PLANNING ACT 2008
INFRASTRUCTURE PLANNING
(APPLICATIONS: PRESCRIBED FORMS AND PROCEDURE) REGULATIONS 2009
REGULATION 5 (2) (a)

PROPOSED PORT TERMINAL AT FORMER TILBURY POWER STATION

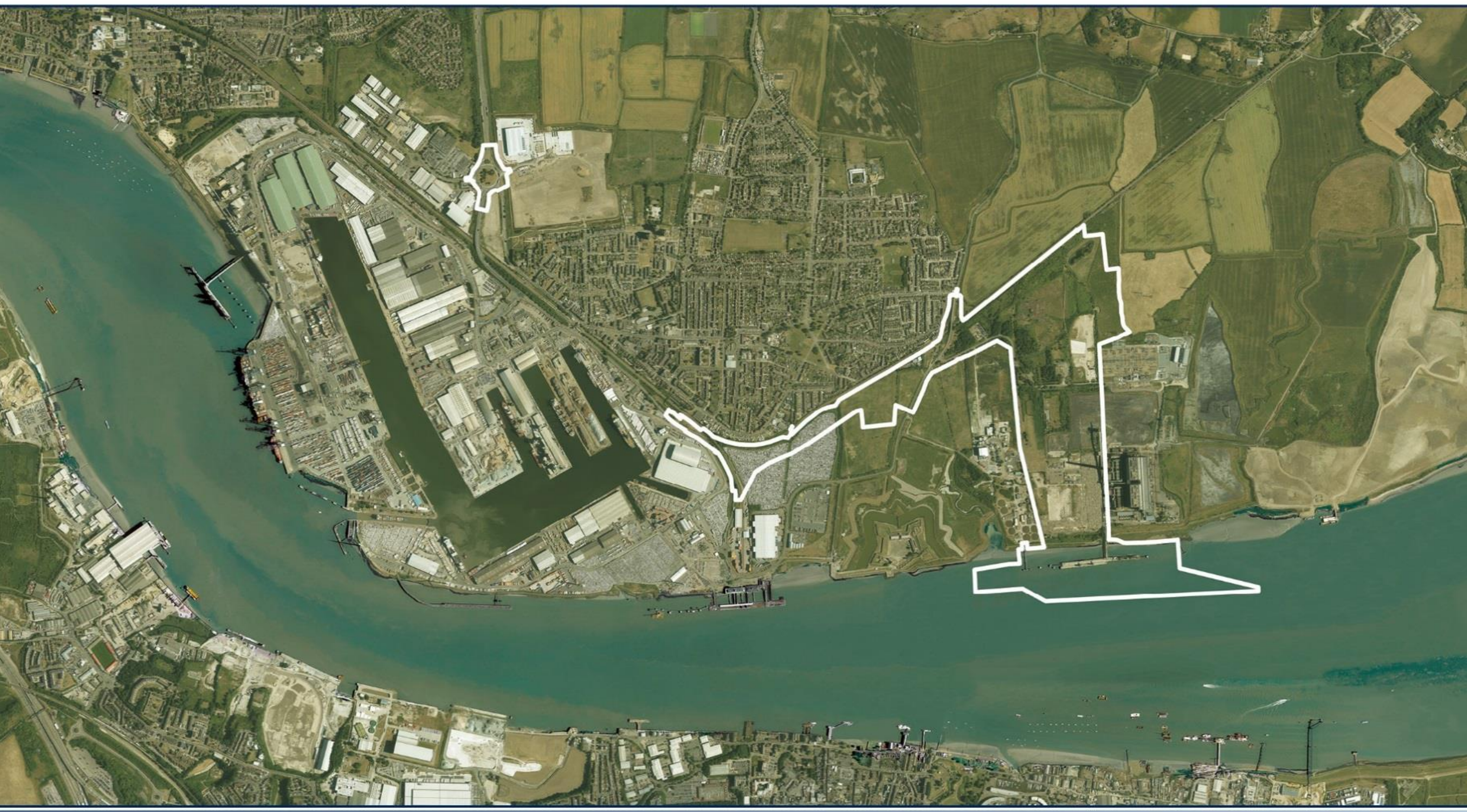
TILBURY2

TR030003

VOLUME 6 PART B

ES APPENDIX 16.B: LEVEL 3 FLOOD RISK ASSESSMENT

DOCUMENT REF: 6.2 16.B



TILBURY2

Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position
1	15/09/2017	Draft report for Client and Stakeholder Review		Jon Robinson	Director
2	27/09/2017	Final report incorporating Client comments		Jon Robinson	Director
3	03/10/2017	Final report updated with Client comments		Jon Robinson	Director

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1. Introduction

1.1 Background

The Port of Tilbury London Limited (PoTLL) is planning a new port terminal and associated facilities on land at the former Tilbury Power Station. The proposals will form an extension of the operations at the existing Port of Tilbury. The project is considered a Nationally Significant Infrastructure Project and as such formal consultation with the local community and stakeholders was commenced in May 2017. As part of the consultation stage, a Level 2 Flood Risk Assessment (FRA)[1] was completed in addition to a Preliminary Environmental Information Report (PEIR)[2] containing an assessment of Water Resources and Flood Risk. These documents (as well as the developing water resources chapter) have been used to inform this Level 3 FRA.

The Level 2 FRA is based on readily available information including Environment Agency (EA) Flood Maps, Thurrock Strategic Flood Risk Assessment[3] and the Tilbury Integrated Flood Strategy (IFS)[4].

The Level 2 FRA provides a suitable level of assessment for the consultation stage of planning. However, as the project progresses, further detail is required to assess the potential impact of development on flood risk. CIRIA C624 'Development and Flood Risk – Guidance for the Construction Industry'[5] outlines a three phased approach to the assessment of flood risk. A Level 2 FRA has been completed as part of the consultation stage of the planning process, and this report constitutes a Level 3 FRA – 'quantitative analysis on flood risk' to support the Development Consent Order (DCO) application. This report should not be read in isolation and builds upon the Level 2 FRA. An Environmental Statement (ES) Chapter on Water Resources has also considered the findings of the Level 2 FRA and this Level 3 FRA, alongside all relevant policy, to consider the potential impacts and cumulative impacts on water resources and flood risk as a result of the proposed development.

1.2 Report Scope, Aims and Objectives

A Level 3 FRA, building upon the completed Level 2 FRA is required to further assess the risks of all forms of flooding to, and created by, the proposals and to demonstrate how these flood risks will be managed so that the development remains safe throughout its lifetime, taking into account climate change. In order to address this requirement, site specific hydraulic breach modelling will be completed as part of this Level 3 FRA to represent the following:

i. Baseline flood conditions on site should existing flood defences fail; and

ii. Post development scenario; in order to quantify the potential impact of the proposed development on tidal residual flood risk, the baseline model will be updated to include the proposed development outline.

Both models will be run for the following scenarios:

- Design flood event: 1 in 200 years (present day 2017) and 1 in 200 years (with a climate change allowance to 2117)
- Extreme flood event: 1 in 1000 years (present day 2017) and 1 in 1000 years (with a climate change allowance to 2117)

Flood depth and hazard information will be interrogated to fully quantify the potential impact of development at this location on tidal residual flood risk.

[1] Port of Tilbury Terminal 2 Development Level 2 Flood Risk Assessment, May 2017 Atkins global
[2] Tilbury 2 Volume 1 Preliminary Environmental Information Report, June 2017, Port of Tilbury London.
[3] Scott Wilson 2009 & 2010 Thurrock Level 1 and Level 2 SFRA
[4] JBA, 2017 Tilbury Integrated Flood Strategy
[5] Construction Industry Research and Information Association (CIRIA), 2004, C624 Development and Flood Risk – Guidance for the Construction Industry

2. Site and Surrounding Area

2.1 Site Location

The site is to be known as 'Tilbury2' and is located to the south- east of Tilbury at approximate National Grid Reference (NGR) TQ 65741 75931. The site area comprises approximately 61 hectares of the former Tilbury A Power Station. The northern boundary of the Tilbury2 site is defined by the Tilbury Loop of the London-Southend rail line. The southern boundary is defined by the River Thames with a river frontage of approximately 290m including a deep water jetty previously used for the import of coal. To the east the site is bounded by agricultural land, part of the Tilbury substation and the Power Station B complex, and to the west lies an Anglian Water Sewerage Treatment Works and open land.

Figure 2-1 Aerial image of site location

Source: Port of Tilbury: Tilbury2 Consultation Document June 2017

2.2 Existing Development

The ***Tilbury2 site area*** itself is divided by an access road which runs east-west, known as 'Substation Road' (as it provides access to the operational Tilbury 400 kV substation). To the south of this road, the Tilbury2 site area comprises the former Tilbury 'A' power station (and associated jetty), former coal storage areas and ancillary buildings/land.

Land to the north of Substation Road is partially occupied by open storage of new cars by Hyundai (PoTLL was granted temporary planning permission for 5 years for this use in September 2016 by Thurrock Council) with the remainder existing as unkempt scrub land. The remainder of the land north of Substation Road is largely brownfield land with areas of plantation woodland and developing scrub although there are some areas of relic grazing marsh. Parts of the northern Tilbury2 site area were formerly used to manufacture 'Lytag' blocks as a by-product of fuel ash from the power station.

The Tilbury2 site area is currently accessed directly from Fort Road to the west. A former rail connection point is located to the north which was last used in the 1960s.

The existing ***infrastructure corridor*** area currently includes the railway corridor which links the Tilbury Town and East Tilbury train stations. The infrastructure corridor comprises a number of different land use types immediately adjoining the existing railway corridor. At its eastern end, the land includes Fort Road itself and the existing bridge where Fort Road crosses the railway at elevation. Immediately to the west of Fort Road is an area of scrub, beyond which is a small industrial/depot site containing a number of small single storey storage buildings and an area of external vehicle and plant storage. At its western end, the corridor includes land occupied by an existing rail siding and operational land used by the Port for external storage (presently for imported new motor vehicles) known as the 'Fortland' site, and a narrow corridor of landscaping between this and the railway itself. Between these two developed areas at either end of the corridor is an area of land typically used for the grazing of horses.

2.3 Proposed Development

The proposals for the Tilbury2 site include the construction of a new port terminal with associated facilities for importing, exporting and processing a variety of goods. It is an extension to the existing port and will be managed by PoTLL staff. The main components of the development will be:

- A Roll-on/roll-off (RoRo) terminal for importing and exporting containers and trailers, located in the southern part of the site;
- A 'Construction Materials and Aggregates Terminal' (CMAT) for handling and processing bulk construction materials, located in the northern part of the site, and;
- Remainder of the site to be used for storage of bulk goods, cars etc. as per the existing Port.

The Consultation Booklet that formed part of the statutory consultation materials for the proposals included the following illustrative depiction of the proposals which is reproduced below:

Figure 2-2 Tilbury2 Site Before Redevelopment

Figure 2-3 Tilbury2 Site After Redevelopment proposals

The proposals can be subdivided into two main zones:

- Tilbury2 site: the new port terminal and associated infrastructure; and
- Infrastructure corridor: providing road access and rail freight to the port terminal.

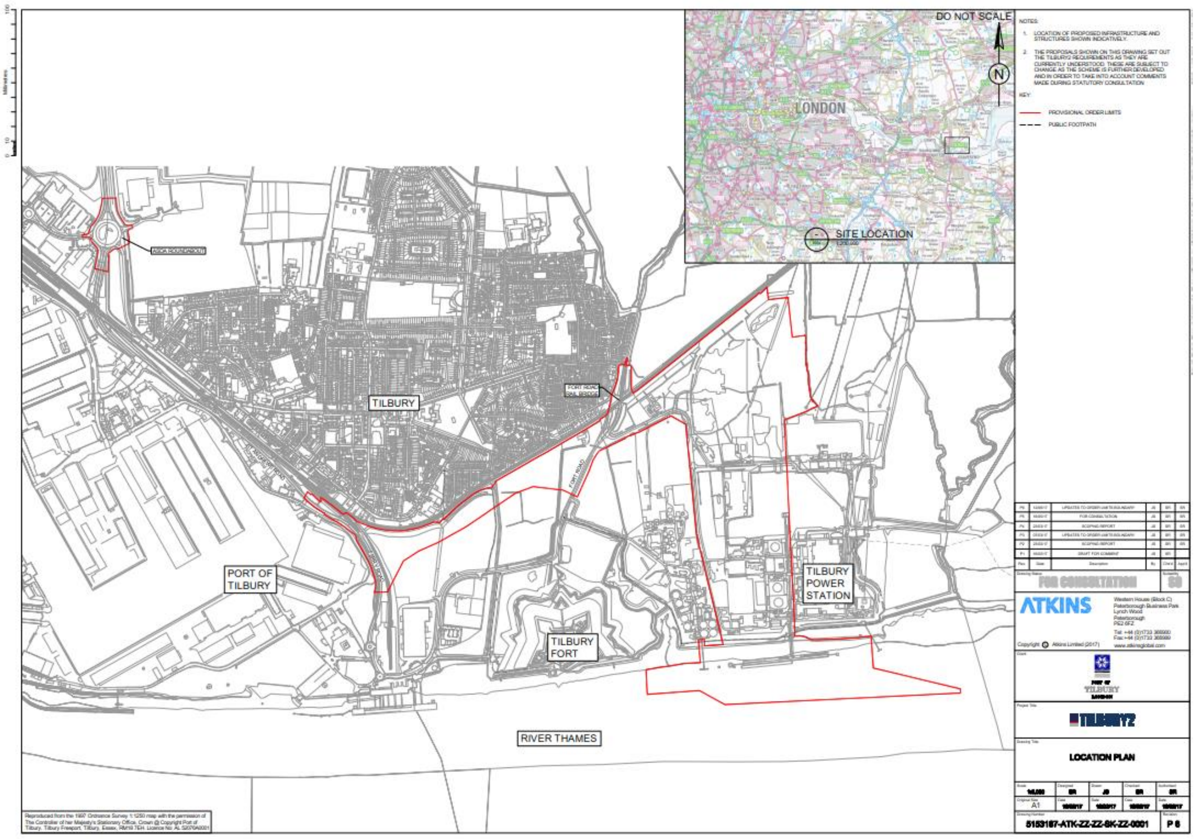

Figure 2-4 Proposed Development area showing the Tilbury2 Site and Infrastructure Corridor

A large proportion of the materials passing through the site will leave by rail. In addition, a new road link is proposed linking Ferry Road and Fort Road. The road will be single carriageway with provision for pedestrians and cyclists.

The Level 2 Flood Risk Assessment (FRA)[1] made an assessment of the risks to the Tilbury2 site and the infrastructure corridor from potential sources of flooding within the context of the National Planning Policy Framework (NPPF)[6], NPPF Planning Practice Guidance Documents[7] and the National Policy Statement for Ports (NPSP)[8].

The NPPF aims to prevent inappropriate development in areas at risk of flooding, and to ensure that if development is necessary in areas at risk of flooding it is made safe, and the risk of flooding elsewhere does not increase as a result of the development. The NPPF outlines the risk framework and vulnerability classification used to assess the appropriateness of a development; by defining the 'Flood Zone' and 'Vulnerability and Development Type'.

As stated in the Level 2 FRA, the NPSP is part of the planning system established under the Planning Act 2008 to deal with nationally significant infrastructure proposals, to provide the framework for decisions on proposals for new port developments. The policies within it aim to make it safe where new development, including 'water compatible' development, is necessary in areas at highest risk of flooding.

[6] Department for Communities and Local Government (March 2012); National Planning Policy Framework. Department for Communities and Local Government, Eland House, Bressenden Place London.
[7] National Planning Policy Framework for England and planning practice guidance, Accessed May 2017, http://planningguidance.communities.gov.uk/blog/guidance/.
[8] Department for Transport, 2012 - National Policy Statements for Ports

The proposed development is classified as a 'Water Compatible' in line with the NPPF and the NPSP. As stated in the Level 2 FRA; 'a port terminal and the associated proposed infrastructure are considered water-compatible land uses because they cannot reasonably be located anywhere except a waterfront location.' Because of this, and the discussion given in Chapter 6 of the ES outlining the reasons for which the Tilbury2 site has been chosen, it is considered that the proposals can demonstrate satisfaction of the Sequential Test as an appropriate location in a flood risk zone and would not necessarily need to consider the Exception Test.

However, even if not formally required, it is considered that the proposals would also pass the Exception Test:

- The proposed development will bring wider sustainability benefits to the community;
- The proposals are located on developable land that have previously been developed; and
- The proposed development will be safe, without increasing flood risk anywhere else, as stated in the Level 2 FRA.

Therefore it is considered that the proposed development is acceptable in terms of flood risk policy.

2.4 Topography

A topographical survey of the site indicates that the Tilbury2 site area is relatively flat with elevations between approximately 2.5m AOD and 3.0m AOD; however, there are some occasional topographical irregularities associated with the existing buildings/structures where greater elevations are present.

The topography of the infrastructure corridor area is influenced by the presence of the mainline railway. Specifically, the western portion of this area is characterised by an embankment which forms the southern boundary of the railway with elevations ranging between approximately 3.5m AOD and 4m AOD. The embankment elevations progressively reduce eastwards where these are generally between 1.8m AOD and 2.2m AOD. The area surrounding Fort Road to the south of the ridge presents elevations which range approximately between 0.6m AOD and 1.1m AOD. On the contrary, the elevation of the railway track increases from west to east (approximately 2.0m AOD to 2.3m AOD).

2.5 Geology & hydrogeology

Site geology and hydrogeology has been reviewed in the Level 2 FRA and RPS 2015 Ground Investigation Report[9] and these documents should be referenced for further detail. As a summary, the site is largely comprised of made ground of between 0.4m and 3.3m in thickness underlain by alluvium, between 13 and 15m thick, Kempton Park Gravels and Seaford and Newhaven Chalk.

The RPS Ground investigation 2015[9] identified perched groundwater present across the site lying between the base of the made ground and the uppermost parts of the alluvium. This perched groundwater is not linked with groundwater found within the Kempton Park Gravels, levels of which are influenced by the River Thames.

2.6 Water Features

The main hydrological feature present in the area is the Gravesend Reach of the River Thames which flows immediately south of the site. In addition, there are a number of watercourses and drains which flow through the site and surrounding area.

As outlined in the Tilbury Integrated Flood Strategy[10,] the central/eastern side of Tilbury drains into the Chadwell Cross Sewer which flows in a southerly direction, crossing the infrastructure corridor to the west of the development site before outfalling to the River Thames at the Worlds End Outfall and pumps. A second watercourse called the Pincocks Trough Sewer serves the upper eastern catchment including the eastern Tilbury Flood Storage Area. It flows in a south westerly direction, through the infrastructure corridor before its confluence with the Chadwell Cross Sewer just north of Tilbury Fort, outfalling to the Thames at the Worlds End Outfall. These are illustrated in Figure 2-5.

[9] RPS, 2015 Ground Investigation Interpretive Report, Tilbury Power Station
[10] Tilbury Integrated Flood Strategy, JBA, 2017

In addition to the two networks outlined above, the East Tilbury Dock Sewer also crosses the infrastructure corridor. This drainage network serves the eastern side of Tilbury including the western flood storage area which outfalls to the River Thames via gravity at the Hotel Gardens (Chadwell Sluice) outfall.

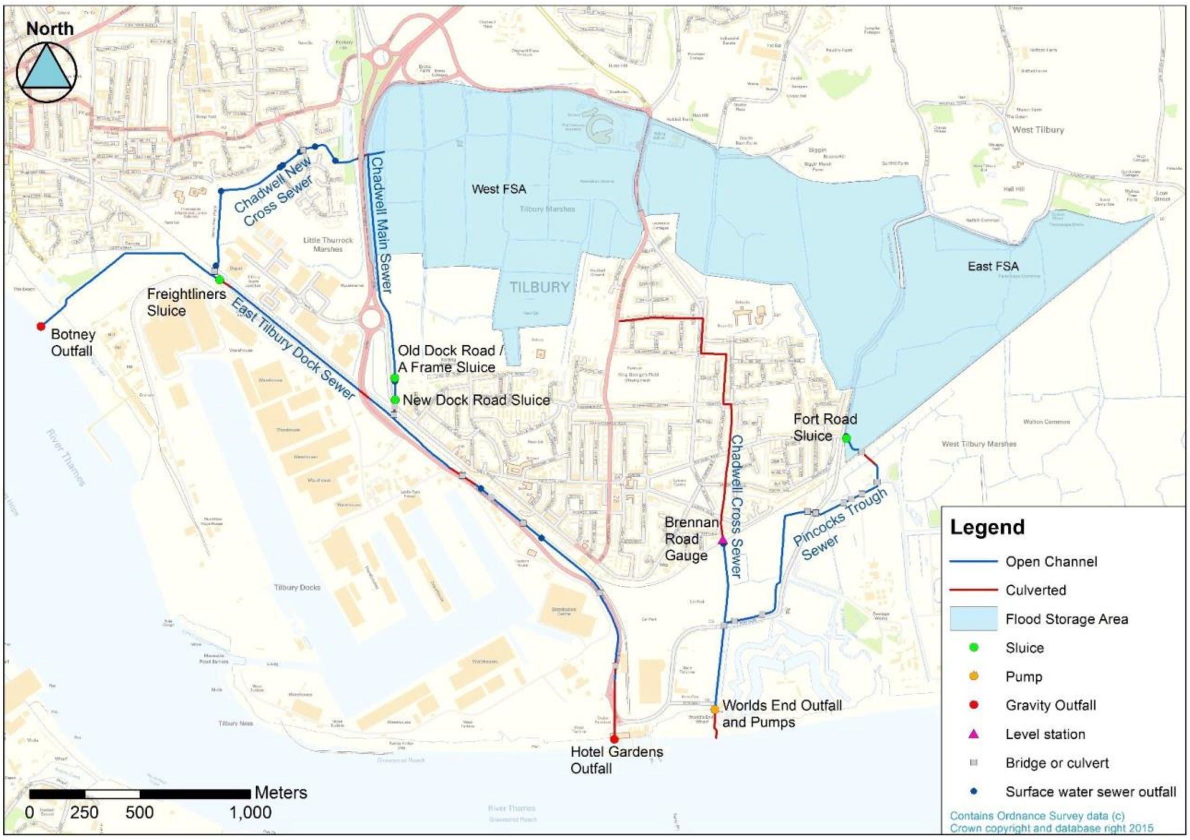

Figure 2-5 Illustrates Land Drainage and Tilbury Flood Storage Areas

Source: Tilbury Integrated Flood Strategy, 2017

In addition to the 'main' drainage network described above, there are networks of smaller un-named ditches which are located within or cross the proposed development site and the infrastructure corridor as shown in Figure 2-6 below.

