

FLOOD RISK ASSESSMENT

TKRE, Grain-Tilbury and Kingsnorth-Tilbury 400kV Uprating FEED

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1. Introduction

1.1. Project Overview

The existing National Grid Grain-Tilbury and Kingsnorth-Tilbury 400kV circuits are forecasted to become significantly overloaded in their current capacity and require uprating. The circuits are predominantly overhead line, with cabled sections installed within a deep tunnel crossing the River Thames.

BakerHicks has been appointed to undertake the Front-End Engineering Design (FEED) of the TKRE, Grain-Tilbury and Kingsnorth-Tilbury 400kV uprating scheme and associated works, which will support the project's development at TP500 stage 4.3.

The Front-End Engineering design (FEED) study for uprating of the Grain-Tilbury and Kingsnorth-Tilbury 400kV circuits involves:

- Installation of 400kV cables within a new tunnel connection under the river Thames to match the required 3325MVA maximum rating
- Uprating of 400kV 4TK Grain-Tilbury and 4VG Kingsnorth-Tilbury overhead lines including downloads by reconductoring of the existing 4 x 400 ACSR (2780MVA) OHL sections of the Tilbury-Grain/Tilbury-Kingsnorth circuits (A784/A785) to make the entire route 3 x AAAC (3820MVA)
- Uprating of substation bays at Grain, Kingsnorth and Tilbury substations

1.2. Scope of the Document

This report will consider planning provisions, sources of flood risk, site-specific flood risk and flood risk strategy for of the shafts, sealing end compounds and tunnel associated with the TKRE, Grain-Tilbury and Kingsnorth-Tilbury 400 kV uprating. These shafts are to be located at:

1. Tilbury Cable Sealing End Compound
2. Gravesend Cable Sealing End Compound

This report will provide a general indication of the potential flood risk to the site and identify whether there are any flooding or surface water management issues that may warrant further consideration or may affect the feasibility of a development.

This report will provide a Phase 1 Flood Risk Assessment (FRA) screening assessment of flood risk to the shafts from all sources, including: fluvial; tidal; groundwater; surface water; reservoirs; sewers and artificial sources (e.g. canals). The Phase 1 FRA represents an initial consideration of flood risk to each shaft based on the current design, as identified in each Section, and will be used to inform the ongoing design Cable Sealing End Compounds

Based on this screening assessment, site-specific mitigation measures will be recommended to address any identified flood risk. This will inform the design specifications for the project and facilitate a flood resistant and resilient design.

Full details of the assessment process, the design drawings used to undertake the assessment and consideration of all sources of flood risk are provided in Sections 4 through 5 for each shaft location. Design requirements are summarised in Section 8

2. Sources of Information

2.1. Data Sources

- Geological Survey of England and Wales 1:50,000 geological map series. Sheet 271, South London. Solid & Drift Edition 1998.
- Flood Map for Planning – Interactive Flood Map: <https://www.gov.uk/check-long-term-flood-risk>
- Local Authority Strategic Flood Risk Assessments (SFRAs). Individual SFRAs for each of the site areas are referenced throughout
- EA flood mapping shown on 'What's in your backyard? Website
- EA Learn more about flood risk. <https://check-long-term-flood-risk.service.gov.uk/map>
- EA Get flood risk information for planning in England. <https://flood-map-for-planning.service.gov.uk/>
- EA Flood risk assessments: climate change allowances 2017-02-03 (Withdrawn 17/Dec 2019). https://consult.environment-agency.gov.uk/engagement/bostonbarriertwao/results/appendix-9---flood-risk-assessments-climate-change-allowances_20170203.pdf
- British Geological Survey (BGS) Geology of Britain Viewer
- National Library of Scotland – Historical Maps: <http://maps.nls.uk/>; – Refer to Envirocheck report for historic maps (PDD-100116-REP-001 / 30003364-MSE-XX-XX-RP-Y-10000 Geotechnical and geoenvironmental desk study, Appendix D)
- Envirocheck Report 2023 (PDD-100116-REP-001 / 30003364-MSE-XX-XX-RP-Y-10000 Geotechnical and geoenvironmental desk study, Appendix D)
- PDD-100116-REP-001 / 30003364-MSE-XX-XX-RP-Y-10000 Geotechnical and Geoenvironmental Desk Study
- PDD-100116-REP-011 / 30003364-MSE-XX-XX-RP-Y-10010 Options Appraisal and Sift Report
- PDD-100116-REP-021 / 30003364-MSE-XX-XX-RP-Y-10082 Works Area Strategy

2.2. Tilbury specific data sources

- Thurrock Council 2015. Thurrock Local Flood Risk Management Strategy Final Report December 2015
- Thurrock Council 2018. 60492009 Thurrock Borough Council Level 1 Strategic Flood Risk Assessment. Final Report June 2018
- ENV-085-2006 Tilbury application site report March 2006 RWE npower
- NR305781 Product letter for Tilbury
- EA NR305781 a - Product 4 Tilbury Integrated Urban Design (IUD) Fluvial/Pluvial Model
- EA NR305781 b – Product 4 Flood Defence Location Map Ref: EAN/2023/NR305781
- EA NR305781 c – Product 4 Flood Defence Data

- EA NR305781 d – Product 4 Open Government Licence
- EA NR305781 e – Product 4 Supporting Documentation Version 6 May 2023
- EA NR305781 f – Product 6 & 7 JBA consulting - 2015s3073 - Thurrock Flood Strategy - ICM Model Operation Manual & Model Log v2.0
- EA NR305781 g – Product 6 & 7 Environmental Agency Conditional Licence
- PS/2015/994 Tilbury Integrated Flood Strategy Final Report January 2017 provided by the EA with Product 6 & 7
- App A Tilbury Model Manual provided by the EA with Product 6 & 7

2.3. *Gravesend specific data sources*

- EA NR305781 h - Product Letter Gravesend Shaft
- EA NR305781 i - Product 5 Thames Estuary Breach Assessment Methodology Report_v0.1
- EA NR305781 j - Product 5 Thames Estuary Breach Assessment Model User Guide
- EA NR305781 k - Product 5 Thames Estuary Breach Assessment Outputs User Note
- EA NR305781 l - Product 6 KSLES Guidance on using Product 6 data
- EA NR305781 n - Product 6 Model Licence - Thames Tidal Downriver Breach Inundation Modelling 2018
- EA NR305781 o - Product 6 TE2100 Estuary Model Node Location Maps
- EA NR305781 p - Product 6 TE2100 Table 4.7 and 4.8 New Barrier at Tilbury and Long Reach
- EA NR305781 q - Product 6 TE2100 Table 6.1 - Defence levels upriver of the Thames Barrier
- EA NR305781 r - Product 6 TE2100 Table 7.1 and 7.2 Defence levels downriver of the Thames Barrier
- (Gravesham Borough Council 2021) Gravesham Borough Council, Local Plan Regulation 18 Stage 2 Consultation - Gravesham Water and Flood Risk Background paper, October 2021.
- Kent County Council 2023. Flood maps
<https://webapps.kent.gov.uk/GIS/public/Floodmaps/>
- Kent Thameside 2005. Kent Thameside Delivery Board. Strategic Flood Risk Assessment of Kent Thameside

2.4. *Drawings*

- PDD-100116-LAY-122 / 30003364-MSE-XX-XX-DR-Y-10032 Tilbury Shaft General Arrangement
- PDD-100116-LAY-123 / 30003364-MSE-XX-XX-DR-Y-10033 Gravesend Shaft General Arrangement
- PDD-100116-DDR-125 / 30003364-MSE-XX-XX-DR-Y-10037 Tilbury Tunnel Construction Site Layout
- PDD-100116-DDR-125 / 30003364-MSE-XX-XX-DR-Y-10040 Tilbury Shaft Construction Site Layout

- PDD-100116-LAY-128 / 30003364-MSE-XX-XX-DR-Y-10041 Gravesend Shaft Construction Site Layout

2.5. References and Standards

- 1025273 / 001 / P04. Optioneering Report Grain-Tilbury and Kingsnorth-Tilbury 400kV Upgrading, December 2021.
- National Planning Policy Framework from the Department for Levelling Up, Housing and Communities (NPPF)
- Department of Energy and Climate Change (2011). Overarching National Policy Statement for Energy (EN-1).
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf
- Department for Levelling Up, Housing and Communities (2022). Guidance – Flood risk and coastal change. <https://www.gov.uk/guidance/flood-risk-and-coastal-change>
- Environment Agency (2018) SC060064/TR7 Coastal flood boundary conditions for the UK: update 2018. User guide
- Environment Agency (2018). Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels. <https://data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018>.
- Environment Agency (2022a). Guidance - Flood risk assessments: climate change allowances. <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>
- Environment Agency (2022b). Guidance - Peak rainfall climate change allowances by management catchment. <https://www.gov.uk/government/publications/peak-rainfall-climate-change-allowances-by-management-catchment>
- Environment Agency (2023a). Check the Long Term Flood Risk for an Area in England. Accessed April 2023. <https://flood-warning-information.service.gov.uk/long-term-flood-risk>
- Environment Agency (2023b). Flood Map for Planning. Accessed April 2023. <https://flood-map-for-planning.service.gov.uk/>
- Environment Agency (2023c). Product 4: Supporting Documentation. Version 6 Updated May 2023.
- Environmental Agency (2023d) Managing future flood risk and Thames Barrier: Thames Estuary 2100 <https://www.gov.uk/guidance/managing-future-flood-risk-and-thames-barrier-thames-estuary-2100>
- Met Office (2018). UK Climate Projections (UKCP18). Accessed May 2023. <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index>.
- NGTS 2.10.13 Issue 2 February 2016 Generic Electricity Substation Design Manual for Civil, Structural and Building Engineering - Flood Defences for Electricity Substations

NPS 18th Nov 2023

2.6. Definitions

Flood zones and flood risk are defined by The Environment Agency's current guidance on climate change allowances for flood risk assessments (2022a) and are shown in Table 1 for flood zones by river or sea and Table 2 from surface water

Table 1 - Flood Zone Definition by river or sea flooding

Flood Zone	Chance of flooding	Definition
Flood Zone 1 Low probability	Very Low	Land that could be affected by river or sea flooding that has less than a 0.1% (1 in 1,000) chance of occurring each year.
Flood Zone 2 Medium probability	Low	River - Land that could be affected by river flooding, if there were no defences, that has between a 1% (1 in 100) and 0.1% (1 in 1,000) chance of occurring each year; or Sea - Land that could be affected by sea flooding, if there were no defences, that has between a 0.5% (1 in 200) and 0.1% (1 in 1,000) chance of occurring each year.
Flood Zone 3a High probability	Medium	River - Land that could be affected by river flooding, if there were no defences, that has a 1% (1 in 100) or greater chance of happening each year; or Sea - Land that could be affected by sea flooding, if there were no defences, that has a 0.5% (1 in 200) or greater chance of happening each year.
Flood Zone 3b Functional Floodplain	High	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify, in their Strategic Flood Risk Assessments, areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency.

Table 2 - Flood Risk from Surface Water

Flood Risk from surface water	Definition
High Risk	High risk means that this area has a chance of flooding of greater than 3.3% each year . Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding.
Medium Risk	Medium risk means that this area has a chance of flooding of between 1% and 3.3% each year . Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding.
Low Risk	Low risk means that this area has a chance of flooding of between 0.1% and 1% each year . Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding.
Very Low Risk	Very low risk means that this area has a chance of flooding of less than 0.1% each year . Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding.

3. Planning and Flood Risk

3.1. General

Determining an application for planning consent when flood risk is a factor, the decision-making process is set out in the National Planning Policy Framework (NPPF) and the Overarching National Policy Statement for Energy (EN-1).

The Overarching National Policy Statement for Energy (EN-1) sets out national policy for nationally significant infrastructure projects (NSIPs) in the energy sector.

The overall strategic aims of the NPPF and the EN-1 are broadly similar, and their respective requirements are generally harmonised. However, the two have differing but equally important roles to play.

The NPPF provides a framework upon which local authorities can construct local plans to bring forward developments.

The EN-1 contains specific policies for development of Nationally Significant Infrastructure Projects (NSIPs) where particular considerations can apply. The EN-1 assumes that function and provides energy infrastructure policy which will guide individual development brought under it.

3.2. National Planning Policy

3.2.1. National Planning Policy Framework

The NPPF sets out the Government's planning policies for England, sets out how these should be applied and provides advice on how to take account of and address the risks associated with flooding in the planning process.

3.2.2. Overarching National Policy Statement for Energy

The EN-1 notes the minimum requirements for FRAs are that they should:

1. be proportionate to the risk and appropriate to the scale, nature and location of the project.
2. consider the risk of flooding arising from the project in addition to the risk of flooding to the project.
3. take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made.
4. be undertaken by competent people, as early as possible in the process of preparing the proposal.
5. consider both the potential adverse and beneficial effects of flood risk management infrastructure, including raised defences, flow channels, flood storage areas and other artificial features, together with the consequences of their failure.
6. consider the vulnerability of those using the site, including arrangements for safe access.

7. consider and quantify the different types of flooding (whether from natural and human sources and including joint and cumulative effects) and identify flood risk reduction measures, so that assessments are fit for the purpose of the decisions being made.
8. consider the effects of a range of flooding events including extreme events on people, property, the natural and historic environment and river and coastal processes.
9. include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular project.
10. consider how the ability of water to soak into the ground may change with development, along with how the proposed layout of the project may affect drainage systems.
11. consider if there is a need to be safe and remain operational during a worst-case flood event over the development's lifetime.
12. and be supported by appropriate data and information, including historical information on previous events.

While this assessment has been undertaken in line with the requirements of the Infrastructure and Planning Commission (IPC) the project is a strategic development undertaken using National Grids permitted development rights.

- the Sequential Test has been applied as part of site selection.
- a sequential approach has been applied at the site level to minimise risk by directing the most vulnerable uses to areas of lowest flood risk.
- the proposal is in line with any relevant national and local flood risk management strategy, as provided for in section 9(1) of the Flood and Water Management Act 2010.
- priority has been given to the use of sustainable drainage systems (SuDs)(as required in the next paragraph on National Standards).
- and in flood risk areas that the project is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed over the lifetime of the development.

3.3. *Site-specific flood risk assessment –EA guidance.*

From the EA Flood Risk and Coastal Change, ref *Paragraph: 020 Reference ID: 7-020-20220825, revision date 25 08 2022* (<https://www.gov.uk/guidance/flood-risk-and-coastal-change#para40>)

Developers can use the Environment Agency guidance on flood risk assessments when considering the scope of the assessment.

The objectives of a site-specific flood risk assessment are to establish:

- whether a proposed development is likely to be affected by current or future flooding from any source;
- whether it will increase flood risk elsewhere;

- whether the measures proposed to deal with these effects and risks are appropriate;
- the evidence for the local planning authority to apply (if necessary) the Sequential Test
- whether the development will be safe and pass the Exception Test, if applicable.

In the context of how flood risk will be managed now and over the development's lifetime, taking climate change into account, and with regard to the vulnerability of it's users as defined in the NPPF Annex 3 – Flood Risk Vulnerability.

Paragraph: 021 Reference ID: 7-021-20220825 Revision date: 25 08 2022
(<https://www.gov.uk/guidance/flood-risk-and-coastal-change#para40>)

The information provided in the flood risk assessment needs to be credible and fit for purpose. Site-specific flood risk assessments need to be proportionate to the anticipated degree of flood risk and make optimum use of information already available, including information in a Strategic Flood Risk Assessment for the area, and the Environment Agency's <https://flood-map-for-planning.service.gov.uk/> and surface water flood risk information on <https://www.gov.uk/check-long-term-flood-risk>. Flood risk assessments need to include the information set out in the flood risk assessment checklist.

The scope and detail of the flood risk assessment needs to be appropriate to the scale, nature and location of the development. Further advice for applying for planning permission can be found on <https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications>.

Paragraph: 022 Reference ID: 7-022-20220825 (<https://www.gov.uk/guidance/flood-risk-and-coastal-change#para40>)

For large or vulnerable developments in areas of high risk, developers should consider consultation with the Environment Agency and/or any other relevant flood risk management bodies for more detailed advice in advance of submitting their planning application.

Applicants for planning permission (or prior approval for certain permitted development rights, or technical details consent) will find the Agency's advice on assessing flood risk for planning applications <https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications> helpful when preparing a site-specific flood risk assessment.

The checklist may be helpful to applicants/developers in preparing a site-specific flood risk assessment.

Advice should also be sought from the local authority and lead local flood authority. Refer to <https://www.gov.uk/guidance/flood-risk-and-coastal-change#para40>.

3.4. *Design flood and project lifetime*

3.4.1. *Design Flood*

The Flood risk and coastal change guidance (DLUCH, 2022) defines the design flood to be taken as:

- River flooding likely to occur with a 1% (1:100) annual probability with an appropriate allowance for climate change.
- Tidal flooding with a 0.5% (1:200) annual probability with an appropriate allowance for climate change.
- Surface water flooding likely to occur with a 1% annual probability with an appropriate allowance for climate change.

The design approach adopted for the project flood risk assessment includes these guidelines

The design flood must also show compliance with NPS EN-1 Paragraph 5.7.5

- To consider if there is a need to be safe and remain operational during a worst-case flood event over the development's lifetime

And with Paragraph 5.7.24 of NPS EN-1

- Essential energy infrastructure which has to be located in flood risk areas should be designed to remain operational when floods occur.

The design flood is used to demonstrate the compliance with NPPF overarching requirement for

- In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

3.4.2. *Project Lifetime*

The Project has adopted a climate change horizon of 2148 based on becoming operational in 2028, this accommodates the lifetime for the Project of at least 120 years.

The Flood risk and coastal change guidance (DLUCH, 2022) is limited to epoch up to 2125 and advises that where development has an anticipated lifetime significantly beyond 100 years such as some major infrastructure projects it may be appropriate to consider a longer period for the lifetime of development for modelling extreme water levels (EWLs).

The Overarching National Policy Statement for Energy (EN-1) does not specify a lifetime for energy transmission infrastructure.

A precautionary approach has been adopted for assessment of flood risk, this includes

- The Upper end climate change allowances (for sea level rise, peak river flow and peak rainfall) applied in the Project design are precautionary and equate to the 95th percentile of the UKCP18 RCP8.5 climate change scenario.
- An extreme event has been considered for the flood protection measures 0.1% AEP

- The flood defence level has been adopted as the 0.1% AEP tidal Extreme Water Level with climate change allowance, with a residual uncertainty allowance added.
- The 0.1% AEP tidal Extreme Water Level has been adopted as the 0.1% AEP tidal River Thames Extreme Water Level. This is precautionary as it considers the residual flood risk in the event of breach to flood defences.
- A residual uncertainties allowance of 0.3m has been suggested for flood mitigation, however this will need to be addressed separate from this assessment as part of the design.

Whilst the Project has been designed to remain operational until 2148 during the design flood, and the 0.1% AEP tidal flood, with precautionary climate change allowances. The Project design will need to consider how readily adaptable the structure needs to be to accommodate a more extreme climate change scenario (including the credible maximum climate change scenario. This report has considered a project lifetime of 120 years, however NGTS 2.10.13 recommends a 50 year period

3.5. *Climate Change*

3.5.1. *General*

Climate change has the potential to increase peak rainfall intensity. This results in a corresponding increase in the rate and volume of runoff being discharged to local watercourses and subsequently creates an escalation in flood risk. Furthermore, sea levels are also projected to increase as a result of climate change.

Part 2 of the NPS EN-1 covers the Government's energy and climate change strategy, including policies for mitigating climate change. This part of the EN-1 sets out how the effects of climate change need to be taken into account when developing and consenting infrastructure. While climate change mitigation is essential to minimise the most dangerous impacts of climate change, previous global greenhouse gas emissions have already committed us to some degree of continued climate change for at least the next 30 years. If new energy infrastructure is not sufficiently resilient against the possible impacts of climate change, it will not be able to satisfy the energy needs as outlined in Part 3 of the NPS EN-1. Refer to Section 4.8 of EN-1 for further details on climate change adaptation.

The Environment Agency's current guidance on climate change allowances for flood risk assessments (2022a) has undergone a number of iterations since publication of UK Climate Change Predictions 2018 (UKCP18) (Met Office, 2018). These iterations are detailed in The Environment Agency's current guidance on climate change allowances for flood risk assessments (2022a).

3.5.2. *Peak rainfall intensity allowances*

The anticipated changes in peak rainfall intensity allowances by management catchment (Environment Agency, 2022b) for the management catchment for South Essex (Table 3) and Medway (Table 4).

Table 3. South Essex Management Catchment peak rainfall allowances

Epoch	Allowance ¹			
	3.3% AEP event		1% AEP event	
	Central	Upper end	Central	Upper end
2050s epoch (2022 and 2060)	20%	35%	20%	45%
2070s epoch (2061 and 2125)	20%	35%	25%	40%

Table 4. Medway Management Catchment peak river flow allowances

Epoch	Allowance ¹			
	3.3% AEP event		1% AEP event	
	Central	Upper end	Central	Upper end
2050s epoch (2022 and 2060)	20%	35%	20%	45%
2070s epoch (2061 and 2125)	20%	35%	20%	40%

¹ EA Climate change allowances <https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall>

The development is planned to have a minimum lifetime of 120 years and for the purposes of appraisal of climate change allowances, the lifetime of the project is assumed to be up to 2148. For a development lifetime beyond 2100 the guidance stipulates flood risk assessments and strategic flood risk assessments should assess the upper end allowances for both the 1% and 3.3% annual exceedance probability (AEP) events for the 2070s epoch (2061 to 2125).

The development must also be designed so that for the upper end allowance in the 1% AEP event;

- there is no increase in flood risk elsewhere
- your development will be safe from surface water flooding
- In some locations the allowance for the 2050s epoch is higher than that for the 2070s epoch. If so, and development has a lifetime beyond 2061, the guidance requires the use the higher value of the two allowances.
- The Environment Agency guidelines (2022a) do not specify peak rainfall allowances for extreme climate change scenarios (H++).

Increased rainfall affects surface water flood risk and how you need to design drainage systems. River flow allowances are not to be used together with rainfall allowances as they are not compatible and are essentially modelling the same hazard in different ways.

3.5.3. Peak river flow allowances

Peak river flow allowances show the anticipated changes to peak flow by management catchment. Management catchments are sub-catchments of river basin districts.

The range of allowances is based on percentiles, which describe the proportion of possible scenarios that fall below an allowance level. The percentiles for peak river flow allowances are as follows:

The central allowance is based on the 50th percentile.

The higher central allowance is based on the 70th percentile.

The upper end allowance is based on the 95th percentile.

Table 5 and Table 6 shows anticipated peak river flow allowances for the South Essex Management Catchment and Medway Management Catchment for the Thames River Basin District (Department for Environment, Food and Rural Affairs (Defra), 2022).

Table 5. South Essex Management Catchment peak river flow allowances

Epoch	Allowance		
	Central (50 th percentile)	Higher central (70 th percentile)	Upper end (95 th percentile)
2020s epoch (2015 to 2039)	6%	11%	22%
2050s epoch (2040 to 2069)	5%	11%	27%
2080s epoch (2070 to 2125)	17%	26%	48%
EA Climate Change Allowances, DEFRA 2022 https://environment.data.gov.uk/hydrology/climate-change-allowances/river-flow			

Table 6. Medway Management Catchment peak river flow allowances

Epoch	Allowance		
	Central (50 th percentile)	Higher central (70 th percentile)	Upper end (95 th percentile)
2020s epoch (2015 to 2039)	14%	19%	29%
2050s epoch (2040 to 2069)	15%	21%	37%
2080s epoch (2070 to 2125)	27%	37%	62%
EA Climate Change Allowances, DEFRA 2022 https://environment.data.gov.uk/hydrology/climate-change-allowances/river-flow			

The application of the river flow allowances is a function of the flood risk vulnerability classification classify the vulnerability for the type of development and flood zone.

Refer to Table 7 for allocation of allowances based on the Environment Agency's guidance on climate change allowances (2022a).

Table 7. Peak river flow allowances by flood risk vulnerability and the flood zone

Flood Zone	Allowance Category applied				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
2	Higher central	Central	Central	Central	Central
3a	Higher central	Development should not be permitted	Central	Central	Central
3b	Higher central	Development should not be permitted	Development should not be permitted	Development should not be permitted	Central

The project is designated as essential infrastructure, lies in Flood Zone 3a and has a minimum lifetime of 120 years, the 'higher central' peak river flow allowances for the 2080s epoch should be used to assess fluvial flood risk.

Impacts and calculation of floodplain storage compensation is also required to be assessed where the appropriate allowance to assess off-site impacts and calculate floodplain storage compensation depends on land uses in affected areas. As this project is defined as essential infrastructure, lies in Flood Zone 3a and has a minimum lifetime of 120 years, the 'higher central' allowance for the 2080s epoch should be used to assess fluvial flood risk.

The Environment Agency guidelines (2022a) do not specify peak river flow allowances for extreme climate change scenarios (H++).

3.5.4. Sea level allowances

The Environment Agency's guidance on climate change allowances (2022a) specifies UKCP18 to provide projections of relative mean sea level rise around the whole UK coast. On the basis of the UKCP18 Representative Concentration Pathway (RCP) 8.5 the following specifications are used:

- 70th percentile (higher central) as the design allowance
- 95th percentile (upper end) allowance in planning for more severe climate impacts

An allowance based on the 70th percentile is exceeded by 30% of the projections in the range. At the 95th percentile it is exceeded by 5% of the projections in the range.

The Environment Agency's guidance on climate change allowances (2022a) specifies the use of climate change allowances from UKCP18 and the present-day extreme sea levels from Coastal design sea levels - coastal flood boundary extreme sea levels CFB2018. The present-day extreme sea levels CFB2018 also account for the astronomical tide level and the surge.

The UKCP18 dataset projects to 2100 and the guidance uses the UKCP18 RCP 8.5 climate change model which is considered to be the reasonable worst case scenario.

To perform extra assessment for the lifetime of the scheme after 2125, the Environment Agency's guidance on climate change allowances (2022a) specifies the use of the UKCP18 sea level rise projections to 2300 for RCP 8.5.

The sea level rise data for each epoch until 2125 data is presented in "Table 1" of the Environment Agency's guidance on climate change allowances (2022a) is taken from the UKCP18 user interface dataset. It presents change using RCP8.5 at the *Higher Central*, 70th percentile and *Upper End* 95th percentile, based on a 1981 to 2000 baseline. Environment Agency's guidance on climate change allowances (2022a) recommends using the climate change allowances from the UKCP18 interface in flood risk assessments.

The Environment Agency's guidance on climate change allowances (2022a) specifies sea level rise allowances to be applied in flood risk assessments. Assessment for the Thames River basin district should use 'south east' sea level rise allowances, these allowances are reproduced in Table 8. These sea level allowances by river basin district for each epoch in mm for each year (based on a 1981 to 2000 baseline) – the total sea level rise for each epoch is in brackets.

Table 8. Sea level allowances by river basin district

Area of England	Allowance	2000 to 2035 (mm/yr)	2036 to 2065 (mm/yr)	2066 to 2095 (mm/yr)	2096 to 2125 (mm/yr)	Cumulative rise 2000 to 2125 (metres)	2126 to 2048 extrapolated (mm/yr)	Extrapolated Cumulative rise 2025 to 2148 (metres)
South east	Higher central	5.7 (200)	8.7 (261)	11.6 (348)	13.1 (393)	1.20	13.1 (301.3)	1.50
South east	Upper end	6.9 (242)	11.3 (339)	15.8 (474)	18.2 (546)	1.60	18.2 (418.6)	2.02

Data from EA sea level allowances by river basin district, Table 1 <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#river-basin-district>

Notes

The site is located within the Thames river basin district, therefore the 'south east' sea level rise allowances should be used

The total sea level rise for each epoch is shown in brackets (mm).

The cumulative rise 2017 to 2148 has been extrapolated beyond 2125.

The allowances in this table account for slow land movement. This is due to 'glacial isostatic adjustment' from the release of pressure at the end of the last ice age.

For use of the 2018 Coastal Flood Modelling Data outputs: The upper end allowance becomes progressively higher each year than the climate change flood level outputs used in the current EA 2018 coastal flood model. So as an approximation the EA recommends that the following uplift values (Table 9) are added on to the on-site climate change flood levels provided in the Product 4:

Table 9. Upper End CFB2018 Coastal Flood Modelling uplifts

	Allowance	2122 (mm)	2123 (mm)	2124 (mm)	2125 (mm)	Extrapolated to 2048 (mm/yr)
Tilbury Site	Upper End	+0.34m	+0.36m	+0.38m	+0.40m	+0.86

The Environment Agency's guidance on climate change allowances (2022a) specifies 'For flood risk assessments and strategic flood risk assessments, assess both the higher central and upper end allowances.'

3.5.5. H++ sea level rise allowance

Where it is appropriate to apply a credible maximum scenario, use the H++ allowance. There is no H++ value for sea level rise beyond 2100.

The Environment Agency also states

- For the change to relative mean sea level use the H++ scenario of 1.9m for the total sea level rise to 2100. However the lifetime of the project extends 48 years beyond 2100, therefore this is not appropriate to be applied and may be misleading. For assessment of the H++ scenario beyond 2100 the guidance recommends contacting the EA for further guidance.
- MSES is awaiting guidance on an accepted approach to extend the H++ climate scenario beyond 2100

3.5.6. Offshore wind speed and extreme wave height allowance

Wave heights may change because of increased water depths and changes to the frequency, duration and severity of storms

It is assuming offshore wind speed and extreme wave height allowance is included in the TE2100 and CFB2018 baseline EWLs. UKCP18 on other hand only comprises the predicted sea level rise from the CFB2018 baseline EWLs.

Table 2 of the Environment Agency's guidance on climate change allowances (2022a) specifies the appropriate allowance for wind speed and wave height (Table 10) if not already included in the coastal model used. The appropriate allowance is selected by the epoch that the lifetime of the development fall into, or use the 2056 to 2125 epoch where the development lifetime is beyond 2056

The guidance (Environmental Agency 2022a) recommends using the epoch that the lifetime of the development falls into to choose the appropriate allowance. If the development lifetime is beyond 2056, the guidance recommends using the allowance for the 2056 to 2125 epoch. The allowances are not cumulative across the epochs.

Where it is appropriate to apply a credible maximum scenarios the sensitivity test allowances are used in addition to the offshore wind speed and extreme wave height allowances for assessments.

Table 10. offshore wind speed and extreme wave height allowance (based on a 1990 baseline)

Applies all around the English coast	2000 to 2055	2056 to 2125
Offshore wind speed allowance	5%	10%
Offshore wind speed sensitivity test	10%	10%
Extreme wave height allowance	5%	10%
Extreme wave height sensitivity test	10%	10%
Data from EA sea level allowances by river basin district, Table 2 https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#river-basin-district		

3.5.7. Storm surge

The present day extreme sea levels in Coastal design sea levels – coastal flood boundary extreme sea levels (CFB2018) accounts for storm surge <https://www.data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018>. Most Environment Agency coastal models use these extreme sea levels.

The guidance recommends in the case the selected coastal model used in the EWL assessment does not include an allowance for storm surge, the Environment Agency's guidance on climate change allowances (2022a) specifies the use of CFB2018 extreme sea levels. Then apply the climate change sea level rise values in table 1 of the guidance (summarised in Table 8 above).

Where it is appropriate to assess a credible maximum scenario, add 2mm for each year starting from 2017.

The EA has provided a coastal flood boundary extreme sea levels estuary (2018) dataset for key estuaries around the UK

3.5.8. Credible maximum scenarios

Although this project is not an NSIP the process has been followed as if it were and as such, assessed the flood risk from a credible maximum climate change scenario.

For a credible maximum climate change scenario, Environment Agency's guidance on climate change allowances (2022a) recommends the following:

- The H++ climate change allowances for sea level rise.
- The upper end allowance for peak river flow.
- The sensitivity test allowances for offshore wind speed and extreme wave height.
- An additional 2mm for each year on top of sea level rise allowances from 2017 for storm surge.

Paragraph 4.8.8 from the EN-1 recommends it must be demonstrated there are no features of the design of new energy infrastructure critical to its operation which may be seriously affected by more radical changes to the climate beyond that projected in the latest set of UK climate projections, taking account of the latest credible scientific evidence on, for example, sea level rise (for example by referring to additional maximum credible scenarios - " i.e. from the Intergovernmental Panel on Climate Change or EA) and that necessary action can be taken to ensure the operation of the infrastructure over its estimated lifetime.

The credible maximum scenarios act as a 'sensitivity test', that will help to assess how sensitive the proposed construction is to changes in the climate for different future scenarios. This will help to ensure your development can be adapted to large-scale climate change over its lifetime.

3.5.9. *Credible Sea level allowances*

Calculation of the EWL for the 0.5% and 0.1% AEP events for Tilbury (the Project location) was based on the Thames Estuary 2100 Plan (TE2100), (Environment Agency, 2018) Extreme Water Levels (EWL), the current coastal boundary dataset (Environment Agency, 2018) (CFB2018), UK Climate Projections (UKCP18) and the Environment Agency's guidance on climate change allowances for flood risk assessments (2022a). It is noted the TE2100 EWL has not yet been updated since it was developed in 2008, while the EA current coastal boundary dataset has been updated in 2018 and been updated since. Therefore the TE2100 EWLs may not provide the most current EWLs. Using a comparative approach between CFB2018 + UKCP18 and TE2100, the Design EWL for the 0.5% AEP event at Tilbury (Gravesend Power Station node) was taken as 6.9m above ordnance datum (mAOD). Derivation of the EWLs can be found in Section 4.7.3.

The H++ sea level rise allowance is specified in the current guidance as +1.9m in 2100, with no specified value beyond 2100. H++ storm surge allowances are specified as annual rates of rise of 2mm/year from 2017 onwards. The expected lifetime of the project is however until at least 2148, therefore the H++ sea level rise allowance to 2100 is not suitable. At the time of writing this revision of the report, MSES was awaiting information from the EA to confirm and accepted approach for estimating H++ for 2148.

3.5.10. *Consideration of current CFB2018 and UKCP18 datasets*

The TE2100 flood level modelling based on 2008 climate modelling was undertaken before the current EA Coastal Flood Boundary 2018 (CFB2018) dataset and UKCP18 climate change allowances were available. TE2100 flood level modelling is based on statistical analysis of historic sea level data to set a baseline for each water level. These baselines provide a starting point from which the Environmental Agency can monitor change in the estuary. There are 2 baselines. One baseline is for a storm tide with a 1 in 1000 (0.1%) chance of occurring in any year. The other baseline is for the Mean High Water Springs tide.

Therefore for consideration of residual flood risk due to breach of flood defences TE2100 EWLs need to be adjusted to account for the CFB2018 and UKCP18 datasets. The Environmental Agency guidance for sea level rise for this consideration specifies the 70% percentile (Higher Central) and CRP8.5 climate warming scenario to provide design values, and the 95% percentile (Upper End) for maximum credible values.

TE2100 EWLs have been adjusted in line with latest CFB2018 and UKCP18 datasets as follows:

- Select the south end location where TE2100 and UKCP18 can be directly compared and assess the EWLs based on application of UKCP18 sea level rise (SLR) to CFB2018 EWLs (Table 11 for Higher Central EWLs, Table 13 for Upper End EWLs).
- Compare the EA TE2100 EWLs specified at Southend for different future years with EWLs at Southend derived by applying the current coastal flood boundary dataset (CFB2018) and the current UKCP18 sea level rise (SLR) allowances (Table 12 for Higher Central EWLs, Table 14 for Upper End EWLs).

- Assign revised future years to the TE2100 EWLs at Southend (the years for which the TE2100 EWLs would apply if current datasets are used), and hence different years to the corresponding TE2100 EWLs in the Thames Estuary (i.e. at the TE2100 Tilbury Ferry model node).
- Interpolate or extrapolate EWLs for 2148 based on the revised future years for the TE2100 EWLs for Gravesend Power Station.

The project requires EWLs for 2028 and 2148. These values are interpolated from values in Table 12 and Table 14 as 5.78 mOD and 6.98 mOD respectively for the 1000-year return period at the TE2100 Gravesend Power Station model node. For the 200-year return period the EWLs are 5.45 mOD and 6.76 mOD respectively.

Table 11. CFB2018 and UKCP18 (Higher Central) EWLs for South End (1 in 1000)

Year of CFB2018 and UKCP18	CFB2018 1 in 1000 EWL at Southend (mOD)	UKCP18 1 in 1000 sea level rise (SLR) at Southend (mOD)	Offshore wind 2056 to 2125 (%)	Extreme wave height 2056 to 2125 (%)	Surge 2mm/yr from 2017 (m)	Difference (m): UKCP18 EWL - CFB2018 EWL (base year 2017) 1 in 1000	UKCP18 EWL (mOD) (applying UKCP18 SLR to CFB2018 EWLs)
2005							
2018	5.02						
2040		5.18	5	5	0.046	0.23	5.25
2070		5.44	10	10	0.106	0.63	5.65
2100		5.78	10	10	0.166	1.11	6.13
2120		6.03	10	10	0.206	1.46	6.48
2148		6.36	10	10	0.262	1.92	6.94
2170		6.62	10	10	0.306	2.29	7.31

Table 12. Higher Central Adjusted 200 year and 1000 year return period TE2100 EWLs at Gravesend Power Station

Year of TE2100 EWL	TE2100 1 in 1000 EWL at Southend (mOD)	1 in 1000 Difference (m): TE2100 EWL - CFB2018 EWL (base year 2017)	Revised year in which CFB2018 1 in 1000 value matches TE2100 EWL 1 in 100 value at Southend (applying UKCP18 SLR to CFB2018 EWLs)	1in 200 EWL at Gravesend Power Station for revised year (mOD)*	1in 1000 EWL at Gravesend Power Station for revised year (mOD)*
2005	5.03	0.01	2019	5.38	5.71
	-	-	2028	5.47	5.80
2040	5.24	0.22	2039	5.59	5.92
2070	5.55	0.53	2063	5.75	6.08
2100	5.95	0.93	2091	6.05	6.38
2120	6.25	1.23	2111	6.28	6.61
	-	-	2148	6.90	7.09
2170	7.00	1.98	2155	7.03	7.19

Table 13. CFB2018 and UKCP18 (Upper End) EWLs for South End (1 in 1000)

Year of CFB2018 and UKCP18	CFB2018 1 in 1000 EWL at Southend (mOD)	UKCP18 1 in 1000 sea level rise (SLR) at Southend (mOD)	Offshore wind 2056 to 2125 (%)	Extreme wave height 2056 to 2125 (%)	Surge 2mm/yr from 2017 (m)	Difference (m): UKCP18 EWL - CFB2018 EWL (base year 2017) 1 in 1000	UKCP18 EWL (mOD) (applying UKCP18 SLR to CFB2018 EWLs)
2005							
2018	5.02						
2040		5.25	5	5	0.046	0.30	5.32
2070		5.58	10	10	0.106	0.80	5.82
2100		6.05	10	10	0.166	1.44	6.46
2120		6.40	10	10	0.206	1.91	6.93
2148		6.88	10	10	0.262	2.54	7.56
2170		7.25	10	10	0.306	3.04	8.06

Table 14. Upper End Adjusted 200 year and 1000 year return period TE2100 EWLs at Gravesend Power Station

Year of TE2100 EWL	TE2100 1 in 1000 EWL at Southend (mOD)	1 in 1000 Difference (m): TE2100 EWL - CFB2018 EWL (base year 2017)	Revised year in which CFB2018 1 in 1000 value matches TE2100 EWL 1 in 100 value at Southend (applying UKCP18 SLR to CFB2018 EWLs)	1in 200 EWL at Gravesend Power Station for revised year (mOD)*	1in 1000 EWL at Gravesend Power Station for revised year (mOD)*
2005	5.03	0.01	2019	5.38	5.71
-	-	-	2028	5.52	5.85
2040	5.24	0.22	2032	5.59	5.92
2070	5.55	0.53	2054	5.75	6.08
2100	5.95	0.93	2076	6.05	6.38
2120	6.25	1.23	2089	6.28	6.61
2170	7.00	1.98	2123	7.03	7.19
-	-	-	2148	7.58	7.61

4. New Tilbury CSEC

4.1. Development site and location

4.1.1. Location

Nearest address: Cooper Shaw Road, West Tilbury, Thurrock, England, RM18 8TH, United Kingdom.

Coordinates:

Table 15. New Tilbury CSEC coordinates

Shaft	X (Easting)	Y (Northing)
Tilbury Shaft	566288.08	175840.65

4.1.2. Current use

The proposed site location is currently a hardstanding area surrounded by historic ash landfill site to the east and the former Tilbury B Power Station site to the west (Figure 1).

4.1.3. Flood Zone

The New Tilbury CSEC site is located at the above coordinates with the boundary located in the figure below. The proposed site is situated within **Flood Zone 3**

4.1.4. Other sources of flooding

The Tilbury CSEC site is not located in an 'Area of Critical Drainage'(AoCD), which are defined as being 'A discrete geographic area where multiple and/or interlinked sources of flood risk (surface water, groundwater, sewer, main rivers and/or tidal) cause flooding in one or more Local Flood Risk Zones (LFRZ) during severe weather thereby affecting people, property or local infrastructure'. However, the site location is susceptible surface water flooding.

A summary of source of sources of flooding is made in Table 16.

Table 16. Sources of flooding

Source	Y	N
Residual flood risk due to breach or overtopping of flood defences	Y	
Located near a main river	N	Not located near a main river, but located adjacent to drainage ditches
Located within an area of Critical Drainage	N	Not located in an area of Critical Drainage
Areas Susceptible to Groundwater Flooding	Y <25%	
Climate change over the lifetime of the development	Y	
Surface water flood risk	Y	
Sewers	N	
Canal	N	



Figure 1. Tilbury CSEC location and potential site boundary. (Imagery Date: 8/05/2022 Google earth V 7.3.3.9345 (64-bit). (December 29, 2022). 51° 27' 04.85"N, 0° 23' 39.74"E, Eye alt 1.77km)

4.2. Flood Risk Screening

A summary of flood risk to the Tilbury CSEC from all sources is provided in Table 17.

Table 17. Flood risk screening: New Tilbury CSEC

Flooding source	Chance of Flooding	Source	Pathway/Comment
Fluvial	Very Low Risk to Low Risk	Thames River Estuary	Flood Zone 3a Very low to low risk. Flood defences reduce the risk but do not completely stop the chance of flooding as they can be overtopped, or fail.
Tidal	Very Low Risk to Low Risk	Thames River Estuary	Flood Zone 3a Very low to low risk. Residual Risk for breach or overtopping: Medium risk of flooding from the south via Land that could be affected by sea flooding, if there were no defences, that has a 0.5% (1 in 200) or greater chance of happening each year. Flood risk to increase over time due to flood defence levels being maintained at their current levels under TE2100 Policy Plans
Groundwater	Low Risk	Groundwater emergence	Limited potential for groundwater flooding to occur, BGS flood GFS Data. The BGS Geology and available ground investigations shows Chalk overlain by superficial deposits of alluvial gravels sands clays and peats capped by made ground. There is anticipated to be a low risk of localised emergence of groundwater at shallow depths within the superficial geology and fill. Flooding of this nature is likely to be localised and shallow in depth. Boreholes indicate there is a wider scale deposit of granular material and the chalk is anticipated to have an emergence of groundwater at depth, but will not be expected to come to the surface.
Sewers	No	None	None
Surface water	Very low to High	Surface water features and drainage channels	High risk means that this area has a chance of flooding of greater than 3.3% each year. Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding. Run-on: an area within the site near to the north side of the proposed shaft is at risk of surface water flooding as identified by the EA flood risk maps in a low area. This would likely be eliminated through ground re-profiling and

Flooding source	Chance of Flooding	Source	Pathway/Comment
			establishment surface gradients to direct runoff from the site as part of the construction of the proposed site works. Run-off: surface water run-off rates and volumes are dependent upon the final site layout and design; to be assessed in greater detail in Phase 2 of the FRA.
Reservoirs	Coverage	Not specified	No reservoir influence on the site
Artificial sources (e.g. canals)	Coverage	Not specified	No artificial sources risk flooding the site

A more comprehensive assessment of flood risk from High, Medium and Low flood risk sources is provided in Section 4.6 Covering the tidal, groundwater and surface water.

4.3. Development Description

This section will provide a general summary of the development proposals.

4.3.1. Development proposal

At the Tilbury site the project proposal is for a new Cable Sealing End Compound comprising of electrical equipment associated with the transfer from overhead line to the tunnel, a head house and a shaft connecting to the proposed tunnel.

4.3.2. Flooding Vulnerability Classification

Using Annex 3 of the National Planning Policy Framework, flood risk vulnerability classification the development falls under the Essential Infrastructure vulnerability classification.

- Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including infrastructure for electricity supply and distribution systems.

4.3.3. Expected estimated lifetime

The expected estimated lifetime for the proposed development is 120 years.

Table 18 is based on Table 2 of the DLUHC guidance (DLUHC, 2022).

This table shows the compatibility of flood risk vulnerability classifications and Flood Zones. As essential infrastructure, the Project is appropriate in all Flood Zones. However, for development in Flood Zones 3a and 3b, an Exception Test must be undertaken.

Table 18. Flood risk vulnerability and flood zone 'incompatibility'

Flood Zones	Flood Risk Vulnerability Classification				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	X	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	X	X	X	✓ *

Key:

✓ Exception test is not required

X Development should not be permitted

This table does not show the application of the Sequential Test which should be applied first to guide development to the lowest flood risk areas; nor does it reflect the need to avoid flood risk from sources other than rivers and the sea;

The Sequential and Exception Tests do not need to be applied to those developments set out in National Planning Policy Framework footnote 56. The Sequential and Exception Tests should be applied to 'major' and 'non major' development.

Some developments may contain different elements of vulnerability and the highest vulnerability category should be used unless the development is considered in its component parts.

"†" In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

"*" In Flood Zone 3b (functional floodplain) essential infrastructure that has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

remain operational and safe for users in times of flood.

result in no net loss of floodplain storage.

not impede water flows and not increase flood risk elsewhere.

4.4. Sequential Test

4.4.1. Site search area

The assumptions and requirements considered for the location of the Tilbury CSEC Shaft are detailed in Section 2 of the Options Appraisal and Sift Report, Report No. PDD-100116-REP-011 / 30003364-MSE-XX-XX-RP-Y-10010

4.4.2. Wider sustainable development objectives

The Mott Macdonald Optioneering Report 102573/001/P04 report that preceded the Options Appraisal and Sift Report, identified a number of alternative solutions for the upgrade of the cable crossing. These options included: the reuse of the existing tunnel; the use of the new Lower Thames Crossing; and a pylon crossing over the River Thames. Findings identified the existing cable tunnel will not be able to meet the requirements of the new cable design; The Lower Thames crossing will not be built by 2028 to meet OFGEM requirements, and the Pylons would need to be sited in the RAMSAR site to the south of the existing Gravesend Sealing End Compound.

Historic, current and known future land use is considered in the Options Appraisal and Sift Report were used to consider multiple sites. Wider sustainable development objectives that would otherwise steer the development to other locations are inappropriate due to the environmental and infrastructure constraints.

4.4.3. Alternative sites

The Options Appraisal and Sift Report identified constraints from the desk study which are indicated on drawings PDD-100116-DDR-006/30003364-MSE-XX-XX-DR-Y-10011 for Tilbury and PDD-100116-DDR-008/30003364-MSE-XX-XX-DR-Y-10013 for the crossing of the River Thames.

No other alternative sites are reasonably available to provide practical or viable options for construction of a shaft or cable tunnel and meet the assumptions and requirements identified in the Options Appraisal and Sift Report. The selection of the preferred site is however not based on Flood Risk.

4.4.4. Accounting of other sources of flooding

All sources of flooding have been accounted for and will be required to be designed for in the development.

4.4.5. Application of the Sequential Test

The Sequential Test is a risk-based approach to locating a development designed to steer a new development to areas with the lowest probability of flooding or demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the development being proposed.

Application of the Sequential Test is set out in Diagram 2 of the DLUHC guidance (DLUHC, 2022) and described in paragraph 5.7.13 of the EN-1.

Table 19, which is based on Diagram 2 of the DLUHC guidance (DLUHC, 2022), sets out the application process for the Sequential Test as used for the Tilbury Site.

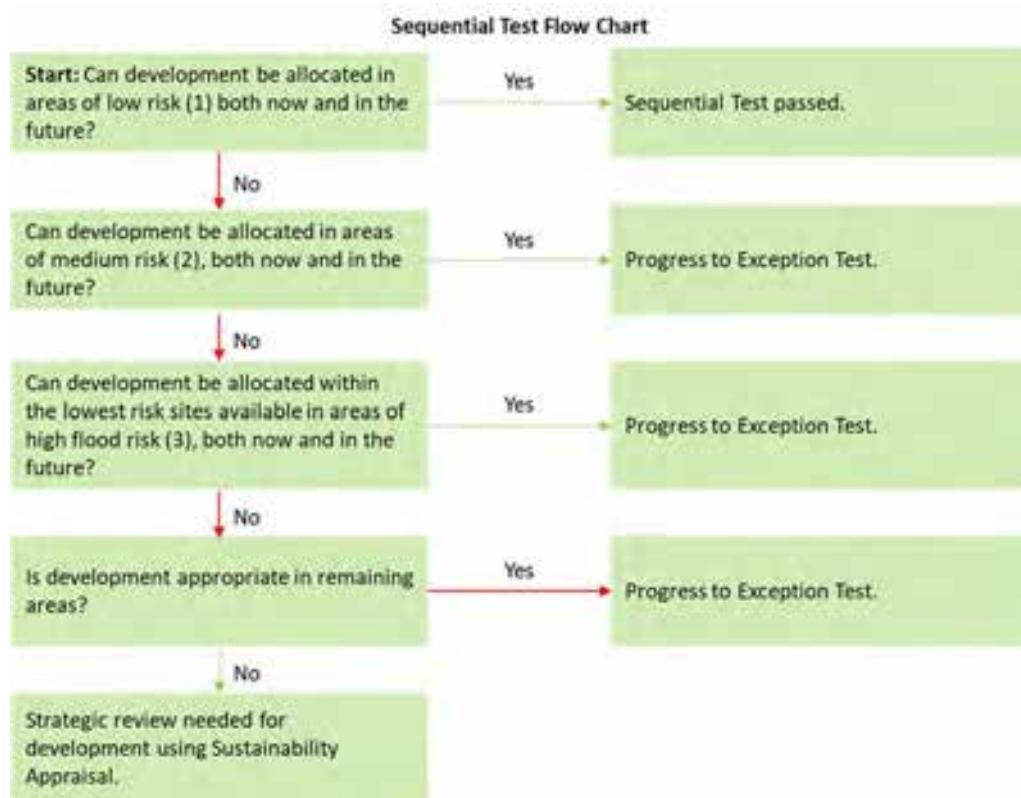


Table 19. Sequential test flow chart for Tilbury

In the case for the Tilbury site the preferred site location has not been selected on the basis of lowest flood risk, but on the basis of an options appraisal in the Options Appraisal and Sift Report. Therefore, the Sequential test flow chart defaults to development that is appropriate in the remaining areas and will require an Exceptions Test.

4.5. Exceptions Test

Where application of the sequential test is not possible, or the sequential test flow chart in Table 19 indicates the Exceptions test is required, the flow chart in Table 20 is required to be followed.

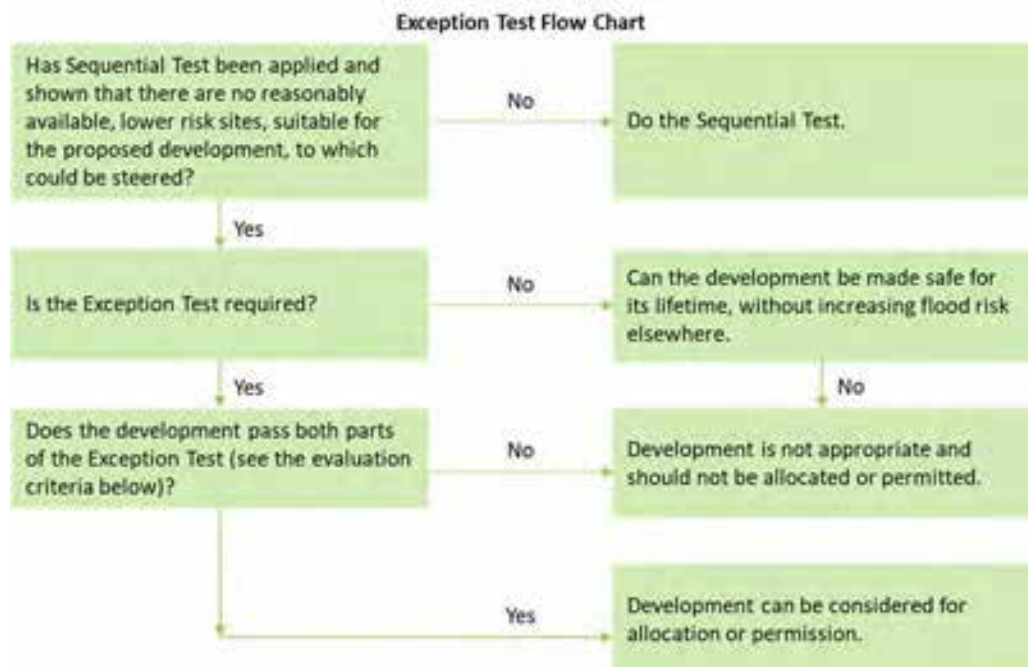


Table 20. Exceptions test flow chart

4.5.1. Test evaluation criteria

The evaluation criteria for the Exception Test is set out in the DLUHC guidance (DLUHC, 2022) and paragraph 5.7.16 of the EN-1 and shown in Table 20. For the Exception Test to be passed, the following must be demonstrated:

- it must be demonstrated that the project provides wider sustainability benefits to the community (These would include the benefits (including need), for the infrastructure set out in Part 3 of EN-1.) that outweigh flood risk;
- the project should be on developable, previously developed land as defined in EN-1 or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously developed land subject to any exceptions set out in the technology-specific NPSs; and
- a FRA must demonstrate that the project will be safe, without increasing flood risk elsewhere subject to the exception below and, where possible, will reduce flood risk overall.
- In addition to the above, paragraph 5.7.17 of the EN-1 states where an increase in flood risk elsewhere cannot be avoided or wholly mitigated, the increase in present and future flood risk must be demonstrated that it can be mitigated to an acceptable level and taking account of the benefits of, including the need for, nationally significant energy infrastructure as set out in Part 3 of the EN-1.

4.5.2. *Wider sustainability benefits*

National Grid has identified there is a requirement to upgrade the TKRE, Grain-Tilbury and Kingsnorth-Tilbury cable connection to 400kV to replace the existing circuits that are predicted to reach capacity by 2028. This fulfils the benefits (including need), for the infrastructure set out in Part 3 of EN-1.

The wider sustainability benefits afforded by the Project are considered to outweigh flood risk, provided that appropriate mitigation, protection and resilience measures are implemented, and that the residual flood risk is evaluated and managed.

4.5.3. *Developable land*

The preferred option as identified in the Options Appraisal and Sift Report locates the proposed Tilbury CSEC on previously developed land. This land fulfils the definition of developable, previously developed land as defined in paragraph 5.7.16 Note 117

4.5.4. *Safety of the development over its lifetime*

The Project would incorporate flood protection, flood mitigation and flood resilience measures.

These measures would ensure that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere.

Refer to later sections in the report where these are detailed, and site-specific measures are discussed.

4.5.5. *Compliance with EN-1 Paragraph 5.7.17*

There will not be an increase in flood risk elsewhere as existing drainage flows will not be affected and there will not be a significant loss of flood storage capacity.

The Tilbury SEC will be constructed on an existing hardstanding, therefore there will not be an increase in flood risk.

The drainage management plan for the Tilbury CSEC should be designed in accordance with SuDs.

4.6. *Site-specific flood risks*

4.6.1. *Sources of fluvial and tidal flooding*

Fluvial flooding would occur when flow through the un-named local watercourse adjacent to the site exceeds its capacity.

Fluvial (tidal) flooding risk is low to very low, but would occur when tide levels in the River Thames are exceptionally high combined with surge tides moving up the Thames Estuary. The flooding mechanism would comprise overtopping or breaching of flood defences, resulting in the rapid onset of fast flowing and deep-water flooding with little or no warning. Mechanical failure of sluice gates at the Port of Tilbury may also result in tidal flooding.

4.6.2. Existing flood defences

The existing tidal flood defences in this catchment comprise sea walls that comprise earth embankments topped with concrete walls. These walls are located along reaches of the river where ground levels are low enough for overtopping may occur. This type of flood defence relative to the existing Tilbury CSEC compound extends approximately 270m downstream to an area of higher ground and 760m upstream to the Tilbury Fort flood defences. Refer to Defence AIMSID 152988 on the Flood Defence Location Map Ref: EAN/2023/NR305781 (EA NR305781 b / Appendix A). The map datasheet describes the flood defence as a wall constructed for 1000 standard of protection, is 3-fair condition with a crest level of 6.49m (EA NR305781 c / Appendix A)

4.6.3. Long-term flood risk information map

The EA Flood Map for Planning (A) drawing (EA NR305781 a / Appendix A) shows all parts of the Tilbury site that are at risk of fluvial or tidal flooding and lie within the areas that benefit from flood defences as depicted on the EA Flood Map for Planning (B) drawing, (EA NR305781 a / Appendix A). The flood defences do not completely eliminate the risk of flooding as they can be overtopped or fail. Refer to Figure 2 for the Environmental Agency online long term fluvial / tidal flood risk map (Environmental Agency 2023b)



Figure 2. Fluvial / tidal flood risk map (Environmental Agency 2023b)

4.6.4. *Hydraulic modelling maps*

Flood maps have been provided as part of the Product 4 data that provide more detail than the long-term flood risk information map (Environmental Agency, 2023d) and include climate change allowances. Model output data has also been provided as part of the Product 6 & 6 data.

EA Guidance for essential infrastructure requires a detailed hydrohalic modelling to be done to assess fluvial flooding. However, for specific local considerations, where the Environment agency and the applicant/consultant has agreed, a basic level of assessment may be appropriate where a precautionary allowance for potential climate change impacts on peak 'design' or 1% annual probability) fluvial flood level can be assumed instead of undertaking detailed modelling.

4.6.5. *Surface Water*

The long-term flood risk information map for surface water (Environment Agency, 2023d) indicates there are potentially discrete areas of medium risk surface water flooding at and adjacent to the proposed site location. However, high risk of surface water flooding is concentrated in areas that generally follow the watercourse to the east of the site and roadside drainage and in isolated pockets (local depressions).

There is a potential for run-on from areas of higher ground to the east of the proposed site location. The catchment area draining to the Tilbury CSEC is limited, extending approximately 400m eastwards into the ash fields.

Surface water features are identified in Drawing UKP/TLB/0214/API Surface water features. Report ENV-085-2006 Tilbury application site report March 2006 ENV_085_2006 page 54.

The extents of surface water flooding, flood depth and flood velocity across the site location are indicated in Figure 3 through to Figure 9.



Figure 3. Surface water flood risk map (Environmental Agency 2023b)



Figure 4. Surface water flood risk map – depth in high risk scenario (Environmental Agency 2023b)



Figure 5. Surface water flood risk map – Velocity in high risk scenario (Environmental Agency 2023b)



Figure 6. Surface water flood risk map – depth in medium risk scenario (Environmental Agency 2023b)



Figure 7. Surface water flood risk map – velocity in medium risk scenario (Environmental Agency 2023b)



Figure 8. Surface water flood risk map – depth in low risk scenario (Environmental Agency 2023b)



Figure 9. Surface water flood risk map – velocity in low-risk scenario (Environmental Agency 2023b)

4.6.6. Groundwater

4.6.7. Groundwater flooding records

A generic description of groundwater flood risk is provided in Thurrock Council's (2018) Level 1 SFRA and includes reference to the BGS groundwater susceptibility mapping. The Level 1 SFRA identifies susceptibility to groundwater flood risk in the southern parts of Thurrock, particularly where the Chalk Formation is covered by permeable Alluvium and River Terrace Deposits. The Project Tilbury site location is located in an area of limited potential for ground water flooding to occur.

