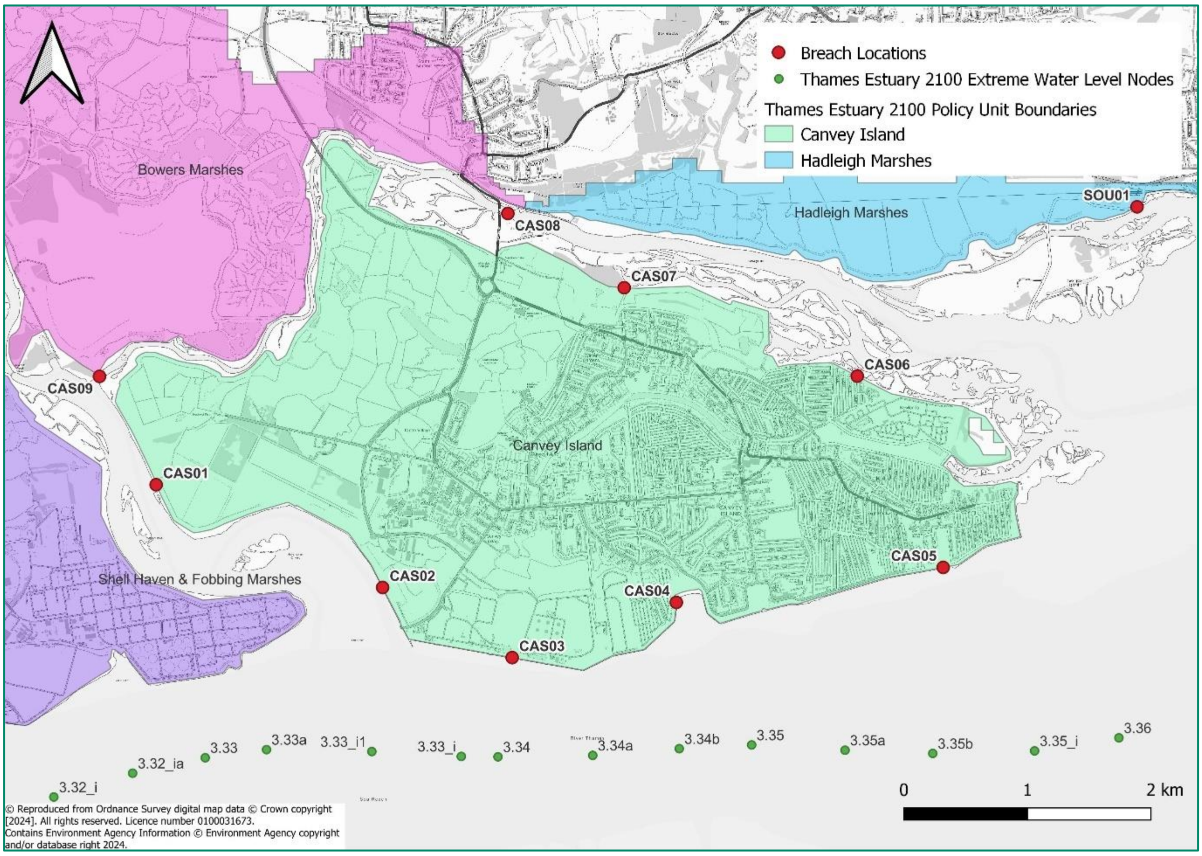

Figure 3-1: Thames Estuary 2100 Extreme Water Level Nodes

Table 3-1: Extreme Water Levels

Location	Thames Estuary 2100 Modelling Study Node Reference	0.5% AEP 2025	0.1% AEP 2025	0.5% AEP 2125 Higher Central	0.1% AEP 2125 Higher Central	0.5% AEP 2125 Upper End	0.1% AEP 2125 Upper End
CAS01	3.33_i1	5.01	5.36	6.02	6.31	6.34	6.65
CAS02	3.33_i1	5.01	5.36	6.02	6.31	6.34	6.65
CAS03	3.34	4.99	5.34	6.00	6.31	6.33	6.64
CAS04	3.34b	4.96	5.31	5.98	6.29	6.31	6.63
CAS05	3.35b	4.91	5.27	5.94	6.27	6.29	6.61
CAS06	3.35a	4.93	5.28	5.96	6.27	6.29	6.62
CAS07	3.34a	4.97	5.33	5.99	6.30	6.32	6.64
CAS08	3.34	4.99	5.34	6.00	6.31	6.33	6.64
CAS09	3.33	5.04	5.38	6.05	6.33	6.36	6.66
SOU01	3.36a	4.91	5.27	5.94	6.27	6.29	6.61

3.3 Model Simulations

Table 3-2 summarises the model runs completed for each event. After derivation of the tidal boundaries, it was found that the breach trigger elevation was not reached for some events. The scenarios that were not simulated are shown in red. In total, there are 52 simulations.

Table 3-2: Model Simulation List

Location	0.5% AEP 2025	0.5% AEP 2125 HC	0.5% AEP 2125 UE	0.1% AEP 2025	0.1% AEP 2125 HC	0.1% AEP 2125 UE
CAS01		X	X		X	X
CAS02		X	X		X	X
CAS03		X	X		X	X
CAS04		X	X		X	X
CAS05		X	X	X	X	X
CAS06		X	X		X	X
CAS07		X	X		X	X
CAS08	X	X	X	X	X	X
CAS09	X	X	X	X	X	X
SOU01		X	X	X	X	X
SOU01 Overtopping Only	X	X	X	X	X	X

4. Model Health

The model health of the breach and overtopping scenario modelling can be summarised:

