Technical Note

Project number	60653132
Project (Client)	Partnership for South Hampshire Strategic Flood Risk Assessment (Portsmouth City Council)
Subject	Southampton Water Model Re-Simulation

Revision	Date	Prepared by	Checked by	Verified by
Version 1 (Draft)	15 Aug 2022	Sophie Brewer (Graduate Consultant) Sarah Littlewood (Principal Consultant) Baoxing Wang (Principal Coastal Modeller)	Richard Moore (Principal Consultant)	Helen Judd (Associate)
Version 2 (Final)	28 Jun 2023	Sarah Littlewood (Principal Consultant)	Veronica Makhesh (Senior Consultant)	Helen Judd (Associate)

1. Introduction

1.1 Overview

1.1.1 AECOM has been commissioned by Portsmouth City Council (PCC), on behalf of ten planning authorities in South Hampshire (the 'Partnership for South Hampshire' (PfSH)) to prepare an updated Strategic Flood Risk Assessment (SFRA). The PfSH SFRA covers the administrative areas of Portsmouth City, Havant Borough, Gosport Borough, Fareham Borough, Eastleigh Borough, Southampton City, Winchester City, Test Valley Borough, New Forest District and New Forest National Park Authority.

1.1.2 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.

1.1.3 The PfSH SFRA is being prepared in line with the requirements of the National Planning Policy Framework[1] (NPPF) and supporting Planning Practice Guidance[2] (PPG). Reference has also been made to the Environment Agency guidance 'How to prepare a strategic flood risk assessment'[3].

1.1.4 This guidance advises that one of the elements the SFRA should provide is maps showing the risk of flooding from **rivers, the sea, and estuaries**, using the Flood Map for Planning and detailed flood modelling. Detailed flood modelling, where available, may be used to show the impact of climate change on flood risk. New or updated flood modelling may be required if flood models are not available, or the climate change allowances in the model are not in line with current climate change guidance.

1.1.5 The Environment Agency supplied the existing 2D hydrodynamic model from the Southampton Water Coastal Modelling Study[4] to inform the PfSH SFRA. This technical note describes the work undertaken to re-simulate the flood model from the Southampton Water Coastal Modelling Study, to provide the required outputs to inform the PfSH SFRA.

1.2 Existing Southampton Water Model

1.2.1 The Southampton Water Coastal Modelling Study was completed by JBA Consulting in 2014 using TUFLOW software. It was commissioned by the Environment Agency to produce a single Southampton Water model to

[1] MHCLG, July 2021, National Planning Policy Framework https://www.gov.uk/government/publications/national-planning-policy-framework--2
[2] DLUHC, MHCLG, August 2022, Planning Practice Guidance https://www.gov.uk/guidance/flood-risk-and-coastal-change
[3] Defra, Environment Agency, March 2022 https://www.gov.uk/guidance/local-planning-authorities-strategic-flood-risk-assessment
[4] JBA Consulting, 2014, Southampton Water Coastal Modelling Study.

improve understanding and confidence in the prediction of exposure to coastal flood risk within the Solent Estuary.

1.2.2 The "With Defences" scenario was simulated for a range of events to understand the present day and future flood risk from tidal sources. The "Without Defences" scenario was also required to update the current Environment Agency's Flood Zones and enable the mapping of areas benefitting from defences (ABDs) at that time.

1.2.3 The area modelled includes Southampton Water, the tidal regions of the River Hamble, River Itchen and River Test. The downstream extent of the model is the mouth of Southampton Water, extending from the high ground at Calshot in the west to high ground south of Warsash in the east. The model extent is shown in Figure 1-1.

1.2.4 The following model simulations were completed as part of the 2014 project:

- With defences 0.5% and 0.1% for 2075 and 2115 (UKCP09)
- Without defences 0.5% and 0.1% for 2115 (using both Defra 2006 and UKCP09 estimates)

1.2.5 The following model outputs are available: maximum flood depth, water level, velocity, hazard (ZUK0).

2. Model Updates

2.1 LiDAR DTM

2.1.1 The TUFLOW model build relies on a Digital Terrain Model (DTM) created from light detecting and ranging (LiDAR) data to represent the ground levels across the model domain.

