

Thurrock Council

Level 1 Strategic Flood Risk Assessment

Appendix B: Tidal Modelling Methodology

Revision 2

Thurrock Council

AECOM Project Number: 60689110

January 2024

Quality information

Prepared by	Checked by	Verified by	Approved by
Isabel de Cala Coastal Consultant	Ralph Collard Senior Consultant	Helen Judd Associate Water and Flood Risk Consultant	Sarah Littlewood Project Manager
Justyna StarowiczKubas Flood Risk Modeller			
Sarah Littlewood Principal Consultant			
Becci Ward Consultant			

Revision History

Revision	Revision date	Details	Authorized	Name	Position
01	10 th March 2023	Version 1	SL	Sarah Littlewood	Project Manager
02	30 th Jan 2024	Final	SL	Sarah Littlewood	Project Manager

Prepared for:

Thurrock Council

Prepared by:

AECOM Limited
Midpoint, Alencon Link
Basingstoke
Hampshire RG21 7PP
United Kingdom

T: +44(0)1256 310200
aecom.com

© 2024 AECOM Limited.

AECOM Limited ("AECOM") has prepared this Report for the sole use of Thurrock Council ("Client") in accordance with the terms and conditions of appointment ref: PS/2022/131 dated 07.06.2022 ("the Appointment").

AECOM shall have no duty, responsibility and/or liability to any party in connection with this Report howsoever arising other than that arising to the Client under the Appointment. Save as provided in the Appointment, no warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by AECOM.

This Report should not be reproduced in whole or in part or disclosed to any third parties for any use whatsoever without the express written authority of AECOM. To the extent this Report is reproduced in whole or in part or disclosed to any third parties (whether by AECOM or another party) for any use whatsoever, and whether such disclosure occurs with or without the express written authority of AECOM, AECOM does not accept that the third party is entitled to rely upon this Report and does not accept any responsibility or liability to the third party. To the extent any liability does arise to a third party, such liability shall be subject to any limitations included within the Appointment, a copy of which is available on request to AECOM.

Where any conclusions and recommendations contained in this Report are based upon information provided by the Client and/or third parties, it has been assumed that all relevant information has been provided by the Client and/or third parties and that such information is accurate. Any such information obtained by AECOM has not been independently verified by AECOM, unless otherwise stated in this Report. AECOM accepts no liability for any inaccurate conclusions, assumptions or actions taken resulting from any inaccurate information supplied to AECOM from the Client and/or third parties.

Table of Contents

1.	Introduction.....	1
1.1	Background.....	1
1.2	Consultation.....	1
1.3	Information received	2
2.	Methodology	3
2.1	Software.....	3
2.2	Model Build	3
2.3	Breach parameters	9
2.4	Overtopping Scenarios	16
2.5	Tidal Boundaries	16
2.6	Simulations	19
2.7	Model Health.....	19
2.8	Model Limitations.....	19
3.	Model Outputs	21
4.	Future Thames Barrier Analysis	22
4.1	Introduction	22
4.2	Thames Estuary 2100 Plan.....	22
4.3	Extreme Water Level Comparison	23

Figures

Figure 2-1	Cross section through breach PUR003.....	10
Figure 2-2	Example of determination of defence	14
Figure 2-3	Example Tide Curve Including Surge Profile.....	17
Figure 4-1	Potential locations for a future barrier and flood storage.....	22
Figure 4-2	TE2100 Model Nodes	24

Tables

Table 1-1	Information and datasets used in the tidal modelling.....	2
Table 2-1	AIMS Spatial Flood Defence Adjustments	4
Table 2-2	Modifications to ground models	6
Table 2-3	Roughness values applied to OSMM features	9
Table 2-4	Breach locations and parameters.....	11
Table 2-5	Breach Trigger Elevations	15
Table 2-6	Extreme water levels	17
Table 2-7	Breach Scenario Simulation List.....	18
Table 4-1	Extreme Water Level data	23
Table 4-2	Extreme Water Level comparison.....	25

1. Introduction

1.1 Background

- 1.1.1 AECOM Limited has been commissioned to update the Strategic Flood Risk Assessment (SFRA) for Thurrock Council. As part of the SFRA, tidal modelling has been undertaken for the River Thames. This report summarises the methodology, assumptions and limitations of the modelling.
- 1.1.2 The southern boundary of Thurrock Council is the tidal River Thames, and as such, large areas of Thurrock are at risk of tidal flooding. The Thames Tidal Defences (TTD) protect these areas, and therefore the risk of flooding to Thurrock is a residual risk in the event these defences are overtopped or fail (breach).
- 1.1.3 The last SFRA for Thurrock was prepared in 2016/2017 and included 21 tidal breach models built in TUFLOW software. These models have been used as the basis for this update. The following changes have been made:
1. The models have been updated with the most up to date ground level information (LiDAR data).
 2. Extreme water levels have been taken from the latest Thames Estuary 2100 Modelling Study (provided by the Environment Agency) for the years 2025 and 2125.
 3. The models have been run to simulate overtopping (only) scenarios.
 4. The breach locations have been reviewed resulting in one additional breach location being added at Bowater's Sluice (TIL006) and the removal of the breach at St Clere's Sluice (TIL001).
 5. The timing and duration of the breach events have been revised in the light of breach modelling guidance published by the Environment Agency in June 2021¹ and discussions with representatives from the Essex Thameside Asset Performance team.
 6. The models have been simulated in the latest version of TUFLOW software (at the start of the project).

1.2 Consultation

- 1.2.1 AECOM has consulted the Environment Agency regarding the modelling approach and specific details of the methodology. The approach documented in this report has been agreed with the Environment Agency.

¹ Environment Agency, 29 June 2021 LIT 56413 Breach of defences guidance.

1.3 Information received

1.3.1 The information and datasets summarised in Table 1-1 have been used in the hydraulic modelling.

Table 1-1 Information and datasets used in the tidal modelling

Dataset	Description and use in tidal modelling	Format	Source
Light Detection and Ranging (LiDAR) Digital Terrain Model Data – 1m resolution flown in 2020.	Light Detection and Ranging (LIDAR) is an airborne mapping technique, which uses a laser to measure the distance between the aircraft and the ground. The DTM (Digital Terrain Model) is produced from the last return LIDAR signal. Surface objects are removed from the Digital Surface Model (DSM), using bespoke algorithms and manual editing of the data, to produce a terrain model of just the surface. The DTM data is read into TUFLOW to provide the ground surface across the modelled flood cells.	ASCII	Defra Data Services Platform https://environment.data.gov.uk/
Ordnance Survey MasterMap (OSMM) Data	Ordnance Survey MasterMap is a GIS shapefile showing different land use types (roads, fields, buildings, fences, paths etc). These shapefiles are used within the TUFLOW model to specify different roughness coefficients and runoff rates to different land use types.	.shp	Thurrock Council
Thurrock administrative boundary	A GIS shapefile of the administrative boundary of for Thurrock Council boundary.	.shp	Thurrock Council
2016 SFRA Breach Locations / Details	GIS shapefile and MS Excel workbook recording details of the 21 breach locations modelled as part of the 2016 SFRA.	Excel .shp	Previous SFRA (2016)
Environment Agency, Breach of defences guidance.	Specification for breach modelling provided by the Environment Agency (29 June 2021 LIT 56413 Breach of defences guidance). The guidance specifies parameters for timing of breach, typical breach widths and length of time to closure.	MS Word Document	Environment Agency
Tidal Water Levels from the Thames Estuary 2100 Modelling Study	MS Workbooks detailing the extreme water levels in the Tidal Thames for a range of annual exceedance probability events over a range of epochs. This information is used to generate the tidal boundary conditions for the SFRA tidal models.	Excel	Environment Agency
As built drawings of sluice structures	Details of sluice structures are used to inform the breach widths specified in the SFRA models.	PDF	Environment Agency
AIMS Spatial Flood Defences GIS Layer	The Environment Agency's Spatial Flood defences GIS layer is the only comprehensive and up-to-date dataset in England that shows flood defences currently owned, managed or inspected by the Environment Agency. This was verified by the Environment Agency in July 2023 and November 2023. Flood defences can be structures, buildings or parts of buildings. Typically these are earth banks, stone and concrete walls, or sheet-piling that is used to prevent or control the extent of flooding. The GIS layer provides details of the type of defence, it's spatial extent and the crest level which is used to inform the model development.	.shp	Defra Data Services Platform https://environment.data.gov.uk/

2. Methodology

2.1 Software

- 2.1.1 TUFLOW 2020-10-AD-IDP-w64 has been used to run the models. ESTRY units were used to represent floodplain structures, such as those beneath embankments. This software is well suited to the requirements of the study (representing structures whilst linking dynamically to TUFLOW). ESTRY also allows floodplain structures to “run dry” when no water is present on the floodplain.