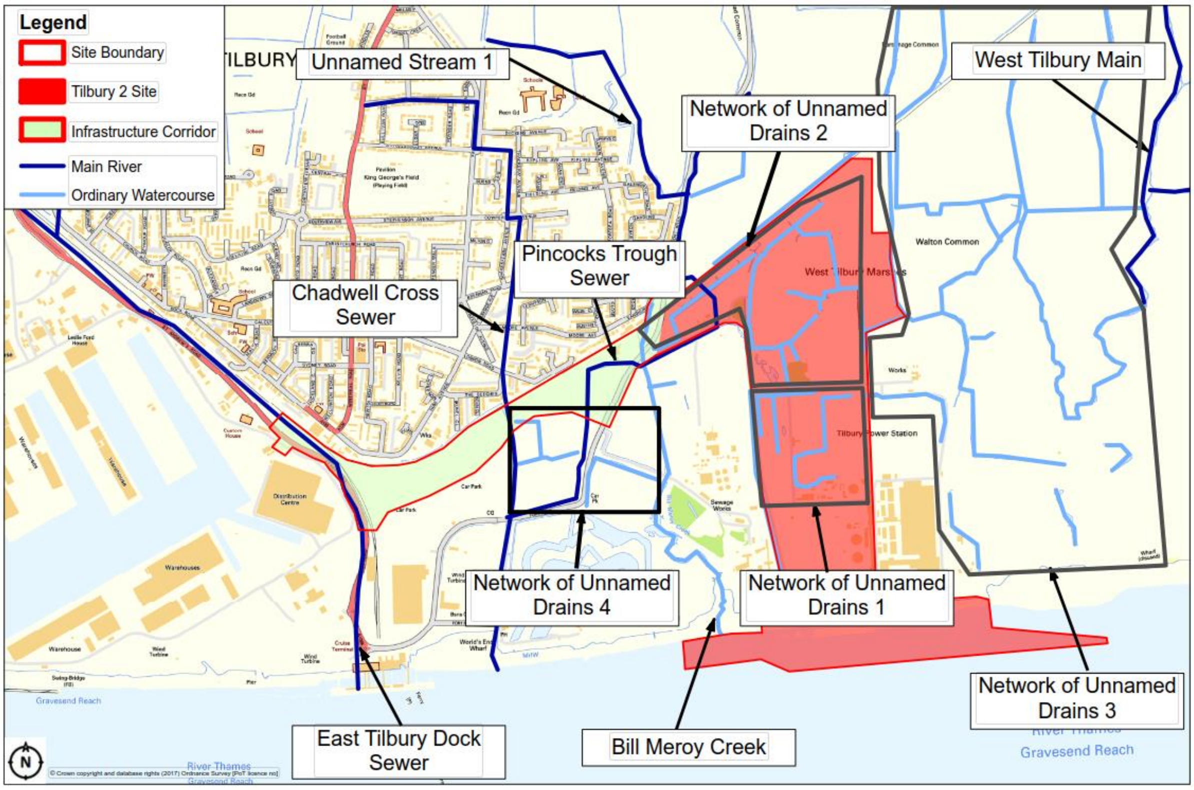

Figure 2-6 Surface Water Features at the Application Site[1]

Proposed crossings of these watercourses are discussed further in Section 6.2 of this report.

2.7 Sewers

The public sewer system is owned and managed by Anglian Water. The western boundary of the site borders with the Anglian Water Sewage Treatment Works (STW). Consultation with Anglian Water, completed as part of the Level 2 FRA, revealed that in addition to the STW, there are several existing foul sewers within the boundary of the site which are essential assets to serve the foul water system. There is an existing sewer outfall which discharges into the River Thames within proximity of the proposed RoRo berth.

2.8 Flood Defences

The reach of the River Thames adjacent to the site is defended against tidal and fluvial flood events by flood defence walls, with a current standard of protection of 0.1 % AEP (a 1 in 1000 year) event. This level of protection will be maintained up until 2030. Post 2030, the standard of protection will decrease to less than 0.1% AEP (1 in 1000 year) as sea levels rise associated with climate change. The EA's approach to managing flood risk in the Thames Estuary up to 2100 is outlined in the Thames Estuary 2100 project.

Tilbury falls into Policy unit P4 Purfleet, Grays & Tilbury and the EA recommend that further action is taken to keep up with climate change so that flood risk does not increase.

Condition surveys of the flood defence walls are carried out by the EA. Previous asset condition surveys have identified the grade of the defences in front of the Power Station as 'good', however, consultation with the Environment Agency has identified that the current condition of the asset is 'Poor' (See Appendix A)'. Therefore, any required maintenance to the flood defences will need to be determined and agreed with the EA following submission of the DCO application, pursuant to the protective provisions for their benefit in the DCO.

3. Flood Risk

This section provides a summary of the findings of the Level 2 FRA on assessment of flood risk from all sources for the proposed Tilbury2 site and infrastructure corridor. It also provides an assessment of the impact of climate change on all flood sources with reference to the latest EA guidance; summarising and expanding upon the findings of the Level 2 FRA, where necessary.

Latest guidance released by the EA (2016) provides climate change allowances for peak river flows, peak rainfall intensity, sea level rise and offshore wind speed/ extreme wave height. These allowances are based on the climate change projections and different scenarios of carbon dioxide (CO2) emissions. The allowances change for different periods of time over the next century, and have been considered in developing flooding mitigation measures to ensure the development is compliant with EA guidance.

3.1 Flood History

As stated in the Level 2 FRA, the only flooding to ever affect the site is associated with high tides, which occurred prior to the raising of flood defences. Flooding to the Site and surrounding areas in January/February 1953 was caused by an intense low-pressure system that developed in the North Sea causing a storm surge to propagate south along the east coast and creating a tide level of 5.03m AOD, the highest ever recorded.[11]

The flood defences at the time were not sufficient and consequently overtopped, flooding Tilbury including a large area of the site. The flood event had a large impact on property and life along the affected areas on the east coast, and subsequently led to a Government initiative for an improved flood defence scheme for barriers and raised walls in the Thames Estuary.[11]

3.2 Tidal Flooding

The Level 2 FRA stated that the site is situated within Flood Zone 3, which has a 0.5% (1 in 200) or greater chance of flooding each year. However, it was noted that the EA flood maps assume that no defences are in place, but the site benefits from the Thames Tidal Defences to a crest height of between 6.9m AOD to 7.2m AOD; providing defence above a 1 in 1,000 year tidal event (present day).

The Level 2 FRA referred to the Hydrological Assessment of the Site[12], which stated that the current condition grade for defences in the area is 2 (good) on a scale of 1 (very good) to 5 (very poor). Consultation with the EA (see Appendix A) has confirmed that the current condition grade for the defences on the site is poor. Despite the fact that flood defences are present, there is still a risk that defences could be overtopped or beached. Breach modelling from the Thurrock Level 2 SFRA was summarised, with ‘breach modelling outputs suggest[ing] that the site is at High risk of flooding in the case of a breach of the tidal defences. The flood hazard is currently ‘Significant’ (2009) throughout the majority of the site and it is likely to be classified as ‘Extreme’ by 2109. The most at risk areas of the site are those located within proximity of the breach where the time of inundation is less than one hour.’[1]

The Catchment Flood Management Plan (CFMP) for South Essex[13] predicts that there will be a total sea level rise of 112mm by the year 2100, increasing the risk of tidal flooding. This impact will need to be accounted for when assessing the residual risk of overtopping of the coastal defences.

Given the above, the Tilbury2 site and infrastructure corridor is deemed to be at high risk of flooding in the event of a breach and/or overtopping of the existing flood defences. Further breach modelling and resulting mitigation measures provided in this report are necessary to address this residual risk, above those measures that are stated in the Level 2 FRA report; including:

- To undertake a Level 3 FRA (this report);

[11] Scott Wilson, 2009 – Thurrock Strategic Flood Risk Assessment. Level 1 Report
[12] RPS, 2015 – Tilbury Power Station Surplus Land. Hydrological Assessment
[13] EA, 2009 – South Essex Catchment Flood Management Plan

- Consultation with the EA on all works that may damage or interfere with the existing flood defences (secured through DCO protective provisions); and
- Permanent non-moveable aspects of the proposals to be at least 16m away from the landward toe of the flood defence to allow for any future construction/raising works in line with increased flood risk from climate change.

3.2.1 Sea Level Allowances

The EA provide a regional allowance for sea level rise for each time frame[14], showing a cumulative allowance up to the year 2115. These allowances differ depending on the part of the country due to an account of slow land movement, as a result of 'glacial isostatic adjustment'. This is caused by the release of pressure after ice that covered large parts of northern Britain melted at the end of the last ice age. The northern part of the country is slowly rising and the southern part is slowly sinking. Table 3.1 provides the EA sea level allowance for each time frame (epoch) and cumulative rise.

Table 3-1: EA sea level rise allowances for each epoch (1990 used as the baseline)

Area of England	1990 to 2025	2026 to 2055	2056 to 2085	2086 to 2115	Cumulative rise 1990 to 2115 / metres (m)
East, east midlands, London, south east	4 (140mm)	8.5 (255mm)	12 (360mm)	15 (450mm)	1.21m

This exceeds the predicted sea level increase of the South Essex CFMP. Flood defences will need to be accessible for increases in height in line with the Thames Plan 2100 as sea levels increase, in a 'managed adaptive approach'.

3.3 Fluvial Flooding

The Level 2 FRA states that there are a number of watercourses and drains that flow through the Site and surrounding area which may experience flooding as a result of; 'high rainfall events in the local catchment, blocked channels, rainfall exceeding pump capacity at channel outlets or pump failure at the downstream end of drainage channels which may cause out of bank flows or the backing up of water behind defences at the channel outlets.'[1]

However, these watercourses have a very small catchment, and there has been no flood zones generated by the EA for these watercourses, which suggests they do not pose a serious flood risk to the Site.

The infrastructure corridor will however create infrastructure passing over main rivers and ordinary watercourses, which could potentially restrict water flow and potentially increase the risk of flooding from fluvial sources.

The South Essex CFMP[13] has predicted a sea level increase of 112mm and a 20% increase in peak flow in all watercourses by 2100, which will increase the length of time that the watercourses are not able to flow freely into the sea during high tide (tide-locked), which could have a significant impact on flood risk. The Drainage Strategy (Document Reference 6.2 16.E) accounts for this increase in potential flood risk beyond these predictions in line with the EA guidance on sea level allowance in Section 3.2 and peak river flow as provided in table 3.2 below.

3.3.1 Peak River Flow

Table 3-2 presents the latest EA guidance on the climate change allowances that should be applied to peak river flow in the Thames River basin district. Given that the proposals are classified as 'water compatible' as outlined in Section 2.3, the EA recommend that increase in peak river flow should be

[14] Environment Agency (2016) 'Flood risk assessments: climate change allowances', available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1

considered from the central allowance category[14]. This represents a 25% increase in peak river flow in 2100; which exceeds the prediction of the South Essex CFMP.

Table 3-2: Peak river flow allowances for the Thames river basin district (use 1961 to 1990 baseline)

Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper estimate	25%	35%	70%
Higher Central	15%	25%	35%
Central	10%	15%	25%

There has been no fluvial modelling of the existing surface water drainage network completed as part of this flood risk assessment, as despite this increase in predicted peak river flows, there has been no history of fluvial flooding in the area for development and the Drainage Strategy has taken account of the EA climate change guidance. Reference has therefore been made to the Tilbury Integrated Flood Strategy[10].

3.4 Groundwater Flooding

The Level 2 FRA states that there is a shallow perched groundwater system between the Alluvium and the Made Ground, with the Alluvium layer acting as an aquitard and providing a barrier to groundwater level rises. Furthermore, there are no records of historical groundwater flooding at the site or the surrounding areas.

Whilst the risk of groundwater flooding is deemed to be low during the operational phase of the proposed development, the Level 2 FRA states that there is a moderate risk of groundwater flooding during the construction phase due to excavations that might encounter the shallow perched water table or penetrate the Alluvium aquitard. This might pose a potential risk for workers and machinery on site. The Level 2 FRA proposes mitigation measures including dewatering and placing low permeability layers at the base of excavations. This will be dealt with through the protective provisions for the Environment Agency's benefit in the DCO.

3.5 Surface Water Flooding

The Level 2 FRA states that surface water (pluvial) flooding is likely to occur at the Site and the surrounding areas, due to impermeable soils and local topography. It is also noted that the development is likely to create large areas of impermeable surfaces which will generate large volumes of surface water run-off unless suitable mitigation measures are implemented. Section 6 provides further details on the proposed mitigation for this risk in the form of a Drainage Strategy.

Table 3-3 presents the latest EA guidance on climate change allowances that have been applied to rainfall intensity for use in surface water drainage designs (discussed further in Section 7.2). These allowances are uniform across the whole country.

Table 3-3: Peak rainfall intensity allowance in small urban catchments[14]

Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

The EA guidance suggests that both the central and upper end allowances should be assessed, to understand the range of impact. Therefore the Drainage Strategy has considered up to 40% increase in peak rainfall intensity up to 2100.

3.6 Sewerage Flooding

The Level 2 FRA states that no flooding from water mains and drains has been recording within the Site or in the surrounding area. The implementation of sustainable drainage (SuDS) techniques are therefore recommended to mitigate for this. Section 6 details how the proposed use of SuDS has been incorporated within the Outline Drainage Strategy.

4. Site Specific Hydraulic Breach Modelling

As identified in the Level 2 FRA, one of the primary sources of flood risk to the site is tidal flood risk should existing flood defence walls fail. In order to better understand the risk that this source poses, a site specific breach model has been built as part of this assessment. The methodology and results are outlined below, supported by a more detailed Breach Modelling Methodology in Appendix B.

4.1 Generation of Tide Data

The water levels during a tidal flood event were generated by a summation of the astronomical tide levels and the storm surge residual. The tidal water levels used for the breach modelling analysis are shown in Table 4-1.

Table 4-1: Extreme tide level data

Event	Extreme High Tide (mAOD)	
	2017	2117
1 in 200 year	5.562	6.576
1 in 1000 year	6.089	7.06

4.2 Summary of Breach Modelling Methodology

To investigate the flood propagation resulting from the breach, the two dimensional (2D) hydraulic modelling software TUFLOW (2016-03-AE) has been used.

The parameters used in the assessment of a breach in flood defences consist of:

- The breach is located in the centre of the Thames frontage as shown in Figure 3.1, located at X565894, Y175350, which is located approximately 300m east of the proposed bridge over the defences, near to the location of the existing jetty;
- The breach is within hard defences and is therefore 20m wide;
- The breach extends to ground level local to the defence, established through the interrogation of LiDAR data and taken to be 2.6mAOD;
- No overtopping of the defences is permitted in the model;
- The model is run over tidal cycles, a period of 36 hours;
- The proposed culvert sizes were conservatively assumed at 2m x 1.5m with levels derived from topographic data;
- The breach has been run for the following events[15]:
  - Design Flood Event: 1 in 200 years (present day 2017) and 1 in 200 years (with a climate change allowance to 2117)
  - Extreme Flood Event: 1 in 1000 years (present day 2017); and 1 in 1000 years (with a climate change allowance to 2117);
- A baseline scenario has been modelled using site topographical data and LiDAR data. This includes the majority of the local drainage network as identified on the site survey, excluding culverts to the north-west of the site as these are seen to be blocked with debris; and

[15] Given the nature of the activities on the proposed port site, it has been assumed that they are not safety critical and therefore would not be required to remain operational; therefore the Upper End scenario (referred to as the United Kingdom Climate Projections 2009 H scenario) has not been included as a simulation in the breach model.

- A ‘proposed’ scenario has used the proposed layout, including the development outline and ground levels and the new infrastructure corridor, overlain into the model to show how water will propagate around the site in the event of a breach, post development. Four culverts have been added where the proposed road and railway cross existing watercourses.

Contains Ordnance Survey data © Crown copyright and database right 2017.

Figure 4-1: Breach location

4.3 Model Uncertainty

Uncertainties associated with computational modelling stem from a number of different sources. The accumulated effect of each source should be taken into account when evaluating the model results. The main sources of uncertainty stem from the accuracy of the hydrology, hydraulic modelling and the flood spread modelling used to generate the results.

The effect of climate change incorporated into the hydrology is based on the same parameters as the wider Thurrock breach model. However knowledge and understanding of climate change is still growing and there are aspects that are still uncertain. New scenarios of future climate change in the UK are constantly updated through projects such as UK Climate Impacts Programme (UKCIP).

Assumptions made as part of the hydraulic modelling include land usage and cover, which influence the surface roughness on the ground. Lack of refined data on channel geometry along the flow paths and drainage channels may also influence the model results - in particular with regards to the inundation rate.

The dispersion of floodwater on the ground is influenced by the accuracy of the Digital Terrain Model (DTM) and how accurate structures such as culverts and embankments have been represented in the model domain. The accuracy of the DTM is influenced by the accuracy of the LiDAR used to generate the DTM and the representation of these features.

5. Hydraulic Breach Modelling Results

The main output of the flood modelling is the production of flood depth and flood hazard maps, which provide information on the flow characteristics within the site and surrounding area. The model results include:

- Flood depth maps for all model scenarios and return period events are shown in Appendix C, Figures 1 -4;
- Comparison of the existing (baseline) and post development breach model results both within the site and off the site enable any change in residual risk to be identified. The depth difference maps used for this comparison can be seen in Appendix C Figures 5-8. LiDAR data used in the model build has a vertical accuracy of +/- 150mm. Therefore to remove the background model 'variance', any changes in depths of less than 100mm have been removed from the mapping;
- Flood hazard uses the FD2320 approach of depth and velocity as a function of hazard, these hazard maps are shown in Appendix C Figures 9-12; and
- Flood time to inundation maps for all model scenarios and return period events are shown in Appendix C, Figures 13-14.

5.1 Flooding Summary

Flood risk can be defined as the product of probability of flooding and the consequence of the flooding. Warning time can be a very important factor in limiting the consequence of flooding. Therefore, the available warning times on site have also been assessed.

During the ebb tide flood water will decrease on site, as it drains back into the Thames. The length of inundation to the flood cell and recovery time will depend on the length of time it takes to repair the breach. Considering the extensive size of the flood cell and settlement areas that would be affected, it is considered that a breach in the defences would be quickly repaired as a matter of urgency. This cannot however be assumed and as such three tidal cycles have been modelled (36 hours). Following a repair of the breach any remaining floodwater could then be pumped from the site using the existing drainage system.

Within the Tilbury2 site and the infrastructure corridor, results indicate that there will be a change to the residual risk as a result of the proposals. For the majority of the site, the change is positive i.e. a reduction in flood depth, which is reflective of the proposed increase in site levels compared to the existing as a result of adding pavement areas, or neutral i.e. no change in flood depth. Some localised areas within the CMAT and Ro-Ro storage areas of the site are shown to have a slight increase in flood depth as a result of the development.

For the majority of the area off site, including the town of Tilbury and the flood storage areas, the change is positive, i.e. a slight reduction in flood depth or neutral i.e. no change in flood depth. The exceptions are a field located to the east of Fort Road which is shown to experience a minor increase in flood depth in all modelled flood events and a ditch and small field to the north west of Tilbury Fort which experiences an increase during the 200yr 2017 and the 1000yr 2017 flood events.

5.2 Propagation of water through the flood cell

This section considers only the 200 year 2117 flood event but the sequence of inundation will be similar for the other flood events also.

During the first tidal cycle under the existing baseline scenario, water inundates to the south of the Tilbury2 site before flowing up the main ditch to the west of the site. Water also reaches further into the Tilbury2 site, and also flows out to the east, towards the centre of the Tilbury B power station site. Water also flows out to the west of the Tilbury2 site, covering part of the north of the sewage works before flowing out into surrounding fields, reaching as far as the infrastructure corridor. Water splits into several ditches then heads south in the Pincocks Trough sewer and then into the Chadwell Cross sewer.

Water flows over the majority of theTilbury2 power station site and the sewage works before flowing over the railway line and starting to extend into Tilbury Town. Water also flows out towards west tilbury marshes as well as part of the existing port. The majority of Tilbury Town is inundated in the first tidal cycle.

Some water then drains back through the breach as the flood waters recede after the first tidal cycle.

During the second tidal cycle water propagates through the flood cell as in the first tidal cycle increasing the depths of water on the site and crossing the railway to the east of the town, into the east FSA, before flow extends into the west FSA also. A larger area of the existing port is also flooded and the flood waters cover a greater area to the west of Tilbury Fort. Flood depths increase in west tilbury marshes also.

Again water drains from the Tilbury2 site, the power station, the sewage works and the existing port after the second tidal cycle but there is no change in Tilbury Town as water is trapped behind the railway line and so areas north of the railway are unable to drain.

The third tidal cycle re-inundates areas flooded during the first two tidal cycles that drained as the tide receded.

During the proposed development scenario, flood water is increasingly restricted by the proposed infrastructure corridor with flows restricted by culverts so flooding fields to the east of Fort Road much earlier. Water also reaches further onto the site earlier due to the flatter topography. Water recedes more from off the site as culverts restrict the flow back through the infrastructure corridor.

5.3 Flood depth and Velocity

The maximum flood level, depth and velocity have been extracted from the modelled scenarios at the major buildings on site (see Figure 5-1 and Table 5-1).

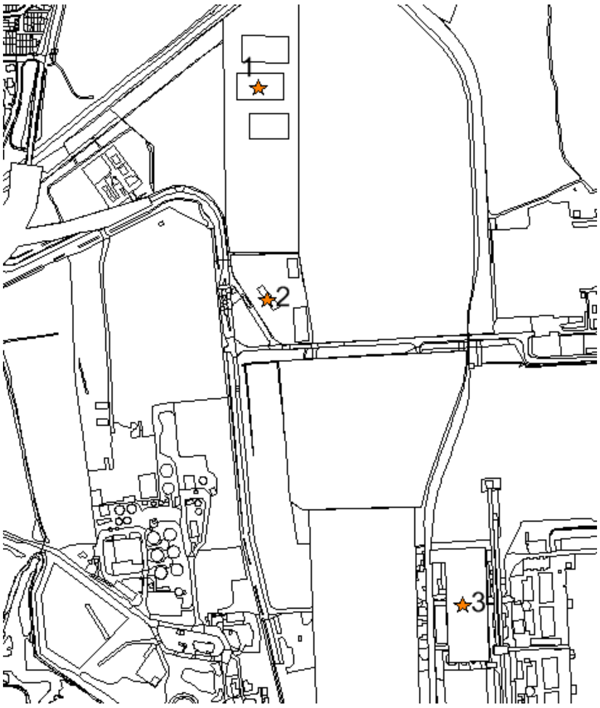

Figure 5-1: Location of level comparison points

Table 5-1: Flood level affecting buildings (200 year 2117)

Point Reference	Description	Proposed Development Model Water Level (mAOD)	Proposed Development Model Velocity (m/s)
1	CMAT Processing Buildings	2.75	0.081
2	Administrative/ Workshop Buildings	3.02	0.222
3	Warehouse	3.62	0.125

The depth maps (see Appendix C) show that the proposed port development increases flood depths in several locations within the Tilbury2 site boundary. These increases are a maximum in the 1000yr 2117 flood event where changes are as high as 0.5 – 0.6m.