- Initial Mass Balance Error Spike – all breach simulations have an initial spike in cumulative mass balance error of c.6%. This is due to the 2D cells wetting up at the start of the simulation.
- Mass balance error fall within tolerance – all breach scenarios from CAS01 to CAS07, with the exception of CAS04, fall within (+/-1%).
- Overtopping – mass balance of scenarios that assessed still water overtopping of the defences were all within what is considered acceptable (+/- 1%).
- CAS04 - the mass balance exceeds the tolerance slightly (maximum c. -1.3%), occurring around 65 hours, which coincides with the breach closure. Given the level of inundation in the area, it is unlikely that this will significantly impact the overall results.
- 2D Negative depths – A small number of negative depths were observed in most simulations. Given the brief duration and small size these are deemed to be within model tolerances.
- CAS03 2D Negative depths – shows 345 negative 2D depths in the 2125 Higher Central 0.1% AEP scenario. This issue was reviewed, and stability patches were applied to reduce the negative depths, but it could not be fully resolved. Given the brief duration of the negative depths and their occurrence in only one simulation, this is considered to not impact results to an unacceptable level.
- Stability patches – Stability patches were applied in areas of model instability, likely caused by quick topographic changes through potential errors in the underlying LiDAR DTM or rapid wetting of cells due to large water volumes and velocities. Patches of 2d_mat file with high Manning's roughness values (0.2–0.5) were used to slow the water and stabilise the flow. As these patches cover a small portion of

the overall model and are not near important receptors, they are considered within acceptable model tolerances.

5. Model Limitations

The model's performance is subject to several limitations that affect its accuracy and representation of real-world conditions. The following key limitations have been identified:

- Structure representation - Culverts/crossings within the floodplain are represented as topographic patches and their location and dimensions have been assumed based upon available LiDAR DTM and aerial photography. All major overland flow paths have been captured though smaller flow paths may not be represented.
- Defence representation – It is assumed that the 'effective crest' elevations from the Environment Agency AIMS dataset is an accurate representation of the defence elevations.
- Model stability – Not all indicators of model instability could be removed from the model (Section 4). These are not considered to have a significant impact on the accuracy of the model results but should be reviewed in future hydraulic modelling studies.
- Data (gaps and age) – The LiDAR DTM and AIMS datasets are assumed to be accurate enough to represent the key parameters of the defences at the breach locations like toe level, defence etc. No data was available for structures within the floodplain.
- Topographic limitations – LiDAR DTM data is a composite of data collected from 2003 to 2022 and is the best available topographic data. This has been reviewed to identify if there have been any significant changes within the area since collection. None were identified and is considered acceptable for use.
- Grid orientation – The grid orientation was selected to best represent the direction of water flow at the breach location, ensuring accurate modelling at this critical point. However, this choice means that, across the model domain, certain structures, like culverts, may need to be adjusted. For example, some culverts have been widened to ensure they are one grid cell thick to allow water flow, as their actual alignment does not match the grid orientation.
- Model domain - The maximum water level may not be reached at the extents of the floodplain at the time of the end of the model simulation. This is because water may still be inundating the floodplain at the edges of the flood extent. The model simulation is sufficiently long that any change in depth and/or extent is likely to be small compared to the overall flood extent.
- Cell size – A 5m grid cell size was chosen due to the comprise between being able to represent enough detail to capture the main flow paths whilst still being able to achieve a manageable run time (<8 hours). Smaller grid cell sizes would be able to capture finer topographical detail and increase model accuracy.
- Application of outputs - The model results are assumed to be suitable for the strategic purposes of the SFRA. For future use these models should be updated with the latest data available.

6. Model Outputs

6.1 Overview

Results from the models are provided in the form of ASCII grids for maximum flood depth, maximum water level and maximum flood hazard.

Flood hazard rating categorises the danger to people for different combinations of flood water depth and velocity. The derivation of these categories is based on the methodology set out by Defra in Flood Risks Assessment Guidance for New Development FD2320/TR27 using the following equation:

*Flood Hazard Rating = ((v+0.5)*D) + DF*

Where v = velocity (m/s), D = depth (m), DF = debris factor

[7] Defra and Environment Agency (2005) FD2320/TR2 Flood Risk Assessment Guidance for New Development. https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/flood-risk-assessment-guidance-for-new-development

In line with the guidance, a debris factor of 0.5 was used for depths < 0.25m and a debris factor of 1.0 was used for depths > 0.25m.

Flood Hazard		Description
Low	HR < 0.75	Caution – Flood zone with shallow flowing water or deep standing water
Moderate	0.75 ≥ HR ≤ 1.25	Dangerous for some (i.e. children) – Danger: flood zone with deep or fast flowing water
Significant	1.25 > HR ≤ 2.0	Dangerous for most people – Danger: flood zone with deep fast flowing water
Extreme	HR > 2.0	Dangerous for all – Extreme danger: flood zone with deep fast flowing water

6.2 Mapping

The following maps are included within the Appendix C and D of the SFRA Report.

Appendix C Overtopping Results

- Map 1: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Depth (m)
- Map 2: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Hazard Rating
- Map 3: Overtopping 0.5% AEP (1 in 200 year) (2125) (HC) – Maximum Depth (m)
- Map 4: Overtopping 0.5% AEP (1 in 200 year) (2125) (HC) – Maximum Hazard Rating
- Map 5: Overtopping 0.5% AEP (1 in 200 year) (2125) (UE) – Maximum Depth (m)
- Map 6: Overtopping 0.5% AEP (1 in 200 year) (2125) (UE) – Maximum Hazard Rating
- Map 7: Overtopping 0.1% AEP (1 in 1000 year) (2025) – Maximum Depth (m)
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- Map 9: Overtopping 0.1% AEP (1 in 1000 year) (2125) (HC) – Maximum Depth (m)
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- Map 7: Tidal Breach 0.1% AEP (1 in 1000 year) (2025) (UE) – Maximum Depth (m)
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- Map 9: Tidal Breach 0.5% AEP (1 in 200 year) (2125) (HC) – Maximum Hazard Rating
- Map 10: Tidal Breach 0.5% AEP (1 in 200 year) (2125) (UE) – Maximum Hazard Rating
- Map 11: Tidal Breach 0.1% AEP (1 in 1000 year) (2025) – Maximum Hazard Rating
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Appendix A – Tidal Boundary Development

Castle Point Strategic Flood Risk Assessment

Appendix A – Tidal Boundary Development

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Quality information

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1. Introduction

AECOM has been commissioned to update the Level 1 Strategic Flood Risk Assessment (SFRA) for Castle Point Borough Council (CPBC). The purpose of the SFRA is to assess the risk to an area from flooding from all sources, now and in the future, taking account the impacts of climate change, and to assess the impact that land use changes and development in the area will have on flood risk. This report documents the assessment of fluvial flood risk within the CPBC administrative area.