2.1.2 The latest available LiDAR topographic survey data has been downloaded from the Data Services Platform[5] and included the Environment Agency's National LiDAR Programme. This was used to update the Southampton Water TUFLOW model. The 2020 LiDAR Composite contains surveys undertaken between 6th June 2000 and 1st September 2020.

2.1.3 Table 2-1 records the datasets that have been used to update the model. It should be noted that the 'Soton_LiDAR_001' dataset represents mainland while the 'DTM_1m_SouthamptonArea2' represents the Solent Estuary and associated watercourses. This layer helped with model stability as the representation of this area was more consistent and accurate.

2.1.4 With new LiDAR data available, the bathymetry data that represented the estuary / sea bed in the existing model was replaced. This caused model instabilities as ground levels associated with this dataset differed significantly when compared with the LiDAR data. This is likely due to the time in which the LiDAR was flown i.e. high vs low tide.

Table 2-1 Updates to DTM

Model	DTM used in 2015 Study	Updated DTM
Southampton Water	Filename: lidar2m, lidar1m Command: Read GRID Zpts TUFLOW reads an ASCII grid of points attributed with elevations derived from 1m filtered LIDAR data flown between 2007 and 2011. Previous 2m DTM is sat underneath to provide full coverage.	Filename: Soton_LiDAR_001, DTM_1m_SouthamptonArea2_trim Command: Read GRID Zpts TUFLOW reads in a text file of points attributed with elevations derived from 1m LIDAR flown in 2020. The following tiles were used: National LiDAR Programme DTM 1m SU31NW (2020), SU31NE (2020), SU31SW (2020), SU31SE (2020), SU30NE (2020), SU40NW (2020), SU40SW (2020), SU40SE (2020), SU40NE (2020), SU41SE (2020), SU41SW (2020), SU41NW (2020), SU41NE (2020), SU51SW (2020), SU50NW (2020) LiDAR Composite DTM 1m SU50SW (2020)

2.2 Tidal boundaries

2.2.1 In order to inform the PfSH SFRA, the Southampton Water model needed to be re-simulated to provide an assessment of the risk of flooding both now and into the future, taking account of the new climate change projections on sea level rise. The epochs of interest for the PfSH SFRA are:

- 2022 (present day scenario).
- 2055 (to provide consistency with the North Solent Shoreline Management Plan[6]).
- 2122 (to inform local plan preparation and design life of residential developments (100 years)).

[5] Defra Data Services Platform https://environment.data.gov.uk/

[6] North Solent Shoreline Management Plan https://www.northsolentsmp.co.uk/

Existing boundary set-up

2.2.2 Two types of boundary data were used as inputs into the model, these are:

1) a still water boundary, located at the mouth of Southampton Water, which allows propagation of the tide and surge into the model domain from the Solent; and,

2) wind boundary data applied across the entire model domain, which applies wind stresses to the water surface and creates a wind setup upstream in the study estuaries.

2.2.3 Derivation of the extreme tidal curves for the still water level boundary requires three components:

- extreme still water sea level estimates taken from the latest coastal extreme guidance for the UK for the return periods of interest,
- a design surge shape taken from the latest coastal extreme guidance for the UK, and
- a design astronomical tide taken from a gauge local to the site.

Climate change allowances

2.2.4 Current guidance on the climate change allowances that should be applied are set out by the Environment Agency[7]. There are a range of allowances for each river basin district and epoch for sea level rise. The allowances for the south-west and south east river basin district are included in Table 2-2. The guidance states that for flood risk assessments and SFRAs, LPAs should assess both the higher central and the upper end allowances.