There is a decrease in flood depth to the north of the railway line within the Tilbury Town area in all modelled flood events. This is detailed further in Section 6.2 of this report.

The differences in flood depth seen in the field to the east of Fort Road and in the ditch and small field to the north west of Tilbury Fort are a result of the modified flow paths during the breach event resulting from the changes to ground levels and additional restrictors to flow in the form of proposed buildings and the infrastructure corridor.

The small increase in flood depth within the areas off site are balanced by the decrease in flood depth within the Tilbury Town region. A increase in flood depth in the fields surrounding the Tilbury2 site would have less of an impact on the receptor as this area is undeveloped rural land, than an increase in flood depth in the urban area of Tilbury Town. The potential increase in flood depth off site is also not consistent across the different events modelled which could suggest that they could be the result of modelling uncertainty and inaccuracies as outlined in Section 4.3.

6. Site Layout & Design Recommendations

This Section sets out the recommended measures for site layout and design as a result of the breach modelling at the Tilbury2 Site and the Infrastructure Corridor.

6.1 Tilbury2 Site

The breach model results indicate that the majority of the site itself shows either no change or a positive change to the residual risk. There are a few localised areas of the Tilbury2 site which have an increase in flood risk. These areas include part of the proposed CMAT area and part of the Ro-Ro storage. These types of uses are classed as Water Compatible which is an appropriate use for Flood Zone 3[16]. To manage the residual risk to the site itself a Flood Emergency Plan should be developed for the whole Tilbury2 site to establish a procedure to reduce the potential for future users of the Tilbury2 site being exposed to the flood hazard as a result of a potential breach on the site (see Section 8.1).

Interrogation of maximum flood level data at indicative building locations on the site has been undertaken for the 1 in 200yr event with the climate change allowance to 2117, in order to provide advice on suitable finished floor levels to allow for flood risk to be minimised (see Table 5-1).

These results indicate the minimum recommended finished floor level for the various buildings: 2.75mAOD for the CMAT Processing Buildings located to the north of the site, 3.02mAOD for the Administrative/Workshop Buildings, located to the west of the CMAT aggregates storage yard, and 3.62mAOD for the Warehouse located to the east of the Ro-Ro storage. It is recommended that an additional 300mm is added to these levels to include an allowance for freeboard. If these finished floor levels are not achieveable due to other design constraints for the site, alternative proposals for incorporating flood rsistance and resilience into the buildings design have been outlined in Section 8.1.

6.2 Infrastructure Corridor

The proposed infrastructure corridor is located on the floodplain and therefore the impact is required to be assessed.

The infrastructure corridor itself has a lowered flood risk as a result of ground levels being raised. However, the infrastructure corridor is understood to alter flow patterns on site, as it forms an obstacle to the flow of water north into Tilbury, thus reducing the volume of water passing over into Tilbury, and therefore reducing flood depths north of the infrastructure corridor. This altered flow patterns results in water backing up more to the south of the infrastructure corridor, in the field to the east of Fort Road and in localised areas of the site.

As part of the development it is proposed that a number of the ditches and the Pincocks Trough Sewer are realigned locally and culverts added under the proposed road and railway adjacent to Fort Road. An indication of how this provision may look is set out in Figure 6-1. As a minimum it is recommended that the proposed realigned culverts are the same size as the existing culverts but opportunities to upsize these should be explored and proposed, if feasible through discussions with the Environment Agency and Thurrock Council (as LLFA) pursuant to their Protective Provisions.

[16] https://www.gov.uk/guidance/flood-risk-and-coastal-change#flood-zone-and-flood-risk-tables

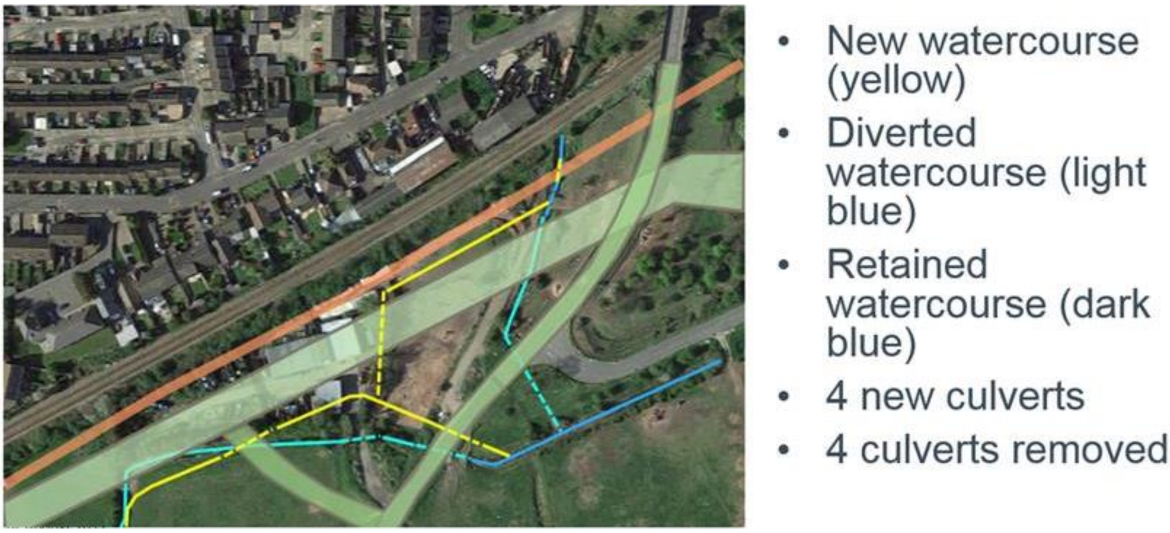

Figure 6-1: Proposed culvert alignments as part of the proposed infrastructure corridor adjacent to Fort Road Source: Atkins

Where the proposed infrastructure corridor crosses existing open channels such as the Chadwell Cross Sewer and the East Tilbury Dock Sewer, a new culvert is proposed. An indicative design for the Chadwell Cross Sewer crossing is provided in Figure 6-2. It is recommended that these proposed culverts are suitably sized so they can accommodate peak flows, including allowance for climate change in accordance with the latest EA guidance. Suitably sized culverts will avoid the introduction of a potential restriction in flow within these channels, preventing any increase in flood risk locally, and will also enable flows from a future breach event on the Tilbury2 site to propagate to surrounding areas similar to the baseline scenario.

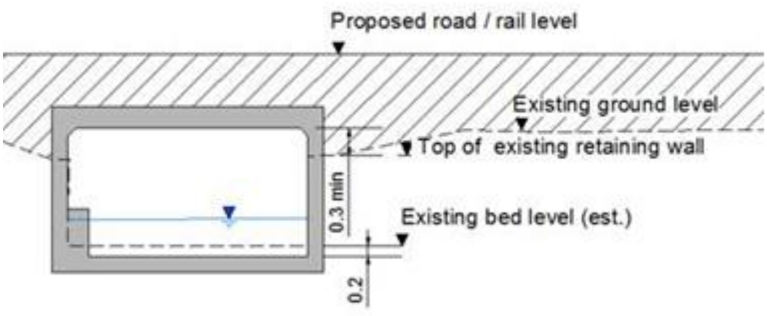

Figure 6-2: Proposed Chadwell Cross Sewer culvert design Source: Atkins

Given the design recommendations outlined above, there should be no increase in flood risk as a result of the proposed changes to the existing culverts adjacent to Fort Road and the proposed introduction of new lengths of culvert to accommodate the crossings at the Chadwell Cross Sewer and East Tilbury Dock Sewer. All proposals are subject to confirmation at detailed design, to be discussed with the Environment Agency and Thurrock Council (as LLFA) pursuant to protective provisions for their benefit in the DCO.

6.3 Works adjacent to Flood Defences

6.3.1 Proposed flood defence crossing

As part of the proposals for the site a new bridge crossing is required in order to provide access for the movement of people and vehicles across the existing flood wall to the new pontoon which is proposed as part of the site redevelopment. The proposed bridge abutment for the new roadway on the bridge will be constructed on the line of the existing flood wall (as shown in Figure 6-3 overleaf) with provision included for installation of a flood gate at a future date to accommodate the need to provide improvements (through raising or replacing) of the existing defences to maintain the current standard of protection. The proposed height of the top of the bridge abutment is 6.88mAOD, with the existing flood defence height of 6.7mAOD in this location.

These proposals have been the subject of discussions between Atkins and the EA to ensure any required future flood defence works along this section of the frontage are not likely to be compromised by the proposed crossing, and have been accepted in general terms by the EA. These discussions will continue in detailed design pursuant to the protective provisions for the EA's benefit within the DCO.

6.3.2 Proposed outfall

As part of the proposed Drainage Strategy for the site (see Section 7.2) there will be a new outfall to discharge runoff from part of the site. There should not be any impact from the proposed new outfall as it is understood that the proposed level will be close to the river bed and therefore well below the existing defences. The outfall will be fitted with two flap valves and a penstock, in line with EA requirements, to reduce potential for ingress of tidal water back through the drainage system during periods of tidal cycle when the outfall is submerged.

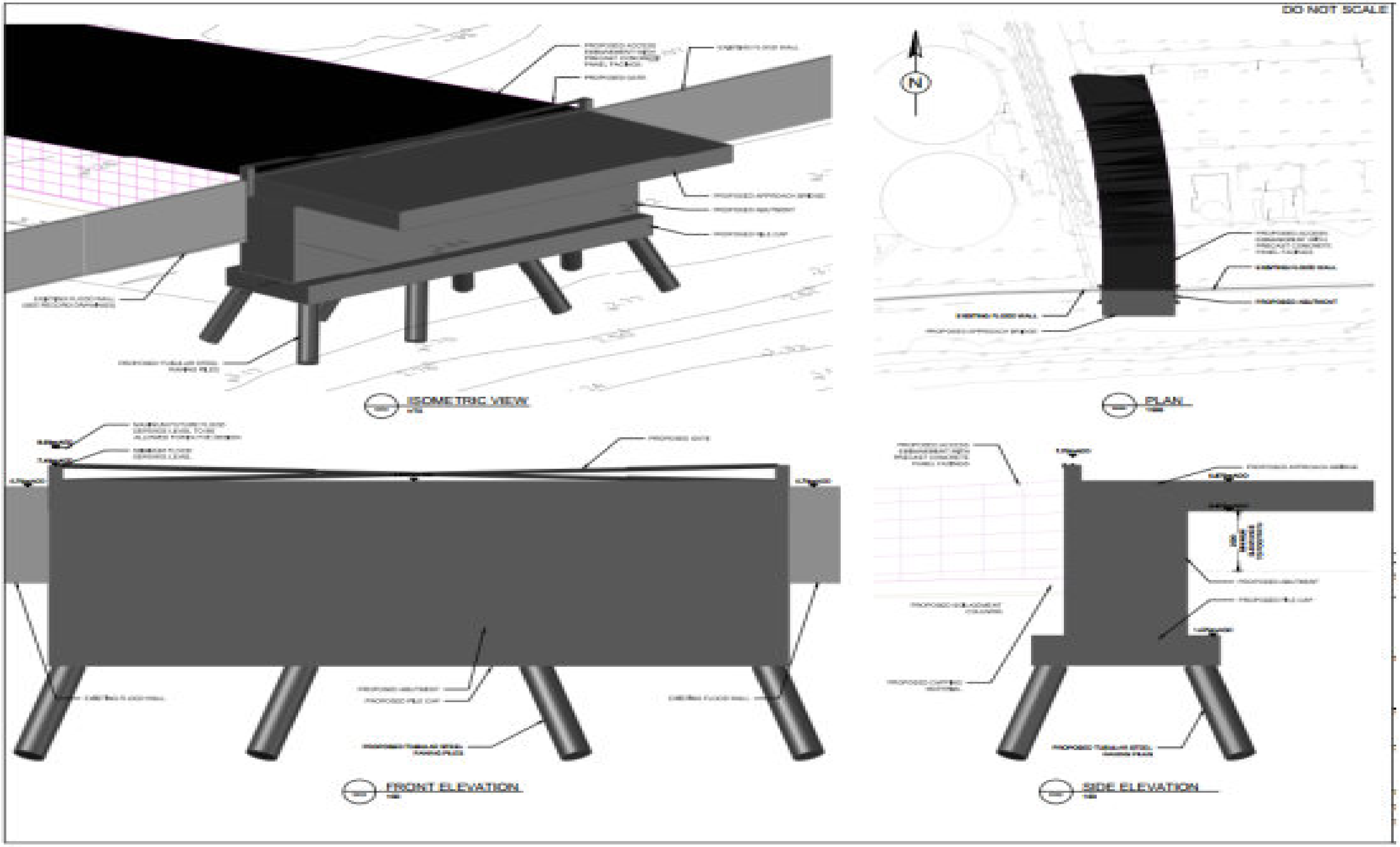

Figure 6-3: Proposed bridge interaction with existing floodwall

7. Surface Water Drainage Strategy

7.1 Existing Surface Water Drainage

As can be seen in Figure 2-6, a number of ordinary watercourses and main rivers cross through the existing site and then discharge into the River Thames.

Within the Tilbury2 Site, The Network of Unnamed Drains 1 & 2 flow into the Pincocks Trough Sewer, this then discharges into the Chadwell Cross Sewer to the south of the proposed Infrastructure Corridor. Water levels in these watercourses depend heavily on the state of tide[1] with a dependency on pumping capacity when there are tidal conditions preventing gravity outflow. Within the proposed Infrastructure Corridor are a number of drainage channels referred to as the Network of Unnamed Drains 4, and the Bill Meroy Creek which discharges into the River Thames to the west of the Tilbury 2 site.

The EA surface water flooding map[17] suggests the existing site contains localised areas (especially within the low lying areas generated by the watercourses/drains) that have a high risk of surface water flooding, although the vast majority of the site lies in an area of very low pluvial flood risk. These confined areas of high risk are as a result of large areas of impermeable surfaces generating large volumes of surface water, as well as relatively impermeable underlying soils with a high water table. This combination results in surcharging of the existing watercourses and drains. An increase in hardstanding areas as a result of the development will result in an increase of surface water flood risk and therefore mitigation measures should be undertaken, as outlined in Section 5 of the Level 2 FRA[1] and the proposed surface water drainage strategy outlined in Section 7.2 below.

As referred to in Section 3, climate change will also have a significant effect on the potential for flood risk on the site, due to increase in peak flow in watercourses and sea level rise resulting in longer periods of tide that discharge into the River Thames is ‘tide-locked’. Providing appropriate flood storage and capacity within the drainage features is imperative to account for the potential impacts of climate change upon the site and surrounding areas.

7.2 Proposed Surface Water Drainage

As stated in the Drainage Strategy (Document Reference 6.2 16.E), the new surface water drainage pipework has been designed to meet the requirements of the ‘BS EN 752:2008 – Drain and Sewer Systems Outside Buildings’. This includes the provision that there will be no pipe surcharging in a 1 in 2-year rainfall event, and no surface flooding in a 1 in 30-year rainfall event. Consideration will also be taken of a 1 in 100-year rainfall event to ensure that extreme flood flows are directed away from critical infrastructure and offsite areas.
Sustainable Urban Drainage systems will be implemented wherever possible, in accordance with national guidance[18]. Preferred SuDS, identified within the evaluation of options in development of the Drainage Strategy, included ponds, wetlands, filter strips, bio-retention systems, and detention basins.

The Drainage Strategy also states a number of requirements regarding pollution control:

- The CMAT design will be undertaken by the occupier, and pollution control must ensure that outflow to the site wide system meets acceptable water quality criteria;
- The design will make allowance for the handling of hazardous materials and to control other potential pollution sources (such as from hydrocarbons). No fuelling from the pontoon or maintenance will be undertaken on the ships that dock at the Jetty, and pollution will be controlled on the jetty by deploying spill kits;
- Petrol interceptors to be provided to concrete apron;
- Some areas discharge into unlined swales; and
- Shut off valves at RoRo outfall points.

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[17] Environment Agency (2017). What’s in Your Backyard? Accessed May 2017, http://apps.environment-agency.gov.uk/wiyby/default.aspx
‘Non-Statutory Technical Standards for Sustainable Drainage Systems’ (2015), DEFRA

7.2.1 Tilbury2 Site

The Drainage Philosophy put forward for the Tilbury2 site as part of the Drainage Strategy is that the north of the site discharges to the existing watercourse at a greenfield run-off rate, with existing ditches upsized to drain northern and western sections of the RoRo area. The southern section would discharge to the River Thames, with the existing ditch upsized to drain the road along the western boundary and a proposed attenuation tank with pumped discharge to the River Thames. This would be dependent on site levels and would gravity outfall if possible during low tides.

As seen in the Drainage Strategy, the drainage discharges to the Thames Water outfall at the Tilbury2 site entrance, with potential for oversized pipework or an attenuation tank at the entrance road and potential to utilize the existing ditches for storage. Porous paving is also proposed in the parking areas. Although not shown in the figures, all roads will also drain to gullies unless otherwise stated.

At the ancillary buildings, there is a discharge to the watercourse at Greenfield runoff rate, with porous paving to the parking areas and green roofs to buildings.

A dedicated CMAT outfall will discharge to the watercourse at Greenfield runoff rate, with an oversized swale to drain the roadway. The CMAT area is restricted to Greenfield runoff rate.

In the southern section of the Tilbury2 site, filter drains take water away from the railway corridor and the site to two new culvert lines and the existing ditch. The existing ditch along the southern section of the site will also be upsized to drain the road at the west of the catchment.

The culverts are to be laid at the shallowest possible gradient, to maximise gravity discharges at low tides. The culverts will confluence into an attenuation tank at the south of the site, behind the bank of the River Thames. The tank volume will need to be confirmed, but a larger tank as much as 15,351m^3 would mean a lower pump rate of 200l/s could be utilized. This would pump to the River Thames via the either the existing outfall or a new outfall.

7.2.2 Infrastructure Corridor

The Drainage Strategy for the Infrastructure Corridor consists of roadside swales and storage ponds – oversized to attenuate in large events, gully road drainage, diverted ditches around Fort Road Bridge, and Greenfield restricted discharge.

At the western end of the corridor, the road will flow unrestricted into the East Tilbury Dock Sewer as it does currently. Eastwards from here, the proposed road connection will flow into a new swale that runs along the southern side of the road, with ground regraded at 1:1000 along the length of the swale towards the Chadwell Cross Sewer. At the Chadwell Cross and Pincocks Trough Sewers, either storage ponds or oversized upstream swales will attenuate waters to restrict discharge to a Greenfield run-off rate. All proposals are subject to confirmation of rerouting of watercourses at detailed design, to be discussed with the Environment Agency and Thurrock Council (as LLFA) pursuant to protective provisions for their benefit in the DCO.

7.2.3 Assessment of Drainage Strategy Impact

The Thurrock Local Flood Risk Management Strategy[19] outlines the local sources of flooding for the district. This states that unnamed watercourses flow into the Main Rivers, and '*they also form an extensive network of channels that provide storage when gravity outfalls are tide locked such as within the Tilbury and Aveley Marshes.*'

The report also states that '*The responsibility for maintenance of ordinary watercourses falls to riparian owners who own land on either bank. Thurrock Council is only responsible for ordinary watercourses where land on either bank is in Council ownership or where historical agreements have been made.*' The Drainage Strategy proposes widening existing drainage channels that currently fall under this classification of 'ordinary watercourse' within the site area, so that they have sufficient attenuation during high tides. Though this will provide improved flow and attenuation, it will be the responsibility of the site owner to maintain this capacity through periodic maintenance.

[19] Thurrock Local Flood Risk Management Strategy (2015); Thurrock Council

Modelling of blockage and maintenance scenarios for siltation, vegetation, structure blockage and outfall pump failure were undertaken to assess flood damages up to a 1 in 100-year event in the Tilbury IFS[10]. The results showed that the most significant maintenance issue that affected flood risk in Tilbury was the function of the World's End Pumping Station, with up to a £3,812,000 increase in flood damages as a result of loss of function.

Despite the capacity of the watercourses not being the critical issue in this system, insufficient flow could also lead to increased flood damages and in combination with a pump station failure would result in 99 further flooded homes. There is therefore a modelled benefit in '*maintaining the channel capacity and ensuring clear flows within the system*.' Attenuating flows via oversized swales or ponds will also mean there is not an increased risk of backing up of flows at the outfall as a result of the proposals. Therefore, mitigation measures have been included in the Drainage Strategy for the site that were also recommended by the Tilbury IFS. These include:

- Green roofs
- Filter strips
- Permeable Parking/Paving
- Swales
- Detention Basin/Pond
- Increased conveyance / upsize of pipes and ditches
- Underground Storage Tanks

7.2.4 National Policy

The Environment Agency Flood Map for Planning[17] states that the site is situated within a Flood Zone 3 area that benefits from defences. This refers to a '*flood zone [that] would have a high probability of flooding without the local flood defences. These protect the area against a river flood with a 1% chance of happening each year, or a flood from the sea with a 0.5% chance of happening each year.*'

There is also however a high risk of surface water flooding in specified areas within this Site. The Policy Aims stated by the NPPF[20] for a site in Flood Risk Zone 3 include:

- '*Developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area through the layout and form of the development, and the appropriate application of sustainable drainage systems*.'
- '*Create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage*.'

By increasing the capacity of existing ditches, create swales along new road collections, and creating flood storage to restrict discharge to Greenfield rates the Drainage Strategy is meeting these Policy Aims.

7.2.5 Local Policy

The Thurrock Core Strategy[21] stated in Policy CSTP27 – Management and Reduction of Flood Risk that '*Developers will be required to incorporate sustainable drainage systems as a priority and to contribute towards flood risk management infrastructure where appropriate*.'

It was also stated in Policy PMD15 – Flood Risk Assessment that '*Developments will be expected to incorporate Sustainable Drainage Systems (SUDS) to reduce the risk of surface water flooding, both to the site in question and to the surrounding area. Where the potential for surface water flooding has been identified, site specific Flood Risk Assessments should ensure that suitable SUDS techniques are incorporated as part of the redevelopment*.'

[20] Technical Guidance to the National Planning Policy Framework (2012); Department for Communities and Local Government
[21] Thurrock Local Development Framework: Core Strategy and Policies for Management of Development (Adopted 2015); Thurrock Council

Both these Policies state the requirement for sustainable drainage systems – which refer to drainage solutions that do not simply direct surface water straight to the nearby watercourses via pipes and sewers[22].

With the incorporation of green roofs, permeable paving, attenuation via oversized ditches, swales and storage ponds/tanks the Drainage Strategy fulfils this requirement - to reduce the risk of surface water flooding both to the site and to the surrounding area, and providing a contribution to local flood risk management infrastructure as part of the development.