This note details how the tidal boundaries have been developed which have then been applied to the hydraulic models.

1.1 Purpose of this Report

Tidal curves derived from the latest extreme water level data and climate change projects are required to serve as a tidal boundary in the hydraulic modelling exercise. Tidal curves for the 0.5% Annual Exceedance Probability (AEP) event and 0.1% AEP event are required for the years 2025 and 2125. Values are required for two emission scenarios: higher central (70th percentile) and upper end (95th percentile).

The Thames Estuary 2100 (TE2100) dataset has been utilised where appropriate (14 nodes adjacent to the study site). However, a tidal curve was also required for the River Roach which is outside of the TE2100 extent and therefore the curve for this location has been developed using the Coastal Flood Boundary (CFB, 2018) Dataset and UKCP18 sea level rise projections.

This report is divided into two parts:

- Part 1: Tidal Boundary Development for the Thames Estuary
  Explains the derivation of tidal curves using the TE2100 dataset for the 14 nodes adjacent to the study site.
- Part 2: Tidal Boundary Development for the River Roach
  Explains the derivation of tidal curves using the CFB (2018) and UKCP18 datasets for the River Roach.

2. Part 1: Tidal Boundary Development for the Thames Estuary

The Thames Estuary 2100 (TE2100) dataset provides estimated extreme water levels at different nodes along the tidal Thames Estuary. For each node a range of return periods are provided for different time periods; this includes the 0.5% AEP and 0.1% AEP events for the years 2020, 2040, 2065, 2070, 2100, 2120, 2135 and 2170.

For the purposes of this project extreme water level values for 14 locational nodes were required. These nodes are shown in Figure 1 below.

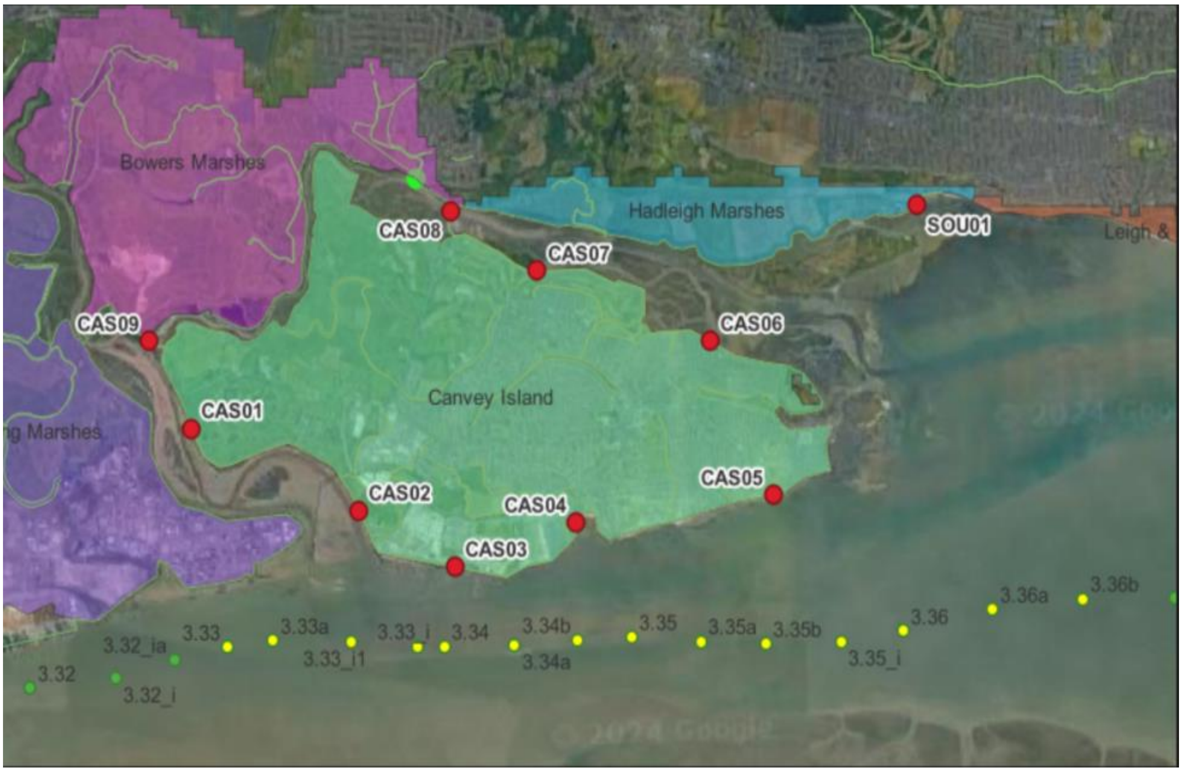

Figure 1: Target nodes (yellow) from the TE2100 dataset

2.1 Extreme Water Levels

The TE2100 dataset does not provide extreme water level estimates for the years 2025 and 2125. To calculate the 0.5% AEP and 0.1% AEP water levels for these years the values were interpolated from the corresponding return periods available for the years either side of the required years:

- 2025 values were interpolated from the 2020 and 2040 values
- 2125 values were interpolated from the 2120 and 2135 values

Tables 1 and 2 below show extreme water levels from the TE2100 data for 2020, 2040, 2120 and 2135 and the interpolated values for 2025 and 2125 (highlighted in red). Table 1 shows the values for the higher central scenario, and Table 2 shows the values for the upper end allowance.