Table 2-2 Sea level allowances by river basin district for each epoch in mm for each year (based on 1981 to 2000 baseline) – the total sea level rise for each epoch is in brackets

Area of England	Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise 2000 to 2125 (metres)
South east	Higher central	5.7 (200)	8.7 (261)	11.6 (348)	13.1 (393)	1.20
South east	Upper end	6.9 (242)	11.3 (339)	15.8 (474)	18.2 (546)	1.60
South west	Higher central	5.8 (203)	8.8 (264)	11.7 (351)	13.1 (393)	1.21
South west	Upper end	7 (245)	11.4 (342)	16 (480)	18.4 (552)	1.62

2.2.5 The guidance states, to calculate sea level using Table 2-2, add the allowances for the appropriate one of the 6 geographical areas:

- up to 2035, use the mm for each year rates for the appropriate geographical area, starting from the present day extreme sea levels from Coastal design sea levels – coastal flood boundary extreme sea levels (2018)[8].
- from 2036 to 2065, get the increase in sea level by adding the number of years on from 2035 (to 2065), multiplied by the respective rate shown in table 2 for the appropriate geographical area – if the whole time period applies use the cumulative total.
- treat time periods 2066 to 2095 and 2096 to 2125 as you would 2036 to 2065.

Where it is appropriate to apply a credible maximum scenario, use the H++ allowance. There is no H++ value for sea level rise beyond 2100. For the change to relative mean sea level use the H++ scenario of 1.9m for the total sea level rise to 2100.

[7] Environment Agency, May 2022, Flood risk assessments: climate change allowances https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

[8] Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels (2018) https://data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018

Updated boundaries

2.2.6 AECOM obtained the latest Coastal Flood Boundary (CFB) dataset (2018) and calculated the revised extreme still water levels using UKCP18 climate change projections for RCP 8.5 at 70th (higher central) and 95th percentiles (upper end) for the 0.5% AEP event for the years 2022, 2055 and 2122.

2.2.7 To generate the extreme tidal curve, the same approach was applied as that implemented in the JBA 2014 study. The surge profile at Portsmouth was used and the astronomical tides were generated using harmonic constants given in Admiralty Tide Tables. The same period tides (13/10/2012 and 19/10/2012) have been used as presented in 2014 JBA report. An example of the resulting extreme tidal curve for chainage point '4631' at Calshot Castle at the mouth of Southampton Water is shown in Figure 2-1.

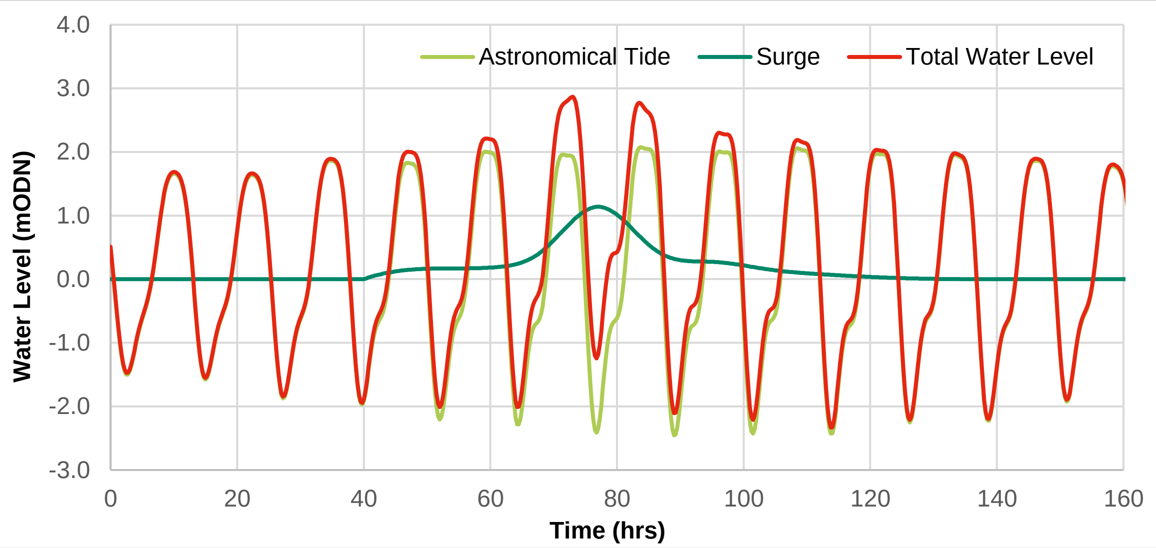


Figure 2-1 Design tidal graph for 0.5% AEP event (2022) based on CFB chainage points 4632 at Calshot Castle