2.2 Model Build

Flood cells

- 2.2.1 The Thurrock study area has been divided into flood cells, based on where water would flow in the event of a breach or overtopping of the defences. A flood cell is defined through a review of the LiDAR data against the extreme water levels and includes all land that is at a lower elevation than the extreme water level. Five flood cells have been defined, as shown in the figures within the SFRA Appendix C and Appendix D. These are as follows:

- Mardyke flood cell (40km²),
- Purfleet, Grays and Tilbury flood cell (25km²),
- East Tilbury flood cell (4km²),
- Mucking flood cell (3km²), and
- Fobbing flood cell (17km²).

Grid size

- 2.2.2 A fixed 5m cell size was adopted for each model, except for the Mardyke flood cell which was 6m. This was the highest resolution possible for a model of this size that would produce a model with manageable simulation times. 5m/6m cell size is considered to be detailed enough to represent flow paths as roads, for example, are typically 15m wide allowing for a clear flow path. The grids are orientated as much as possible to be perpendicular to the defence line (and the associated breach).
- 2.2.3 As is often the case with 2D modelling, greater detail could be achieved using a finer grid resolution, but this would make the model simulation time and results file sizes unmanageable.

Model topography

- 2.2.4 Digital terrain data has been obtained from the Defra Data Services Platform and used to develop the 2D model surface. Light Detection and Ranging Data (LiDAR) of 1m resolution flown in 2020 has been used.

Defence Elevations

- 2.2.5 For the overtopping scenarios the flood defence elevation determines the elevation at which the tidal inundation can begin within a flood cell. AIMS Spatial Flood Defences data supplied by the Environment Agency was used to determine the flood defence elevation using the ‘effective’ crest elevation. Where this was not available the lowest elevation from the ‘ACTUAL_DCL’, ‘ACTUAL_UCL’ or ‘DESIGN_DCL’ was used.
- 2.2.6 Following a review of the defence crest elevations by the Environment Agency in July 2023 a number of defences were updated within the Mucking, East Tilbury, Purfleet, Grays and Tilbury flood cells. Defence crest elevations were provided by the Environment Agency and included with the model.
- 2.2.7 It was found that there were some data gaps/inconsistencies within the AIMS Spatial Flood Defence data, particularly at gate structures or where private defences were present. In those instances, the Environment Agency was consulted and Table 2-1 shows the defences that were adjusted from the original dataset.

Table 2-1 AIMS Spatial Flood Defence Adjustments

Flood Cell	AIMS ID	Defence Type	Crest Elevation Used (mAOD)	Description
Mardyke	556611	Control Gate	6.98mAOD	Mardyke Sluice Gate updated to include height of gate and defences tied into left and right banks
	14542	Embankment	6.86mAOD	Crest elevation supplied by Environment Agency, uses DCL elevation
Purfleet, Grays and Tilbury	Unknown	Wall/High Ground	7.04mAOD	Land between AIMS ID 150543 and AIMS ID 150541. Elevation is assumed.
	543704	Gate	7.0mAOD	Tilbury Barrier crest level set to 7.0m AOD.
East Tilbury	152777	Wall	6.6mAOD	Defences including the crest of Gobians Sluice updated to 6.6mAOD.
	152778	Wall	6.7mAOD, apart from section between OS Grid co-ordinates E 569279.801, N 177823.998 to E 569278.367, N 177811.354 (survey node points 36-37) which should be set at 6.32mAOD	Agreed with the Environment Agency to have the defence set to 6.7mAOD along the majority of the wall except for small reach which is at a lower elevation of 6.32mAOD.
	152779	Embankment	7.02	Defence crest supplied by the Environment Agency.

Further Modifications

- 2.2.8 As well as the modifications to enforce defence crest elevations, during the model development further modifications were needed to ensure that key overland flow paths were suitably represented in the models and model stability was improved.
- 2.2.9 Table 2-2 summarises the modifications made to the model topography in each flood cell.
- 2.2.10 Topographic patches were 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 ensure that the water was entering the 2D domain at the correct breach elevation.
- 2.2.11 A second topographic modification was placed along the length of the breach and at the cells at the breach sides for each breach scenario. This was set as a glasswall to ensure that no overtopping of the defences would occur when the breach was closed after the specific time. This results in a couple of cells either side of the breach being raised during the breach opening but this is not considered to significantly impact the conveyance of water through the breach opening.
- 2.2.12 For the TIL003 (Tilbury Barrier) breach scenario an initial water level of 0.89mAOD was specified for the Tilbury Harbour. It is assumed that if a breach occurred then water would flow out of the harbour to the level of the tide at the beginning of the breach. The breach is triggered at the low tide and therefore the initial water level has been set to match this.
- 2.2.13 For the overtopping scenario for the 'Purfleet, Grays and Tilbury' flood cell a 2d z-shape topographic patch was applied at Ordnance Survey grid reference X568593, Y176084 on the landward side of the defences to smooth the flow over the defences into the floodplain and aid model stability. The topographic

adjustment is small compared to the wider floodplain and is away from any vulnerable flood risk receptors and is therefore not considered to have a significant impact on the results.

Table 2-2 Modifications to ground models

Layer Name	Command (e.g. Read MI Z Shape ADD)	Purpose of terrain modification and source of elevation data
Mardyke Flood Cell		
mar_tq57_tq58_tq68_1m_dtm_2020.asc	Read Grid Zpts	TUFLOW reads an ASCII grid of points attributed with elevations derived from 1m filtered LIDAR data flown in 2020.
2d_zln_flood_defences_AIMS_2022.MIF 2d_zln_flood_defences_AIMS_MAR_2022.MIF	Read MI Z Line THICK	Polylines and points to define defence crest levels informed by survey provided by the Environment Agency. Crest elevations improved at Mardyke Sluice to include
2d_zln_gully_MAR_004.MIF	Read MI Z Line THICK	Polyline used to define significant drains / rivers.
2d_zsh_MAR_breach.MIF	Read MI zpts	Lowers 2d zpts to the invert level of the breach at the activated 2D HT boundary cells. Breach scenarios only.
2d_zsh_MAR001_GW_001.MIF	Read MI zpts	Raises 2d zpts to glasswall at the sides and across the breach to prevent overtopping of the defences when the breach is closed. Overwritten by the variable z-shape of the breach when open. Breach scenarios only.
Purfleet, Grays and Tilbury Flood Cell		
Purfleet_Tilbury_Grays_1m_DTM_2020.ASC		
purfleet_tilbury_grays_1m_dtm_2020_extension.asc	Read Grid Zpts	TUFLOW reads an ASCII grid of points attributed with elevations derived from 1m filtered LIDAR data flown in 2020. LiDAR extended to the east to include area around
2d_zln_flood_defences_AIMS_2023.MIF 2d_zln_flood_defences_AIMS_inland_2022.MIF	Read MI Z Line THICK	Polylines and points to define defence crest levels informed by survey provided by the Environment Agency.
2d_zln_gully_XXX_004.MIF (Where XXX is breach name PUR,GRY or TIL)	Read MI Z Line THICK	Polyline used to define significant drains / rivers.
2d_zsh_flyover_XXX_001.MIF (Where XXX is breach name PUR,GRY or TIL)	Read MI Z Shape Gully	Polygon used to lower the DTM at the flyover to allow water to flow under the road.
2d_zplg_lakes_XXX_001.MIF (Where XXX is breach name PUR,GRY or TIL)	Read MI zpts	Lake water levels set to be constant based on aerial / LiDAR review.
2d_zsh_XXXX_001.mif (where XXXX is breach name PUR, GRY or TIL)	Read MI zpts	Lowers 2d zpts to the invert level of the breach at the activated 2D HT boundary cells. Breach scenarios only.
2d_zsh_XXXX_GW_001.MIF (where XXXX is breach name PUR, GRY or TIL)	Read MI zpts	Raises 2d zpts to glasswall at the sides and across the breach to prevent overtopping of the defences when the breach is closed. Overwritten by the variable z-shape of the breach when open. Breach scenarios only.