Table 1: Extreme Water Levels, m AOD (interpolated levels in bold) – Higher Central scenario (70th percentile)

Node	Epoch	0.5%AEP	0.1%AEP
3.33	2020	5.01	5.35
	2025	**5.04**	**5.38**
	2040	5.13	5.47
	2120	5.99	6.28
	2125	**6.05**	**6.33**
	2135	6.16	6.44
3.33a	2020	5.00	5.34
	2025	**5.03**	**5.37**
	2040	5.12	5.46
	2120	5.98	6.27

Node	Epoch	0.5%AEP	0.1%AEP
3.35	2020	4.91	5.27
	2025	**4.94**	**5.30**
	2040	5.04	5.40
	2120	5.91	6.22
	2125	**5.97**	**6.28**
	2135	6.08	6.39
3.35a	2020	4.90	5.25
	2025	**4.93**	**5.28**
	2040	5.03	5.38
	2120	5.90	6.21

	2125	**6.04**	**6.32**
	2135	6.15	6.43
3.33_i1	2020	4.98	5.33
	2025	**5.01**	**5.36**
	2040	5.11	5.45
	2120	5.96	6.26
	2125	**6.02**	**6.31**
	2135	6.13	6.42
3.33_i	2020	4.97	5.32
	2025	**5.00**	**5.35**
	2040	5.10	5.44
	2120	5.95	6.25
	2125	**6.01**	**6.31**
	2135	6.12	6.42
3.34	2020	4.96	5.31
	2025	**4.99**	**5.34**
	2040	5.09	5.44
	2120	5.94	6.25
	2125	**6.00**	**6.31**
	2135	6.11	6.42
3.34a	2020	4.94	5.30
	2025	**4.97**	**5.33**
	2040	5.07	5.42
	2120	5.93	6.24
	2125	**5.99**	**6.30**
	2135	6.10	6.41
3.34b	2020	4.93	5.28
	2025	**4.96**	**5.31**
	2040	5.06	5.41
	2120	5.92	6.23
	2125	**5.98**	**6.29**
	2135	6.09	6.40

	2125	**5.96**	**6.27**
	2135	6.07	6.38
3.35b	2020	4.88	5.24
	2025	**4.91**	**5.27**
	2040	5.01	5.37
	2120	5.88	6.21
	2125	**5.94**	**6.27**
	2135	6.06	6.38
3.35_i	2020	4.87	5.23
	2025	**4.90**	**5.26**
	2040	5.00	5.36
	2120	5.87	6.20
	2125	**5.93**	**6.26**
	2135	6.05	6.37
3.36	2020	4.86	5.22
	2025	**4.89**	**5.25**
	2040	4.99	5.34
	2120	5.85	6.19
	2125	**5.91**	**6.25**
	2135	6.04	6.36
3.36a	2020	4.83	5.19
	2025	**4.86**	**5.22**
	2040	4.96	5.32
	2120	5.83	6.17
	2125	**5.89**	**6.23**
	2135	6.01	6.35
3.36b	2020	4.81	5.18
	2025	**4.85**	**5.21**
	2040	4.95	5.31
	2120	5.83	6.17
	2125	**5.89**	**6.23**
	2135	6.01	6.35

Table 2: Extreme Water Levels, m AOD (interpolated levels in bold) – Upper end scenario (95th percentile)

Node	Epoch	0.5%AEP	0.1%AEP
3.33	2020	5.00	5.34
	2025	**5.04**	**5.38**
	2040	5.16	5.50
	2120	6.29	6.58

Node	Epoch	0.5%AEP	0.1%AEP
3.35	2020	4.91	5.27
	2025	**4.95**	**5.31**
	2040	5.07	5.43
	2120	6.22	6.54

	2125	**6.36**	**6.66**
	2135	6.50	6.81
3.33a	2020	5.00	5.34
	2025	**5.04**	**5.38**
	2040	5.15	5.49
	2120	6.28	6.57
	2125	**6.35**	**6.65**
	2135	6.50	6.80
3.33_i1	2020	4.98	5.32
	2025	**5.02**	**5.36**
	2040	5.14	5.48
	2120	6.27	6.57
	2125	**6.34**	**6.65**
	2135	6.49	6.80
3.33_i	2020	4.96	5.32
	2025	**5.00**	**5.36**
	2040	5.12	5.47
	2120	6.26	6.56
	2125	**6.33**	**6.64**
	2135	6.48	6.80
3.34	2020	4.96	5.31
	2025	**5.00**	**5.35**
	2040	5.12	5.47
	2120	6.26	6.56
	2125	**6.33**	**6.64**
	2135	6.48	6.79
3.34a	2020	4.94	5.30
	2025	**4.98**	**5.34**
	2040	5.10	5.45
	2120	6.25	6.56
	2125	**6.32**	**6.64**
	2135	6.47	6.79
3.34b	2020	4.93	5.28
	2025	**4.97**	**5.32**
	2040	5.09	5.44
	2120	6.23	6.55
	2125	**6.31**	**6.63**
	2135	6.46	6.78

	2125	**6.30**	**6.62**
	2135	6.46	6.78
3.35a	2020	4.90	5.25
	2025	**4.94**	**5.29**
	2040	5.05	5.41
	2120	6.21	6.54
	2125	**6.29**	**6.62**
	2135	6.44	6.78
3.35b	2020	4.88	5.24
	2025	**4.92**	**5.28**
	2040	5.04	5.40
	2120	6.21	6.53
	2125	**6.29**	**6.61**
	2135	6.44	6.78
3.35_i	2020	4.87	5.23
	2025	**4.91**	**5.27**
	2040	5.03	5.38
	2120	6.20	6.52
	2125	**6.28**	**6.60**
	2135	6.44	6.76
3.36	2020	4.86	5.22
	2025	**4.90**	**5.26**
	2040	5.02	5.37
	2120	6.19	6.52
	2125	**6.27**	**6.60**
	2135	6.43	6.76
3.36a	2020	4.83	5.19
	2025	**4.87**	**5.23**
	2040	4.99	5.35
	2120	6.16	6.51
	2125	**6.24**	**6.59**
	2135	6.41	6.76
3.36b	2020	4.81	5.18
	2025	**4.85**	**5.22**
	2040	4.98	5.34
	2120	6.17	6.51
	2125	**6.25**	**6.59**
	2135	6.42	6.76

2.2 Tidal Curve Development

Using the interpolated extreme water levels from Tables 1 and 2, tidal curves for a 100-hour time period were created for use in the model boundaries. The steps for creating these tidal curves are outlined below:

1. Obtain a typical Mean High Water Springs (MHWS) base tide for the area. Admiralty TotalTide software was used to obtain this information for Coryton. The levels were adjusted to Ordnance Datum using 0mCD = -3.05mOD from the 2022 Admiralty Tide Tables (ATT) (UKHO, 2022).
2. Uplift the base tide with sea level rise to the required year and emissions scenario (e.g. 2025 or 2125). The sea level rise values from the TE2100 dataset were used for this and were interpolated to the required year (Table 3.9, Environment Agency, 2022). The interpolated values are shown in Table 3.