[22] Sustainable Drainage Systems (SuDS) © NERC (2017); British Geological Survey, Accessed at http://www.bgs.ac.uk/suds/

8. Residual Flood Risk Mitigation Measures

8.1 Flood Risk to the Development

8.1.1 Site planning and design

Based on the results of the hydraulic modelling, the majority of the site would become inundated in the event the defences were to fail at the modelled breach location. The predicted flood depth and flow velocities will vary across the site, with generally lower depth and velocities experienced in the raised areas of the site. Suitable site planning as part of the detailed design process should therefore be adhered to reduce and mitigate the residual flood risk.

Buildings should, where operationally feasible, be located in the middle of the site or towards the north of the site. This ensures distance between a potential breach location and the proposed buildings. This is the case as the majority of the buildings are located towards the centre and towards the back of the site.

Flood resistant measures could be considered, where practicable, such that floodwater is excluded from the main buildings and structures by virtue of the materials used in the construction, inclusion of floodgates on buildings housing vital operational machinery. The proposed buildings should utilise flood resistant measures to exclude flood waters.

To minimise flood recovery time flood resilience measures should be partnered with flood resistant measures, where practicable. Flood resilience measures include: the choice of construction materials used, location of electrical plant and equipment, process materials stored in such a way as to prevent contamination by saline/dirty water. This option is more relevant for the areas of the Tilbury2 site that are modelled to experience deep water, where flood resistance under such conditions could result in structural damage.

Measures to minimise the potential damage to the building from floodwater could include:

- Raise floor levels above the floodwater inundation level for the 1 in 200 year plus climate change event, with a 300mm freeboard.
- Where possible water resistant building materials e.g. concrete slab floors, well compacted hardcore, engineering bricks up to the flood level should be used to limit the potential damage from floodwater inundation up to the maximum predicted water levels tabulated in Table 5-1 plus an additional 300mm freeboard (see Improving the Flood Performance of New Buildings, flood resilient construction, Communities and Local Government, 2007 and other relevant texts).
- The hydrostatic pressure that may act on the building in the event of a breach of the flood defences should be taken into consideration in the final designs depending on the proposed proactive/reactive mitigation options.
- Any lifts leading to upper floors should be deactivated in times of a flood to prevent accidents and the malfunction of this mechanism. Therefore internal stair access should be included for all floors.

The Department of Communities and Local Government (DCLG) document ‘Improving the flood performance of new buildings’ (May 2007) should be taken into account in detailed design where practicable. This document recommends that ‘for flood depths greater than 0.6m, it is likely that structural damage could occur in traditional masonry construction due to excessive water pressures (differential head between outside and inside of the property); this can be worsened by impact from water-borne debris. In these circumstances, the strategy should be to allow water into the building, i.e. the water entry strategy. This should apply irrespective of the flood duration or frequency. The key consideration here is the use of materials that retain their structural integrity, but allow passage of water. Materials should also have good drying and cleaning properties. Use of sacrificial materials can be considered as internal or external finishes; e.g. gypsum plasterboard’.

8.1.2 Flood warning and evacuation

Given the nature of the activities on the proposed port site, it has been assumed that they are not safety critical and therefore would not be required to remain operational during a potential future breach scenario. Therefore, in the event of a breach on the site, or an off-site breach which could also impact on the site, it is assumed that all operational staff would be able to evacuate the site.

To manage the residual risk to the site itself a Flood Emergency Plan should be developed for the whole site to establish a procedure to reduce the potential for future users of the site being exposed to the flood hazard as a result of a potential breach on the site.

The EA issue flood warnings to alert to the potential risk of flooding and these are communicated through the Floodline Service and displayed on their website. This website is available 24 hours a day and Floodline (0345 988 1188) provides recorded flood warning information 24 hours a day. Recorded flood warning information can also be automatically sent out to all phones, including mobile phones. It is recommended that PoTLL subscribes to the Environment Agency's Floodline service as part of the Flood Emergency Plan.

It is possible that a breach event could occur without suitable prior warning/alert for all staff to safely evacuate from the site and a suitable refuge area should be available in the upper levels of the ancillary buildings in the event that a full evacuation cannot take place. The duration of refuge would be linked to the repair time for the breach and is anticipated as less than 36 hours.

Evacuation routes should be outlined in a Flood Emergency Plan and it is advised that these follow the proposed access road towards Fort Road given that the new infrastructure corridor is raised above the rest of the site levels and would therefore provide the safest access and egress point from the Tilbury2 site.

9. Conclusions

This Level 3 FRA demonstrates that the site is at an acceptable level of flood risk given the water compatible nature of the development, and there is not an unacceptable increase in flood risk to the surrounding areas, subject to the implementation of the flood mitigation measures set out in the Level 2 FRA and the Environment Agency Guidance, Site Layout & Design Recommendations, Drainage Strategy and Residual Flood Risk Mitigation Measures set out in this report.

This assessment has focused on the findings of the Level 2 FRA, along with the impact of the proposed Drainage Strategy, and the potential for breaching of the existing flood defences along the site boundary with the River Thames. The following mitigation has been advised to ensure that the proposed development is at an acceptable level of flood risk:

- Implementation of the mitigation measures provided in the Drainage Strategy and summarised in Section 7;
- Incorporation of suitable flood resistance and resilience measures into the proposed buildings; and
- A Flood Emergency Plan is developed for the whole site to establish a procedure to reduce the potential for future users of the site being exposed to the flood hazard as a result of a potential breach on the site, including the provision of a safe refuge area within the upper level of the buildings.

The majority of the areas off site, including the town of Tilbury and the existing Tilbury flood storage areas, experience either a positive or neutral change. The slight increase in flood depth to the field to the west of the development site is not considered significant. The localised nature of the increase could mean it is the result of model inaccuracies. Mitigation measures are not considered necessary for any off site areas.

In compliance with the requirements of the NPPF and subject to the mitigation measures proposed, the development can proceed without being subject to significant flood risk.

Appendix A – Environment Agency Consultation

Mr Pete Ward
Port of Tilbury
Leslie Ford House
Tilbury
Essex
RM18 7EH
T2consultation@potll.com

Our ref: AE/2017/121765/01-L01
Your ref: Tilbury2

Date: 28 July 2017

Dear Mr Ward

EXPANSION OF THE PORT OF TILBURY - "TILBURY2".
STATUTORY CONSULTATION ON A PROPOSED APPLICATION FOR DEVELOPMENT CONSENT.
SECTION 42 PLANNING ACT 2008.

TILBURY 2, FORMER POWER STATION SITE, FORT ROAD, TILBURY, ESSEX, RM18 7NR.

Thank you for your consultation received on 19 June 2017. We have reviewed the Preliminary Environmental Information Report (PEIR), Vol 1. June 2017, its technical appendices and non-technical summary and have some environmental concerns regarding this proposal. Further to our comments made at the EIA Scoping stage, reference: AE/2017/121510/01-L01, 25 April 2017 we have the following comments to make.

Safeguarding For a Future Thames Barrier

We have previously highlighted the Thames Estuary 2100 Plan (TE2100 Plan) in our EIA scoping response and noted we were initially pleased to see that acknowledgement was given to the Plan and recognition that the Plan may require potential future space for construction of and improvements to flood risk management infrastructure – namely the construction of a future Thames Barrier at this site. We would therefore now expect to see consideration to how the TE2100 Plan requirements can be taken into account as part of this proposal.

We are, however, very concerned that we have not seen any reference to this in the current proposal. We note that neither *Port of Tilbury Terminal 2 Development Level 2 Flood Risk Assessment Port of Tilbury London Limited (May 2017)* nor Drawing Number 5153187-ATK-Z3-XX-SK-RL-1002 *Roro Container & Trailer Yard General Arrangement (12 June 2017)* make reference to safeguarding land for a future flood barrier site, as referenced in our prior correspondence dated 23 March 2017

(Appendix D of *Port of Tilbury Terminal 2 Development Level 2 Flood Risk Assessment Port of Tilbury London Limited (May 2017)*.

We retain our position that we expect to see consideration given to how the TE2100 Plan requirements can be taken into account as part of this proposal. As this is a complex issue, we strongly recommend we have discussions around design and set out the likely significant effects of Tilbury 2 on the TE2100 Plan and the options to mitigate this, prior to a Development Consent Order (DCO) application being submitted.

Given the proposed nature of the application (low density permanent structures on the landward side of the defence), we would welcome further discussions on how to incorporate space for any potential future barrier within the proposals and look at opportunities for interim land uses within this area, as we are unlikely to have any construction or operational need over land along this frontage for over 40 years.

If a DCO application were to be submitted without a consideration of how the proposal future TE2100 Plan requirements could be accommodated, we are likely to raise an objection. We would be pleased to provide any further information to help facilitate our aspirations under the TE2100 Plan.

Flood Risk Mitigation Measures

Appendix 16.A contains a Flood Risk Assessment by Atkins, referenced 5156260 and dated May 2017. This outlines the sources of flood risk to the proposed development but does not yet provide details of the levels of flood risk or how the potential impacts on the development will be managed.

Section 5.1 outlines that a Level 3 FRA will be undertaken in the future which may include a breach model for the development site, and will consider specific flood risk management measures including safe access and egress, finished floor levels and flow paths and flood compensation.

The Level 3 FRA should include a site specific breach assessment if the mitigation measures for the development want to work to site-specific accurate breach flood depths. If a breach is not undertaken then the FRA would need to work to a worst-case comparison of the EA’s modelled River Thames flood levels with the site levels to determine the potential breach flood depths on the site. The FRA would not be able to use the breach assessment in the SFRA from breach location C007 as this is considered too far east from the development site, and so is not site specific or precautionary enough.

In terms of the management measures proposed, it is your responsibility to decide what would be an acceptable method to ensure the safety of the proposed port development. The National Policy Statement for Ports (NPSP) states that *‘Applicants will be in the best position to make a commercial judgement on the required appropriate adaptation measures to reduce the risk from long-term climate change as it affects their own facilities’.*

Climate Change

The NPSP also provides guidance on the relevant climate change allowances that should be taken into account. Paragraph 4.13.7 states that the applicants should apply, as a minimum, the 10%, 50% and 90% estimate ranges of the emissions scenario that the Independent Committee on Climate Change suggests that the world is most closely following, and consider the results alongside relevant research which is based on the climate change projections such as EA flood maps. We recommend that the medium and high emissions scenarios are assessed. The FRA should assess a range of risk to understand potential future flood risk impacts and to justify the proposed approach for managing and responding to future flood risk implications through a combination of built-in resilience and managed adaptation to climate change. An important principle to work to is avoiding a ‘cliff edge’ effect, where a small increase in flood risk will result in a significant increase in the flooding hazard.

Paragraph 4.13.8 of the NPSP also states that where port infrastructure has safety-critical elements, such as the storage of gas or petro-chemicals, the applicant should apply the high emissions scenario (high impact, low likelihood) to those elements critical to the safe operation of the port infrastructure. As an indicator, where an element of the design must remain operational during a high impact low-likelihood scenario, to ensure that occupants/staff and the environment remain safe from the potential impacts (e.g. flooding), then the particular element should be considered safety critical.

These climate change allowances can be found on the UK climate change projections website which provides allowances for the 10th, 50th and 90th percentiles for the medium and high emissions scenario. The climate change allowances should be compared to the NPPF climate change allowances for sea level rise, which is what the EA’s River Thames modelled flood levels and the SFRA outlines use. If it is found that the NPPF sea level rises are higher than these alternative emissions scenarios climate change allowances, then to be precautionary it would be acceptable if the FRA uses the EA modelled flood levels if this is considered preferable or easier. These EA River Thames flood levels can be obtained by emailing enquiries_eastanglia@environment-agency.gov.uk.

4.13.11 also states that the decision maker should satisfy itself that there are not critical features of the design of new ports infrastructure which may be seriously affected by more radical changes to the climate by referring to the maximum credible scenarios from the Intergovernmental Panel on Climate Change (this is considered to be the UKCP09 H scenario, which is called the Upper End scenario in the following guidance Adapting to climate change: Advice for Flood and Coastal Erosion risk Management Authorities). Therefore this climate change scenario should be modelled and the risk to any critical port infrastructure assessed, along with details of how the risk will be managed. The developer should define those elements of the development that are ‘features of the design critical to its operation/critical features of the design that may be more seriously affected by climate change’. But as an indicator, where an element of the design must remain operational during the credible maximum scenario, to ensure that the facility can operate and the occupants and staff and the environment remain safe from the potential impacts (e.g. flooding), then the particular element should be considered ‘features of the design critical to its operation/critical features of the design that may be more seriously affected by climate change’.

Flood Defences

In reviewing the plans, the supporting wall of East Dock Sewer in the section where the new Approach Corridor joins the Dock Road is in very poor condition and will need to be replaced to allow the construction of the new road connections. You must ensure that the outflows from the Tilbury Flood Storage Area are not interrupted and that any potential interruption to these flows must be subject to review by a Reservoir Construction Engineer and agreed with us.

The condition grade of the defences in front of the Tilbury 2 site is poor, not good as stated within the flood risk assessment. These defences are presently being assessed by the TEAM2100 programme and plans developed for repairs.

We have not seen any mention made within the consultation of provision for future raising of the tidal defences at the site. We have previously informed you (meeting 10 Feb and letter 25 April 2017) that a maximum future crest level of 8.0mAOD will need to be considered for this site. Under the TE2100 Plan it is expected that the defences at this location will require raising to a level of 7.4m AOD by 2070 but may require raising to 8mAOD. This is the proposed crest level of the defences and does not include allowance for settlement or construction. Provision must be made for this within the design of the Linkspan Bridge over the tidal defences, and we suggested that a minimum clearance of 1m over the 2070 level of 8m AOD is provided. This will allow for both future raising of tidal defences to the 2070 level, as well as potential future raising requirements owing to climate change.

The reason for this height is that there are two future options for defence raising under the TE2100 strategy post-2050: Option 1.4 (the existing Thames Barrier site is retained) and Option 3.2 (a new Thames Barrier site is secured further downstream). Option 3.2 has 4 high-level potential sites, one of which is at Tilbury. Right now we cannot say for certain which site will be required, if at all, but we cannot rule out Tilbury at this point in time.

The levels referenced above are based on a future flood barrier site at Long Reach, Purfleet, therefore these levels will need to be revised and reissued if the preferred site is determined to be Tilbury. It is strongly advised that you prepare for the “worst-case” from the outset as this would be beneficial for future adaptation of the site’s tidal defences.

Flood Defences - Contributions

As identified in section 4.4 (pg. 19) of *Port of Tilbury Terminal 2 Development Level 2 Flood Risk Assessment Port of Tilbury London Limited (May 2017)*, “the site benefits from the Thames Tidal Defences”, including those up and downstream from the site’s primary riverside frontage. Any financial investment in flood defences within Thurrock Council’s area throughout the TE2100 Plan will be subject to Defra’s flood and coastal resilience partnership funding policy statement. Under these terms financial contributions will be required from partners (including Thurrock Council, Environment Agency, landowners and other key stakeholders) to attract the maximum amount of Flood Defence Grant in Aid funding based upon all economic benefits from the investment and numbers of households moved to a lower flood risk category. This will enable the necessary flood risk management infrastructure required to protect the proposed development over its lifetime, as outlined in our correspondence dated 21 September 2016 (Appendix D of *Port of Tilbury Terminal 2 Development Level 2 Flood Risk Assessment Port of Tilbury London Limited (May 2017)*.

Works to Main Rivers

Section 5.3 of the FRA states that the infrastructure corridor will pass over three main rivers which could cause a constriction of flow and increase flood risk. Therefore the applicant is giving careful thought to the design of the road crossings, such as using open span bridges, and avoiding culverting unless absolutely necessary. We welcome this amendment to the plans. The river crossings would require a Flood Risk Activity Permit, under the Environmental Permitting Regulations.

We would welcome discussions to allow the alignment of Pincocks Trough Sewer between the Tilbury Loop mainline and the southern edge of the approach corridor to be adapted to improve conveyance of water and reduce the number of culverts that require construction.

Terrestrial Biodiversity

The positions laid out in the PEIR regarding the terrestrial ecology of the area remain appropriate, yet there appears to have been little progress made in the PEIR Report in terms of demonstrating how you will achieve these requirements.

The PEIR Report serves as a comprehensive (but as yet incomplete) record of the ecological and biodiversity resources supported within the proposed development Site of Tilbury2. A broad range of surveys have been completed, and as a result a number of locally and nationally-important habitats and species have been identified giving a good baseline resource for assessing impacts and for informing necessary mitigation measures.

However, the PEIR Report significantly lacks detail regarding appropriate mitigation measures to address the very real losses of ecological features that will follow from this development. Appendix 10A (Ecological Survey and Mitigation Plan), Chapter 9.0. only assesses the effects of the demolition of existing infrastructure, stating that; "Compensation, enhancement and ecological management for habitat lost as a result of the site's redevelopment are not considered here, but will be considered as future redevelopment plans are drawn up". However, this aspect (the site redevelopment) is the most important element, as it effectively covers the wholesale habitat destruction as part of the development of these works. Therefore, there is not sufficient evidence to support the most important mitigation elements required of this proposal.

Habitat and Species Losses

As is clear in both the Non-Technical Summary (NTS) (1.58.) and throughout the PEIR Report, there is "expected to be a net-negative effect on ecology". This is not an acceptable position, and we expect that any development, at the very least, should have an aggregated no-net-loss to biodiversity in the area under consideration for development.

Similarly, in the NTS section 1.59 there is the expectation that the "magnitude and significance of adverse effects will gradually decrease as on- and off-site mitigation measures mature", and that an "optimistic scenario" will be close to a net neutral effect. Again, this is a singularly underwhelming target. A no-net-loss scenario should be the bare minimum against which the proposal is measured, and where possible the objective should be to enhance biodiversity as part of the project delivery.

Using the premise of no-net-loss as a baseline is in accordance with the NPS for ports, national and local strategies and objectives. Table 10.2 outlines the Thurrock Core Strategy (2015) policies, including how development is encouraged to include measures to contribute positively to overall biodiversity in the borough, and to enhance where possible to mitigate for past losses. PMD7 of this same report outline their requirements for mitigation and compensation. This is in line with the England Biodiversity Strategy 2020.

This requirement is made more important when referring to sections 10.25, 10.26, and Figure 10.1 of the PEIR Report. This details how there are wider aspirations and plans for the expansion of existing Local Wildlife Sites (LoWS) and deployment of new LoWS within the Site and the adjacent land. Effectively, therefore, this development as it stands will not only remove existing sites (and the species and habitats contained therein) but also it will affect the plans to increase the LoWS network in the local area. Therefore, the calculation of compensation sites for mitigation of these losses should take into account the total potential habitat lost.

Table 10.45 outlines the high magnitude and high impact on LoWS of national importance, on priority species, habitats, rare/scarce plants and inverts. It states that "in time, compensation may ameliorate or offset negative effects". This is, once again, an inadequate objective, and mitigation measures must be put in place so that there is a degree of confidence that negative effects will not only be offset, but potential gains are realised.

Table 10.19 gives a good summary of the scoping comments received in relation to terrestrial ecology. There is a need to contribute to the overall biodiversity of the borough (as detailed in NPS Ports (2012) and Core Strategy CSTP19, seen in Table 9.1). However, this development is, at present, going to have a net-negative effect in terms of biodiversity. The report identifies the requirements in regards to Schedule 2 species of the Habitats Directive (10.5-8), species detailed in the Wildlife and Countryside Act 1981 Schedules 1,5,8, as well as habitats of importance as detailed in Natural Environment and Rural Communities Act 2006. It is also identified throughout the PEIR Report that this development will have an impact on species and habitats in all of these groups.

Section 10.33 indicated the presence of significant numbers of species including water voles. Water voles (s5 Wildlife and Countryside Act 1981 and s42 NERC Act [2006]) were so prevalent and field sign density so high, that a relative index needed to be employed to map them on Site (Figs. 10.8.a-b). Caution is required in the further use of this, as it should be remembered that this is a relative index, and even areas that are deemed of lower importance are still, overall, important areas of habitat for Water voles more widely. Section 10.104 outlines the extensive survey conducted in 2007, noting a suite of scarce and rare invertebrate species, mostly found on the Lytag LoWS (scheduled under development to be completely lost). Table 10.25 gives a very long list of notable plant species, many of which are nationally rare.

All these resources are, as it stands, predicted to be completely lost from the site, and therefore require compensatory measures.

Compensation for Losses to Habitats and Supported Species

Compensation for the loss of habitats (e.g. coastal floodplain grazing marsh, Brownfield Wild land and reedbed, as detailed in local Thurrock BAP [2007-12]) is required to maintain NPPF compliance. This should be at a ratio of at least 1:1, with a preference for the creation of more habitat that is of at least equal quality to that being lost.

The main issues arises from the projected complete loss of LoWS within site – Table 10.24 details the notifying features of these sites, and 10.153-64 give species lists and data for individual sites. Section 10.278 and 10.284 indicate the "complete removal of existing habitat".

There seems to be some arguments in sections 10.274-6 that the quality of the existing habitats is deteriorating, and that the dominant issue is due to habitat succession as a result of low or no management. This seems to infer that therefore, it is acceptable to lose these habitats. This is, however, not acceptable. The point is raised in PEIR 10.276 that the loss of these sites will be balanced by the development of post-industrial habitat. However, it is hard to say how effective this will be without supplying a management plan for creating this habitat on site. Furthermore, the developers should not rely on this recreation simply 'happening' – if it does, then this should be considered an additional gain but not count towards mitigation. There must be a plan to compensate for these losses. Concrete and complete plans for habitat creation are needed, and it is essential that these are accompanied by ongoing future monitoring and management to maintain their viability and health.

PEIR section10.279 (On site compensation) discusses the use of an existing feature (Tilbury Pond Wildlife Site) for on-site mitigation. This would be acceptable, however the capacity to carry species needs to be fully assessed. Similarly, the intention to use adjacent green belt land also should be assessed for carrying capacity, and checked for suitability of quality/appropriateness.

Section 10.280 suggests that Water voles can be mitigated for on-site, and section

10.279 states that receptor sites for Water voles will be created in “habitat created along infrastructure corridor”. Assessments need to be made that enough habitat is created to receive the number of water voles translocated, and that the habitat is of a high quality.

Off-site ecological compensation land is discussed in section 4.25, but is yet to be identified. It is imperative to get this right. PEIR section 10.280 identifies the off-site needs for reptiles. It is important to note that if suitable habitat is not found locally, then this will need to be created to provide adequate receptor sites. Similarly for invertebrates, off-site receptors should not be limited to “kick-start recreation” (PEIR s10.281), but should provide suitable habitat that promotes the long-term conservation of locally and nationally-important species. Off-site mitigation plans needs detailing, and must be of at the very least a ratio of 1:1 to the area that is being lost, and furthermore should be of a suitable quality. Section 10.292 talks about the residual impacts of mitigation being “net-negative” due to lack of mature habitats for compensation. The imperative therefore is to begin creating suitable habitat in advance so that it has a chance to establish and develop ahead of the losses expected on Site.