Layer Name	Command (e.g. Read MI Z Shape ADD)	Purpose of terrain modification and source of elevation data
2d_zsh_TIL003_002.MIF	Read MI zpts	TIL003 breach only. Reduces elevation of the harbour to -5mAOD
2d_iwl_TIL003_01.MIF	Read MI zpts	TIL003 breach only. Set's initial water level of the harbour to the 0.89mAOD.
2d_zsh_topo_patch_GRY_001.MIF	Read MI zpts	Overtopping Scenario only. Topographic patch at NGR 568593, 176084 to smooth sharp elevation drop from defence to floodplain. Required for stability of hydraulic mode.
2d_iwl_GRY_OT_01	Read MI IWL	Overtopping Scenario only. Sets initial water level in Tilbury Harbour to 3.9mAOD.
East Tilbury Flood Cell		
East_Tilbury_1m_DTM_2020.asc	Read Grid Zpts	TUFLOW reads an ASCII grid of points attributed with elevations derived from 1m filtered LIDAR data flown in 2020.
2d_zln_flood_defences_ETIL_AIMS_2023.MIF	Read MI Z Line THICK	Polylines and points to define defence crest levels informed by survey provided by the Environment Agency.
2d_zplg_lakes_ETIL_002.MIF	Read MI zpts	Lake water levels set to be constant based on aerial / LiDAR review.
2d_zsh_ETIL_ditches_003.MIF	Read MI Z Shape	Polygons to represent culverts from latest LiDAR and Asset Information Management System data provided by the Environment Agency.
2d_zsh_ETIL002_001.MIF	Read MI zpts	Lowers 2d zpts to the invert level of the breach at the activated 2D HT boundary cells. Breach scenarios only.
2d_zsh_ETIL002_GW_001.MIF	Read MI zpts	Raises 2d zpts to glasswall at the sides and across the breach to prevent overtopping of the defences when the breach is closed. Overwritten by the variable z-shape of the breach when open. Breach scenarios only.
Mucking Flood Cell		
Mucking_1m_DTM_2020.asc	Read Grid Zpts	TUFLOW reads an ASCII grid of points attributed with elevations derived from 1m filtered LIDAR data flown in 2020.
2d_zln_flood_defences_AIMS_2023.MIF	Read MI Z Line THICK	Polylines and points to define defence crest levels informed by survey provided by the Environment Agency.
2d_zln_gully_MUC_004.MIF	Read MI Z Line THICK	Polyline used to define significant drains / rivers.
2d_zplg_Lakes_MUC_002.MIF	Read MI zpts	Stanford Warren Nature Reserve lake levels set to 2.2 mAOD.
2d_zsh_MUC001_001.mif	Read MI zpts	Lowers 2d zpts to the invert level of the breach at the activated 2D HT boundary cells. Breach scenarios only.

Layer Name	Command (e.g. Read MI Z Shape ADD)	Purpose of terrain modification and source of elevation data
2d_zsh_MUC001_GW_001.MIF	Read MI zpts	Raises 2d zpts to glasswall at the sides and across the breach to prevent overtopping of the defences when the breach is closed. Overwritten by the variable z-shape of the breach when open. Breach scenarios only.
Fobbing Flood Cell		
Fobbing_1m_DTM_2020.asc	Read Grid Zpts	TUFLOW reads an ASCII grid of points attributed with elevations derived from 1m filtered LIDAR data flown in 2020.
2d_zln_flood_defences_AIMS_2023_001.MIF	Read MI Z Line THICK	Polylines and points to define defence crest levels informed by survey provided by the Environment Agency.
2d_zsh_FOB_ditches.MIF	Read MI Z Shape	Zshps to remove culverts from LiDAR - 2022 update
2d_zplg_tanks_FOB_001.MIF	Read MI zpts	Set tank elevation to 1.7 mAOD.
2d_zsh_FOBXXX_001.mif (Where XXX is the breach number)	Read MI zpts	Lowers 2d zpts to the invert level of the breach at the activated 2D HT boundary cells. Breach scenarios only.
2d_zsh_FOBXXX_GW_001.MIF (Where XXX is the breach number)	Read MI zpts	Raises 2d zpts to glasswall at the sides and across the breach to prevent overtopping of the defences when the breach is closed. Overwritten by the variable z-shape of the breach when open. Breach scenarios only.

Roughness

- 2.2.14 Ordnance Survey Master Map (OSMM) area polygon data from the 2018 hydraulic model has been used to specify varying Manning's roughness coefficients throughout the model extent. The OSMM polygons are grouped according to land use and Manning's n roughness coefficients have been applied according to those groups.
- 2.2.15 The OSMM materials layer was reviewed and updated to reflect any major development change within the different flood cells. These were applied as material patches which overwrites the 2018 materials layer.
- 2.2.16 Table 2-3 presents the coefficients for each of the OSMM land use descriptions identified within the study area. Buildings have been represented by polygons with the roughness coefficient value set to 0.3. The values specified are based on the previous SFRA breach modelling and recent breach modelling carried out by AECOM. These are based on engineering judgement and are broadly consistent with Environment Agency² and Natural Resources Wales³ guidance for 2D roughness in hydraulic models.

Table 2-3 Roughness values applied to OSMM features

OSMM Land Use Description	Feature Code	Manning's 'n'
Building	10021	0.3
General Surface (multi-surface)	10053	0.04
General Surface (man-made / natural)	10056	0.04
Water	10089	0.03
Landform (slope)	10096	0.03
Natural environment (non-coniferous trees)	10111	0.1
Path (man-made)	10123	0.025
Roadside (natural)	10183	0.035
Road Or Track (structure)	10185	0.025
Road or track (man-made)	10172	0.025
Land (unclassified)	10217	0.04
Stability	98/99	0.2/0.4

- 2.2.17 It was found during the modelling process that the rapid inundation water caused by the onset of the breach or overtopping resulted in some instability within the hydraulic model, particularly at breach openings. Stability patches of high manning's roughness were therefore applied to enable to improve model stability. It is noted that stability patches were assigned on a scenario by scenario basis and therefore different stability patches may be applied within a single flood cell. The stability patches are small compared to the size of floodplain inundation and are not considered to significantly impact the results. Details of the applied stability patches can be found in the supplied model logs.

2.3 Breach parameters

Locations

- 2.3.1 A review of the breach locations was carried out during a series of meetings and correspondence with Environment Agency representatives from the Partnership and Strategic Overview team and Asset Performance Team during January 2022 – October 2022. The majority of the breach locations have been retained. An additional breach location has been added at Bowater's Sluice (TIL006) in the Tilbury flood cell. The breach at St Clere's (ETIL001) has been removed.

² Environment Agency 2021, Fluvial Modelling Standards, available from <https://www.gov.uk/government/publications/river-modelling-technical-standards-and-assessment>

³ Natural Resources Wales 2021, Indicative Roughness Values available from <https://naturalresources.wales/flooding/indicative-2d-roughness-values/?lang=en>

- 2.3.2 Breach locations have been selected based on three main considerations: vulnerability to a breach; proximity to potential new development allocations; and low points behind the defences. The breach locations are presented in Table 2-4 and the figures in Appendix C and Appendix D of the SFRA.

Breach set up in TUFLOW

- 2.3.3 The breaches have been applied using the Read GIS Variable Z Shape command in TUFLOW. This enables the breach to be simulated 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 enter the 2D domain at the intended elevation (Table 2-2).

Breach width

- 2.3.4 The breach widths are stated in Table 2-4 and are consistent with the Environment Agency guidance. As built drawings of the sluice and outfall structures have been provided by the Environment Agency and used to inform the selection of breach widths where available.

Breach Invert level

- 2.3.5 The invert level of the breach is determined through an interrogation of the LiDAR on the landward side of the breach location. The invert levels have been reviewed and updated based on the latest LiDAR data received. As a rule of thumb the lowest ground level within a radius the same width as the breach is used as the breach invert level. For example, at breach location PUR003, the breach width is 20m and the invert level is set to -1mAOD.