Table 3: Interpolated sea level rise values for 2025 and 2125, higher central and upper end scenarios

Epoch	70th percentile (higher central)	95th percentile (upper end)
2025	0.053m	0.060m
2125	1.093m	1.477m

3. Apply a surge profile to the base tide from step 2 (with sea level rise) to match the peak water level with the desired extreme water level value from Tables 1 and 2. The shape of the surge profile was obtained from the CFB (2018) dataset using the Sheerness donor site.
4. Tidal curves were generated for each scenario required; the 0.5% AEP and 0.1% AEP scenarios for 2025 and 2125 for both the higher central and upper end sea level rise projections.

Figure 2 and Figure 3 show two examples of the tidal curves generated:

- Figure 2 shows the tidal curve for node 3.33 for a 0.5% AEP event in 2125 using the higher central (70th percentile) sea level rise scenario. The peak water level in this tidal curve is 6.05m AOD.
- Figure 3 shows the tidal curve for node 3.33 for a 0.5% AEP event in 2125 but using the upper end (95th percentile) sea level rise scenario. As can be seen, the peak extreme water level is 6.36m AOD.

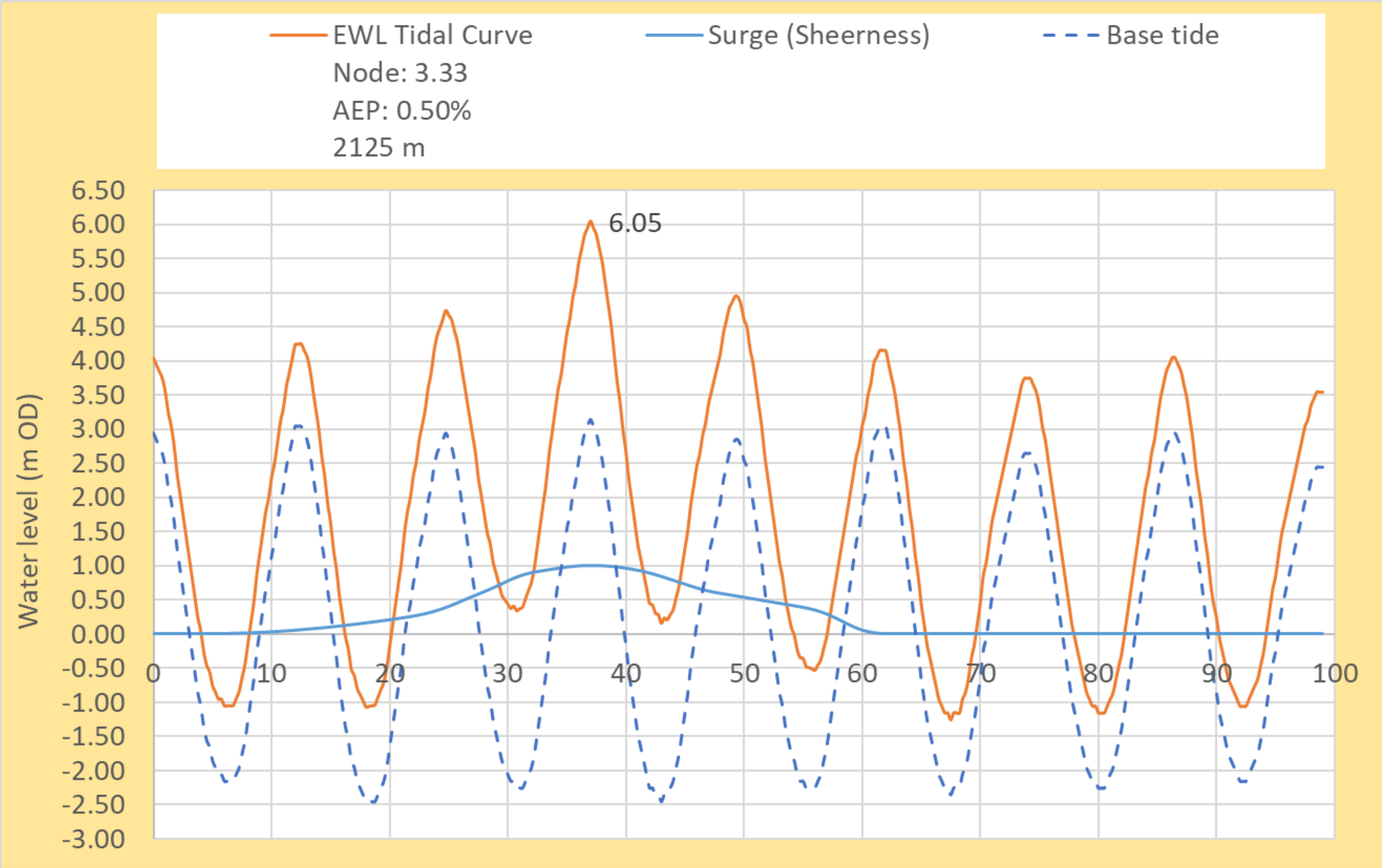

Figure 2: Example tidal curve for Node 3.33, 2125 AEP 0.5% higher central scenario