The Thurrock Local Flood Risk Management Strategy (Thurrock Council, 2015) states that no incidents of groundwater flooding had been reported either to the council or the Environment Agency.

4.6.8. Flood risk mapping and hydrogeology

The Tilbury site location is located in an area of limited potential for ground water flooding to occur that is likely associated with cohesive alluvial deposits. However, there may be isolated locations where groundwater is close to the surface, particularly as perched layers, where there may be potential for groundwater seepage.

Groundwater level in the underlying Chalk Formation may be influenced by pumping from the water supply well at Linford. Chalk Formation groundwater in this area is unconfined or semi-confined and in parts may exhibit artesian behaviour. At low-lying areas where the confining cover thins or where there are permeable windows in the overlying deposits.

Superficial aquifers are also known to be widespread north of the river Thames, particularly in the River Terrace Deposits.

A Hydrogeological Risk Assessment will need to be undertaken separate from this report to assess the risk of groundwater to deep excavations for shaft and tunnel construction and identify potential mitigations.

4.6.9. *Drainage strategy and groundwater*

A SuDS Suitability map is provided in Thurrock Council's (2018) Level 1 SFRA and includes the Tilbury site is mostly located in an area where very significant constraints are indicated. There is a very significant potential for one or more geohazards associated with infiltration.

There may however be localised areas in the north part of the site that may provide Opportunities for bespoke infiltration SuDS: The subsurface is potentially suitable for infiltration SuDS, although design will be influenced by ground conditions.

Consequently, the Project drainage strategy would likely be based on the use of gravity systems that discharge to surface watercourses via retention ponds.

Drainage can be connected to local watercourses / drainage ditches with some potential for collected water discharged to ground (infiltration) in the north part of the site. With appropriate design, these drainage designs should not contribute to additional ground water flood risk.

An assessment of drainage design principles will be undertaken in the project drainage management plan.

4.6.10. *Sewers and water mains*

When sewers are blocked or overwhelmed there is potential to cause flooding. There do not appear to be any trunk sewers, but there are drainage pipes and sewer pipes present around the Tilbury Site. The potential risk of damage to drainage and sewers is to be assessed and is assumed the risk if any will be negligible or reduced to negligible.

Water mains have the potential to cause flooding if they are damaged. The potential risk of damage to water mains due to the construction phase is to be assessed and is assumed the risk if any will be negligible or reduced to negligible.

4.6.11. *Reservoirs*

The Tilbury site is shown on the Environment Agency long-term flood risk information map for reservoirs (Environment Agency, 2023d) is not located in an area that is at risk from reservoir flooding.

4.7. Climate Allowances for the site– Tilbury

4.7.1. Peak rainfall intensity

For elements of the drainage design, peak rainfall intensity would normally be calculated in accordance with the Environment Agency's guidance on climate change for flood risk assessments (Environment Agency, 2022a). The guidance stipulates that to accommodate climate change to 2125, a 35% and 45% uplift is required to be applied to 3.3% AEP event and 1% AEP event peak rainfall intensities for assessment and the development must also be designed so that for the upper end allowance in the 1% AEP event. These climate change uplifts are summarised in Table 21

Table 21. Tilbury peak rainfall allowances summary table for design

Analysis	Epoch	Allowance	
Beyond 2100 the upper end allowances for both the 1% and 3.3%	3.3% AEP event	Upper end	+35%
	1% AEP event	Upper end	+45%
Design and 'credible maximum' climate change scenario	1% AEP event	Upper end	+45% adopted for 2148

There are no rainfall allowances specified for the H++ scenario. Further information has been requested from the Environmental Agency as to how the H++ scenario can be extended to 2148.

4.7.2. Peak river flow allowances

As the Project is designated as essential infrastructure, lies in Flood Zone 3a and has a minimum lifetime of 120 years, the 'higher central' peak river flow allowances for the 2080s epoch have been used to assess fluvial flood risk (Table 5)

To understand the impact of peak river flow allowances over the lifetime of the Project, the 'higher central' peak river flow allowances for the 2020s epoch should also be assessed.

Peak river flow allowances of +11% in 2028 and +26% should be applied for assessment of the 2028 and 2148 'higher central' climate scenarios.

To understand the impact of peak river flow allowances for different storm events, the 'central' peak river flow allowances for the 2020s epoch and 2080s epoch should also be assessed. Peak river flow allowances of +6% and +17% should be applied for assessment of the 2028 and 2148 'central' climate scenarios.

The upper end peak river flow allowance (+48% in 2125) should be applied to represent the 'credible maximum' climate change scenario for 2148 (see Table 7).

It should be noted that the 2080s epoch only covers the period from 2070 to 2125. In the absence of climate change allowances for 2148, the peak river flow allowances for 2125 has been used for the assessment.

Peak river flow allowances for Tilbury are summarised in Table 22.

Table 22. Tilbury peak river flow allowances summary table for design

Analysis	Epoch	Allowance	
for assessment of the 2028 and 2148 'higher central' climate scenarios	2020s	higher central	+11%
	2080s	higher central	+26%
impact of peak river flow allowances for different storm events for assessment of the 2028 and 2148 'central' climate scenarios	2020s	Central	+6%
	2080s	Central	+17%
'credible maximum' climate change scenario		upper end	+48% in 2148

While the Tilbury Site low lying, it is not located near to significant fluvial or river water courses. Therefore the most significant risk of flooding will likely be from surface water runoff. However, alternatively as a precautionary allowance (basic approach can be made for a depth of fluvial flooding hazard of 500mm as suggested by the Product 4: Supporting Documentation (Environment Agency (2023c). However this allowance must be agreed with the Environment Agency. On this basis fluvial flood risk will not be considered further.

4.7.3. Sea level allowances

Site-specific sea-level allowances have not been provided by the Environmental Agency as Product 8 was withheld due to discrepancies in the ESL model. Therefore, this assessment will only consider the EWLs in relation to TE2010 Gravesend Power Station node.

4.8. Flood Analysis

4.8.1. General

The Environmental Agency hydraulic model provided as part of Product 6 and 7 for Tilbury was used to provide information for the analysis of flooding.

4.8.2. Estimated flood levels for the development

The estimated flood level for the development, taking into account the impacts of climate change over its lifetime of 120 years.

The estimated flood level is the depth of flooding anticipated at the Tilbury site in a:

- river flood with a 1 in 100 annual probability plus an allowance for climate change
- tidal flood with a 1 in 200 annual probability plus an allowance for climate change

As flood defences are present, the estimated flood level will account for the residual flood risk if they are breached or overtopped.

4.8.3. Pluvial (Surface Water) / Fluvial Flooding

A summary of surface water risk for the permanent Tilbury CSEC site up to 2110 taken from the Environmental Agency product 6 and 7 flood risk model is provided in Table 23.

Table 23. Surface water flood risk summary for the proposed Tilbury CSEC site compound

Year and return period	Surface water risk		
	1 in 30 year (mm)	1 in 100 year (mm)	1 in 1000 year
Baseline	1 to 106	1 to 161	1 to 242
2110	1 to 126	1 to 183	1 to 261

River flow allowances are not considered due to the Tilbury site being located away from major river channels and is only affected by minor watercourses adjacent to the site.

4.8.4. Sea level Rise Allowances

Sea level rise allowances have been specified and applied for the 'south east', according to current Environment Agency guidance (2022a) (Table 8).

The effect of a sea level rise at Tilbury on the River Thames extreme water levels (EWLs) at the Project location, was assessed based on an interpretation of outputs of the Environment Agency's Thames Estuary 2100 (TE2100) modelled River Thames EWLs adjusted against the current CBR2019 EWLs and UKCP18 sea level rise datasets. Sea level rise allowances at Tilbury for the Design 'higher central' and Sensitivity analysis 'upper end' scenarios in 2028 and 2148 are summarised in Table 24.

Table 24. Sea level rise allowances at Tilbury for the adjusted TE2100, 'upper end' and 'higher central' climate scenarios.

Location	Sea level rise climate scenarios					
	Year	Allowance	Higher Central (mOD)		Upper End (mOD)	
			1 in 200 (0.5%)	1 in 1000 (0.1%)	1 in 200 (0.5%)	1 in 1000 (0.1%)
Tilbury	2005	TE2100	5.38	5.71		
	2028	TE2100 adjusted and interpolated	5.47	5.80	5.52	5.85
	2148	TE2100 adjusted and interpolated (Higher Central) extrapolated (Upper End)	6.90	7.09	7.58	7.61
	H++	Allowance for 2148 not available	-	-	--	-

The EWL climate data provided in the Environmental Agency Product 5 & 6 does not extend further than 2115, therefore a separate water depth model has been made in GIS using the Higher Central 1 in 200 sea level rise scenarios in Table 12. This assessment indicates the existing flood defences will be overtopped by at least 0.41m in 2148 with up to 4.2m of flood inundation at the Tilbury Shaft Location (Figure 10). Therefore, it is expected that the Environmental Agency will have raised the flood defence level as part of the Thames Estuary 2100 program.

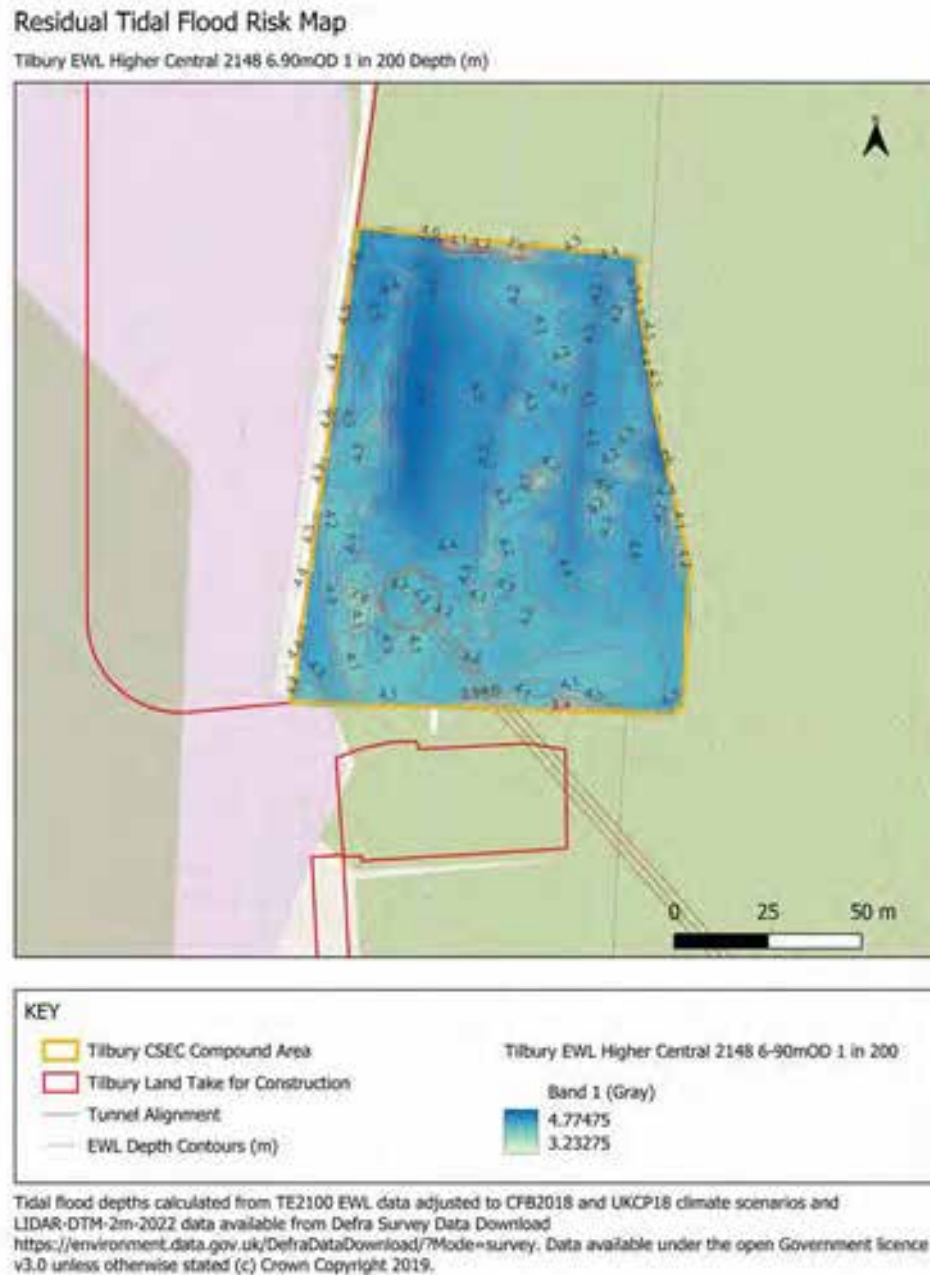


Figure 10. Design EWL 2148 1 in 200 (Higher Central) Residual Tidal Flood Risk – Design flood depth

4.8.5. Credible maximum scenarios

4.8.6. Introduction

The climate change analysis guidance (Environmental Agency 2022a) advises credible maximum scenarios should be considered for NSIPs.

4.8.7. Peak river flow allowance

For assessment of credible maximum climate change scenario the flood risk from a high impact climate change scenario the following maximum allowance uplift values in Table 25 should be applied:

Table 25. Credible maximum climate change scenario for Tilbury – rainfall and river flow

Upper end allowances		Allowance
Peak rainfall intensity	3.3% AEP event	35%
	1% AEP event	45%
The upper end allowance for peak river flow		48%

The peak rainfall allowances in the Environment Agency's guidance on climate change allowances (2022a) only extend to 2125. In the absence of climate change allowances for 2148, the rainfall allowance for 2125 was adopted for the purposes of this assessment. However, drainage design should be cognisant that this allowance may not be conservative.

4.8.8. Sea level rise and storm surge (H++)

The guidance on climate change allowances (Environment Agency's 2022a) does not provide data for the use of the H++ climate scenario beyond 2100. The H++ allowance for 2100 is also not appropriate to be adopted for use to estimate extreme levels for 2148.

The 0.1% AEP EWL at Gravesend Power Station in 2148 is 6.94mOD for the 'Higher Central' / 'Design' level, or 7.61mOD for the 'Upper End' level. If these scenarios were realised the project could adapt a Tilbury CSEC Shaft with flood protection raised to 7.94mOD or 8.61mOD respectively.

4.8.9. Breach Analysis

The Thurrock Strategic Flood Risk Assessment (SFRA) has simulated breach models for multiple scenarios and locations (TIL003, Tilbury Docks; TIL004, Worlds End; TIL005, Tilbury Station for breach of the River Thames defences during the following tidal events:

The 0.5% AEP tidal flood event up to 2116

The 0.1% AEP tidal flood event up to 2116

Overtopping of the existing defences would occur if River Thames EWLs exceed the defence crest levels, However the TE2100 Plan (Environment Agency, 2012) policy details that the crest levels will be increased in the future to maintain a 0.1% AEP

standard of protection (as a minimum). Therefore, the Thames River flood defences are assumed to keep up with climate change so that flood risk does not increase. On this basis, overtopping over the defence crest levels was not considered.

A conservative estimate of peak water levels in the tidal River Thames floodplain is assumed to be equal to River Thames flood levels.

The 0.1% AEP tidal event EWL in 2148 for the Gravesend Power Station node (Project location) Design level is 7.61mAOD which would in the case of breach or overtopping result in 5m of flood water depth at the shaft location (Figure 11). It is expected the Thames Flood defences would be raised above this level.

As the tidal levels are cyclic, the landward ground water table / flood levels are assumed to not be affected.

If the River Thames tidal defences were not upgraded in the future, the flood defences would be overtopped before the end of the lifetime of the project, and the project location would be inundated during the 0.1% AEP event EWL in 2148.

As a 'sensitivity test', it will help to assess how sensitive the proposed construction is to changes in the climate for different future scenarios. This will help to ensure your development can be adapted to large-scale climate change over its lifetime.

4.8.10. *Residual uncertainties allowance*

It is expected the Thames Flood Defences crest level would include a residual uncertainties allowance of 1m.

4.8.11. *Residual Flood Risk*

At the time of writing this report, the EA could not provide their Thames Breach Modelling for Tilbury as it is a different model to the latest revised OM12 Thames Model. Due to discrepancies with the revised OM12 Thames Model, the breach flood level information is considered unreliable, and this incorrect data would likely lead to miss-information for any potential flood risk assessment or planning application. The EA Thames Breach Modelling will be withheld until such time the model has been revised and discrepancies resolved.

However, Breach Modelling from other sources can be used to assess the residual flood risk.

4.8.12. *Details of the finished floor levels*

The Tilbury CSEC has not yet been designed, however ground levels at the Tilbury CSEC construction site are approximately 2.7mOD. Sensitivity analysis indicates ground level would be susceptible to surface water flooding and a residual uncertainties allowance of 0.3m (if the Environmental Agency agrees) could be used to raise the final formation level for the compound to a maximum of 3.0mOD to mitigate all fluvial and surface water flood risk.

Residual flood risk for breach of flood defences indicates the area is also susceptible to flooding from design breach flood events, however hydraulic flood level modelling has not been provided from the Environmental Agency due to data discrepancies.

4.8.13. Details of flood resistance and resilience plans

Details for flood resistance and resilience plans are not yet available, however typically flood defences could be built 0.3 m above available levels (3.0mOD) or have in place a reactionary mitigation measure to respond to climate induced increase in sea level.

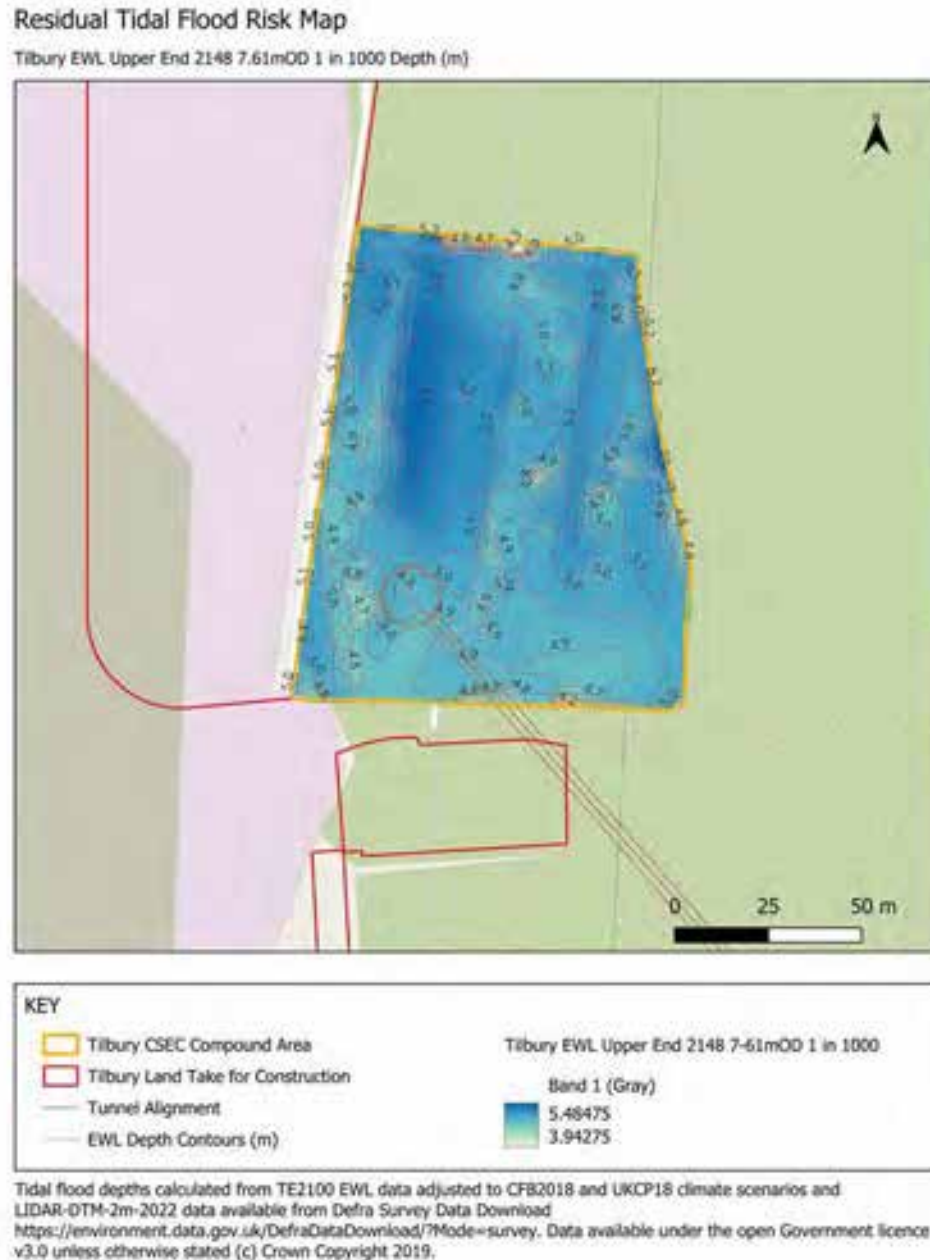


Figure 11. Flood water inundation for worst credible 0.1% AEP tidal event EWL in 2148 – Worst credible tidal flood depth

4.9. *Flood risk mitigation measures*

4.9.1. *Fluvial/tidal flood risk*

The Tilbury CSEC site is located in Flood Zone 3a protected by flood defences; no further mitigation measures may be necessary to address fluvial/tidal flood risk. However, it is recommended that the ground level for the proposed development be at a minimum match the existing ground level at the existing Tilbury CSEC of 2.45m OD as measured from nearby boreholes.

The existing Tilbury CSEC shaft may have been design for the same level of flood risk; however the design is not available to check, therefore the levels would provide adequate protection of the lifetime of the New Tilbury CSEC.

4.9.2. *Watercourse channels and structures*

Watercourses are not expected to be altered or restricted. The only works expected that may alter drainage at Tilbury is modification of the ditch to the north where the construction of a new haul road to accommodate a westward expansion of the site across the existing access road. The existing ditch on the western side of the existing access road will partially be filled in.

4.9.3. *Compulsory flood storage areas*

The site is not located within or near to a compensatory flood storage area.

4.9.4. *Hydraulic structures*

There are no culverts within the land take area, however there are drainage pipes associated with access road drainage that may be affected by construction works.

4.9.5. *Flood protection measures*

The area is benefited by the Thames River Flood Defences with a low risk of tidal flooding. As part of the TE2100 policy programme the crest level of the flood defences are expected to be raised to keep up with rising sea levels.

4.9.6. Residual Flood Risk

Residual flood risks along with associated mitigation measures are presented in Table 26.

Table 26. Tilbury Site Residual Risk and Mitigation

Ref	Residual risk	Mitigation measures
1	Overwhelming of the compound drainage system due to a severe storm event or a blockage may result in onsite and/or offsite flooding and the potential for runoff to enter the tunnel.	Drainage asset inspections would be undertaken. A planned, risk-based maintenance programme to be undertaken. Planned maintenance interventions would ensure efficient operation of the drainage network
2	Overtopping of the silt retention ponds may occur in the event of a severe storm during construction. This may lead to development of secondary flow paths.	The capacity of retention ponds would include provision for climate change allowances in accordance with the Environment Agency guidance. Drainage asset inspections would be undertaken and maintenance programmes would be established, all as described above. Planned maintenance interventions would ensure continued efficient operation of the retention ponds
3	Overtopping of the flood protection due to a severe tidal event could result in inundation of the tunnel.	A tunnel safety consultation has been undertaken on emergency preparedness. This consultation establishes measures to be implemented during an incident.
4	Structural failure (breach) of the Thames River flood defences.	The 0.1% AEP tidal event EWL of the River Thames in 2148 for Gravesend Power Station node (Project location) 7.61mOD. An emergency escape plant is to be put in place as a contingency.

5. Gravesend CSEC

5.1. Development site and location

5.1.1. Location

Nearest address: Milton Rifle Range, High Street, Denton, Gravesend, Gravesham, Kent, England, DA12 2HR, United Kingdom.

The New Gravesend CSEC is located at the following coordinates (Table 27) with the boundary located in Figure 12.

Table 27. Gravesend CSEC coordinates

Shaft	X (Easting)	Y (Northing)
Gravesend Shaft	567445.66	174136.58

5.1.2. Current use

The proposed site is to be located on previously undeveloped land south of the existing Gravesend CSEC. The area currently comprises grassed land with water courses on the southeast, south and east sides of the site.

5.1.3. Flood Zone

The New Gravesend CSEC is located at the above coordinates with the boundary located in the figure below. The proposed site is situated within Flood Zone 3

5.1.4. Other sources of flooding

The Gravesend CSEC site is not located in an 'Area of Critical Drainage'(AoCD), which are defined as being 'A discrete geographic area where multiple and/or interlinked sources of flood risk (surface water, groundwater, sewer, main rivers and/or tidal) cause flooding in one or more Local Flood Risk Zones (LFRZ) during severe weather thereby affecting people, property or local infrastructure'. However, the site location is susceptible surface water flooding.

Sources of flooding to affect the Gravesend Site are summarised in Table 28.

Table 28. Sources of flooding

Source	Y	N
Residual flood risk due to breach or overtopping of flood defences	Y	
Located near a main river	N	Not located near a main river, but located adjacent to an ordinary watercourse
Located within an area of Critical Drainage	N	Not located in an area of Critical Drainage
Areas Susceptible to Groundwater Flooding	Y <25%	
Climate change over the lifetime of the development	Y	
Surface water flood risk	Y	
Sewers	N	
Canal	Y	



Figure 12. Gravesend CSEC location and site boundary. (Imagery Date: 8/05/2022 Google earth V 7.3.3.9345 (64-bit). (December 29, 2022). 51° 26' 04.85"N, 0° 24' 45.53"E, Eye alt 1.77km)

5.2. Flood Risk Screening

A summary of flood risk to the Gravesend CSEC from all sources is provided in Table 29.

Table 29. Flood risk screening: New Gravesend CSEC

Flooding source	Chance of Flooding	Source	Pathway/Comment
Fluvial	Very Low Risk to Low Risk	Thames River Estuary	Flood zone 3a 0.1% each year to 1% each year. Flood defences reduce the risk but do not completely stop the chance of flooding as they can be overtopped, or fail.
Tidal	Very Low Risk to Low Risk	Thames River Estuary	Medium risk of sea flooding, if there were no defences, that is a 0.5% (1 in 200)
Groundwater	Low Risk	Groundwater emergence	Limited potential for groundwater flooding to occur, BGS flood GFS Data.
Sewers	No	None	None
Surface water	Low	Surface water features and drainage channels	High risk 3.3% each year. Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding.
Reservoirs	Coverage	Not specified	Included in coverage area at risk for flooding from dam or reservoir embankment failure or breach.
Artificial sources (e.g. canals)	Coverage	Not specified	Included in coverage areas at risk of flooding from canal or aqueduct failure or breach. Please note that all canals in this area may not have been mapped for failure or breach.

A more comprehensive assessment of flood risk from High, Medium and Low flood risk sources is provided below. At the New Gravesend CSEC this comprises tidal, groundwater and surface water. In addition, fluvial flood risk is also considered in greater detail as the site was previously identified as having a Medium chance of flooding.

5.3. *Development Description*

This section will provide a general summary of the development proposals.

5.3.1. *Development proposal*

The current proposed location of the Gravesend CSEC is located to the west of the Milton Rifle Range and south of the existing Gravesend CSEC. The proposed new Gravesend shaft will be 15m internal diameter connection to a cable tunnel at 35m below ground level. The site area has maximum dimensions of 182m x 143m that encompasses the existing CSEC.

5.3.2. *Flooding Vulnerability Classification*

According to Annex 3 of the National Planning Policy Framework Annex 3: Flood risk vulnerability classification the development falls under the Essential Infrastructure vulnerability classification.

The Project is considered to represent essential infrastructure for the following reason

- Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including infrastructure for electricity supply and distribution systems.

5.3.3. *Expected estimated lifetime*

The expected estimated lifetime for the proposed development is 120 years.

5.3.4. *Flood risk compatibility*

Table 30 is based on Table 2 of the DLUHC guidance (DLUHC, 2022).

This table shows the compatibility of flood risk vulnerability classifications and Flood Zones. As essential infrastructure, the Project is appropriate in all Flood Zones. However, for development in Flood Zones 3a and 3b, an Exception Test must be undertaken.

Table 30. Flood risk vulnerability and flood zone 'incompatibility'

Flood Zones	Flood Risk Vulnerability Classification				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	X	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	X	X	X	✓ *

Key:

✓ Exception test is not required

X Development should not be permitted

This table does not show the application of the Sequential Test which should be applied first to guide development to the lowest flood risk areas; nor does it reflect the need to avoid flood risk from sources other than rivers and the sea;

The Sequential and Exception Tests do not need to be applied to those developments set out in National Planning Policy Framework footnote 56. The Sequential and Exception Tests should be applied to 'major' and 'non major' development.

Some developments may contain different elements of vulnerability and the highest vulnerability category should be used unless the development is considered in its component parts.

“†” In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

“*” In Flood Zone 3b (functional floodplain) essential infrastructure that has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

remain operational and safe for users in times of flood.

result in no net loss of floodplain storage.

not impede water flows and not increase flood risk elsewhere.

5.4. Sequential Test

5.4.1. Site search area

The assumptions and requirements considered for the location of the Gravesend CSEC Shaft are detailed in Section 2 of the Options Appraisal and Sift Report,

5.4.2. Wider sustainable development objectives

The Mott Macdonald Optioneering Report 102573/001/P04 report that preceded the Options Appraisal and Sift Report, identified a number of alternative solutions for the upgrade of the cable crossing. These options included: the reuse of the existing tunnel; the use of the new Lower Thames Crossing; and a pylon crossing over the River Thames. Findings identified the existing cable tunnel will not be able to meet the requirements of the new cable design; The Lower Thames crossing will not be built by 2028 to meet OFGEM requirements, and the Pylons would need to be sited in the RAMSAR site to the south of the existing Gravesend Sealing End Compound.

Historic, current and future land use is considered in the Options Appraisal and Sift Report were used to consider multiple sites. Wider sustainable development objectives that would otherwise steer the development to other locations are inappropriate due to the environmental, infrastructure and land availability that severely constrains potential locations.

5.4.3. Alternative sites

The Options Appraisal and Sift Report identified constraints from the Desk Study Report which are indicated on drawings PDD-100116-DDR-007/30003364-MSE-XX-XX-DR-Y-10012 for Gravesend and PDD-100116-DDR-008/30003364-MSE-XX-XX-DR-Y-10013 for the crossing of the River Thames.

The Options Appraisal and Sift Report presents the combined options appraisal taking into account past, current and future land use, land ownership, existing infrastructure and constructability constraints combined with an ecological options appraisal for 3 locations. On this basis the Options Appraisal and Sift Report summarises a ranking assessment of land areas around the project area conducted by AECOM, resulting in recommendation of one single location. For Gravesend site the most viable and most favourable option is based on the southernmost shaft position G as shown in Table 31.



Table 31. Gravesend SCEC Shaft Option locations (Options Appraisal and Sift Report)

No other alternative sites are reasonably available to provide practical or viable options for construction of a shaft or cable tunnel and meet the assumptions and requirements identified in the Options Appraisal and Sift Report. The selection of the preferred site is however not based on Flood Risk.

5.4.4. Accounting of other sources of flooding

All sources of flooding have been accounted for and will be required to be designed for in the development.

5.4.5. Application of the Sequential Test

The Sequential Test is a risk-based approach to locating a development designed to steer a new development to areas with the lowest probability of flooding or demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the development being proposed.

Application of the Sequential Test is set out in Diagram 2 of the DLUHC guidance (DLUHC, 2022) and described in paragraph 5.7.13 of the EN-1.

Table 32, which is based on Diagram 2 of the DLUHC guidance (DLUHC, 2022), sets out the application process for the Sequential Test as used for the Tilbury Site.

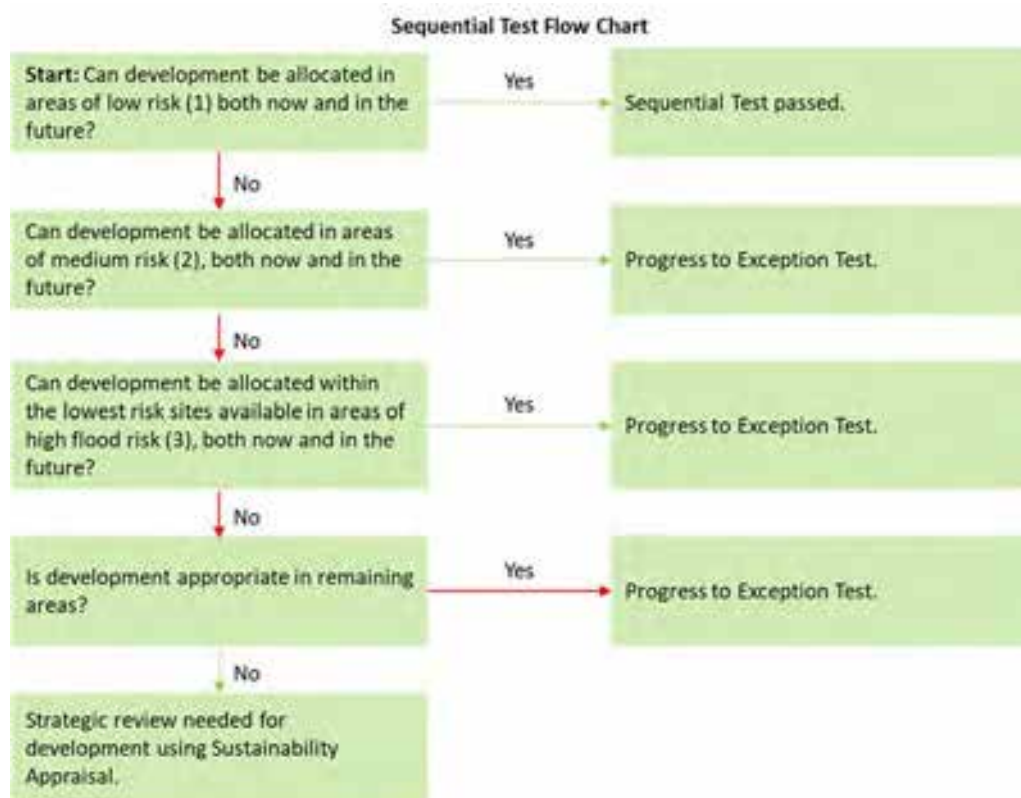


Table 32. Sequential test flow chart for Gravesend

In the case for the Gravesend site the preferred site location has not been selected on the basis of lowest flood risk, but on the basis of an options appraisal in the Options Appraisal and Sift Report. Therefore, the Sequential test flow chart defaults to development that is appropriate in the remaining areas and will require an Exceptions Test.

5.5. Exceptions Test

Where application of the sequential test is not possible, or the sequential test flow chart in Table 32 indicates the Exceptions test is required, the flow chart in Table 33 is required to be followed.

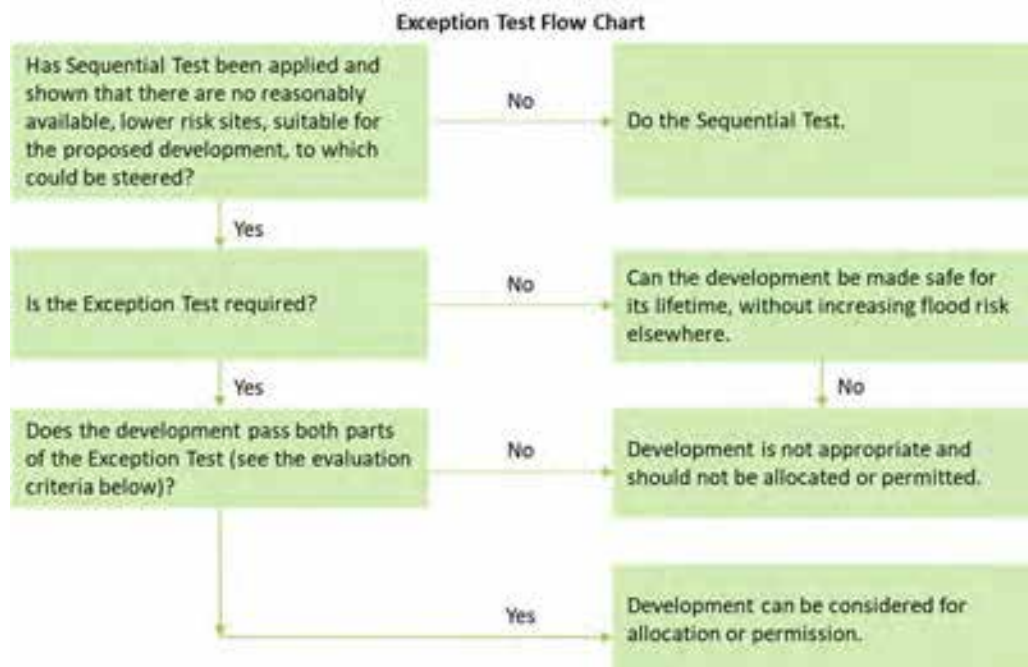


Table 33. Exceptions test flow chart

5.5.1. Test evaluation criteria

The evaluation criteria for the Exception Test is set out in the DLUHC guidance (DLUHC, 2022) and paragraph 5.7.16 of the EN-1. For the Exception Test to be passed, the following must be demonstrated:

- it must be demonstrated that the project provides wider sustainability benefits to the community (These would include the benefits (including need), for the infrastructure set out in Part 3 of EN-1.) that outweigh flood risk;
- the project should be on developable, previously developed land as defined in EN-1 or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously developed land subject to any exceptions set out in the technology-specific NPSs; and
- a FRA must demonstrate that the project will be safe, without increasing flood risk elsewhere subject to the exception below and, where possible, will reduce flood risk overall.
- In addition to the above, paragraph 5.7.17 of the EN-1 states where an increase in flood risk elsewhere cannot be avoided or wholly mitigated, the increase in present and future flood risk must be demonstrated that it can be mitigated to an acceptable level and taking account of the benefits of, including the need for, nationally significant energy infrastructure as set out in Part 3 of the EN-1.

5.5.2. *Wider sustainability benefits*

Sustainability is generally defined as meeting the needs of the present without compromising the ability of future generations to meet theirs.

Ofgem has identified there is a requirement to upgrade the TKRE, Grain-Tilbury and Kingsnorth-Tilbury cable connection to 400kV to replace the existing circuits that are predicted to reach capacity by 2028. This fulfils the benefits (including need), for the infrastructure set out in Part 3 of EN-1.

The wider sustainability benefits afforded by the Project are considered to outweigh flood risk, provided that appropriate mitigation, protection and resilience measures are implemented, and that the residual flood risk is evaluated and managed.

5.5.3. *Developable land*

The preferred option as identified in the Options Appraisal and Sift Report locates the proposed Gravesend CSEC on previously undeveloped land. This land does not fulfil the definition of developable, previously developed land as defined in paragraph 5.7.16 Note 117. However, the Options Appraisal and Sift Report demonstrates there are no reasonable alternative sites on developable previously developed land that could be used to construct the new infrastructure. The available site locations are severely restricted by infrastructure, existing developments and RAMSAR sites, there is no other land available at that site.

5.5.4. *Safety of the development over its lifetime*

The Project would incorporate flood protection, flood mitigation and flood resilience measures.

These measures would ensure that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere.

Refer to later sections in the report where these are detailed, and site-specific measures are discussed.

5.5.5. *Compliance with EN-1 Paragraph 5.7.17*

There will not be an increase in flood risk elsewhere as existing drainage flows will not be affected and there will not be a significant loss of flood storage capacity.

For the new Gravesend CSEC there will be a new hardstanding area and new drainage management plan designed in accordance with SuDs.

5.6. *Site-specific flood risks*

5.6.1. *Sources of flooding*

The main sources of flooding as identified in the Kent Thameside SFRA are:

- failure/overtopping of the River Thames Tidal Defences;
- failure/overtopping of the River Thames Tributary Defences;
- surface water (including sewer flooding) and groundwater flooding;
- failure to operate flood defence gates (through mechanical fault or human error).

Fluvial (tidal) flooding risk is low, but would occur when tide levels in the River Thames are exceptionally high combined with surge tides moving up the Thames Estuary. The flooding mechanism would comprise overtopping or breaching of flood defences, resulting in the rapid onset of fast flowing and deep-water flooding with little or no warning. Mechanical failure of sluice gates for the watercourse or other rivers along the North Kent Marches to the east may also result in tidal flooding.

Fluvial flooding would occur when flow through the un-named local watercourse adjacent to the site exceeds its capacity. Low to medium risk surface water flooding is concentrated in the drainage channels located to the east, crossing the southern portion of the National Grid site and running northwards adjacent to the site. Fluvial flooding would also be exacerbated during tidal highs and the Denton Outfall becomes blocked and the watercourse becomes tidally locked for the duration of the high.

Pluvial (from rainfall, as surface water runoff) flooding would occur during excessive rainfall events and due to accumulation of runoff in low lying areas.

Groundwater flooding for Gravesham in general is predominantly the result of the rebound of water levels from the cessation of pumping associated with industrial activity and quarrying. The risk from groundwater flooding at the site is negligible.

5.6.2. *Existing flood defences*

The existing tidal flood defences adjacent to the Gravesend site comprise full height earth embankments. These defences are located along reaches of the river where ground levels are low enough for overtopping to occur. This type of flood defence relative to the existing Gravesend CSEC compound extends approximately 4360m downstream to an area of higher ground at Brett Aggregates and RSPB Cliffe Pools and 600m upstream to the Denton Wharfs. The Environmental Agency declined to provide Product 4 that would have given some details on the flood defences. Lidar downloaded from the available Environmental Agency data indicates the minimum levels of the embankment crest to be about 6.26 to 6.29m across the north of the Gravesend Site.

The local watercourses drain to the Thames Estuary to the north of the site through the Denton Outfall. This outfall comprises a steel trash screen and outfall inlet with a Penstock type of control gate.

5.6.3. *Historical Flooding*

The EA/NRW Historic Flood Map (1:10,000) (Envirocheck Report 2023 extracts, Appendix B) shows the Gravesend site has a historic flood event that has overtopped flood defences and local watercourses nearby to the east have exceeded channel capacity and locally flooded the rifle range.

Historic flood extent identified by the SFRA covered large areas of the River Darent floodplain, the Dartford Marshes, the Swanscombe Peninsula and the Shorne Marshes to the west of Gravesend were subject to extensive flooding during the 1953 tidal surge and that the River Darent flooded extensively in 1958, 1968, 1974 and 1978. (Kent Thameside 2005).

5.6.4. *Long-term flood risk information map*

The Environmental Agency 2023b flood maps and Envirocheck Report 2023 flood maps (Appendix B) shows all parts of the Gravesend site that are at risk of fluvial or tidal flooding and lie within the areas that benefit from flood defences (Envirocheck Report 2023 extracts, Appendix B). The flood defences do not completely eliminate the risk of flooding as they can be overtopped or fail, as evidenced by historic overtopping of flood defences.

The flood risk map in Figure 13 shows:

The water courses have a high risk of fluvial flooding. High risk means that this area has a chance of flooding of greater than 3.3% each year. This takes into account the effect of any flood defences in the area. These defences reduce but do not completely stop the chance of flooding as they can be overtopped, or fail.

The area in general has a low risk of tidal flooding. Low risk means that this area has a chance of flooding of between 0.1% and 1% each year. This takes into account the effect of any flood defences in the area. These defences reduce but do not completely stop the chance of flooding as they can be overtopped, or fail.



Figure 13. Fluvial / tidal flood risk map (Environmental Agency 2023b)

5.6.5. Hydraulic modelling maps

The Environmental Agency have declined to provide Product 4 therefore in absence of more detail than the long-term flood risk information map (Environmental Agency, 2023d) and include climate change allowances. Model output data has also been provided as part of the Product 5 & 6 data, however The Environmental Agency only provided a combined flood depth output for tidal breach of the flood defences.

EA Guidance for essential infrastructure requires a detailed hydrohalic modelling to be done to assess fluvial flooding. However for specific local considerations, where the Environment agency and the applicant/consultant has agreed, a basic level of assessment may be appropriate where a precautionary allowance for potential climate change impacts on peak 'design' or 1% annual probability) fluvial flood level can be assumed instead of undertaking detailed modelling.

The Envirocheck Report 2023 flood maps (Appendix B) provides further hydraulic flood modelling in the JBA 75, 100, 200, and 1000, Year Return Flood Maps (Undefended).

5.6.6. Surface Water

The long-term flood risk information map for surface water (Environment Agency, 2023b) indicates there are potentially discrete areas of low to medium risk surface water flooding is concentrated in areas that generally follow the watercourses surrounding the site to the southwest, south and east of the proposed site location. Areas of high risk for surface water flooding were not identified at or near the site location.

Water course mapping (Envirocheck Report 2023 extracts, Appendix B) indicates a sizable area is drained by the water courses, however the full extent of the catchment drained is not available in the available information reviewed.

Environmental Agency flood mapping shows the extents of surface water flooding across the site location are indicated in Figure 14 with depth and velocities for high, medium and low risk scenarios depicted in Figure 15 to Figure 20. In addition, the JBA 1000 Year Return Flood Map (Undefended) (Envirocheck Report 2023 extracts, Appendix B) indicates a modelled flood depth up to 1m of surface flooding will occur across the existing ground surface in the area of the proposed New Gravesend CSEC (Figure 21).

The surface water drainage infrastructure drains to the River Thames via outfalls through the Thames Tidal Defences. These outfalls are controlled with flap-valves and penstocks designed to prevent water flowing from the Thames into the drainage system during high tide when the water level in the Thames is above the level of the outfall, thereby 'locking' the surface drainage system. During high tides in the Thames Estuary surface and fluvial water is unable to discharge to the Thames due to this tide-locking effect. Lower lying areas adjacent to the Thames are therefore at risk from flooding during rainfall events combined with high tides. As the tide cycle takes approximately 12 hours there is a period of approximately 6 hours when tide levels are at or above the mean tide level. During these periods the tide locking may contribute to flood risk in low-lying areas adjacent to the Thames. The watercourses around the Gravesend Site are therefore expected to be tidally locked during the high tides.

5.6.7. Flood risk extent from Reservoirs

There is no risk from flood risk due to failure of reservoirs (Figure 22).



Figure 14. Surface water flood risk map (Environmental Agency 2023b)



Figure 15. Surface water flood risk map – depth in high-risk scenario (Environmental Agency 2023b)



Figure 16. Surface water flood risk map – Velocity in high-risk scenario (Environmental Agency 2023b)



Figure 17. Surface water flood risk map – depth in medium risk scenario (Environmental Agency 2023b)



Figure 18. Surface water flood risk map – velocity in medium risk scenario (Environmental Agency 2023b)



Figure 19. Surface water flood risk map – depth in low risk scenario (Environmental Agency 2023b)



Figure 20. Surface water flood risk map – velocity in low risk scenario (Environmental Agency 2023b)



Figure 21. Excerpt from JBC 1000 Year Return Flood Map (Undifferentiated) (Envirocheck Report 2023 extracts, Appendix B)



Figure 22. Surface Extent of food risk from reservoirs (Environmental Agency 2023b)

5.6.8. Groundwater

5.6.9. Groundwater flooding records

Groundwater was not studied in detail in the Kent Thameside SFRA and the scale of flooding is considered to be considerably less than the scale of tidal flooding.

5.6.10. Flood risk mapping and hydrogeology

The Kent Thameside 2005 SFRA indicates the Gravesend site is not located within an area of groundwater flooding risk. This is supported by the BGS groundwater flooding susceptibility map that indicates the Gravesend Site to have limited potential for ground water flooding to occur. The limited potential for ground water flooding is likely associated with cohesive alluvial deposits. However, there may be isolated locations where groundwater is close to the surface, particularly as perched layers, where there may be potential for groundwater seepage, or in very low-lying areas.

Groundwater flooding is also dependent, however, on the underlying rock type, with rocks that hold a large amount of water and have a fluctuating water table being more susceptible. Most of the catchments within Kent Thameside drain towards the River Thames and are underlain with chalk. Chalk is highly permeable and given the right conditions (very wet winter for example) can give raise to groundwater flooding issues. Groundwater level in the underlying Chalk Formation may be influenced by pumping from the water supply and seasonal rainfall.

The BGS groundwater flooding susceptibility map identifies area to the south of the site has potential for Groundwater Flooding of Property Situated Below Ground Level and therefore not likely to be a source of surface water flooding.

The bedrock chalk is a primary aquifer with superficial deposits considered as Secondary Aquifer – Undifferentiated.

5.6.11. *Drainage strategy and groundwater*

A SuDS Suitability map is not provided in Kent Thameside (2005) SFRA, therefore constraints will need to be assessed for the Gravesend site to identify potential for one or more geohazards associated with infiltration.

Consequently, in absence of assessed constraints and given the cohesive alluvium deposits present, the Project drainage strategy would likely be based on the use of gravity systems that discharge to surface watercourses via retention ponds.

Drainage can be connected to local watercourses ditches with retention ponding / silt fencing to protect the local watercourse. With appropriate design, these drainage designs should not contribute to additional ground water flood risk.

An assessment of drainage design principles will be undertaken in the project drainage management plan to prevent a reduction in the drainage discharge rate capacity of the existing watercourse drainage catchment.

5.6.12. *Other Sources of Flooding*

5.6.13. *Flash Flood*

Flash flooding from minor tributaries/dry valleys for rainfall exceeding infiltration rates which would result in surface water flow in excess of the capacity of the surface drainage infrastructure could be another potential scenario. Low-lying narrow valleys could be at risk. However, in Kent Thameside there is no evidence of such event taking place and given the high infiltration rate of the chalk. Flash flooding is therefore less likely in Kent Thameside. However, in extreme events (such as frozen catchment), rivers in dry valleys could become active thereby causing flash flooding.

5.6.14. *Human Error*

Failure to operate one or more of the tidal gates during a significant tidal event could result in a flood breach event scenario. Section 5 of the Kent Thameside SFRA makes a detailed break modelling assessment for Gravesend.

5.6.15. *Sewers and water mains*

When sewers are blocked or overwhelmed in low-lying areas there is potential to cause flooding. The Kent Thameside SFRA notes there are historically very few incidents of surface/foul water flooding problems. The potential risk of damage to drainage and sewers is to be assessed and is assumed the risk if any will be negligible or reduced to negligible.

Water mains have the potential to cause flooding if they are damaged. The potential risk of damage to water mains due to the construction phase is to be assessed and is assumed the risk if any will be negligible or reduced to negligible.

5.6.16. *Reservoirs*

The Gravesend site is shown on the Environment Agency long-term flood risk information map for reservoirs (Environment Agency, 2023b) is not located in an area that is at risk from reservoir flooding.

5.6.17. Canals

Despite there being a canal present to the south of the Gravesend site, the JBA Canal Failure Map (1:1000) from the Envirocheck Report 2023 indicates there is no flood risk from canal failure.

5.7. Climate Allowances for the site– Gravesend

5.7.1. Peak rainfall intensity

For elements of the drainage design, peak rainfall intensity would normally be calculated in accordance with the Environment Agency's guidance on climate change for flood risk assessments (Environment Agency, 2022a). The guidance stipulates that to accommodate climate change to 2125, a 35% and 45% uplift is required to be respectively applied to 3.3% AEP event and 1% AEP event peak rainfall intensities for assessment and the development must also be designed so that for the upper end allowance in the 1% AEP event. The rainfall allowances are summarised in Table 34

Table 34. Medway Management Catchment peak rainfall allowances

Analysis	Epoch	Allowance	
Beyond 2100 the upper end allowances for both the 1% and 3.3%	3.3% AEP event	Upper end	+35%
	1% AEP event	Upper end	+45%
Design and 'credible maximum' climate change scenario	1% AEP event	Upper end	+45% adopted for 2148

There are no rainfall allowances specified for the H++ scenario. Further information has been requested from the Environmental Agency as to how the H++ scenario can be extended to 2148.

5.7.2. Peak river flow allowances

As the Project is designated as essential infrastructure, lies in Flood Zone 3a and has a minimum lifetime of 120 years, the 'higher central' peak river flow allowances for the 2080s epoch should be used to assess fluvial flood risk (Table 5)

To understand the impact of peak river flow allowances over the lifetime of the Project, the 'higher central' peak river flow allowances for the 2020s epoch should also be assessed.

Peak river flow allowances of +19% in 2028 and +37% should be applied for assessment of the 2028 and 2148 'higher central' climate scenarios.

To understand the impact of peak river flow allowances for different storm events, the 'central' peak river flow allowances for the 2020s epoch and 2080s epoch should also be assessed. Peak river flow allowances of +14% and +27% should be applied for assessment of the 2028 and 2148 'central' climate scenarios.

The upper end peak river flow allowance (+62% in 2125) should be applied to represent the 'credible maximum' climate change scenario for 2148 (see Table 7).

It should be noted that the 2080s epoch only covers the period from 2070 to 2125. In

the absence of climate change allowances for 2148, the peak river flow allowances for 2125 should be used for the assessment.

Peak river flow allowances for Gravesend are summarised in Table 35.

Table 35 - Medway peak river flow allowances summary table for design

Analysis	Epoch	Allowance	
for assessment of the 2028 and 2148 'higher central' climate scenarios	2020s	higher central	+19%
	2080s	higher central	+37%
impact of peak river flow allowances for different storm events for assessment of the 2028 and 2148 'central' climate scenarios	2020s	Central	+14%
	2080s	Central	+27%
'credible maximum' climate change scenario		upper end	+62% in 2148

While the Gravesend Site is low lying, it is located near to significant fluvial or river water courses designated as a main river in the Kent County Council Flood Maps (Kent County Council 2023), and the watercourse adjacent to the site is one of two outfalls draining the low-lying marshes to the east of the site (Eastcourt Marches, Shorne Marshes and Higham Marches) and to the south of the canal (Great Clane Lane Marches and Filborough Marches). Therefore the most significant risk of flooding will likely be from the marsh's catchment with additional risk due to surface water runoff.

The Environmental Agency has declined to provide the product 4 data (EA NR305781 h), therefore a detailed assessment of model data cannot be made to identify a minimum allowance for peak river flow. Also an alternative precautionary allowance (basic approach made for a depth of fluvial flooding hazard suggestion) has also not been provided for potential agreement.

However JBA Flood Maps in the Envirocheck report (Envirocheck Report 2023) for the Desk Study report (PDD-100116-REP-001 / 30003364-MSE-XX-XX-RP-Y-10000 Appendix D) do provide an indication of potential peak river flow levels. These flood maps are included in Appendix B. The JBD 1000 Year Return (Undefended) hydraulic model indicates peak river flow levels / surface water flooding could be up to 1m above the current ground level for the new Gravesend CSEC. It is also noted the area occupied by the current Gravesend CSEC has had the hardstanding area raised above this potential flood level.

5.7.3. Sea level allowances

The Environmental Agency did not provide Product 8 analysis as this data can be derived using the depth (d) and velocity (v) and hazard (ZKU0) 2D grids provided with the Product 6 dataset. The Environmental Agency has not provided Product 4 and/or 8 PDF format citing this as a way to improve efficiency within the EA and provide more rapid and flexible responses to customers. Therefore assessment of EWLs for Gravesend will consider the EWLs from the data provided in relation to TE2010 Gravesend Power Station node EWLs discussed in Section 0.

5.8. Flood Analysis

5.8.1. General

The Environmental Agency hydraulic model provided as part of Product 6 for Gravesend was used to provide information for the analysis of flooding.

5.8.2. Estimated flood levels for the development

The estimated flood level for the development, taking into account the impacts of climate change over its lifetime of 120 years.

The estimated flood level is the depth of flooding anticipated in a:

- river flood with a 1 in 100 annual probability plus an allowance for climate change

- tidal flood with a 1 in 200 annual probability plus an allowance for climate change

As flood defences are present, the estimated flood level will account for the residual flood risk if they are breached or overtopped. However, the site is in an area of flood defences that are intended to only be maintained under the TE2100 Policy Plan, therefore the risk of flood defences being breached or overtopped will increase over the lifetime of the project.

5.8.3. Pluvial (Surface Water) / Fluvial Flooding

Only the combined tidal breach flood levels were provided by the Environmental Agency in the Product 5 and 6 data, therefore the contribution for climate change allowance for fluvial flooding cannot be estimated from this data. However a baseline surface water, pluvial, fluvial and coastal flood risk can be estimated from JBA flood maps from the Envirocheck Report (2003) Table 36 and Table 37. It is assumed the coastal flood risk is due to tidal locking of the watercourse outlet during high tide. Pluvial, fluvial and coastal baseline flooding on the JBA flood mapping is estimated to be about 1m at the deepest or conservatively about 2.7 mOD. The estimated flood level of 2.7 mOD approximately the lowest elevation for the hardstanding area surrounding the existing Gravesend CSEC interpreted from the Environmental Agency DEM 2m elevation data.

Table 36. Surface water flood risk summary for the proposed Gravesend CSEC site compound

Year and return period	JBA Surface water risk		
	1 in 30 year (mm)	1 in 100 year (mm)	1 in 1000 year
Baseline	Negligible	Negligible	Negligible

Table 37. Pluvial, fluvial and coastal flood risk summary for the proposed Gravesend CSEC site compound

Year and return period	JVB Pluvial flood water risk			
	1 in 75 year (m)	1 in 100 year (m)	1 in 100 year (m)	1 in 1000 year (m)
Pluvial Baseline	Negligible	Negligible	Negligible	0.1 – 1m
Fluvial Baseline	Negligible	Negligible	Negligible	Negligible
Coastal Baseline	0.3-1.0	0.3-1.0	0.3-1.0	0.3-1.0

5.8.4. Sea level Rise Allowances

Sea level rise allowances have been specified and applied for the 'south east', according to current Environment Agency guidance (2022a) (Table 8).

The effect of a sea level rise at Gravesend on the River Thames extreme water levels (EWLs) at the Project location, was assessed based on an interpretation of outputs of the Environment Agency's Thames Estuary 2100 (TE2100) modelled River Thames EWLs adjusted against the current CBR2019 EWLs and UKCP18 sea level rise datasets. Sea level rise allowances at Gravesend for the Design 'higher central' and Sensitivity analysis 'upper end' scenarios in 2028 and 2148 are summarised in

Table 38

A water depth model has been made in GIS using the Higher Central 1 in 200 sea level rise scenario in

Table 38. This assessment indicates the existing flood defences will be overtopped by up to 0.8m in 2148 (Table 39). The Environmental Agency as part of the Thames Estuary 2100 program will only maintain the current levels of the tidal flood defences for the Gravesend Reach. The minimum flood defence level based on Environmental Agency DEM 2m data is about 6.2m to the north of the site, and the EA accepts that the flood risk for this area will increase. The EWL levels estimated for 2148 are similar to the EWLs estimated for 2137 in the Gravesham Water and Flood Risk

Background paper (Gravesham Borough Council 2021). It is expected for a 1 in 200 year design tidal level, significant overtopping will occur and will likely result in full flooding of the Marshlands.

Table 38. Sea level rise allowances at Tilbury for the adjusted TE2100, 'upper end' and 'higher central' climate scenarios.