Figure 2-1 Cross section through breach PUR003

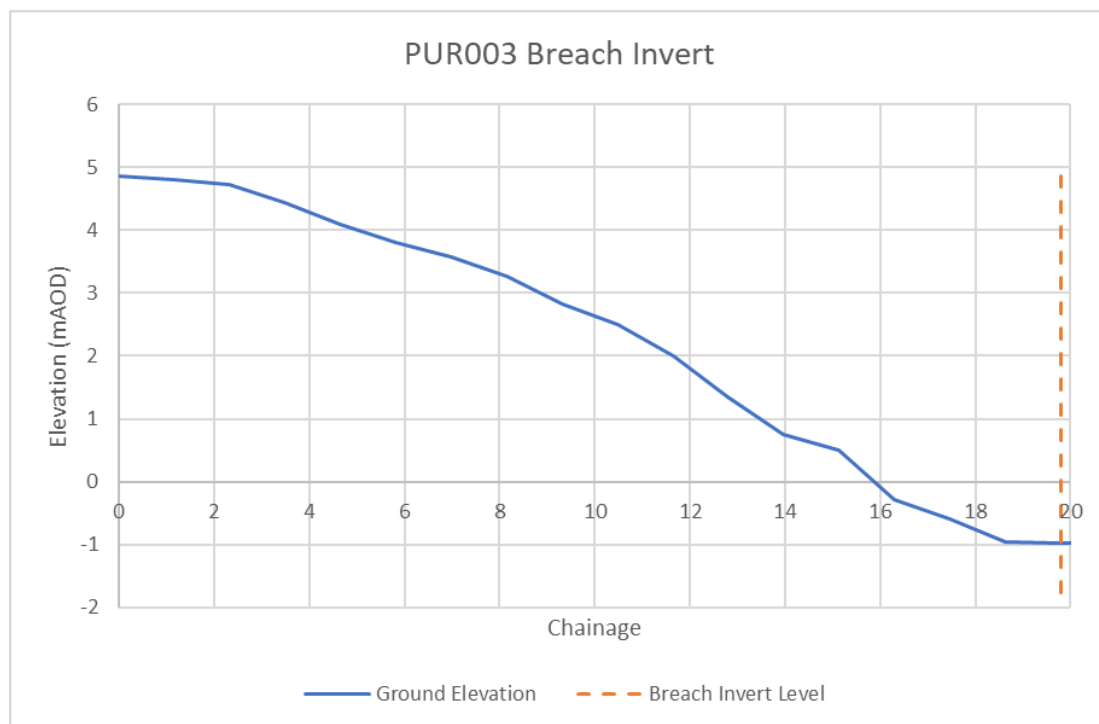


Table 2-4 Breach locations and parameters

Breach ID	Location	Easting	Northing	Defence type	Width (m)	Invert level (mAOD)	Time of breach / gate failure and time to closure
MAR001	Mardyke Sluice	554826	178741	Sluice	12	-0.80m	Barrier opens from low tide preceding the peak level. Open for 30 hours.
PUR001	Purfleet Gas Terminal	555288	178034	Hard defence	20	4.51m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
PUR002	Purfleet Deep	555944	177456	Hard defence	20	0.42m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
PUR003	Stonehouse Sluice	556924	176898	Hard defence / sluice	20	-1.00m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
PUR004	West Thurrock Sluice	558883	176487	Hard defence / sluice	20	2.95m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
GRY001	Drapers Yard	559687	177309	Hard defence	20	3.92m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
GRY002	Wouldham Road Jetty	560188	177511	Hard defence	20	5.38m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
GRY003	Grays	560825	177566	Hard defence	20	4.06m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
GRY004	Grays Town Flood Gate	561413	177502	Hard defence	20	4.42m	Gate fails on low tide preceding the peak level with emergency closure effected during the following low tide.
TIL001	AW Pumping Station	561616	177288	Hard defence	20	2.74m	Breach occurs when water level reaches 1/2 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
TIL002	Botney Sluice	561813	177069	Sluice	20	0.06m	Breach occurs when water level reaches 1/2 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
TIL003	Tilbury Barrier	562570	175474	Sluice	35	-5.00m	Barrier open from low tide preceding the peak level. Open for 30 hours.

Note: This approach is in line with the breach guidance for barriers and has been agreed with the Environment Agency as appropriate to inform the assessment of residual risk for the Thurrock Council SFRA. However, the Environment Agency have noted that as part of the Thames Estuary 2100 programme of work and modelling studies, the Environment Agency will be developing a more detailed rationale for simulating a failure of the Tilbury Dual Function Lock Gate in the future, based on the specific mechanisms.

Breach ID	Location	Easting	Northing	Defence type	Width (m)	Invert level (mAOD)	Time of breach / gate failure and time to closure
TIL004	Tilbury Fort Worlds End Sluice	564776	175269	Hard defence / sluice	20	1.76m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
TIL005	Tilbury Power Station	565741	175349	Hard defence	20	2.67m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
TIL006	Bowaters Sluice	567865	175773	Sluice/hard defence/embankment	50	-0.66m	Breach occurs when water level reaches 1/2 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
ETIL002	Gobions Sluice	569474	179172	Sluice	20	1.33m	Breach occurs when water level reaches 1/2 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
MUC001	Mucking Sluice	569148	180821	Sluice	15	1.00m	Breach occurs when water level reaches 1/2 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
FOB001	Reactor Quay	570840	181560	Hard defence	20	2.73m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
FOB002	Thames Haven railhead	574353	181584	Hard defence	20	1.98m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
FOB003	Coryton Peninsular	576192	182175	Hard defence	20	1.71m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.
FOB004	Coryton Gas Pipeline	574773	183555	Hard defence	20	1.89m	Breach occurs when water level reaches 3/4 height of defence. Open for 30hrs and then model simulated for a further 12hrs closed.

Time of breach and time to closure

- 2.3.6 The timing of when the breach occurs and the length of time anticipated prior to closure is dependent on the type of structure and its location. The Breach Modelling Guidance⁴ specifies parameters but makes clear that these should be verified by local understanding. The following approach has been established with the Environment Agency. The specific parameters for each breach location are detailed in Table 2-4.
- 2.3.7 For tidal gates, the Breach Modelling Guidance suggests that *"Gates fail on low tide preceding the peak level with emergency closure effected during the following low tide"*. This is considered suitable for smaller gates (for example GRY004). For larger gates including Mardyke Sluice (MAR001) and Tilbury Barrier (TIL003), the barrier is modelled to fail at low tide and remain open for a longer period of 30 hours.
- 2.3.8 For tidal defences, a time to close of 18 hours, as suggested in the Breach Modelling Guidance, is considered to be challenging in this location. A time to close of 30 hours has been modelled as a more realistic timeframe. The model was simulated for an additional 12 hrs following the closure of the breach to allow peak water levels to be resolved at the extents of the flood cell.
- 2.3.9 With respect to the time of breach for tidal defences, the Breach Modelling Guidance states that this should occur when there is at least some loading on the defence to ensure the approach is not overly precautionary, and specifies the following:
- In a river or 'non wave' tidal situation this can be considered to be a water level at $\frac{3}{4}$ of the defence height (consider datum is toe level from depth of breach consideration).
 - Where there is wave loading, we can consider the breach starts either when still water level reaches half defence height or when any overtopping begins whichever is first.
- 2.3.10 In Thurrock, wave loading is considered to be relevant out towards Coalhouse, facing Tilbury Barrier from the Swanscombe peninsular, and the Gobians Sluice area. This is pertinent to breach locations TIL01, TIL02, TIL06, ETIL02 and MUC01. For these locations, the breach is modelled to start when water level reaches half the defence height.
- 2.3.11 For the remaining locations, the breach is modelled to start when water reaches $\frac{3}{4}$ defence height (PUR01, PUR02, PUR03, PUR04, GRY01, GRY02, GRY03, TIL04, TIL05, FOB01, FOB02, FOB03, FOB04).
- 2.3.12 In all breach scenarios triggered by loading on the defence the breach was set to occur on the rising limb of the hydrograph preceding the peak tide level (c.37hrs). A sensitivity analysis was undertaken on the Tilbury flood cell to understand if moving the trigger time to the preceding tide impacted the results. It was found that the results were not sensitive and it was agreed with the Environment Agency that for consistency of assessment it was better to apply the breach on the same tide.