Translocations of species must be appropriate, it is not sufficient to simply move species to areas with other individuals present, and often this is actually not advisable. You should identify new areas for translocated species, or failing that should create suitable habitat in the wider landscape (of a good quality). As noted in section 10.289, full details of translocation methods to reduce impact are required.

Sustainable Drainage Systems (SuDS)

Table 1.1 of the NTS discusses “structural landscaping, including SuDS features”, but no details are presented in the PEIR Report relating to terrestrial ecology and SuDS. This is important to get right, especially if it is envisaged to provide habitat as a compensatory measure. In section 5.39, discussing the treatment of surface water, the ambition should be to use SuDS techniques, not collection drains. SuDS features should follow national guidelines.
(see; http://www.susdrain.org/resources/SuDS_Manual.html).

PEIR Section 10.286 mentions SuDS being created as part of the infrastructure corridor. Again, more detail is required, especially if this is supposed to also be delivering habitat. There are significant opportunities to use green roofs as part of the development, and these and other features should be used as widely as possible. For example, creating wetlands, reedbeds, etc. are effectively SuDS strategies. These techniques are identified in Table 9.1, taken from CSTP18 laid out in NPS Ports (2012), and should be deployed where appropriate.

Water Framework Directive (WFD) Compliance / Assessment

Previous guidance sent in response to the Scoping Report (25 April 2017) should be adhered to and followed as best practice. Culverting should be avoided where possible, and only used when there is no reasonable alternative. Implementing clear-span bridges is an advisable alternative to avoid any detrimental effects on water bodies, and to avoid unnecessary loss of habitat on a scheme that already proposes a significant impact on biodiversity. Given that both Pincocks Trough (M1) and Chadwell Cross Sewer (M2) currently provide suitable habitat for aquatic macrophytes and macroinvertebrates, culverting would likely have a predictably negative environmental impact and therefore is not an appropriate course of action.

Sections 5.31, 5.83, and 5.86 mention the crossing of water courses, stating that “where necessary, these water courses will be diverted”. The clear-spanning and/or diversion of Pincocks Trough is not mentioned in the PEIR chapter on terrestrial ecology, and so it is hard to gauge the effects of this measure. Diverting watercourses should be a last resort, and other options should be fully explored, including appropriate evidence. If necessary, new habitat is required to be of as good a quality as that to be lost, and enhanced where possible. More details are therefore required to ensure that development does not have a net-negative ecological effect and we would be happy to discuss options with you.

The WFD Assessment (Appendix 16.B) states that “the loss of an extensive network of drainage ditches and ponds is likely to result in a significant reduction in aquatic habitat available for biological quality elements, as well as other ecological receptors such as mammals and plants” (1.63). Also, as it states in the same paragraph, “the loss of seven watercourses and two ponds is considered to be significant at the local scale and impacts may potentially also be realised at the regional scale.” Therefore, this recourse of aquatic ecosystems and wetland habitats needs to be fully mitigated for, and recreated off-site if there are no on-site compensation opportunities. These must be of at least equal condition to those watercourses being lost, and should be of a nature that there is free fish and eel passage through the ditch network, as per (amongst others) the Eel Regulations (2009).

Invasive Non-Native Species (INNS)

PEIR section 10.214 details the existing INNS identified on site, including Japanese Rose and Wall cotoneaster. Further survey work is required to fully identify the presence and distribution of INNS species on site, especially if material is to leave the site or be significantly moved around the site. This should follow standard guidance measures for identifying, reporting, and managing INNS.

Saltmarsh

Section 7.92 state that *The Thames Estuary has an extensive area of saltmarsh on both the north and south shores. Large areas of maritime saltmarsh are present along the foreshore of the Thames Estuary in the vicinity of Tilbury, becoming more extensive to the east of the port.*’ This statement is inaccurate.

The Thames Estuary has seen vast losses of saltmarsh throughout history. Today only tiny fragments remain. Therefore we would not regard the Thames as having extensive saltmarsh, hence why further losses of this habitat type is significant.

The report has mentioned the likelihood of damage or loss of inter-tidal habitats during construction and operation. Given the nature of the development this would seem probable, due to shading, piling, dredging and operation of the port. However no mention has been made of where and how mitigation will take place, which would be a requirement.

As mentioned it is likely that the flood defence at this site will need raising or be able to accommodate raising and therefore it would seem sensible to incorporate mitigation at the site by redesigning and setting back defences to mitigate for damage and disturbance to the inter-tidal impacts.

By utilising 'Estuary Edges' guidance* and considering all the wider ecological impacts of the scheme on the foreshore and Thames river corridor a suitable design for enhancement along this frontage as part of the development may be possible. If it is not possible to accommodate all mitigation at this site, some may be possible at an alternative location. However damage to inter-tidal habitat on the Thames must be mitigated for.

*Note 'Estuary Edges' guidance -
http://www.ecrr.org/Portals/27/Publications/Estuary%20Edges%20-%20design%20advice.pdf

Water Quality

We have had some detailed discussion with you already on water quality. With no further details our comments are as previously outlined in earlier pre-application consultations.

The marine parts of the work include dredging and minor construction that would be subject to consultation with the Marine Management Organisation and the Port of London Authority. We would expect to see full consideration of compliance with the Water Framework Directive, by provision within the EIA of a standalone WFD assessment. The most recent revised guidance for undertaking such an assessment is available at:
https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters and is known as “Clearing the Waters for All” (which supercedes the earlier “Clearing the Waters” guidance which is now withdrawn).

We understand that currently there are proposals for a considerable dredge in the order of 100 000 cubic metres, and that this is proposed to be undertaken using a removal dredge technique, with disposal of the dredged material as appropriate to the chemical nature of the sediment, which has yet to be tested for the standard CEFAS suite chemicals appropriate to MMO, dredge licence applications.

Our initial view, though we reserve judgement until the WFD assessment is provided, is that a removal dredge can be managed to comply with WFD for water quality, though the timing of the dredge may influence the sensitivity somewhat. A removal dredge will tend not to mobilise much material into the water column and so timing of dredge is rather less important than for dispersive dredges where more material may enter the watercolumn. We note that whilst removal may be more protective of water quality (particularly should sediments show signs of significant levels of contamination and the marine team would be happy to consent to removal methods being used as it poses lower potential risks for water column chemistry), if sediments are less contaminated there may still be potential to use more dispersive dredge methods such as the much cheaper water injection techniques commonly used in the mud reaches, whilst probably remaining WFD compliant, though we would want to see the justifications within the WFD assessment.

We would not seek to constrain the operator to a specific dredge technique or combination of techniques until they have assessed the risks of any other options they wish to consider.

As Tilbury is right on the boundary of where we and the Port of London generally prohibit dispersive dredge techniques during the months of June-August inclusive (specifically to protect the water column (and fish) at a time when dissolved oxygen may be low and subject to further crashes if storm sewage enters upriver) there would need to be greater attention to when (what time of year and suitable tidal states) the dredge occurred should dispersive dredge techniques be chosen over removal techniques.

Until we can be certain the sediments to be removed are not unacceptably contaminated, a presumption of a removal dredge with appropriate offsite disposal (either to land requiring EA waste permits, or to a licensed marine disposal site; whichever is most appropriate for the chemical nature of the material) would be the safer option in terms of gaining WFD approval from us. But we wish to emphasize that at this point we have not yet ruled out the possibility that cheaper, dispersive dredge options with appropriate mitigation and timing, might also be demonstrated to be WFD compliant, however we'd need a more detailed analysis of sediment quality, currents, dilution potential, and the ultimate fate of the sediment (with respect to pathways for material deposition on the protected areas) before we could be convinced that such a large dredge could be done by dispersive means and still remain WFD compliant.

We welcome review of the completed WFD assessment justifying why the dredge and any in-river construction works will not compromise attainment of WFD objectives for the Thames Middle, waterbody or any adjoining linked waterbodies (Thames Lower, Thames Upper- though transfer of effects to Thames Upper can probably be discounted due to distance). We would prefer the WFD assessment to take the form of a standalone document, though this could be a standalone chapter of the EIA.

Land Contamination

We have reviewed section 15 Hydrogeology and Ground Conditions of the Preliminary Environmental Information Report of June 2017 (Volume 1). Overall we agree with the content of this section of the report.

A full preliminary risk assessment should include the sources of evidence informing the report. For example, historic maps, operational plans, building blueprints and pollution incidents. This should be included in future works to provide evidence for risk based conclusions.

We note that section 15.24 has an error in the sentence “Error! Reference source not found”. With section 15.120 having a similar error and we recommend these are corrected for completeness. (A search of the entire document highlighted this error in section 16.41, 16.78, 16.85, 16.110, 18.17, 18.69, 18.111 and Table 18.23).

In Table 15.8, historic tipping was noted in the northern part of the new port terminal area. This will require investigation and does not appear to be mentioned further in the report.

We look forward to reviewing the ground investigation and associated risk assessment in due course prior to submission.

Waste Water

We wish to make you aware that there are concerns with the capacity of Tilbury Water Recycling Centre (WRC). Our calculations indicate that, at present, Tilbury WRC is operating at about 96% capacity. As Tilbury is a large WR Centre, this does leave a sufficient volumetric capacity available and this operation on its own is unlikely to cause problems. However, with the large amounts of development activity going on at Tilbury at present, we would encourage you to engage closely with Anglian Water on the capacity remaining. If available capacity is used up before this development comes on line, new capacity can take several years to fund and generate, and development may not be able to commence until this is done.

Tilbury Power Station Environmental Permit

Our comments made previously remain in place regarding the surrender of the Tilbury Power Station Environmental Permit.

Part of the development falls within the boundary of the Tilbury Power Station environmental permit. The permit remains in force until it has been surrendered by the operator, RWE Generation UK plc. The developer should be aware that there is a formal process to fully or partially surrender this permit. Supporting information will need to be provided as part of the surrender application. We recommended that the developer and permit holder discuss this to ensure permit surrender links in with development plans. Further information can be found at:
https://www.gov.uk/guidance/change-transfer-or-cancel-your-environmental-permit

Regulatory guidance note RGN9- Surrender:
https://www.gov.uk/government/publications/rgn-9-surrender

Site condition report:
https://www.gov.uk/government/publications/environmental-permitting-h5-site-condition-report

Environmental Permitting Regulations 2016
Paragraph 2.9 refers to The Environmental Permitting Regulations 2010. A new, consolidated version of these regulations came into force on 1 January 2017. Reference should be made to The Environmental Permitting (England and Wales) Regulations 2016, rather than the 2010 regulations.

http://www.legislation.gov.uk/uksi/2016/1154/made

Sustainability

Climate change is one of the biggest threats to the economy, environment and society. New development should therefore be designed with a view to improving resilience and adapting to the effects of climate change, particularly with regards to already stretched environmental resources and infrastructure such as water supply and treatment, water quality and waste disposal facilities. We also need to limit the contribution of new development to climate change and minimise the consumption of natural resources.

Opportunities should therefore be taken to contribute to tackling these problems. In particular we recommend the following issues are considered:

- Overall sustainability: a pre-assessment under the appropriate Code/BREEAM standard should be submitted with the application. We recommend that design Stage and Post-Construction certificates (issued by the Building Research Establishment or equivalent authorising body) are sought through planning conditions.
- Resource efficiency: a reduction in the use of resources (including water, energy, waste and materials) should be encouraged to a level which is sustainable in the long term. As well as helping the environment, Defra have advised that making simple changes resulting in the more efficient use of resources could save UK businesses around £23bn per year.
- Net gains for nature: opportunities should be taken to ensure the development is conserving and enhancing habitats to improve the biodiversity value of the immediate and surrounding area.
- Sustainable energy use: the development should be designed to minimise energy demand and have decentralised and renewable energy technologies (as appropriate) incorporated, while ensuring that adverse impacts are satisfactorily addressed.

These measures are in line with the 'criteria for good design for port infrastructure' of the NPS and objectives of the NPPF, and are supported by Thurrock's Core Strategy and Development Management Policies DPD which requires these measures to be incorporated into new development. In particular policy Core Strategy CSTP25 supports climate change adaptation being considered early in a development proposal and advises that developers must consider the effect of climate change on their development. Policy PMD12 sets out the Code for BREEAM rating the development should reach as well as requiring the application to be supported by an Energy and Water Statement. Other relevant policies include CSTP18 (green infrastructure); CSTP19 (biodiversity); CSTP26 (renewable and low carbon energy generation), CSTP29 (waste), PMD13 (Decentralised, renewable and low carbon energy generation) and PMD14 (carbon neutral development).

Reference should also be made to the Climate Change section of the NPS for ports and guidance from the National Planning Practice Guidance, in particular: "Why is it important for planning to consider climate change?" and "Where can I find out more about climate change mitigation and adaptation?"
http://planningguidance.planningportal.gov.uk/blog/guidance/

We suggest the following points are addressed to limit the developments impact on the environment and ensure it is resilient to future climate change.

Water Efficiency

Over the next 20 years demand for water is set to increase substantially yet there is likely to be less water available due to a drier climate and tighter controls on abstraction. To address this new development should be designed to be as water efficient as possible. This will not only reduce water consumption but also reduce energy bills.

The payback following investment in water saving devices is often higher in commercial units than residential due to the higher frequency of use. Simple measures such as urinal controls or waterless urinals, efficient flush toilets and automatic or sensor taps are therefore very effective. Likewise investment in water recycling schemes is also more viable in business settings. Further advice is available at:
http://www.anglianwater.co.uk/business/business-services

We also recommend that developers consider using equipment on the Water and Energy Technology List, a directory of products which have met an approved water and energy efficiency eligibility criteria.

Any submitted scheme should include detailed information (capacities, consumption rates, etc) on proposed water saving measures. Where rainwater recycling or greywater recycling is proposed, this should be indicated on site plans. Applicants are also advised to refer to the following for further guidance:
http://www.water-efficient-buildings.org.uk and
http://www.savewatersavemoney.co.uk

Waste and Resource Management

Waste should no longer be regarded as a problem to be disposed of, but a resource in its own right. The management of waste should be considered early in the design phase and all developments encouraged to follow the Construction Waste Hierarchy of prevention > re-use > recycling > recovery > disposal. Further information on this can be found at www.defra.gov.uk/publications/files/pb13530-waste-hierarchy-guidance.pdf.

Measures to be included to reduce construction waste include procedures to prevent the over-ordering of materials, reducing damage to materials before use by careful handling and segregating waste on site into separate skips. The developer should also consider how they will incorporate recycled/recovered materials into the building programme, including the use of secondary and recycled aggregates, and re-use of any on-site demolition waste.

Development design can also facilitate household waste recycling and we would suggest that designs incorporate facilities to aid this in line with local recycling provision, especially in multiple-occupancy buildings. We would also suggest that consideration is given to the provision for recycling opportunities within public areas. We recommend the following websites which provide ideas and further information: http://www.wrap.org.uk and http://www.tcpa.org.uk/pages/towards-zero-waste.html.

Net Gains for Nature

Landscaping proposals should demonstrate that thought has been given to maximising potential ecological enhancement. The NPS for ports sets out that planning should seek positive improvements and the applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity. The scheme should aim to move from a net loss of biodiversity to achieving net gains for nature in line with the Natural Environment White Paper (2011). The scheme presents an opportunity to provide multi-functional benefits - providing, sustainable transport links, wildlife/ecological value, climate change resilience, improved water quality and flood risk management. Incorporating green and/or brown roofs and walls are particularly effective. They provide valuable urban habitats, increased energy efficiency of buildings and attenuation of rain water. Research from the journal '*Environmental Science and Technology*' claims that green walls deliver cleaner air at street level where most people are exposed to the highest pollution. They can also add to an attractive street scene if designed well – a good example of this is the Transport for London Green Wall near Blackfriars station.

We trust this advice is of use and look forward to discussing the points raised in more detail when we meet with you in the near future.

Yours Sincerely,

[redacted]

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Appendix B – Breach Modelling Methodology

Subject:	Tilbury Breach Modelling Methodology		
Revision:	1	Date:	September 2017
Author:	AI	Reviewed by:	JL

1. INTRODUCTION

AECOM Infrastructure & Environment UK Ltd. ('AECOM") (formerly URS and URS Scott Wilson) has been commissioned to prepare a Flood Risk Assessment (FRA) for Atkins as part of the planning application for a new port in Tilbury, Thurrock.

The southern boundary of Thurrock Council is the Tidal Thames, and as such, large areas of Thurrock, including Tilbury, are at risk of tidal flooding. The Thames Tidal Defences (TTD) protects these areas and therefore the risk of flooding to Tilbury (as well as Thurrock as a whole) is only if the defences fail (breach).

Results from the breach modelling completed for the update to the Thurrock Strategic Flood Risk Assessment (SFRA) at breach location TIL005 has been used to inform this FRA.

As part of the FRA, AECOM has undertaken tidal breach modelling in order to quantify the potential impact of the proposed development on flood risk and inform the assessment of residual flood risk.

The purpose of this note is to document the methodology for the breach modelling that has been undertaken to support the FRA.

1.1. Information received

Information received / carried forward from the previous SFRA relevant to the breach modelling is summarised in Table 1-1.

Table 1-1: Information received / carried forward relevant to Tilbury Breach modelling

Dataset	Description and use in breach modelling	Format
Light Detecting and Ranging Data (LiDAR) – 0.25m, 0.5m, 1m and 2m' resolution flown in 2015	Terrain data obtained from Environment Agency	ASCI
OS 1 to 10,000 raster mapping	Background mapping obtained from Thurrock Council to be used in flood mapping	JPEG
OS MasterMap Data	Background mapping obtained from Thurrock Council to be used to apply roughness to ground surfaces	GIS / CAD
2010 SFRA Breach Locations / Details	Breach location TIL005 used	Excel
Requirements for Hazard Mapping v5_EA Breach modelling methodology	Specification for breach modelling provided by the Environment Agency	PDF
Thames Tidal Defences, Joint Probability Modelling (2008)	Extreme water levels in the Tidal Thames to be used as the boundary conditions in the breach modelling	Excel
Proposed Infrastructure corridor	Proposed levels used in development of proposed development breach model	CAD/GIS
Proposed site layout	Proposed layout and levels used in development of proposed development breach model	CAD/GIS

2. METHODOLOGY

2.1. Software

2D modelling of the breach scenarios is required to provide flood hazard information suitable for use in the FRA. Version 2016-03-AE of TUFLOW has been used for this modelling. The main reason for this software choice is to be consistent with other breach models along this coastline.

2.2. Breach Parameters

2.2.1. Locations

The vulnerability of a site to a breach depends to a great extent on the location chosen for the breach of the flood defences. Based on the breach locations used in the Thurrock Breach Modelling, breach TIL005 was chosen as the most critical to the development, which is at coordinates X565894, Y175350, which is located approximately 300m east of the proposed bridge over the defences, near to the location of the existing jetty.

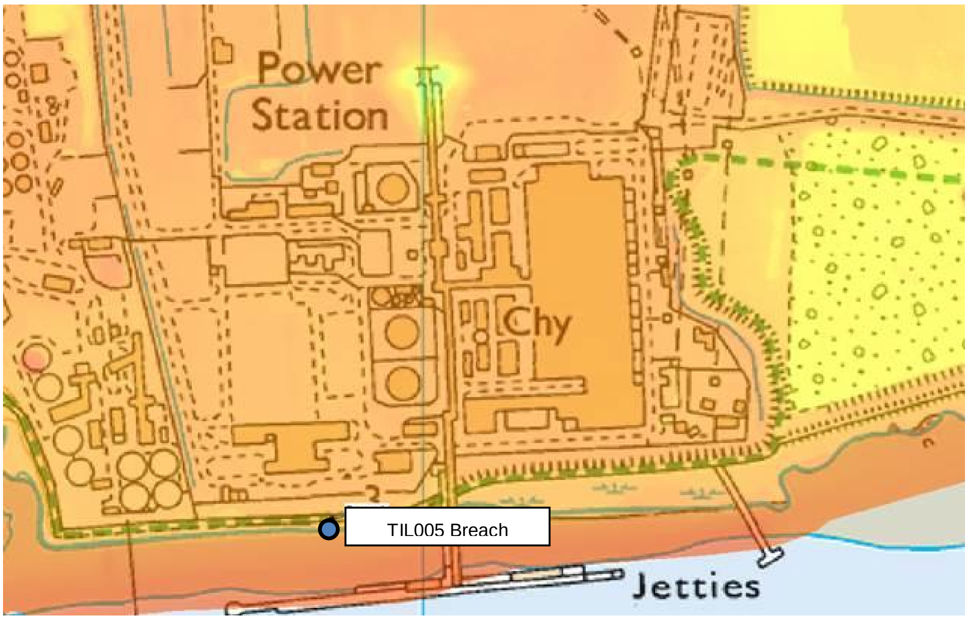


Figure 1: **Breach location used for the Tilbury Port 2 Expansion Project**

2.2.2. Widths and time of closure

The breach width used is 20m which is consistent with the Environment Agency's guidance for a breach in hard defences. It is assumed that the breach is 'open' for the duration of three tidal cycles (36 hours) which is the same duration as used in the previous Thurrock breach models.

2.2.3. Breach Invert Level

The invert level of the breach was determined through an interrogation of the LiDAR on the landward side of the breach location. At this breach location the invert level is proposed to be set at 2.6mAOD. The breach invert level will be set using a 2d_zplg in the TUFLOW model.

2.3. Overtopping

Overtopping of the defences will occur if the extreme water levels are greater than the defence crest levels. The Thames Estuary 2100 Plan[1] developed by the Environment Agency recommends how tidal flood risk is managed in the short, medium and long term – this includes recommendations for defence heights.

Tilbury falls under the following policy unit:

- **'Policy Unit – Purfleet, Grays & Tilbury – Our recommended flood risk management policy is policy P4 to take further action to keep up with climate and land use change so that flood risk does not increase.'**

2.4. Extreme Water Levels (Boundary Conditions)

2.4.1. Design tide boundaries

The breach model is required to simulate:

- **A tidal flood event with a return period of 1 in 200 years (present day 2017);**
- **A tidal flood event with a return period of 1 in 200 years (with a climate change allowance to 2117);**
- **A tidal flood event with a return period of 1 in 1000 years (present day 2017); and,**
- **A tidal flood event with a return period of 1 in 1000 years (with a climate change allowance to 2117)**

[1] **Environment Agency (2012) *'Thames Estuary 2100 – Managing flood risk through London and the Thames Estuary',* Environment Agency: London.**

As with the Thurrock Breach Modelling, the extreme water level data for use in this modelling was obtained from the Environment Agency Thames Tidal Defences Joint Probability Extreme Water Level 2008, Final Modelling Report (April 2008).

A series of 3 typical spring tides spanning a period of 36 hours was included. The surge was gradually applied with the maximum surge effect occurring on the second high tide (about 18 hours after the start of the simulation), as seen in the figure below. The model then continued to run for the remainder of the 36hr simulation period.