Location	Sea level rise climate scenarios					
	Year	Allowance	Higher Central (mOD)		Upper End (mOD)	
			1 in 200 (0.5%)	1 in 1000 (0.1%)	1 in 200 (0.5%)	1 in 1000 (0.1%)
Tilbury	2005	TE2100	5.38	5.71		
	2028	TE2100 adjusted and interpolated	5.47	5.80	5.52	5.85
	2148	TE2100 adjusted (Higher Central interpolated) (Upper End extrapolated)	6.90	7.09	7.58	7.61
	H++	Allowance for 2148 not available	-	-	--	-



Table 39. Water depth for the design EWL 2148 1 in 200 (Higher Central) Tidal Flood Risk

5.8.5. Credible maximum scenarios

5.8.6. Introduction

The climate change analysis guidance (Environmental Agency 2022a) advises credible maximum scenarios should be considered for NSIPs.

5.8.7. Peak river flow allowance

For assessment of credible maximum climate change scenario the flood risk from a high impact climate change scenario the following maximum allowance uplift values in Table 40 should be applied:

Table 40. Credible maximum climate change scenario for Gravesend – rainfall and river flow

Upper end allowances		Allowance	
Peak rainfall intensity	3.3% AEP event	35	%
	1% AEP event	45	%
The upper end allowance for peak river flow		62	%

The peak rainfall allowances in the Environment Agency's guidance on climate change allowances (2022a) only extend to 2125. In the absence of climate change allowances for 2148, the rainfall allowance for 2125 should be adopted for the purposes of this assessment. However, drainage design should be cognisant that this allowance may not be conservative.

5.8.8. Sea level rise and storm surge (H++)

The guidance on climate change allowances (Environment Agency's 2022a) does not provide data for the use of the H++ climate scenario beyond 2100. The H++ allowance for 2100 is also not appropriate to be adopted for use to estimate extreme levels for 2148.

The 0.1% AEP EWL at Gravesend Power Station in 2148 is 6.90mOD for the 'Higher Central' / 'Design' level, or 7.61mOD for the 'Upper End' level. If these scenarios were realised the project could adopt a Shaft design with flood protection raised to 7.9mOD or 8.61mOD respectively. While the site currently benefits from flood defences, and it is expected the Theme Estuary flood defences will not be raised under current TE2100 Policy to keep up with sea level rise. This would in theory require raising the top of the shaft to above future predicted EWLs for the asset to remain operational during flood events.

5.8.9. Breach Analysis

The Kent Thameside Delivery Board Strategic Flood Risk Assessment (SFRA) (Kent Thameside 2005) has simulated breach models for multiple scenarios and locations, however this SFRA predates TE2100 and UKCP18 climate models and does not assess the impact of climate according to these scenarios.

The Environmental Agency Product 5 and 6 hydraulic modelling has simulated breach models for multiple scenarios and locations along the Gravesend reach of the River Thames defences during the following tidal events:

The 0.5% AEP tidal flood event up to 2115

The 0.1% AEP tidal flood event up to 2115

However, the EWL climate data provided in the Environmental Agency Product 5 & 6 does not extend further than 2115. To compensate for this flood model will be scaled to the current coastal boundary flood and UKCP18 climate data.

Overtopping of the existing defences would occur if River Thames EWLs exceed the defence crest levels, The TE2100 Plan (Environment Agency, 2012) policy details that the crest levels for the Gravesend Reach will not be increased in the future to maintain a 0.1% AEP standard of protection (as a minimum). The current level of the Thames River flood defences will however be maintained. On this basis, overtopping over the defence crest levels will be considered.

During the lifetime of the project while tidal flood defences are not planned to be upgraded in the future overtopping will occur during EWL events, while flooding would occur general advice indicates flooding from overtopping would be more gradual than a breach. However, by 2148 the flood defences could be overtopped by as much as 0.8m during a design tidal flood event. With such a significant overtopping of the flood defences significant flooding would still occur. A conservative estimate of peak water levels in the tidal River Thames floodplain is assumed to be equal to River Thames flood levels (Figure 23). This is conservative because the EWLs may not persist long enough for the landward side flood level of the flood defences to equalise, however hydraulic modelling data for overtopping is not available.

The 0.1% AEP tidal event EWL in 2148 for the Gravesend Power Station node (Project location) Design level is 7.61mAOD which would conservatively result in 5.3m of flood inundation at the Gravesend Shaft location were the site to not benefit from flood defences. It is noted the existing flood defences would be over topped by 1.4m (Figure 23) in a 0.1% AEP tidal event. Should the flood defences not be raised or flood mitigation measures not designed for the shaft to remain operational during 0.1% AEP event EWL in 2148 the cable tunnel would not remain operational.



Figure 23. Flood water inundation for worst credible 0.1% AEP tidal event EWL in 2148

As the tidal levels are cyclic, the landward ground water table / flood levels are assumed to not be affected.

As a 'sensitivity test', it will help to assess how sensitive the proposed construction is to changes in the climate for different future scenarios. This will help to ensure the development can be adapted to large-scale climate change over its lifetime.

Assuming flood defences are raised, and the risk of overtopping is mitigated, the primary residual risk is breach of the flood defences. This is considered more

catastrophic risk as a breach is unpredictable, inundation is more rapid, and can lead to loss of life and significant flood damage. EA Product 5 data for breach hydraulic flood modelling assumes a design 50m wide breach in soft flood defences (earthen embankment), and that flooding to the full tidal level will not take place due to the cyclic nature of the tidal cycle. The level of landward flooding from a breach immediately north of the site location is summarised in Table 41 below.

The Environmental Agency Product 5 Thames Estuary Breach Assessment Methodology Report_v0.1 (EA NR305781 i) indicates for the modelled data the *peak water level predictions were extended using the latest National Planning Policy Framework (NPPF) guidance (Environment Agency, 2017). The existing 2100 peak levels were extended to 2115, using an increase of 1.21m from the 1990 peak tidal levels applied at the downstream boundary of the ISIS model. The 2115 epoch was chosen as this is the latest prediction of peak level increase that is available with National Planning Policy Framework (NPPF) (Environment Agency, 2017), with the primary purpose of this modelling to support future Flood Risk Assessments.* This suggests the modelling was completed prior to release of the UKCP18 SLR to CFB2018 EWLs. Therefore based on the EWL used in the modelling the year has been adjusted to match TE2100 1 in 1000 EWL adjusted for UKCP18 SLR to CFB2018 EWLs. On this basis the maximum tidal defence level may be reached by 2104, beyond which overtopping of flood defences during the design EWL. The modelled breach flood level for the shaft is 4.39mOD in 2104.

If the TE2100 policy changes then a conservative assumption the landward breach peak flood level can be extrapolated linearly the breach flood level at the proposed location of the Gravesend Shaft is estimated to be about 4.47mOD.

Table 41. Gravesend CSEC Shaft summary of Environmental Agency Product 5 and 6 breach flood modelling.

Data	Flood defences breach hydraulic modelling scenarios					
	Year	*Year adjusted	1 in 200 (0.5%)		1 in 1000 (0.1%)	
			Depth (m)	Flood Level (mOD)	Depth (m)	Flood Level (mOD)
Product 5 & 6 2005 and 2115 models (2023)	2005	2009	1.747	4.180	1.800	4.233
	2115	2104	1.884	4.316	1.959	4.391
Interpolated	2028	2028	1.774	4.207	1.832	4.264
Extrapolated #	2148	2148	1.948	4.380	2.034	4.465
* Revised year to match TE2100 1 in 1000 EWL adjusted for UKCP18 SLR to CFB2018 EWLs # Extrapolated flood level if flood defences were raised to keep pace with sea level rise and climate change. Product 5 & 6 2005 and 2115 model levels and depths read from the Environmental model outputs provided						

It should be noted that breaches of wider than the design 50m breach that would result in higher flood levels cannot be ruled out.

For overtopping flood event, flood water depth levels would no longer be limited by the hydraulic limitations of a 50m wide breach and flood levels would increase and may reach the full tidal flood level.

5.8.10. *Residual uncertainties allowance*

It is expected that while flood defences have sufficient height to withstand 0.1% AEP event EWL an overtopping event will need not be considered. However, by 2148, and under current TE2100 Policy plans on only maintain current flood defence levels, the flood defences will not be sufficient for 1% or 0.1% AEP events. Therefore, an overtopping event will need not be considered for future flood events. In this case the shaft design will need to consider design for full tidal flood levels to 6.9m for a 1 in 200-year design tidal EWL and consider a further residual uncertainties allowance for 1 in 1000-year flood events.

The available combined flood breach levels in the case where flood defences are not overtopped it is estimated flood levels could be to be 4.39mOD. However, after 2104 overtopping will become more likely and it is recommended the shaft design should consider the full tidal EWL to remain operational.

In the case of fluvial, pluvial and surface water flooding the flood levels are about 2.7mOD for the baseline flood levels, this is expected to increase with climate allowances, therefore a residual allowance of 3.0mOD may be required for peak river level or peak rainfall events during tidal locking of the adjacent watercourse. With EA agreement, it is proposed the residual allowance of 3.0mOD be used instead of undertaking a hydraulic modelling assessment of future climate scenarios.

5.8.11. *Details of the finished floor levels*

The Gravesend CSEC has not yet been designed, however ground levels at the proposed site are approximately 2.3mOD. Sensitivity analysis indicates this ground level would be susceptible to fluvial flooding, therefore the ground levels are recommended to be raised to t to 3.0mOD to account for future climate change.

The predicted breach level on site will be 4.47mOD and allowing for a 1m resilience allowance a level of 4.77mOD should be considered in design if the infrastructure is to remain operable in these conditions.

For the extreme flood levels resulting in overtopping of the current flood defences, which are not due to be raised, a level of 6.9mOD design EWL with and allowing for a 0.3m resilience allowance a level of 7.2mOD should be considered in design if the infrastructure is to remain operable in these conditions.

5.8.12. *Details of flood resistance and resilience plans*

Details for flood resistance and resilience plans are not yet available, however the floor level could be built 0.3m above the peak river flow levels during tidal lock with additional contingency height built into the shaft to withstand a design flood breach event. Alternatively, the design could put in place a reactionary mitigation measure to respond to climate induced increase in sea level.

5.9. *Flood risk management measures*

5.9.1. *Flood mitigation measures*

5.9.2. *Alteration of watercourse channels and structures*

As good practice, the watercourses and drainage should not be altered or restricted in any way. The project site area is confined to the National Grid land and there is not expected to be any loss of flow path or flow capacity changes, and the existing structures are not expected to be altered. Therefore, no mitigation measures are considered.

5.9.3. *Compensatory flood storage areas*

A raised hardstanding area for the permanent new Gravesend cable sealing end compound would result in some loss of the flood plain storage volume. As an essential mitigation practice any loss of flood plain storage should be offset by provision of compensatory flood storage. Direct or 'level for level' compensation, or indirect compensations methods for release of water at controlled rates can be used.

The Eastcourt Marshes and canal basin area is a flat low-lying area that may not be appropriate for conventional compensatory flood storage areas. The loss in flood plan storage volume in comparison to the size of the available flood plain is by inspection considered to likely be negligible. The main part of the flood plain and the watercourse are both located to the east of the proposed New Gravesend CSEC, therefore any impact on flow during maximum flood will also likely be negligible.

5.9.4. *CSEC Compound Drainage*

Due to the size and location of the compound, surface water runoff is will not contribute to increasing risk elsewhere.

The drainage strategy would generally be based on the use of gravity systems that discharge to surface watercourses via retention ponds.

The drainage strategy will need to be considered as part of the detailed design.

5.9.5. *Hydraulic structures*

The main culvert to the north of the site limits conveyance of flood flows between the floodplain watercourse north into the Thames River. This existing culvert would not be altered as part of mitigation measures.

5.9.6. *Flood Protection Measures*

The Gravesend CSEC site is located within the North Kent Marshes Policy Unit TE2100 Policy 3 (P3) Area. This policy requires the Environmental Agency to take action to maintain flood defences at their current level, accepting that the flood risk will increase would be vulnerable to overtopping during a tidal flood event and would need to be protected. The design tidal EWL for a 1 in 200-year design flood level is 6.9mOD which means by 2148 the tidal flood defences will be overtopped on a regular basis and potentially by as much as 0.8m.

The Environmental Agency advises landowners who wish to give their property a higher level of flood risk protection than the policy set by the Environmental Agency can manage their flood risk in consultation with the Environment Agency and other risk management authorities.

On the basis of the design EWL of 6.9mOD for 1 in 200-year TE2100 EWL adjusted to CFB2018 EWL and UKCP18 sea level rise and residuals uncertainties allowance of 1m. To provide full flood protection resilience to level required to remain in operation in 2148, flood defences or the shaft/compound level would need to be raised to 7.20mOD.

The Gravesend Reach is considered by TE2100 to be a potential location for a second set of barrier gates to keep high tides and storm tides out of the upstream areas. It is currently not known where the second barrier will finally be located or of it will be constructed at Gravesend or another reach of the Thames.

Flood resilience design will need to be included in the detailed design undertaken by the principal contractor.

The Gravesend CSEC formation level could be raised to a level above the design breach combined flood level of 4.47mOD for 2148 to provide flood resilience against breach of the flood defences.

As a minimum the Gravesend CSEC formation level should be raised to the same level as the existing Gravesend CSEC hardstanding of about 3.7mOD to provide resilience against fluvial and surface water flooding. However, it would be recommended to raise this level a further 0.3m to account for a residual uncertainties allowance as climate change modelling is was not provided in the information made available from the Environmental Agency.

5.9.7. Flood resilience measures

5.9.7.1. Compound final formation level.

Raising the final formation level of the sealing end compound 0.3m above the 1% AEP flood level (design flood) for 2148 with river flow allowances applied, this will reduce the fluvial, surface water flood risk to negligible.

5.9.7.2. Flood compatibility design.

Where raising levels may not be practical, the design could consider options that can be partially or wholly inundated and remain operational while submerged.

5.9.7.3. Drainage maintenance

Drainage infrastructure and treatment systems should be inspected and maintained.

5.9.7.4. Climate change allowances

The design of the compensatory flood storage and the flood protection measures should be considered in the design and include allowances for projected climate change.

5.9.7.5. Residual uncertainties allowance

A residual uncertainties (freeboard) allowance of 1.0m would be added to the 0.1% AEP tidal flood level to determine the crest level of the flood protection measures.

5.9.8. Residual Flood Risk

Residual flood risks along with associated mitigation measures are presented in Table 42

Table 42. Gravesend Site Residual Risk and Mitigation

Ref		Residual risk	Mitigation measures
1		Overwhelming of the compound drainage system due to a severe storm event or a blockage may result in onsite and/or offsite flooding and the potential for runoff to enter the tunnel.	Drainage asset inspections would be undertaken. A planned, risk-based maintenance programme to be undertaken. Planned maintenance interventions would ensure efficient operation of the drainage network Include a residual uncertainty allowance in the design to raise the final formation levels for the compound and raise the top of the shaft to a suitable level.
2		Overtopping of the silt retention ponds may occur in the event of a severe storm during construction. This may lead to development of secondary flow paths and silt pollution of the local watercourse or Thames estuary.	The capacity of retention ponds would include provision for climate change allowances in accordance with the Environment Agency guidance. Drainage asset inspections would be undertaken and maintenance programmes would be established, all as described above. Planned maintenance interventions would ensure continued efficient operation of the retention ponds
3		Overtopping of the tidal flood protection due to a severe tidal event could result in inundation of the tunnel.	A tunnel safety consultation has been undertaken on emergency preparedness. This consultation establishes measures to be implemented during an incident.
4		Structural failure (breach) of the Thames River flood defences.	The 0.1% AEP tidal event EWL of the River Thames in 2148 for Gravesend Power Station node (Project location) 7.61mOD. An

			emergency escape plant is to be put in place as a contingency.
5		Reliance on the Environmental Agency to implement the TE2100 policy programme to raise tidal flood defences to cope with future extreme water level flood events	Monitoring the TE2100 Policy programme and its implementation. Consider contingencies to react to increased flood risk in the event tidal flood defences are not raised quickly enough.
6		Alteration of the watercourse and catchment water storage capacity.	Undertake a full impact assessment to determine effects of raising the ground level to the required level to provide resilience against flooding. This may require hydraulic assessment to determine and verify changes in the flood storage volume has a negligible effect on flood levels.

6. Construction Phase Flood Risk

6.1. General

The Project would necessitate construction work being undertaken in Flood Zone 3 for both CSECs.

6.2. Temporary works

Refer to the Works Area Strategy for the conceptual project and site facilities (Report PDD-100116-REP-021 / 30003364-MSE-XX-XX-RP-Y-10082)

Temporary structures will be finalised in the detailed design may include and not be limited to

- Dewatering works
- Cofferdams
- Trench supports
- Working platforms
- Tunnel and shaft openings

The construction would also be supported by haul roads, site roads and utilities (power, lighting, communications, water, wastewater)

Surface water drainage would be provided for any surfaced roads and yards, buildings and any other hard or impermeable surfaces. Depending upon the final site layout, berms, bunds and silt traps may be constructed to manage surface water runoff. Typically, this would be done to protect watercourses, prevent ponding and to keep general runoff separate from contaminated runoff and prevent silt pollution of the local watercourses and Themes Estuary.

The Contractor would establish a planned maintenance programme to keep the site drainage system in good working order.

6.3. Climate Change

Fluvial flood risk would be assessed for a range of events up to the 1% AEP event with the allowances for climate change.

Construction is due to be completed in 2028. The climate change allowances for the construction phase are based on the information in Section 3 and are presented in Table 43 and Table 44.

Table 43. Tilbury climate change allowances for construction

Project site	Division	Allowance for 2028
Peak rainfall intensity	Central	20%
Peak River Flow Allowance	Upper End	22%
	Higher Central	11%
	Central	6%
Sea level rise	Upper end (higher central not specified here as similar to Upper end for the change period 2017 to 2028)	EWLs calculated following the method set out in Section 3

Table 44. Gravesend climate change allowances for construction

Project site	Division	Allowance for 2028
Peak rainfall intensity	Central	20%
Peak River Flow Allowance	Upper End	29%
	Higher Central	19%
	Central	14%
Sea level rise	Upper end (higher central not specified here as similar to Upper end for the change period 2017 to 2028)	EWLs calculated following the method set out in Section 3

7. Thames Estuary 2100 Plan

7.1. Introduction

The TE2100 Plan (Environment Agency, 2012) is the Environmental Agency's long-term strategy for managing tidal flood risk in the Thames Estuary. This plan has been withdrawn and is currently under revision.

The revised TE2100 Plan (Environmental Agency 2023d) published online sets flood risk management policies for each area of the estuary. The policies outline each area's tidal defences are managed as sea levels rise. They range from policy 3 (P3) to policy 5 (P5), and are based on social, economic and environmental factors. These policies help target Thames Estuary 2100 investment to the areas that need it the most.

The Environmental Agency advises some landowners may wish to give their property a higher level of flood risk protection than the policy set by the Environmental Agency. The Environmental Agency recognises each landowner has the right to invest and manage their flood risk in consultation with the Environment Agency and other risk management authorities.

The policies are:

- Policy 5 (P5) – take further action to reduce the risk of flooding
- Policy 4 (P4) – take further action to keep up with climate and land use change so that flood risk does not increase
- Policy 3 (P3) – take action to maintain flood defences at their current level, accepting that the flood risk will increase

The Environmental Agency has divided the estuary into 23 areas called policy units and given each unit a flood risk management policy based on local factors. These policy units subdivide the larger policy areas. The policy units and TE2100 policy plans for each site are summarised in Table 45.

Table 45. TE2100 policy units and policies

Project site	Policy Unit	TE2100 policy (2023)
New Tilbury CSEC	Purfleet, Grays and Tilbury	Policy 4 (P4) – take further action to keep up with climate and land use change so that flood risk does not increase
New Gravesend CSEC	North Kent Marshes	Policy 3 (P3) – take action to maintain flood defences at their current level, accepting that the flood risk will increase

7.2. Impact of the Project

The project has no impact on future work for the TE2100 plan as both sites are located landward of the flood defences.

8. Summary

8.1. *Planning and flood risk*

The Project was assessed against the provisions of the National Planning Policy Framework (NPPF) and the Overarching National Policy Statement for Energy (EN-1).

8.2. *Sequential Test and Exception Test*

The Project surface construction sites wholly lies within zone 3a and have been subject to the Sequential Test. Both sites do not meet the requirements of the Sequential Test but had to undergo the Exception Test as the development lies within Flood Zone 3.

The project sites are deemed to have passed the Exception Test because it is considered that the following apply

- The Project provides wider sustainability benefits to the community that would outweigh flood risk.
- The Project would be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and would reduce flood risk overall.

It has been demonstrated the provisions in Paragraph 5.7.24 of NPS EN-1 which states essential energy infrastructure which has to be located in flood risk areas should be designed to remain operational when floods occur.

8.3. *Climate Change*

Climate change has the potential to increase peak rainfall intensity with corresponding increase in the rate and volume of runoff, surface water flooding and discharged levels in watercourses. Furthermore, sea levels are also projected to increase as a result of climate change with increasing severities in climate conditions.

The Environment Agencies current guidance on climate change allowances for flood risk assessments (2022a) has been the primary source of assessing climate change allowances for peak rainfall intensity, peak river flows and sea level rises as applied to the Project.

8.4. Sources of Flood Risk

The likelihood of each flood risk source is summarised in Table 46

Table 46. Summary of flood risk sources

Site	Fluvial	Tidal	Pluvial	Groundwater	Sewers	Reservoirs	Canals	Water mains
Tilbury	N	P	P	N/A	N	N/A	N/A	N
Gravesend	P	P	P	P	N/A	N/A	N/A	N/A
P is Potential N is Negligible N/A is No Risk								

8.5. Flood risk alleviation

The flood risk management strategy considers a range of flood alleviation measures required to make the project safe without increasing flood risk elsewhere. These include flood mitigation, flood protection and flood resilience measures.

The project is still in early stages of design and some alleviation methods will still need to be considered in the detailed design.

8.5.1. Tilbury flood alleviation

The Tilbury CSEC is located in a Thames Estuary 2100 Policy 3 (P4) area for the Purfleet, Grays and Tilbury Policy Unit. This area will benefit from flood defences that will be raised to keep pace with increase in sea level. And will require fewer flood alleviation measures that Gravesend.

8.5.2. Gravesend flood alleviation

At Gravesend the loss of flood plan storage due to a raised hardstanding has not been assessed. The benefits of a potential compensatory flood storage area have not been assessed due to the effectiveness being unknown. Generally, compensatory flood storage areas for flood alleviation is considered an essential mitigation measure but may not be suitable in all cases.

Gravesend may require consideration for flood bunds or a flood wall to provide the cable sealing end compound with higher flood risk protection than the Thames Estuary 2100 Policy 3 (P3) for the North Kent Marshes Policy Unit area will provide.

Climate change allowances will be used to define the required finished ground level for the cable sealing end compound to ensure the site remains operational through to 2148.

8.6. Residual Risk

Residual risk remains after the flood risk management strategy. While generally these risks have a low probability of occurrence, impacts can be severe.

Refer to Table 47 for a summary of residual risks.

Table 47. Residual risk by site location

Risk	Tilbury	Gravesend	Mitigation and project response
Inundation of the sealing compound drainage	✓	✓	Implementation of an inspection and maintenance programme
Overtopping of siltation retention ponds	✓	✓	Implementation of an inspection and maintenance programme
Inundation of flood storage areas		✓	Implementation of an appropriate maintenance programme
Breach of tidal defences at Gravesend culvert		✓	The risk of a breach of River Thames tidal flood defences is considered to be negligible, but will increase during the lifetime of the project
Overtopping of tidal defences at Gravesend culvert		✓	The risk of overtopping will increase with the lifetime of the project. Localised flood defences or other mitigation or resilience design will be required to maintain a negligible risk of flooding.
Blockage of the Gravesend culvert		✓	The hydraulic modelling has not been made available from the EA.
Breach of tidal flood defences at Tilbury	✓		The risk of a breach of River Thames tidal flood defences is considered to be negligible for the lifetime of the project

8.7. *Combined flood events*

8.7.1. *Tilbury*

The Environmental Agency did not provide flood breach modelling for Tilbury as there is an inconsistency in the that would result in erroneous assessment of flood levels. However fluvial and surface water flooding modelling was provided.

8.7.2. *Gravesend*

The hydraulic modelling that was provided for the Gravesend site by the Environmental Agency for the combined tidal breach analysis and did not include fluvial or fluvial and pluvial event flood levels.

While the Thames flood defences are not overtopped or breached, the watercourse to east of the Gravesend site the Thames that drains into the Thames is assumed to be 100% blocked so River Thames tide conditions do not influence flood levels to be tidally locked during the tidal cycle. However, it will be expected to be tidally blocked during high tide conditions.

8.8. *Thames Estuary 2100 Policy Plan.*

The review of TE2100 concluded that the ability to implement the TE2100 Plan would not be affected by the Project. However, the TE2100 policies do have an impact on the Project.

8.8.1. *Tilbury*

For the Tilbury site, the flood defences are expected to be raised in line to keep up with climate change and sea level rise and the risk of tidal flood is expected to not change for the lifetime of the project.

8.8.2. *Gravesend*

The flood defences at Gravesend are to be maintained at their current level resulting in an increase in flood risk during the lifetime of the project.

8.9. *Construction Phase Flood Risk*

The location of the project necessitates construction work to take place in Flood zone 3, and it is not possible to avoid working in Flood Zone 3.

All temporary works of the construction project should be limited to the following

- Water compatible facilities
- Flood-resilient facilities
- Flood repairable facilities
- Site roads and underground utilities

The Contractor would be responsible for preparing a site-specific flood risk assessment to demonstrate that the site set up and temporary works comply with the requirements of the NPPF

The Contractor would establish emergency response measures for construction activities in flood risk areas. The two key emergency response measures are:

- Readiness for the possibility of flooding
- Development of a flood response plan

8.10. Drainage strategy

A drainage management strategy will be required as part of the detailed design and may include no may not be limited to the following

- Construction flood risk for each of the Gravesend and Tilbury Sites
- Temporary drainage design
- Construction water management
- Dewater management plan
- Protection of watercourses during works
- Infiltration ponds and drains during construction
- Silt retention ponds during construction
- Compensatory flood storage areas
- Avoiding impacts on ground water resources

9. Appendix A – Tilbury Flood Data

EA/NRW Flood Data Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

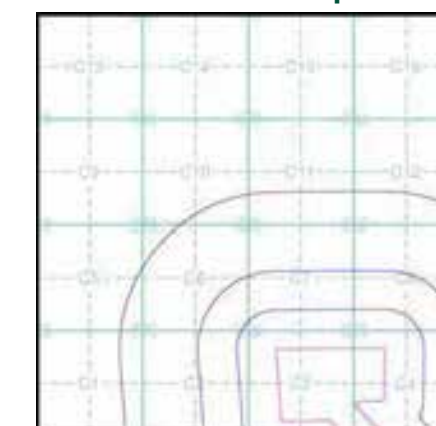
Flood Data

- Extrema Flooding from Rivers or Sea without Defences (Zone 2)
- Flooding from Rivers or Sea without Defences (Zone 3)
- ▨ Area Benefiting from Flood Defence
- Flood Water Storage Areas
- Flood Defence

Contours (height in metres)

- Standard Contour 0.5m
- Master Contour 1.0m
- Spot Height 1.5m
- MLW Mean Low Water
- MHW Mean High Water

EA/NRW Flood Data Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA 75 Year Return Flood Map (Undefended) (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

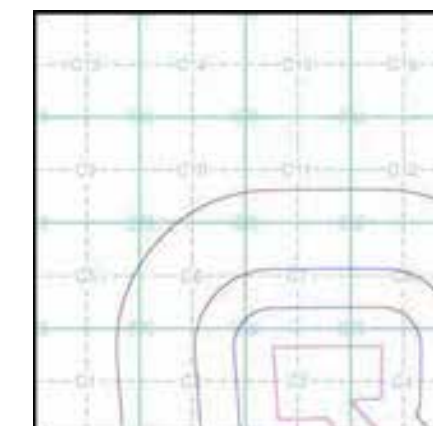
Modelled Flood Depth

Pluvial Depth	Fluvial Depth	Coastal Depth
0.1m	0.01m - 0.05m	0.01m - 0.05m
0.1m - 0.3m	0.05m - 0.1m	0.05m - 0.1m
0.3m - 1m	0.1m - 0.3m	0.1m - 0.3m
>1m	0.3m - 1m	0.3m - 1m
	>1m	>1m

Contours (height in metres)

- Standard Contour
- Master Contour
- Spot Height
- Mean Low Water
- Mean High Water

JBA 75 Year Return Flood Map (Undefended) - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA 100 Year Return Flood Map (Undefended) (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

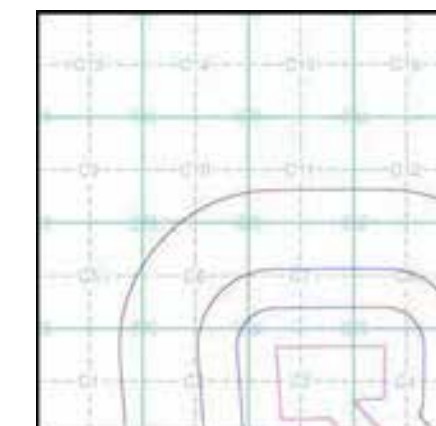
Modelled Flood Depth

Fluvial Depth	Coastal Depth
0.01m - 0.05m	0.01m - 0.05m
0.05m - 0.1m	0.05m - 0.1m
0.1m - 0.3m	0.1m - 0.3m
0.3m - 1m	0.3m - 1m
>1m	>1m

Contours (height in metres)

- Standard Contour
- Master Contour
- Spot Height
- MLW Mean Low Water
- MHW Mean High Water

JBA 100 Year Return Flood Map (Undefended) - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA 200 Year Return Flood Map (Undefended) (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

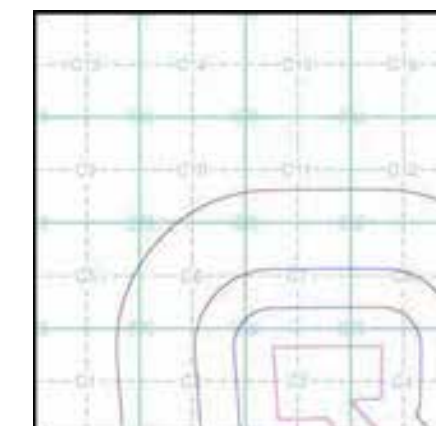
Modelled Flood Depth

Pluvial Depth	Fluvial Depth	Coastal Depth
0.1m	0.01m - 0.05m	0.01m - 0.05m
0.1m - 0.3m	0.05m - 0.1m	0.05m - 0.1m
0.3m - 1m	0.1m - 0.3m	0.1m - 0.3m
>1m	0.3m - 1m	0.3m - 1m
	>1m	>1m

Contours (height in metres)

- Standard Contour
- Master Contour
- Spot Height
- Mean Low Water
- Mean High Water

JBA 200 Year Return Flood Map (Undefended) - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA 1000 Year Return Flood Map (Undefended) (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

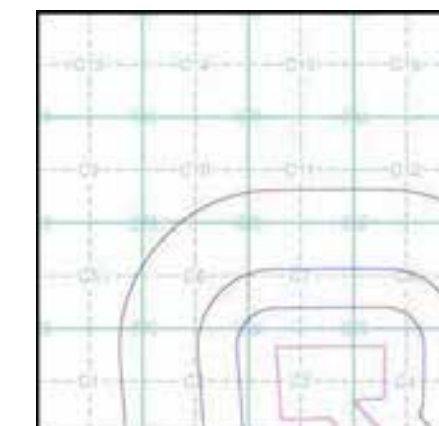
Modelled Flood Depth

Pluvial Depth	Fluvial Depth	Coastal Depth
0.1m	0.01m - 0.05m	0.01m - 0.05m
0.1m - 0.3m	0.05m - 0.1m	0.05m - 0.1m
0.3m - 1m	0.1m - 0.3m	0.1m - 0.3m
>1m	0.3m - 1m	0.3m - 1m
	>1m	>1m

Contours (height in metres)

- Standard Contour
- Master Contour
- Spot Height
- Mean Low Water
- Mean High Water

JBA 1000 Year Return Flood Map (Undefended) - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA Canal Failure Map (1:10,000)

General

-  Specified Site
-  Specified Buffer(s)
-  Bearing Reference Point

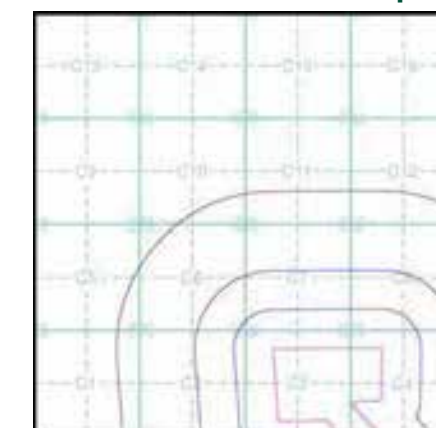
Flood Data

-  Canal Failure
-  Coverage

Contours (height in metres)

- Standard Contour  105  100  95  MLW  Mean Low Water
- Master Contour  105  100  95  MHW  Mean High Water
- Spot Height  167.8

JBA Canal Failure Flood Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 30 Year Return Depth Map (1:10,000)

General

Specified Site Specified Buffer(s) X Bearing Reference Point

Surface Water Depth

0 - 0.15m
0.15 - 0.30m
0.30 - 0.60m
0.60 - 0.90m
0.90 - 1.20m
> 1.20m

Contours (height in metres)

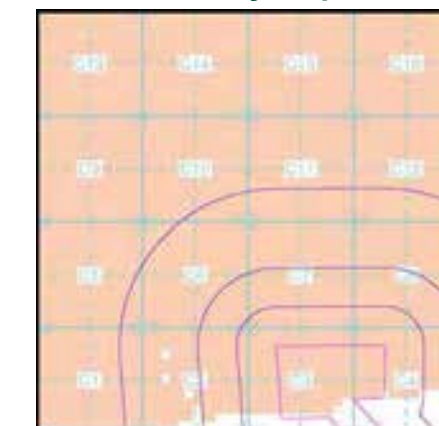
Standard Contour 105 100 95
Master Contour
Spot Height *167.8
MLW Mean Low Water
MHW Mean High Water

Suitability

See the suitability map below

National to county
County to town
Town to street
Street to parcels of land
Property

EA/NRW Suitability Map - Slice C



Order Details

Order Number: 302366136_1_1
Customer Ref: 500199 TKRE
National Grid Reference: 566170, 175970
Slice: C
Site Area (Ha): 72.49
Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 100 Year Return Depth Map

General
 Specified Site Specified Buffer(s) X Bearing Reference Point

Surface Water Depth

0 - 0.15m
 0.15 - 0.30m
 0.30 - 0.60m
 0.60 - 0.90m
 0.90 - 1.20m
 > 1.20m

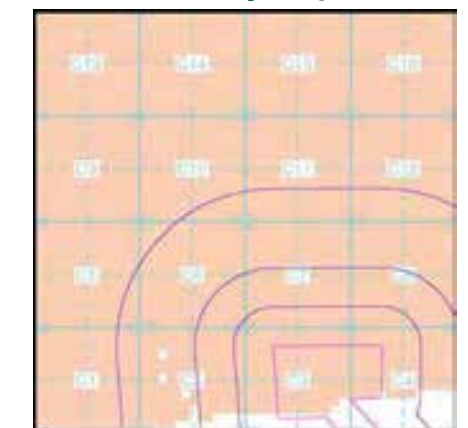
Contours (height in metres)

Standard Contour 105 100 95
 Master Contour 100 95
 Spot Height *167.8
 MLW Mean Low Water
 MHW Mean High Water

Suitability

See the suitability map below
 National to county
 County to town
 Town to street
 Street to parcels of land
 Property

EA/NRW Suitability Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 1000 Year Return Depth Map (1:10,000)

General
 Specified Site Specified Buffer(s) X Bearing Reference Point

Surface Water Depth

0 - 0.15m
 0.15 - 0.30m
 0.30 - 0.60m
 0.60 - 0.90m
 0.90 - 1.20m
 > 1.20m

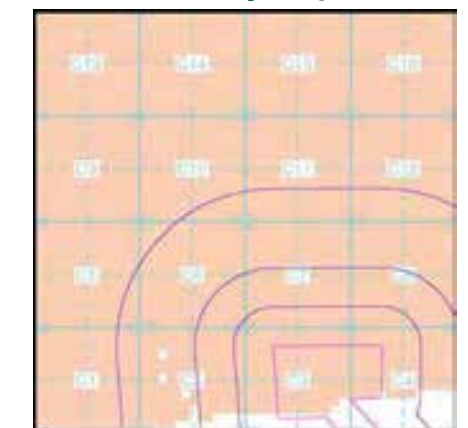
Contours (height in metres)

Standard Contour 105 100 95
 Master Contour
 Spot Height *167.8
 MLW Mean Low Water
 MHW Mean High Water

Suitability

See the suitability map below
 National to county
 County to town
 Town to street
 Street to parcels of land
 Property

EA/NRW Suitability Map - Slice C



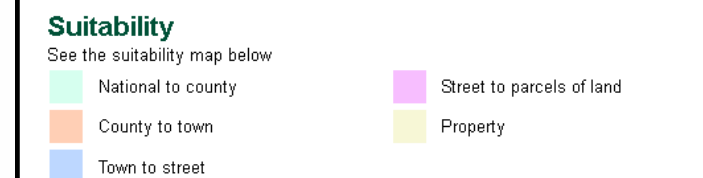
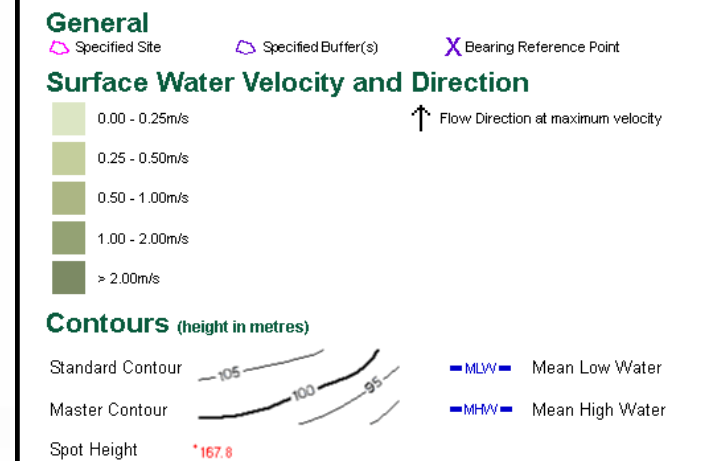
Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

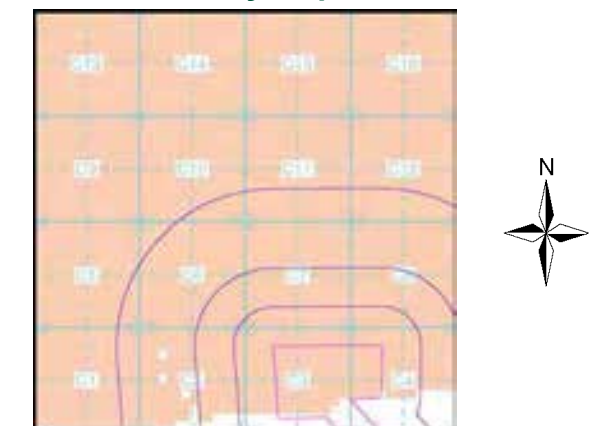
Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 30 Year Return Velocity and Flow Direction Map (1:10,000)



EA/NRW Suitability Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 100 Year Return Velocity and Flow Direction Map (1:10,000)

General
 Specified Site Specified Buffer(s) X Bearing Reference Point

Surface Water Velocity and Direction
 0.00 - 0.25m/s
 0.25 - 0.50m/s
 0.50 - 1.00m/s
 1.00 - 2.00m/s
 > 2.00m/s
 ↑ Flow Direction at maximum velocity

Contours (height in metres)
 Standard Contour 105 100 95
 Master Contour
 Spot Height *167.8
 — MLW — Mean Low Water
 — MHW — Mean High Water

Suitability
 See the suitability map below
 National to county
 County to town
 Town to street
 Street to parcels of land
 Property

EA/NRW Suitability Map - Slice C



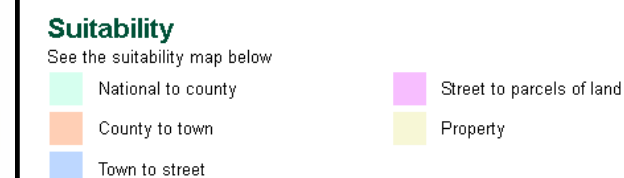
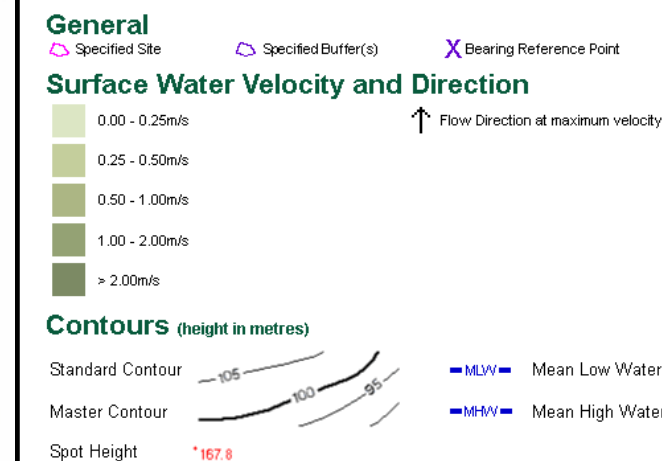
Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 1000 Year Return Velocity and Flow Direction Map (1:10,000)



EA/NRW Suitability Map - Slice C



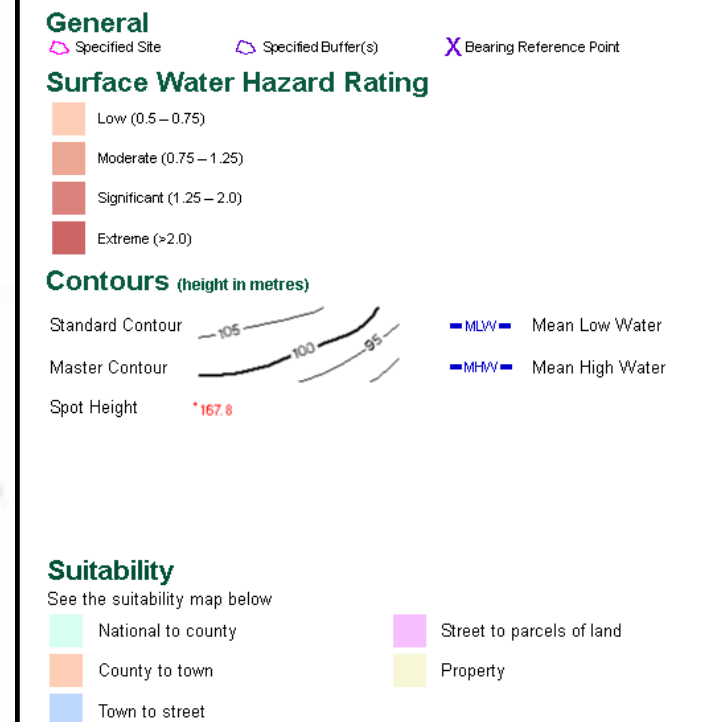
Order Details

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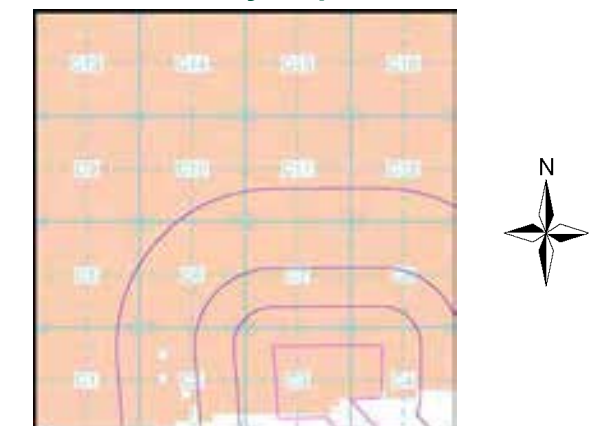
Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 30 Year Return Hazard Rating Map (1:10,000)



EA/NRW Suitability Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 100 Year Return Hazard Rating Map (1:10,000)

General
 Specified Site Specified Buffer(s) X Bearing Reference Point

Surface Water Hazard Rating

Low (0.5 – 0.75)
 Moderate (0.75 – 1.25)
 Significant (1.25 – 2.0)
 Extreme (>2.0)

Contours (height in metres)

Standard Contour 105 100 95
 Master Contour
 Spot Height *167.8
 MLW Mean Low Water
 MHW Mean High Water

Suitability

See the suitability map below

National to county
 County to town
 Town to street
 Street to parcels of land
 Property

EA/NRW Suitability Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 1000 Year Return Hazard Rating Map (1:10,000)

General
 Specified Site Specified Buffer(s) X Bearing Reference Point

Surface Water Hazard Rating

Low (0.5 – 0.75)
 Moderate (0.75 – 1.25)
 Significant (1.25 – 2.0)
 Extreme (>2.0)

Contours (height in metres)

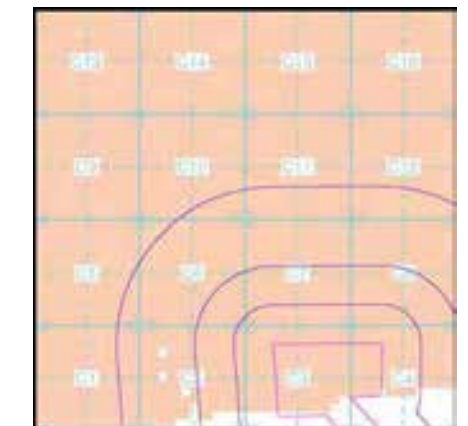
Standard Contour 105 100 95
 Master Contour
 Spot Height *167.8
 MLW Mean Low Water
 MHW Mean High Water

Suitability

See the suitability map below

National to county
 County to town
 Town to street
 Street to parcels of land
 Property

EA/NRW Suitability Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

OS Water Network Lines Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

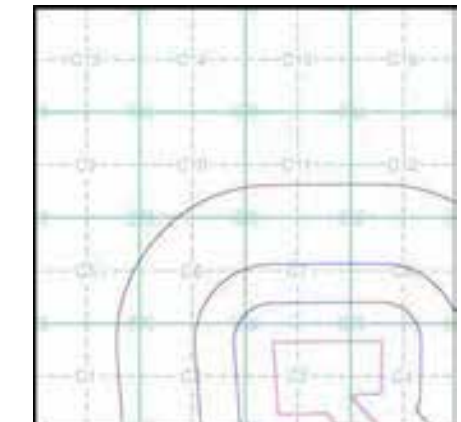
OS Water Network Data

- | | |
|----------------|---------------------------|
| — Canal | — Drain |
| — Reservoir | — Other |
| — Foreshore | — Lake |
| — Marsh | — Transfer |
| — Tidal River | — Lock Or Flight Of Locks |
| — Inland River | — Sea |
| ● Junction | ● Source |
| ● Outlet | ● Other |
| ● Pseudo | |

Contours (height in meters)

- Standard Contour — 10m
- Master Contour — 100m
- Spot Height — 1m
- MLW — Mean Low Water
- MHW — Mean High Water

OS Water Network Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Historic Flood Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Map ID

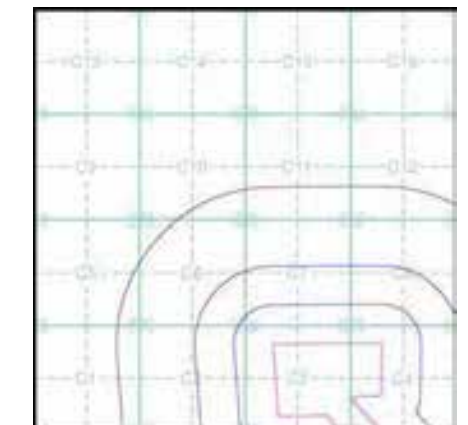
Historic Flood Events Data

- | | |
|--|--|
| Channel Capacity Exceeded (no raised defences) | Obstruction/Blockage - Culvert |
| Channel Capacity Exceeded /Surface Water | Obstruction/Blockage - Debris Screen |
| Groundwater/High Water Table | Operational Failure/ Breach of Defence |
| Local Drainage/Surface Water | Other |
| Mechanical Failure | Overtopping of Defences |
| Obstruction/Blockage - Bridge | Surface Water |
| Obstruction/Blockage - Channel | Unknown |
| Historical Flood Liabilities | |

Contours (height in metres)

- Standard Contour 105 100 95
- Master Contour
- Spot Height 167.8
- MLW Mean Low Water
- MHW Mean High Water

EA/NRW Historic Flood Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point

Risk of Flooding from Surface Water

- High - 30 Year Return
- Medium - 100 Year Return
- Low - 1000 Year Return

Suitability

See the suitability map below

- National to county
- County to town
- Town to street
- Street to parcels of land
- Property

EA/NRW Suitability Map - Slice C

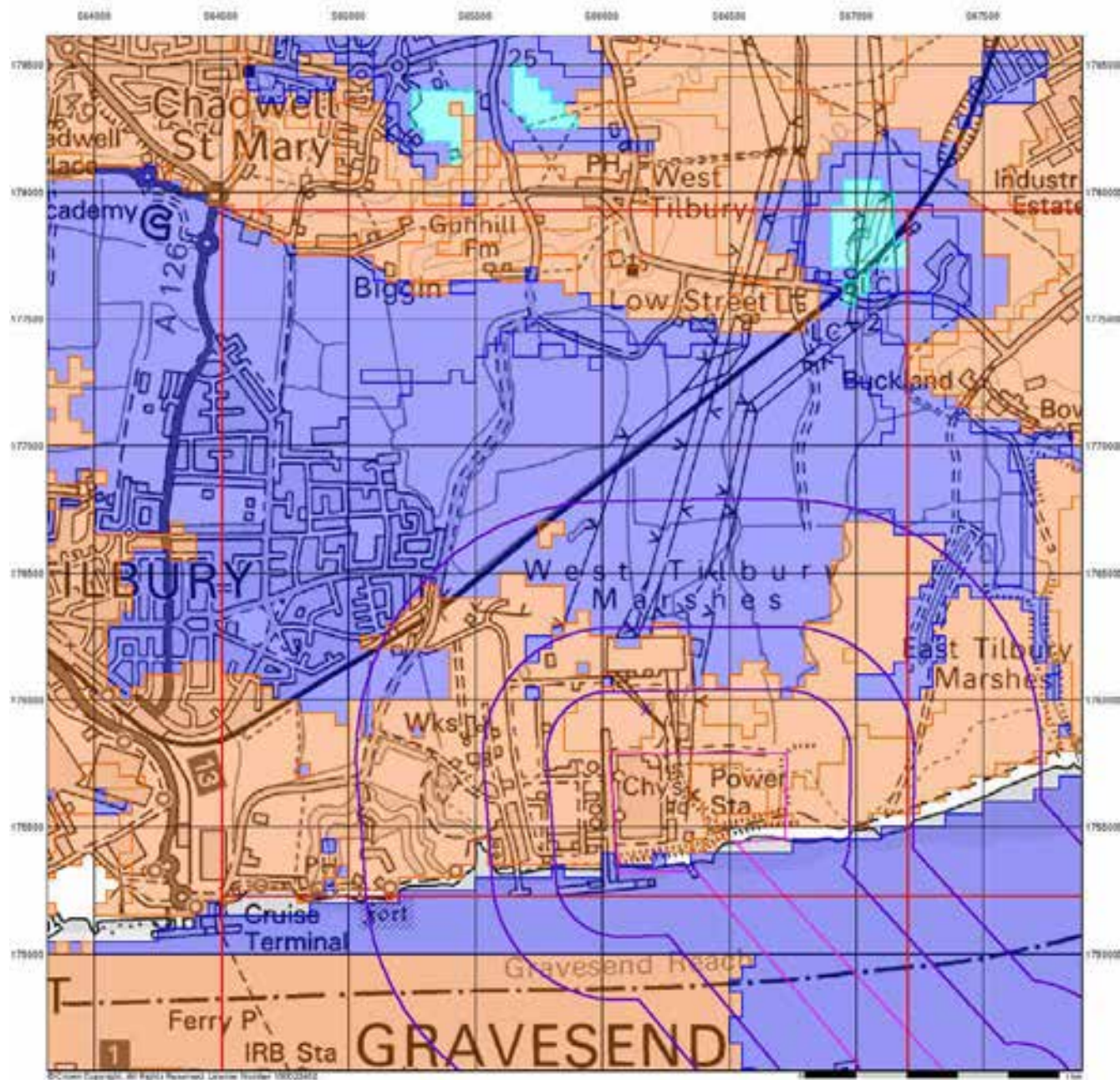


Order Details

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 Slice: C
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 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock



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BGS Flood GFS Data

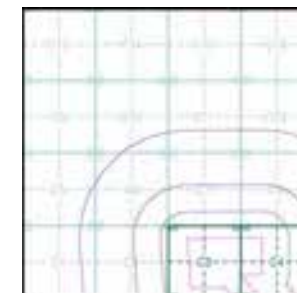
General

- Specified Site
- Specified Buffer(s)
- Missing Reference Point
- Slice

Agency and Hydrological (Flood)

- Limited Potential for Groundwater Flooding to Occur
- Potential for Groundwater Flooding of Property Situated Below Ground Level
- Potential for Groundwater Flooding to Occur at Surface

Site Sensitivity Context Map - Slice C



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

Landmark[®]
 LANDMARK INFORMATION GROUP

Tel: 0844 844 9952
 Fax: 0844 844 9951
 Web: www.envirocheck.co.uk

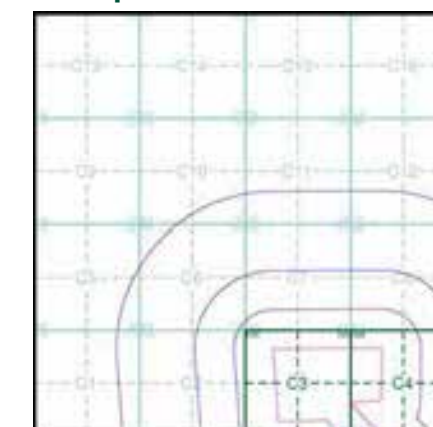
General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point

Agency and Hydrological (Flood)

- Extreme Flooding from Rivers or Sea without Defences (Zone 2)
- Flooding from Rivers or Sea without Defences (Zone 3)
- Area Benefiting from Flood Defence
- Flood Water Storage Areas
- Flood Defence

Flood Map - Slice C

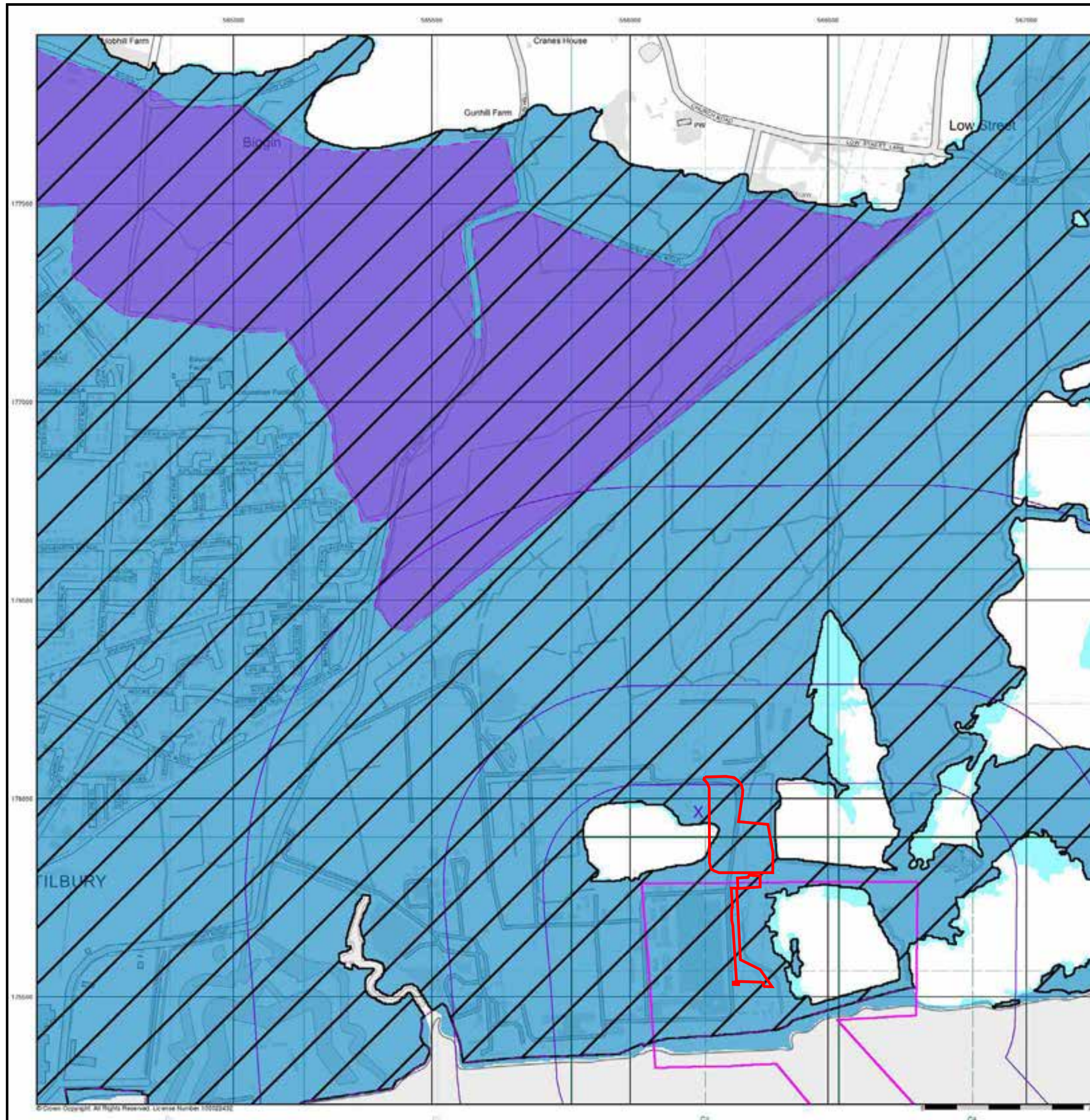


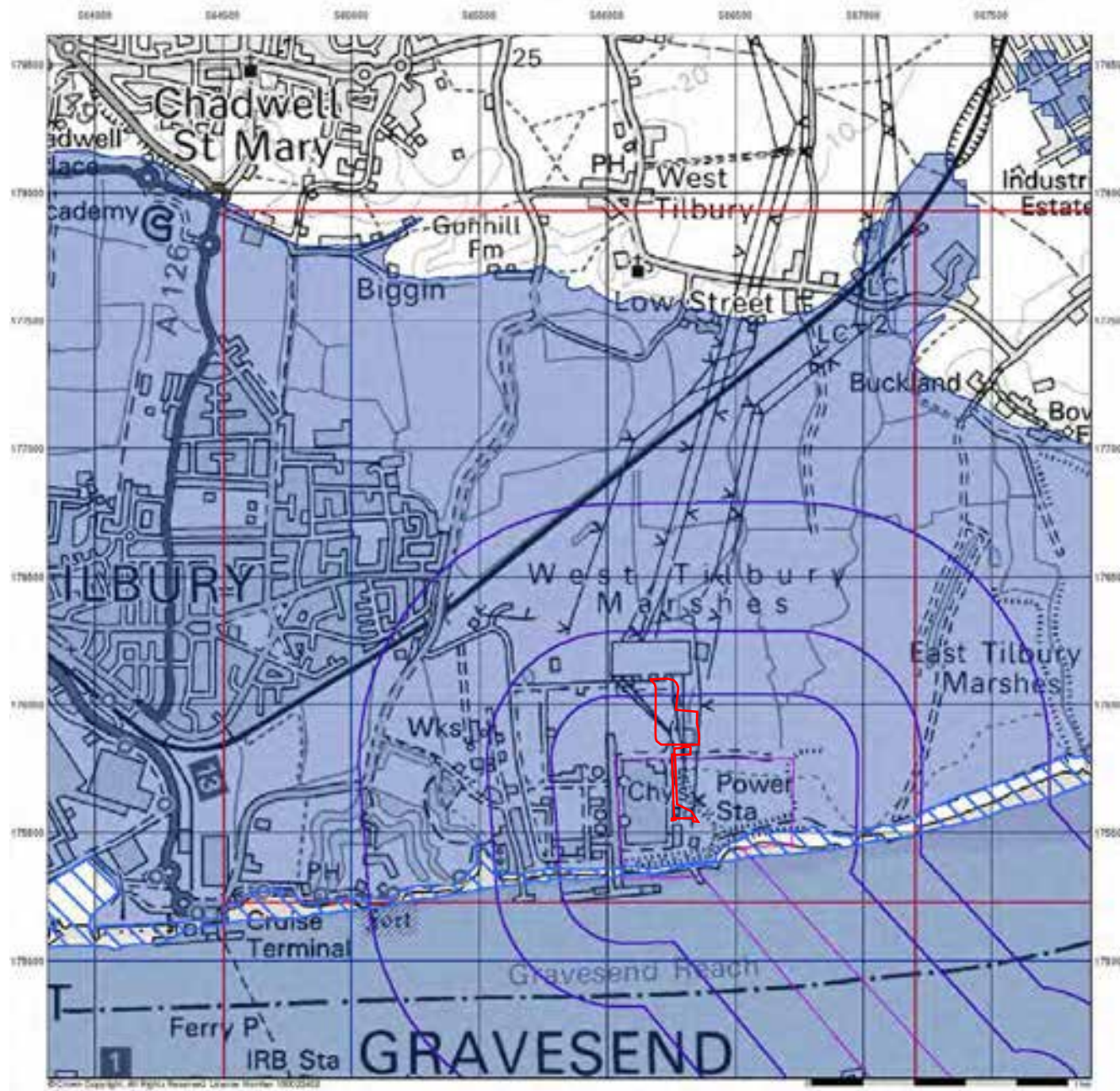
Order Details

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 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock





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BGS Flood Data (1:50,000)

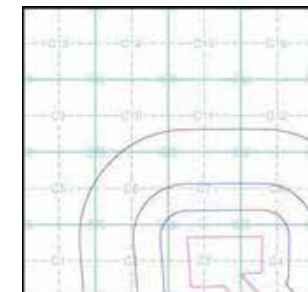
General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Slice
- Map ID

BGS Geological Indicators of Flooding

- Coastal
- Inland
- Bodies of Water

BGS Flood Data Map - Slice C



Order Details

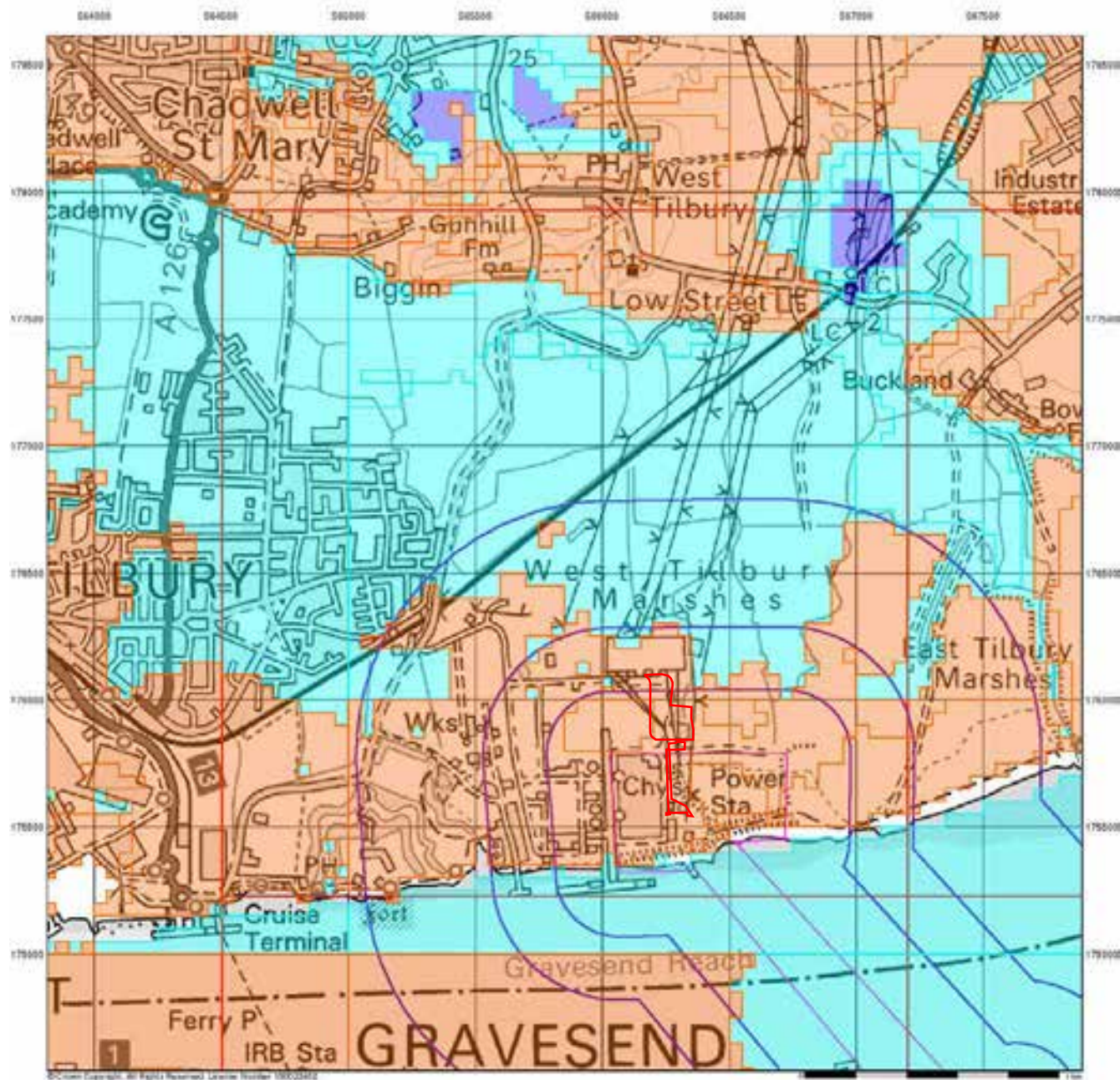
Order Number: 302366136_1_1
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 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

Landmark
 INFORMATION GROUP

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 Web: www.envirocheck.co.uk



BGS Flood Data (1:50,000)

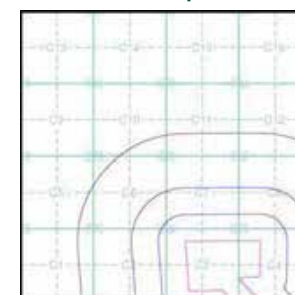
General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Slice
- Map ID

BGS Groundwater Flooding Susceptibility

- Potential for Groundwater Flooding to Occur at Surface
- Potential for Groundwater Flooding of Property Situated Below Ground Level
- Limited Potential for Groundwater Flooding to Occur

BGS Flood Data Map - Slice C

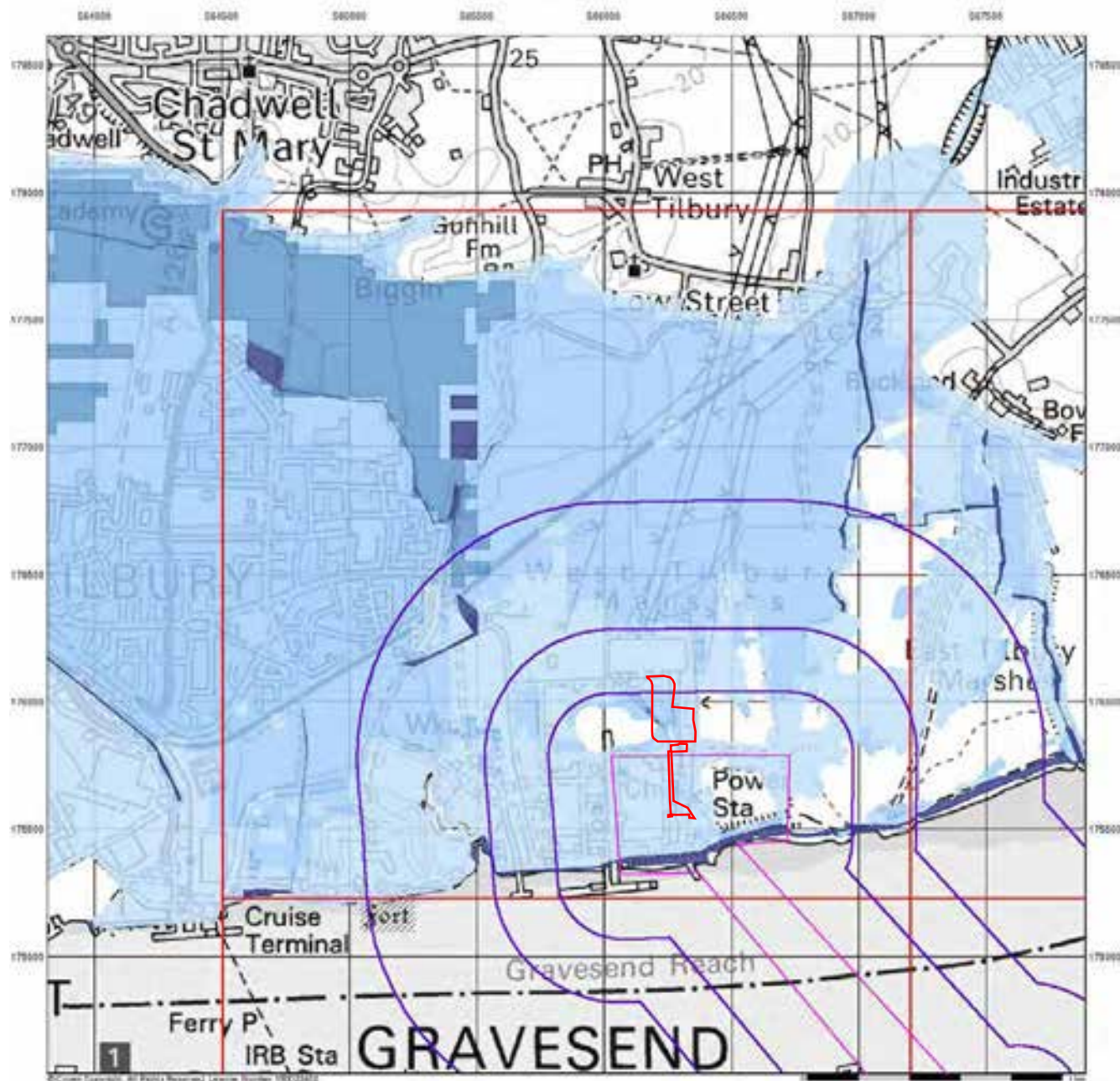


Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock



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EA/NRW RoFRS Data (1:50,000)

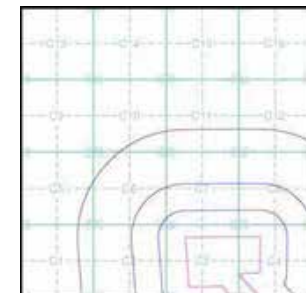
General

- ◊ Specified Site
- ◊ Specified Buffer(s)
- X Bearing Reference Point
- Slice
- 8 Map ID

Risk of Flooding from Rivers and Sea (RoFRS)

- High Risk
- Medium Risk
- Low Risk
- Very Low Risk

EA/NRW RoFRS Data Map - Slice C



Order Details

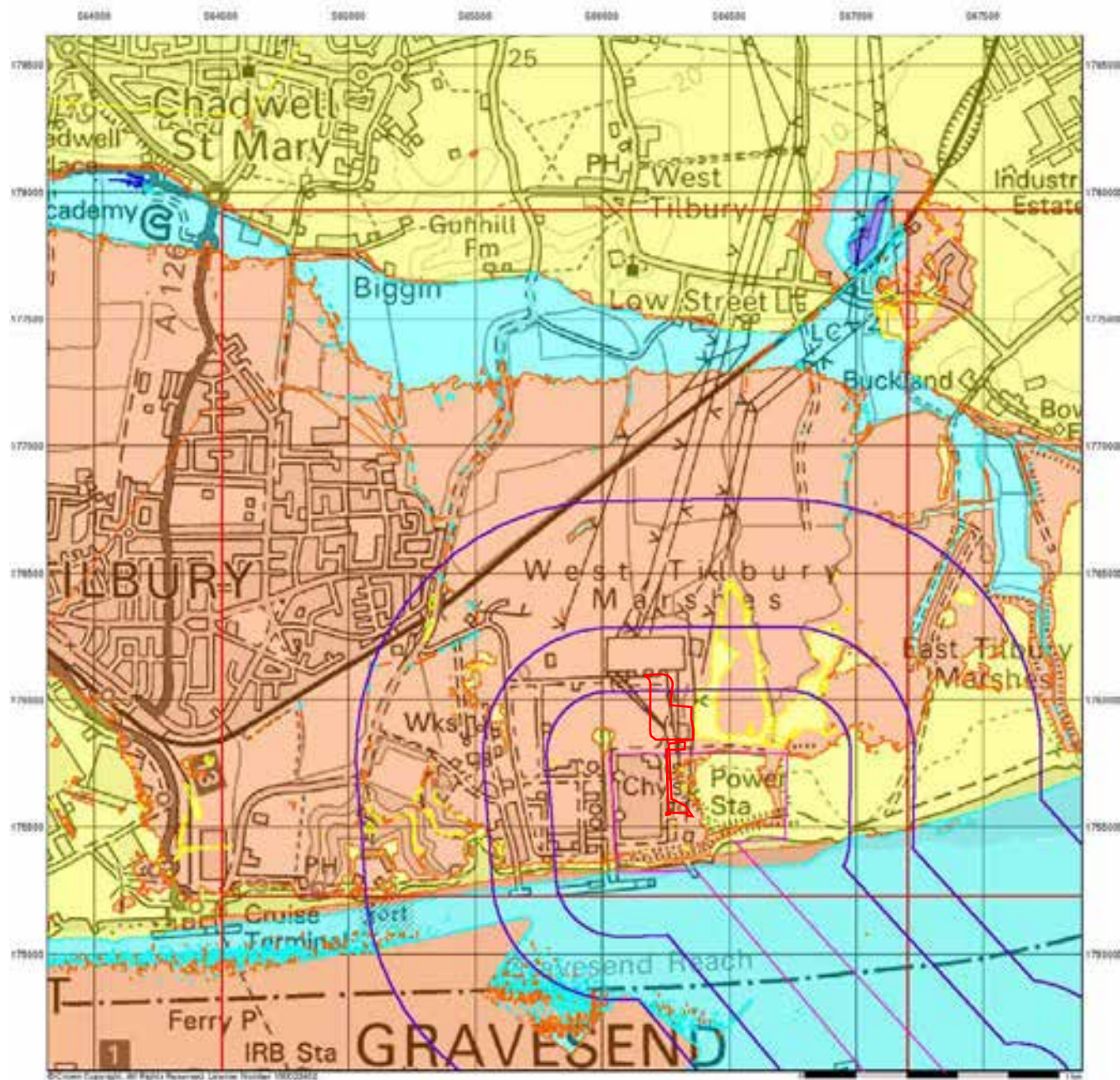
Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566170, 175970
 Slice: C
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

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GeoSmart Information Groundwater Flood Map (1:50,000)

General

Specified Site Specified Buffer(s) Bearing Reference Point

Slice

GeoSmart Information Groundwater Flooding Risk

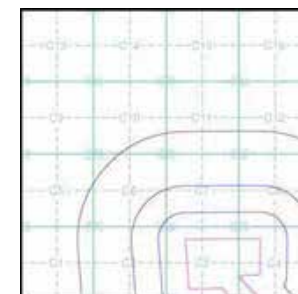
High Risk

Moderate Risk

Low Risk

Negligible Risk

GeoSmart Information Groundwater Flood Map - Slice C



Order Details

Order Number: 302366136_1_1
Customer Ref: 500199 TKRE
National Grid Reference: 566170, 175970
Slice: C
Site Area (Ha): 72.49
Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

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LANDMARK INFORMATION GROUP

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

Flood map for planning

Your reference
Tilbury CSEC

Location (easting/northing)
566311/175856

Created
23 Mar 2023 14:02

**Your selected location is in flood zone 3
– an area with a high probability of flooding.**

This means:

- you may need to complete a flood risk assessment for development in this area
- you should ask the Environment Agency about the level of flood protection at your location and request a Flood Defence Breach Hazard Map (You can email the Environment Agency at: enquiries@environment-agency.gov.uk)
- you should follow the Environment Agency's standing advice for carrying out a flood risk assessment (find out more at www.gov.uk/guidance/flood-risk-assessment-standing-advice)

Notes

The flood map for planning shows river and sea flooding data only. It doesn't include other sources of flooding. It is for use in development planning and flood risk assessments.

This information relates to the selected location and is not specific to any property within it. The map is updated regularly and is correct at the time of printing.

Flood risk data is covered by the Open Government Licence which sets out the terms and conditions for using government data. <https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>

Use of the address and mapping data is subject to Ordnance Survey public viewing terms under Crown copyright and database rights 2022 OS 100024198. <https://flood-map-for-planning.service.gov.uk/os-terms>

Flood map for planning

Your reference
Tilbury CSEC

Location (easting/northing)
566311/175856

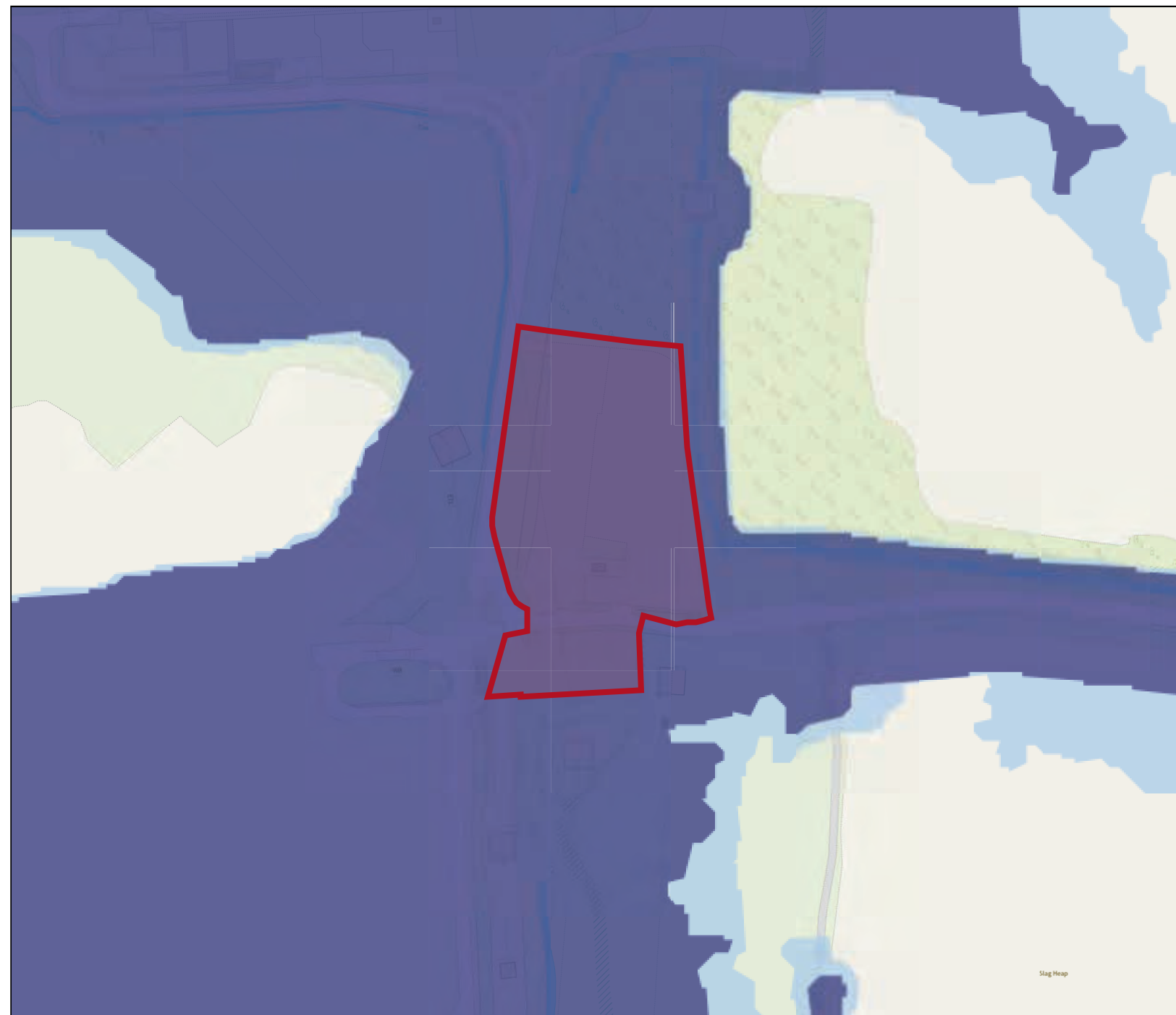
Scale
1:2500

Created
23 Mar 2023 14:02

-  Selected area
-  Flood zone 3
-  Flood zone 2
-  Flood zone 1
-  Flood defence
-  Main river
-  Water storage area

0 20 40 60m

Page 2 of 2



Flood map for planning

Your reference
Tilbury CSEC

Location (easting/northing)
566311/175856

Created
23 Mar 2023 14:01

**Your selected location is in flood zone 3
– an area with a high probability of flooding.**

This means:

- you may need to complete a flood risk assessment for development in this area
- you should ask the Environment Agency about the level of flood protection at your location and request a Flood Defence Breach Hazard Map (You can email the Environment Agency at: enquiries@environment-agency.gov.uk)
- you should follow the Environment Agency's standing advice for carrying out a flood risk assessment (find out more at www.gov.uk/guidance/flood-risk-assessment-standing-advice)

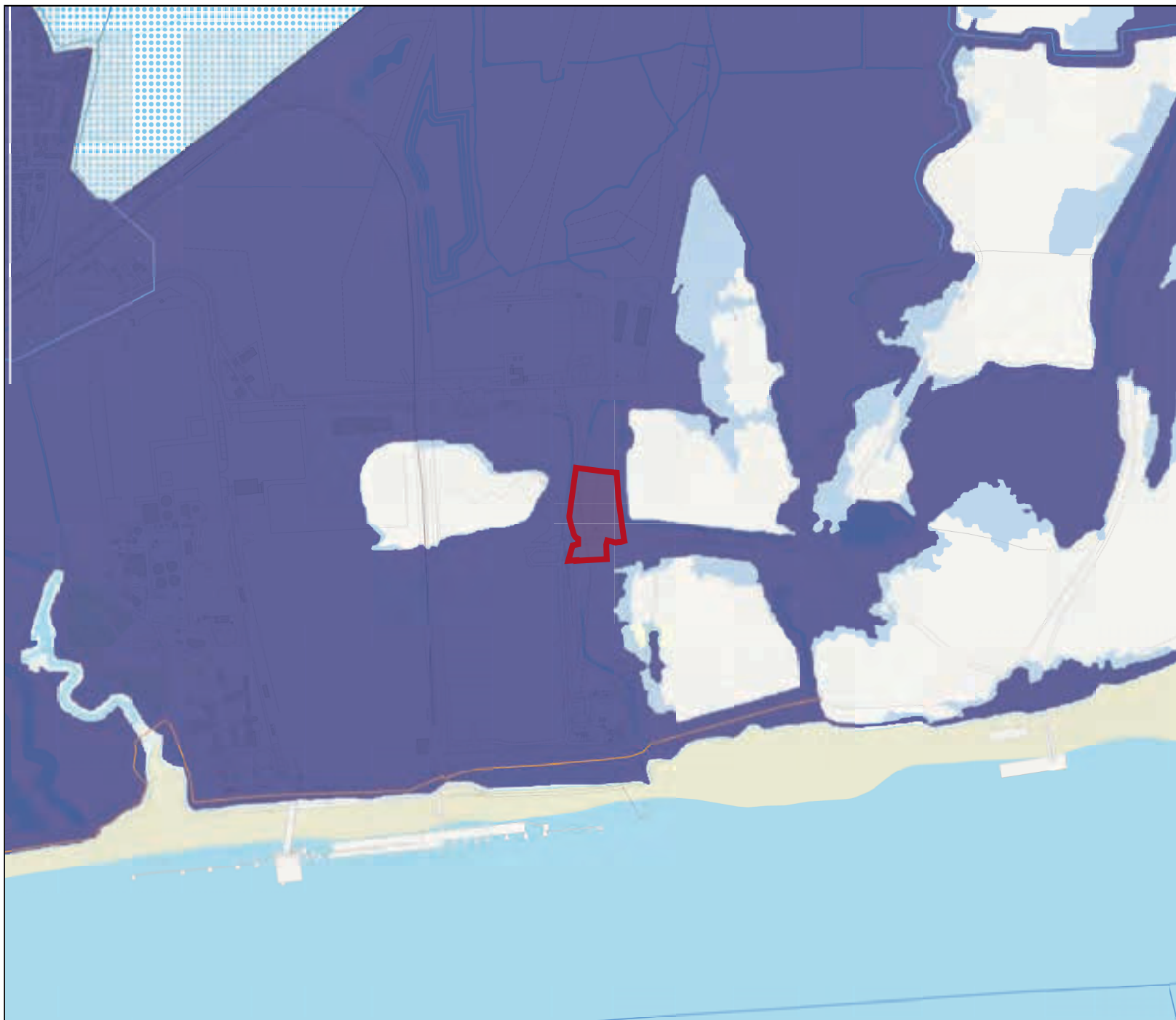
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Flood map for planning

Your reference
Tilbury CSEC

Location (easting/northing)
566311/175856

Scale
1:10000

Created
23 Mar 2023 14:01

-  Selected area
-  Flood zone 3
-  Flood zone 2
-  Flood zone 1
-  Flood defence
-  Main river
-  Water storage area

0 100 200 300m

Nigel Hill
Nigel.Hill2@morgansindall.com

Our ref NR305781
Date 13 April 2023

Dear Nigel

Enquiry regarding Product 4, 5, 6, 7 & 8 for Tilbury.

Thank you for your enquiry which was received on 23 March 2023.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

Product 4

The Product 4 information and supporting documentation has been uploaded to our sharefile system and can be accessed for 30 days using this link: <https://ea.sharefile.com/d-s72f8c728edfd4a80942164936beeb9f6>

Name	Product 4
Description	Detailed Flood Risk Assessment Map for Tilbury Intergrated Urban Design
Licence	Open Government Licence
Information Warnings	None
Information Warning - OS background mapping	<i>The mapping of features provided as a background in this product is © Ordnance Survey. It is provided to give context to this product. The Open Government Licence does not apply to this background mapping. You are granted a non-exclusive, royalty free, revocable licence solely to view the Licensed Data for non-commercial purposes for the period during which the Environment Agency makes it available. You are not permitted to copy, sub-license, distribute, sell or otherwise make available the Licensed Data to third parties in any form. Third party rights to enforce the terms of this licence shall be reserved to OS.</i>
Attribution	Contains Environment Agency information © Environment Agency and/or database rights. Contains Ordnance Survey data © Crown copyright 2022 Ordnance Survey 100024198.

East Anglia Area

Ipswich Office, Icen House, Cobham Road, Ipswich, Suffolk, IP3 9JD
Brampton Office, Bromholme Lane, Brampton, Huntingdon, PE28 4NE
General Enquiries: 03708 506506

Email: enquiries@environment-agency.gov.uk

Website: <https://www.gov.uk/government/organisations/environment-agency>

Product 5, 6 & 7

The Product 5, 6 & 7 information we hold has been uploaded to our sharefile system and can be accessed for 30 days using this link: <https://ea.sharefile.com/d-s094b2d0e66c34e088b4cb10571e29b0c>

Name	Products 5, 6 and 7
Description	Tilbury IUD, 2017, JBA Model output data for Tilbury IUD, 2017, JBA Calibrated and Verified Model Input Data for Tilbury IUD, 2017, JBA
Licence	The following information is not available under the Open Government Licence but we may be able to license it to you under the Environment Agency Conditional Licence Environment Agency Conditional Licence: However, you MUST first check the supporting information and the above link to determine if the conditions on use are suitable for your purposes. If they aren't, this information is not provided with a licence for use, and the data is provided for read right only.
Conditions	1.0 You may use the Information for your internal or personal purposes and may only sublicense others to use it if you do so under a written licence which includes the terms of these conditions and the agreement and in particular may not allow any period of use longer than the period licensed to you. 2.0 Notwithstanding the fact that the standard wording of the Environment Agency Conditional Licence indicates that it is perpetual, this Licence has a limited duration of 5 years at the end of which it will terminate automatically without notice. 3.0 We have restricted use of the Information as a result of legal restrictions placed upon us to protect the rights or confidentialities of others. In this instance it is because of third party data. If you contact us in writing (this includes email) we will, as far as confidentiality rules allow, provide you with details including, if available, how you might seek permission from a third party to extend your use rights. 4.1 The Information may contain some data that we believe is within the definition of "personal data" under the Data Protection Act 1998 but we consider that we will not be in breach of the Act if we disclose it to you with conditions set out in this condition and the conditions above. This personal data comprises names of individuals or commentary relating to property that may be owned by an individual or commentary relating to the activities of an individual. 4.2 Under the Act a person who holds and uses or passes to others personal data is responsible for any compliance with the Act and so we have no option but to warn you that this means you have responsibility to check that you are compliant with the Act in respect of this personal data. 5.0 The location of public water supply abstraction sources must not be published to a resolution more detailed than 1km2. Information

East Anglia Area

Ipswich Office, Icen House, Cobham Road, Ipswich, Suffolk, IP3 9JD

Brampton Office, Bromholme Lane, Brampton, Huntingdon, PE28 4NE

General Enquiries: 03708 506506

Email: enquiries@environment-agency.gov.uk

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	about the operation of flood assets should not be published. 6.1 Where we have supplied model data which may include model inputs or outputs you agree to supply to the Environment Agency copies of any assessments/studies and related outputs, modifications or derivatives created pursuant to the supply to you of the Information, all of which are hereinafter referred to as “the Data”. 6.2 You agree, in the public interest to grant to the Environment Agency a perpetual royalty free non-exclusive licence to use the Data or any part thereof for its internal purposes or to use it in any way as part of Environment Agency derivative products which it supplies free of charge to others such as incorporation into the Environment Agency's Open Data mapping products.
Information Warnings	Please be aware that model data is not raw, factual or measured but comprises of estimations or modelled results based on the data available to us.
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Product 8

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Information Commissioner's Office
Wycliffe House
Water Lane
Wilmslow
Cheshire
SK9 5AF
Tel: 0303 123 1113
Website: <http://ico.org.uk>

Appendix for Product 8

The exceptions that apply to the withheld information are:

Relevant exception – Product 8

In this case, EIR Regulation 12(4)(d) applies because the request relates to material which is still in the course of completion, to unfinished documents or to incomplete data. Therefore we would not advise using the breach flood level information for Tilbury Shaft, as to release the information at this stage could mean that incorrect flood risk information could be used to inform in any potential planning application.

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We have weighed the public interest factors in favour of maintaining the exceptions and find that they outweigh the public interest factors in disclosing the information. In carrying out the public interest test we have considered:

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- **Contribution to sustainable development or public health and safety.** The interest here is in ensuring that the best environmental options are being selected for Tilbury Shaft.

2. Factors in favour of withholding the information:

- **Whether information would be misleading or cause alarm.** There is a public interest in ensuring that any documentation we disclose is factually correct and not likely to be misleading to the public. This factor is relevant to the release of breach flood level information for Tilbury Shaft due to the data not being representative of the flood risk. There is no date by which the model will have been fixed.

As indicated, upon assessing the factors in the public interest test, we have assessed that in relation to the breach flood level information for Tilbury Shaft in supplying misleading information, we find that the factors in favour of withholding information outweigh the public interest factors in disclosing the information.

Data Available Online

Many of our flood datasets are available online:

- Flood Map For Planning ([Flood Zone 2](#), [Flood Zone 3](#), [Flood Storage Areas](#), [Flood Defences](#), [Areas Benefiting from Defences](#))
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- [Historic Flood Map](#)
- [Current Flood Warnings](#)

Additional information

Please be aware that we now charge for planning advice provided to developers, agents and landowners. If you would like advice to inform a future planning application for this site then please complete our <https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion> and email it to our Sustainable Places team planning.eastanglia@environment-agency.gov.uk. They will initially provide you with a free response identifying the following:

- the environmental constraints affecting the proposal;
- the environmental issues raised by the proposal;
- the information we need for the subsequent planning application to address the issues identified and demonstrate an acceptable development;
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Climate Change Allowances

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Should this line also be included: If you want to discuss this please call our Sustainable Places team on 0203 025 5475 (East) or 020 8474 5242 (West).

TEAM2100: delivering the first 10 years of investment in tidal flood defences for the Thames Estuary 2100 Plan. For more information, visit [the TEAM2100 website](https://www.team2100.org.uk) or email thamesestuary2100@environment-agency.gov.uk

Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Yours sincerely

S Clemens

Samantha Clemens
Customers and Engagement Officer

Direct dial: 02030 255472

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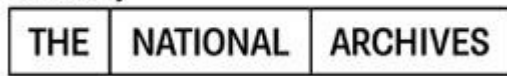
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Nigel Hill
Nigel.Hill2@morgansindall.com

Our ref NR305781
Date 13 April 2023

Dear Nigel

Enquiry regarding Product 4, 5, 6, 7 & 8 for Tilbury.

Thank you for your enquiry which was received on 23 March 2023.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

Product 4

The Product 4 information and supporting documentation has been uploaded to our sharefile system and can be accessed for 30 days using this link: <https://ea.sharefile.com/d-s72f8c728edfd4a80942164936beeb9f6>

Name	Product 4
Description	Detailed Flood Risk Assessment Map for Tilbury Intergrated Urban Design
Licence	Open Government Licence
Information Warnings	None
Information Warning - OS background mapping	<i>The mapping of features provided as a background in this product is © Ordnance Survey. It is provided to give context to this product. The Open Government Licence does not apply to this background mapping. You are granted a non-exclusive, royalty free, revocable licence solely to view the Licensed Data for non-commercial purposes for the period during which the Environment Agency makes it available. You are not permitted to copy, sub-license, distribute, sell or otherwise make available the Licensed Data to third parties in any form. Third party rights to enforce the terms of this licence shall be reserved to OS.</i>
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Product 5, 6 & 7

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Yours sincerely

S Clemens

Samantha Clemens
Customers and Engagement Officer

Direct dial: 02030 255472

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Tilbury Intergrated Urban Design (IUD) Fluvial/Pluvial Model

Included:

- Flood Map (A & B)
- Historic Flood Outlines Map

Model: Thames (TE2100) 2008

- 1D Levels Node Map
- 1D Levels Node Table

Model: Tilbury Integrated Flood Strategy 2015

- North West 1D Depths & Flows Nodes Map and Tables
- South East 1D Depths & Flows Nodes Map and Tables
- Fluvial Depths Maps:
 - 1 in 20 (5%) (Present Day)
 - 1 in 100 (1%) (Present Day)
 - 1 in 1000 (0.1%) (Present Day)
 - 1 in 20 (5%) (Climate Change)
 - 1 in 100 (1%) (Climate Change)
 - 1 in 1000 (0.1%) (Climate Change)

Important information to note with your Product:

Flood Risk Assessments (FRAs)

If you are obtaining this information for use within a Flood Risk Assessment (FRA) required for a planning application, please include our unaltered Product 4 data within an appendix of your FRA.

Flood Zones

Please see the attached map showing the Flood Zones (outlines) for the area of the site. Our maps show the site is located in fluvial Flood Zone 1, 2 and 3. For further information with regards to Flood Zones, please see below:

Table 1: Flood Zones

These Flood Zones refer to the probability of river and sea flooding, ignoring the presence of defences.

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map)

Tilbury IUD

We have worked with Essex County Council Lead Local Flood Authority (LLFA) and Anglian Water to develop a model which considers the interaction and interdependencies between the different sources of flooding in Tilbury. We have included modelled pluvial depths showing a 1 in 20 (5%), 1 in 100 (1%) and 1 in 1,000 (0.1%) chance of flooding in any one given year (annual probability of flooding) and with climate change. In each event the depth of flooding has been modelled and is displayed on the attached maps. This information should be used to inform non-tidal risk as part of a Flood Risk Assessment. The depth levels from this model must be used in conjunction with an up to date topographical survey to produce water levels

Tilbury IUD & Climate Change

Please note, this model is a combined fluvial and pluvial model and therefore increasing the allowance for climate change would not give you a correct representation of the fluvial risk to your site. The greatest risk to your site is tidal flood risk and therefore this is the risk that needs to be assessed.

Historic Flood Events

Examinations of our records of historic flooding show that the general area has previously flooded. Please note that these records show flooding to the land and do not necessarily indicate that properties within the historic flood events were flooded internally. It is also possible that the pattern of flooding in this area has changed and that this area would now flood under different circumstances. Please see the attached PDF for flood history information.

Surface Water

Please be aware that in recent years, there has been an increase in flood damage caused by surface water flooding or drainage systems that have been overwhelmed. We have worked with Lead local Flood Authorities (LLFAs) to develop a map which incorporates the best local and national scale information on surface water flood risk. These maps can be viewed on our website at the following:-

<https://flood-warning-information.service.gov.uk/long-term-flood-risk/>

Reservoir Flooding

You can obtain a map which shows the extent of flooding if a reservoir was to fail and release the water that it holds. The map shows the worst case scenario. These maps can be viewed on our website at the following:-

<https://flood-warning-information.service.gov.uk/long-term-flood-risk/>

Flood Map for Planning (A)



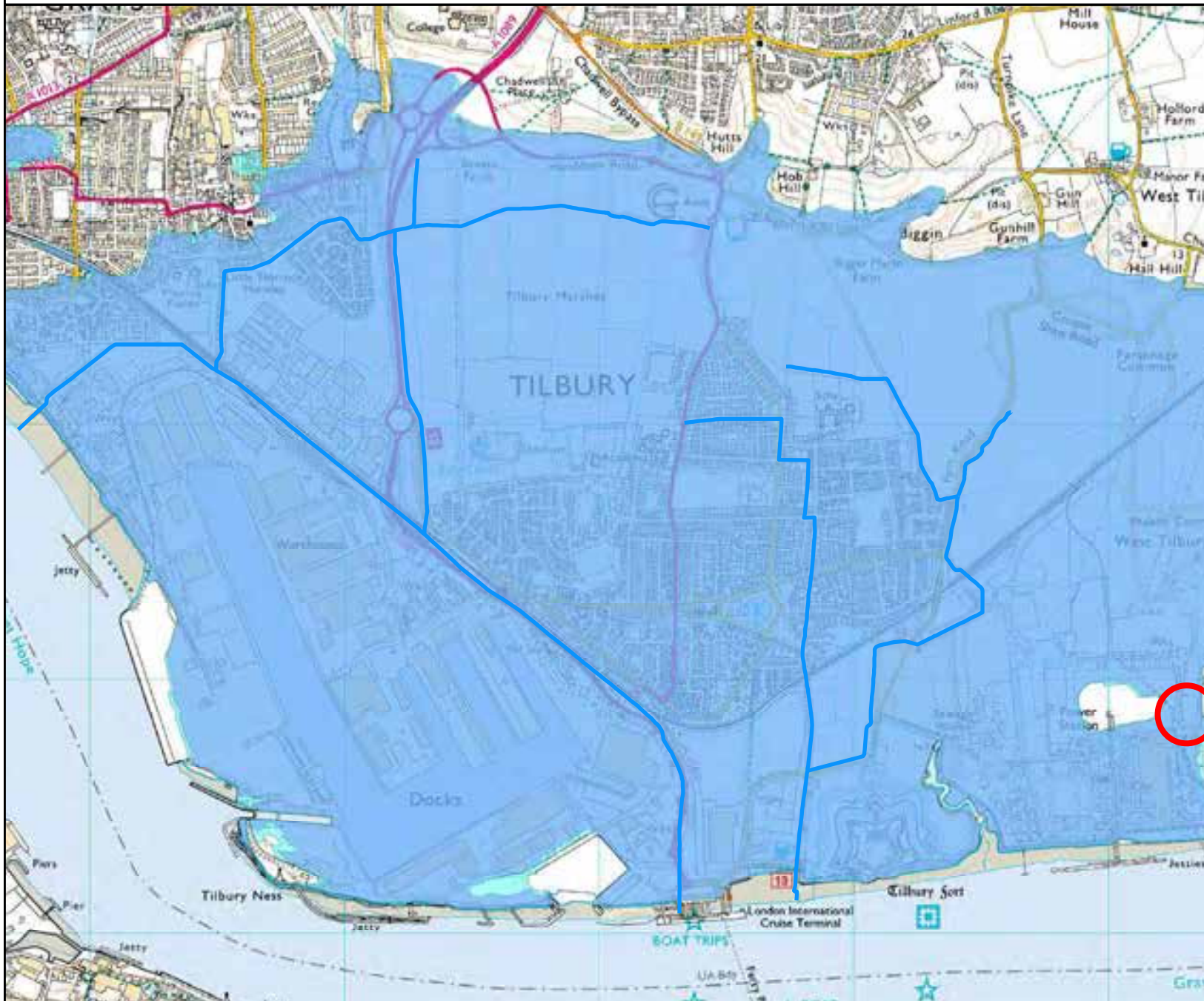
Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



0 255 510 1,020
Metres
1:22,000

Legend

- Main Rivers
- Flood Zone 3
- Flood Zone 2



Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Flood Map for Planning (B)



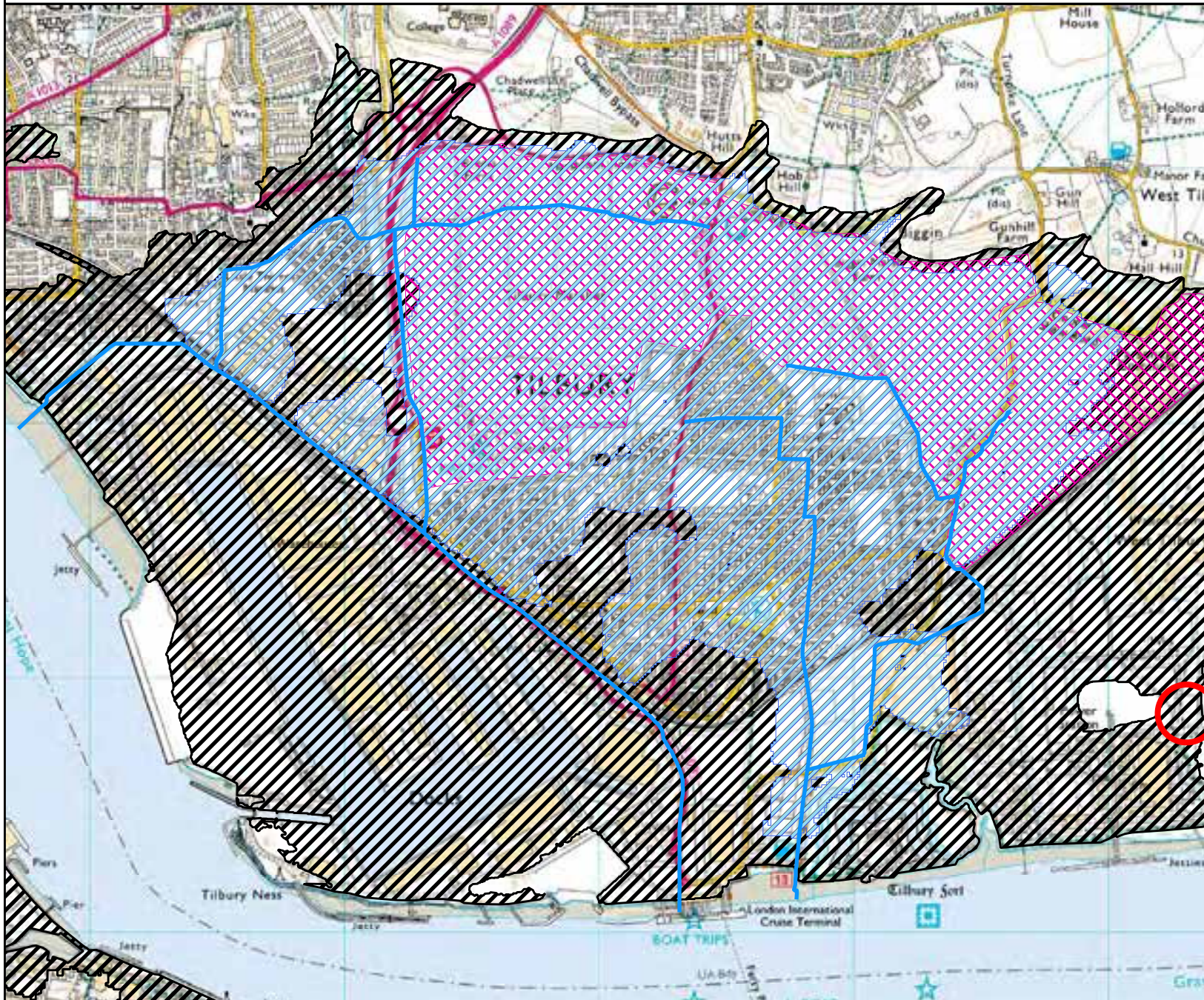
Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



0 255 510 1,020
Metres
1:22,000

Legend

- Main Rivers
- Outline_Reservoir_Flood_Maps
- Flood Storage Area
- Areas Benefiting from Defence



Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Recorded Flood Events Outlines Map

This map displays the recorded flood event outlines for Tilbury. The flood-affected areas are shaded in purple. Key locations labeled on the map include Tilbury Marshes, TILBURY, Docks, and Tilbury Ness. A red circle is drawn on the right side of the map, highlighting a specific area of interest.



Legend

— Main Rivers

1953 Outline

The historic flood event outlines are based on a combination of anecdotal evidence, Environment Agency staff observations and survey.

Our historic flood event outlines do not provide a definitive record of flooding. It is possible that there will be an absence of data in places where we have not been able to record the extent of flooding. It is also possible for errors occur in the digitisation of historic records of flooding.

Thames (TE2100) Nodes



Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



0 350 700 1,400
Metres
1:30,000

Legend

- TE2100
- Main Rivers



This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within the catchment. Modelled outlines take into account catchment wide defences if present.

Thames Estuary 2100 (TE2100)



Location	Node Ref	Easting	Northing	2070 Defence Crest Levels		2005							2040						
				Ex_Barr	New_Barr	1 in 5 (20% AEP)	1 in 10 (10% AEP)	1 in 20 (5% AEP)	1 in 50 (2% AEP)	1 in 100 (1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)	1 in 5 (20% AEP)	1 in 10 (10% AEP)	1 in 20 (5% AEP)	1 in 50 (2% AEP)	1 in 100 (1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)
Dartford	3.15	554397	178402	7.60	6.10	4.88	5.03	5.16	5.33	5.51	5.64	5.97	5.09	5.24	5.37	5.54	5.72	5.85	6.18
Dartford Marshes	3.16	555012	177896	7.60	6.10	4.86	5.01	5.14	5.31	5.49	5.62	5.95	5.07	5.22	5.35	5.52	5.70	5.83	6.16
Long Reach	3.17	555831	177179	7.60	8.50	4.85	5.00	5.13	5.30	5.48	5.61	5.94	5.06	5.21	5.34	5.51	5.69	5.82	6.15
Dartford Tunnel	3.18	557090	176390	7.50	8.50	4.85	5.00	5.13	5.30	5.48	5.61	5.94	5.06	5.21	5.34	5.51	5.69	5.82	6.15
Stone Ness	3.19	558175	175703	7.50	8.50	4.83	4.98	5.11	5.28	5.46	5.59	5.92	5.04	5.19	5.32	5.49	5.67	5.80	6.13
West Thurrock	3.20	559355	176131	7.50	8.50	4.81	4.96	5.09	5.26	5.44	5.57	5.90	5.02	5.17	5.30	5.47	5.65	5.78	6.11
Swanscombe	3.21	560139	177011	7.50	8.50	4.80	4.95	5.08	5.25	5.43	5.56	5.89	5.01	5.16	5.29	5.46	5.64	5.77	6.10
Grays	3.22	561470	176679	7.50	8.00	4.77	4.92	5.05	5.22	5.40	5.53	5.86	4.98	5.13	5.26	5.43	5.61	5.74	6.07
Tilbury	3.23	562066	175589	7.50	8.00	4.76	4.91	5.04	5.21	5.39	5.52	5.85	4.97	5.12	5.25	5.42	5.60	5.73	6.06
Northfleet	3.24	562675	174950	7.40	8.00	4.74	4.89	5.02	5.19	5.37	5.50	5.83	4.95	5.10	5.23	5.40	5.58	5.71	6.04
Tilbury Ferry	3.25	564109	174800	7.40	8.00	4.72	4.87	5.00	5.17	5.35	5.48	5.81	4.93	5.08	5.21	5.38	5.56	5.69	6.02
Gravesend	3.26	565307	174848	7.40	8.00	4.69	4.84	4.97	5.14	5.32	5.45	5.78	4.90	5.05	5.18	5.35	5.53	5.66	5.99
Gravesend Power Station	3.27	566916	174908	7.40	8.00	4.62	4.77	4.90	5.07	5.25	5.38	5.71	4.83	4.98	5.11	5.28	5.46	5.59	5.92
East Tilbury Marshes	3.28	568488	175258	7.00	7.00	4.55	4.70	4.83	5.00	5.18	5.31	5.64	4.76	4.91	5.04	5.21	5.39	5.52	5.85
Coalhouse Point	3.29	569850	176137	6.48	6.48	4.49	4.64	4.77	4.94	5.12	5.25	5.58	4.70	4.85	4.98	5.15	5.33	5.46	5.79
Coastguard Cottages	3.30	570320	178011	6.75	6.75	4.45	4.60	4.73	4.90	5.08	5.21	5.54	4.66	4.81	4.94	5.11	5.29	5.42	5.75
Mucking Flats	3.31	571235	179824	7.50	8.10	4.40	4.55	4.68	4.85	5.03	5.16	5.49	4.61	4.76	4.89	5.06	5.24	5.37	5.70
Corringham Marshes	3.32	573440	180782	7.50	8.10	4.32	4.47	4.60	4.77	4.95	5.08	5.41	4.53	4.68	4.81	4.98	5.16	5.29	5.62
Blythe Sands	3.33	575633	181137	7.50	8.10	4.24	4.39	4.52	4.69	4.87	5.00	5.33	4.45	4.60	4.73	4.90	5.08	5.21	5.54
Halstow Marshes	3.34	577953	181149	7.40	8.10	4.19	4.34	4.47	4.64	4.82	4.95	5.28	4.40	4.55	4.68	4.85	5.03	5.16	5.49
West Point	3.35	579995	181222	7.40	8.10	4.13	4.28	4.41	4.58	4.76	4.89	5.22	4.34	4.49	4.62	4.79	4.97	5.10	5.43
East Canvey Point	3.36	583007	181318	7.40	8.10	4.05	4.20	4.33	4.50	4.68	4.81	5.14	4.26	4.41	4.54	4.71	4.89	5.02	5.35
Leigh	3.37	585820	181583	6.70	7.40	3.97	4.12	4.25	4.42	4.60	4.73	5.06	4.18	4.33	4.46	4.63	4.81	4.94	5.27
Southend	3.38	588653	181517	6.70	7.40	3.94	4.09	4.22	4.39	4.57	4.70	5.03	4.15	4.30	4.43	4.60	4.78	4.91	5.24

Location	Node Ref	Easting	Northing	2070 Defence Crest Levels		2070							2100						
				Ex_Barr	New_Barr	1 in 5 (20% AEP)	1 in 10 (10% AEP)	1 in 20 (5% AEP)	1 in 50 (2% AEP)	1 in 100 (1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)	1 in 5 (20% AEP)	1 in 10 (10% AEP)	1 in 20 (5% AEP)	1 in 50 (2% AEP)	1 in 100 (1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)
Dartford	3.15	554397	178402	7.60	6.10	5.24	5.39	5.52	5.69	5.87	6.00	6.33	5.56	5.71	5.84	6.01	6.19	6.32	6.65
Dartford Marshes	3.16	555012	177896	7.60	6.10	5.22	5.37	5.50	5.67	5.85	5.98	6.31	5.54	5.69	5.82	5.99	6.17	6.30	6.63
Long Reach	3.17	555831	177179	7.60	8.50	5.21	5.36	5.49	5.66	5.84	5.97	6.30	5.53	5.68	5.81	5.98	6.16	6.29	6.62
Dartford Tunnel	3.18	557090	176390	7.50	8.50	5.20	5.35	5.48	5.65	5.83	5.96	6.29	5.51	5.66	5.79	5.96	6.14	6.27	6.60
Stone Ness	3.19	558175	175703	7.50	8.50	5.19	5.34	5.47	5.64	5.82	5.95	6.28	5.51	5.66	5.79	5.96	6.14	6.27	6.60
West Thurrock	3.20	559355	176131	7.50	8.50	5.18	5.33	5.46	5.63	5.81	5.94	6.27	5.49	5.64	5.77	5.94	6.12	6.25	6.58
Swanscombe	3.21	560139	177011	7.50	8.50	5.15	5.30	5.43	5.60	5.78	5.91	6.24	5.46	5.61	5.74	5.91	6.09	6.22	6.55
Grays	3.22	561470	176679	7.50	8.00	5.15	5.30	5.43	5.60	5.78	5.91	6.24	5.45	5.60	5.73	5.90	6.08	6.21	6.54
Tilbury	3.23	562066	175589	7.50	8.00	5.13	5.28	5.41	5.58	5.76	5.89	6.22	5.43	5.58	5.71	5.88	6.06	6.19	6.52
Northfleet	3.24	562675	174950	7.40	8.00	5.10	5.25	5.38	5.55	5.73	5.86	6.19	5.40	5.55	5.68	5.85	6.03	6.16	6.49
Tilbury Ferry	3.25	564109	174800	7.40	8.00	5.08	5.23	5.36	5.53	5.71	5.84	6.17	5.38	5.53	5.66	5.83	6.01	6.14	6.47
Gravesend	3.26	565307	174848	7.40	8.00	5.05	5.20	5.33	5.50	5.68	5.81	6.14	5.35	5.50	5.63	5.80	5.98	6.11	6.44
Gravesend Power Station	3.27	566916	174908	7.40	8.00	4.99	5.14	5.27	5.44	5.62	5.75	6.08	5.29	5.44	5.57	5.74	5.92	6.05	6.38
East Tilbury Marshes	3.28	568488	175258	7.00	7.00	4.92	5.07	5.20	5.37	5.55	5.68	6.01	5.23	5.38	5.51	5.68	5.86	5.99	6.32
Coalhouse Point	3.29	569850	176137	6.48	6.48	4.84	4.99	5.12	5.29	5.47	5.60	5.93	5.16	5.31	5.44	5.61	5.79	5.92	6.25
Coastguard Cottages	3.30	570320	178011	6.75	6.75	4.80	4.95	5.08	5.25	5.43	5.56	5.89	5.10	5.25	5.38	5.55	5.73	5.86	6.19
Mucking Flats	3.31	571235	179824	7.50	8.10	4.77	4.92	5.05	5.22	5.40	5.53	5.86	5.09	5.24	5.37	5.54	5.72	5.85	6.18
Corringham Marshes	3.32	573440	180782	7.50	8.10	4.72	4.87	5.00	5.17	5.35	5.48	5.81	5.07	5.22	5.35	5.52	5.70	5.83	6.16
Blythe Sands	3.33	575633	181137	7.50	8.10	4.67	4.82	4.95	5.12	5.30	5.43	5.76	5.05	5.20	5.33	5.50	5.68	5.81	6.14
Halstow Marshes	3.34	577953	181149	7.40	8.10	4.61	4.76	4.89	5.06	5.24	5.37	5.70	5.00	5.15	5.28	5.45	5.63	5.76	6.09
West Point	3.35	579995	181222	7.40	8.10	4.57	4.72	4.85	5.02	5.20	5.33	5.66	4.96	5.11	5.24	5.41	5.59	5.72	6.05
East Canvey Point	3.36	583007	181318	7.40	8.10	4.54	4.69	4.82	4.99	5.17	5.30	5.63	4.93	5.08	5.21	5.38	5.56	5.69	6.02
Leigh	3.37	585820	181583	6.70	7.40	4.51	4.66	4.79	4.96	5.14	5.27	5.60	4.90	5.05	5.18	5.35	5.53	5.66	5.99
Southend	3.38	588653	181517	6.70	7.40	4.46	4.61	4.74	4.91	5.09	5.22	5.55	4.86	5.01	5.14	5.31	5.49	5.62	5.95

Location	Node Ref	Easting	Northing	2070 Defence Crest Levels		2120							2170						
				Ex_Barr	New_Barr	1 in 5 (20% AEP)	1 in 10 (10% AEP)	1 in 20 (5% AEP)	1 in 50 (2% AEP)	1 in 100 (1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)	1 in 5 (20% AEP)	1 in 10 (10% AEP)	1 in 20 (5% AEP)	1 in 50 (2% AEP)	1 in 100 (1% AEP)	1 in 200 (0.5% AEP)	1 in 1000 (0.1% AEP)
Dartford	3.15	554397	178402	7.60	6.10	5.76	5.91	6.04	6.21	6.39	6.52	6.85	6.24	6.39	6.52	6.69	6.87	7.17	7.33
Dartford Marshes	3.16	555012	177896	7.60	6.10	5.73	5.88	6.01	6.18	6.36	6.49	6.82	6.22	6.37	6.50	6.67	6.85	7.15	7.31
Long Reach	3.17	555831	177179	7.60	8.50	5.72	5.87	6.00	6.17	6.35	6.48	6.81	6.19	6.34	6.47	6.64	6.82	7.12	7.28
Dartford Tunnel	3.18	557090	176390	7.50	8.50	5.70	5.85	5.98	6.15	6.33	6.46	6.79	6.16	6.31	6.44	6.61	6.79	7.09	7.25
Stone Ness	3.19	558175	175703	7.50	8.50	5.69	5.84	5.97	6.14	6.32	6.45	6.78	6.14	6.29	6.42	6.59	6.77	7.07	7.23
West Thurrock	3.20	559355	176131	7.50	8.50	5.67	5.82	5.95	6.12	6.30	6.43	6.76	6.13	6.28	6.41	6.58	6.76	7.06	7.22
Swanscombe	3.21	560139	177011	7.50	8.50	5.65	5.80	5.93	6.10	6.28	6.41	6.74	6.12	6.27	6.40	6.57	6.75	7.05	7.21
Grays	3.22	561470	176679	7.50	8.00	5.64	5.79	5.92	6.09	6.27	6.40	6.73	6.10	6.25	6.38	6.55	6.73	7.03	7.19
Tilbury	3.23	562066	175589	7.50	8.00	5.62	5.77	5.90	6.07	6.25	6.38	6.71	6.09	6.24	6.37	6.54	6.72	7.02	7.18
Northfleet	3.24	562675	174950	7.40	8.00	5.60	5.75	5.88	6.05	6.23	6.36	6.69	6.09	6.24	6.37	6.54	6.72	7.02	7.18
Tilbury Ferry	3.25	564109	174800	7.40	8.00	5.58	5.73	5.86	6.03	6.21	6.34	6.67	6.10	6.25	6.38	6.55	6.73	7.03	7.19
Gravesend	3.26	565307	174848	7.40	8.00	5.56	5.71	5.84	6.01	6.19	6.32	6.65	6.10	6.25	6.38	6.55	6.73	7.03	7.19
Gravesend Power Station	3.27	566916	174908	7.40	8.00	5.52	5.67	5.80	5.97	6.15	6.28	6.61	6.10	6.25	6.38	6.55	6.73	7.03	7.19
East Tilbury Marshes	3.28	568488	175258	7.00	7.00	5.47	5.62	5.75	5.92	6.10	6.23	6.56	6.08	6.23	6.36	6.53	6.71	7.01	7.17
Coalhouse Point	3.29	569850	176137	6.48	6.48	5.42	5.57	5.70	5.87	6.05	6.18	6.51	6.06	6.21	6.34	6.51	6.69	6.99	7.15
Coastguard Cottages	3.30	570320	178011	6.75	6.75	5.37	5.52	5.65	5.82	6.00	6.13	6.46	6.04	6.19	6.32	6.49	6.67	6.97	7.13
Mucking Flats	3.31	571235	179824	7.50	8.10	5.36	5.51	5.64	5.81	5.99	6.12	6.45	6.03	6.18	6.31	6.48	6.66	6.96	7.12
Corringham Marshes	3.32	573440	180782	7.50	8.10	5.34	5.49	5.62	5.79	5.97	6.10	6.43	6.02	6.17	6.30	6.47	6.65	6.95	7.11
Blythe Sands	3.33	575633	181137	7.50	8.10	5.32	5.47	5.60	5.77	5.95	6.08	6.41	6.00	6.15	6.28	6.45	6.63	6.93	7.09
Halstow Marshes	3.34	577953	181149	7.40	8.10	5.28	5.43	5.56	5.73	5.91	6.04	6.37	5.99	6.14	6.27	6.44	6.62	6.92	7.08
West Point	3.35	579995	181222	7.40	8.10	5.25	5.40	5.53	5.70	5.88	6.01	6.34	5.98	6.13	6.26	6.43	6.61	6.91	7.07
East Canvey Point	3.36	583007	181318	7.40	8.10	5.22	5.37	5.50	5.67	5.85	5.98	6.31	5.95	6.10	6.23	6.40	6.58	6.88	7.04
Leigh	3.37	585820	181583	6.70	7.40	5.19	5.34	5.47	5.64	5.82	5.95	6.28	5.93	6.08	6.21	6.38	6.56	6.86	7.02
Southend	3.38	588653	181517	6.70	7.40	5.16	5.31	5.44	5.61	5.79	5.92	6.25	5.91	6.06	6.19	6.36	6.54	6.84	7.00

Thames Estuary 2100 (TE2100)

You have requested in-channel flood levels for the tidal river Thames. These have been taken from the Thames Estuary 2100 study completed by HR Wallingford in 2008.