⁴ Environment Agency (2021), *LIT 56413: Breach of Defence Guidance*

Defence Height Determination

- 2.3.13 To determine the trigger timing of the opening of a breach it was necessary to first estimate the defence height to understand at what trigger water elevation the breach occurred. The AIMS data does not provide this information and there is no specific guidance on estimating the defence height therefore, a GIS analysis was undertaken at the landward side to determine the defence toe level. The defence height was then estimated by subtracting the defence crest elevation from the defence toe level. Figure 2-2 shows an example of how the defence toe level was determined and the defence toe elevations and final trigger elevations are shown in Table 2-5.

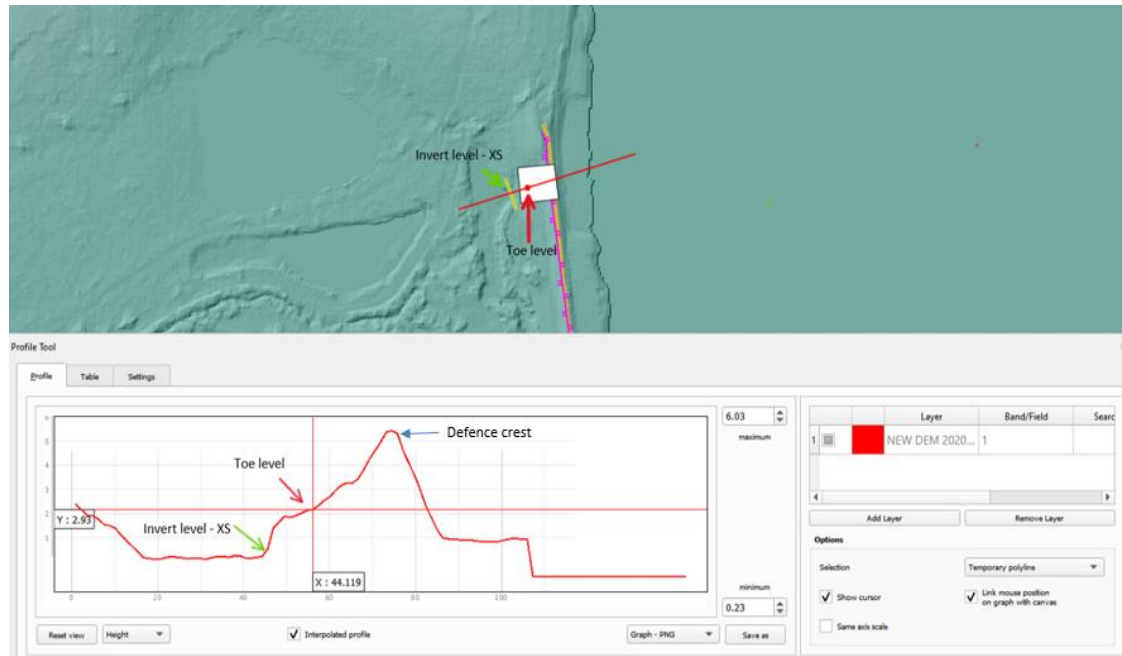


Figure 2-2 Example of determination of defence

Table 2-5 Breach Trigger Elevations

Breach ID	Defence Crest (mAOD)	Revised crest level	Time of breach, from Table 2-4	Defence Toe Level (mAOD)	Defence Height (m) revised	Breach Trigger Elevation (mAOD) revised
MAR001	NA	NA		NA	NA	NA
PUR001	6.94	6.88	Breach at 3/4	4.80	2.08	6.36
PUR002	6.82	6.87	Breach at 3/4	1.40	5.47	5.5
PUR003	6.8	6.89	Breach at 3/4	0.70	6.19	5.34
PUR004	6.59	No change	Breach at 3/4	3.50	3.09	5.82
GRY001	7	No change	Breach at 3/4	4.44	2.56	6.36
GRY002	7.04	No change	Breach at 3/4	5.00	2.05	6.54
GRY003	6.75	6.78	Breach at 3/4	4.39	2.39	6.18
GRY004	NA	NA		NA	NA	NA
TIL001	6.76	6.79	Breach at 1/2	4.46	2.33	5.63
TIL002	6.9	No change	Breach at 1/2	2.18	4.72	4.54
TIL003	NA	NA		NA	NA	NA
TIL004	6.67	6.86	Breach at 3/4	2.44	4.23	5.61
TIL005	6.48	6.43	Breach at 3/4	3.38	3.05	5.67
TIL006	4.5	No change	Breach at 1/2	0.99	3.51	2.75
ETIL002	6.72	6.60	Breach at 1/2	3.03	3.57	4.82
MUC001	5.65	6.55	Breach at 1/2	3.31	3.24	4.93
FOB001	6.39	No change	Breach at 3/4	3.18	3.21	5.59
FOB002	6.54	No change	Breach at 3/4	3.18	3.21	5.59
FOB003	6.56	No change	Breach at 3/4	2.50	4.06	5.55
FOB004	6.26	No change	Breach at 3/4	5.02	1.24	5.95

2.4 Overtopping Scenarios

- 2.4.1 A series of overtopping scenarios were simulated for each flood cell to understand the flood risk impacts should defences not be raised in line with future climate change predictions.
- 2.4.2 The overtopping scenario hydraulic models were set up was the same as the breach scenarios with the exception of a 2D HT boundary along the defence frontage to allow tidal inundation into the catchment. For the Purfleet, Grays and Tilbury flood cell additional topographic amendments were required at NGR 568593, 176084 to stabilise flows over the defences (Table 2-2). The topographic amendments are small compared to the wider floodplain and not considered to significantly impact results.
- 2.4.3 In the Purfleet, Grays and Tilbury flood cell an initial water level of 3.9mAOD was applied within the Tilbury Harbour to ensure a consistent starting water level. This is slightly higher than the LiDAR DTM elevation and is considered conservative as it reduces the capacity of Tilbury Harbour.

2.5 Tidal Boundaries

Design events

- 2.5.1 Tidal boundaries have been generated for the following annual exceedance probability (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,
 - A tidal flood event with a return period of 1 in 1000 years (0.1% AEP) for the year 2025 and,
 - A tidal flood event with a return period of 1 in 1000 years (0.1% AEP) for the year 2125.

Tidal curve generation

- 2.5.2 Design tidal-graphs are time-series data that quantifies how water levels are expected to change through time during an extreme event. Derivation of the design tidal-graphs requires three principal sources of information:
- extreme still water sea level estimates for the return periods of interest,
 - a design surge shape, and,
 - a design astronomical tide taken from a gauge local to the site.
- 2.5.3 Tidal data for Tilbury over a period of 4.5 days (between 2022-2023) is shown in Figure 2-3. It depicts a series of typical spring tides including a high tide of approximately MHWS (6.4m CD) and the tidal surge data for Sheerness based on the CFB 2018 data (Environment Agency 2019). These datasets are the baseline conditions for each tidal curve.
- 2.5.4 The Environment Agency have supplied outputs from the Thames Estuary 2100 Modelling Study which provides extreme water levels throughout the Thames for a range of AEP events and epochs including the 0.5% AEP and 0.1% AEP events for 2025 and 2125. Values from nodes 3.15 to 3.31 have been used to inform the extreme water levels along the Thurrock frontage.
- 2.5.5 The modified tidal curve has been calculated to reach the extreme water levels for each location by taking account of the sea level rise from the baseline year (2025) to the scenario year (2125) (UKCP18 8.5 emissions scenario, 95th percentile).
- 2.5.6 As the tidal water levels vary from the western extent of the Thurrock frontage downstream to the east, the peak water levels are extracted from the Thames Estuary 2100 Modelling Study from nodes 3.15 to 3.31 and tidal boundaries generated for each location. For each breach location, the tidal curve for the node closest to that breach is applied. For the overtopping scenarios, the tidal boundary is applied as a series of boundaries along the sections of the frontage corresponding to each node location.
- 2.5.7 Table 2-6 identifies the node from the Thames Estuary 2100 Modelling Study that has been applied at each breach location.