Other Model Updates

2.2.8 Other minor updates to the Southampton Water model include:

- Simulation time changed in the event file (.trf) to 52.25 hours start and 101.75 hours end. This was consistent with the simulations undertaken as part of the East Solent modelling and now includes three tidal cycles including the peak of the event (73.50 hours).
- A number of patches were introduced into the model to smooth ground levels where LiDAR had not been filtered correctly (2d_zsh_SOTON_005_lidar_corr).
- The Initial Water Levels (IWLs) were updated to reflect the changes to the tidal boundary.
- With new LiDAR data being used, improvements were made around the inlet to Bartley Water. This involved modifying the layers '2d_zsh_SOTON_Bartley_Water_001' and '2d_zsh_SOTON_002' to include updated ground levels using the latest LiDAR dataset.

2.3 Modelled Scenarios

2.3.1 The scenarios simulated as part of this study alongside the peak extreme still water level are presented in Table 2-3.

Table 2-3 Modelled Scenarios

AEP	Epoch	Climate Change	Peak Extreme Still Water Level (m AOD)
Defended			
3.3%	2022	Present Day (70th)	2.68
3.3%	2122	Higher Central (70th)	3.72
0.5%	2022	Present Day (70th)	2.87
0.5%	2055	Higher Central (70th)	3.11
0.5%	2122	Higher Central (70th)	3.91
0.5%	2055	Upper End (95th)	3.18
0.5%	2122	Upper End (95th)	4.28
0.1%	2055	Upper End (95th)	3.31
0.1%	2122	Upper End (95th)	4.41
Undefended			
0.5%	2055	Higher Central (70th)	3.11
0.5%	2122	Higher Central (70th)	3.91
0.1%	2055	Higher Central (70th)	3.24
0.1%	2122	Higher Central (70th)	4.04
0.5%	2055	Upper End (95th)	3.18
0.5%	2122	Upper End (95th)	4.28
0.1%	2055	Upper End (95th)	3.31
0.1%	2122	Upper End (95th)	4.41

2.3.2 The undefended model scenario provides an indication of the extent of the Flood Map for Planning Flood Zone 3 for the present day and in the future (2122) which is useful for applying the sequential test during local plan preparation.

2.4 Outputs

2.4.1 The following outputs have been supplied to the client group for each modelled scenario:

- Maximum depth grid (ASCII format).
- Maximum hazard (ZUK0) grid (ASCII format).
- Maximum water level grid (ASCII format).
- Maximum flood extent grid (GIS shapefile).

2.5 Future Flood Zones

2.5.1 In order to provide an indication of how the Flood Zones may change in the future as a result of climate change, a future Flood Zone 2 and future Flood Zone 3 have been generated:

- Future Flood Zone 2 was generated from the maximum flood extents for the 0.1% AEP (Upper End) 2122 undefended scenario.
- Future Flood Zone 3 was generated from the maximum flood extents for the 0.5% AEP (Upper End) 2122 undefended scenario.

3. Breach modelling

3.1 Residual risk

3.1.1 The Planning Practice Guidance[2] (PPG), defines residual risks as those remaining after applying the sequential approach to the location of development and taking mitigating actions. Examples of residual flood risk include:

- the failure of flood management infrastructure such as a breach of a raised flood defence, blockage of a surface water conveyance system, overtopping of an upstream storage area, or failure of a pumped drainage system;
- failure of a reservoir, or,
- a severe flood event that exceeds a flood management design standard, such as a flood that overtops a raised flood defence, or an intense rainfall event which the drainage system cannot cope with.

3.1.2 Areas behind flood defences are at particular risk from rapid onset of fast-flowing and deep-water flooding, with little or no warning if defences are overtopped or breached.