Details about the TE2100 plan

The TE2100 plan is now live and within it are a set of levels on which the flood risk management strategy is based. The plan is the overarching flood management strategy for the Thames Estuary and therefore any development planning should be based on

Details about the TE2100 in-channel levels

The TE2100 in-channel levels take into account operation of the Thames Barrier when considering future levels.

Tilbury Nodes (Present Day) North West	
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Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



0 115 230 460

Metres

1:9,600

Legend

-  Nodes (Present Day)
 Main Rivers

This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within the catchment. Modelled outlines take into account catchment wide defences if present.

Datasheet Title: Present Day Data - Levels - North West
Source of information: Tilbury Integrated Flood Strategy 2015
Source of Flooding: JBA for Thurrock Council, Anglian Water and The Environment Agency
Flood Depths Provided: Pluvial
In-Channel

Key
CC Climate Change
AEP Annual Exceedance Probability
mAODN Metres Above Ordnance Datum Newlyn
m³s⁻¹ Cubic Metres Per Second (Cumecs)
DS Downstream
US Upstream

Depths (m) _____

Baseline

Node	100% (1:1) US	100% (1:1) DS	10% (1:10) US	10% (1:10) DS	5% (1:20) US	5% (1:20) DS	3.33% (1:30) US	3.33% (1:30) DS	2.5% (1:40) US	2.5% (1:40) DS	2% (1:50) US	2% (1:50) DS	1.33% (1:75) US	1.33% (1:75) DS	1% (1:100) US	1% (1:100) DS	0.5% (1:200) US	0.5% (1:200) DS	0.1% (1:1,000) US	0.1% (1:1,000) DS
0	0.51	0.31	1.08	0.87	1.25	1.04	1.35	1.15	1.42	1.22	1.48	1.27	1.56	1.36	1.61	1.41	1.72	1.52	1.97	1.76
1	1.01	0.48	1.31	0.79	1.44	0.92	1.51	0.99	1.57	1.04	1.61	1.08	1.68	1.16	1.73	1.21	1.88	1.36	2.21	1.69
7	0.15	4.76	0.72	4.76	0.89	4.76	0.99	4.76	1.07	4.76	1.12	4.76	1.21	4.76	1.26	4.76	1.37	4.76	1.62	4.76
9	0.15	0.15	0.72	0.72	0.89	0.89	0.99	0.99	1.07	1.07	1.12	1.12	1.21	1.21	1.26	1.26	1.37	1.37	1.62	1.62
11	0.47	0.47	0.78	0.77	0.90	0.90	0.98	0.98	1.03	1.03	1.07	1.07	1.14	1.14	1.20	1.20	1.34	1.34	1.67	1.67
13	1.00	1.01	1.31	1.31	1.44	1.44	1.51	1.51	1.57	1.57	1.61	1.61	1.68	1.68	1.73	1.73	1.88	1.88	2.22	2.21
14	0.02	0.30	0.59	0.60	0.76	0.73	0.87	0.81	0.94	0.86	1.00	0.90	1.08	0.97	1.13	1.02	1.24	1.17	1.49	1.49
19	0.50	0.50	1.07	1.07	1.24	1.24	1.35	1.35	1.42	1.42	1.48	1.47	1.56	1.56	1.61	1.61	1.72	1.72	1.97	1.97
20	0.31	0.31	0.87	0.87	1.04	1.04	1.15	1.15	1.22	1.22	1.27	1.27	1.36	1.36	1.41	1.41	1.52	1.52	1.76	1.77
27	0.30	0.30	0.87	0.87	1.04	1.04	1.14	1.14	1.21	1.21	1.27	1.27	1.35	1.35	1.40	1.40	1.51	1.51	1.76	1.76
29	0.48	0.48	0.79	0.79	0.92	0.92	0.99	0.99	1.04	1.04	1.08	1.08	1.16	1.16	1.21	1.21	1.36	1.36	1.68	1.68
31	0.47	0.47	1.04	1.04	1.21	1.21	1.31	1.31	1.38	1.38	1.44	1.44	1.52	1.52	1.57	1.57	1.68	1.68	1.93	1.93
45	0.67	0.47	0.97	0.78	1.10	0.90	1.18	0.98	1.23	1.03	1.27	1.07	1.34	1.14	1.39	1.20	1.54	1.34	1.86	1.67
46	0.31	0.85	0.87	1.42	1.04	1.59	1.15	1.69	1.22	1.76	1.27	1.82	1.36	1.90	1.41	1.95	1.52	2.06	1.77	2.31
47	0.85	0.60	1.42	1.17	1.59	1.34	1.69	1.44	1.76	1.51	1.82	1.57	1.90	1.65	1.95	1.70	2.06	1.81	2.31	2.06
48	0.47	0.74	1.04	1.31	1.21	1.48	1.31	1.58	1.38	1.65	1.44	1.71	1.52	1.79	1.57	1.84	1.68	1.95	1.93	2.20
49	0.74	1.16	1.31	1.73	1.48	1.90	1.58	2.00	1.65	2.07	1.71	2.13	1.79	2.21	1.84	2.26	1.95	2.37	2.20	2.62
50	1.16	1.05	1.73	1.62	1.90	1.79	2.00	1.89	2.07	1.97	2.13	2.02	2.21	2.11	2.26	2.16	2.37	2.27	2.62	2.52
51	0.63	1.00	0.94	1.31	1.07	1.44	1.14	1.51	1.20	1.57	1.24	1.61	1.31	1.68	1.36	1.73	1.51	1.88	1.86	2.22
52	0.35	0.67	0.65	0.97	0.78	1.10	0.85	1.18	0.90	1.23	0.95	1.27	1.02	1.34	1.07	1.39	1.22	1.54	1.54	1.86
54	0.90	0.36	1.46	0.92	1.63	1.09	1.73	1.20	1.81	1.27	1.86	1.32	1.94	1.40	1.99	1.45	2.10	1.56	2.32	1.78
55	0.50	1.55	1.07	2.12	1.24	2.29	1.34	2.39	1.41	2.47	1.47	2.52	1.55	2.61	1.61	2.66	1.72	2.77	1.97	3.02
56	0.71	0.90	1.27	1.46	1.44	1.63	1.55	1.73	1.62	1.81	1.67	1.86	1.75	1.94	1.80	1.99	1.91	2.10	2.13	2.32

Datasheet Title: Present Day Data - Flows - North West
Source of information: Tilbury Integrated Flood Strategy 2015
 JBA for Thurrock Council, Anglian Water and The Environment Agency
Source of Flooding: Pluvial
Flood Depths Provided: In-Channel

Key
CC Climate Change
AEP Annual Exceedance Probability
mAODN Metres Above Ordnance Datum Newlyn
m³s⁻¹ Cubic Metres Per Second (Cumeecs)
DS Downstream
US Upstream

Flows (m³s⁻¹) **AEP**
 Baseline

Node	100% (1:1) US	100% (1:1) DS	10% (1:10) US	10% (1:10) DS	5% (1:20) US	5% (1:20) DS	3.33% (1:30) US	3.33% (1:30) DS	2.5% (1:40) US	2.5% (1:40) DS	2% (1:50) US	2% (1:50) DS	1.33% (1:75) US	1.33% (1:75) DS	1% (1:100) US	1% (1:100) DS	0.5% (1:200) US	0.5% (1:200) DS	0.1% (1:1,000) US	0.1% (1:1,000) DS
0	-0.25	-0.26	-0.34	-0.35	-0.38	-0.39	0.43	0.43	0.51	0.51	0.58	0.58	0.74	0.74	0.82	0.83	1.00	1.00	1.25	1.25
1	0.28	0.27	0.48	0.47	0.57	0.55	0.63	0.61	0.66	0.64	0.67	0.65	0.68	0.66	0.69	0.67	0.69	0.67	1.11	1.12
7	0.17	0.17	1.56	1.56	2.04	2.04	2.33	2.33	2.54	2.54	2.71	2.71	2.97	2.97	3.14	3.14	3.48	3.48	4.43	4.43
9	0.17	0.17	1.56	1.56	2.04	2.04	2.33	2.33	2.54	2.54	2.71	2.71	2.97	2.97	3.14	3.14	3.48	3.48	4.43	4.43
11	-0.08	-0.08	-0.12	-0.12	-0.13	-0.13	-0.14	-0.14	0.14	0.14	0.16	0.16	0.20	0.20	0.23	0.23	0.30	0.30	0.61	0.61
13	0.28	0.28	0.48	0.48	0.57	0.57	0.63	0.63	0.66	0.66	0.67	0.67	0.68	0.68	0.69	0.69	0.69	0.69	1.11	1.11
14	-0.02	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.36	-0.36
19	0.28	0.28	1.08	1.08	1.43	1.43	1.67	1.67	1.84	1.84	1.99	1.99	2.24	2.24	2.41	2.41	2.73	2.73	3.56	3.56
20	-0.26	-0.26	-0.35	-0.35	-0.39	-0.39	0.43	0.43	0.51	0.51	0.58	0.58	0.74	0.74	0.83	0.83	1.00	1.00	1.25	1.25
27	0.15	0.15	0.42	0.42	0.52	0.52	0.59	0.59	0.67	0.67	0.74	0.74	0.90	0.90	0.99	0.99	1.18	1.18	1.48	1.48
29	0.27	0.27	0.46	0.46	0.54	0.54	0.60	0.60	0.63	0.63	0.64	0.64	0.65	0.65	0.66	0.66	0.66	0.66	0.77	0.77
31	0.15	0.15	0.42	0.42	0.52	0.52	0.59	0.59	0.67	0.67	0.75	0.75	0.90	0.90	1.00	1.00	1.18	1.18	1.48	1.48
45	0.09	-0.08	-0.11	-0.12	-0.11	-0.13	-0.11	-0.14	0.13	0.14	0.14	0.16	0.17	0.20	0.19	0.23	0.25	0.30	0.64	0.61
46	0.58	0.46	1.06	0.94	1.22	1.12	1.32	1.24	1.39	1.31	1.44	1.38	1.66	1.71	1.87	1.91	2.29	2.32	2.94	2.96
47	0.48	0.41	1.00	0.93	1.19	1.12	1.32	1.24	1.40	1.32	1.46	1.47	1.72	1.78	1.92	1.98	2.33	2.36	2.98	3.00
48	0.46	0.43	1.00	0.85	1.18	1.05	1.29	1.26	1.36	1.43	1.50	1.57	1.81	1.87	2.02	2.07	2.40	2.44	3.03	3.05
49	0.45	0.26	0.88	0.89	1.05	1.21	1.26	1.43	1.43	1.60	1.57	1.74	1.87	2.02	2.07	2.20	2.44	2.53	3.05	3.11
50	0.30	0.25	0.90	1.05	1.22	1.40	1.44	1.63	1.61	1.81	1.75	1.95	2.03	2.20	2.22	2.37	2.55	2.68	3.15	3.25
51	0.31	0.28	0.53	0.48	0.63	0.57	0.70	0.63	0.74	0.66	0.75	0.67	0.77	0.68	0.78	0.69	0.79	0.69	0.79	1.11
52	0.04	-0.22	0.05	-0.47	0.06	-0.55	0.06	-0.61	0.07	-0.65	0.07	-0.67	0.07	-0.71	0.07	-0.73	0.08	-0.80	-0.29	-1.02
54	0.27	-0.04	0.38	-0.06	0.44	-0.06	0.47	-0.07	0.49	-0.07	0.51	-0.07	0.54	-0.08	0.55	-0.09	0.59	-0.11	0.68	-0.50
55	0.28	0.17	1.08	1.55	1.43	2.03	1.67	2.32	1.84	2.53	1.99	2.69	2.24	2.95	2.41	3.11	2.73	3.45	3.56	4.36
56	0.50	0.27	0.70	0.38	0.79	0.44	0.84	0.47	0.88	0.49	0.90	0.51	0.94	0.54	0.98	0.55	1.05	0.59	1.21	0.68

Tilbury Nodes (Climate Change) North West



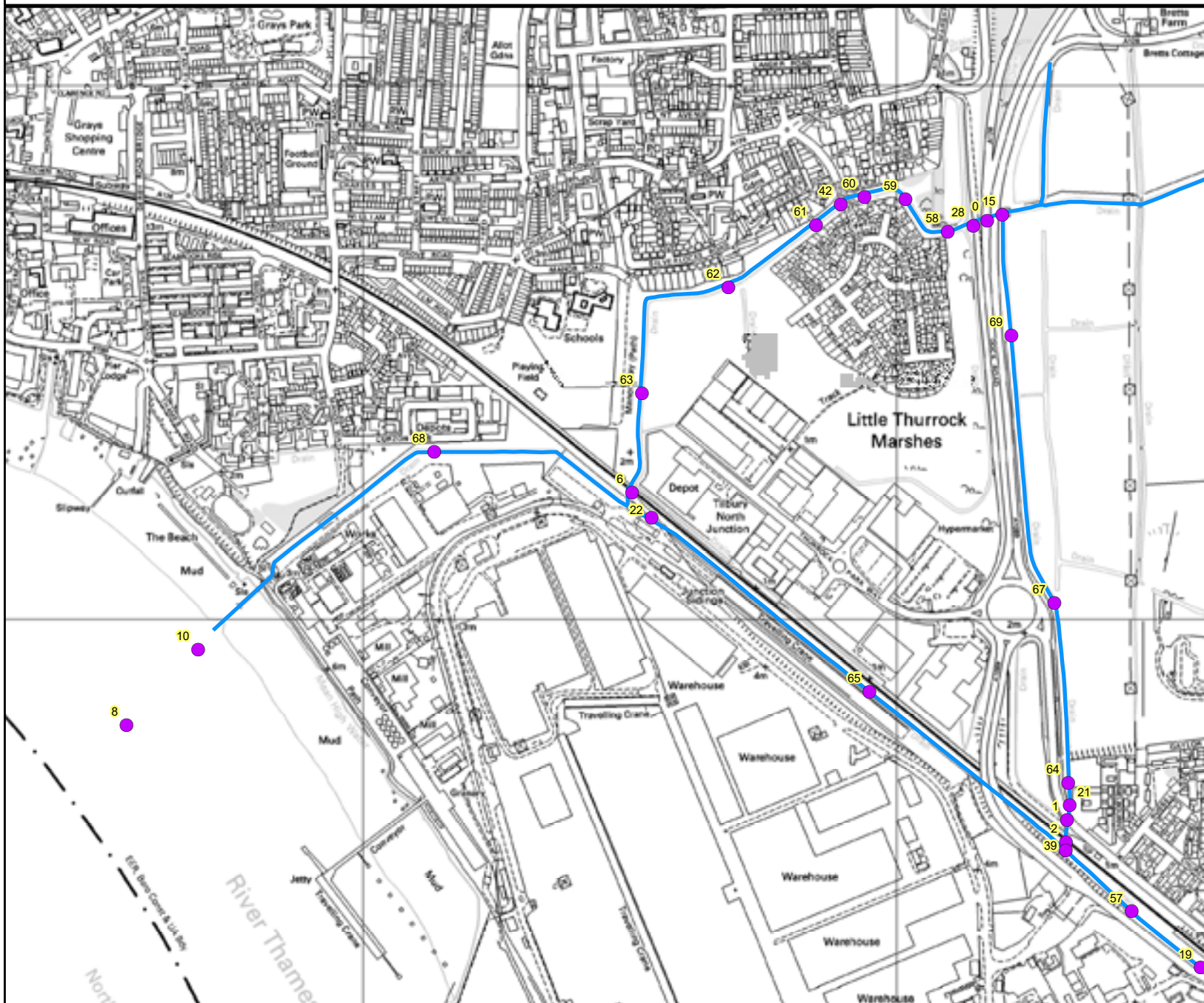
Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



0 125 250 500
Metres
1:10,500

Legend

- Nodes (Climate Change)
- Main Rivers



This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within the catchment. Modelled outlines take into account catchment wide defences if present.



Datasheet Title: Climate Change Levels - North West
Source of information: Tilbury Integrated Flood Strategy 2015
 JBA for Thurrock Council, Anglian Water and The Environment Agency
Source of Flooding Pluvial
Flood Depths Provided In-Channel

Key
CC Climate Change
AEP Annual Exceedance Probability
mAODN Metres Above Ordnance Datum Newlyn
m³s⁻¹ Cubic Metres Per Second (Cumecs)
DS Downstream
US Upstream

Depths (m) _____

Baseline

Node	100% (1:1) DS	100% (1:1) US	10% (1:10) DS	10% (1:10) US	5% (1:20) DS	5% (1:20) US	3.33% (1:30) DS	3.33% (1:30) US	2.5% (1:40) DS	2.5% (1:40) US	2% (1:50) DS	2% (1:50) US	1.33% (1:75) DS	1.33% (1:75) US	1% (1:100)	0.5% (1:200)	0.1% (1:1,000)
0	0.48	0.69	1.08	1.29	1.26	1.46	1.34	1.55	1.39	1.60	1.43	1.64	1.50	1.71	1.54	1.63	1.89
1	0.56	1.08	0.94	1.46	1.07	1.59	1.14	1.66	1.19	1.71	1.23	1.75	1.34	1.86	1.40	1.58	1.79
2	0.56	0.56	0.94	0.94	1.07	1.07	1.14	1.14	1.19	1.19	1.23	1.23	1.34	1.34	1.40	1.56	1.78
6	0.83	0.97	1.43	1.57	1.60	1.75	1.69	1.83	1.74	1.89	1.78	1.93	1.85	2.00	1.89	1.99	2.25
8	5.79	0.33	5.79	0.93	5.79	1.11	5.79	1.19	5.79	1.25	5.79	1.29	5.79	1.36	5.79	5.79	5.79
10	0.33	0.33	0.93	0.93	1.11	1.11	1.19	1.19	1.25	1.25	1.29	1.29	1.36	1.36	1.40	1.49	1.76
15	0.69	0.69	1.29	1.29	1.46	1.46	1.55	1.55	1.60	1.60	1.64	1.63	1.71	1.70	1.74	1.84	2.09
19	0.55	0.55	0.93	0.93	1.06	1.06	1.13	1.13	1.18	1.18	1.22	1.22	1.33	1.33	1.39	1.55	1.77
21	1.08	1.08	1.46	1.47	1.59	1.59	1.66	1.67	1.71	1.71	1.75	1.76	1.86	1.86	1.92	2.10	2.32
22	0.38	0.20	0.76	0.80	0.89	0.98	0.96	1.06	1.01	1.12	1.05	1.16	1.15	1.23	1.21	1.37	1.59
28	0.48	0.48	1.08	1.08	1.26	1.26	1.34	1.34	1.40	1.39	1.43	1.43	1.50	1.50	1.54	1.64	1.90
39	0.56	0.56	0.94	0.94	1.07	1.07	1.14	1.14	1.19	1.19	1.23	1.23	1.34	1.34	1.40	1.56	1.78
42	0.64	0.65	1.24	1.25	1.42	1.42	1.51	1.51	1.56	1.56	1.60	1.60	1.67	1.67	1.71	1.80	2.07
57	0.55	0.75	0.93	1.13	1.06	1.25	1.13	1.33	1.18	1.38	1.22	1.42	1.33	1.52	1.39	1.55	1.77
58	1.03	0.48	1.63	1.08	1.80	1.26	1.89	1.34	1.94	1.40	1.98	1.43	2.05	1.50	2.09	2.18	2.45
59	0.78	1.03	1.38	1.63	1.55	1.80	1.64	1.89	1.69	1.94	1.73	1.98	1.80	2.05	1.84	1.93	2.20
60	0.57	0.78	1.17	1.38	1.34	1.55	1.43	1.64	1.48	1.69	1.52	1.73	1.59	1.80	1.63	1.72	1.99
61	0.92	0.64	1.52	1.24	1.69	1.42	1.78	1.51	1.83	1.56	1.87	1.60	1.94	1.67	1.98	2.07	2.34
62	1.34	0.92	1.93	1.52	2.11	1.69	2.20	1.78	2.25	1.83	2.29	1.87	2.36	1.94	2.40	2.49	2.76
63	1.23	1.34	1.83	1.93	2.00	2.11	2.09	2.20	2.14	2.25	2.18	2.29	2.25	2.36	2.29	2.39	2.65
64	1.08	0.71	1.47	1.10	1.59	1.22	1.67	1.30	1.71	1.35	1.76	1.39	1.86	1.49	1.92	2.10	2.33
65	0.75	0.43	1.13	0.80	1.25	0.93	1.33	1.00	1.38	1.05	1.42	1.09	1.52	1.20	1.58	1.75	1.96

Tilbury Nodes (Present Day) South East



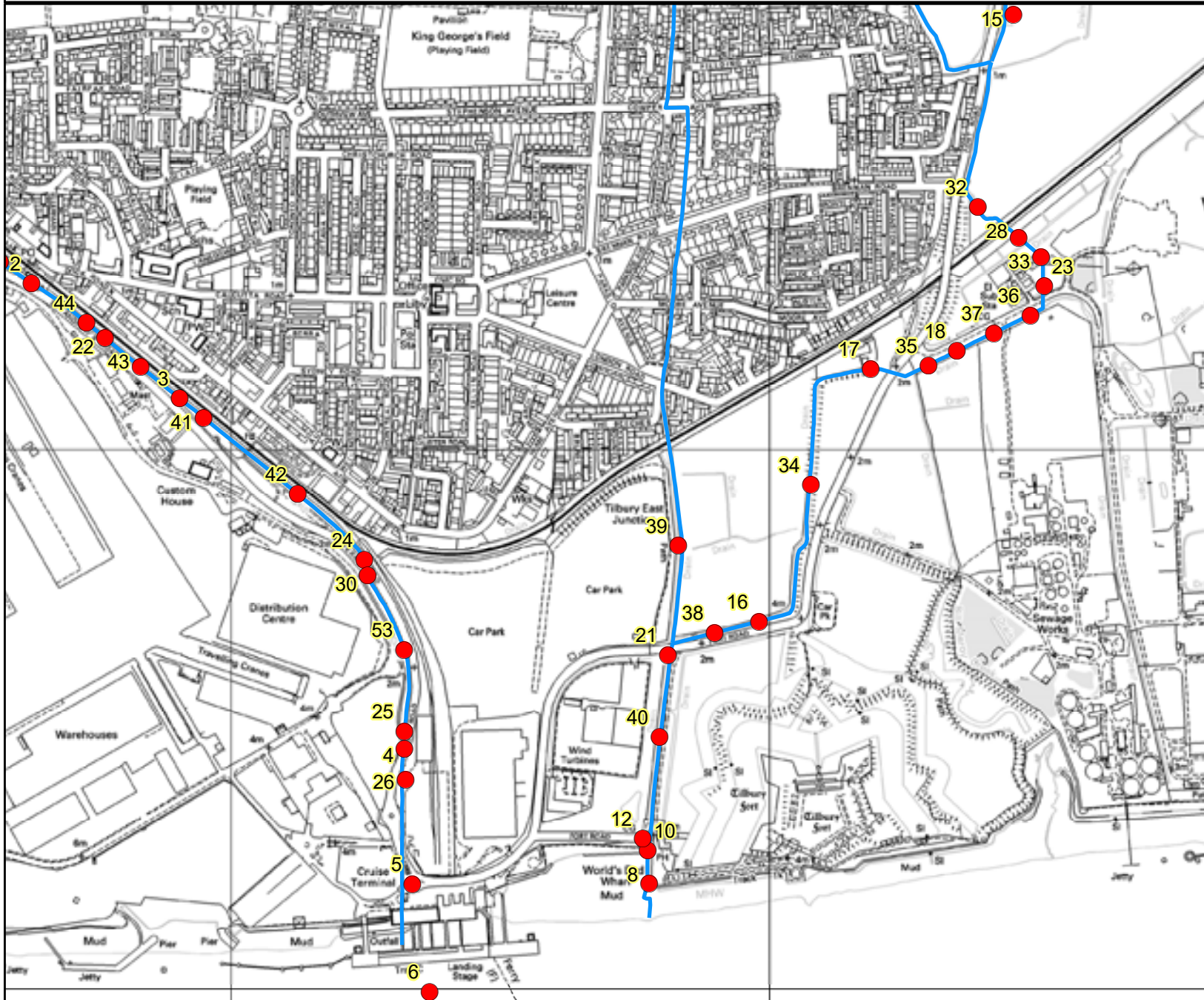
Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



0 125 250 500
Metres
1:10,400

Legend

- Nodes (Present Day)
- Main Rivers



This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within the catchment. Modelled outlines take into account catchment wide defences if present.

Datasheet Title: Present Day Data - Levels - South East
Source of information: Tilbury Integrated Flood Strategy 2015
Source of Flooding: JBA for Thurrock Council, Anglian Water and The Environment Agency
Flood Depths Provided: Pluvial
In-Channel

Key
CC Climate Change
AEP Annual Exceedance Probability
mAODN Metres Above Ordnance Datum Newlyn
m³s⁻¹ Cubic Metres Per Second (Cumecs)
DS Downstream
US Upstream

Depths (m)

Node	100% (1:1) US	100% (1:1) DS	10% (1:10) US	10% (1:10) DS	5% (1:20) US	5% (1:20) DS	3.33% (1:30) US	3.33% (1:30) DS	2.5% (1:40) US	2.5% (1:40) DS	2% (1:50) US	2% (1:50) DS	1.33% (1:75) US	1.33% (1:75) DS	1% (1:100) US	1% (1:100) DS	0.5% (1:200) US	0.5% (1:200) DS	0.1% (1:1,000) US	0.1% (1:1,000) DS
2	0.47	0.12	0.77	0.24	0.90	0.37	0.98	0.45	1.03	0.50	1.07	0.54	1.14	0.61	1.20	0.66	1.34	0.81	1.67	1.14
3	0.65	0.46	0.71	0.52	0.81	0.62	0.88	0.69	0.94	0.75	0.98	0.79	1.05	0.86	1.11	0.92	1.25	1.06	1.58	1.39
4	0.52	0.55	0.97	1.00	1.11	1.14	1.19	1.22	1.24	1.27	1.28	1.31	1.36	1.39	1.41	1.44	1.56	1.59	1.89	1.92
5	0.77	0.87	1.22	1.32	1.36	1.46	1.44	1.54	1.49	1.59	1.53	1.63	1.61	1.71	1.66	1.76	1.81	1.91	2.14	2.24
6	0.87	5.38	1.32	5.38	1.46	5.38	1.54	5.38	1.59	5.38	1.63	5.38	1.71	5.38	1.76	5.38	1.91	5.38	2.24	5.38
8	0.74	5.11	0.93	5.11	0.98	5.11	1.03	5.11	1.03	5.11	1.03	5.11	1.03	5.11	1.03	5.11	1.03	5.11	1.06	5.11
10	0.74	0.74	0.93	0.93	0.98	0.98	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.06	1.06
12	0.16	0.00	0.35	0.00	0.40	0.00	0.45	0.00	0.45	0.00	0.45	0.00	0.45	0.00	0.45	0.00	0.45	0.00	0.48	0.00
15	0.46	0.45	0.75	0.74	0.84	0.84	0.91	0.90	0.95	0.95	0.99	0.99	1.07	1.06	1.13	1.12	1.26	1.25	1.52	1.51
16	0.45	0.44	0.73	0.69	0.77	0.74	0.76	0.75	0.79	0.75	0.81	0.75	0.84	0.77	0.88	0.81	0.92	0.84	0.99	0.92
17	0.68	0.68	0.97	0.96	1.03	1.02	1.06	1.04	1.09	1.07	1.12	1.10	1.16	1.14	1.20	1.17	1.26	1.23	1.37	1.34
18	0.65	0.64	0.95	0.94	1.03	1.01	1.07	1.05	1.11	1.09	1.14	1.12	1.19	1.17	1.23	1.21	1.32	1.29	1.47	1.44
21	0.61	0.61	0.83	0.82	0.88	0.87	0.92	0.91	0.93	0.92	0.92	0.92	0.92	0.91	0.93	0.92	0.94	0.93	1.00	0.98
22	0.48	0.48	0.55	0.55	0.64	0.64	0.72	0.72	0.77	0.77	0.81	0.81	0.88	0.88	0.94	0.94	1.09	1.08	1.41	1.41
23	0.79	0.78	1.11	1.10	1.20	1.20	1.26	1.25	1.31	1.30	1.34	1.34	1.41	1.41	1.47	1.46	1.58	1.57	1.81	1.80
24	0.50	0.50	0.72	0.72	0.86	0.86	0.94	0.94	0.99	0.99	1.04	1.04	1.11	1.11	1.16	1.16	1.31	1.31	1.64	1.64
25	0.52	0.52	0.97	0.97	1.11	1.11	1.19	1.19	1.24	1.24	1.28	1.28	1.36	1.36	1.41	1.41	1.56	1.56	1.89	1.89
26	0.77	0.77	1.22	1.22	1.36	1.36	1.44	1.44	1.49	1.49	1.53	1.53	1.61	1.61	1.66	1.66	1.81	1.81	2.14	2.14
28	0.66	0.66	0.98	0.97	1.07	1.06	1.13	1.12	1.17	1.16	1.21	1.20	1.28	1.27	1.33	1.32	1.45	1.43	1.68	1.65
30	0.49	0.49	0.72	0.72	0.86	0.86	0.93	0.93	0.99	0.99	1.03	1.03	1.10	1.10	1.16	1.16	1.30	1.30	1.64	1.64
32	0.45	0.59	0.74	0.92	0.84	1.02	0.90	1.08	0.95	1.13	0.99	1.18	1.06	1.25	1.12	1.31	1.25	1.44	1.51	1.71
33	0.66	0.79	0.97	1.11	1.06	1.20	1.12	1.26	1.16	1.31	1.20	1.34	1.27	1.41	1.32	1.47	1.43	1.58	1.65	1.81
34	0.68	0.52	0.96	0.81	1.02	0.87	1.05	0.87	1.08	0.90	1.10	0.92	1.14	0.97	1.17	1.01	1.23	1.07	1.34	1.18
35	0.64	0.83	0.94	1.13	1.01	1.21	1.05	1.25	1.09	1.29	1.12	1.32	1.17	1.37	1.21	1.41	1.29	1.49	1.44	1.65
36	0.82	0.56	1.13	0.88	1.23	0.98	1.28	1.03	1.33	1.08	1.36	1.12	1.43	1.18	1.48	1.23	1.59	1.35	1.81	1.56
37	0.60	0.74	0.91	1.05	1.00	1.14	1.05	1.19	1.09	1.23	1.13	1.27	1.19	1.34	1.24	1.38	1.34	1.48	1.54	1.68
38	0.44	0.30	0.69	0.55	0.74	0.60	0.75	0.65	0.75	0.66	0.75	0.65	0.77	0.65	0.81	0.66	0.84	0.67	0.92	0.80
39	1.04	0.68	1.28	0.94	1.33	0.99	1.38	1.03	1.40	1.04	1.40	1.04	1.40	1.04	1.41	1.04	1.43	1.06	1.54	1.19
40	0.61	0.73	0.82	0.93	0.87	0.98	0.91	1.02	0.92	1.02	0.92	1.02	0.91	1.02	0.92	1.02	0.93	1.02	0.98	1.05
41	0.46	0.18	0.52	0.24	0.62	0.33	0.69	0.41	0.75	0.46	0.79	0.50	0.86	0.58	0.91	0.63	1.06	0.78	1.39	1.11
42	0.18	0.59	0.24	0.82	0.33	0.96	0.41	1.03	0.46	1.09	0.50	1.13	0.58	1.20	0.63	1.26	0.78	1.40	1.11	1.74
43	0.48	0.65	0.55	0.71	0.64	0.81	0.72	0.88	0.77	0.94	0.81	0.98	0.88	1.05	0.94	1.11	1.08	1.25	1.41	1.58
44	0.41	0.92	0.48	0.98	0.57	1.08	0.65	1.16	0.70	1.21	0.74	1.25	0.82	1.32	0.87	1.38	1.02	1.53	1.34	1.85
53	0.49	0.52	0.72	0.97	0.86	1.11	0.93	1.19	0.99	1.24	1.03	1.28	1.10	1.36	1.16	1.41	1.30	1.56	1.64	1.89

Datasheet Title: Present Day Data - Flows - South East
Source of information: Tilbury Integrated Flood Strategy 2015
Source of Flooding: JBA for Thurrock Council, Anglian Water and The Environment Agency
Flood Depths Provided: Pluvial
In-Channel

Key
CC Climate Change
AEP Annual Exceedance Probability
mAODN Metres Above Ordnance Datum Newlyn
m³s⁻¹ Cubic Metres Per Second (Cumeecs)
DS Downstream
US Upstream

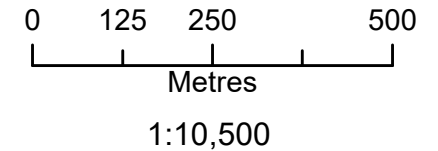
Flows (m³s⁻¹) **AEP**
Baseline

Node	100% (1:1) US	100% (1:1) DS	10% (1:10) US	10% (1:10) DS	5% (1:20) US	5% (1:20) DS	3.33% (1:30) US	3.33% (1:30) DS	2.5% (1:40) US	2.5% (1:40) DS	2% (1:50) US	2% (1:50) DS	1.33% (1:75) US	1.33% (1:75) DS	1% (1:100) US	1% (1:100) DS	0.5% (1:200) US	0.5% (1:200) DS	0.1% (1:1,000) US	0.1% (1:1,000) DS
2	-0.08	-0.09	-0.12	-0.15	-0.13	-0.17	-0.14	-0.18	0.14	-0.19	0.16	-0.19	0.20	0.20	0.23	0.23	0.30	0.31	0.61	0.62
3	-0.03	-0.04	0.05	0.05	0.10	0.10	0.14	0.14	0.17	0.17	0.19	0.19	0.23	0.23	0.26	0.27	0.36	0.36	0.63	0.63
4	0.07	0.07	0.20	0.23	0.29	0.32	0.35	0.37	0.39	0.42	0.43	0.45	0.49	0.51	0.54	0.56	0.69	0.71	1.09	1.10
5	0.09	0.28	0.25	0.42	0.33	0.49	0.39	0.53	0.44	0.56	0.47	0.59	0.53	0.63	0.58	0.67	0.73	0.77	1.12	1.13
6	0.28	0.28	0.42	0.42	0.49	0.49	0.53	0.53	0.56	0.56	0.59	0.59	0.63	0.63	0.67	0.67	0.77	0.77	1.13	1.13
8	0.49	0.49	0.71	0.71	0.72	0.72	0.71	0.71	0.74	0.74	0.76	0.76	0.77	0.77	0.77	0.77	0.84	0.84	0.91	0.91
10	0.49	0.49	0.71	0.71	0.72	0.72	0.71	0.71	0.74	0.74	0.76	0.76	0.77	0.77	0.77	0.77	0.84	0.84	0.91	0.91
12	0.46	0.46	0.89	0.89	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
15	0.18	0.18	0.38	0.38	0.45	0.45	0.50	0.50	0.53	0.53	0.56	0.56	0.61	0.61	0.64	0.64	0.70	0.70	5.49	5.49
16	0.15	0.15	0.34	0.34	0.41	0.41	0.46	0.46	0.50	0.50	0.52	0.52	0.57	0.57	0.60	0.60	0.68	0.68	0.84	0.84
17	0.16	0.16	0.35	0.35	0.42	0.42	0.47	0.47	0.50	0.50	0.53	0.53	0.58	0.58	0.61	0.61	0.68	0.68	0.82	0.82
18	0.16	0.16	0.36	0.36	0.43	0.43	0.48	0.48	0.51	0.51	0.53	0.53	0.58	0.58	0.62	0.62	0.68	0.68	0.82	0.82
21	0.48	0.48	0.87	0.87	0.95	0.95	1.34	1.34	1.43	1.43	1.42	1.42	1.39	1.39	1.42	1.42	1.58	1.58	1.88	1.88
22	0.04	0.04	0.04	0.04	0.10	0.10	0.13	0.13	0.15	0.15	0.18	0.18	0.22	0.22	0.25	0.25	0.33	0.33	0.62	0.62
23	0.17	0.17	0.36	0.36	0.43	0.43	0.48	0.48	0.52	0.52	0.54	0.54	0.59	0.59	0.62	0.62	0.69	0.69	1.01	1.01
24	0.07	0.07	0.16	0.16	0.20	0.20	0.23	0.23	0.26	0.26	0.29	0.29	0.34	0.34	0.39	0.39	0.52	0.52	0.84	0.84
25	0.07	0.07	0.20	0.20	0.29	0.29	0.35	0.35	0.39	0.39	0.43	0.43	0.49	0.49	0.54	0.54	0.69	0.69	1.09	1.09
26	0.09	0.09	0.24	0.24	0.33	0.33	0.39	0.39	0.44	0.44	0.47	0.47	0.53	0.53	0.58	0.58	0.73	0.73	1.12	1.12
28	0.17	0.17	0.37	0.37	0.44	0.44	0.49	0.49	0.52	0.52	0.55	0.55	0.60	0.60	0.63	0.63	0.69	0.69	1.36	1.36
30	0.07	0.07	0.16	0.16	0.20	0.20	0.24	0.24	0.27	0.27	0.29	0.29	0.35	0.35	0.39	0.39	0.52	0.52	0.85	0.85
32	0.18	0.17	0.38	0.37	0.45	0.44	0.50	0.49	0.53	0.52	0.56	0.55	0.61	0.60	0.64	0.63	0.70	0.69	5.46	1.39
33	0.17	0.17	0.37	0.36	0.44	0.43	0.49	0.48	0.52	0.52	0.55	0.54	0.60	0.59	0.63	0.62	0.69	0.69	1.36	1.01
34	0.16	0.15	0.35	0.34	0.42	0.41	0.47	0.46	0.50	0.50	0.53	0.52	0.58	0.57	0.61	0.60	0.68	0.68	0.82	0.84
35	0.16	0.16	0.36	0.35	0.43	0.42	0.48	0.47	0.51	0.50	0.53	0.53	0.58	0.58	0.62	0.61	0.68	0.68	0.82	0.82
36	0.17	0.17	0.36	0.36	0.43	0.43	0.48	0.48	0.52	0.51	0.54	0.54	0.59	0.59	0.62	0.62	0.69	0.68	0.99	0.82
37	0.17	0.16	0.36	0.36	0.43	0.43	0.48	0.48	0.51	0.51	0.54	0.54	0.59	0.58	0.62	0.62	0.68	0.68	0.82	0.82
38	0.15	0.15	0.34	0.34	0.41	0.40	0.46	0.46	0.50	0.50	0.52	0.53	0.57	0.57	0.60	0.60	0.68	0.68	0.84	0.85
39	0.55	0.48	1.15	1.05	1.39	1.23	1.49	1.30	1.55	1.35	1.59	1.39	1.65	1.48	1.69	1.56	1.74	1.70	1.82	2.10
40	0.48	0.49	0.87	0.98	0.95	1.03	1.34	1.85	1.43	1.85	1.42	1.85	1.39	1.85	1.42	1.85	1.58	1.85	1.88	2.12
41	-0.04	-0.05	0.05	0.05	0.10	0.11	0.14	0.15	0.17	0.18	0.19	0.20	0.23	0.25	0.27	0.28	0.36	0.38	0.63	0.64
42	0.18	0.07	0.29	0.16	0.33	0.20	0.34	0.23	0.36	0.26	0.36	0.29	0.38	0.34	0.39	0.39	0.41	0.52	0.69	0.84
43	0.04	-0.03	0.04	0.05	0.10	0.10	0.13	0.14	0.15	0.17	0.18	0.19	0.22	0.23	0.25	0.26	0.33	0.36	0.62	0.63
44	0.05	0.04	0.04	0.04	0.09	0.09	0.13	0.13	0.15	0.15	0.17	0.18	0.21	0.21	0.24	0.24	0.32	0.33	0.62	0.62
53	0.07	0.07	0.16	0.20	0.20	0.29	0.24	0.35	0.27	0.39	0.29	0.43	0.35	0.49	0.39	0.54	0.52	0.69	0.85	1.09

Tilbury Nodes (Climate Change) South East

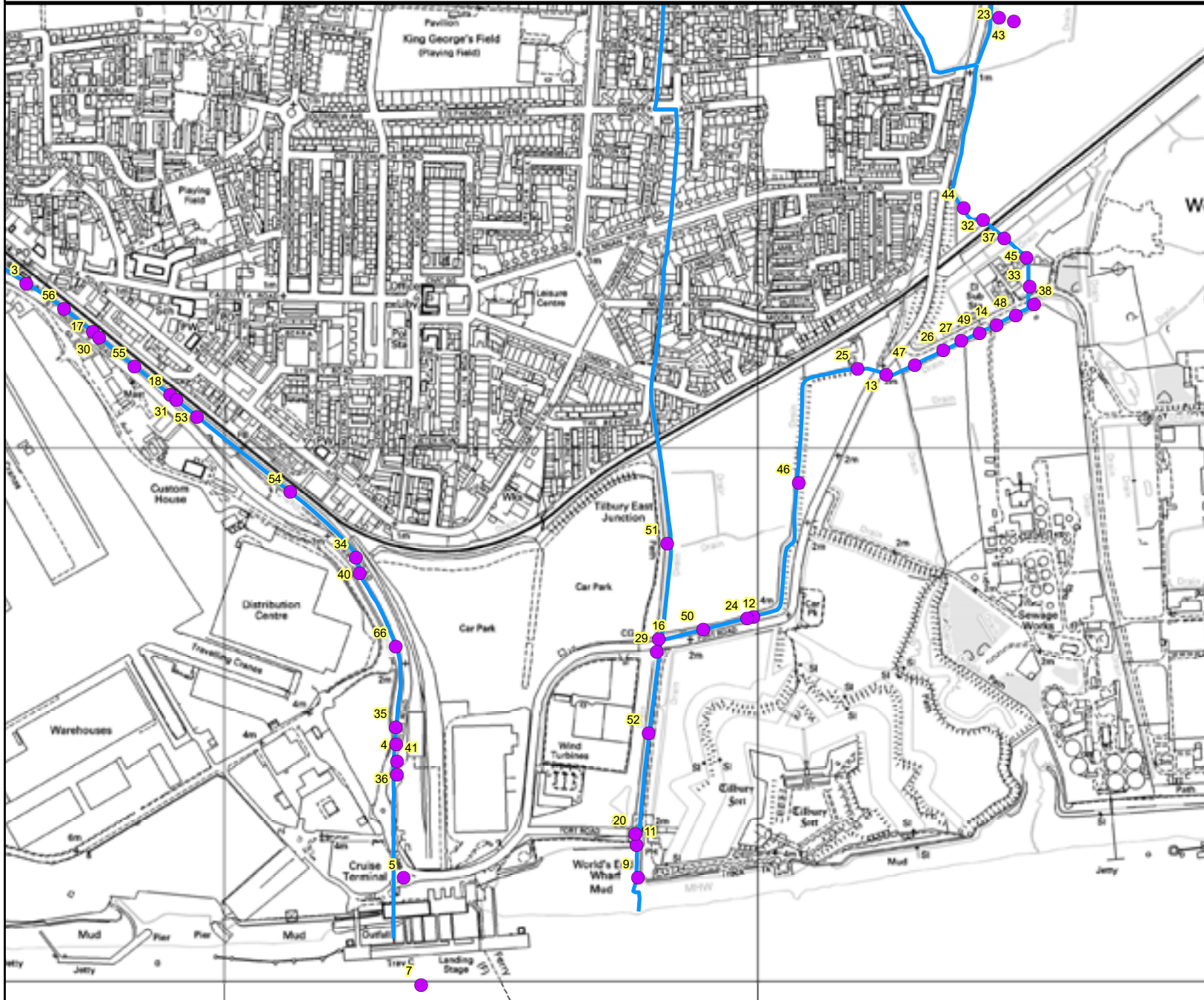


Environment Agency
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IP3 9JD



Legend

- Nodes (Climate Change)
- Main Rivers



This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites within the catchment. Modelled outlines take into account catchment wide defences if present.



Datasheet Title: Climate Change Levels - South East
Source of information: Tilbury Integrated Flood Strategy 2015
JBA for Thurrock Council, Anglian Water and The Environment Agency
Source of Flooding Pluvial
Flood Depths Provided In-Channel

Key
CC Climate Change
AEP Annual Exceedance Probability
mAODN Metres Above Ordnance Datum Newlyn
m³s⁻¹ Cubic Metres Per Second (Cumecs)
DS Downstream
US Upstream

Depths (m) _____

Baseline

Node	100% (1:1) DS	100% (1:1) US	10% (1:10) DS	10% (1:10) US	5% (1:20) DS	5% (1:20) US	3.33% (1:30) DS	3.33% (1:30) US	2.5% (1:40) DS	2.5% (1:40) US	2% (1:50) DS	2% (1:50) US	1.33% (1:75) DS	1.33% (1:75) US	1% (1:100)	0.5% (1:200)	0.1% (1:1,000)
3	0.14	0.55	0.40	0.93	0.53	1.06	0.60	1.13	0.65	1.18	0.69	1.22	0.79	1.33	0.85	1.02	1.23
4	0.65	0.62	1.17	1.14	1.30	1.27	1.37	1.34	1.42	1.39	1.46	1.44	1.57	1.54	1.63	1.80	2.02
5	0.97	0.87	1.49	1.39	1.62	1.52	1.69	1.59	1.74	1.64	1.78	1.68	1.89	1.79	1.95	2.12	2.34
7	6.41	0.97	6.41	1.49	6.41	1.62	6.41	1.69	6.41	1.74	6.41	1.78	6.41	1.89	6.41	6.41	6.41
9	6.14	0.83	6.14	1.03	6.14	1.03	6.14	1.03	6.14	1.03	6.14	1.03	6.14	1.03	6.14	6.14	6.14
11	0.83	0.83	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.28
12	0.54	0.55	0.80	0.84	0.78	0.85	0.82	0.89	0.84	0.92	0.87	0.95	0.90	0.98	0.91	0.94	1.05
13	0.89	0.90	1.22	1.24	1.28	1.30	1.33	1.35	1.36	1.39	1.39	1.42	1.43	1.46	1.46	1.52	1.66
14	0.62	0.63	0.98	1.00	1.07	1.09	1.13	1.16	1.18	1.21	1.21	1.24	1.27	1.30	1.31	1.39	1.60
16	0.70	0.72	0.90	0.94	0.90	0.95	0.91	0.96	0.91	0.96	0.92	0.97	0.93	0.99	0.93	0.94	1.17
17	0.94	0.94	1.11	1.11	1.24	1.24	1.31	1.31	1.36	1.36	1.40	1.40	1.51	1.51	1.57	1.73	1.95
18	0.67	0.67	0.83	0.83	0.96	0.97	1.04	1.04	1.09	1.09	1.13	1.13	1.24	1.24	1.30	1.46	1.68
20	0.00	0.18	0.00	0.38	0.00	0.38	0.00	0.38	0.00	0.38	0.00	0.38	0.00	0.38	0.00	0.00	0.00
23	0.52	0.52	0.86	0.87	0.96	0.97	1.03	1.04	1.09	1.10	1.13	1.14	1.20	1.21	1.25	1.37	1.63
24	0.54	0.56	0.78	0.82	0.74	0.80	0.76	0.83	0.79	0.86	0.82	0.89	0.83	0.91	0.84	0.86	1.06
25	0.75	0.75	1.05	1.06	1.08	1.10	1.12	1.15	1.15	1.18	1.18	1.20	1.21	1.24	1.23	1.28	1.39
26	0.71	0.72	1.04	1.05	1.10	1.12	1.15	1.17	1.19	1.21	1.21	1.24	1.26	1.29	1.29	1.36	1.51
27	0.77	0.78	1.11	1.13	1.19	1.20	1.24	1.26	1.28	1.30	1.31	1.33	1.36	1.39	1.40	1.47	1.65
29	0.71	0.72	0.91	0.92	0.92	0.92	0.92	0.93	0.92	0.93	0.93	0.94	0.93	0.94	0.94	0.95	1.17
30	0.50	0.50	0.67	0.67	0.80	0.80	0.87	0.87	0.92	0.92	0.96	0.96	1.07	1.07	1.13	1.29	1.51
31	0.48	0.48	0.64	0.64	0.77	0.77	0.85	0.85	0.90	0.90	0.94	0.94	1.04	1.05	1.10	1.27	1.49
32	0.65	0.67	1.01	1.05	1.11	1.15	1.18	1.22	1.23	1.28	1.27	1.32	1.35	1.40	1.40	1.51	1.76
33	0.86	0.86	1.22	1.23	1.32	1.32	1.38	1.39	1.43	1.44	1.47	1.47	1.53	1.56	1.57	1.67	1.90
34	0.55	0.56	0.89	0.89	1.02	1.02	1.09	1.10	1.15	1.15	1.19	1.19	1.29	1.29	1.35	1.52	1.74
35	0.62	0.62	1.14	1.14	1.27	1.27	1.34	1.34	1.39	1.39	1.44	1.44	1.54	1.54	1.60	1.77	1.99
36	0.87	0.87	1.39	1.39	1.52	1.52	1.59	1.59	1.64	1.64	1.68	1.68	1.79	1.79	1.85	2.02	2.24
37	0.73	0.74	1.09	1.10	1.18	1.19	1.24	1.25	1.29	1.30	1.33	1.34	1.41	1.43	1.45	1.55	1.80
38	0.89	0.89	1.25	1.26	1.34	1.35	1.41	1.41	1.45	1.46	1.49	1.50	1.55	1.56	1.59	1.68	1.90
40	0.54	0.55	0.88	0.88	1.01	1.01	1.09	1.09	1.14	1.14	1.18	1.18	1.29	1.29	1.35	1.51	1.74
41	0.65	0.65	1.17	1.17	1.30	1.30	1.37	1.37	1.42	1.42	1.46	1.46	1.57	1.57	1.63	1.80	2.02
43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44	0.67	0.52	1.05	0.86	1.15	0.96	1.22	1.03	1.28	1.09	1.32	1.13	1.40	1.20	1.45	1.56	1.83
45	0.86	0.73	1.23	1.09	1.32	1.18	1.39	1.24	1.44	1.29	1.47	1.33	1.56	1.41	1.61	1.71	1.95
46	0.62	0.75	0.91	1.05	0.91	1.08	0.95	1.13	0.98	1.15	1.01	1.18	1.05	1.21	1.07	1.12	1.23
47	0.90	0.71	1.24	1.04	1.30	1.10	1.35	1.15	1.39	1.19	1.42	1.21	1.46	1.26	1.50	1.56	1.72
48	0.63	0.89	1.00	1.25	1.09	1.34	1.16	1.41	1.21	1.45	1.24	1.49	1.30	1.55	1.35	1.44	1.66
49	0.81	0.67	1.17	1.02	1.25	1.10	1.31	1.17	1.36	1.21	1.39	1.24	1.45	1.30	1.49	1.57	1.77
50	0.42	0.54	0.65	0.78	0.65	0.74	0.66	0.76	0.67	0.79	0.67	0.82	0.69	0.83	0.70	0.73	0.96
51	0.81	1.15	1.03	1.38	1.04	1.40	1.05	1.41	1.05	1.43	1.06	1.43	1.07	1.45	1.08	1.12	1.35
52	0.83	0.71	1.02	0.91	1.02	0.92	1.02	0.92	1.02	0.92	1.02	0.93	1.03	0.93	1.03	1.03	1.28
53	0.20	0.48	0.36	0.64	0.49	0.77	0.56	0.85	0.61	0.90	0.65	0.94	0.76	1.04	0.82	0.99	1.21
54	0.65	0.20	0.98	0.36	1.11	0.49	1.19	0.56	1.24	0.61	1.28	0.65	1.39	0.76	1.45	1.61	1.84
55	0.67	0.50	0.83	0.67	0.96	0.80	1.04	0.87	1.09	0.92	1.13	0.96	1.24	1.07	1.29	1.46	1.68
56	0.43	0.19	0.60	0.40	0.73	0.52	0.80	0.60	0.85	0.65	0.89	0.69	1.00	0.79	1.06	1.22	1.44
66	0.62	0.54	1.14	0.88	1.27	1.01	1.34	1.09	1.39	1.14	1.44	1.18	1.54	1.29	1.60	1.77	1.99

1 in 20 (5%) Depth Levels (Present Day) Map



Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



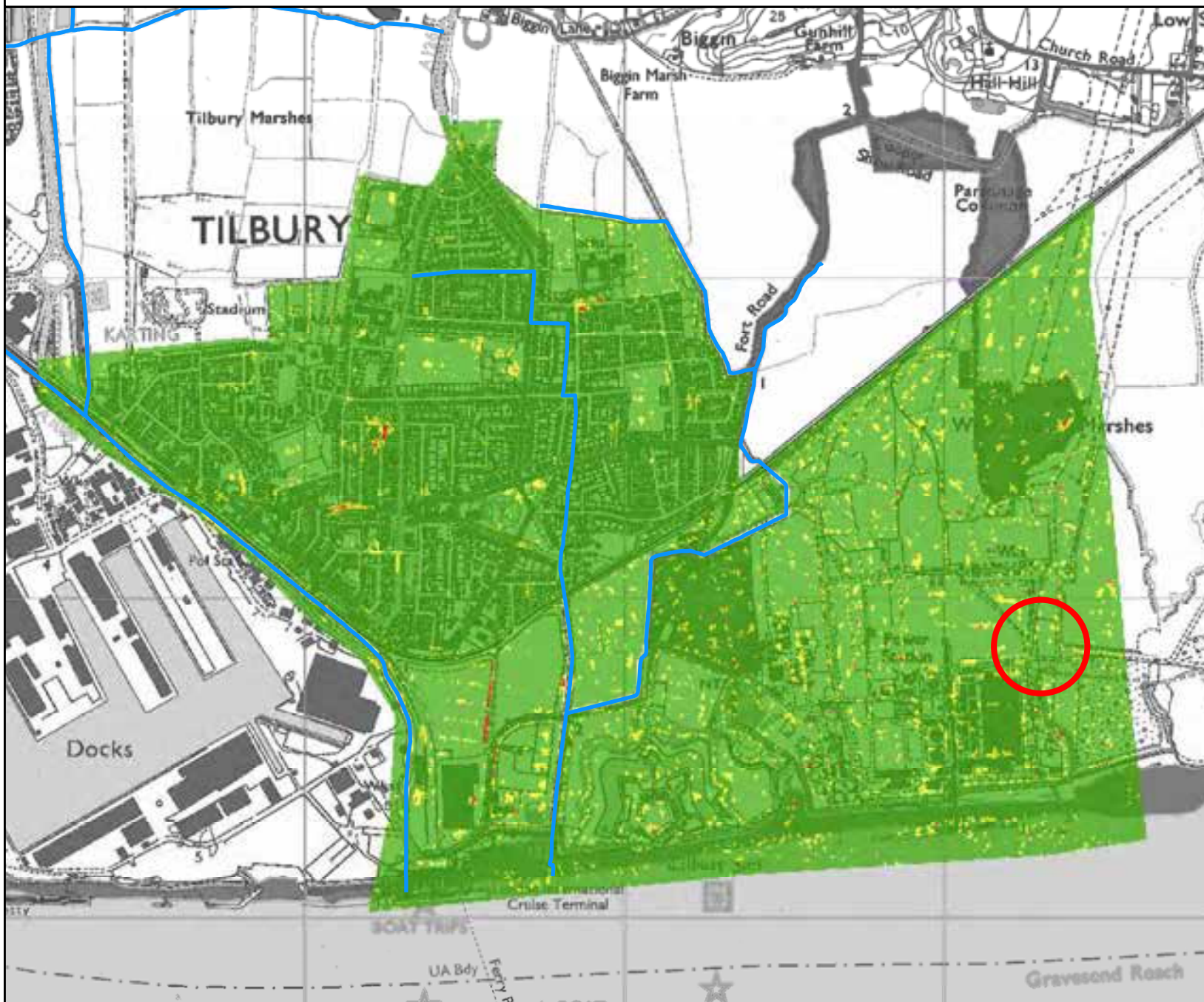
0 210 420 840
Metres
1:17,500

Legend

— Main Rivers

Max Depth 5% AEP Baseline (in metres)