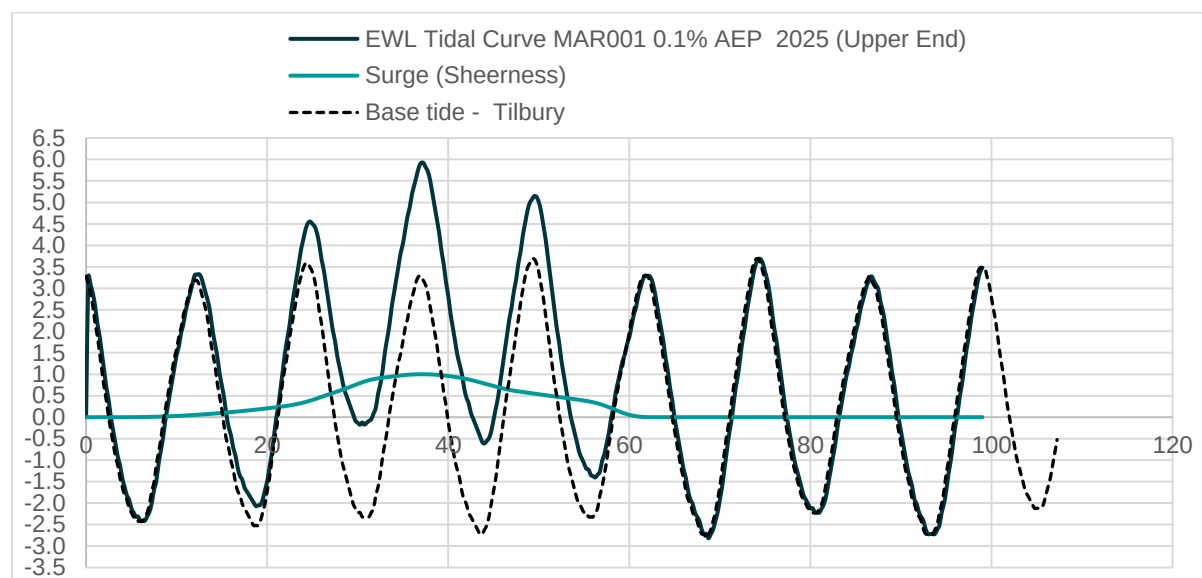


Figure 2-3 Example Tide Curve Including Surge Profile

Table 2-6 Extreme water levels

Breach Location	Thames Estuary 2100 Modelling Study – Node Reference	Extreme Water Level (mAOD)			
		0.5% AEP 2025	0.1% AEP 2025	0.5% AEP 2125	0.1% AEP 2125
MAR001	3.15u	5.61	5.92	6.85	7.08
PUR001	3.16	5.60	5.91	6.84	7.06
PUR002	3.17	5.57	5.90	6.82	7.04
PUR003	3.17i	5.55	5.87	6.80	7.03
PUR004	3.20_i	5.46	5.77	6.72	6.97
GRY001	3.21	5.44	5.75	6.70	6.95
GRY002	3.21	5.44	5.75	6.70	6.95
GRY003	3.21_i	5.42	5.73	6.67	6.93
GRY004	3.21_i	5.42	5.73	6.67	6.93
TIL001	3.21_i	5.42	5.73	6.67	6.93
TIL002	3.22	5.40	5.72	6.66	6.93
TIL003	3.23	5.37	5.70	6.64	6.90
TIL004	3.25_i	5.32	5.63	6.57	6.84
TIL005	3.26	5.29	5.61	6.56	6.83
TIL006	3.28	5.21	5.53	6.49	6.78
ETIL002	3.30_i	5.13	5.47	6.48	6.72
MUC001	3.31	5.11	5.45	6.47	6.71
FOB001	3.31_i	5.10	5.44	6.47	6.70
FOB002	3.32_i	5.07	5.41	6.44	6.66
FOB003	3.33a	5.05	5.38	6.42	6.64
FOB004	3.33_i1	5.02	5.36	6.41	6.64

Application of boundaries in TUFLOW

- 2.5.8 The design boundary conditions are applied directly to the 2D model using a 2d_bc boundary containing Height / Time (HT) information of the tidal cycles. For the overtopping scenarios, the boundary has been applied along the entire frontage of the flood cell. For the majority of the breach scenarios the boundary has been applied solely across the breach width. This enables the breach assessments to display solely the extent of flooding as a result of the breach, rather than in combination with the effects of overtopping.
- 2.5.9 There is one exception to this approach; following discussion with the Environment Agency the breach assessment for ETIL02 applies the HT boundary along the entire frontage, and therefore simulates a combined overtopping and breach scenario. This is based upon the Thames Estuary 2100 Plan Policy Approach P3 which states for the East Tilbury defences that *"Flood defences will be maintained at their current level, accepting that the likelihood and/or consequences of a flood will increase because of climate change"*.
- 2.5.10 Where the peak tidal elevation did not reach the trigger elevation shown in Table 2-5 the scenario was not simulated as no breach would occur. Table 2-7 shows the scenarios that were not simulated in red.

Table 2-7 Breach Scenario Simulation List

Breach Location	Breach Scenario			
	0.5% AEP 2025	0.1% AEP 2025	0.5% AEP 2125	0.1% AEP 2125
MAR001	X	X	X	X
PUR001			X	X
PUR002	X	X	X	X
PUR003	X	X	X	X
PUR004			X	X
GRY001			X	X
GRY002			X	X
GRY003			X	X
GRY004	X	X	X	X
TIL001		X	X	X
TIL002	X	X	X	X
TIL003	X	X	X	X
TIL004			X	X
TIL005			X	X
TIL006	X	X	X	X
ETIL002	X	X	X	X
MUC001	X	X	X	X
FOB001			X	X
FOB002			X	X
FOB003			X	X
FOB004			X	X

2.6 Simulations

2.6.1 The following scenarios have been simulated for the overtopping only:

- 0.5% AEP (1 in 200 year) for year 2025
- 0.1% AEP (1 in 1000 year) for year 2025
- 0.5% AEP (1 in 200 year) for year 2125 (Upper End climate change allowance)
- 0.1% AEP (1 in 1000 year) for year 2125 (Upper End climate change allowance)

2.6.2 The overtopping scenarios were simulated for the 2025 present day event though only the Mucking and Purfleet, Grays and Tilbury flood cells showed overtopping of the defences. The 2025 present day results have been presented for these flood cells only.

2.6.3 The following scenarios have been simulated for breach only (refer to Table 2-7 for details of which breaches occur during which AEP events):

- 0.5% AEP (1 in 200 year) for year 2025
- 0.1% AEP (1 in 1000 year) for year 2025
- 0.5% AEP (1 in 200 year) for year 2125 (Upper End climate change allowance)
- 0.1% AEP (1 in 1000 year) for year 2125 (Upper End climate change allowance)

2.7 Model Health

2.7.1 The cumulative mass balance error for the hydraulic models ranges between +2% and -2%. In all breach scenarios there is an initial spike in mass balance error where there is a rapid inundation of the 2d domain at the breach location. This falls to within +/- 2% within 1hr to 2hr with the exception of the present day PUR003 breach scenarios which peak marginally over -2% later in the simulation. A review of the Dvol plots shows good transition of flow and is not considered to impact the results. It is acknowledged that the mass balance error is outside of expected tolerances of +/- 1% for some simulations. This is a challenge due to the rapid inundation of grid cells due to the breach, large floodplain depths and floodplain roughness and elevation changes over small areas.

2.7.2 Through modelling process it was found that in areas of large elevations drops or quick transitions of hydraulic roughness in the floodplain there were locations where 2d negative depths were present. Attempts were made to reduce the number of 2D negative depths through the use of topographic and roughness patches. It was not possible to remove them completely however, where 2D negative depths remain in the models they are present for a short period of time in areas of large flood depths where it is expected that they will not have a significant impact on the results.

2.8 Model Limitations

2.8.1 The models are based on information made available by the Environment Agency up to November 2022. It is understood that the Environment Agency is undertaking a program of updating the Asset Information Management System (AIMS) data in the Thurrock area therefore any changes to the AIMS data since then may require modifications to the models.

2.8.2 It is noted that there has been continuous development within the Thurrock study area since 2020, particularly around the London Gateway within the Fobbing flood cell. As a consequence, ground elevations may have changed through the study area since the LiDAR was flown leading to overland flow paths that are no longer representative. It is beyond the scope of this study to acquire site specific topographic data and therefore this is a limitation of the methodology.