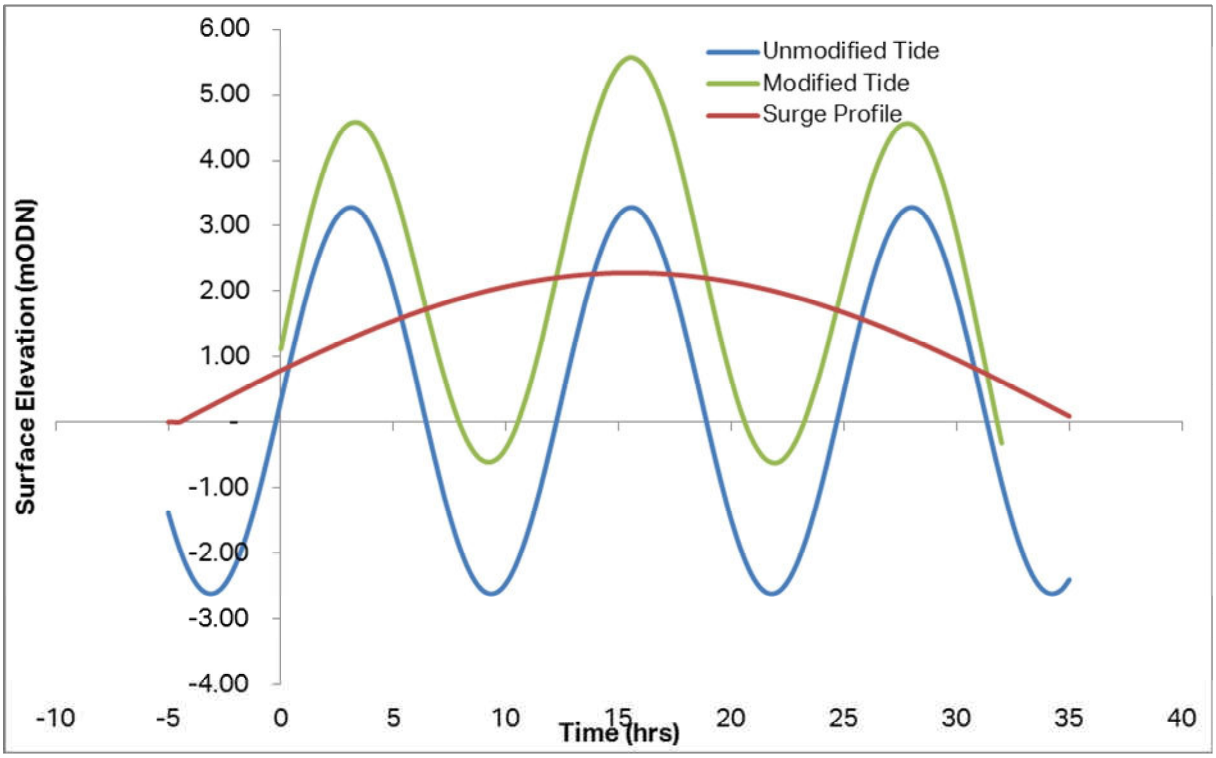


Figure 2: Example Tide Curve Including Surge Profile

For the 0.5% (1 in 200 year) and 0.1% (1 in 1000 year) AEP 2117 scenarios, the recommended climate change factors (UKCP09 medium emissions 95% tile) was applied to generate the extreme water level with allowances for sea level rise for the 2117 scenarios. Thames Tidal Defences Joint Probability Extreme Water Levels (2008) data contains modelling extreme water levels up to 2115 and therefore two years of climate change was applied.

2.4.1. Skew Surge Analysis

The addition of the surge skew analysis as described in the UKCP09 guidance has been reviewed for the study area. A slight negative surge component is predicted for these areas in Thurrock. However, given the very small negative magnitude (<1mm) increment for each return period, the level of uncertainty and to ensure consistency with previous studies, these slight modifications to the tidal boundary have been excluded from this strategic analysis. This assumption provides a slightly more conservative boundary condition which is not considered significant and well within the level of uncertainty of the modelling study.

2.4.2. Application of boundaries to TUFLOW

The design boundary conditions were applied directly to the 2D model using a 2d_bc boundary containing Height / Time (HT) information of the tidal cycles. The boundary was applied across the breach width.

2.5. Flood Cells

The extent of the 2D models for the Thurrock SFRA were defined by adopting a flood cell approach. 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. Only 1 of the flood cells used in the previous Thurrock Breach Modelling is applicable to the Tilbury Port model and so only the Purfleet and Tilbury Flood Cell will be retained, although it will also be cut to reduce the size of the flood cell without affecting the results.

2.6. Model Topography

A fixed square TUFLOW (finite difference modelling) was constructed to cover the flood cell using filtered LiDAR data provided by the Environment Agency. The grid was orientated as much as possible perpendicular to the breaches. The choice of grid cell size influences how accurately the model represents the LiDAR data, the finer the resolution the more accurate the representation is. However, a finer grid resolution will cause longer run times which may not be acceptable, therefore a balance needs to be achieved. A 5m grid resolution was set and confirmed after the initial runs.

The version of TUFLOW used for this modelling automatically creates an ASCI file of the model topography (DEM_Z). This output was used to check the model topography against the original LIDAR data. Where surface features, for example ditches, are not represented in the model topography, additional TUFLOW geometry files will be used for definition.

Where it has been determined that overtopping will occur defence crest levels received from the AIMS data and Environment Agency topographic spot level data were enforced using a 2d_zline.

The proposed development has been added in multiple layers:

- Railway – points extracted and added to a 2d_ztin layer. Ztin created by a boundary around all points;
- Road – 3D proposed formation level points extracted and triangulated to form a dtm asc file;
- Proposed development – polygons drawn in 2d_zplg layer and set at levels defined on proposed design drawings;

- Site ditches – zsh used to add ditches based on topographical data; and
- Proposed culverts – added in as ESTRY file.

2.7. Roughness

Ordnance Survey Master Map (OSMM) area polygon data was used to specify varying Manning's roughness coefficients throughout the model extent. The OSMM polygons were grouped according to land use and Manning's n roughness coefficients were applied according to those groups.

Table 2-1 outlines the proposed coefficients for each of the OSMM land use descriptions identified within the study area. The values specified are based on the previous SFRA breach modelling and recent breach modelling carried out by AECOM.

Table 2-1: OSMM defined roughness

OSMM Land Use Description	Feature Code	Manning's 'n'
Building	10021	0.3 (this value was not specifically assigned in the previous SFRA modelling)
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

Roughness values of additional elements added were modified accordingly, i.e. the proposed road modified to that of a road (10,172).

2.8. Buildings

Representation of buildings in hydraulic modelling varies from either increasing the roughness across a building polygon to blocking buildings completely out of the floodplain, thus assuming no water would flow through.

The Environment Agency methodology document[Error! Bookmark not defined.] does not specify how buildings should be represented. Raising buildings as solid blocks assumes that no flow can pass through the buildings which can be considered an over-conservative assumption. Therefore for this FRA modelling, buildings were represented by polygons with the roughness coefficient value set to 0.3 (see also Table 2-1), which is in line with previous breach modelling studies within Thurrock.

2.9. Naming convention and folder structure

The model folder structure follows the standard TUFLOW structure.

2.10. Simulations

For each breach the following scenarios will be run:

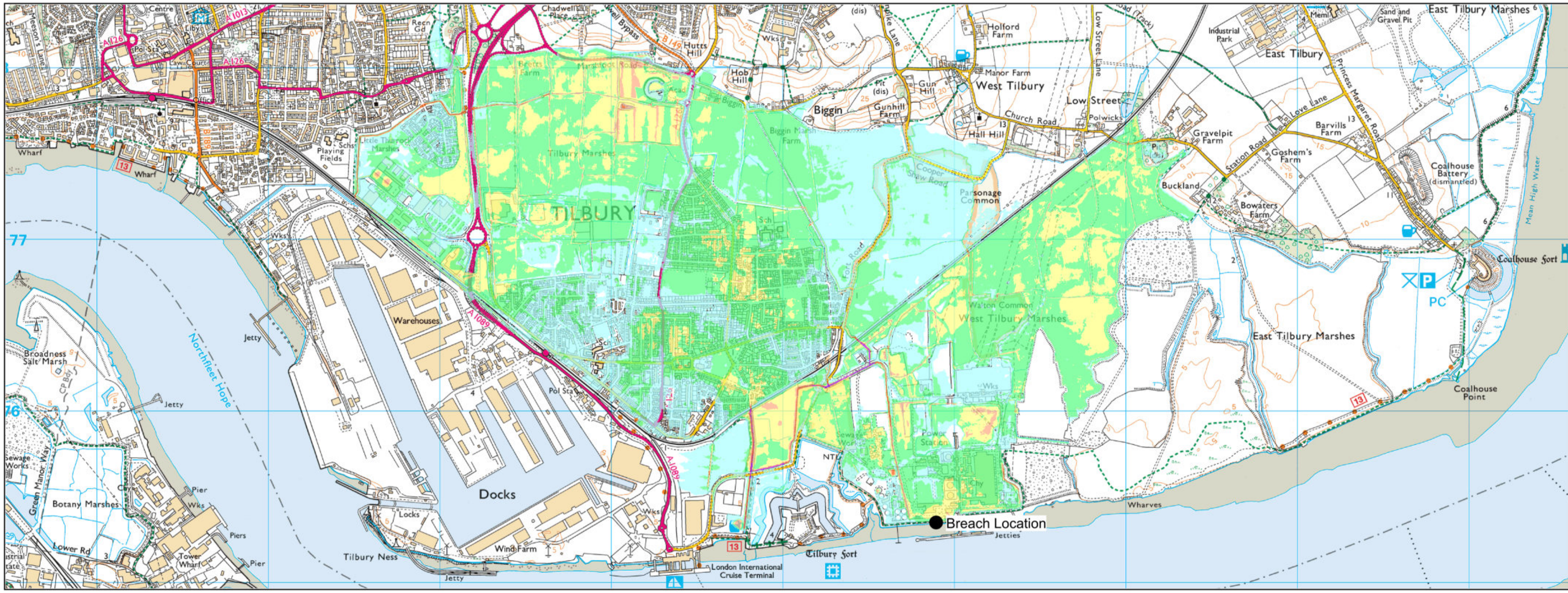
- A tidal flood event with a return period of 1 in 200 years (present day 2017);
- A tidal flood event with a return period of 1 in 200 years (with a climate change allowance to 2117);
- A tidal flood event with a return period of 1 in 1000 years (present day 2017); and,
- A tidal flood event with a return period of 1 in 1000 years (with a climate change allowance to 2117)

2.11. Outputs

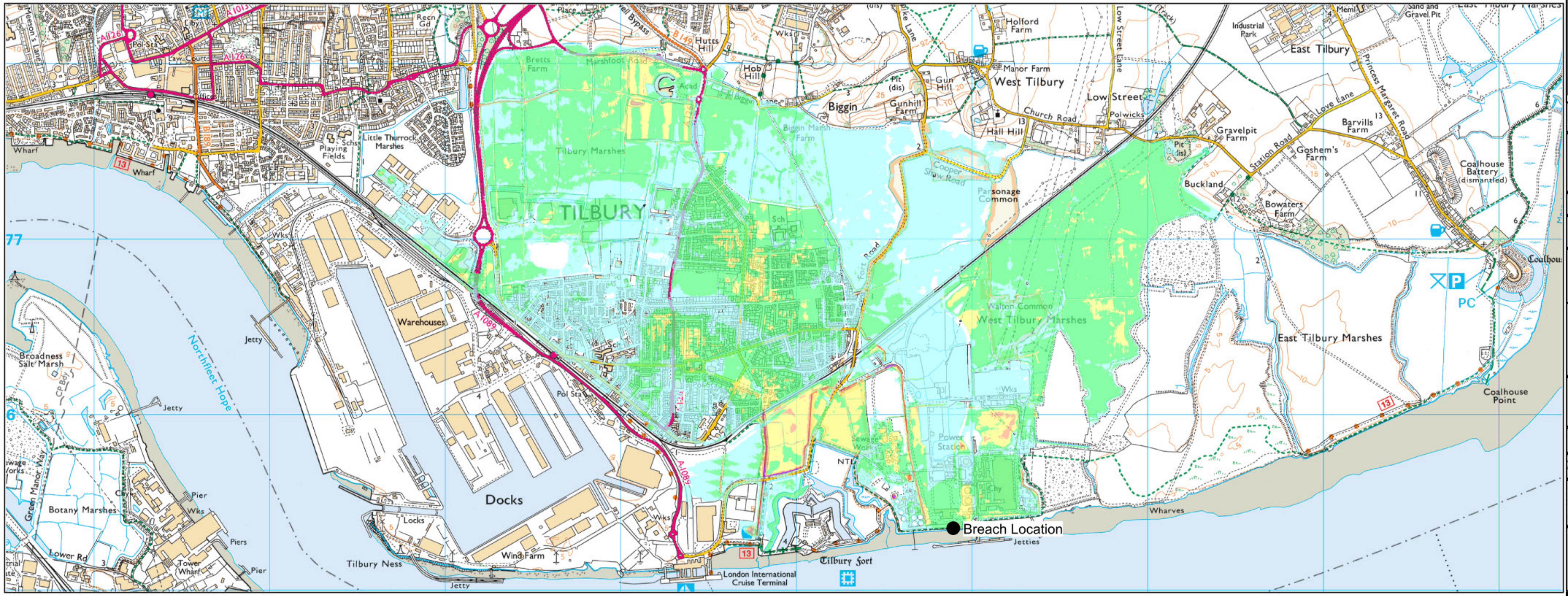
All of the results have been post-processed to provide figures for flood depth, flood hazard and time to inundation. These outputs are seen in Appendix B.

Appendix C – Breach Modelling Outputs

Figure 1	Flood depth maps (baseline & proposed)	0.5% AEP (1 in 200) 2017
Figure 2	Flood depth maps (baseline & proposed)	0.5% AEP (1 in 200) 2117
Figure 3	Flood depth maps (baseline & proposed)	0.1% AEP (1 in 1000) 2017
Figure 4	Flood depth maps (baseline & proposed)	0.1% AEP (1 in 1000) 2117
Figure 5	Flood difference map	0.5% AEP (1 in 200) 2017
Figure 6	Flood difference map	0.5% AEP (1 in 200) 2117
Figure 7	Flood difference map	0.1% AEP (1 in 1000) 2017
Figure 8	Flood difference map	0.1% AEP (1 in 1000) 2117
Figure 9	Flood hazard map	0.5% AEP (1 in 200) 2017
Figure 10	Flood hazard map	0.5% AEP (1 in 200) 2117
Figure 11	Flood hazard map	0.1% AEP (1 in 1000) 2017
Figure 12	Flood hazard map	0.1% AEP (1 in 1000) 2117
Figure 13	Time to inundation map	0.5% AEP (1 in 200) 2017
Figure 14	Time to inundation map	0.5% AEP (1 in 200) 2117



Baseline Model



Proposed Development Model

LEGEND

Max Modelled Depth (m)

- 2.5 to 3.5
- 2 to 2.5
- 1.5 to 2
- 1 to 1.5
- 0.5 to 1
- 0 to 0.5

Notes

See Figure 5 for depth difference map

Revision Details | Suffix

Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 1: 200yr 2017 Max Modelled Depth

Drawn	Checked	Approved	Date
AI	BM	JR	15/09/2017

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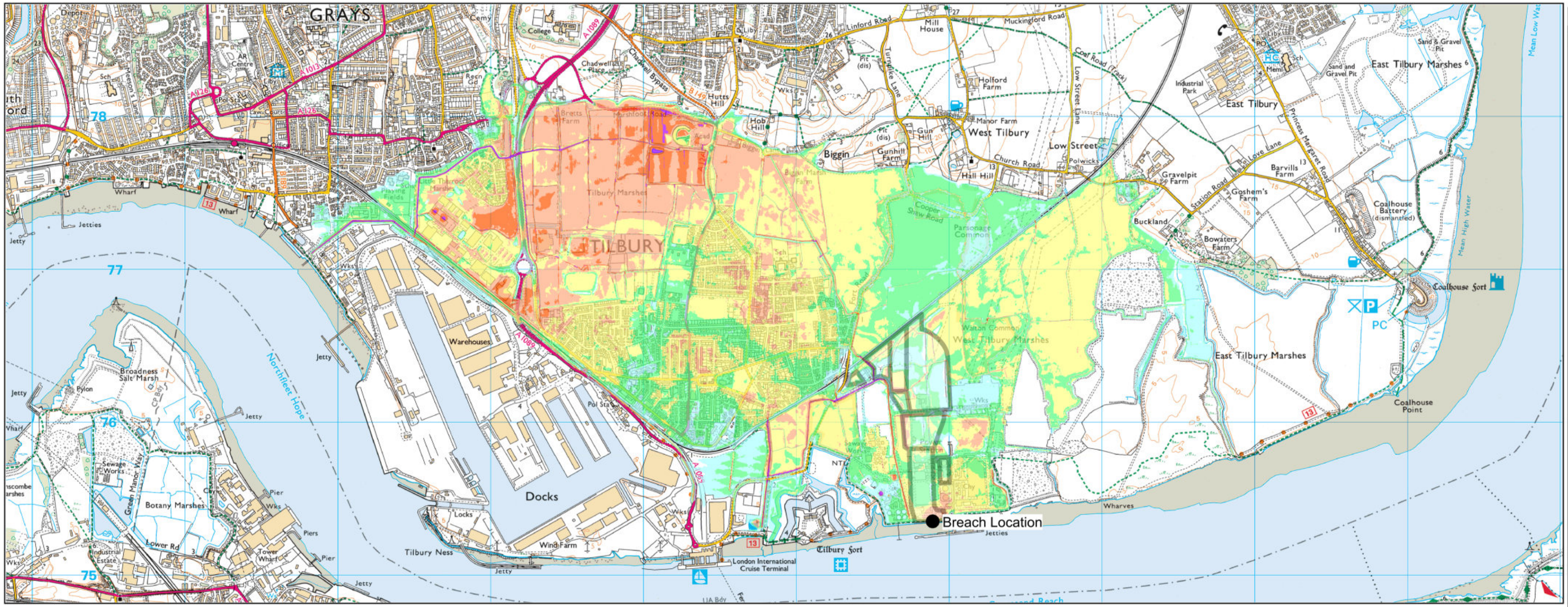
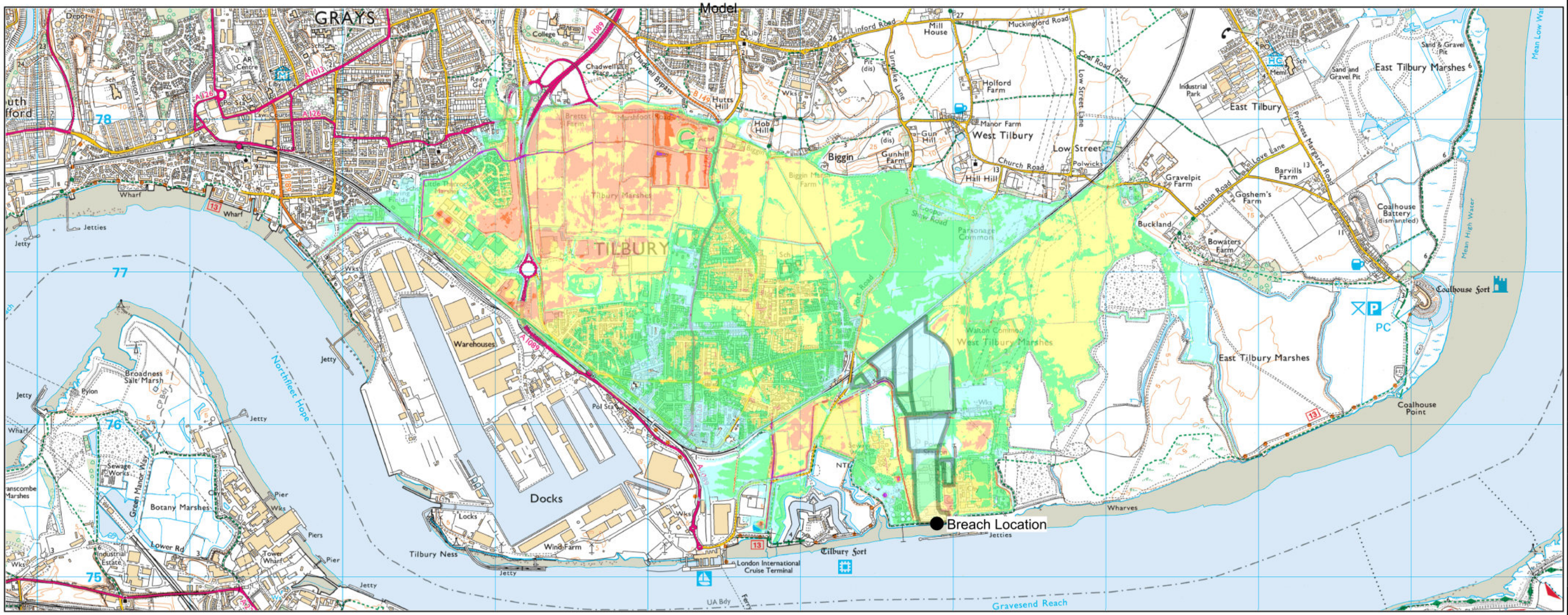


Baseline Model



Proposed Development Model

LEGEND

Max Modelled Depth (m)

- 2.5 to 2.5
- 2 to 2.5
- 1.5 to 2
- 1 to 1.5
- 0.5 to 1
- 0 to 0.5

Notes

See Figure 6 for depth difference map

Revision Details | Suffix

Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 2: 200yr 2117 Max Modelled Depth