- 0 - 0.05
- 0.05 - 0.2
- >0.2



1 in 20 (5%) Depth Levels (Climate Change) Map



Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



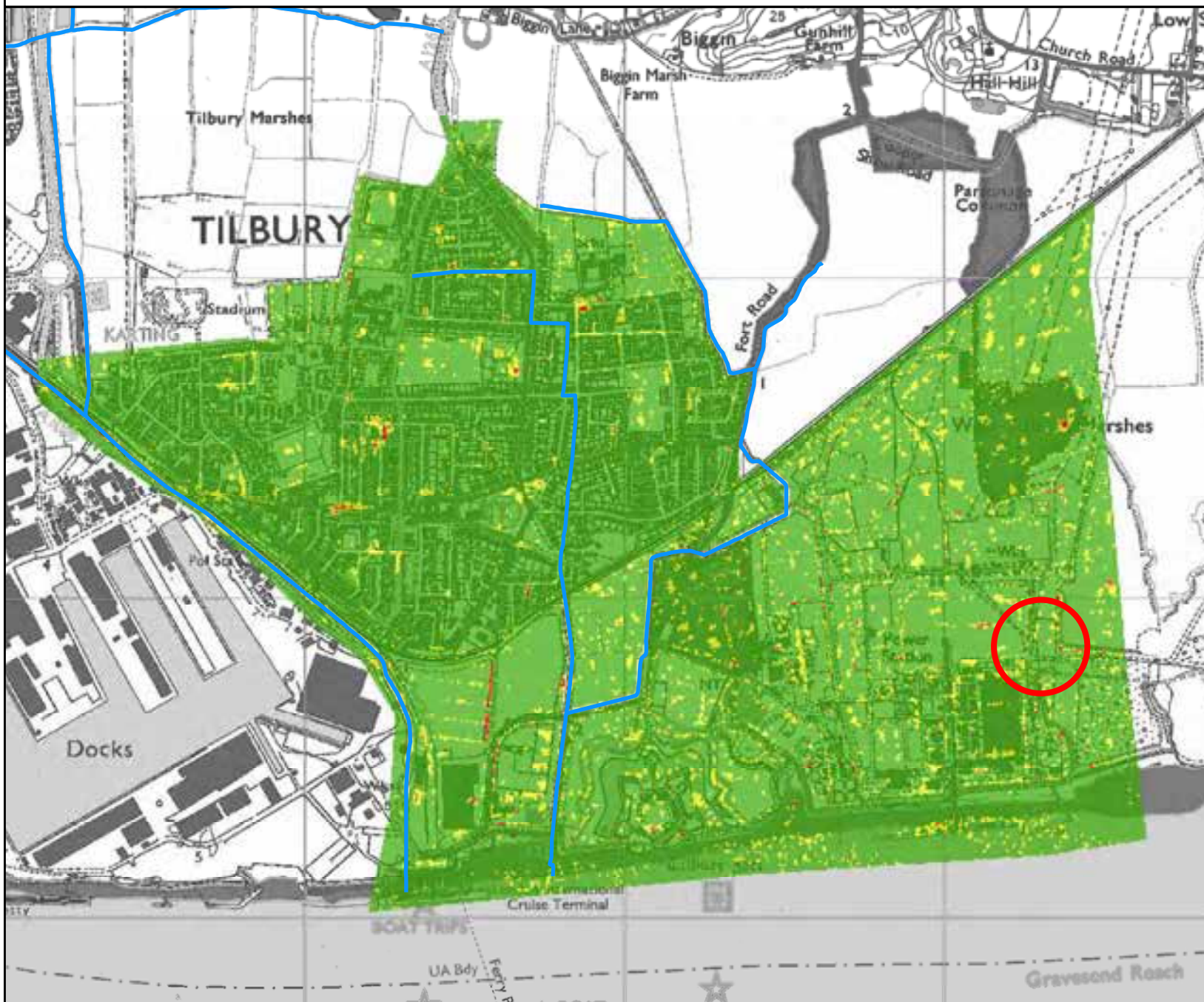
0 210 420 840
Metres
1:17,500

Legend

— Main Rivers

**Max Depth 5% AEP 2110
(in metres)**

- 0 - 0.05
- 0.05 - 0.2
- >0.2



1 in 100 (1%) Depth Levels (Present Day) Map



Environment Agency
Iceni House
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Suffolk
IP3 9JD



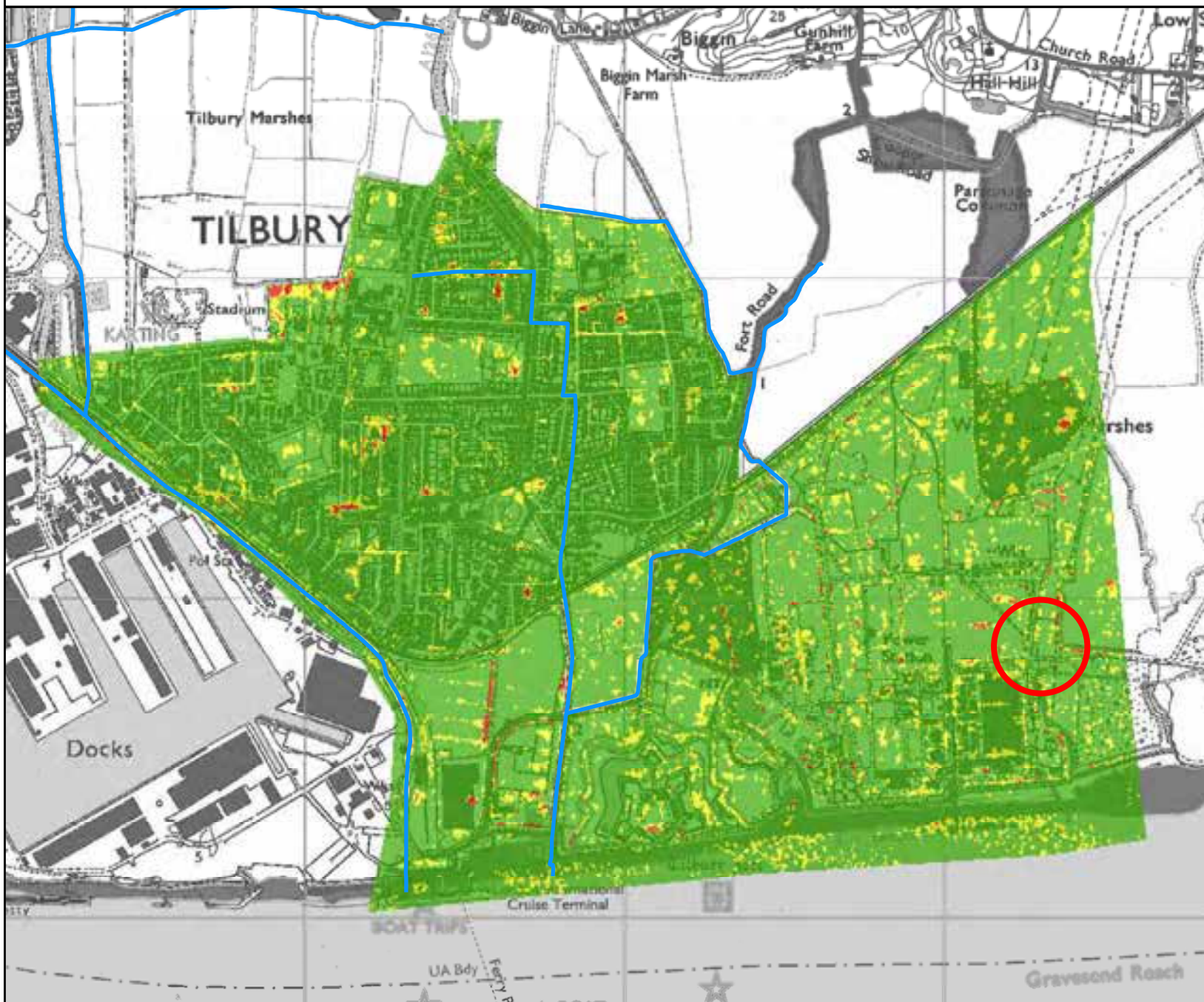
0 210 420 840
Metres
1:17,500

Legend

— Main Rivers

Max Depth 1% AEP Baseline (in metres)

- 0 - 0.05
- 0.05 - 0.2
- >0.2



1 in 100 (1%) Depth Levels (Climate Change) Map



Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



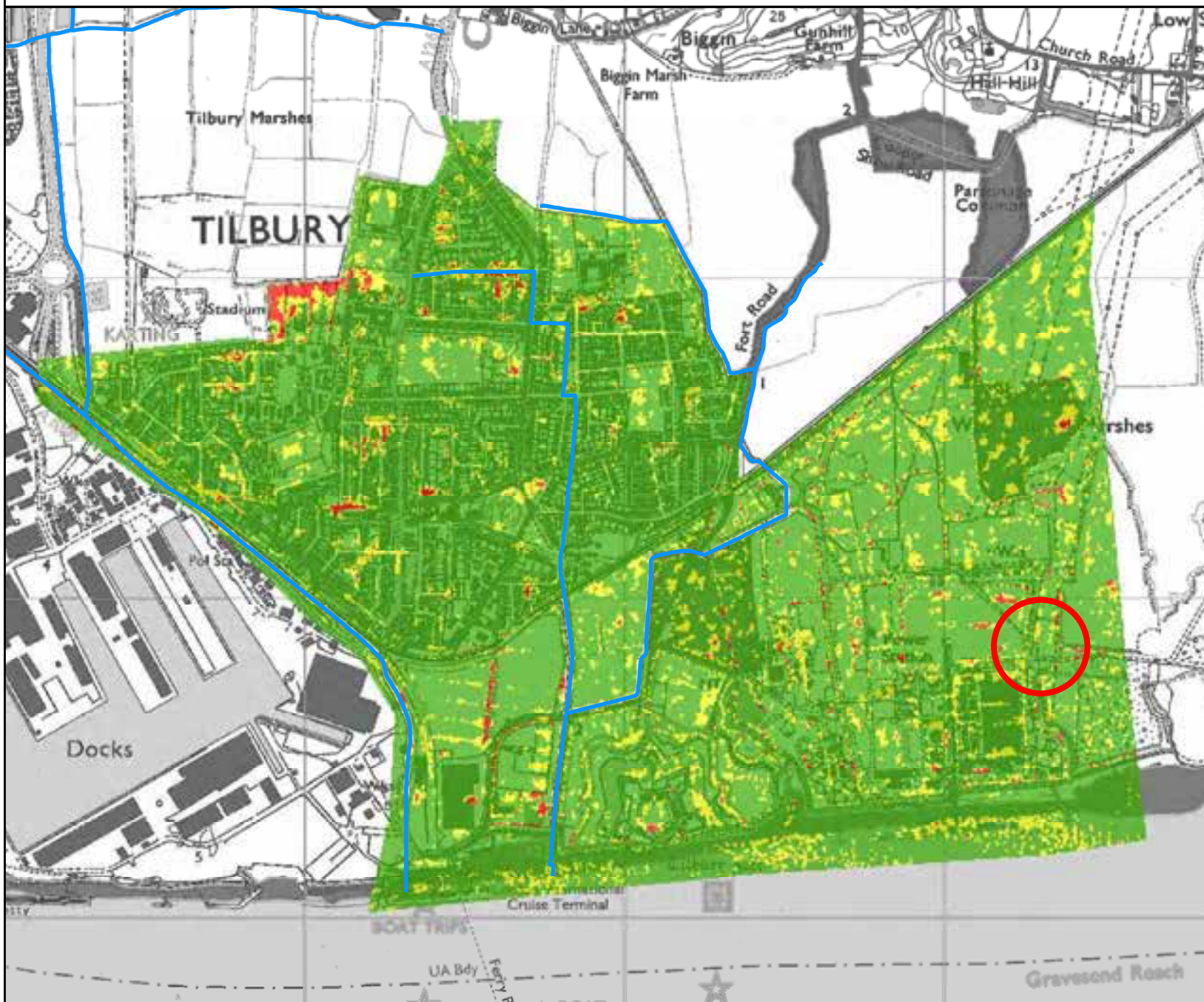
0 210 420 840
Metres
1:17,500

Legend

— Main Rivers

**Max Depth 1% AEP 2110
(in metres)**

0 - 0.05
0.05 - 0.2
>0.2



1 in 1000 (0.1%) Depth Levels (Present Day) Map



Environment Agency
Iceni House
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Suffolk
IP3 9JD



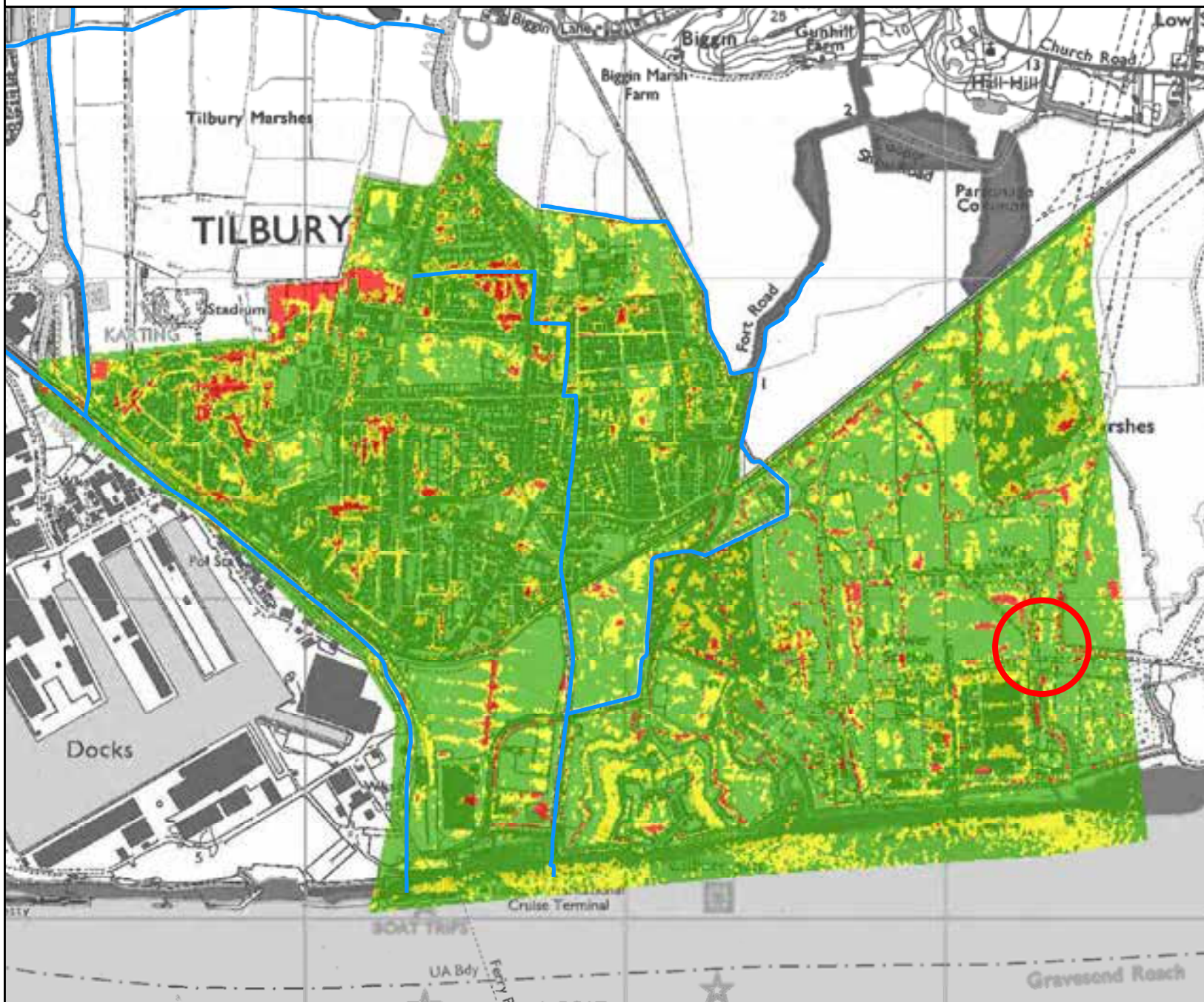
0 210 420 840
Metres
1:17,500

Legend

— Main Rivers

Max Depth 0.1% AEP Baseline (in metres)

- 0 - 0.05
- 0.05 - 0.2
- >0.2



1 in 1000 (0.1%) Depth Levels (Climate Change) Map



Environment Agency
Iceni House
Cobham Road
Ipswich
Suffolk
IP3 9JD



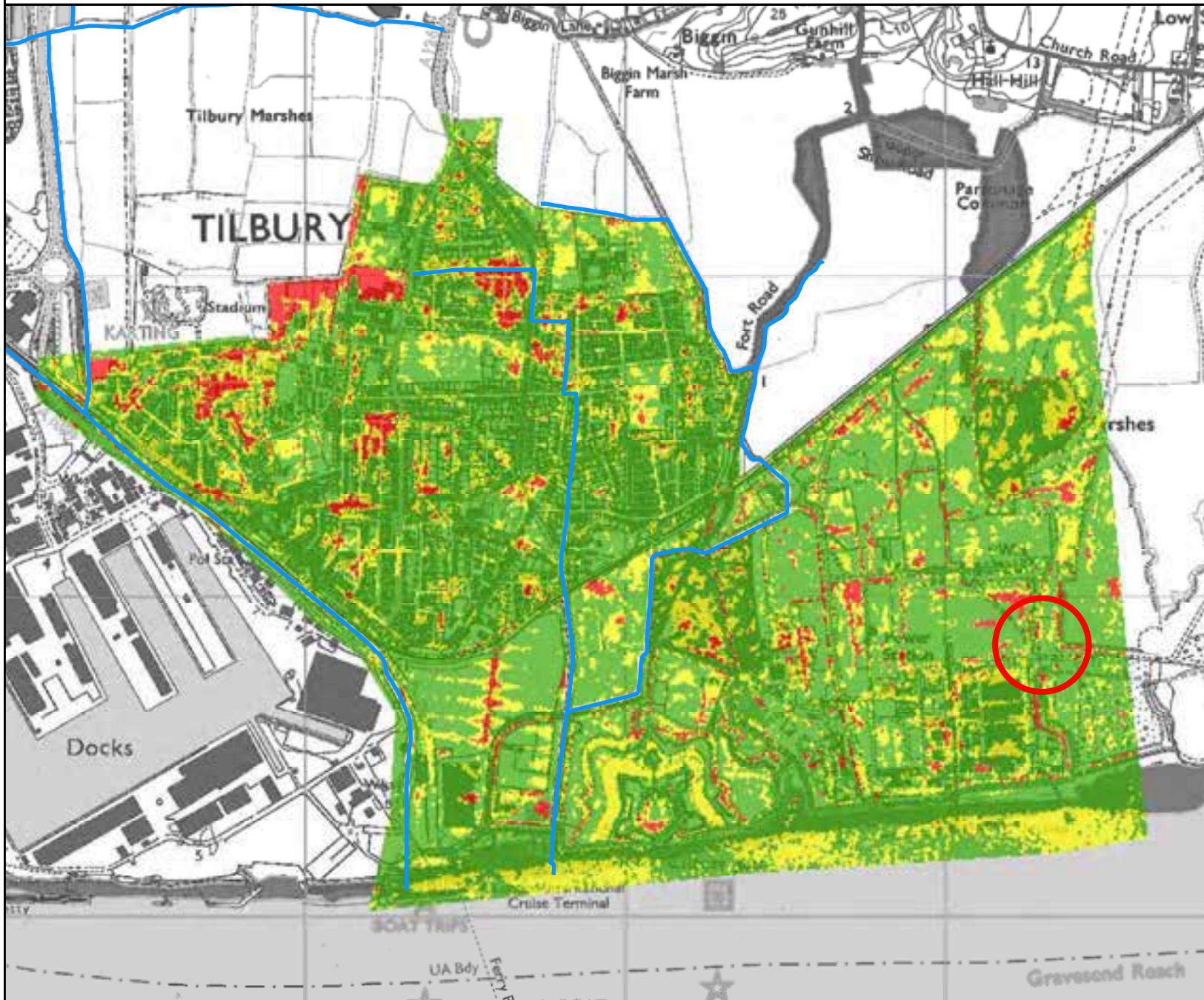
0 210 420 840
Metres
1:17,500

Legend

— Main Rivers

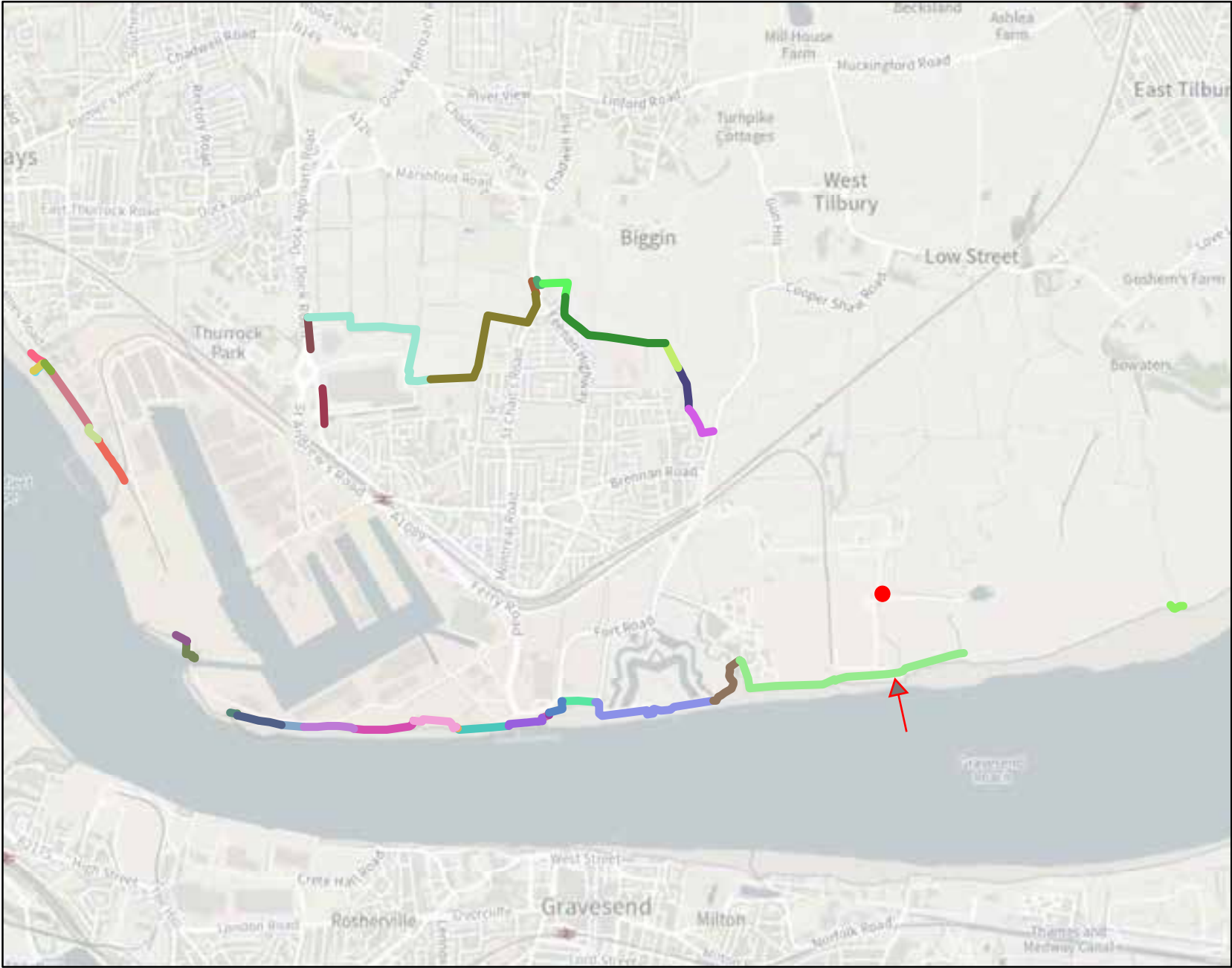
**Max Depth 0.1% AEP 2110
(in metres)**

0 - 0.05
0.05 - 0.2
>0.2



Flood Defence Location Map

Ref: EAN/2023/NR305781



Legend

Defences	
AIMSID	152404
	152988
109492	183528
109493	26652
109494	331263
11635	331269
11636	33954
11691	33955
130132	36238
130315	36282
130316	396252
130317	396254
151977	475722
151978	595957
151979	749229
151980	749231
151981	
151982	
152002	
152003	
152004	
152005	
152006	
152008	
152403	



Date: 06/04/2023

Datasheet Reference: EAN/2023/NR305781



Defence Information

Asset Reference	Maintainer	Asset Type	Asset Description	Standard of Protection	Overall Condition Grade	Crest Level
151977	Environment Agency	Wall	steel pile wall with Essex Block Revetment front face. back slope has scour protection, some of which buried due to land raising around the grain terminal.	1000	4 - Poor	6.73
36282	Environment Agency	Wall		200	3 - Fair	1.1
11691	Environment Agency	Wall		200	3 - Fair	1.43
151979	Environment Agency	Wall	Foreshore and Wall	1000	4 - Poor	6.64
152003	Environment Agency	Wall	Piling	1000	3 - Fair	6.75
130315	Environment Agency	Wall	Steel Wall (no info on whats underneath the jetty holding it up)	1000	3 - Fair	6.48
33955	Environment Agency	Embankment		200	3 - Fair	1.45
749231	Environment Agency	Wall	left bank retaining wall		0 - Unchecked	
151978	Environment Agency	Wall	Wall with concrete fence	1000	4 - Poor	6.68
151981	Environment Agency	Wall	Concrete Wall	1000	3 - Fair	6.9
130317	Environment Agency	Wall	Wall	1000	4 - Poor	6.45
152005	Environment Agency	Wall	Piling	1000	3 - Fair	6.85
11636	Environment Agency	Embankment		1000	3 - Fair	1.37
151982	Environment Agency	Wall	typical TTD Wall with embankment	1000	3 - Fair	6.71
130316	Environment Agency	Wall		1000	3 - Fair	6.63
152008	Environment Agency	Wall	Wall	1000	3 - Fair	6.77
109494	Environment Agency	Wall	typical TTD Wall with embankment and Essex Block revetment	1000	3 - Fair	6.72
331263	Environment Agency	Wall	Piling section		3 - Fair	6.8
152404	Environment Agency	Wall	Piling	1000	3 - Fair	6.62
475722	Environment Agency	Wall	Concrete Wall		3 - Fair	6
595957	Environment Agency	Wall	Steel SSP with Concrete Cap		0 - Unchecked	
26652	Environment Agency	Wall		200	3 - Fair	1.04
152006	Environment Agency	Embankment	Embankment	1000	4 - Poor	6.64
331269	Environment Agency	Wall	Piling		3 - Fair	6.84
11635	Environment Agency	Embankment		1000	3 - Fair	1.45
109493	Environment Agency	Wall		1000	4 - Poor	6.67
183528	Environment Agency	Embankment		1000	3 - Fair	1.43
749229	Environment Agency	Wall	Right Bank Retaining wall		0 - Unchecked	
109492	Environment Agency	Wall		1000	4 - Poor	6.54
152403	Environment Agency	Wall	Piling Wall	1000	3 - Fair	6.92
396254	Environment Agency	Wall			3 - Fair	1.22
152002	Environment Agency	Wall	Wall	1000	3 - Fair	6.75
33954	Environment Agency	Embankment		200	3 - Fair	1.18
151980	Environment Agency	Wall	Piling Wall	1000	3 - Fair	6.76
152004	Environment Agency	Wall	large concrete upstand wall with ragstone revetment	1000	3 - Fair	6.8
396252	Environment Agency	Embankment			3 - Fair	1.11
152988	Environment Agency	Wall		1000	3 - Fair	6.49
130132	Environment Agency	Wall	Typical TTD defence. large concrete up stand wall with ragstone foreshore and landward backslope	1000	3 - Fair	6.71
36238	Environment Agency	Embankment	Clay embankment that forms part of FSA. Goes past football club down towards boundary of Olive Academy	200	4 - Poor	1.09

Key to Overall Condition Grades

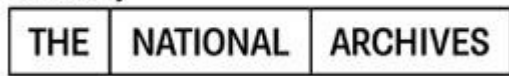
Grade	Rating
1	Very Good
2	Good
3	Fair
4	Poor
5	Very Poor



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Further context, best practice and guidance can be found in the [UK Government Licensing Framework section](#) on The National Archives website.



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Product 4: Supporting Documentation

GUIDANCE INCLUDED:

1. **PRODUCT 4 FACT SHEET.**
2. **FLOOD ZONE 3 FACTSHEET - EAST ANGLIA (EAST)**
3. **FLOOD RISK ASSESSMENT (FRA) CHECKLIST**
4. **NEW TIDAL CLIMATE CHANGE ALLOWANCES FOR ESSEX, NORFOLK AND SUFFOLK**
5. **UPDATED FLUVIAL CLIMATE CHANGE ALLOWANCES FOR ESSEX, NORFOLK AND SUFFOLK**

PARTNERSHIP AND STRATEGIC OVERVIEW TEAM – EAST ANGLIA (EAST) Version 6 Updated May 2023

customer service line
03708 506 506

incident hotline
0800 80 70 60

floodline
03459 88 11 88

Product 4 Fact Sheet

Thank you for your enquiry.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

Please refer to the Open Government Licence available here:

<http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/> which explains the permitted use of this information.

You should consider contacting the relevant Local Planning Authority and/or water/sewerage undertaker for the area.

Please be aware that flooding can come from different sources. Examples of these are:

- from rivers or the sea
- surface water (i.e. rainwater flowing over or accumulating on the ground before it is able to enter rivers or the drainage system)
- overflowing or backing up of sewer or drainage systems which have been overwhelmed
- groundwater rising up from underground aquifers

Currently the Environment Agency can only supply flood risk data relating to the chance of flooding from rivers or the sea.

Areas Benefiting from Flood Defences

Areas benefiting from flood defences are defined as those areas which benefit from formal flood defences specifically in the event of flooding from rivers with a 1% (1 in 100) chance in any given year or flooding from the sea with a 0.5% (1 in 200) chance in any given year.

If the defences were not there, these areas would be flooded. An area of land may benefit from the presence of a flood defence even if the defence has overtopped, if the presence of the defence means that the flood water does not extend as far as it would if the defence were not there.

Flood Risk Assessment Checklist

If you are planning on using this data within a Flood Risk Assessment, we recommend that you take the time to fill in the attached FRA checklist, and to read the attachments which contain information relevant to the area that interests you.

We would like to stress the importance of filling in the Flood Risk Assessment check list and providing up-to-date and correct data. The data will be checked against our records when we review the Flood Risk Assessment in our role as statutory consultee.

It is important that you provide a map in section 2 of the FRA checklist (See Appendix A), including the highest and most representative flood levels for your site. We recommend using a number of nodes that provide a fair representation of the modelled data across your site. For example, if it is a small extension (< 250 square metres) then approximately 5-10 nodes would be sufficient. For larger sites, approximately 10 to 20 nodes would be appropriate.

If you have a new enquiry or would like us to review the information we have provided under the Freedom of Information Act 2000 and Environmental Information Regulations 2004 please contact us within two months by email at Enquiries_EastAnglia@environment-agency.gov.uk

East Anglia Area

Ipswich Office, Icen House, Cobham Road, Ipswich, Suffolk, IP3 9JD

General Enquiries: 03708 506506

Email: enquiries@environment-agency.gov.uk

Website: <https://www.gov.uk/government/organisations/environment-agency>

Flood Zone 3 Factsheet

East Anglia (East)

Oct 2017 - v.7

This factsheet provides information to assist with the preparation of a Flood Risk Assessment (FRA) in support of development proposals reviewed by the East Anglia teams, based at Ipswich. It should be read alongside the Environment Agency's general FRA advice ([FRA Guidance note 3](#)). For information relating to proposals managed by East Anglia teams please contact: planning.eastanglia@environment-agency.gov.uk.

This factsheet covers issues relating to FRAs only and does not address other matters we may take into account when considering development proposals (e.g. proximity to a watercourse, contaminated land, Water Framework Directive and biodiversity requirements). For further information on those issues, please contact: planning.....@environment-agency.gov.uk

Sequential Test and Exception Test

The Local Planning Authority (LPA) will need to be satisfied that the proposed development passes the flood risk Sequential Test, and if applicable, the first part of the Exception Test, in line with requirements of the National Planning Policy Framework (NPPF). We therefore strongly suggest you speak to them prior to commencing work on an FRA. Information regarding the [aim of the Sequential Test](#), [applying the Sequential Test](#) and the [Exception Test](#) can all be found in the Practice Guide supporting the NPPF.

Inappropriate development

[Table 2](#) of the Practice Guide categorizes developments according to their vulnerability and [table 3](#) sets out which vulnerabilities are inappropriate in Flood Zone 3. You should be aware that we are likely to object in principle where it is indicated that a development is not compatible in Flood Zone 3. Please note that Flood Zone 3b is defined by the Local Planning Authority's Strategic Flood Risk Assessment, or by the 5% (1 in 20 year) modelled flood outlines and levels held by the Environment Agency.

More detail on what should be in the FRA (additional to that highlighted in Guidance Note 3):

The FRA should assess all sources of flooding and provide sufficient information on the characteristics of flooding at the site, such as frequency, depth, velocity, speed of onset, and duration. As a minimum the FRA needs to assess the flood risk on site by comparing our modelled flood levels with a GPS verified topographical survey of the site to determine the anticipated flood depths during the 5% (1 in 20), 1% / 0.5% (1 in 100 / 200) (design) and 0.1% (1 in 1000) (extreme) events including allowances for climate change. Climate change allowances can be found on [our website](#). If the area is protected by defences then the FRA should consider both the actual flood risk to the site through overtopping of the defences, and the residual risk posed by the defences being breached.

- **Sequential approach on site**

If the site contains a range of Flood Zones, the sequential approach should be applied within the site to direct development to the areas of lowest flood risk. If it isn't possible to locate all development in Flood Zone 1, then the most vulnerable elements should be located in the lowest risk parts of the site.

- **Finished Floor Levels**

Proposals for 'more vulnerable' development should include floor levels set no lower than 300 mm above the level of any flooding that would occur if defences were overtopped in a 1% / 0.5% flood event (including allowances for climate change). Safe refuge should also be provided above the 0.1% undefended/breach flood level (including allowances for climate change). We are likely to raise an objection where these requirements are not achieved.

We recommend 'less vulnerable' development also meets this requirement to minimize disruption and costs in a flood event. If this is not achievable then it is recommended that a place of refuge is provided above the 0.1% flood level (including allowances for climate change). Where safety is reliant on refuge it is important that the building is structurally resilient to withstand the pressures and forces (hydrostatic & hydrodynamic) associated with flood water. The LPA may need to receive supporting information and calculations to provide certainty that the buildings will be constructed to withstand these water pressures.

- **Safe Access**

During a flood, the journey to safe, dry areas completely outside the extent of a 1% / 0.5% flood event (including allowances for climate change), should not involve crossing areas of potentially fast flowing water. Those venturing out on foot in areas where flooding exceeds 100 millimetres or so would be at risk from a wide range of hazards, including, for example unmarked drops, or access chambers where the cover has been swept away. Safe access and egress routes should be assessed in accordance with the guidance document '[FD2320 \(Flood Risk Assessment Guidance for New Developments\)](#)'.

- **Emergency Flood Plan**

Where safe access cannot be achieved, or if the development would be at actual flood risk or residual risk of flooding in a breach, an emergency flood plan must be provided. The plan should deal with matters of evacuation and refuge, and should demonstrate that people will not be exposed to flood hazards. The emergency flood plan should be submitted as part of the FRA and will need to be agreed with the Local Planning Authority.

- **Flood Resilience / Resistance Measures**

To minimize the disruption and cost implications of a flood event we encourage development to incorporate flood resilience/resistance measures up to the extreme 0.1% climate change flood level.

Information on preparing property for flooding can be found in the documents '[Improving the Flood performance of new buildings](#)' and '[Prepare your property for flooding](#)'.

- **Betterment**

Every effort should be made by the applicant to improve the flood risk to the local area, especially if there are known flooding issues. Opportunities should also be taken to provide environmental enhancements as part of the design, for example naturalizing any rivers on the site with a buffer zone on both sides.

- **Increases in Built Footprint (excluding open coast situations)**

It will need to be shown that any increase in built footprint within the extent of a 1% flood event (including allowances for climate change), can be directly compensated for on a volume-for-volume and level-for-level basis to prevent a loss of floodplain storage. If there are no available areas for compensation above the design flood level and compensation will not be possible, then a calculation of the offsite flood risk impacts will need to be undertaken. If this shows significant offsite impacts then no increases in built footprint will be allowed. Further guidance on the provision of compensatory flood storage is provided in section A3.3.10 of the CIRIA document C624.

Flood Defence Consent

Flood Defence Consents now fall under the Environmental Permitting (England and Wales) Regulations 2010 system (EPR). You may need an environmental permit for flood risk activities if you want to do work in, under, over or within 8 metres of a fluvial river or any flood defence structure or culvert / 16m from a tidal river or any flood defence structure or culvert. New forms and further information can be found at: <https://www.gov.uk/guidance/flood-risk-activities-environmental-permits>.

Local policies and recommendations

You will need to demonstrate to the Local Planning Authority that the requirements of any local flood risk planning policies have been met and the recommendations of the relevant Strategic Flood Risk Assessment, Shoreline Management Plans and Catchment Flood Management Plans have been considered.

Further Information:

If you require the flooding information we hold for this site then please email our local Customers and Engagement Team: enquiries_eastanglia@environment-agency.gov.uk. For further details on our flood map products please visit our website at: www.environment-agency.gov.uk/research/planning/93498.aspx.

Flood Risk Assessment (FRA) Checklist

This document should be attached to the front of the Flood Risk Assessment (FRA) issued to Local Planning Authorities (LPA) in support of a development proposal which may be at risk of flooding. This document is not a substitute for a FRA. Please note, under our responsibilities as a statutory consultee we will review any submitted FRA only in respect to fluvial and tidal risk. Your FRA should also consider other sources of flooding such as surface water, drainage, and ground water flooding.

1. Development Proposal

Site name	
National Grid Reference (NGR)	
Flood Risk Assessment	Reference/Title: Date:
Existing site use & vulnerability classification	
Proposed site use & vulnerability classification	

2. Flood Risk

Flood Zone(s) affecting the site/property	
Sources of flooding affecting the site	
Have you considered flood storage compensation?	Yes/No **

3. Please provide a node map and accompanying table in the Flood Risk Assessment similar to the example given (see Appendix A). You should clearly demonstrate the highest and most representative flood levels for your proposed development. For example, if it is a small extension (< 250 square metres) then approximately 5-10 nodes would be sufficient. For larger sites, approximately 10 to 20 nodes would be appropriate.

4. Mitigation

Finished floor levels (in mAOD) for each proposed floor.	
Have you considered a freeboard for these Finished Floor Levels?***	
Drawing reference showing Finished Floor Levels for proposed development	
Have you considered suitable internal and external access for safe refuge above the flood level?	Yes/No

5. Proximity to the watercourse/ flood defence/ culvert

Are the proposed developments on, over, under or within 8 metres of a fluvial main river or 16 metres of a tidal main river or flood defence?	Yes/No If yes, please provide a cross section drawing in your planning application showing the distance of the proposed development in relation to the watercourse/flood defence/culvert. If yes, this will require a Flood Risk Activity Permit.
---	---

Map Many of our flood datasets are available online:

Flood Map For Planning ([Flood Zone 2](#), [Flood Zone 3](#), [Flood Storage Areas](#), [Flood Defences](#), [Areas Benefiting from Defences](#), [Risk of Flooding from Rivers and Sea](#), [Historic Flood Map](#), [Current Flood Warnings](#))

**** Please be aware floodplain compensation may be required for your site. Floodplain compensation is normally required when the proposed site use has an increased built footprint in relation to the existing site use and lies primarily in Flood Zone 3, which is considered the fluvial floodplain. This is normally demarked in the modelled data by the 1 in 100 + Climate Change flood return period.**

***** Please refer to the Local Authority's SFRA for further guidance on freeboard requirements for each type of development**

Environment Agency, Icen House, Cobham Road, Ipswich, IP3 9JD

Customer services line: 03708 506 506

Email: enquiries@environment-agency.gov.uk

www.environment-agency.gov.uk

Planning advice and guidance

The Environment Agency are keen to work with partners to enable development which is resilient to flooding for its lifetime and provides wider benefits to communities. If you have requested this information to help inform a development proposal, then we recommend engaging with us as early as possible by using the pre-application form available from our website:

<https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion>

Complete the form in the link and email back to planning.eastanglia@environment-agency.gov.uk

We recognise the value of early engagement in development planning decisions. This allows complex issues to be discussed, innovative solutions to be developed that both enables new development and protects existing communities. Such engagement can often avoid delays in the planning process following planning application submission, by reaching agreements up-front. We offer a charged pre-application advice service for applicants who wish to discuss a development proposal.

We can also provide a preliminary opinion for free which will identify environmental constraints related to our responsibilities including flooding, waste, land contamination, water quality, biodiversity, navigation, pollution, water resources, foul drainage or Environmental Impact Assessment.

Flood Risk Assessments guidance

In preparing your planning application submission, you should refer to the Environment Agency's Flood Risk Standing Advice and the Planning Practice Guidance for information about what flood risk assessment is needed for new development in the different Flood Zones. This information can be accessed via:

<https://www.gov.uk/flood-risk-assessment-standing-advice>

<http://planningguidance.planningportal.gov.uk/>

<https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications>

<https://www.gov.uk/guidance/flood-risk-and-coastal-change>

You should also consult the Strategic Flood Risk Assessment and flood risk local plan policies produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk Assessment where one is required, but does not constitute such an assessment on its own.
2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or overland runoff. You should discuss surface water management with your Lead Local Flood Authority.
3. Where a planning application requires a FRA and this is not submitted or deficient, the Environment Agency may well raise an objection due to insufficient information

Advice to Consultants

The data provided in the checklist and FRA will be checked against our records as we review the FRAs when consulted on by the Local Planning Authority in our remit as statutory consultee for flood risk from tidal and fluvial sources. We require you to get in touch with us to check for the most up to date model information and FRA checklist. Having the latest data is important as not having the data will possibly delay us in reviewing your application at planning stage.

Appendix A: (This is an example only for how to do the node map and accompanying table)



1. Outline your site boundary clearly
2. Clearly mark the node points where you are extracting data from
3. Select node points that cover the site, around the site itself, and along the access route to the site to give a representative sample

	National Grid Reference		Modelled Levels
Node	Easting	Northing	[insert return period]
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Flood risk assessments: Climate change allowances

Application of the allowances and local considerations

East Anglia; Essex, Norfolk, Suffolk, Cambridgeshire and Bedfordshire

1) The climate change allowances

The [National Planning Practice Guidance](#) refers planners, developers and advisors to the Environment Agency guidance on considering climate change in Flood Risk Assessments (FRAs). This guidance was updated in October 2021 and is available on [Gov.uk](#). The guidance can be used for planning applications, local plans, neighbourhood plans and other projects. It provides climate change allowances for peak river flow, peak rainfall, sea level rise, wind speed and wave height. The guidance provides a range of allowances to assess fluvial flooding, rather than a single national allowance. It advises on what allowances to use for assessment based on vulnerability classification, flood zone and development lifetime.

2) Assessment of climate change impacts on fluvial flooding

Where existing EA flood risk datasets and models do not provide the required climate change allowances, it is up to developers to undertake any work needed to appropriately assess the impacts of climate change on flood risk. They can do this by using the approaches in **Table A** below:

Table A below indicates the level of technical assessment of climate change impacts on fluvial flooding appropriate for new developments depending on their scale and location. This should be used as **a guide only**. Ultimately, the agreed approach should be based on expert local knowledge of flood risk conditions, local sensitivities and other influences. **For these reasons, we recommend that applicants and / or their consultants should contact the Environment Agency at the pre-planning application stage to confirm the assessment approach, on a case by case basis.** The email addresses for our Sustainable Places teams at our respective offices can be found in Section 8 below.

Table A defines three possible approaches to account for flood risk impacts due to climate change, in new development proposals:

- **Basic:** Developer can add an allowance to the 'design flood' (i.e. 1% annual probability) peak levels to account for potential climate change impacts. The allowance should be derived and agreed locally by Environment Agency teams.
- **Intermediate:** Developer can use existing modelled flood and flow data to construct a stage-discharge rating curve, which can be used to interpolate a flood level based on the required peak flow allowance being applied to the 'design flood' flow.
- **Detailed:** Perform detailed hydraulic modelling, either through re-running Environment Agency hydraulic models (if available) or construction of a new model by the developer.

Table A – Indicative guide to assessment approach

VULNERABILITY CLASSIFICATION	FLOOD ZONE	DEVELOPMENT TYPE		
		NON-MAJOR	SMALL-MAJOR	LARGE-MAJOR
ESSENTIAL INFRASTRUCTURE	Zone 2	Detailed		
	Zone 3a	Detailed		
	Zone 3b	Detailed		
HIGHLY VULNERABLE	Zone 2	Intermediate/ Basic	Intermediate/ Basic	Detailed
	Zone 3a	Not appropriate development		
	Zone 3b	Not appropriate development		
MORE VULNERABLE	Zone 2	Basic	Basic	Intermediate/ Basic
	Zone 3a	Intermediate/ Basic	Detailed	Detailed
	Zone 3b	Not appropriate development		
LESS VULNERABLE	Zone 2	Basic	Basic	Intermediate/ Basic
	Zone 3a	Basic	Basic	Detailed
	Zone 3b	Not appropriate development		
WATER COMPATIBLE	Zone 2	None		
	Zone 3a	Intermediate/ Basic		
	Zone 3b	Detailed		

Note: Where the table states 'not appropriate development', this is in line with national planning policy. If in exceptional circumstances such development types are proposed in these locations, we would expect a detailed modelling approach to be used.

NOTES:

- Non-Major: 1-9 dwellings/ less than 0.5 ha | Office / light industrial under 1ha | General industrial under 1 ha | Retail under 1 ha | Gypsy/traveller site between 0 and 9 pitches
- Small-Major: 10 to 30 dwellings | Office / light industrial 1ha to 5ha | General industrial 1ha to 5ha | Retail over 1ha to 5ha | Gypsy/traveller site over 10 to 30 pitches
- Large-Major: 30+ dwellings | Office / light industrial 5ha+ | General industrial 5ha+ | Retail 5ha+ | Gypsy/traveler site over 30+ pitches | any other development that creates a non-residential building or development over 1000 sq m.

The assessment approach should be agreed with the Environment Agency as part of pre-planning application discussions to avoid abortive work.

3) Specific local considerations

Where the Environment Agency and the applicant and / or their consultant has agreed that a 'basic' level of assessment is appropriate, the figures in Table B below can be used as a precautionary allowance for potential climate change impacts on peak 'design' (i.e. 1% annual probability) fluvial flood level rather than undertaking detailed modelling.

Table B – Local precautionary allowances for potential climate change impacts

Essex, Norfolk and Suffolk

Hydraulic Model (Watercourse)	Precautionary allowance (basic approach)
Blackwater & Brain - Blackwater between TL7520925623 and TL7820324314 Brain between TL7373323312 and TL7683821321	500mm
Other main rivers, tributaries and ordinary watercourses	For other main rivers, tributaries and ordinary watercourses that are not stated above, basic allowances have not been calculated. In this instance you can either: • If flow data is available you can request this data from us and can conduct an intermediate assessment yourself • Or alternatively, you can choose to undertake a Detailed Assessment and "perform detailed hydraulic modelling, through either re-running our hydraulic models (if available) or constructing a new model

Cambridgeshire and Bedfordshire

Watercourse / Model	Precautionary allowance (basic approach)
Alconbury Brook	600mm
River Kym	
Lower Ouse (Model Extent)	700mm
Mid Ouse (Cold Brayfield to Bromham – between SP9156852223 and TL0132950919)	700mm
Mid Ouse (East of Bedford to Roxton – between TL0791848903 and TL1618854543)	700mm
River Hiz and River Purwell	400mm
River Ivel	500mm
Pix Brook	450mm
Potton Brook	500mm
River Cam and tributaries (excluding the Cam Lodes and the Slade System)	450mm
Great Barford (ordinary watercourses)	500mm
Bromham (ordinary watercourse)	550mm

NOTES:

Urban areas excluded from the 'basic' approach: St Ives, Holywell, Godmanchester, Swavesey, Over, Bedford, Newport Pagnell, Buckingham and Leighton Buzzard. More detailed assessment of climate change allowances will need to be undertaken in these locations.

Use of these allowances will only be accepted after discussion with the Environment Agency.

4) Fluvial flood risk mitigation

For planning consultations where we are a statutory consultee and our [Flood risk standing advice](#) **does not** apply we use the following benchmarks to inform flood risk mitigation for different [vulnerability classifications](#). **These are a guide only. We strongly recommend you contact us at the pre-planning application stage to confirm this on a case by case basis.** For planning consultations where we are not a statutory consultee or our [Flood risk Standing advice](#) applies, we recommend that local planning authorities and developers use these benchmarks but we do not expect to be consulted.

- For development classed as **'essential infrastructure'** our benchmark for flood risk mitigation is for it to be designed to the **'higher central'** climate change allowance for the epoch that most closely represents the lifetime of the development, including decommissioning. Please note that nationally significant infrastructure projects (NSIPs) may also need to assess a **credible maximum climate change scenario** by applying the **'upper end'** allowance for peak river flow as a sensitivity test. This will help to determine how sensitive the development is to changes in the climate and to ensure that it can be adapted to large-scale climate change over its lifetime.
- For **highly vulnerable, more vulnerable, less vulnerable and water compatible** developments in flood zones 2 and 3a, the **'central'** climate change allowance is our minimum benchmark for flood risk mitigation. For large urban settlement extensions or developments that form new communities, the credible maximum climate change scenario must be assessed; in these circumstances, you should use the **'upper end'** allowance.
- For **water compatible** development in flood zone 3b, the **'central'** climate change allowance for the epoch that most closely represents the lifetime of the development is our minimum benchmark for flood risk mitigation.

For peak river flow allowances and a visual representation of the above, please see Tables 1 and 2 below.

Management Catchment	Allowance category	Total potential change anticipated for '2020s' (2015 to 39)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2125)
Upper and Bedford Ouse	Upper end	24%	30%	58%
	Higher central	10%	11%	30%
	Central	5%	4%	19%
Cam and Ely Ouse	Upper End	21%	22%	45%
	Higher Central	7%	5%	19%
	Central	2%	-2%	9%
Old Bedford and Middle Level	Upper End	23%	22%	39%
	Higher central	9%	4%	15%
	Central	3%	-3%	6%
North West Norfolk	Upper End	30%	34%	57%
	Higher central	18%	18%	33%
	Central	13%	11%	23%
North Norfolk Rivers	Upper End	26%	27%	48%
	Higher central	13%	11%	24%
	Central	7%	4%	14%
Broadland Rivers	Upper End	27%	27%	44%
	Higher central	14%	10%	20%
	Central	8%	3%	11%
East Suffolk	Upper End	25%	29%	54%
	Higher central	13%	13%	29%
	Central	8%	7%	19%
Combined Essex	Upper End	27%	37%	72%
	Higher central	13%	16%	38%
	Central	7%	8%	25%

South Essex	Upper End	22%	27%	48%
	Higher central	11%	11%	26%
	Central	6%	5%	17%

If you are not sure which management catchment your site falls within, please use the guidance and link to the peak river flow map, which can be found at: <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#peak-river-flow-allowances>

Table 2: Using peak river flow allowances for flood risk assessments

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
2	higher central ¹	central ²	central ²	central	central
3a	higher central ¹	X	central ²	central	central
3b	higher central ¹	X	X	X	central

X – Development should not be permitted

If (exceptionally) development is considered appropriate when not in accordance with flood zone vulnerability categories, then it would be appropriate to use the higher central allowance.

¹ For NSIPs, the ‘upper end’ allowance should be used to assess a credible maximum climate change scenario.

² For large urban settlement extensions or developments that form new communities, the credible maximum climate change scenario must be assessed. In these circumstances, you should use the ‘upper end’ allowance.

There may be circumstances where local evidence supports the use of other data or allowances. Where you think this is the case we may want to check this data and how you propose to use it.

Assessing off-site impacts and calculating floodplain compensation

The appropriate allowance to assess off-site impacts and calculation floodplain compensation requirements depends on the land uses in affected areas.

The ‘**central**’ allowance should be used in most cases. However, the ‘**higher central**’ allowance should be used when the affected area contains essential infrastructure.

5) Development in tidal flood risk areas

For flood risk assessments and strategic flood risk assessments, assess both the **higher central** and **upper end** allowances for all development vulnerability classes (see table 3 below).

For NSIPs and large urban settlement extensions or developments that form new communities, the **credible maximum climate change scenario** should be assessed (sea level rise and sensitivity test allowances for offshore wind speed and extreme wave height and storm surge uplift). To assess the flood risk from a high impact climate change scenario, you should use the H⁺⁺ allowance of 1.9m for the total sea level rise to 2100.

Table 3: sea level allowances for each epoch in mm for each year (based on a 1981 to 2000 baseline) – the total sea level risk for each epoch is in brackets

Area of England	Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise 2000 to 2125 (metres)
Anglian	Higher central	5.8 (203)	8.7 (261)	11.6 (348)	13 (390)	1.20
Anglian	Upper end	7 (245)	11.3 (339)	15.8 (474)	18.1 (543)	1.60
South east	Higher central	5.7 (200)	8.7 (261)	11.6 (348)	13.1 (393)	1.20
South east	Upper end	6.9 (242)	11.3 (339)	15.8 (474)	18.2 (546)	1.60

6) Tidal flood risk mitigation

For planning consultations where we are a statutory consultee and our flood risk standing advice does not apply, we use the following benchmarks to inform flood risk mitigation for different [vulnerability classifications](#). **These are a guide only. We strongly recommend you contact us at the pre-planning application stage to confirm this on a case by case basis. Please note you may be charged for this advice.** For planning consultations where we are not a statutory consultee or our flood risk standing advice applies, we recommend that local planning authorities and developers use these benchmarks but we do not expect to be consulted.

- For development classed as essential Infrastructure, highly vulnerable development and more vulnerable development, our minimum benchmark for flood risk mitigation is the ‘**upper end**’ climate change allowance for the development lifetime (including decommissioning where relevant).
- For water compatible or less vulnerable development (e.g. commercial), our minimum benchmark for flood risk mitigation is the ‘**higher central**’ climate change allowance for the development lifetime. In sensitive locations it may be necessary to use the ‘**upper end**’ allowance to inform built in resilience.

If you are using our 2018 Coastal Flood Modelling Data outputs:

The **upper end** allowance become progressively higher each year than the climate change flood level outputs used in our current 2018 coastal flood model. So as an approximation we recommend that the following uplift values are added on to the on-site climate change flood levels provided in the Product 4:

- For development lifetimes extending to 2122, add 0.34m
- For development lifetimes extending to 2123, add 0.36m
- For development lifetimes extending to 2124, add 0.38m
- For development lifetimes extending to 2125, add 0.40m

If the proposed development is greater than 30 houses and the flood zone is in an open-coast location, we recommend that a more accurate impact of the increased upper end flood levels on the overtopping on-site flood levels is modelled by rerunning our coastal overtopping model with the new flood levels; you can obtain the model from us with a Product 6 and 7 request. If the site is located within a small or constrained tidal or coastal floodplain then regardless of the size of the development, you may also need to undertake remodelling of the flood levels to obtain an accurate assessment of the impacts of climate change; please contact us for advice (contact details in Section 8 below).

If you are using our Broads 2008 Flood Modelling Data outputs:

For the **upper end** allowance, please add the following uplift values onto the climate change flood levels provided in the Product 4:

- For development lifetimes extending to 2122, add 0.34m
- For development lifetimes extending to 2123, add 0.36m
- For development lifetimes extending to 2124, add 0.38m
- For development lifetimes extending to 2125, add 0.40m

If you are using our 2008 Thames Flood Modelling Data outputs:

Please add the appropriate climate change allowances for the South East River Basin District onto the present day flood levels obtained in the Product 4, starting from a base year of 2005. The allowances should be applied to the year appropriate to the respective development lifetime for residential or commercial developments.

**** note**:** *We anticipate that there will be updated flood modelling outputs available for the Thames Estuary in mid-2022. Developers preparing Flood Risk Assessments for developments in this area should check for availability of new data with the East Anglia (East) PSO team (contact details in Section 8 below).*

There may be circumstances where local evidence supports the use of other data or allowances. Where you think this is the case, we may want to check this data and how you propose to use it.

7) Assessment of climate change impacts for Surface Water Management

Please see the latest advice on the use of Peak Rainfall Intensity climate change allowances, which can be found here: <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

The Environment Agency is not a statutory consultee to the land use planning system for the consideration of surface water flood risk and management. We therefore recommend that you contact the relevant Lead Local Flood Authority (contact details listed below) to discuss Flood Risk Assessment requirements to support your development's surface water management proposals.

Cambridgeshire County Council - fr.planning@cambridgeshire.gov.uk
Central Bedfordshire Council - floodrisk@centralbedfordshire.gov.uk
Bedford Borough Council - floodrisk@bedford.gov.uk
Milton Keynes Council - llfa@milton-keynes.gov.uk
Buckinghamshire County Council - floodmanagement@buckscc.gov.uk
Herts County Council - floodandwatermanagement@hertscc.gov.uk
Northamptonshire County Council - floodandwater@northamptonshire.gov.uk
Norfolk County Council - llfa@norfolk.gov.uk
Suffolk County Council - floods@suffolk.gov.uk
Essex County Council - suds@essex.gov.uk
Thurrock Council - TransportDevelopment@thurrock.gov.uk
Southend-on-Sea Council - llfa@southend.gov.uk

8) Our Service

Non-chargeable service

We will give a free opinion on:

- What climate change allowance to apply to a particular development type
- Which technical approach is suitable in the FRA

Chargeable service:

- Review of climate change impacts using intermediate and detailed technical approaches (i.e. modelling review)
- Assessment and review of proposals for managed adaptation.

Contact Details

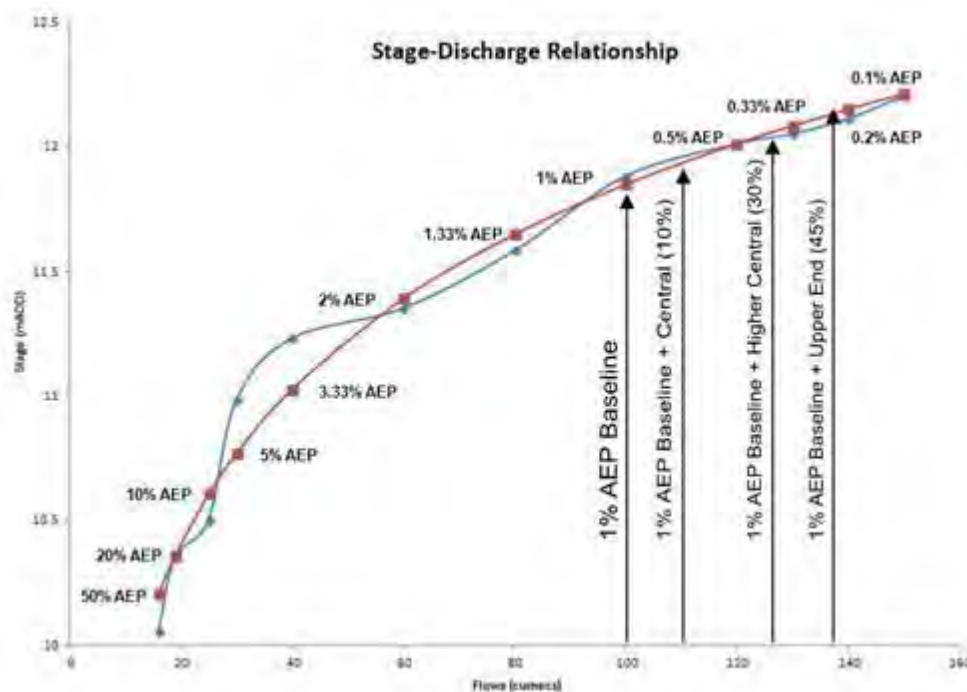
For East Anglia (Great Ouse Catchment): planning.brampton@environment-agency.gov.uk

For East Anglia (East): planning.ipswich@environment-agency.gov.uk

Appendix 1 – Further information on the Intermediate approach.

- 1) The methodology the chart is based on does not produce an accurate stage-discharge rating and is a simplified methodology for producing flood levels that can be applied in low risk small-scale development situations.
- 2) The method should not be applied where there is existing detailed modelled climate change outputs that use the new allowances. In such circumstances, the 'with climate change' modelled scenarios should be applied.

An example stage-discharge relationship is shown below.