2.8.3 Greater detail could be achieved using a finer grid resolution, but this would make the model simulation time and results file sizes unmanageable.

2.8.4 The 0.1% AEP for the year 2125 overtopping results for Purfleet, Grays and Tilbury showed that the maximum water level is c.100mm greater than the East Tilbury Wall (AIMS Asset ID 152778) for c. 30mins of the model simulation. This means that there could be a connection between the East Tilbury and

Purfleet, Grays and Tilbury flood cells. This overtopping occurs for the most extreme event, for a short period of time and in an area of low flood risk and therefore the flood cells have not been combined. Future modelling studies should review the connection between these two flood cells particularly if the estimated tidal water levels increase in the future.

3. Model Outputs

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

3.1.2 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/TR2⁵ using the following equation:

$$\text{Flood Hazard Rating} = ((v+0.5)*D) + DF$$

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

3.1.3 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

Mapping

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

3.1.5 Appendix C Overtopping Results

- Figure 1: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Depth (m)
- Figure 2: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Hazard Rating
- Figure 3: Overtopping 0.1% AEP (1 in 1000 year) (2025) – Maximum Depth (m)
- Figure 4: Overtopping 0.1% AEP (1 in 1000 year) (2025) – Maximum Hazard Rating
- Figure 5: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Depth (m)
- Figure 6: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Hazard Rating
- Figure 7: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Depth (m)
- Figure 8: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Hazard Rating

3.1.6 Appendix D Combined Breach Modelling Results

- Figure 1: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Depth (m)
- Figure 2: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Hazard Rating
- Figure 3: Overtopping 0.1% AEP (1 in 1000 year) (2025) – Maximum Depth (m)
- Figure 4: Overtopping 0.1% AEP (1 in 1000 year) (2025) – Maximum Hazard Rating
- Figure 5: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Depth (m)
- Figure 6: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Hazard Rating
- Figure 7: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Depth (m)
- Figure 8: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Hazard Rating

3.1.7 The rest of the outputs are provided to Thurrock Council as ASCII files.

⁵ 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>

4. Future Thames Barrier Analysis

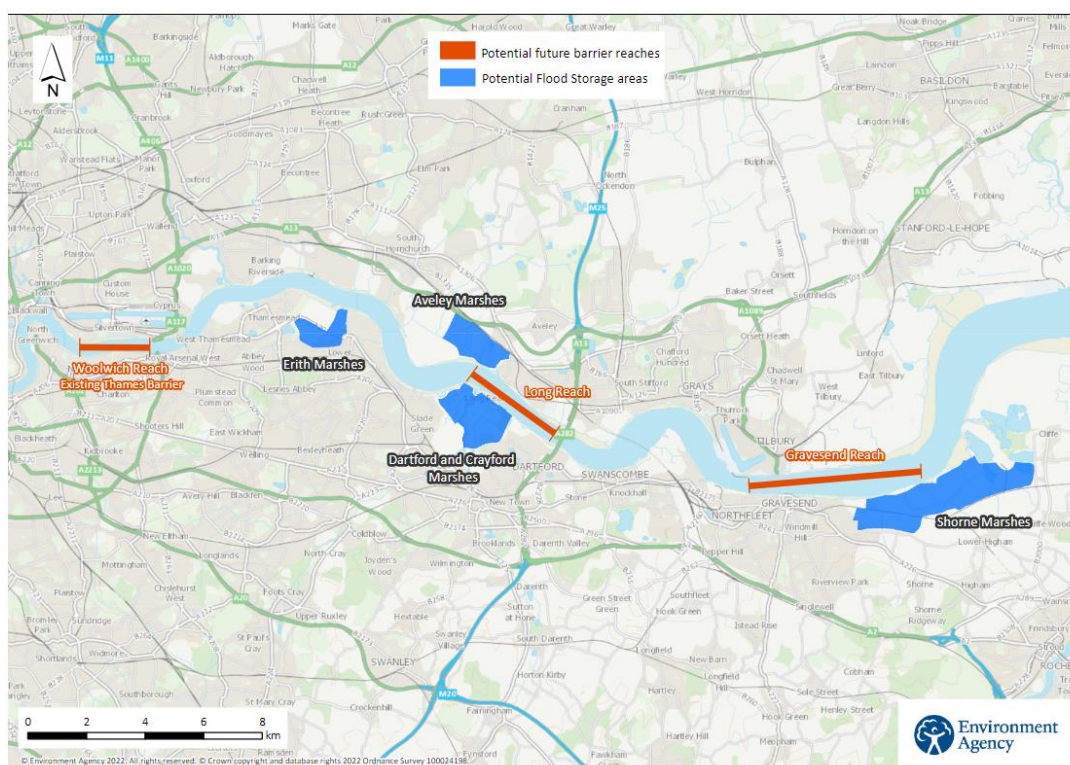
4.1 Introduction

- 4.1.1 The purpose of the SFRA for Thurrock is to consider the risk of flooding from all sources now and in the future. One of the future conditions that could impact the risk of tidal flooding from the Thames Estuary in Thurrock is the potential option to locate a new flood barrier on the River Thames at Long Reach.
- 4.1.2 This Section (first issued as a standalone Technical Note (prepared by AECOM, dated 11th October 2023)) describes the findings of analysis undertaken by AECOM of the Thames Estuary 2100 modelling datasets, to provide an initial understanding of the potential impact of a future flood barrier at Long Reach.

4.2 Thames Estuary 2100 Plan

- 4.2.1 As sea levels rise and defences get older, the risk of flooding from the Thames Estuary increases. The Thames Estuary 2100 (TE2100) Plan⁶ outlines how to manage this risk. Developed by the Environment Agency and its partners, the Plan sets out a vision for the estuary's future, adapting to rising average sea levels, higher high tides, and bigger and more frequent storm tides.

Figure 4-1 Potential locations for a future barrier and flood storage



- 4.2.2 There are 7 'end-of-century' options for the future of the flood defence system. A decision will be made by 2040 on the option to be progressed, and the end-of-century option is expected to be operational by 2070. One of the options is a new barrier at Long Reach within Thurrock Council's boundary (Figure 4-1)⁷. Thurrock Council and the Environment Agency are considering possible options to safeguard land for future construction of the barrier and permanent 'on-shore' facilities associated with it.
- 4.2.3 The impact of a future flood barrier at Long Reach would be to control water levels upstream of the Barrier by reducing tidal ingress up the Thames Estuary. However, immediately downstream of a new barrier, water levels would be elevated. There is therefore potential that the risk of tidal flooding to Grays and Tilbury could increase.

⁶ Thames Estuary 2100 <https://www.gov.uk/government/collections/thames-estuary-2100-te2100>

⁷ Managing future flood risk and Thames Barrier: Thames Estuary 2100 <https://www.gov.uk/guidance/managing-future-flood-risk-and-thames-barrier-thames-estuary-2100>

4.3 Extreme Water Level Comparison

- 4.3.1 As part of the River Thames modelling undertaken to inform the TE2100 Plan, a range of modelling scenarios have been undertaken, including scenarios with the current Thames barrier in place, and with a potential barrier at Long Reach.
- 4.3.2 Following discussion with the Environment Agency, the extreme water levels in the TE2100 modelling study have been analysed to identify the impact of a potential barrier at Long Reach on the water levels within Thurrock Council's boundary. A comparison has been made of the peak water levels along the Thames for the *current barrier location* and the *barrier at Long Reach*.
- 4.3.3 The extreme water levels in the Thames Estuary in Table 4-1 have been provided by the Environment Agency.

Table 4-1 Extreme Water Level data

TE2100 Model Scenario	File	Epochs	Climate Change Scenarios
Current Barrier Closed	<i>Extreme_water_levels_barrier_close_v7.xlsx</i>	2020, 2040, 2065, 2070, 2100, 2120, 2135, 2170	RCP 8.5 70th percentile (M suffix) RCP 8.5 95th percentile (H suffix) * H++ (HPP suffix)
Long Reach Barrier Closed	<i>Extreme_water_levels_LRB_close_v7.xlsx</i>	2070, 2100, 2120, 2135, 2170	RCP 8.5 70th percentile (M suffix) RCP 8.5 95th percentile (H suffix) * H++ (HPP suffix)

* This is the scenario the TE2100 Plan uses for design.