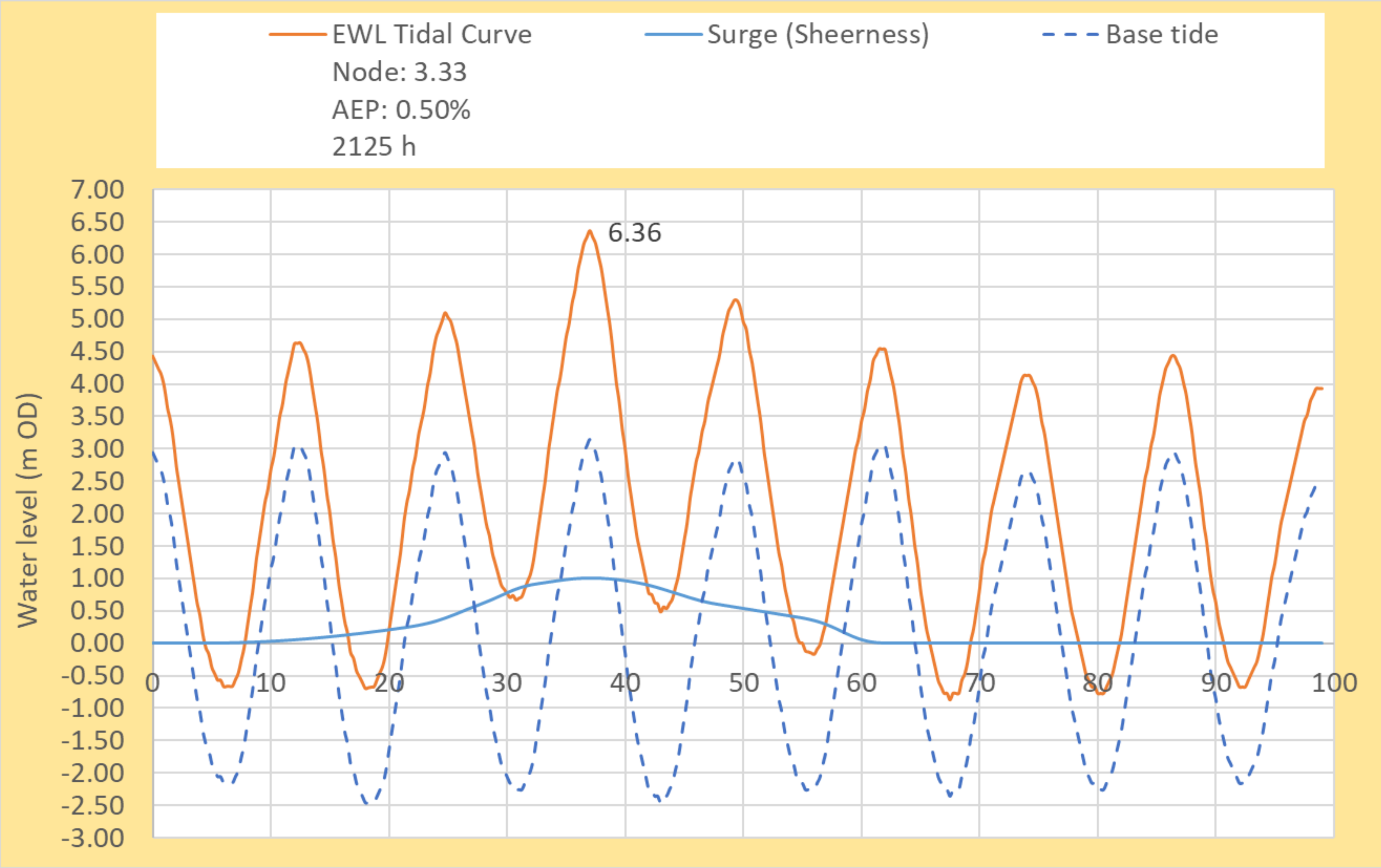

Figure 3: Example tidal curve for Node 3.33, 2125 AEP 0.5% upper end scenario

3. Part 2: Tidal Boundary Development for the River Roach

Tidal boundaries are required for the downstream area of the River Roach. This area is outside of the TE2100 extent and therefore a different approach to calculating the extreme water levels and developing the tidal boundaries has been followed.

3.1 Extreme Water Levels

Coastal Flood Boundary Dataset

Tidal boundary conditions for the River Roach downstream of Burnham-on-Crouch have been created. The boundaries have been developed for the 0.5% AEP and 0.1% AEP events in 2025 and 2125. Values for the UKCP18 RCP 8.5 70th percentile and 95th percentile sea level rise scenarios have been generated.

Extreme water levels have been obtained from the CFB (2018) dataset chainage point 4286. The position of this chainage location is highlighted in Figure 4.