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Revision History

Revision Ref / Date Issued	Amendments	Issued to
Draft Model Report v1.0	-	Lee Stevens (Thurrock Council)
Final Model Report v2.0		Navtej Tung (Thurrock Council)

Prepared by Elizabeth Gorton BA
Analyst

Reviewed by Alistair Clark BSc MSc
Senior Analyst

Purpose

This report provides a record of the information required to operate the InfoWorks ICM hydraulic model constructed for the Tilbury Integrated Flood Strategy. This document provides a technical overview of the hydraulic model complementing the more general and non-technical information within the main study report.

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1. Introduction

JBA Consulting were commissioned by Thurrock Council to investigate Tilbury's flood risk from all non-tidal sources and use this to inform frequent and intermittent maintenance activities, as well as to prioritise future capital expenditure in infrastructure. The outcome of the study is a strategy for managing the flood risk for Tilbury over the next 100 years, with consideration of 2040, 2070 and 2110, to align with the 'epochs' of the TE2100 plan.

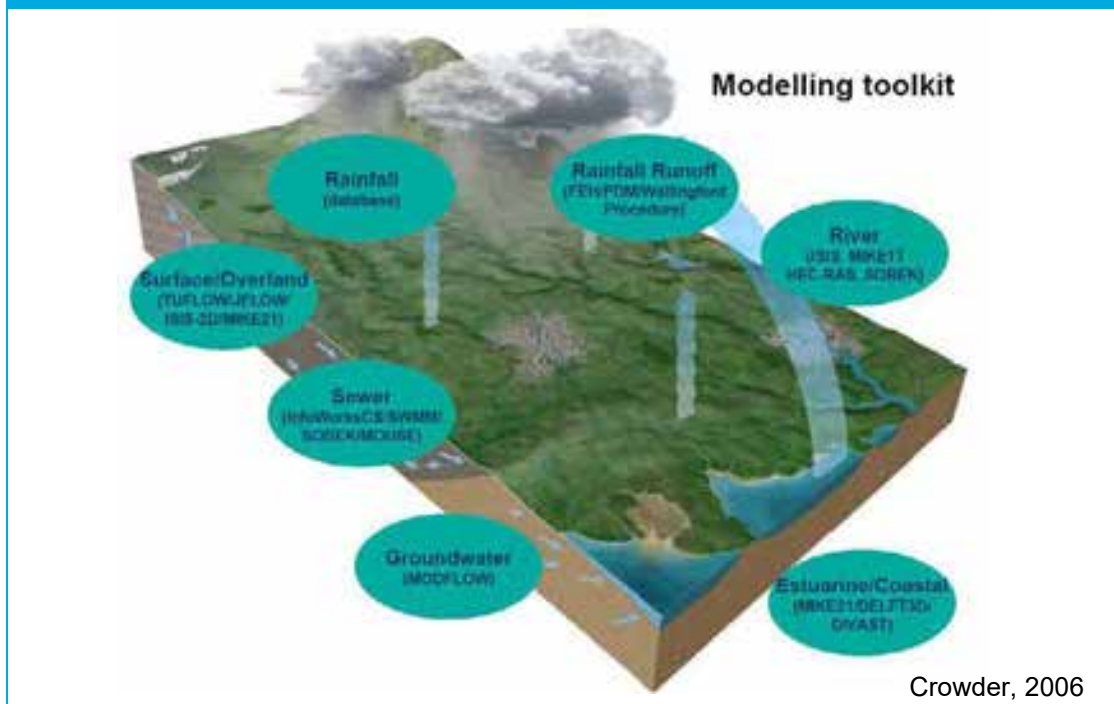
Tilbury is located on the north bank of the Thames Estuary on a low-lying former marshland. Land drainage is composed of two heavily regulated systems. Land to the east of the A126 is drained via the Pincock's Trough and Chadwell Cross Sewer, discharging to the Thames via gravity with pumped assistance at Worlds' End pumping station. Land to the west and north of Tilbury is drained via the Chadwell New Cross Sewer to the Botney Sluice. The East Tilbury Dock Sewer is dedicated to draining the docks and the Western side of Tilbury via a third gravity outfall at Chadwell Sluice. Chadwell and Botney sluices are gravity only, making the west side of Tilbury dependent upon flood storage to reduce flood risk during high tide conditions. The town is protected against non-tidal flooding by two upstream Flood Storage Areas (FSA) north of the town.

Tilbury is served by a separate sewer system with the surface water discharging to the main rivers. Consequently the surface water drainage is vulnerable to flooding when water levels in the main rivers are elevated. As a result the Tilbury catchment requires a modelling approach that considers the interaction and interdependencies of the full drainage arrangement to understand the interactions between the different sources of flooding in response to different rainfall events.

While historically the different aspects of the urban drainage system have been treated in isolation, the technical tools used to represent and understand drainage systems have begun to allow greater interaction of the river, coastal, above ground, and below ground urban drainage environments. These are relatively new techniques, which are commonly referred to as Integrated Urban Drainage (IUD) modelling approaches. The development of IUD techniques has been partly in response to the floods of 2007 and a number of consultations, including Making Space for Water, Foresight Future Flooding, and the Pitt Review. Figure 1-1 below shows some of the modelling platforms and techniques that are commonly used in the UK for hydrologic and hydraulic investigations / engineering design.

As illustrated in Figure 1-1 there are a number of modelling software packages that could be used for IUD modelling. In this case InfoWorks ICM was preferred as it is the most suitable software to represent direct rainfall, overland flows, rivers and sewer networks simultaneously within one modelling platform. Importantly, it also accounts for the interactions between these systems.

Figure 1-1: Integrated Urban Drainage modelling approaches



2. Technical Summary

Item	Comments																				
What software & reason for choice:	InfoWorks ICM v6.0 InfoWorks ICM was chosen due to its suitability to simulate direct rainfall, sewer networks and river channels simultaneously. Version 6.0 was used as this was the latest release of InfoWorks ICM at project commencement.																				
General Schematisation:	The Tilbury model represents the surface water sewer network, highways drainage, watercourses, flood storage areas and topographic catchment. The Anglian Water InfoWorks CS model was imported into InfoWorks ICM to model the surface water sewer network. The river network was imported from an existing Environment Agency ISIS-TUFLOW mode. The structures were reproduced in InfoWorks ICM using the ISIS model and original survey. The Flood Storage Area geometry and variable control structure information was informed from the ISIS-TUFLOW model and modelling report. The hydrology of the study area uses sub-catchments in the urban areas (informed from the Anglian Water InfoWorks CS model) and direct rainfall elsewhere. Additional foul flows have been included in the sewer system based on the existing Anglian Water model. A 2D zone representing the surface of the catchment has been generated. The boundary of this is based on catchment delineation and the Anglian Water CS sewer model. A finer mesh zone has been used in Tilbury and a coarser mesh elsewhere in the 2D zone. The topographic levels of the 2D domain are based on a DTM composite of 1m LIDAR data (provided by Thurrock Council via the EA Geostore) and 2m LIDAR data (EA Open data). This was the best available topographic data at the time of model build. The 2D zone mesh represents a bare earth scenario. In addition, buildings have been represented by porous polygons. These polygons limit the through flow and present an obstacle to overland flow routes. Studies have shown that roads can be a significant conveyance route for surface water in an urban environment. Therefore roads have been represented in this model as breaklines. The different surface roughness's have been represented as roughness zones.																				
Design Events	The following pluvial design events have been run: 1 in 1 year, 10 year, 20 year, 30 year, 40 year, 50 year, 75 year, 100 year, 200 year and 1000 year. In addition four epochs have been run (present, 2040, 2070 and 2110) with climate change uplifts for rainfall and tidal level. Critical duration analysis has been completed using the 1 in 10, 1 in 30 and 1 in 100 year summer and winter storm events. The following durations were tested: 15, 30, 60, 120, 180, 360 and 720 minutes. The results were compared for each of the areas of interest and showed that the greatest risk was the 120 minute storm duration.																				
Rainfall	The ReFH Rainfall Generator was used with both a summer and winter rainfall profile. Table 2-1: DDF catchment descriptors <table><tr><th>C</th><th>D1</th><th>D2</th><th>D3</th><th>E</th><th>F</th><th>Area (km2)</th><th>SAAR</th><th>BFIHOST</th><th>PROPWET</th></tr><tr><td>- 0.026</td><td>0.261</td><td>0.415</td><td>0.240</td><td>0.321</td><td>2.559</td><td>1473</td><td>546</td><td>0.848</td><td>0.27</td></tr></table> Table 2-2: Rainfall Initial Conditions	C	D1	D2	D3	E	F	Area (km2)	SAAR	BFIHOST	PROPWET	- 0.026	0.261	0.415	0.240	0.321	2.559	1473	546	0.848	0.27
C	D1	D2	D3	E	F	Area (km2)	SAAR	BFIHOST	PROPWET												
- 0.026	0.261	0.415	0.240	0.321	2.559	1473	546	0.848	0.27												

		Summer	Winter	
	Antecedent depth (mm)	10	10	
	Evaporation (mm/day)	3	1	
	UCWI	50	120	
	New PR API30 (mm)	2.01	2.88	

Climate Change	Four epochs have been run to align with the Thames Estuary 2100 Plan. These are, present day, 2040, 2070 and 2110.																			
	Environment Agency (February 2016) Climate change allowances for planners ¹ provides change factors to account for climate change to rainfall and tidal levels.																			
	The Mean High Spring Water tide was adjusted by raising the whole tide curve by the sea level rise value. The allowance for climate change used for the epochs are summaries in Table 2-3.																			
	Table 2-3: Climate change uplift parameters																			
	<table><tr><th>Epoch</th><th>Rainfall</th><th>Tide</th><th>River flow</th></tr><tr><td>Present (baseline)</td><td>0%</td><td>Peak = 3.28m AOD</td><td>N/a</td></tr><tr><td>2040</td><td>+10%</td><td>Peak = 3.45m AOD</td><td>N/a</td></tr><tr><td>2070</td><td>+20%</td><td>Peak = 3.76m AOD</td><td>N/a</td></tr><tr><td>2110</td><td>+20%</td><td>Peak = 4.31m AOD</td><td>N/a</td></tr></table>	Epoch	Rainfall	Tide	River flow	Present (baseline)	0%	Peak = 3.28m AOD	N/a	2040	+10%	Peak = 3.45m AOD	N/a	2070	+20%	Peak = 3.76m AOD	N/a	2110	+20%	Peak = 4.31m AOD
Epoch	Rainfall	Tide	River flow																	
Present (baseline)	0%	Peak = 3.28m AOD	N/a																	
2040	+10%	Peak = 3.45m AOD	N/a																	
2070	+20%	Peak = 3.76m AOD	N/a																	
2110	+20%	Peak = 4.31m AOD	N/a																	
Rainfall Runoff	A default rainfall runoff value of 30% has been applied across the modelled domain for any area not covered by sub-catchments. This assumes that 70% of the rainfall onto the model is intercepted by the catchment and is typical of permeable land. This is reasonable as these areas are open spaces whilst the urban areas are covered by sub-catchments.																			
Coefficients:	Standard Manning's n and Colebrook White roughness coefficients are used to represent hydraulic roughness in the open watercourse and surface and waste water drainage network. The Manning's n roughness values and structure coefficients within the watercourses have been retained from the original EA ISIS-TUFLOW model. The values within the channel vary between 0.045 and 0.016, whilst the values on the banks vary between 0.07 and 0.05. In addition, the roughness of culverts along the watercourses has been set using Manning's n to between 0.011 and 0.025. These values were originally informed by survey and photographs. A standard Colebrook-White value of 1.5 for the bottom roughness and 1.5 for the top roughness has been used throughout the storm water network model. This has been retained from the Anglian Water InfoWorks CS model. Headloss coefficients for additional conduits added in were inferred using the InfoWorks ICM inference tool. Roughness zones have been used across the 2D Zone based on OS Mastermap data. The Manning's n value used for each land cover type is displayed in Table 4-2. Where there are no roughness zone a standard 2D roughness value of 0.060 is used.																			
Structures	There are a number of structures on the Chadwell Cross Sewer, Pincocks Trough Sewer, Chadwell Main Sewer, Chadwell Newcross Sewer and East Tilbury Dock Sewer. Details on their representation and coefficients are within Appendix A.3.																			
Model Proving:	The Anglian Water sewer model had previously been verified and no significant changes were made to it within the integrated model. The fluvial model was verified as part of the Tilbury Flood Storage Reservoir Study. It should be noted that although the cross sections and structures were imported from the ISIS model it is not possible to schematise the structures identically. The integrated model has been further verified through internal audit and the draft results reviewed by representatives from Thurrock Council, Anglian Water and the Environment Agency.																			

¹ Environment Agency (February 2016) Climate change allowances for planners (accessible via <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>)

Modelling assumptions and limitations

The representation of any complex system by a model requires a number of assumptions to be made. In the case of the one dimensional element of the model it must be assumed that:

- Network model provided by Anglian Water is accurate.
- ISIS-TUFLOW model provided by Environment Agency is accurate
- Geometry of the cross sections and schematisation of the structures remains as per the Total Surveys Ltd surveys of Tilbury watercourses 2008 on which the ISIS model is built.
- Controls on the variable sluice gates and pumps remain as per the Tilbury Flood Storage Reservoir Study (2015)
- The units used to represent the hydraulic structures within the model represent the situation accurately
- A stable numerical solution can be achieved

In terms of the two dimensional element of the model, the assumptions include:

- LIDAR is representative of the land surface and no errors have been introduced through the filtering algorithms
- ReFH design rainfall inflows accurately represent rainfall for a given return period storm event
- Where roughness zones have not been implemented, a Manning's n value of 0.0125 is representative
- The geometry of the Flood Storage Areas (based on the Tilbury Flood Storage Reservoir Study (2015) model) are accurate

Whilst the accuracy of a hydraulic model depends largely on the accuracy of the hydrological, topographical and structural data some assumptions and uncertainty can be introduced as part of the modelling process. These could include:

- Estimates of model parameters such as roughness, structure coefficients and percentage runoffs are representative
- 30% percentage runoff is representative of the natural land surfaces in Tilbury that aren't covered by sub-catchments
- Gully information was received from Tilbury Council. To model these cover levels were queried from LIDAR level and they were all assumed to be continuous grate type of gully.
- Decisions made during model proving

It should be noted that the model has been built to understand the interaction between rainfall, watercourses and the sewer networks. The model would require additional sensitivity testing before it could be considered suitable for uses other than investigating Tilbury's flood risk from all non-tidal sources.

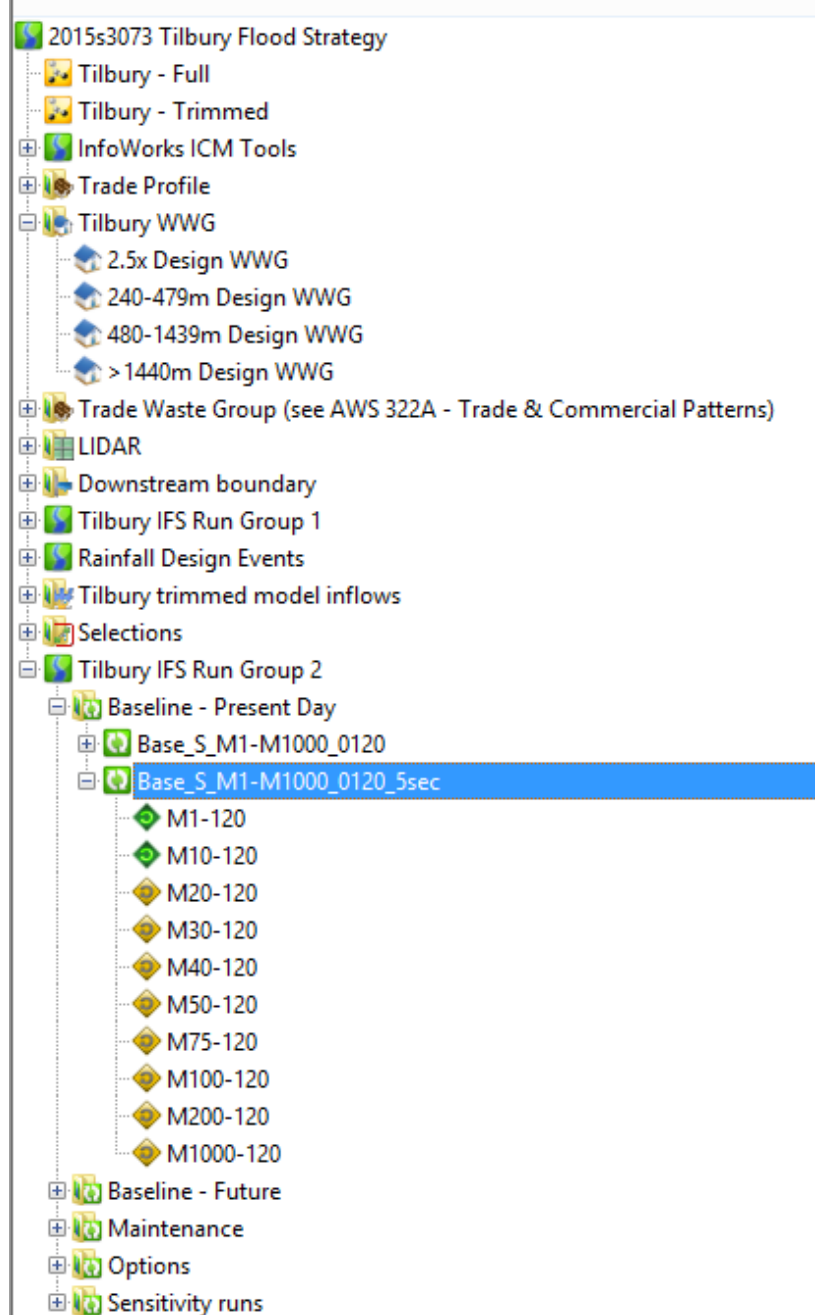
Strengths, Weaknesses and future development	The fluvial model has been built based on the Tilbury Flood Storage Reservoir Study (2015) ISIS model and the original survey it was based on (Total Surveys Ltd, 2008). The location and geometry of the flood storage areas as well as the control information of the variable sluice gates and pumps have also been informed from the ISIS-TUFLOW model. This information was the most up to date available and an EA representative confirmed at the interception meeting the control information has not been updated since. The Anglian Water surface water network had been verified prior to incorporating into the integrated model. Additional gully data was provided by Thurrock Council. Only gullies within Tilbury which could be confidently assumed which part of the network they were linked to were included. This allowed water on the 2D network a greater number of routes into the sewer network as well as more routes for the network to surcharge. The fluvial inflows into the ISIS model have not been incorporated into the integrated model. Instead fluvial inflows are based on drainage of the urban area via outfalls from the sewer network and ReFH rainfall events (from the Anglian Water network model) have been applied, which result in lateral inflows into the watercourses. The tidal boundary has been represented as in the ISIS-TUFLOW model as mean high spring tide profile. Due to the integrated nature of the model there is an improvement in the representation of the interaction between the drainage ditches and the urban sewer system. The ground model was based on the most recent 1m filtered LIDAR data (EA Geostore) where it was available, and elsewhere (northeast corner of 2D domain) 2m Environment Agency OpenData LIDAR was used. Land surfaces, road kerbs and buildings were all represented within the 2D model using roughness zones, breaklines and porous polygons respectively. This is an improvement on the ground model compared to the existing updated Flood Map for Surface Water.
Sensitivity testing	Sensitivity testing has been undertaken as part of the Maintenance Scenarios that have been undertaken as part of this study. The scenarios include testing the following: - Channel roughness (EA Watercourse maintenance) - Downstream boundary (Tide, i.e. climate change events) - Blockage (3 blockage Scenarios) - Extreme rainfall (i.e. climate change events) - Storm duration (CDT testing) - Storm profile (Summer / winter)
Model Convergence and Instability	Some model non-convergence is recorded in the model run however this is not unexpected for an integrated model and checks indicate that it does not significantly impact upon model results.

3. Data Structure and File Names

Table 3-1: Tilbury Integrated Flood Strategy ICM modelling master database

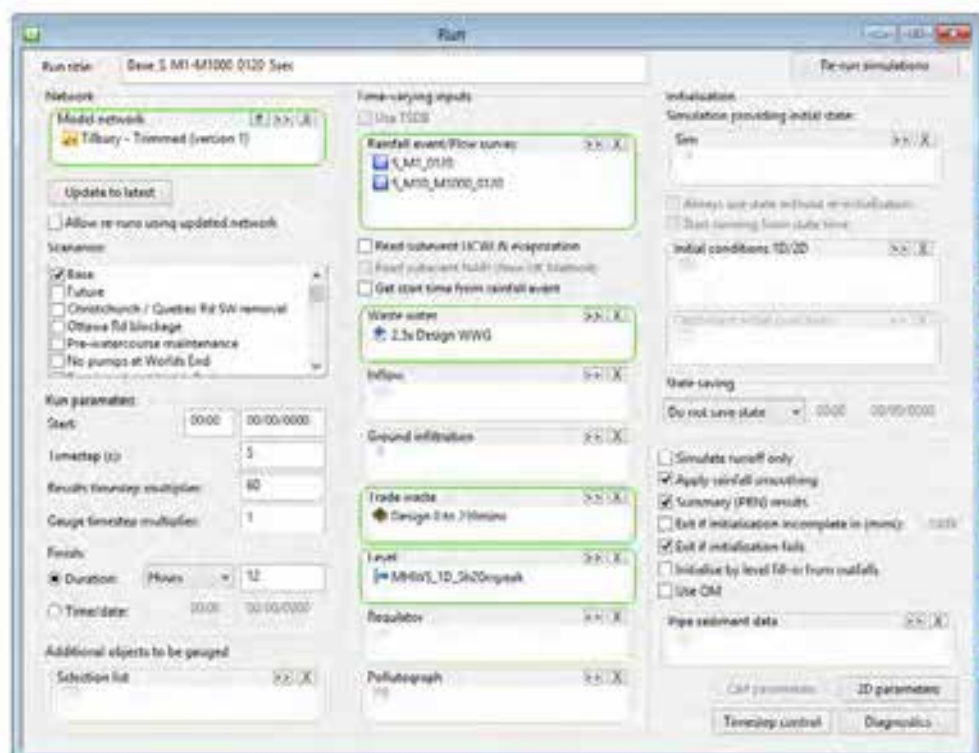
Folder	Sub Folder	Description
Networks	Tilbury – Full	<i>Tilbury model that includes full 2D for whole model extent</i>
	Tilbury - Trimmed	<i>Tilbury model with 2D area trimmed to cover the main urban area and the rural area in the upper catchment replaced with 1D subcatchments. It includes the following all modelled maintenance and options scenarios;</i>
Wastewater Group	Tilbury WWG: 2.5x Design WWG	<i>Dry weather inflows to the foul sewer network from the original Anglian Water model</i>
Trade Waste Group	Design 0 to 239mins	<i>Trade inflows to the foul sewer network from the original Anglian Water model</i>
LIDAR	Tilbury_1mEA_plus_2mOpenData	Combined DTM for the whole model area using 1m LIDAR where available with some infills of 2m data.
Downstream Boundary	MHWS_1D_5h20mpeak MHWS_1D_5h20mpeak_XXXX	Tidal boundary adjusted to coincide with the rainfall peak at significant locations and adjusted for future climate change scenarios
Rainfall design events	Critical Duration Testing: Summer ReFH CDT and Winter ReFH CDT	<i>Critical duration testing for summer and winter storms. The M10 M30 and M100 event was used for the following storm durations: 30, 60, 120, 180, 360, 480, 720, 960 and 1440</i>
	Design Events: Summer ReFH Design and Winter ReFH Design	<i>ReFH design rainfall for 120 minute storm. Includes the following return periods; M1, M5, M10, M30, M40, M50 M75, M100, M200 and M1000</i>
	Climate Change: Summer ReFH Future Scenarios and winter ReFH Future Scenarios	<i>ReFH design rainfall for 120 minute storm. Includes the following return periods; M1, M5, M10, M30, M40, M50 M75, M100, M200 and M1000 with an uplift of 10% for the 2040 scenario and 20% for the 2070 and 2110 events</i>
Runs - Tilbury IFS Run Group 2	Baseline – Present Day	<i>Design runs for all return periods</i>
	Baseline – Future	<i>Design runs for all return periods for future scenarios</i>
	Maintenance	<i>Maintenance model scenarios</i>
	Options	<i>Options testing for all return periods</i>

Figure 3-1: Master Database file tree



4. Model Operation

Run purpose	Integrated Flood Risk Mapping
Operation and model running instructions	1. It is important that the correct version of InfoWorks ICM is installed (version 6.0). If running an updated version of ICM the software will prompt the user to allow it to update the models compatibility with the latest version. Note once this is done you cannot revert to running the model with earlier versions. 2. Import the transportable database into InfoWorks ICM. All necessary files to complete reruns of the model and results are contained within these files. 3. Ideally the InfoWorks root directory should be set to "C:\Infoworks_local_root" to maintain continuity of the original project. 4. Open a new run group; select the network; set the run parameters; set the time-varying inputs and hit 'Run Simulations'
InfoWorks ICM	
Master database	2015s3073 – Tilbury Flood Strategy.icmm All model files are contained within the model database or its equivalent transportable database.
Network	Tilbury - Trimmed
Network version	V1
Scenario	Base
Rainfall Events	The following rainfall events were run for the present day plus three epoch events to consider climate change (2040, 2070, 2110). M1- M10- M20- M30- M40- M50- M75- M100- M200- M1000-
Fluvial Event	None
Run Settings - Design Runs	



Run Parameters

Model start time (hrs)	00:00 00/00/0000	Model end time (hrs)	12
Time Step (s)	5	Results Timestep Multiplier	60

2D parameters

Tolerance	Default
Advanced	Adjust bank levels based on adjacent element ground levels has been ticked
GPU	Use GPU card for 2D calculations if suitable card is available
Steady State	Default

Timestep Control Options

Rainfall	Default	Outflows	Default
Sub-catchments	Default	RTC	Default
Control	Default	Levels	Default
Nodes	Default	Rainfall	Default

Diagnostics	The following options have been selected: Timestep Log
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Comments

Comments on results	A full discussion of the results is found in the main report.
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Appendices

A. Hydraulic Model Check File

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A.1 Modelling Approach

A.1.1 Available Data

Item	Comments
Models	The InfoWorks ICM model was developed from the following existing models: - Tilbury InfoWorks CS network model – Anglian Water - Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015) – Mott MacDonald for the Environment Agency
Survey data	No new survey of assets or river channel sections were undertaken for this project. Any additional information used to update the InfoWorks CS model and ISIS river model are documented below.
Other Network Data	All partners of the Tilbury Integrated Flood Strategy agreed to provide data to support the project. The network and survey information collated and used within the study consisted of: - Gully locations – Thurrock Council - Council owned properties – Thurrock Council - Culvert detailed examination reports – Network Rail - Additional structure information – Environment Agency
LIDAR & other Topographic Data	1m filtered LIDAR data (EA Geostore) covering the majority of the study area with 2m filtered LIDAR data (EA OpenData) covering missing areas.
Map Data	OS MasterMap and OS Open Data
Gauging station flows / levels	None available.
Gauging station rating curves	None available.

A.1.2 Data Flags

Data flags have been used to identify the source of the data with the majority imported with the Anglian Water InfoWorks CS model. Data flags often indicate the confidence of the data. The following were used within the InfoWorks ICM model.

Table 4-1: Data flags

Flag	Description
#A	"Asset Data"
#D	"System Default"
#G	"Data From GeoPlan"
#I	"Model Import"
#S	"System Calculated"
#V	"CSV Import"
A	"Assumed during Tilbury Flood Strategy model build (JBA 2015)"
A1	"As Built - High Confidence"
AC	"Amendments to Model for Design - Current Model"
AD	"Assumed Data"
AS	"From Ancillary Survey"
AW	"Anglian Water network model"
AWS	"Anglian Water MH and gully survey"
B1	"Ancillary Survey - High Confidence"
B2	"Ancillary Survey - Medium Confidence"
C1	"Manhole Survey - High Confidence"
C2	"Manhole Survey - Medium Confidence"
CC	"From CCTV Survey"
CH	"Check data"

DD	"Dummy Data"
DO	"Design Options"
E1	"Flow Survey - High Confidence"
E2	"Flow Survey - Medium Confidence"
EA	"Environment Agency information recieved for JBA Tilbury Flood Strategy"
F	"JBA changes for Tilbury Flood Straetgy - Future scenario"
FS	"From Flow Survey"
H2	"Corporate GIS - Medium Confidence"
HL	"Headloss Coefficients from Angles of Approach"
HY	"Data imported from original HydroWorks DSD file"
I1	"Previous Model - High Confidence"
IA	"From Impermeable Area Survey"
IB	"From 2004 Impermeable Area Survey"
ID	"Interpolated Data"
IF	"Inferred Data"
II	"Infoworks Inference"
IN	"Interpolated Level"
ISIS	"Tilbury Flood Storage Reservoir Study (2010) ISIS model"
J1	"Calculated Value - High Confidence"
KS	"Assumed Roughness Values and Sediment Depths"
MD	"WASSP/Wallrus/Hydroworks Data"
MR	"Assumed data for Manor Rd PS"
MS	"From Manhole Survey"
NR	"Network Rail data"
O	"Optioneering / scenario testing for Tilbury Flood Streatgy (JBA 2015)"
OI	"Operational Information"
OP	"Old Plans Ref:"
P2	"Inferred - Medium Confidence"
P3	"Inferred - Low Confidence"
PS	"Data obtained from Pumping Station Surveys"
Q2	"Interpolated - Medium Confidence"
Q3	"Interpolated - Low Confidence"
R3	"Assumed Data - Low Confidence"
S1	"Flow Survey Verification Change - High Confidence"
S2	"Verification Change - Medium Confidence"
S3	"Flow Survey Verification Change - Low Confidence"
SP	"AWS Standard Procedure"
ST	"STC data from RMS"
SU	"Data obtained from SUS25 Network"
TC	"Thurrock Council data"
TD	"Trade Discharge Data"
TFS	"JBA changes for Tilbury Flood Strategy"
TS	"Total Surveys Ltd"
W1	"Historic Verification Change - High Confidence"
Z1	"CAS Manual Area Take Off - High Confidence"
Z2	"CAS Manual Area Take Off - Medium Confidence"
Z4	"Dummy Data - Low Confidence"

A.2 Model Overview

River	Model Description		
	Channel	Floodplain	Length
Chadwell Cross Sewer	ICM model: 1D sim engine to calculate in channel flows	ICM model: 2D sim engine to calculate floodplain flows	693m
Pincocks Trough Sewer	ICM model: 1D sim engine to calculate in channel flows	ICM model: 2D sim engine to calculate floodplain flows	1395m
Chadwell Main Sewer	ICM model: 1D sim engine to calculate in channel flows	ICM model: 2D sim engine to calculate floodplain flows	1160m
Chadwell New Cross Sewer	ICM model: 1D sim engine to calculate in channel flows	ICM model: 2D sim engine to calculate floodplain flows	1145m
East Tilbury Dock Sewer	ICM model: 1D sim engine to calculate in channel flows	ICM model: 2D sim engine to calculate floodplain flows	3475m

Sewers	Model Description	
	Nodes	Pipes
Surface water system	1106 manholes or outfalls modelled. Flood Type: 2D for manholes within the 2D Zone, Sealed for manholes outside the 2D zone 1551 gullies modelled. Flood Type: Inlet 2D	2697 sewers modelled 80.8km 1D sim engine

Surface	Model Description		
	Buildings	Roads	Roughness
Land cover	10,956 porous polygons modelled Porosity = 0.05 Height = 100mm above LIDAR ground level	Outline/kerbs as break line	34,133 Roughness zones modelled Based on land use from OS MasterMap

A.2.1 Overview of Fluvial Model

General Schematisation:	The watercourses within the Tilbury model have been modelled in 1D. The 1D river reaches in InfoWorks ICM solve the Saint-Venant equations using a 4-point implicit Preissmann scheme. The channel cross sections have been truncated at the join with the bank lines within the river reach where they have been linked to the 2D domain. Bank lines link the channel system to the overland flow environment (2D domain). A modular limit of 0.90 and a coefficient of discharge of 1.10 have been used. These were selected to broadly represent the ability of flow to leave the channels and are based on the recommendations provided within InfoWorks ICM help, as well as through the use of the basic weir equation. The 1D cross sections have been trimmed to the top of bank which allows more accurate flow, hazard and velocity measurements. The river model was developed from the Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015), and the original cross section and survey data (Tilbury Flood Storage Area Survey Work, Total Surveys Limited (July 2008)).
Upstream Boundaries	Chadwell Cross Sewer: CCS_0842 Chadwell Main Sewer: CMS_1160 Chadwell New Cross Sewer: CNCS_1162 Pincocks Trough Sewer: PTS_1420
Lateral Catchments	Lateral inflow occurs throughout the length of the river model as direct rainfall can flow under gravity into the river network. Point inflows occur at surface water outfalls where rain water channelled by the sewer network is discharged.
Downstream Boundaries	There are three downstream boundaries from the fluvial model into the Thames Estuary; Botney Outfall (gravity outfall), Hotel Gardens Outfall (gravity outfall) and Worlds End pumping station and gravity outfall. Detailed information of how the structures are modelled is provided in Section A.3. The flapped gravity outfalls are modelled with either an orifice or culvert link connected to a flapped outfall and 1D outfall node. The Worlds End pumping station has two pumps (duty and assistant) connected in parallel to a 1D outfall node. The Mean High Spring Tide (obtained from the Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015)) has been applied to the 1D outfall nodes. The discharge of the town and East FSA system is limited by the pump capacity at Words End and the prevailing tide locked conditions. The West FSA outfalls under Dock Road and joins the East Tilbury Dock Sewer flowing primarily towards the Botney Outfall. Discharge is limited by the Botney outfall and prevailing tide-locked conditions.
Length of Model (km):	The following lengths of the watercourses have been modelled: Chadwell Cross Sewer: 0.7km Chadwell Main Sewer: 1.2km Chadwell New Cross Sewer: 1.1km East Tilbury Dock Sewer: 3.5km Pincocks Trough Sewer: 1.4km
Total Number structures:	Bridges: 0 Culverts: 24 Weirs: 34 Pumps: 2 Vertical sluice gate: 4 Flap valves: 5 Orifice: 18
Labelling/ Numbering System Used:	Labelling of the cross sections remain broadly as per the 2014 ISIS model and the nomenclature from the respective 2008 survey. E.g. CCS_0151. Interpolated sections have been labelled as InfoWorks ICM labels them when automatically creating interpolated sections at regular intervals. E.g.

Hydraulic roughness values used	CCS_0309-1-CCS_0151. Channel roughness and culvert values within the fluvial model have been imported from the Tilbury Flood Storage Reservoir Study, Phase 1 ISIS model. This model used Manning's 'n' for the open channel sections and for the culverted sections. Channel roughness values vary from 0.016 (concrete lined) to 0.045 for in channel and 0.050 to 0.070 for out of channel roughness. Culvert roughness varies from 0.011 to 0.025. It is assumed that the culverts are in a good state of repair
Amendments to existing model	The original InfoWorks CS model did not contain a fluvial model. The ISIS model contained FEH inflows however these were replaced in the integrated ICM model by outfalls from the CS surface water connecting to the river reaches and surface water flows entering the river reaches at bank lines. Cross sections were cut to bank top and additional changes have been made to the representation of some structures to improve stability.

A.2.2 Overview of Sewer Model

Sewer Network:	The sewer network has been imported from Anglian Water's InfoWorks CS Tilbury model into the InfoWorks ICM model. The sewer network within Tilbury is designated as separate foul and surface water system, therefore only the surface water network was modelled. Outfalls from the surface water network drain into the watercourses and were connected to the fluvial model where appropriate. Gully data was provided by Thurrock Council and incorporated into the model in Tilbury only. InfoWorks ICM calculates in-sewer flows by solving the Saint-Venant equations using a 4-point Preissmann scheme.
Inflows:	Inflows to the surface water network model are generated using subcatchments. The existing InfoWorks CS model contained surface water subcatchments covering the residential and urban areas. These designated runoff areas for different runoff surface type (roads, roofs, permeable) and were not altered. The default infiltration surface of the 2D Zone is set to permeable (fixed runoff value of 0.3). To improve the representation of the rainfall response infiltration zones have been used for roads with a higher fixed runoff value (0.8). Manholes in the 2D zone were coupled to the surface. Therefore, additional inflow could be made if surface water ran over a node. Highway gullies within Tilbury were modelled as 2D inlet nodes so they were coupled with the surface. Therefore additional inflow could be made if surface water ran over a highway gully. Equally, where gullies were surcharged, sewer flow could route onto the surface.
Pipe Inverts:	Pipe inverts have been taken from the original Anglian Water model. Where data was missing or outfall connections inferred to the fluvial model pipe inverts were assumed by interpolating between known data points or estimating. Gully pots were assumed to be 0.3m deep and upstream inverts equivalent to these chamber floor levels. Downstream inverts were assumed to be 0.5m below downstream node ground level.
Pipe Dimensions:	Pipe dimensions have been taken from the original Anglian Water model. Where data was missing, dimensions were inferred from the upstream or downstream connection. No pipe dimension data was available for gullies. Gullies have been assumed to connect with 100mm dimension pipes to their nearest manhole.
Length of Model (km):	80km
Total Number of nodes and	Manholes: 1075 Gullies: 1551

structures:	Outfalls: 31
Labelling/ Numbering System Used:	As per Anglian Water's model: node ID = National Grid reference Nodes added from Thurrock Council highways data: node ID = Gully####
Hydraulic roughness values used	No CCTV data was available to calibrate roughness specifically for this catchment. Colebrook-White values remained as per the Anglian Water CS model. In most cases: Bottom roughness Colebrook-White value = 1.5mm Top roughness Colebrook-White value = 1.5mm
Amendments to existing model	The flood type of the nodes was changed from stored to 2D where the manholes fell within the 2D zone. No additional surface water network has been added. Thurrock Council gully data was included within Tilbury.

A.2.3 Overview of 2D Model

Triangular mesh:	The 2D domain has been constructed internally within InfoWorks ICM using the Delaunay Triangulation Algorithm. This creates a triangular mesh of ground elevation.		
Overland flow:	The 2D domain solves the Shallow Water Equations (SWEs) across the triangular mesh.		
Area of 2D domain:	542 ha		
Boundary condition:	The boundary condition of the 2D Zone is set to be 'normal condition'. Depth and velocity are kept constant when water reaches the boundary, so water can flow out without losses.		
DTM data source:	Filtered LIDAR (1m from EA Geostore, 2m from EA OpenData).	DTM resolution:	1m or 2m
Mesh Modifications			
Flood Storage Areas	The East Flood Storage Area and West Flood Storage Area have been represented in the model as storage nodes and storage areas. The storage array within the storage node, and the location of the storage area boundary have been informed from the Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015).		
Roads	Roads have been represented using the kerb line as a break in the mesh. The uFmFSW lowers roads by 0.15 m (standard UK curb height). As the mesh resolution was fine within Tilbury and the DTM data in Tilbury was LIDAR it was not necessary to lower roads, as the mesh picked up the curb drop in the LIDAR. As the roads are well defined in the mesh, it would be double counting to also lower the roads by an additional 0.15 m – which is UK standard curb height. The use of break lines on the boundary of the road ensures that triangles are snapped to the road outline - best representing the shape.		
Buildings	Buildings have been represented as porous polygons. A porosity of 0.05 has been assigned representing a restriction to flow but allowing a small amount of water to infiltrate. A value of 0.05 is assumed to be the likely percentage of the building where water could enter, for example doors or airbricks. Representing the buildings as porous polygons also means the ground model tin is meshed to the outlines. The building threshold level has been set to 0.1m throughout. A threshold survey of the whole area was not feasible for this study.		
Infiltration Zones	The 2D Zone was set to a permeable infiltration surface with fixed runoff of 30%. Infiltration zones have been applied for roads and roadside areas as defined by OS MasterMap. These were defined a fixed runoff coefficient of 0.8.		

Roughness Zones	The default roughness of the 2D Zone was set to 0.06 which is typical of a rural area. However roughness zones have been used across the majority of the study area with surface types informed from OS MasterMap. Table 4-2 lists the hydraulic roughness values used for the 2D domain.	
	Table 4-2: Hydraulic roughness values used	
	Land Cover	Manning's n
	Manmade general surface	0.020
	Natural general surface	0.040
	Multi-surface	0.030
	Step	0.017
	Coniferous trees	0.100
	Coniferous trees (scattered)	0.060
	Non-coniferous trees	0.070
	Non-coniferous trees (scattered)	0.040
	Marsh reeds or saltmarsh	0.040
	Orchard	0.050
	Rough Grassland	0.040
	Foreshore	0.035
	Boulders	0.045
	Coppice or osiers	0.070
	Scrub	0.050
	Path	0.035
	Structure	0.300
Road or Track	0.030	
Roadside (Pavement)	0.025	
Heath	0.070	
Inland Water	0.035	
Tidal water	0.035	
Terrain Sensitive Meshing	Terrain sensitive meshing has been used to better represent changes in gradient in the DTM. It allows smaller triangles to be generated where there is greater difference in height between triangle vertices. The cost is that more triangles are created – which increases run time, but it is a valuable addition to identify surface water flow routes, particularly in coarser meshes.	
Maximum triangle size (m²):	100	
Minimum element area (m²):	25	
Terrain sensitive meshing:	Yes	
Maximum height variation (m):	1	
Minimum angle (degrees):	25	
Roughness (Manning's n)	0.060	

A.3 Fluvial Structures

This section provides details of the schematisation of each structures along the fluvial watercourses within the study area.

Structure information has been taken from the original ISIS model (Tilbury Flood Storage Reservoir Study (2015)) as well as the original survey used to build the ISIS model (Total Surveys Ltd, 2008). Control information for the variable control structures (vertical sluice gates and pumps) have been taken from the ISIS model and confirmed with the Environment Agency. Geometry of the Flood Storage Areas and elevation of the spills from the FSAs have been informed from the ISIS-TUFLOW model.

Photographs have been included where they are available. Unless otherwise stated they are from the Total Surveys Ltd, 2008, survey data.

A.3.1 Chadwell Cross Sewer

Structure 1

Structure name	Railway culvert
Included in model	Yes
Model label	JNT_90283822
Type	Twin barrel culvert
Survey drawing ref & job number	Anglian Water InfoWorks CS model (Tilbury SW – Design mode, date last modified 27/03/2014) Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: CCS-LS-1.dwg and CCS-XS-1.dwg. Cross section name: CCS_0842.
How has this structure been modelled?	Structure had been modelled within the Anglian Water InfoWorks CS model as a User Control link, Link Type set to compound (i.e. represented as an orifice). Head-discharge table defined. Initial level (i.e. orifice invert level) = -2.065m AOD. Previously connected to an outfall node in InfoWorks CS model, altered within integrated model to connect directly to the upstream of the Chadwell Cross Sewer river reach.
Structure photo	Downstream face 

Structure 2

Structure name	Fort Road bridge
Included in model	Yes
Model label	CCS_0482
Type	Arch sprung culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: CCS-LS-1.dwg and CCS-XS-1.dwg. Cross section name: CCS_0482.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Sprung arch culvert modelled as 4702mm wide, 2923mm height, 1933mm springing height and 20.2m length. Irregular weir models over the top spill.
Structure photo	

Structure 3

Structure name	Worlds End pumping station gravity outfall
Included in model	Yes
Model label	Worlds End Gravity Outfall
Type	Flapped gravity outfall
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: CCS-LS-1.dwg and CCS-XS-1.dwg. Cross section name: CCS_0151.
How has this structure been modelled?	Orifice unit connected to a flapped outfall connected to a 1D outfall node. Orifice unit and flapped outfall invert = -1.83m AOD; orifice unit and flapped outfall diameter = 1.174m (equivalent to 1.080m ² bore area within ISIS model data). 1D outfall linked to downstream boundary condition. Downstream boundary is Mean High Water Springs tide (taken from ISIS model and is the spring tide curve fitted to MHWS peak of 3.28mAOD).
Structure photo	Landward view



Thames Estuary view



Structure 4

Structure name	Worlds End pumps
Included in model	Yes
Model label	Worlds End Pumps
Type	Duty and assistant pumps
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency.
How has this structure been modelled?	Two Variable Speed Pumps (representing duty and assistant pumps) in parallel connected to a 1D outfall node. Rules of pumps are controlled by Real Time Control (RTC) rules. Duty pump: Switch on level = -1.25m AOD; switch off level = -1.35m AOD - No Pumping when Water Level < -1.1m AOD. Discharge entirely by gravity outfall - No Pumping when Water Level > -1.1m AOD and flow in upstream river channel is less than 0.1m³/s

Structure photo	- Pumping at a rate of -0.463m³/s when Water Level > -1.1m AOD and flow in upstream river channel is greater than 0.1m³/s - Pumping at a rate of -0.694m³/s when Water Level > -1.0m AOD - Pumping at a rate of -0.925m³/s when Water Level > -0.9m AOD Assistant pump: Switch on level = -1.18m AOD; switch off level = -1.25m AOD - If flow in upstream river channel is less than 0.01m³/s, for any Water Level, Pumping rate = 0m³/s - Otherwise if flow in upstream river channel is greater than 0.01m³/s the following rules apply - No Pumping when Water Level < -1.18m AOD. - Pumping at a rate of -0.463m³/s when Water Level > -1.18m AOD - Pumping at a rate of -0.694m³/s when Water Level > -1.0m AOD - Pumping at a rate of -0.925m³/s when Water Level > -0.9m AOD - Pumping at a rate of -0.925m³/s when Water Level > -0.8m AOD
	

A.3.2 Pincocks Cross Sewer

Structure 5

Structure name	Fort Road sluice
Included in model	Yes
Model label	East FSA – PTS_1420
Type	Variable vertical sluice gate
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: PTS-LS-1.dwg and PTS-XS-1.dwg. Cross section name: PTS_1420.
	East FSA storage node connects directly to the upstream of the Pincocks Trough Sewer via a variable vertical sluice link representing the Fort Road sluice gate.
How has this structure been modelled?	Geometry of sluice gate from ISIS model and survey data. Invert level = -1.07m AOD; Width = 2.14m; Opening height = 1.44m; Gate depth = 1.91m; Minimum opening = 0.0m; Maximum opening = 1.44m; Positive speed = 2.0m/s and Negative speed = 2.0m/s. Opening rules controlled by RTC data.

Structure photo

Normal flow conditions

- Water Level < -0.5m AOD at Brennan Road Gauge (node CCS_0842)
Fort Road sluice remains full open (1.440m)

Flood Conditions

- Fort Road Sluice is fully closed when Water Level at Brennan Road > -0.5m AOD

Draw-down conditions:

- If change in depth at Brennan Road is greater than 0.0m/s and Water Level is between 1.0m AOD and -0.5m AOD, then sluice gate is fully open (1.440m)

If change in depth at Brennan Road (CCS_0842) is less than 0.0m/s then the following rules apply:

- Water Level < -0.6m AOD at Brennan Road Gauge Fort Road sluice open 0.1m
- Water Level < -0.7m AOD at Brennan Road Gauge Fort Road sluice open 0.2m
- Water Level < -0.9m AOD at Brennan Road Gauge Fort Road sluice open 0.4m
- Water Level < -1.0m AOD at Brennan Road Gauge Fort Road sluice fully open (1.440m)

Irregular weir unit represents spill around the Fort Road sluice. Geometry from Total Surveys Ltd cross section. Discharge coefficient = 1.0, Modular Limit = 0.90.

Upstream



Downstream



Structure 6

Structure name	Railway culvert
Included in model	Yes
Model label	PTS_1323
Type	Circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: PTS-LS-1.dwg and PTS-XS-1.dwg. Cross section name: PTS_1323.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1140mm diameter and 54.6m length. Irregular weir models over the top spill.
Structure photo	Upstream face  Downstream face



Structure 7

Structure name	Power Station road culvert
Included in model	Yes
Model label	PTS_1160
Type	Circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: PTS-LS-1.dwg and PTS-XS-1.dwg. Cross section name: PTS_1160.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1250mm diameter and 37.1m length. Irregular weir models over the top spill.
Structure photo	

Structure 8

Structure name	Access road to Tilbury sewage treatment works
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Included in model	Yes
Model label	PTS_1052J
Type	Circular conduit
Survey drawing ref & job number	Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: PTS-LS-1.dwg and PTS-XS-1.dwg. No cross sectional survey available although invert/length of structure shown in long section. Structure not specifically modelled within Tilbury Flood Storage Reservoir Study ISIS-TUFLOW model (April 2015). Geometry of structure determined from additional EA information received for this project and long section.
How has this structure been modelled?	Cross section copied downstream from PTS_1118 with bed level lowered to match long section. Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1200mm diameter and 17.3m length. Irregular weir models over the top spill.
Structure photo	No photo available.

Structure 9

Structure name	Access bridge
Included in model	Yes
Model label	PTS_0956u1
Type	Circular conduit
Survey drawing ref & job number	Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: PTS-LS-1.dwg and PTS-XS-1.dwg. No cross sectional survey available although invert/length of structure shown in long section. Structure not specifically modelled within Tilbury Flood Storage Reservoir Study ISIS-TUFLOW model (April 2015). Geometry of structure determined from additional EA information received for this project and long section.
How has this structure been modelled?	Cross section copied upstream from PTS_0956 with bed level altered to match long section. Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1200mm diameter and 23.7m length. Irregular weir models over the top spill.
Structure photo	No photo available.

Structure 10

Structure name	Access bridge
Included in model	Yes
Model label	PTS_0956
Type	Circular conduit
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: PTS-LS-1.dwg and PTS-XS-1.dwg. Cross section name: PTS_0956.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1210mm diameter and 16.0m length. Irregular weir models over the top spill.
Structure photo	Upstream face



Downstream face



Structure 11

Structure name	Fort Road culvert
Included in model	Yes
Model label	PTS_0824
Type	Circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: PTS-LS-1.dwg and PTS-XS-1.dwg. Cross section name: PTS_0824.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1200mm diameter and 28.4m length. Irregular weir models over the top spill.
Structure photo	Upstream face



Structure 12

Structure name	Access bridge
Included in model	Yes
Model label	PTS_0782
Type	Circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: PTS-LS-1.dwg and PTS-XS-1.dwg. Cross section name: PTS_0782.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1200mm diameter. Irregular weir models over the top spill.
Structure photo	

Structure 13

Structure name	Access bridge
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Included in model	Yes
Model label	PTS_0182
Type	Circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: PTS-LS-1.dwg and PTS-XS-1.dwg. Cross section name: PTS_0182.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 960mm diameter and 13.1m length. Irregular weir models over the top spill.
Structure photo	Upstream face  Downstream face 

Structure 14

Structure name	Access bridge
Included in model	Yes
Model label	PTS_0005u2

Type	Circular culvert
Survey drawing ref & job number	No survey available for this structure. Structure not modelled within Tilbury Flood Storage Reservoir Study ISIS-TUFLOW model (April 2015). Geometry of structure determined from additional EA information received for this project.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 900mm diameter and 3m length. Invert levels assumed. Irregular weir models over the top spill.
Structure photo	No photo available.

A.3.3 Chadwell Main Sewer

Structure 15

Structure name	New Sluice
Included in model	Yes
Model label	CMS_0180
Type	Variable vertical sluice gate and circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: CMS-LS-1.dwg and CMS-XS-1.dwg. Cross section name: CMS_0180. Chadwell Main Sewer not modelled within Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015).
How has this structure been modelled?	Variable vertical sluice gate link connected at its downstream to a circular culvert. Circular conduit modelled as 1500mm diameter and 12.8m length. Geometry of sluice gate from survey data. Invert level = -1.673m AOD; Width = 1.674m; Initial opening height = 2.0m; Gate depth = 1.62m; Minimum opening = 0.0m; Maximum opening = 2.0m (assumed); Positive speed = 0.1m/s and Negative speed = 0.1m/s (default) Opening rules controlled by RTC data. - If Water Level at Brenan Road (CCS_0842) < -0.5m AOD, gate set to fully open (2.0m). Default conditions. - If Water Level at Brenan Road (CCS_0842) > -0.5m AOD gate set to fully closed (0.0m). Flood conditions.
Structure photo	Irregular weir models over the top spill. Upstream face



Downstream face



Structure 16

Structure name	A Frame sluice / Dock Road sluice
Included in model	Yes
Model label	CMS_0085
Type	Variable vertical sluice gate and circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: CMS-LS-1.dwg and CMS-XS-1.dwg. Cross section name: CMS_0085. Chadwell Main Sewer not modelled within Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015).
How has this structure been modelled?	Variable vertical sluice gate link connected at its downstream to a circular culvert. Circular conduit modelled as 1500mm diameter (assumed) and 53.8m length. Geometry of sluice gate from survey data. Invert level = -2.059m AOD; Width = 1.603m; Initial opening height = 0.0m; Gate depth = 1.559m;

Structure photo	Minimum opening = 0.0m; Maximum opening = 1.65m (assumed); Positive speed = 0.1m/s and Negative speed = 0.1m/s (default) Opening rules controlled by RTC data (always shut) - If Water Level at Brenan Road (CCS_0842) < -0.5m AOD, gate set to fully closed (0.0m). Default conditions. - If Water Level at Brenan Road (CCS_0842) > -0.5m AOD gate set to fully closed (0.0m). Flood conditions. Irregular weir models over the top spill.
	Upstream 

Structure 17

Structure name	Railway culvert
Included in model	Yes
Model label	CMS_0027
Type	Arch sprung culvert
Survey drawing ref & job number	Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: CMS-LS-1.dwg and CMS-XS-1.dwg. Cross section name: CMS_0027. Chadwell Main Sewer not modelled within Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015).
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Sprung arch culvert modelled as 1680mm wide, 1407mm height, 750mm springing height and 20.7m length. Irregular weir models over the top spill.



A.3.4 Chadwell New Cross Sewer

Structure 18

Structure name	Double culvert under A1099
Included in model	Yes
Model label	CNCS_1162
Type	Twin arch sprung culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: CNCS-LS-1.dwg and CNCS-XS-1.dwg. Cross section name: CNCS_1162.
How has this structure been modelled?	Two arch sprung culverts modelled in parallel. Inlet and outlet structures modelled with inlet and outlet links respectively. Left sprung arch culvert modelled as 2000mm wide, 2070mm height, 1560mm springing height and 50m length. Right sprung arch culvert modelled as 2000mm wide, 2065mm height, 1575mm springing height and 50m length.
Structure photo	Downstream face

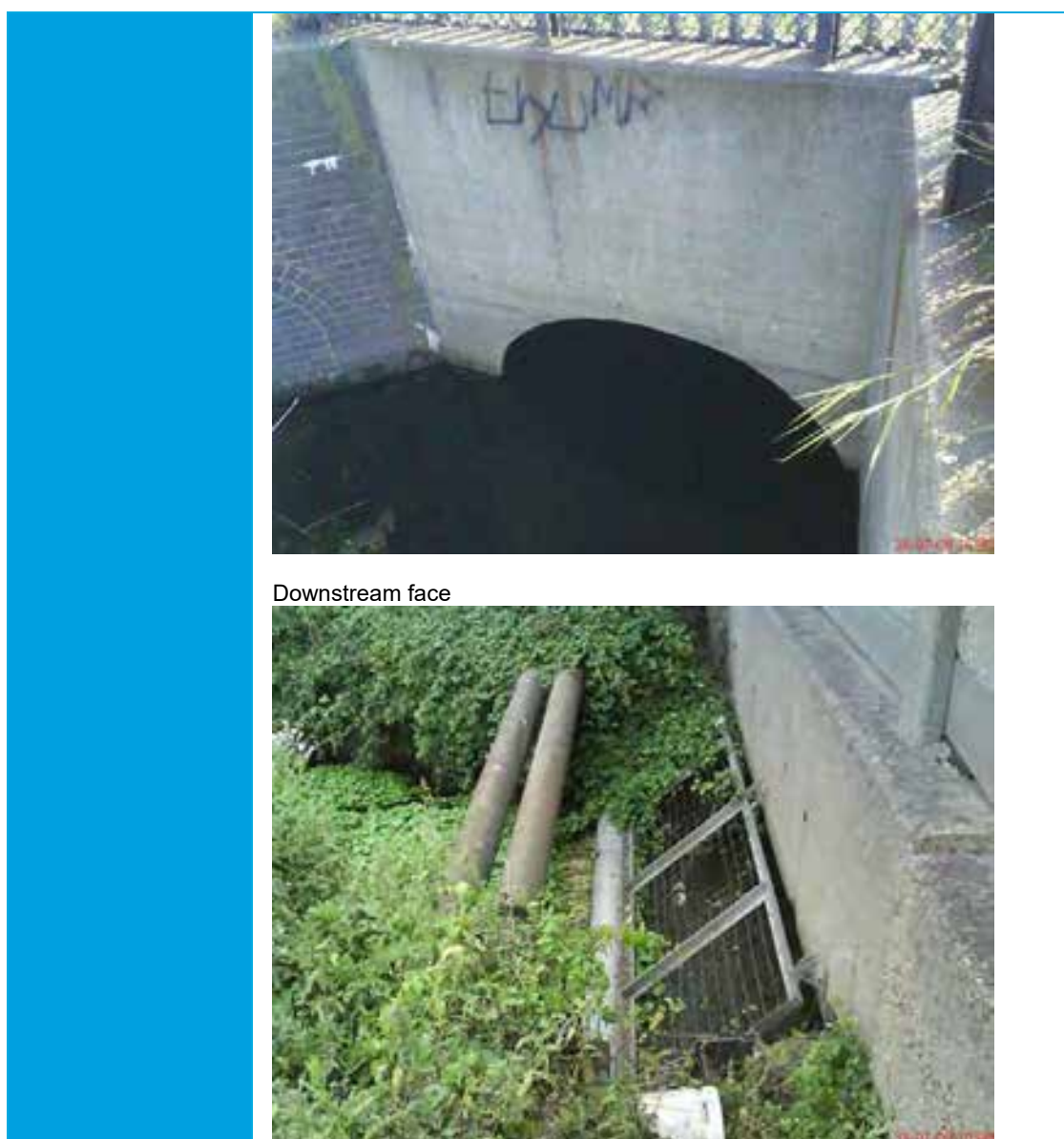


Structure 19

Structure name	Churchill Road bridge
Included in model	Yes
Model label	CNCS_0836
Type	Twin arch sprung culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: CNCS-LS-1.dwg and CNCS-XS-1.dwg. Cross section name: CNCS_0836.
How has this structure been modelled?	Two arch sprung culverts modelled in parallel. Inlet and outlet structures modelled with inlet and outlet links respectively. Left sprung arch culvert modelled as 2000mm wide, 1859mm height, 1000mm springing height and 26.4m length. Right sprung arch culvert modelled as 2000mm wide, 1972mm height, 1000mm springing height and 26.4m length. Irregular weir models over the top spill.
Structure photo	

Structure 20

Structure name	Railway culvert
Included in model	Yes
Model label	CNCS_0037
Type	
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: CNCS-LS-1.dwg and CNCS-XS-1.dwg. Cross section name: CNCS_0037 (upstream face) and CNCS_0008 (downstream face).
How has this structure been modelled?	Survey shows circular culvert at upstream (CNCS_0037) and rectangular culvert at downstream (CNCS_0008). Modelled as approx. half the length of the structure as circular culvert and half the length as rectangular culvert, with break node at junction. Gradient assumed to be equal throughout. Circular conduit modelled as 1851mm diameter and 15.0m length. Rectangular culvert modelled as 4360mm width, 750mm height and 144.0m length. Inlet and outlet structures modelled with inlet and outlet links respectively. Irregular weir models over the top spill.
Structure photo	Upstream face (far)  Upstream face (near)



A.3.5 East Tilbury Dock Sewer

Structure 21

Structure name	Botney Outfall
Included in model	Yes
Model label	Botney Outfall
Type	Flapped gravity outfall
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency.
How has this structure been modelled?	Orifice unit connected to a flapped outfall connected to a 1D outfall node. Orifice unit and flapped outfall invert = -1.48m AOD; orifice unit and flapped outfall diameter = 2.919m (equivalent to 6.69m ² bore area within ISIS model data). 1D outfall linked to downstream boundary condition. Downstream boundary is Mean High Water Springs tide (taken from ISIS model and is the spring tide curve fitted to MHWS peak of 3.28mAOD).