- 4.3.4 The epoch 2100 has been used for comparison. Table 4-2 shows the extreme water level data for the year 2100 for each node along the Thurrock frontage for the current barrier location and the Long Reach barrier location.
- 4.3.5 The comparison identifies that for much of the Thurrock frontage, the peak water levels for *design* event (0.5% AEP) with the *Long Reach barrier* in place, matches closely with the *extreme* event (0.1% AEP) for the *current barrier location*. This is highlighted blue in Table 4-2.
- 4.3.6 Further downstream (east of Tilbury), the water levels for the Long Reach barrier location reduce and are less than the extreme event (0.1% AEP) for the current barrier location. This is highlighted orange and green in Table 4-2.
- 4.3.7 The mapping of the *extreme* event (0.1% AEP) for the current barrier location that is presented within the Level 1 SFRA (Appendix C and Appendix D) can therefore be used as a useful approximation of how the *design* event (0.5% AEP) would change with the Long Reach barrier in place. Noting that downstream from Tilbury this provides a conservative approach.



Table 4-2 Extreme Water Level comparison

Node	Location			Existing Thames Barrier Annual Exceedance Probability					Potential Barrier at Long Reach Annual Exceedance Probability				
	Chainage	Easting	Northing	1%	0.5%	0.2%	0.1%	0.01%	1%	0.5%	0.2%	0.1%	0.01%
3.15u	60282	554474.8	178278.2	6.71	6.79	6.93	7.02	7.33	2.5	2.67	3.13	3.46	4.38
3.15d	60282	554616.6	178187.5	6.71	6.79	6.93	7.02	7.33	2.5	2.67	3.13	3.46	4.38
3.16	60856	554974.6	177855.5	6.7	6.78	6.92	7	7.32	2.5	2.67	3.13	3.46	4.37
Location of potential barrier at Long Reach													
3.16a	61384	555389.5	177529.1	6.69	6.78	6.91	6.99	7.32	6.82	6.97	7.15	7.27	7.56
3.17	61990	555840.4	177124.4	6.67	6.76	6.9	6.98	7.31	6.82	6.97	7.14	7.27	7.56
3.17_i	62854	556556	176639.4	6.64	6.73	6.87	6.96	7.3	6.82	6.96	7.12	7.25	7.56
3.18	63480	557088.9	176311.5	6.62	6.71	6.85	6.95	7.29	6.81	6.96	7.12	7.24	7.56
3.18a	64119	557626.3	175965.6	6.6	6.7	6.83	6.93	7.29	6.8	6.96	7.12	7.23	7.56
3.19	64809	558222.5	175628.3	6.58	6.68	6.81	6.91	7.28	6.79	6.94	7.11	7.22	7.55
3.19a	65168	558580	175638.1	6.58	6.68	6.81	6.91	7.27	6.79	6.94	7.11	7.22	7.55
3.19_i	65603	558982.7	175787.1	6.56	6.67	6.8	6.91	7.27	6.78	6.92	7.1	7.21	7.54
3.20	65894	559201.9	175974.7	6.56	6.66	6.8	6.91	7.27	6.78	6.91	7.09	7.2	7.53
3.20_i	66495	559588	176435.9	6.54	6.65	6.79	6.9	7.27	6.77	6.89	7.07	7.19	7.52
3.21	67297	560138.7	177013.6	6.52	6.63	6.78	6.89	7.26	6.76	6.89	7.04	7.16	7.5
3.21_i	68208	561023.4	177053.6	6.51	6.61	6.76	6.87	7.26	6.76	6.88	7.04	7.14	7.5
3.22	68857	561485.5	176621.7	6.5	6.6	6.75	6.86	7.25	6.77	6.87	7.04	7.14	7.49
3.22a	69481	561781.5	176074.6	6.49	6.59	6.73	6.85	7.25	6.76	6.87	7.03	7.14	7.48
3.23	70214	562089.4	175409.2	6.48	6.58	6.72	6.83	7.24	6.76	6.86	7.02	7.13	7.47
3.23_i	70585	562313	175119	6.47	6.57	6.71	6.82	7.24	6.75	6.85	7.01	7.12	7.46
3.24	71144	562821.9	174892.7	6.46	6.56	6.69	6.81	7.24	6.72	6.83	6.98	7.09	7.44
3.24_i	72029	563698.9	174784	6.43	6.53	6.67	6.79	7.23	6.68	6.79	6.93	7.05	7.41
3.25	72471	564140.1	174777.8	6.42	6.52	6.66	6.78	7.23	6.65	6.77	6.91	7.02	7.4
3.25_i	73228	564894.1	174838.5	6.4	6.51	6.64	6.77	7.22	6.61	6.74	6.88	6.98	7.38

Node	Location			Existing Thames Barrier					Potential Barrier at Long Reach				
	Chainage	Easting	Northing	Annual Exceedance Probability					Annual Exceedance Probability				
				1%	0.5%	0.2%	0.1%	0.01%	1%	0.5%	0.2%	0.1%	0.01%
3.26	73643	565308.6	174848	6.4	6.5	6.64	6.76	7.21	6.59	6.72	6.87	6.97	7.37
3.26_i	74670	566335.4	174867.1	6.38	6.48	6.62	6.75	7.2	6.56	6.67	6.83	6.95	7.34
3.27	75250	566914.4	174903.2	6.37	6.48	6.61	6.74	7.2	6.54	6.66	6.82	6.94	7.34
3.27_i	76274	567917.7	175074.2	6.35	6.45	6.59	6.72	7.19	6.52	6.65	6.8	6.92	7.34
3.28	77089	568676.5	175371.6	6.32	6.43	6.57	6.71	7.19	6.5	6.63	6.79	6.9	7.33
3.28a	77639	569184.9	175582.3	6.31	6.42	6.56	6.7	7.18	6.49	6.62	6.78	6.89	7.32
3.28_i	78191	569680.5	175816.9	6.3	6.4	6.56	6.69	7.17	6.47	6.6	6.76	6.88	7.31
3.29	78668	569931.3	176209.9	6.29	6.39	6.55	6.69	7.17	6.45	6.58	6.74	6.86	7.3
3.29a	79351	570133	176861.9	6.27	6.38	6.54	6.68	7.16	6.43	6.55	6.71	6.84	7.28
3.29b	79857	570242.9	177355.9	6.26	6.37	6.53	6.67	7.15	6.42	6.54	6.7	6.84	7.26
3.30	80373	570332.8	177863.6	6.25	6.36	6.52	6.66	7.14	6.42	6.54	6.7	6.83	7.26
3.30_i	81180	570518.1	178646.5	6.23	6.35	6.5	6.64	7.14	6.41	6.52	6.68	6.81	7.25
3.30_i1	82068	570928.8	179424.6	6.22	6.34	6.49	6.64	7.13	6.39	6.51	6.66	6.79	7.24
3.31	82548	571230.8	179797.9	6.22	6.34	6.48	6.63	7.12	6.38	6.5	6.65	6.78	7.24
3.31_i	82890	571445.2	180064.6	6.22	6.33	6.48	6.63	7.12	6.37	6.48	6.64	6.77	7.23
3.31_ia	83700	572160	180431.5	6.2	6.32	6.47	6.61	7.1	6.34	6.45	6.62	6.75	7.21
3.31_ib	84438	572860.6	180663.2	6.19	6.32	6.46	6.6	7.1	6.3	6.42	6.59	6.73	7.19
3.32	85049	573454.5	180790.6	6.19	6.31	6.46	6.59	7.09	6.27	6.39	6.56	6.71	7.18
3.32_i	85998	574391.9	180885.7	6.18	6.31	6.46	6.59	7.08	6.23	6.36	6.54	6.69	7.17
3.32_ia	86665	575029.9	181078.3	6.17	6.3	6.45	6.58	7.08	6.21	6.35	6.52	6.68	7.16
3.33	87267	575617.7	181203.4	6.16	6.29	6.44	6.58	7.07	6.2	6.34	6.52	6.67	7.16
3.33a	87768	576113.8	181269.1	6.16	6.28	6.43	6.57	7.07	6.2	6.34	6.5	6.67	7.15
3.33_i1	88626	576966.3	181253.6	6.14	6.27	6.42	6.57	7.07	6.18	6.32	6.48	6.65	7.14