3.1.3 The SFRA should consider the residual risk of flooding in the study area.

3.1.4 The coastal modelling described in Section 2 includes 'undefended' scenarios, which enable an assessment of the risks if defences were not in place. However, as described in the Environment Agency Breach of Defences Guidance[9], the development of 'with defences' and 'without defences' modelling and mapping is not a surrogate for residual risk assessment and can both overestimate and in some cases underestimate the 'true' flood risk and hazard. In addition, the hazard from a sudden release of water from a failure is often not properly appreciated in assessments of flood defences.

3.1.5 There is scope within the SFRA to carry out breach assessments at specific locations around the study area, where appropriate. The justification for these specific breach assessments as part of the SFRA will depend on where development is proposed, and the local characteristics of the defences that could make them susceptible to a breach, for example:

- Whether it is a 'breachable' location, i.e. the ground levels behind the defence are lower than the crest level of the defence.
- Whether there are any vulnerable points in the existing defence, for example structures in the defence or a known defect.

3.2 Breach locations and parameters

3.2.1 Breach locations have been identified based on a review of the defence types, the extent of Flood Zone 2 and a review of the ground levels behind the defence using LiDAR topographic data. The breach locations were discussed and agreed with the Environment Agency and steering group in Summer 2021.

3.2.2 The Environment Agency Breach of Defences Guidance[9] sets out the parameters that should be applied for different types of defence. Table 3-1, reproduced from the guidance summarises the breach widths and time to close.

3.2.3 The invert level of the breach has been determined by interrogation of the LiDAR on the landward side of the breach location, applying the rule of thumb that the breach invert level should be the lowest ground level within a radius the same as the breach width.

[9] Environment Agency, 29th June 2021, LIT56413 Breach of Defences Guidance.

Table 3-1 Breach parameters (width and time to close)

Source	Defence Type	Breach Width (m)	Time to close – urban (hrs)	Time to close – rural (hrs)
Estuary/Tidal River	Earth Bank	50	30	30
	Reinforced Concrete	20	18	18
Open Coast	Earth Bank	200	44	56
	Earth Bank with facing	100	44	56
	Dunes	100	44	56
	Shingle Bank	100	30	30
	Reinforced Concrete	50	18	30
River	Earth Bank	40	30	56
	Reinforced Concrete	20	18	18
Tidal/Coastal	Tidal Gates	Gate width	Gates fail on low tide preceding the peak level with emergency closure effected during the following low tide	

3.2.4 The breaches are modelled to occur 1 hour prior to the peak water level and lower the defence to the specific invert level over a set period of time, dependent on the type of defence. The length of defence defined to breach is lowered using a variable zshape feature in TUFLOW.

3.2.5 The following section demonstrates the location of each breach and provides a table presenting the key information such as defence type, source of flood risk, width of the breach, invert levels both seaward and landward and also the length of time the defence is breached. The specific breach reference is also provided which relates directly to the model simulations.

3.2.6 Given the model simulation time (approximately 3 days), breach locations were grouped together based on location and length of time the defences are breached. It was ensured that breach locations that were modelled within the same simulation were located suitably far apart to ensure that the flood extents did not converge.

3.2.7 For Southampton Water a total of 2 breach models were simulated. One included breach locations MAC1, HYT1 and HAM1 while the other included breach locations ELI1 and ITC1.

3.2.8 Each breach model was simulated for the 0.5% AEP event for 2122 using the upper end (95th percentile) climate change allowance on sea level rise.