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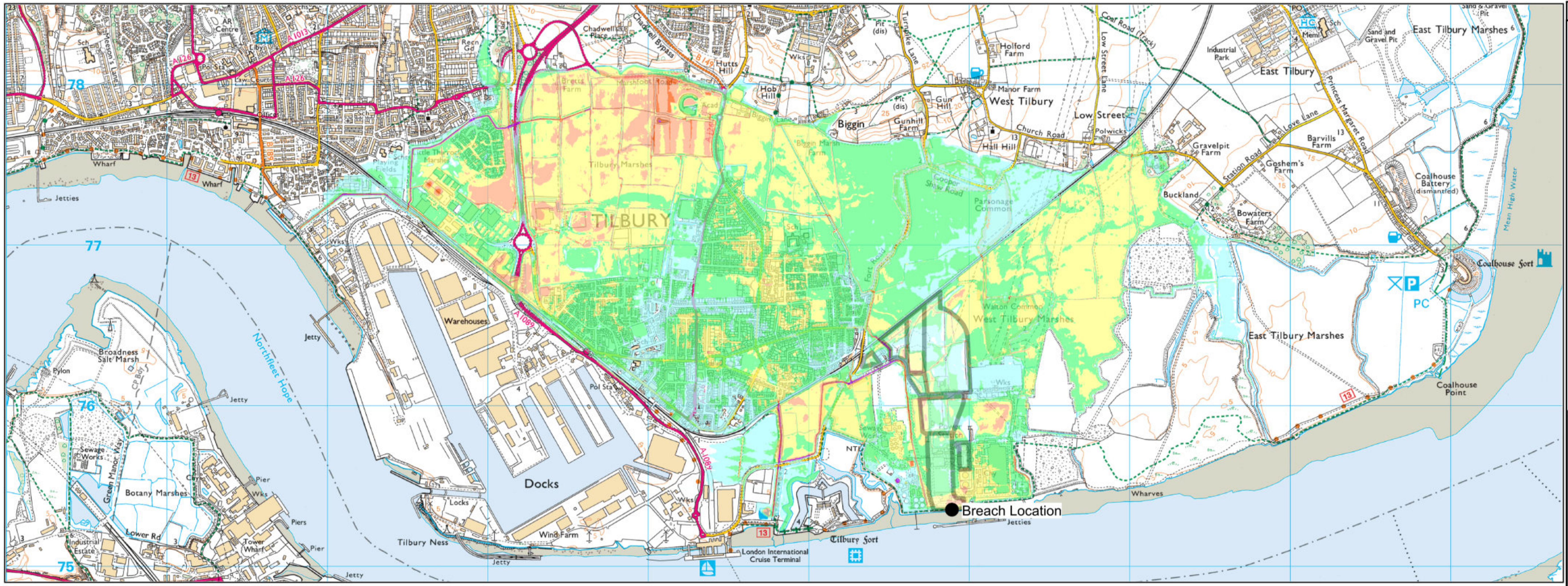
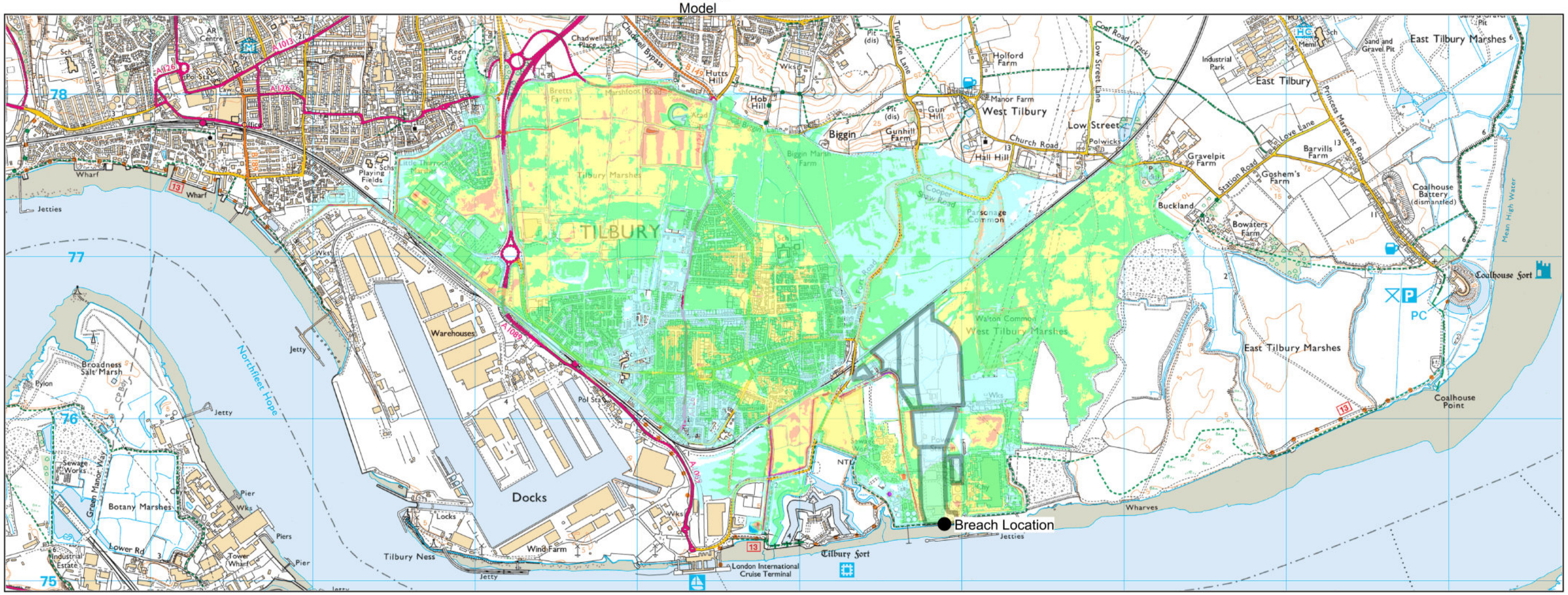


Baseline Model



Proposed Development Model

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LEGEND

Max Modelled Depth (m)

- 2.5 to 2.5
- 2 to 2.5
- 1.5 to 2
- 1 to 1.5
- 0.5 to 1
- 0 to 0.5

Notes
See Figure 3 for depth difference map

Revision Details | Suffix

Purpose of Issue
Version 1

Client

Project Title
Tilbury Port 2 Expansion

Drawing Title
FIGURE 3: 1000yr 2017 Max Modelled Depth

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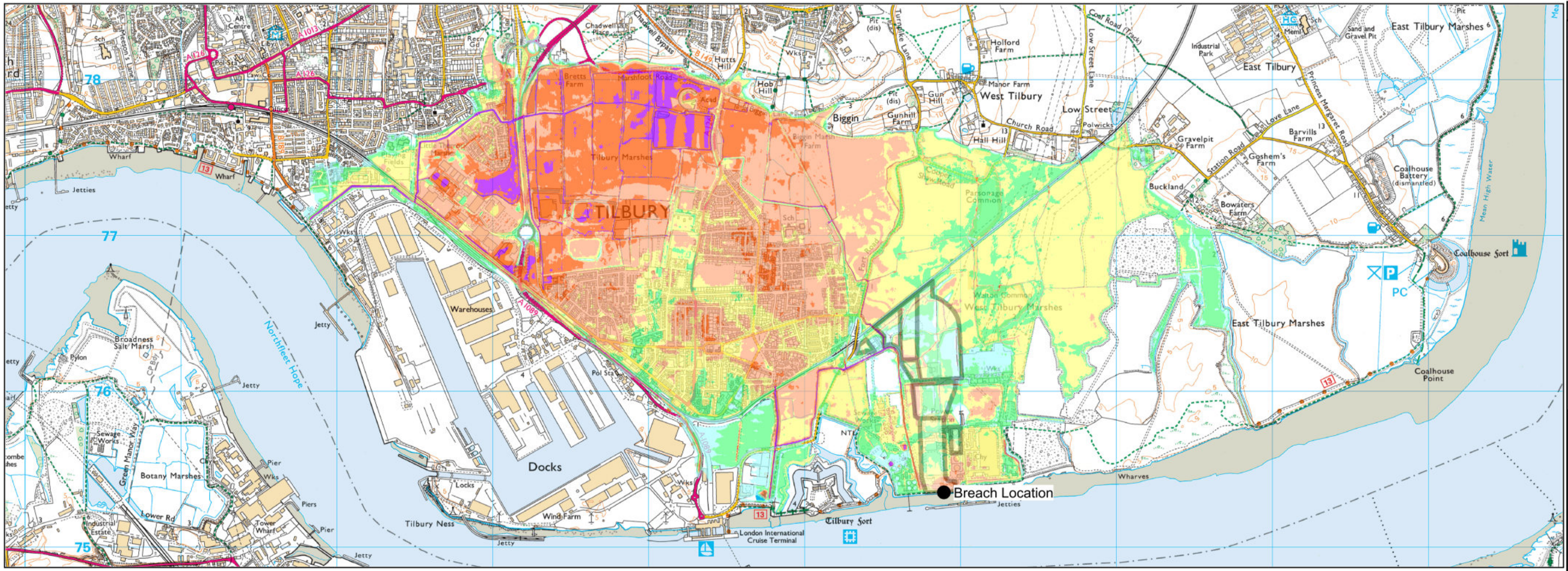
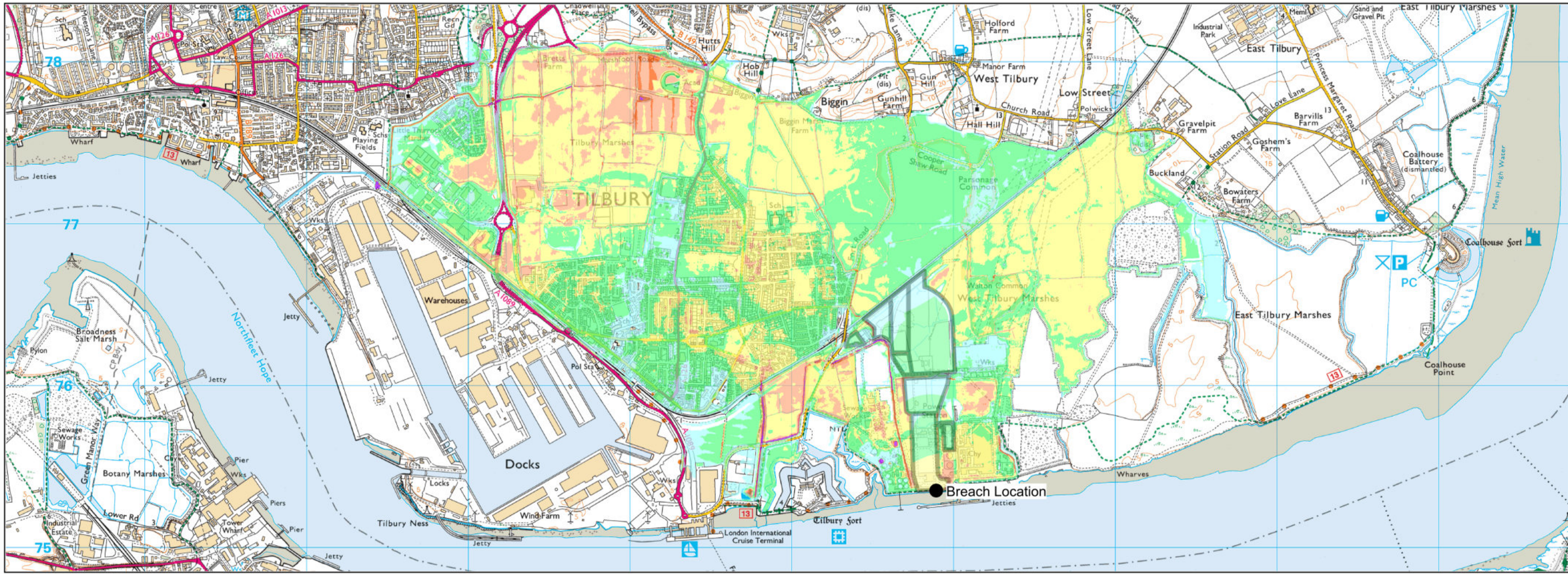


Baseline Model



Proposed Development Model

LEGEND

Max Modelled Depth (m)

Purple	2.5 to 2.5
Dark orange	2 to 2.5
Light orange	1.5 to 2
Yellow	1 to 1.5
Green	0.5 to 1
Light blue	0 to 0.5

Notes

See Figure 4 for depth difference map

Revision Details | Suffix

Purpose of Issue: Version 1

Client:

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 4: 1000yr 2117 Max Modelled Depth

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LEGEND

Depth Difference (m)
Proposed - Baseline

0.7 to 0.88	
0.6 to 0.7	
0.5 to 0.6	
0.4 to 0.5	
0.3 to 0.4	
0.2 to 0.3	
0.1 to 0.2	
-0.1 to 0.1	
-0.25 to -0.1	
-0.5 to -0.25	
-0.75 to -0.5	
-2.86 to -0.75	

Notes

Revision Details

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Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 5: 200yr 2017 Depth Difference

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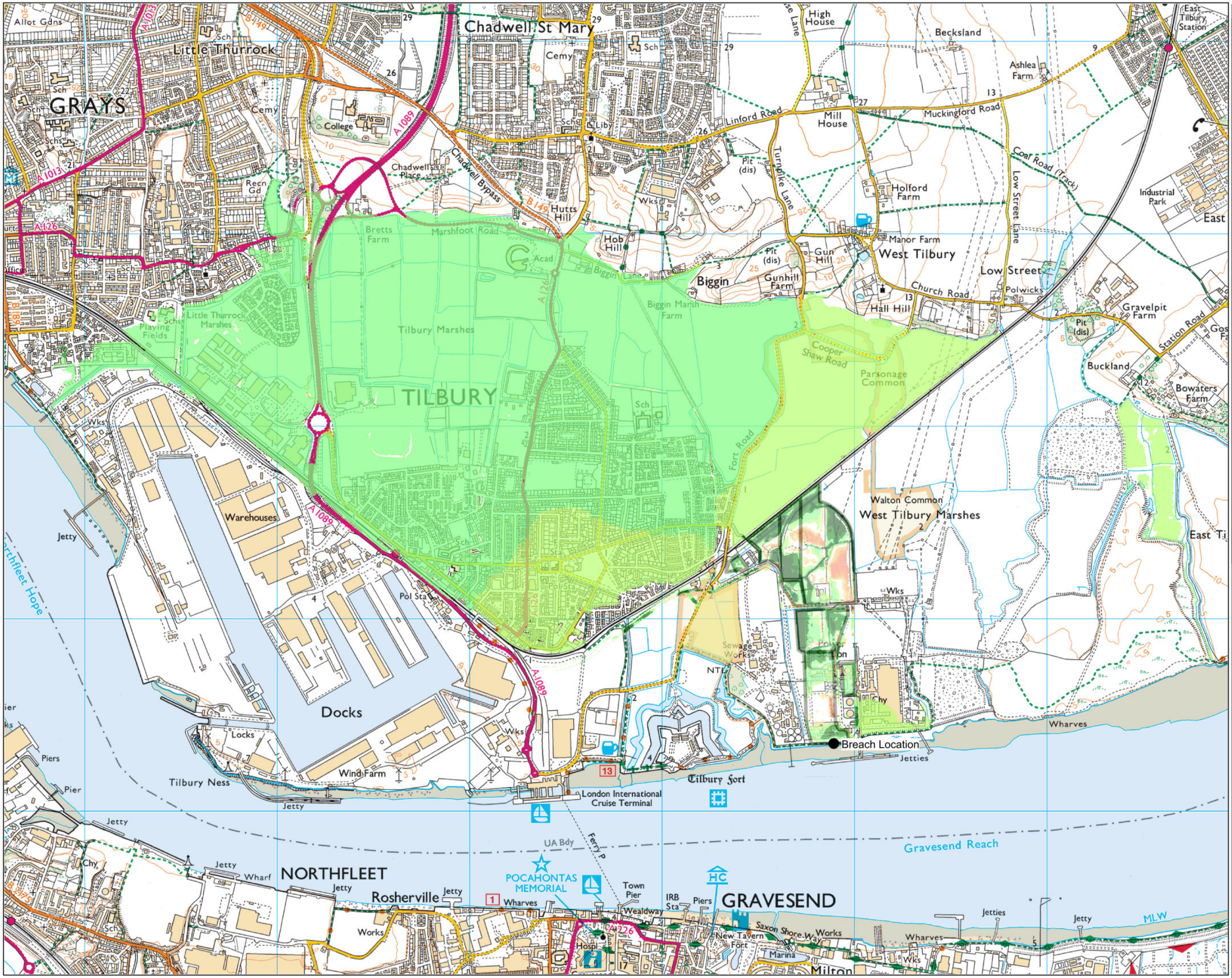

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LEGEND

Depth Difference (m)
Proposed - Baseline

0.7 to 0.88	
0.6 to 0.7	
0.5 to 0.6	
0.4 to 0.5	
0.3 to 0.4	
0.2 to 0.3	
0.1 to 0.2	
-0.1 to 0.1	
-0.25 to -0.1	
-0.5 to -0.25	
-0.75 to -0.5	
-3.19 to -0.75	

Notes

Revision Details | Suffix

Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 6: 200yr 2117 Depth Difference

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LEGEND

Depth Difference (m)
Proposed - Baseline

Depth Difference (m)
0.7 to 0.88
0.6 to 0.7
0.5 to 0.6
0.4 to 0.5
0.3 to 0.4
0.2 to 0.3
0.1 to 0.2
-0.1 to 0.1
-0.25 to -0.1
-0.5 to -0.25
-0.75 to -0.5
-3.12 to -0.75

Notes

Revision Details | Suffix

Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 7: 1000yr 2017 Depth Difference

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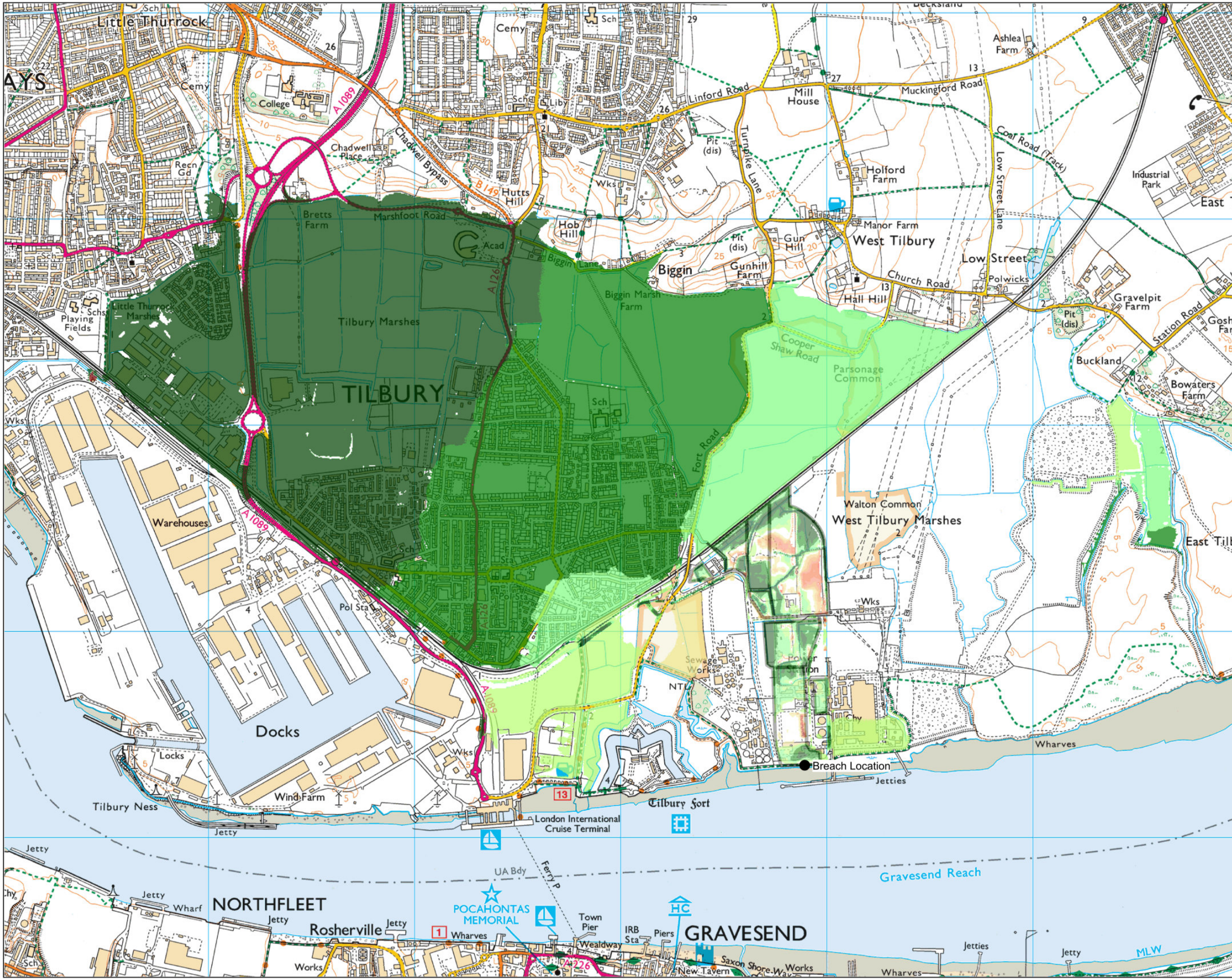

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LEGEND

Depth Difference (m)
Proposed - Baseline

Depth Difference (m)
0.7 to 0.88
0.6 to 0.7
0.5 to 0.6
0.4 to 0.5
0.3 to 0.4
0.2 to 0.3
0.1 to 0.2
-0.1 to 0.1
-0.25 to -0.1
-0.5 to -0.25
-0.75 to -0.5
-3.22 to -0.75

Notes

Revision Details | Suffix

Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 8: 1000yr 2117 Depth Difference

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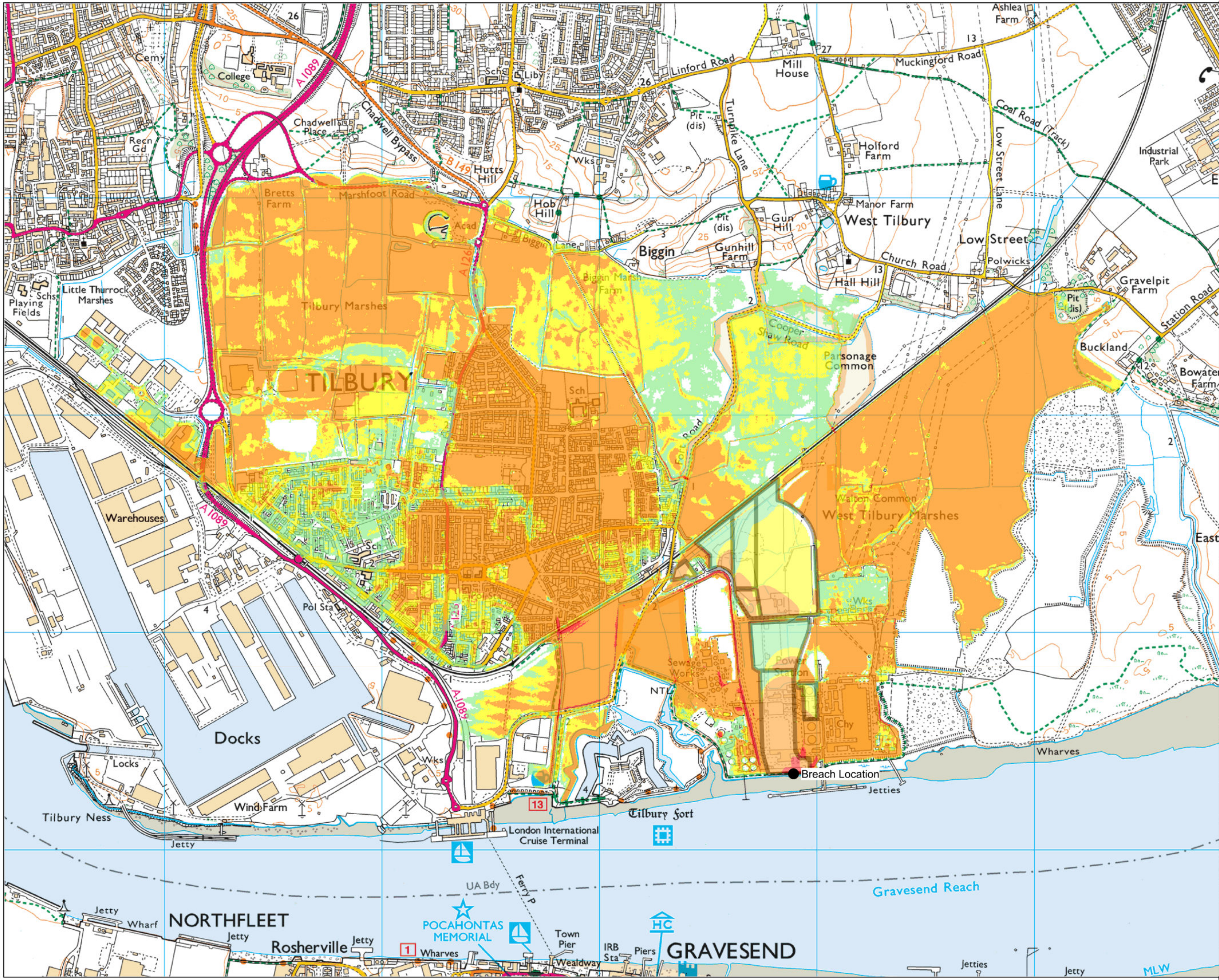