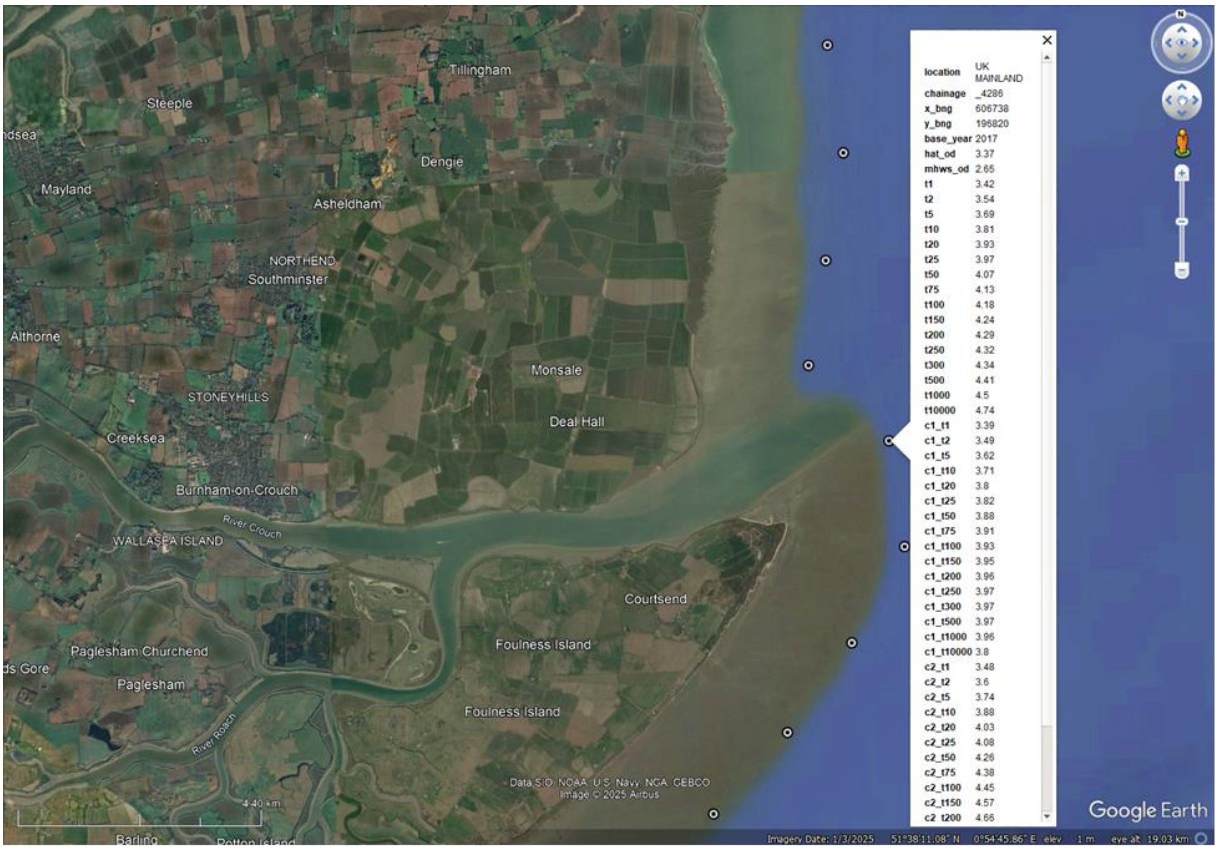

Figure 4: Map of CFB chainage points leading from the Thames Estuary to the River Roach, Chainage 4286 highlighted as the chosen downstream boundary

The base date of the extreme water levels in the CFB dataset is 2017. Table 4 below shows the 0.5% AEP and 0.1% AEP values from this dataset.

Table 4: Extreme water levels from the CFB dataset chainage point 4286

Base date	0.5% AEP	0.1% AEP
2017	4.29m AOD	4.50m AOD

Sea Level Rise

Sea level rise projections from the UKCP18 RCP 8.5 emissions scenario have been used to uplift the extreme water levels to the dates required (2025 and 2125). The 70th percentile (higher central, design scenario) and 95th percentile (upper end allowance) have been used.

Table 5 below shows the uplifted extreme water levels for 2025 and 2125.

Table 5: Extreme water levels uplifted with sea level rise for 2025 and 2125. Note 2017 extreme water level also included, and no SLR has been applied to this. CFB chainage point 4286

Date	Extreme water level, m AOD 70th percentile (higher central)		Extreme water level, m AOD 95th percentile (upper end)	
	0.5% AEP	0.1% AEP	0.5% AEP	0.1% AEP
2017 (CFB base year)	4.29	4.50	4.29	4.50
2025	4.33	4.54	4.34	4.55
2125	5.35	5.56	5.70	5.91

3.2 Tidal Curve Development

Using the extreme water levels from Table 5, tidal curves for a 100 hour time period were created for use in the model boundary. The steps for creating these tidal curves are outlined below:

1. Obtain a typical Mean High Water Springs (MHWS) base tide for the area. Admiralty Total tide software was used to obtain this information for Holliwell Point. The levels were adjusted to Ordnance Datum using 0mCD = -2.75mOD from the 2022 Admiralty Tide Tables (ATT) (UKHO, 2022).
2. Uplift the base tide with sea level rise to the required year and emissions scenario (e.g. 2025 or 2125). The sea level rise values from the CFB (2018) dataset were used for this.
3. Apply a surge profile to the base tide from step 2 (with sea level rise) to match the peak water level with the desired extreme water level value from Table 4. The shape of the surge profile was obtained from the CFB (2018) dataset using the Sheerness donor site.
4. Tidal curves were generated for each scenario required; the 0.5% AEP and 0.1% AEP scenarios for 2025 and 2125 for both the 70th percentile (higher central) and 95th percentile (upper end) sea level rise projections.

Figure 5 and Figure 6 show two examples of the tidal curves generated:

- Figure 5 shows the tidal curve for CFB chainage point 4286 for a 0.5% AEP event in 2125 using the higher central (70th percentile) sea level rise scenario. The peak water level in this tidal curve is 5.35m AOD.
- Figure 6 shows the tidal curve for CFB chainage point 4286 for a 0.5% AEP event in 2125 but using the upper end (95th percentile) sea level rise scenario. As can be seen, the peak extreme water level is 5.70m AOD.