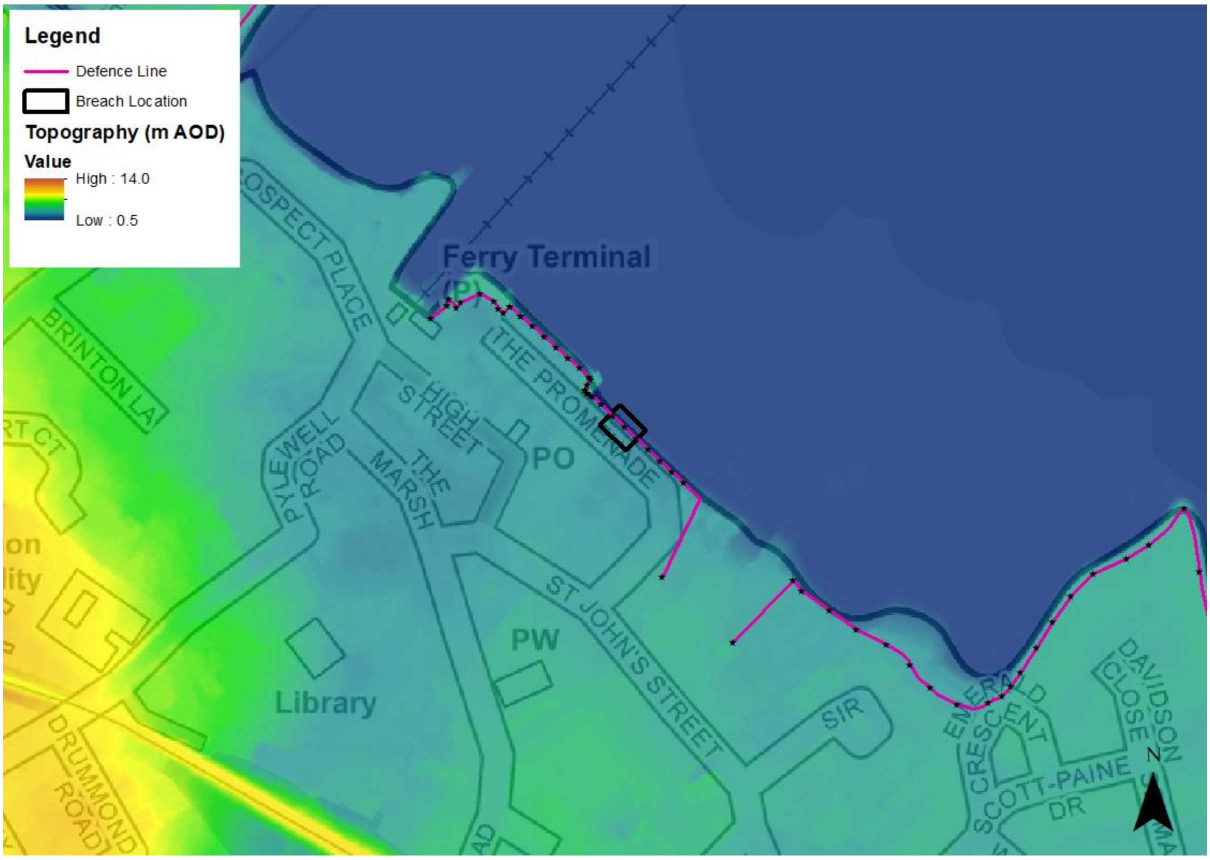
3.3 Breach locations

Breach Location HAM1

Location of breach HAM1

Breach Reference	HAM1
Grid Reference	SU4845807111
Description of location	Port Hamble Marina
Description of defence	Reinforced concrete wall
Source	Estuary/tidal river
Width of breach (m)	20
Seaward invert level (m AOD)	0.2
Inland invert level (m AOD)	2.5
Length of time breached (hrs)	18