LEGEND

Hazard Rating

- Extreme Hazard
- Significant Hazard
- Moderate Hazard
- Low Hazard

Notes

Revision Details

Suffix

Purpose of Issue

Version 1

Client

Project Title

Tilbury Port 2 Expansion

Drawing Title

FIGURE 9: 200yr 2017 Flood Hazard

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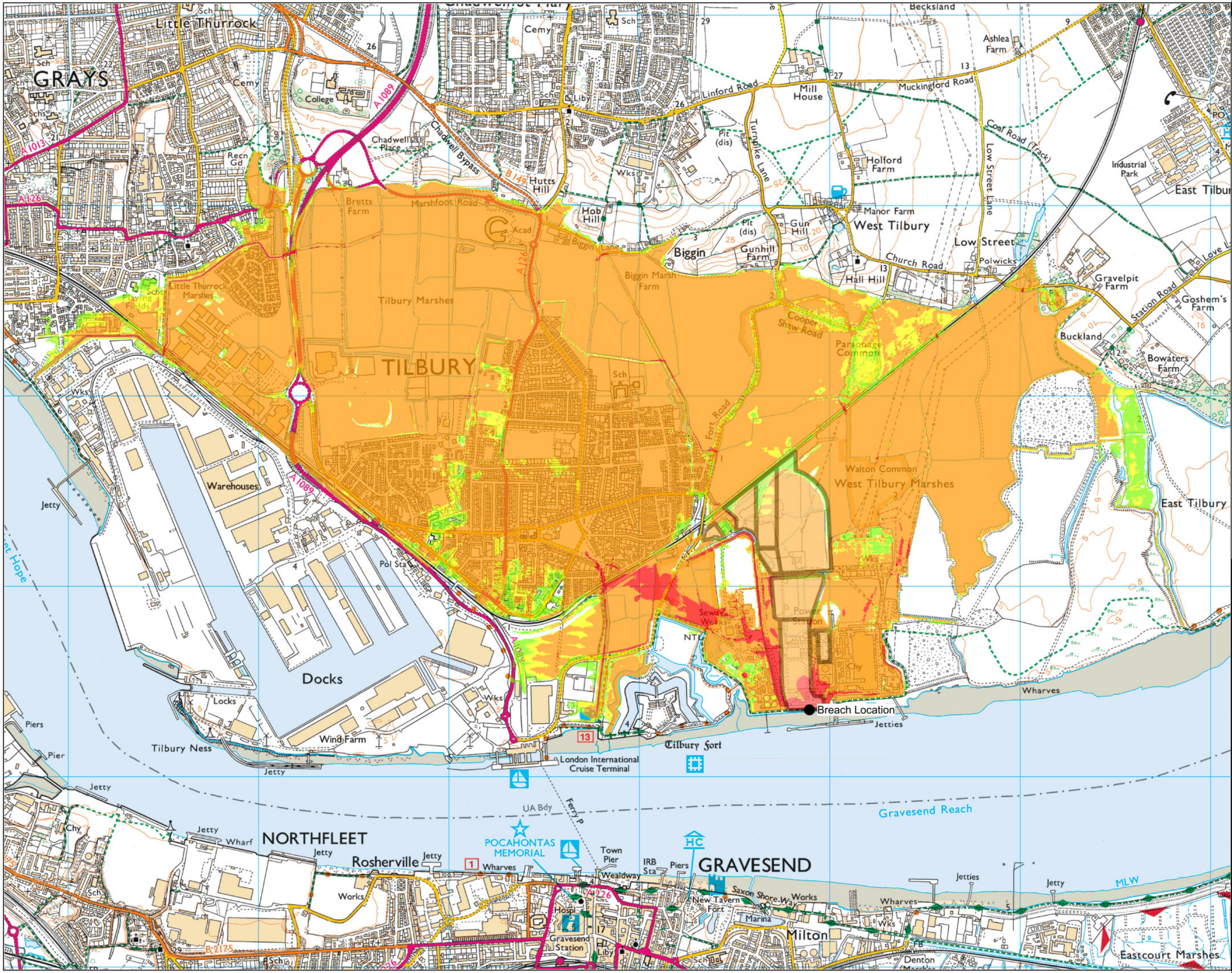

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LEGEND

Hazard Rating

- Extreme Hazard
- Significant Hazard
- Moderate Hazard
- Low Hazard

Notes

Revision Details | Suffix

Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 10: 200yr 2117 Flood Hazard

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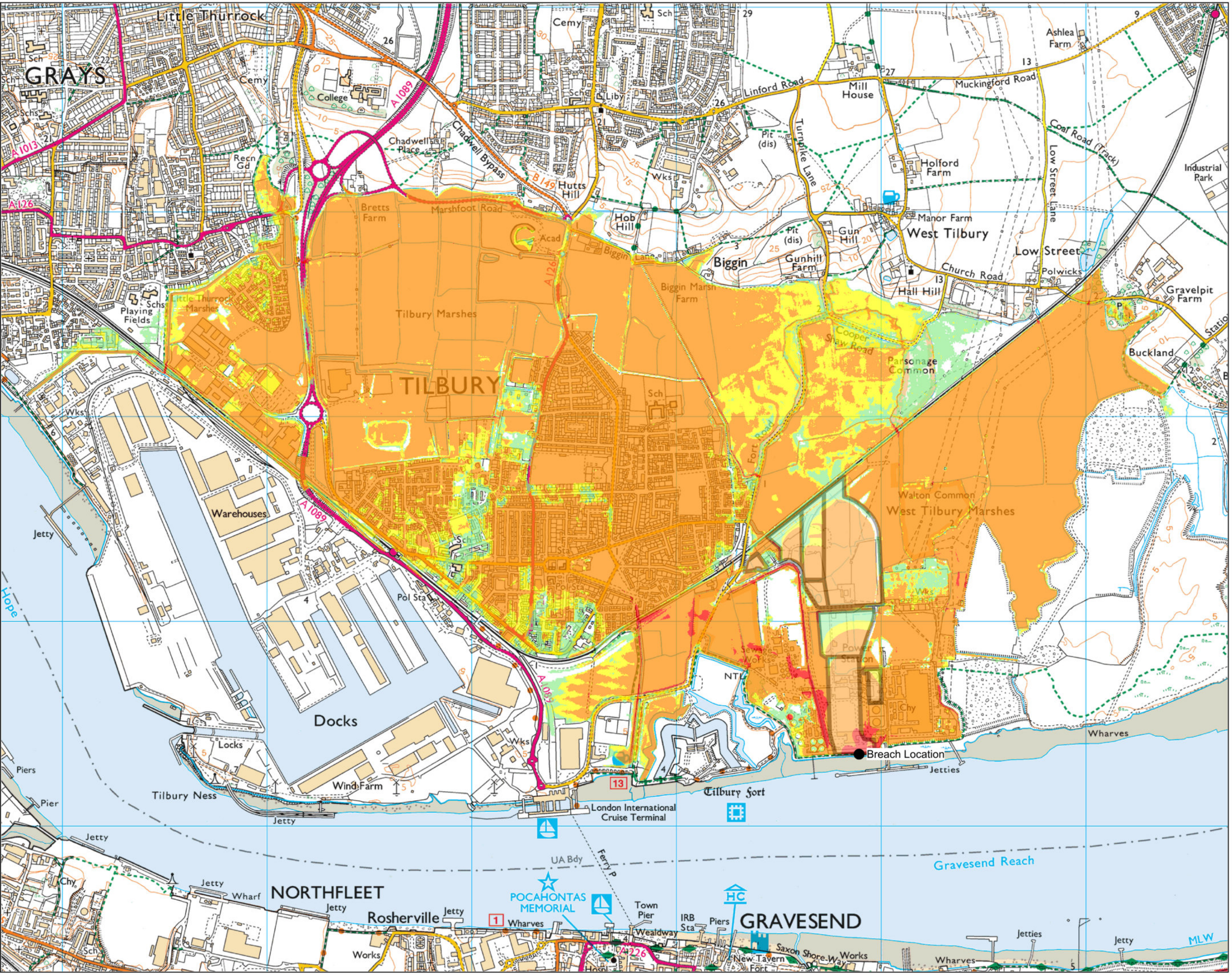
Drawing Number	Rev
10	00



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LEGEND

Hazard Rating

- Extreme Hazard
- Significant Hazard
- Moderate Hazard
- Low Hazard

Notes

Revision Details | Suffix

Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 11: 1000yr 2017 Flood Hazard

Drawn	Checked	Approved	Date
Ai	xx	xx	14/09/2017

AECOM Internal Project No.	Scale at A3
60545507	1:2600

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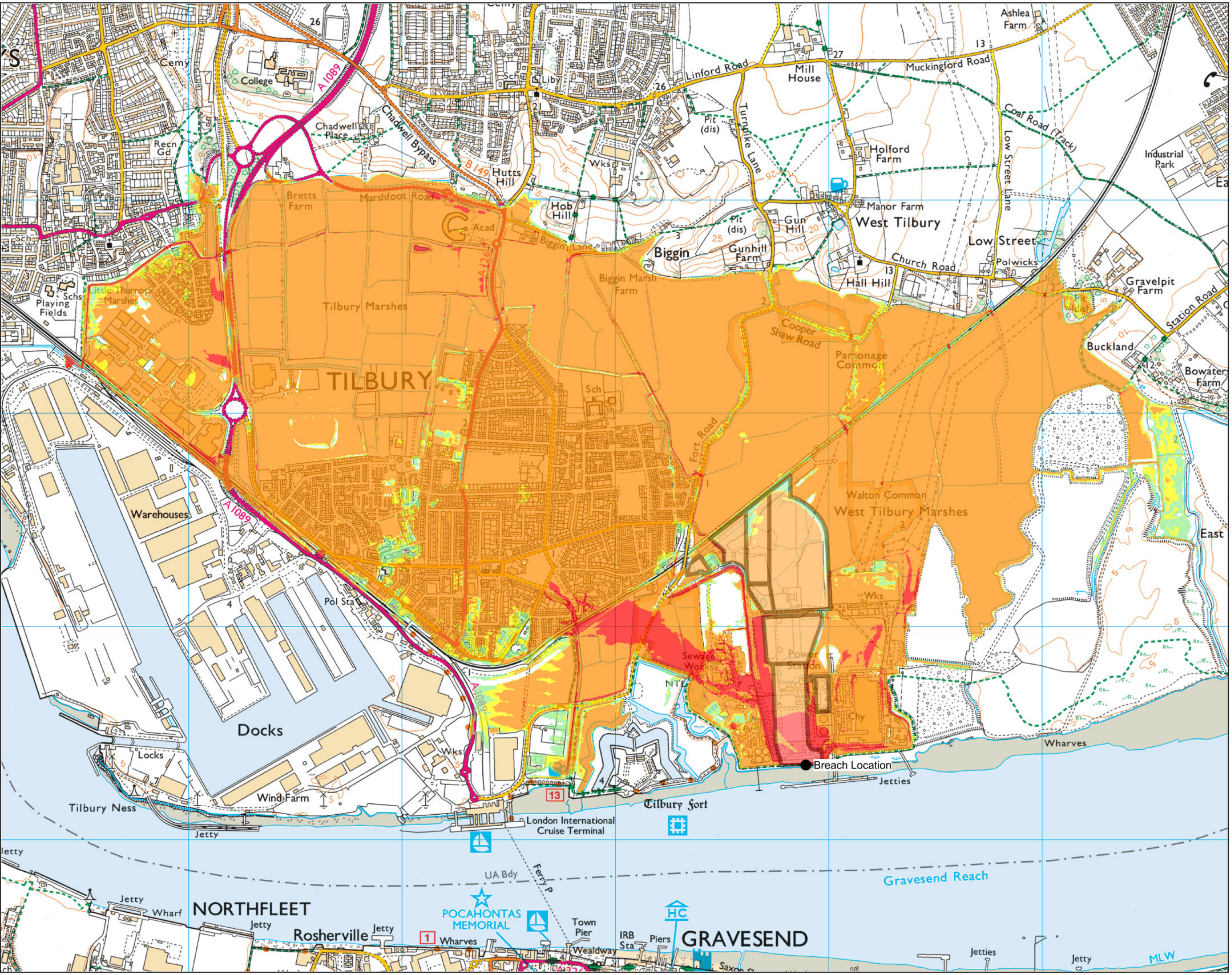
Drawing Number	Rev
11	00



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LEGEND

Hazard Rating

- Extreme Hazard
- Significant Hazard
- Moderate Hazard
- Low Hazard

Notes

Revision Details

Suffix

Purpose of Issue

Version 1

Client

Project Title

Tilbury Port 2 Expansion

Drawing Title

FIGURE 12: 1000yr 2117 Flood Hazard

Drawn	Checked	Approved	Date
Ai	xx	xx	14/09/2017

AECOM Internal Project No.	Scale at A3
60545507	1:2600

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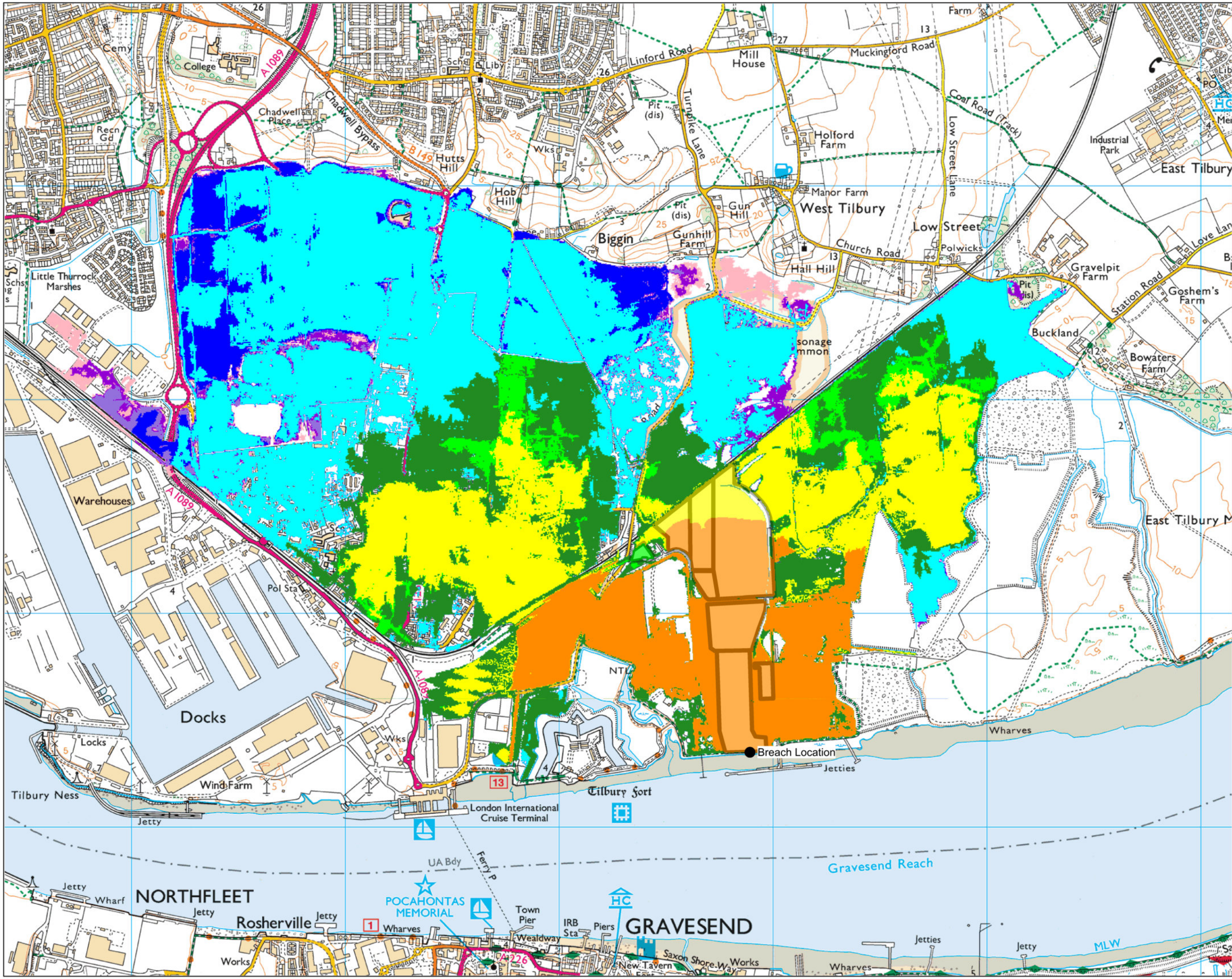
Drawing Number	Rev
12	00



LEGEND

Time to Inundation (hours)

- 1 to 4 hours
- 4 to 8 hours
- 8 to 12 hours
- 12 to 16 hours
- 16 to 20 hours
- 20 to 24 hours
- 24 to 28 hours
- 28 to 32 hours
- 32 to 36 hours

Notes

Revision Details | Suffix

Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 13: 200yr 2017 Time to Inundation

Drawn	Checked	Approved	Date
Ai	BM	JR	14/09/2017

AECOM Internal Project No.	Scale at A3
60545507	1:2600

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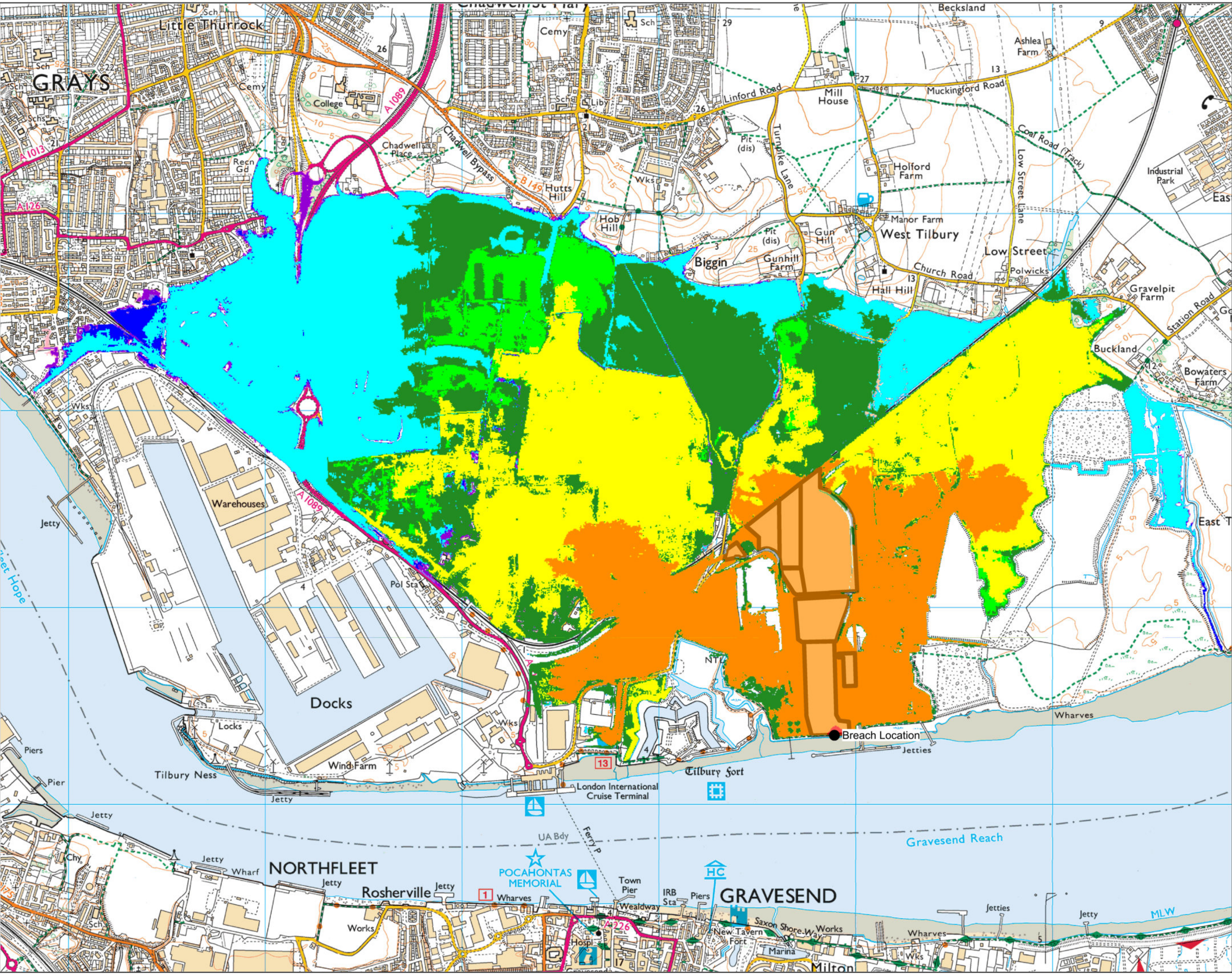
Drawing Number: 13 | Rev: 00



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LEGEND

Time to Inundation (hours)

- 0 to 1 hours
- 1 to 4 hours
- 4 to 8 hours
- 8 to 12 hours
- 12 to 16 hours
- 16 to 20 hours
- 20 to 24 hours
- 24 to 28 hours
- 28 to 32 hours
- 32 to 36 hours

Notes

Revision Details | Suffix

Purpose of Issue: Version 1

Client

Project Title: Tilbury Port 2 Expansion

Drawing Title: FIGURE 14: 200yr 2117 Time to Inundation

Drawn	Checked	Approved	Date
Ai	BM	JR	14/09/2017

AECOM Internal Project No. 60545507

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