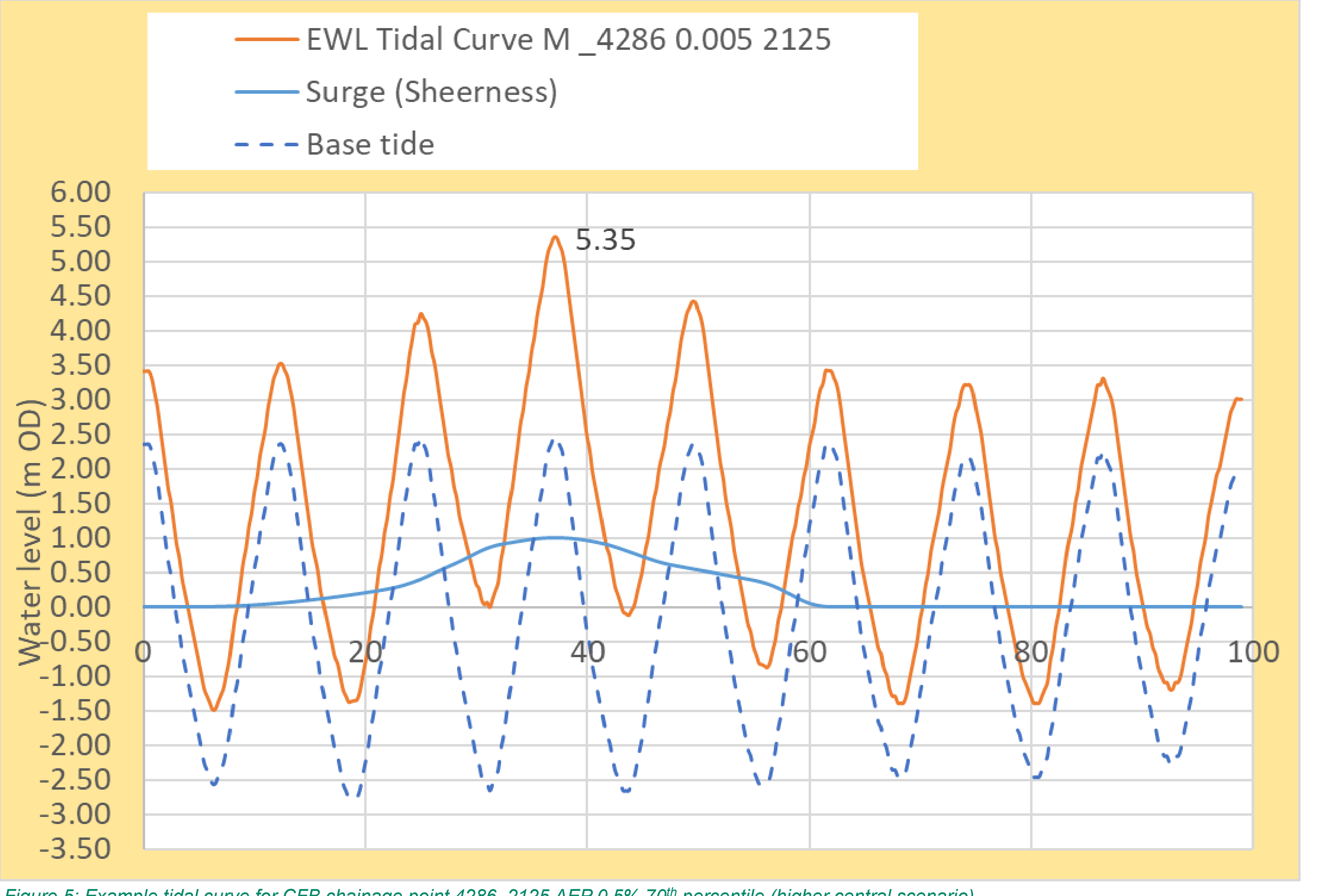

Figure 5: Example tidal curve for CFB chainage point 4286, 2125 AEP 0.5% 70th percentile (higher central scenario)

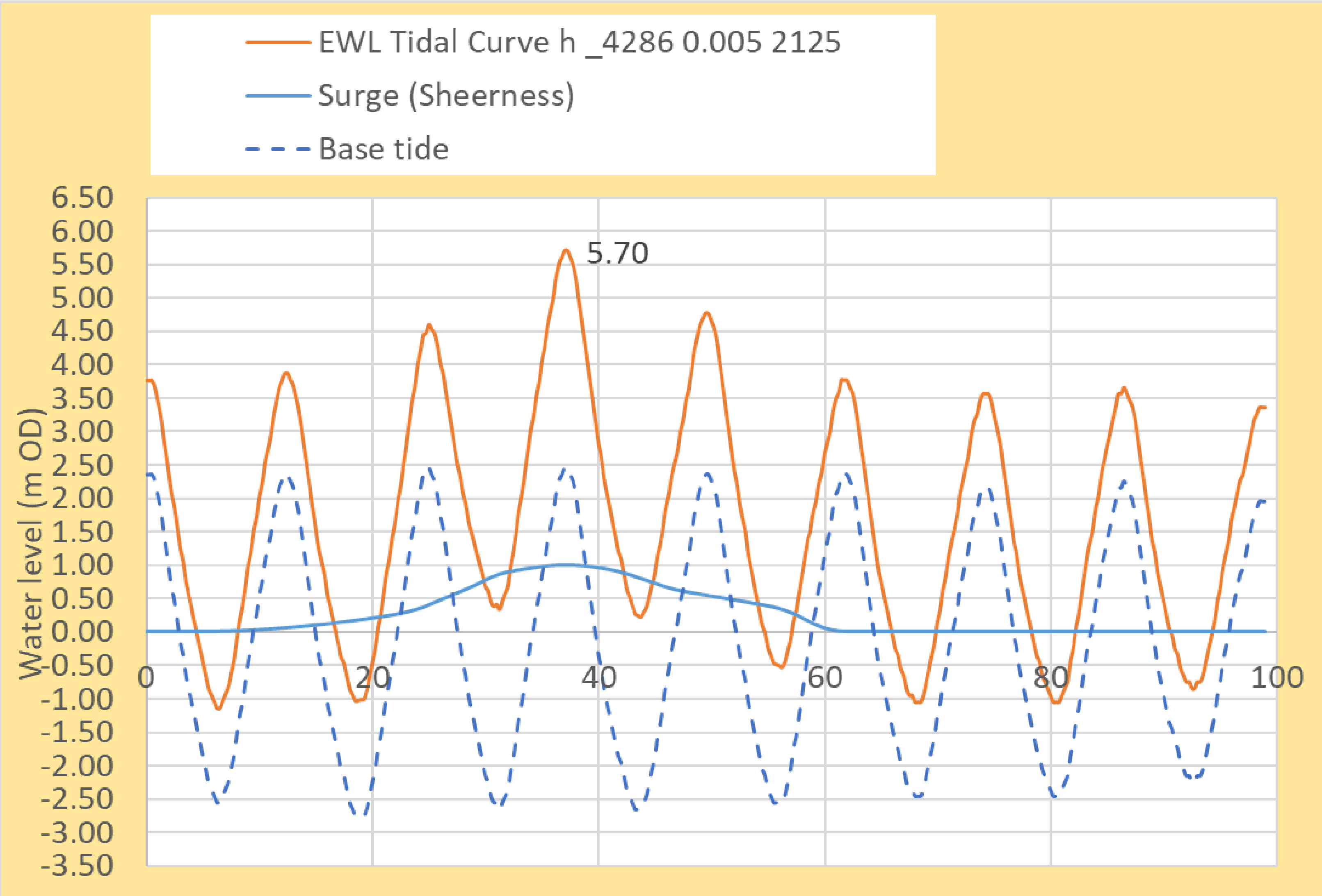

Figure 6: Example tidal curve for CFB chainage point 4286, 2125 AEP 0.5% 95th percentile (upper end scenario)

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