Breach Location HYT1



Location of breach HYT1

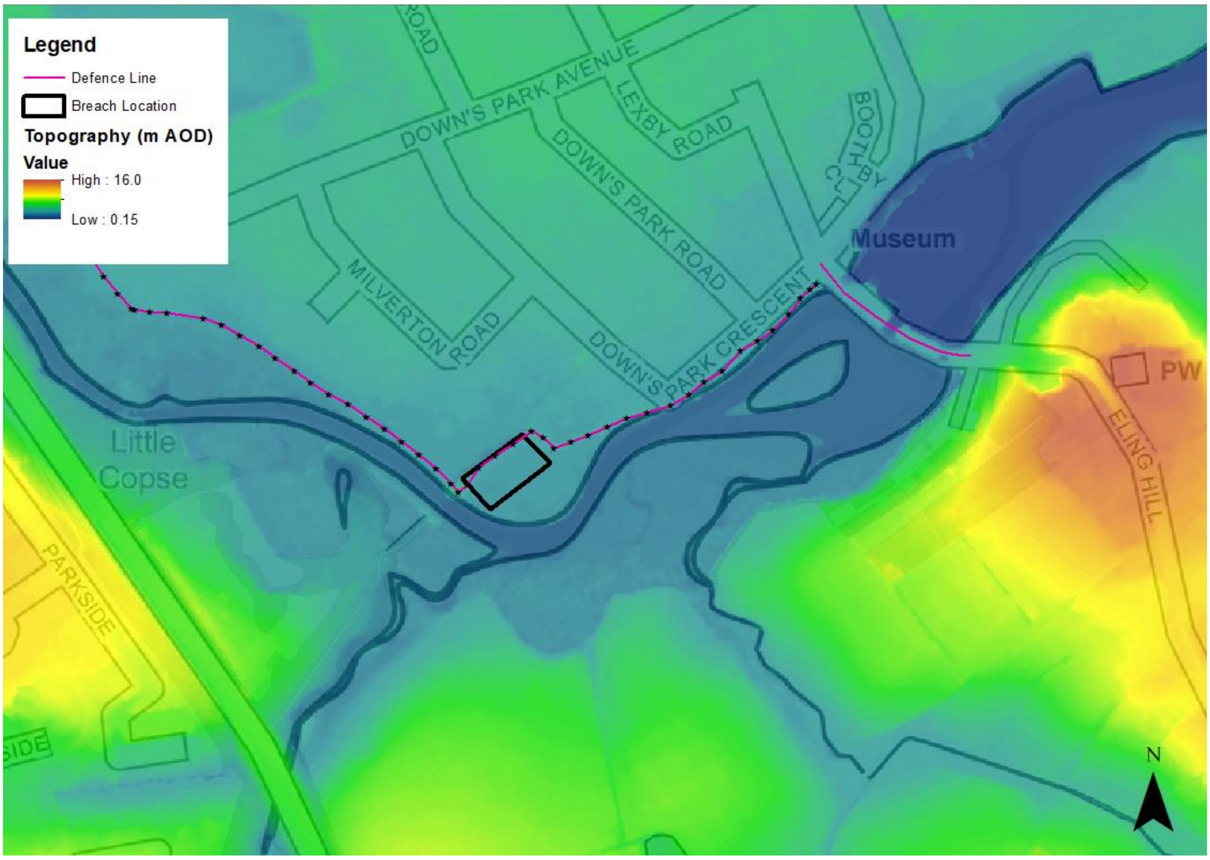
Breach Reference	HYT1
Grid Reference	SU4241108095
Description of location	Hythe
Description of defence	Reinforced concrete wall
Source	Estuary/tidal river
Width of breach (m)	20
Seaward invert level (m AOD)	0.6
Inland invert level (m AOD)	2.3
Length of time breached (hrs)	18

Breach Location MAC1

Location of breach MAC1

Breach Reference	MAC1
Grid Reference	SU3908611498
Description of location	Near Maritime Avenue, Marchwood
Description of defence	Reinforced concrete wall
Source	Estuary/tidal river
Width of breach (m)	20
Seaward invert level (m AOD)	0.6
Inland invert level (m AOD)	2.4
Length of time breached (hrs)	18

Breach Location ELI1



Location of breach ELI1

Breach Reference	ELI1
Grid Reference	SU3627712387
Description of location	Bartley Water, Eling
Description of defence	Earth bank
Source	Estuary/tidal river
Width of breach (m)	50
Seaward invert level (m AOD)	2.2
Inland invert level (m AOD)	2.5
Length of time breached (hrs)	30

Breach Location ITC1

Location of breach ITC1

Breach Reference	ITC1
Grid Reference	SU4359212400
Description of location	Northam, River Itchen near William Street.
Description of defence	Earth bank
Source	Estuary/tidal river
Width of breach (m)	50
Seaward invert level (m AOD)	0.0
Inland invert level (m AOD)	3.2
Length of time breached (hrs)	30