Structure photo	No photo available
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Structure 22

Structure name	Freightliners sluice
Included in model	Yes
Model label	ETDS_2997
Type	Variable vertical sluice gate
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: ETDS-LS-1.dwg and ETDS-XS-1.dwg. Cross section name: ETDS_2997.
How has this structure been modelled?	Variable vertical sluice gate link connected from break node within watercourse to downstream river reach. Geometry of sluice gate from survey data. Invert level = -1.35m AOD; Width = 1.16m; Initial opening height = 0m; Gate depth = 1.23m; Minimum opening = 0.0m; Maximum opening = 1.23m; Positive speed = 0.1m/s and Negative speed = 0.1m/s (default) Opening rules controlled by RTC data (always closed). - If Water Level at Brenan Road (CCS_0842) < -0.5m AOD, gate set to fully closed (0.0m). Default conditions. - If Water Level at Brenan Road (CCS_0842) > -0.5m AOD gate set to fully closed (0.0m). Flood conditions.
Structure photo	

Structure 23

Structure name	Culvert under railway station
Included in model	Yes
Model label	ETDS_1622
Type	Arch sprung culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: ETDS-LS-1.dwg and ETDS-XS-1.dwg. Cross section name: ETDS_1622.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Sprung arch culvert modelled as 1758mm wide, 1446mm height, 976mm springing height and 142.2m length.
Structure photo	No photo available

Structure 24

Structure name	Access bridge
Included in model	Yes
Model label	ETDS_1397
Type	Circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys

How has this structure been modelled? Structure photo	Limited, July 2008. CAD filename: ETDS-LS-1.dwg and ETDS-XS-1.dwg. Cross section name: ETDS_1397.
	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1530mm diameter and 17.1m length. Irregular weir models over the top spill.
	

Structure 25

Structure name	Access bridge
Included in model	Yes
Model label	ETDS_1210
Type	Circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: ETDS-LS-1.dwg and ETDS-XS-1.dwg. Cross section name: ETDS_1210.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1070mm diameter and 16.7m length. Irregular weir models over the top spill.



Structure 26

Structure name	Ferry Road culvert (1)
Included in model	Yes
Model label	ETDS_0745
Type	Circular culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: ETDS-LS-1.dwg and ETDS-XS-1.dwg. Cross section name: ETDS_0745.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Circular conduit modelled as 1540mm diameter and 30.5m length. Irregular weir models over the top spill.
Structure photo	

Structure 27

Structure name	Ferry Road culvert (2)
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Included in model	Yes
Model label	ETDS_0407
Type	Arch sprung culvert
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: ETDS-LS-1.dwg and ETDS-XS-1.dwg. Cross section name: ETDS_0407.
How has this structure been modelled?	Inlet and outlet structures modelled with inlet and outlet links respectively. Sprung arch culvert modelled as 1340mm wide, 1470mm height, 800mm springing height and 65.3m length. Irregular weir models over the top spill.
Structure photo	

Structure 28

Structure name	Hotel gardens gravity outfall
Included in model	Yes
Model label	ETDS_0319 and Hotel Gardens Outfall
Type	Rectangular culvert to flapped outfall in estuary
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency. Tilbury Flood Storage Area: Cross-Sectional Survey Work. Total Surveys Limited, July 2008. CAD filename: ETDS-LS-1.dwg and ETDS-XS-1.dwg. Cross section name: ETDS_0319.
How has this structure been modelled?	Rectangular culvert unit connected to a flapped outfall connected to a 1D outfall node. Rectangular culvert modelled as 1691mm width and 1100mm height. Flapped outfall invert = -2.1m AOD (assumed); flapped outfall diameter = 1.80m (equivalent to 2.54m ² bore area within ISIS model data). 1D outfall linked to downstream boundary condition. Downstream boundary is Mean High Water Springs tide (taken from ISIS model and is the spring tide curve fitted to MHWS peak of 3.28mAOD).



A.4 Other structures

Structure 29

Structure name	East Flood Storage Area
Included in model	Yes
Model label	East FSA
Type	Flood storage area
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency.
How has this structure been modelled?	Flood storage area has been modelled with a storage node and a storage area. The extent of the storage area was informed from the outline in the TUFLOW model. The storage array within the storage node was informed from the reservoir unit in the ISIS model. An inline bank models spill over embankment from Ford Road Sluice to the A126. Location, elevation and coefficients of spill informed from ISIS-TUFLOW model. Irregular weir between East FSA and West FSA to model spill over A 126. Chainage and elevation from ISIS model. East FSA storage node connects directly to the upstream of the Pincocks Trough Sewer via a variable vertical sluice link representing the Fort Road sluice gate. Irregular weir represents spill around the sluice gate.
Structure photo	No photo available

Structure 30

Structure name	West Flood Storage Area
Included in model	Yes
Model label	West FSA
Type	Flood storage area
Survey drawing ref & job number	Tilbury Flood Storage Reservoir Study, Phase 1 ISIS-TUFLOW model (April 2015). Mott MacDonald for the Environment Agency.

How has this structure been modelled?	Flood storage area has been modelled with a storage node and a storage area. The extent of the storage area was informed from the outline in the TUFLOW model. The storage array within the storage node was informed from the reservoir unit in the ISIS model. An inline bank models spill over embankment from A126 to Dock Road, and two inline banks represent spill over Dock Road. Location, elevation and coefficients of spills informed from ISIS-TUFLOW model. Irregular weir between East FSA and West FSA to model spill over A 126. Chainage and elevation from ISIS model. Storage node is connected directly to Chadwell New Cross Sewer and Chadwell Main Sewer.
Structure photo	No photo available

Emergency Alerts (/alerts) Test on Sunday 23 April, 3pm

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Statutory guidance

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Applies to England

[Publication for Wales \(https://naturalresources.wales/our-evidence-and-reports/our-data/accessing-our-data/?lang=en\)](https://naturalresources.wales/our-evidence-and-reports/our-data/accessing-our-data/?lang=en)

[Publication for Scotland \(http://www.sepa.org.uk/environment/environmental-data/\)](http://www.sepa.org.uk/environment/environmental-data/)

[Publication for Northern Ireland \(https://www.doeni.gov.uk/articles/digital-datasets-terms-and-conditions\)](https://www.doeni.gov.uk/articles/digital-datasets-terms-and-conditions)

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10. Appendix B – Gravesend Flood Data

Envirocheck[®] Report:

Flood Screening Report Datasheet

Order Details:

Order Number:

302366136_1_1

Customer Reference:

500199 TKRE

National Grid Reference:

566430, 174430

Slice:

A

Site Area (Ha):

72.49

Search Buffer (m):

1000

Site Details:

Site at
Tilbury
Thurrock

Client Details:

Mr N Hill
Morgan Sindall (Infrastructure) Plc
Corporation Street
Rugby
Warwickshire
CV21 2DW

Report Section and Details	Page Number
Summary	-
The Summary section provides an overview of the data contained within the report, detailing the number of data set features or the existence of a data set in relation to the buffer(s) selected. For ease of reference, the report is broken down into seven sections of data.	
EA / NRW / CEH Flood Data	1
This section details data from the Environment Agency/Natural Resources Wales and the Centre for Ecology and Hydrology. The EA/NRW data is reported to a distance of 250m from the edge of the site polygon and details both Zone 2 (extreme) and Zone 3 flood extents, as well as flood defences, flood water storage areas and areas benefiting from flood defences. The CEH data is reported to a distance of 250m from the edge of the site polygon and covers flood data for Scotland, divided into levels based on the frequency and magnitude of a predicted 100 year term. All data sets within this section are plotted and feature on the EA / NRW / CEH Flood Data (1:10,000) map. For added value, OS Contour data is also plotted, detailing contours, spot heights and land water boundaries.	
JBA Flood Data	3
This section contains the Comprehensive Flood Map ("CFM") data from JBA Risk Management Limited. The data is based upon the likelihood of a flood occurrence for up to 4 flood return periods depending on the type of flooding; these being 75 years, 100 years, 200 years and 1000 years. Each layer being modelled at a 5m cell resolution. Each return period is depicted on a separate 1:10,000 scale map and reports features to a distance of 250m in the datasheet from the edge of the site polygon. For each return period the following three sources of flooding are identified, surface water or pluvial flooding, undefended river flooding or fluvial flooding and undefended coastal flooding. In each case the extent of the flooding source is displayed with the associated depth range. In addition, a 1:10,000 scale map depicting flooding from a Canal Failure and a coverage check for this dataset is included. Where coverage exists, information is reported in the datasheet where the site could be affected by flooding that results from a dam breach. For added value, OS Contour data is also plotted, detailing contours, spot heights and land water boundaries.	
BGS Flood Data	61
This section contains two BGS data sets; namely Geological Indicators of Flooding and Groundwater Flooding Susceptibility, both of which report features out to a possible 1000m, with coverage in England, Wales and Scotland. Each data set is plotted on a separate BGS Flood Data (1:50,000) map.	
GeoSmart Information Groundwater Flood Data	64
This section contains data provided by GeoSmart Information who, building on their expertise, have developed algorithms and calibrated predictions of the risk of groundwater flooding occurring in Great Britain. The resulting map, classifies groundwater flood risk for each 5m x 5m into four categories, negligible, low, moderate and high. These classifications are based on the level of risk, combining severity and uncertainty that a site will suffer groundwater flooding within a return period of about 200 years.	
OS Water Network Data	116
This section details the MasterMap Water Network data sourced from the Ordnance Survey. The OS MasterMap Water Network data details a network representing the watercourse within Great Britain. The OS Water Network Lines data set details the approximate central alignment of a watercourse, including rivers, lakes and canals. The OS Water Network Nodes data set details features that represent a river's source, end, a junction where three or more links meet, and places where the real world related attribution changes; for example a watercourse becoming tidal. The data sets within this section are plotted and feature on the OS Water Network Map (1:10,000) . For added value, OS Contour data is also plotted, detailing contours, spot heights and land water boundaries.	

EA/NRW Historic Flood Events Data	127
This section details Historic Flood data sourced from the Environment Agency/Natural Resources Wales and from data held by Landmark. The EA/NRW Historic Flood Events data is reported to a distance of 1000m from the edge of the site polygon and details recorded historic flood events from 1703 to October 2008. The data also contains information on the source and cause of the flood, and how the flood outline was established. Also included in this section is Landmark's Historical Flood Liabilities data set, which identifies areas that are liable to flood based on systematic analysis of historical mapping dating back to the mid 19th century. Both data sets within this section are plotted and feature on the EA/NRW Historical Flood (1:10,000) map. For added value, OS Contour data is also plotted, detailing contours, spot heights and land water boundaries.	
EA/NRW RoFRS Data	128
This section details the Risk of Flooding from Rivers and Sea (RoFRS) data sourced from the Environment Agency/Natural Resources Wales and is reported to a distance of 1000m from the edge of the site polygon. The RoFRS data provides an indication of areas of land at risk of flooding from rivers and the sea. These areas of land, called impacted cells, are represented as 50 metre squares, or smaller areas where a square is intersected by a river or coastline. The average height information of the impacted cell, modelled river and sea levels and information about over 200,000 flood defences are used as inputs to a computer flood model run by the Environment Agency/Natural Resources Wales. The model compares the probability that the flood defences will overtop or breach and the distance of the impact cell from the river or the sea for 40 scenarios for probabilities of between 100% to 0.1%. The results are then consolidated to calculate a single probability category for each impacted cell. These results have been validated by local staff using their local knowledge and expertise. RoFRS is a national flood risk assessment and does not contain information about property thresholds. Due to variations in the input data and the performance of the computer flood model at particular locations, the resulting category of an impacted cell should only be used at a specific study scale. In certain areas it would only be appropriate to compare risks between towns and counties whereas in other areas they would be more suitable for understanding risk at a street level. The level of suitability for a particular cell is indicated by the cell's suitability scale. The data within this section is plotted and feature on the EA/NRW RoFRS Data (1:50,000) map. This dataset is not available in Scotland.	
Flood Insurance Risk Data	135
This section contains flood risk data from Crawford and Company. This dataset is not plotted on any of the associated Flood maps. Crawford & Co have generated an Insurance Claims rating for Flood Risk. The risk is determined by comparing the number of flood insurance claims made to the number of properties in the postcode sector. The data will also include flood claims from domestic accidents or blocked drains, as well as flooding from river or tidal events. Flood insurance claim ratings are reported for the site only.	
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Data Suppliers	139
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EA / NRW / CEH Flood Data					
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Flooding from Rivers or Sea without Defences	pg 2	2		n/a	n/a
Areas Benefiting from Flood Defences	pg 2	2		n/a	n/a
Flood Water Storage Areas				n/a	n/a
Flood Defences	pg 2	2		n/a	n/a
JBA Flood Data					
JBA 75 Year Return (undefended) - Pluvial	pg 3		27	n/a	n/a
JBA 75 Year Return (undefended) - Fluvial	pg 4	9	30	n/a	n/a
JBA 75 Year Return (undefended) - Coastal	pg 6	11	246	n/a	n/a
JBA 100 Year Return (undefended) - Fluvial	pg 17	10	31	n/a	n/a
JBA 100 Year Return (undefended) - Coastal	pg 19	9	210	n/a	n/a
JBA 200 Year Return (undefended) - Pluvial	pg 29	3	126	n/a	n/a
JBA 200 Year Return (undefended) - Fluvial	pg 35	7	31	n/a	n/a
JBA 200 Year Return (undefended) - Coastal	pg 37	6	183	n/a	n/a
JBA 1000 Year Return (undefended) - Pluvial	pg 45	2	135	n/a	n/a
JBA 1000 Year Return (undefended) - Fluvial	pg 51	5	25	n/a	n/a
JBA 1000 Year Return (undefended) - Coastal	pg 53	7	146	n/a	n/a
JBA Canal Failure					
JBA Dam Break					
BGS Flood Data					
BGS Geological Indicators of Flooding	pg 61	6			4
BGS Groundwater Flooding Susceptibility	pg 61	14	11	3	21
GeoSmart Information Groundwater Flood					
GeoSmart Information Groundwater Flood Risk	pg 64	41	85	228	455
OS Water Network Data					
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Flood Insurance Risk Data					
Postcode Sector Flood Insurance Claim Ratings	pg 135	2	n/a	n/a	n/a

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Envirocheck[®] Report:

Flood Screening Report Datasheet

Order Details:

Order Number:

302366136_1_1

Customer Reference:

500199 TKRE

National Grid Reference:

567880, 174130

Slice:

B

Site Area (Ha):

72.49

Search Buffer (m):

1000

Site Details:

Site at
Tilbury
Thurrock

Client Details:

Mr N Hill
Morgan Sindall (Infrastructure) Plc
Corporation Street
Rugby
Warwickshire
CV21 2DW

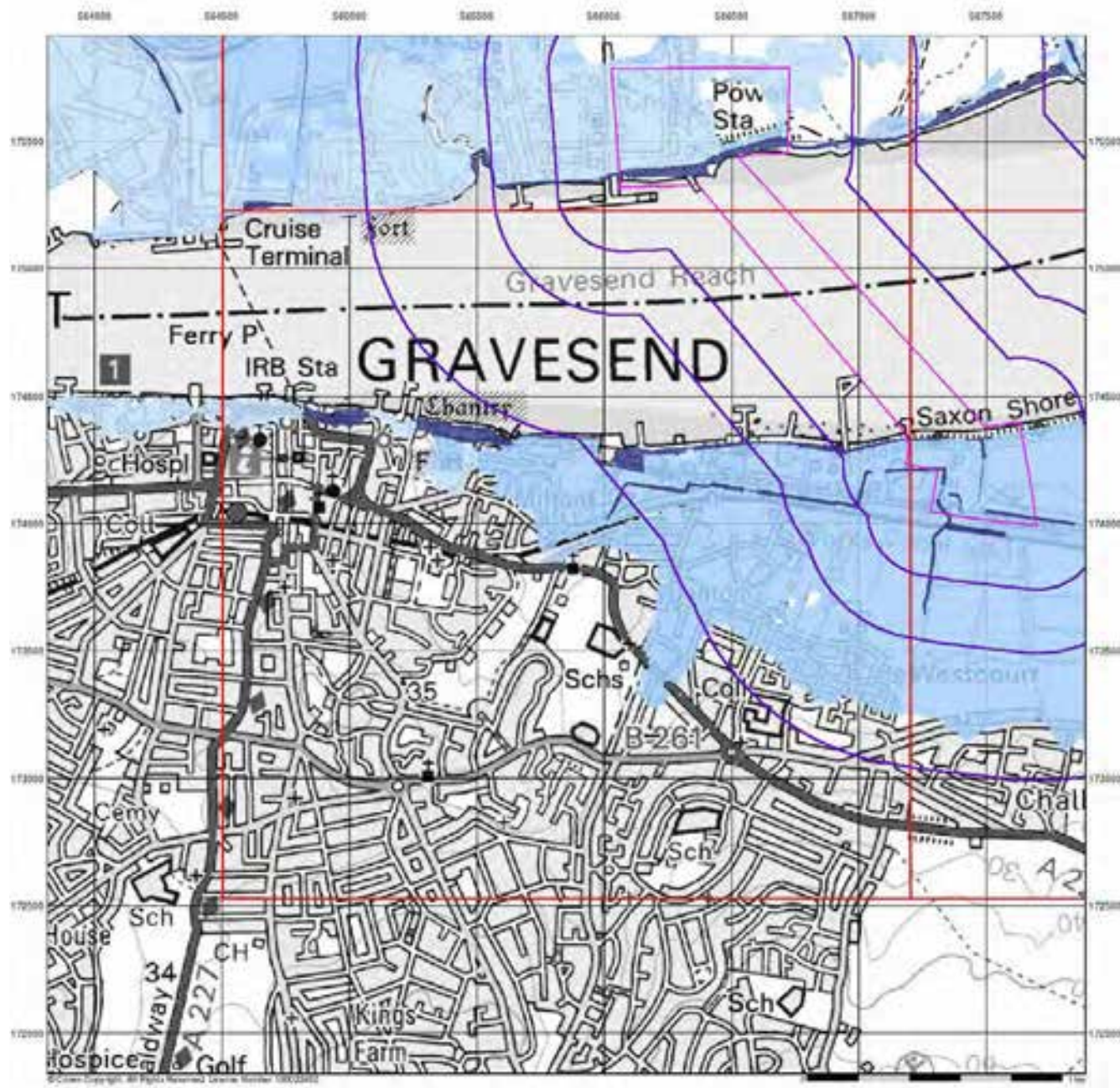
Report Section and Details	Page Number
Summary	-
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JBA Flood Data	3
This section contains the Comprehensive Flood Map ("CFM") data from JBA Risk Management Limited. The data is based upon the likelihood of a flood occurrence for up to 4 flood return periods depending on the type of flooding; these being 75 years, 100 years, 200 years and 1000 years. Each layer being modelled at a 5m cell resolution. Each return period is depicted on a separate 1:10,000 scale map and reports features to a distance of 250m in the datasheet from the edge of the site polygon. For each return period the following three sources of flooding are identified, surface water or pluvial flooding, undefended river flooding or fluvial flooding and undefended coastal flooding. In each case the extent of the flooding source is displayed with the associated depth range. In addition, a 1:10,000 scale map depicting flooding from a Canal Failure and a coverage check for this dataset is included. Where coverage exists, information is reported in the datasheet where the site could be affected by flooding that results from a dam breach. For added value, OS Contour data is also plotted, detailing contours, spot heights and land water boundaries.	
BGS Flood Data	202
This section contains two BGS data sets; namely Geological Indicators of Flooding and Groundwater Flooding Susceptibility, both of which report features out to a possible 1000m, with coverage in England, Wales and Scotland. Each data set is plotted on a separate BGS Flood Data (1:50,000) map.	
GeoSmart Information Groundwater Flood Data	205
This section contains data provided by GeoSmart Information who, building on their expertise, have developed algorithms and calibrated predictions of the risk of groundwater flooding occurring in Great Britain. The resulting map, classifies groundwater flood risk for each 5m x 5m into four categories, negligible, low, moderate and high. These classifications are based on the level of risk, combining severity and uncertainty that a site will suffer groundwater flooding within a return period of about 200 years.	
OS Water Network Data	221
This section details the MasterMap Water Network data sourced from the Ordnance Survey. The OS MasterMap Water Network data details a network representing the watercourse within Great Britain. The OS Water Network Lines data set details the approximate central alignment of a watercourse, including rivers, lakes and canals. The OS Water Network Nodes data set details features that represent a river's source, end, a junction where three or more links meet, and places where the real world related attribution changes; for example a watercourse becoming tidal. The data sets within this section are plotted and feature on the OS Water Network Map (1:10,000) . For added value, OS Contour data is also plotted, detailing contours, spot heights and land water boundaries.	

EA/NRW Historic Flood Events Data	263
This section details Historic Flood data sourced from the Environment Agency/Natural Resources Wales and from data held by Landmark. The EA/NRW Historic Flood Events data is reported to a distance of 1000m from the edge of the site polygon and details recorded historic flood events from 1703 to October 2008. The data also contains information on the source and cause of the flood, and how the flood outline was established. Also included in this section is Landmark's Historical Flood Liabilities data set, which identifies areas that are liable to flood based on systematic analysis of historical mapping dating back to the mid 19th century. Both data sets within this section are plotted and feature on the EA/NRW Historical Flood (1:10,000) map. For added value, OS Contour data is also plotted, detailing contours, spot heights and land water boundaries.	
EA/NRW RoFRS Data	264
This section details the Risk of Flooding from Rivers and Sea (RoFRS) data sourced from the Environment Agency/Natural Resources Wales and is reported to a distance of 1000m from the edge of the site polygon. The RoFRS data provides an indication of areas of land at risk of flooding from rivers and the sea. These areas of land, called impacted cells, are represented as 50 metre squares, or smaller areas where a square is intersected by a river or coastline. The average height information of the impacted cell, modelled river and sea levels and information about over 200,000 flood defences are used as inputs to a computer flood model run by the Environment Agency/Natural Resources Wales. The model compares the probability that the flood defences will overtop or breach and the distance of the impact cell from the river or the sea for 40 scenarios for probabilities of between 100% to 0.1%. The results are then consolidated to calculate a single probability category for each impacted cell. These results have been validated by local staff using their local knowledge and expertise. RoFRS is a national flood risk assessment and does not contain information about property thresholds. Due to variations in the input data and the performance of the computer flood model at particular locations, the resulting category of an impacted cell should only be used at a specific study scale. In certain areas it would only be appropriate to compare risks between towns and counties whereas in other areas they would be more suitable for understanding risk at a street level. The level of suitability for a particular cell is indicated by the cell's suitability scale. The data within this section is plotted and feature on the EA/NRW RoFRS Data (1:50,000) map. This dataset is not available in Scotland.	
Flood Insurance Risk Data	270
This section contains flood risk data from Crawford and Company. This dataset is not plotted on any of the associated Flood maps. Crawford & Co have generated an Insurance Claims rating for Flood Risk. The risk is determined by comparing the number of flood insurance claims made to the number of properties in the postcode sector. The data will also include flood claims from domestic accidents or blocked drains, as well as flooding from river or tidal events. Flood insurance claim ratings are reported for the site only.	
Data Currency	271
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Useful Contacts	275

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Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m
EA / NRW / CEH Flood Data					
Extreme Flooding from Rivers or Sea without Defences	pg 1	11	7	n/a	n/a
Flooding from Rivers or Sea without Defences	pg 2	1		n/a	n/a
Areas Benefiting from Flood Defences	pg 2	1		n/a	n/a
Flood Water Storage Areas				n/a	n/a
Flood Defences	pg 2	1		n/a	n/a
JBA Flood Data					
JBA 75 Year Return (undefended) - Pluvial	pg 3	31	5	n/a	n/a
JBA 75 Year Return (undefended) - Fluvial	pg 4	13	30	n/a	n/a
JBA 75 Year Return (undefended) - Coastal	pg 6	297	774	n/a	n/a
JBA 100 Year Return (undefended) - Fluvial	pg 55	16	32	n/a	n/a
JBA 100 Year Return (undefended) - Coastal	pg 57	266	696	n/a	n/a
JBA 200 Year Return (undefended) - Pluvial	pg 101	67	79	n/a	n/a
JBA 200 Year Return (undefended) - Fluvial	pg 107	26	29	n/a	n/a
JBA 200 Year Return (undefended) - Coastal	pg 110	245	568	n/a	n/a
JBA 1000 Year Return (undefended) - Pluvial	pg 147	245	337	n/a	n/a
JBA 1000 Year Return (undefended) - Fluvial	pg 173	32	20	n/a	n/a
JBA 1000 Year Return (undefended) - Coastal	pg 176	191	356	n/a	n/a
JBA Canal Failure					
JBA Dam Break					
BGS Flood Data					
BGS Geological Indicators of Flooding	pg 202	6			4
BGS Groundwater Flooding Susceptibility	pg 202	12	9	6	24
GeoSmart Information Groundwater Flood					
GeoSmart Information Groundwater Flood Risk	pg 205	22	77	52	94
OS Water Network Data					
OS Water Network Lines	pg 221	21	50	81	117
OS Water Network Nodes	pg 250	15	44	72	110
EA/NRW Historic Flood Events Data					
Historic Flood Events	pg 263	2			
Historical Flood Liabilities					
EA/NRW RoFRS Data					
RoFRS - Risk of Flooding from Rivers and Sea	pg 264	14	23	12	27
Flood Insurance Risk Data					
Postcode Sector Flood Insurance Claim Ratings	pg 270	1	n/a	n/a	n/a

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EA/NRW RoFRS Data (1:50,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point
- Slice
- 8 Map ID

Risk of Flooding from Rivers and Sea (RoFRS)

- High Risk
- Medium Risk
- Low Risk
- Very Low Risk

EA/NRW RoFRS Data Map - Slice A



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566430, 174430
 Slice: A
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Flood Data Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

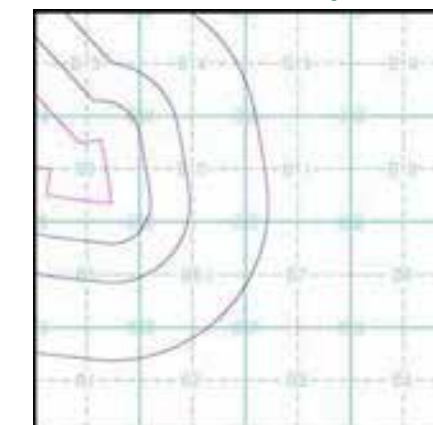
Flood Data

- Extreme Flooding from Rivers or Sea without Defences (Zone 2)
- Flooding from Rivers or Sea without Defences (Zone 3)
- ▨ Area Benefiting from Flood Defence
- Flood Water Storage Areas
- Flood Defence

Contours (height in metres)

- Standard Contour 0.5m
- Master Contour 1.0m
- Spot Height 1.5m
- MLW Mean Low Water
- MHW Mean High Water

EA/NRW Flood Data Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA 75 Year Return Flood Map (Undefended) (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

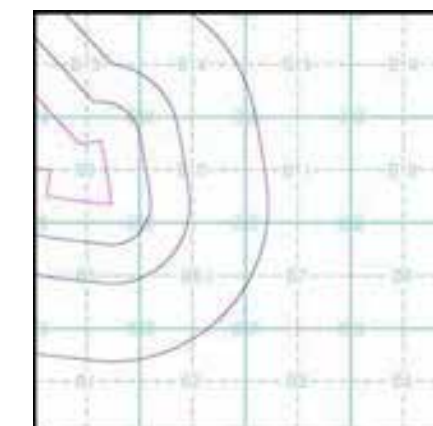
Modelled Flood Depth

Pluvial Depth	Fluvial Depth	Coastal Depth
0.1m	0.01m - 0.05m	0.01m - 0.05m
0.1m - 0.3m	0.05m - 0.1m	0.05m - 0.1m
0.3m - 1m	0.1m - 0.3m	0.1m - 0.3m
>1m	0.3m - 1m	0.3m - 1m
	>1m	>1m

Contours (height in metres)

- Standard Contour: 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, 3.0m, 3.5m, 4.0m, 4.5m, 5.0m, 5.5m, 6.0m, 6.5m, 7.0m, 7.5m, 8.0m, 8.5m, 9.0m, 9.5m, 10.0m
- Master Contour: 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, 3.0m, 3.5m, 4.0m, 4.5m, 5.0m, 5.5m, 6.0m, 6.5m, 7.0m, 7.5m, 8.0m, 8.5m, 9.0m, 9.5m, 10.0m
- Spot Height: 107.8
- Mean Low Water
- Mean High Water

JBA 75 Year Return Flood Map (Undefended) - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA 100 Year Return Flood Map (Un defended) (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point

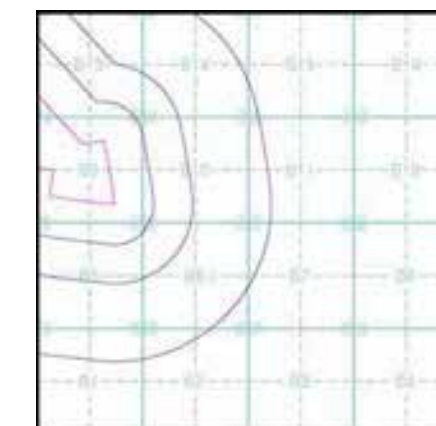
Modelled Flood Depth

Fluvial Depth	Coastal Depth
0.01m - 0.05m	0.01m - 0.05m
0.05m - 0.1m	0.05m - 0.1m
0.1m - 0.3m	0.1m - 0.3m
0.3m - 1m	0.3m - 1m
>1m	>1m

Contours (height in metres)

- Standard Contour
- Master Contour
- Spot Height
- Mean Low Water
- Mean High Water

JBA 100 Year Return Flood Map (Un defended) - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA 200 Year Return Flood Map (Un defended) (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

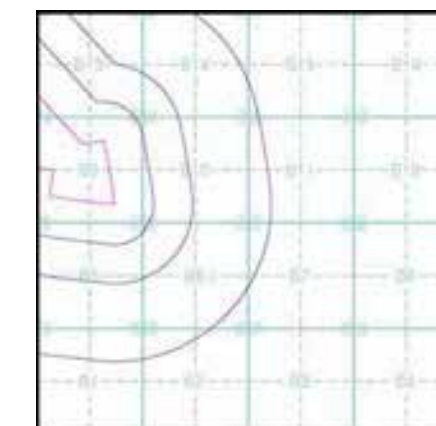
Modelled Flood Depth

Pluvial Depth	Fluvial Depth	Coastal Depth
0.1m	0.01m - 0.05m	0.01m - 0.05m
0.1m - 0.3m	0.05m - 0.1m	0.05m - 0.1m
0.3m - 1m	0.1m - 0.3m	0.1m - 0.3m
>1m	0.3m - 1m	0.3m - 1m
	>1m	>1m

Contours (height in metres)

- Standard Contour
- Master Contour
- Spot Height
- Mean Low Water
- Mean High Water

JBA 200 Year Return Flood Map (Un defended) - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA 1000 Year Return Flood Map (Undefended) (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

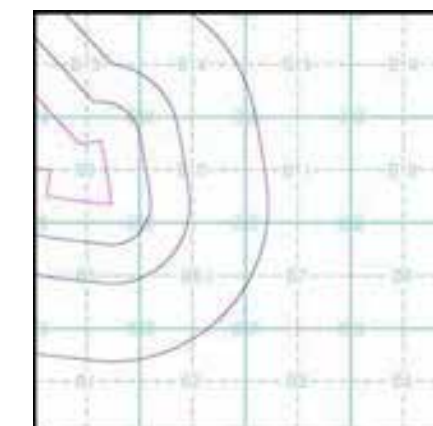
Modelled Flood Depth

Pluvial Depth	Fluvial Depth	Coastal Depth
0.1m	0.01m - 0.05m	0.01m - 0.05m
0.1m - 0.3m	0.05m - 0.1m	0.05m - 0.1m
0.3m - 1m	0.1m - 0.3m	0.1m - 0.3m
>1m	0.3m - 1m	0.3m - 1m
	>1m	>1m

Contours (height in metres)

- Standard Contour
- Master Contour
- Spot Height
- Mean Low Water
- Mean High Water

JBA 1000 Year Return Flood Map (Undefended) - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

JBA Canal Failure Map (1:10,000)

General

-  Specified Site
-  Specified Buffer(s)
-  Bearing Reference Point

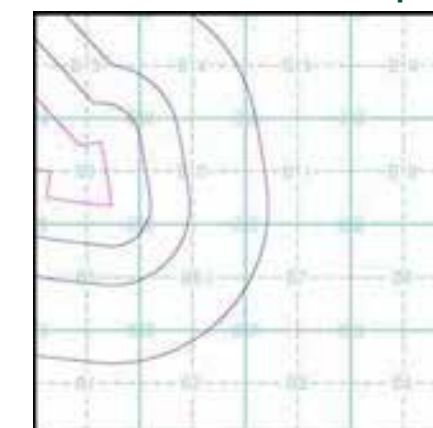
Flood Data

-  Canal Failure
-  Coverage

Contours (height in metres)

- Standard Contour  105  100  95  MLW  Mean Low Water
- Master Contour  100  95  MHW  Mean High Water
- Spot Height  167.8

JBA Canal Failure Flood Map - Slice B



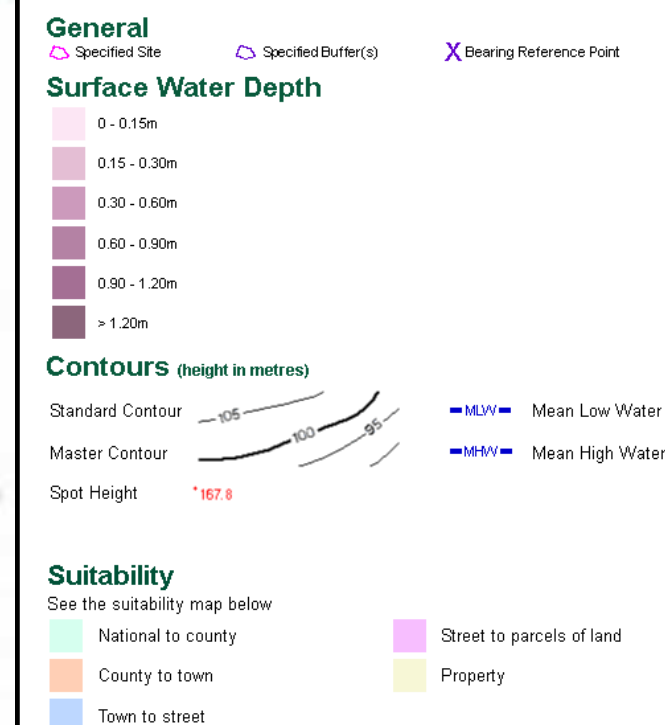
Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

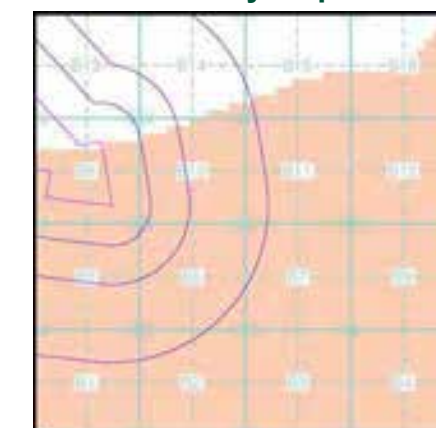
Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 30 Year Return Depth Map (1:10,000)



EA/NRW Suitability Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 100 Year Return Depth Map

General
 Specified Site Specified Buffer(s) Bearing Reference Point

Surface Water Depth

0 - 0.15m
 0.15 - 0.30m
 0.30 - 0.60m
 0.60 - 0.90m
 0.90 - 1.20m
 > 1.20m

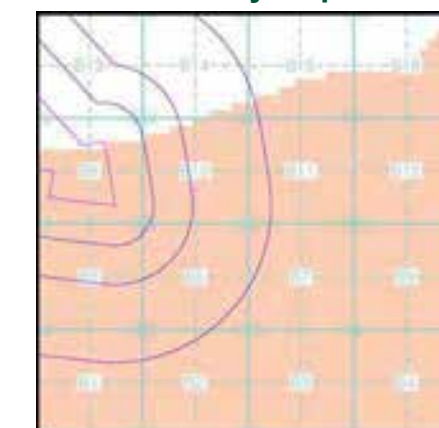
Contours (height in metres)

Standard Contour 105 100 95
 Master Contour 100 95
 Spot Height *167.8
 MLW Mean Low Water
 MHW Mean High Water

Suitability

See the suitability map below
 National to county
 County to town
 Town to street
 Street to parcels of land
 Property

EA/NRW Suitability Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 1000 Year Return Depth Map (1:10,000)

General
 Specified Site Specified Buffer(s) Bearing Reference Point

Surface Water Depth

0 - 0.15m
 0.15 - 0.30m
 0.30 - 0.60m
 0.60 - 0.90m
 0.90 - 1.20m
 > 1.20m

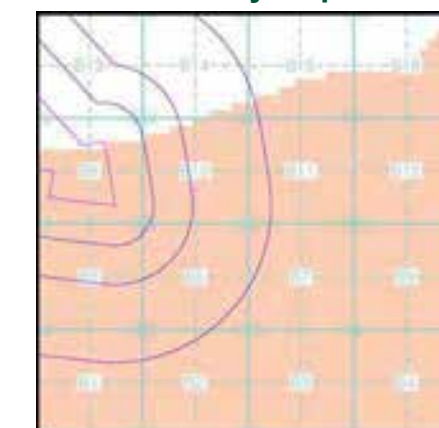
Contours (height in metres)

Standard Contour 105 100 95
 Master Contour 105 100 95
 Spot Height *167.8
 MLW Mean Low Water
 MHW Mean High Water

Suitability

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 County to town
 Town to street
 Street to parcels of land
 Property

EA/NRW Suitability Map - Slice B



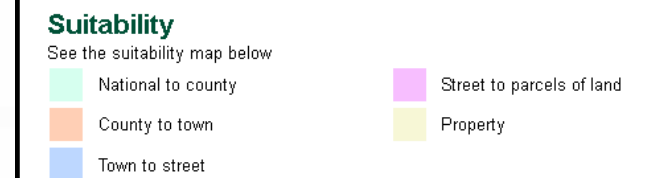
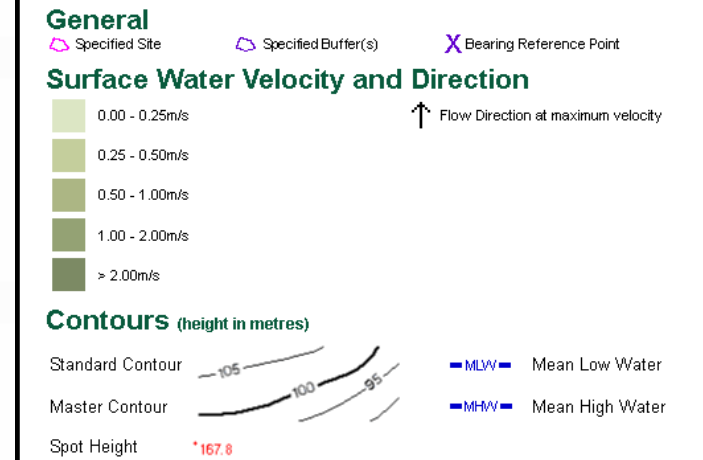
Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

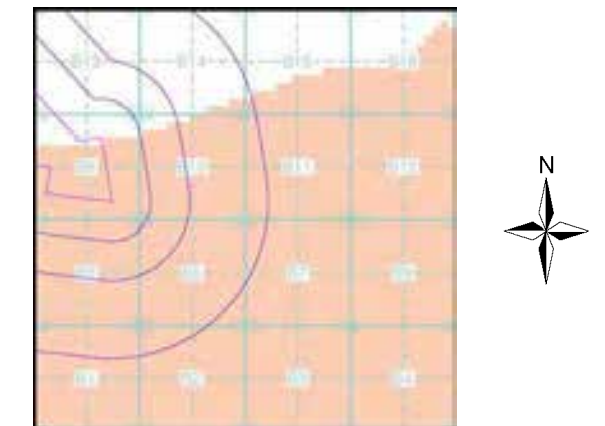
Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 30 Year Return Velocity and Flow Direction Map (1:10,000)



EA/NRW Suitability Map - Slice B



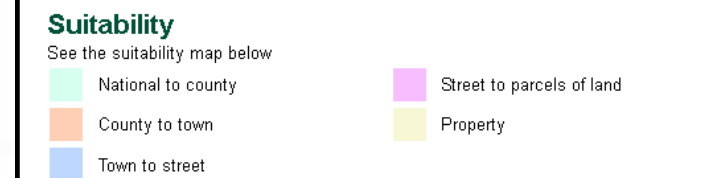
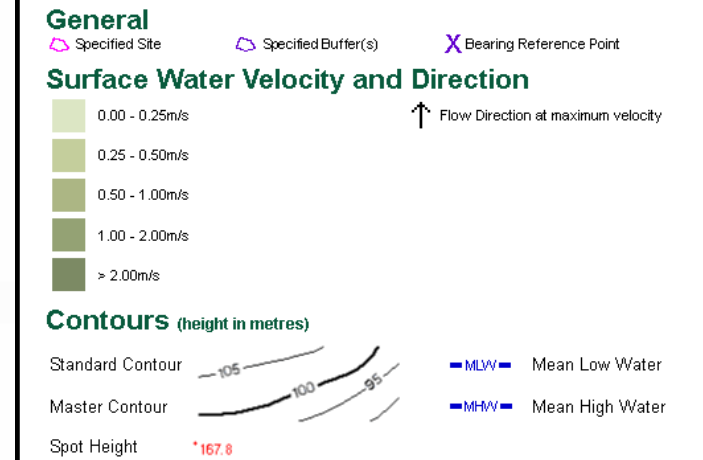
Order Details

Order Number: 302366136_1_1
Customer Ref: 500199 TKRE
National Grid Reference: 567880, 174130
Slice: B
Site Area (Ha): 72.49
Search Buffer (m): 1000

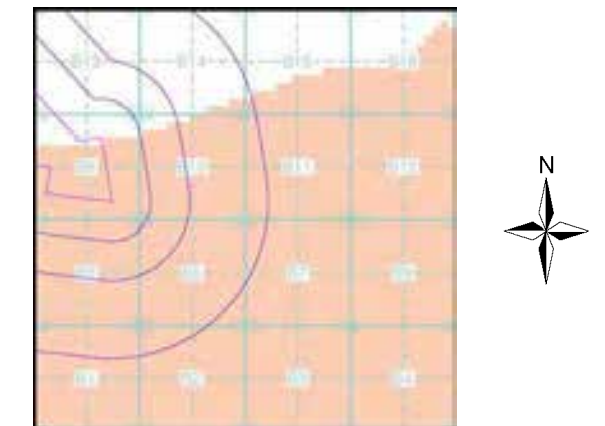
Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 100 Year Return Velocity and Flow Direction Map (1:10,000)



EA/NRW Suitability Map - Slice B



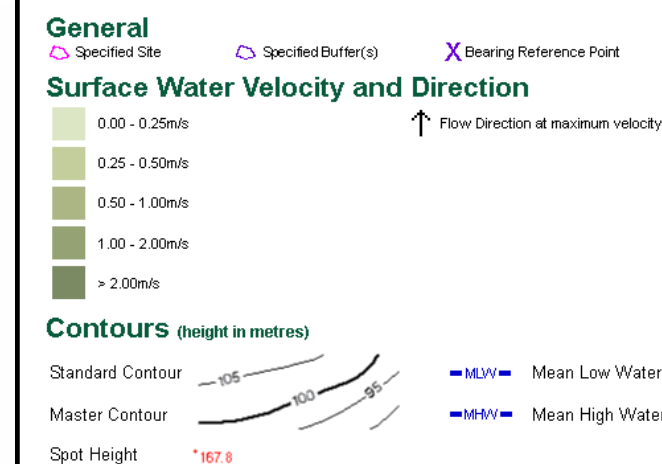
Order Details

Order Number: 302366136_1_1
Customer Ref: 500199 TKRE
National Grid Reference: 567880, 174130
Slice: B
Site Area (Ha): 72.49
Search Buffer (m): 1000

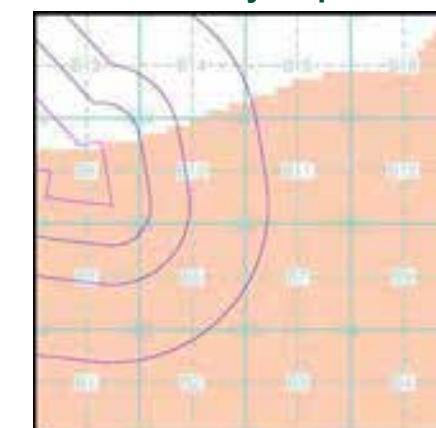
Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 1000 Year Return Velocity and Flow Direction Map (1:10,000)



EA/NRW Suitability Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 30 Year Return Hazard Rating Map (1:10,000)

General
 Specified Site Specified Buffer(s) X Bearing Reference Point

Surface Water Hazard Rating

Low (0.5 – 0.75)
 Moderate (0.75 – 1.25)
 Significant (1.25 – 2.0)
 Extreme (>2.0)

Contours (height in metres)

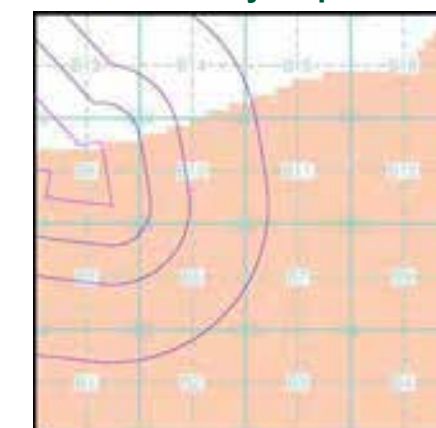
Standard Contour 105 100 95
 Master Contour
 Spot Height *167.8
 MLW Mean Low Water
 MHW Mean High Water

Suitability

See the suitability map below

National to county
 County to town
 Town to street
 Street to parcels of land
 Property

EA/NRW Suitability Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 100 Year Return Hazard Rating Map (1:10,000)

General
 Specified Site Specified Buffer(s) X Bearing Reference Point

Surface Water Hazard Rating

Low (0.5 – 0.75)
 Moderate (0.75 – 1.25)
 Significant (1.25 – 2.0)
 Extreme (>2.0)

Contours (height in metres)

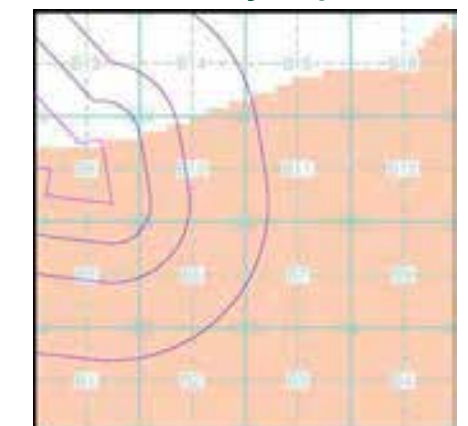
Standard Contour 105 100 95
 Master Contour
 Spot Height *167.8
 MLW Mean Low Water
 MHW Mean High Water

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 Property

EA/NRW Suitability Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Surface Water 1000 Year Return Hazard Rating Map (1:10,000)

General
 Specified Site Specified Buffer(s) X Bearing Reference Point

Surface Water Hazard Rating

Low (0.5 – 0.75)
 Moderate (0.75 – 1.25)
 Significant (1.25 – 2.0)
 Extreme (>2.0)

Contours (height in metres)

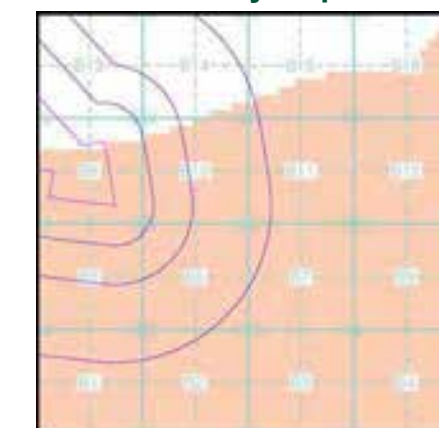
Standard Contour 105 100 95
 Master Contour
 Spot Height *167.8
 MLW Mean Low Water
 MHW Mean High Water

Suitability

See the suitability map below

National to county
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 Property

EA/NRW Suitability Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

OS Water Network Lines Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

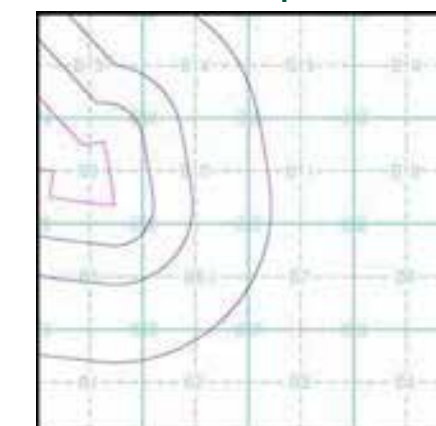
OS Water Network Data

- | | |
|----------------|---------------------------|
| — Canal | — Drain |
| — Reservoir | — Other |
| — Foreshore | — Lake |
| — Marsh | — Transfer |
| — Tidal River | — Lock Or Flight Of Locks |
| — Inland River | — Sea |
| ● Junction | ● Source |
| ● Outlet | ● Other |
| ● Pseudo | |

Contours (height in meters)

- Standard Contour — 10m
- Master Contour — 100m
- Spot Height — 1m
- MLW — Mean Low Water
- MHW — Mean High Water

OS Water Network Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

General

-  Specified Site
-  Specified Buffer(s)
-  Bearing Reference Point

Risk of Flooding from Surface Water

-  High - 30 Year Return
-  Medium - 100 Year Return
-  Low - 1000 Year Return

Suitability

See the suitability map below

-  National to county
-  County to town
-  Town to street
-  Street to parcels of land
-  Property

EA/NRW Suitability Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

EA/NRW Historic Flood Map (1:10,000)

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Map ID

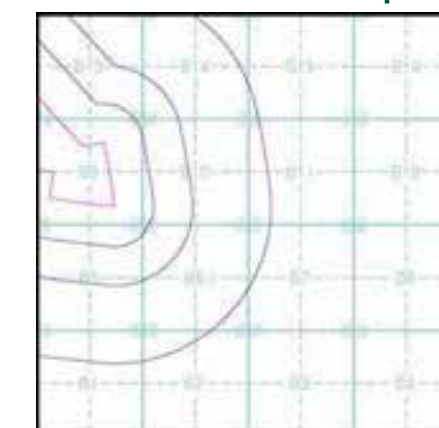
Historic Flood Events Data

- | | |
|--|--|
| Channel Capacity Exceeded (no raised defences) | Obstruction/Blockage - Culvert |
| Channel Capacity Exceeded /Surface Water | Obstruction/Blockage - Debris Screen |
| Groundwater/High Water Table | Operational Failure/ Breach of Defence |
| Local Drainage/Surface Water | Other |
| Mechanical Failure | Overtopping of Defences |
| Obstruction/Blockage - Bridge | Surface Water |
| Obstruction/Blockage - Channel | Unknown |
| Historical Flood Liabilities | |

Contours (height in metres)

- Standard Contour 105 100 95
- Master Contour
- Spot Height *167.8
- MLW Mean Low Water
- MHW Mean High Water

EA/NRW Historic Flood Map - Slice B

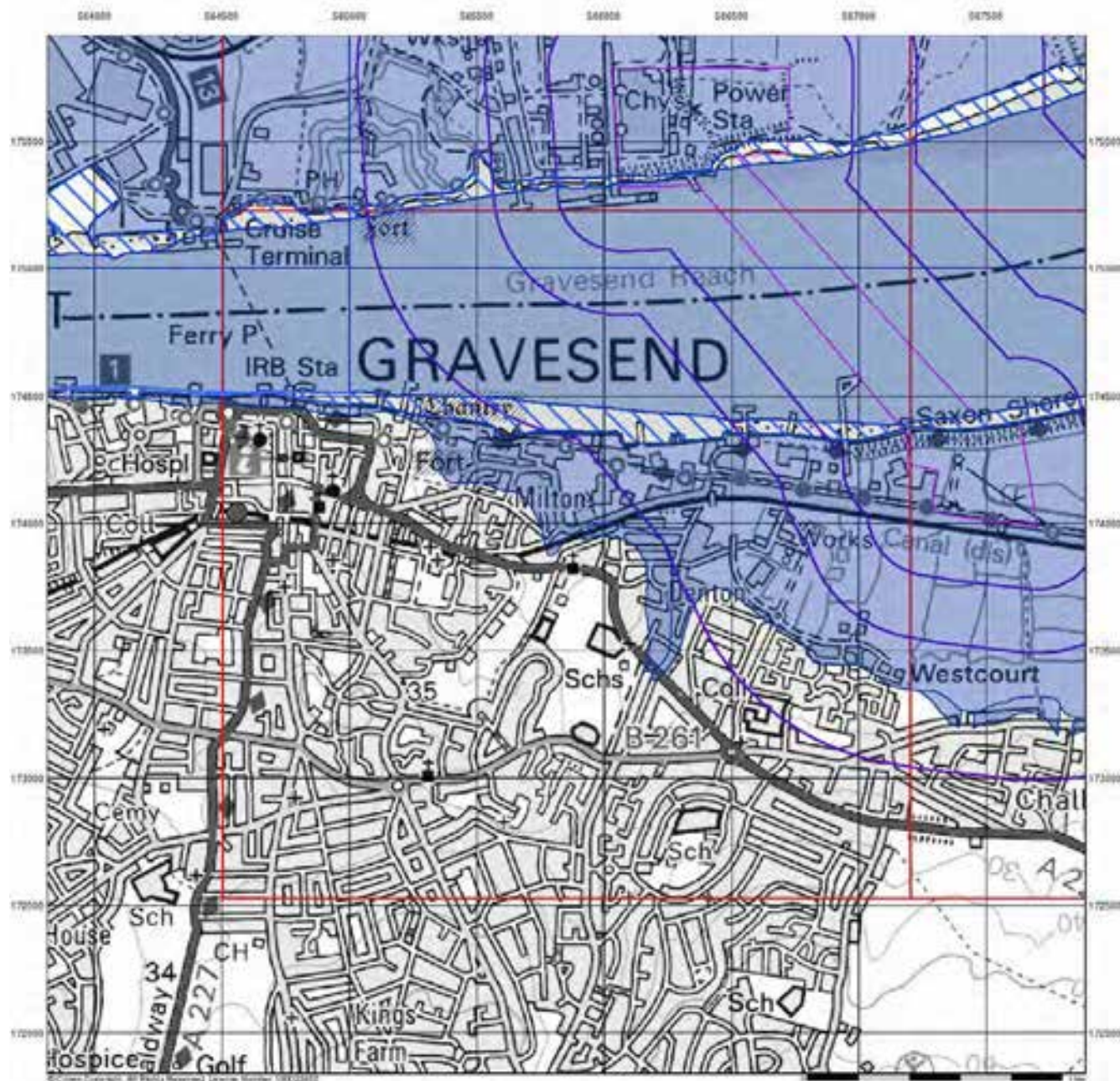


Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock



BGS Flood Data (1:50,000)

General

- ◇ Specified Site
- ◇ Specified Buffer(s)
- X Bearing Reference Point
- Slice
- B Map ID

BGS Geological Indicators of Flooding

- ▨ Coastal
- ▨ Inland
- ▨ Bodies of Water

BGS Flood Data Map - Slice A

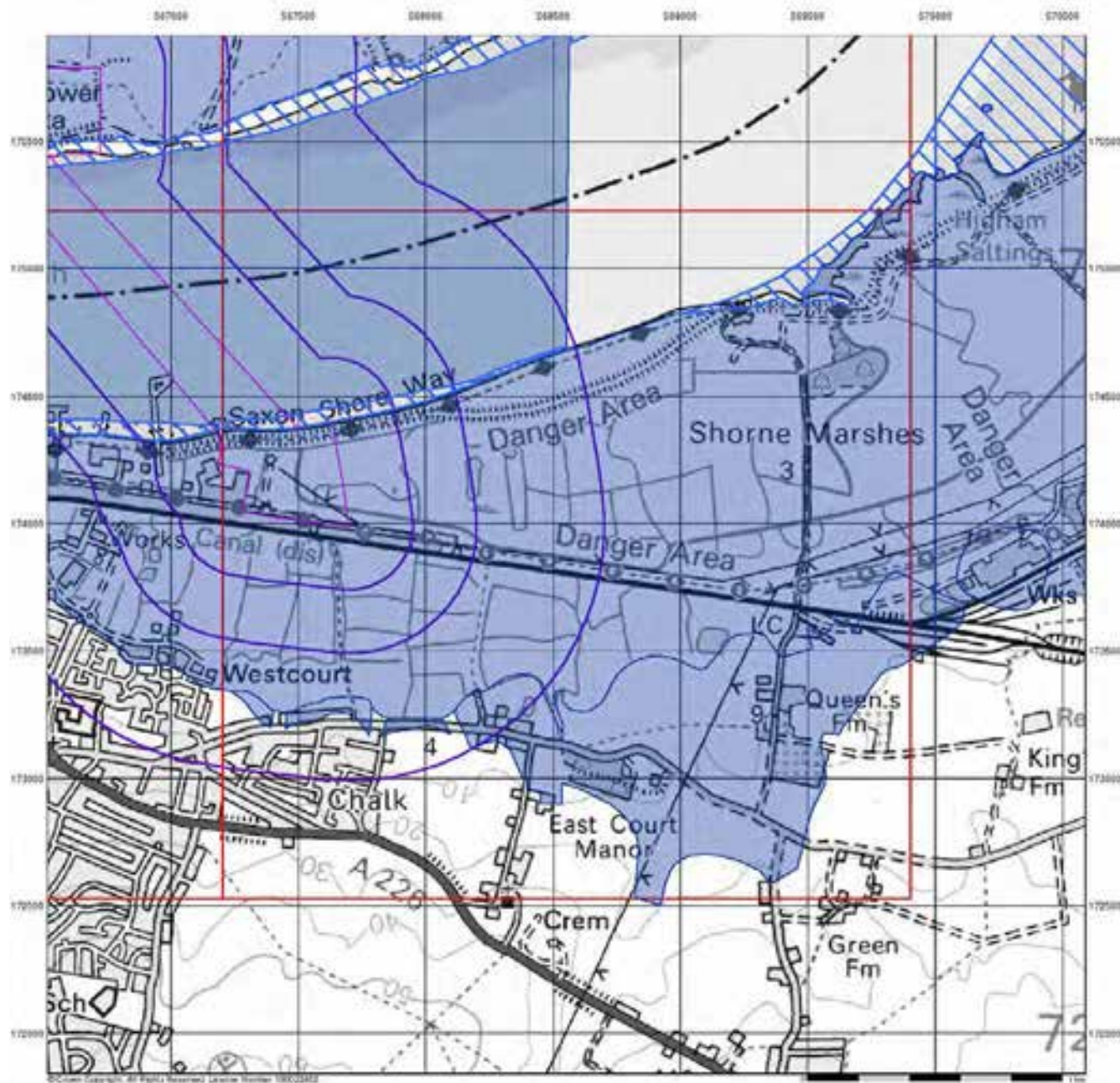


Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566430, 174430
 Slice: A
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock



BGS Flood Data (1:50,000)

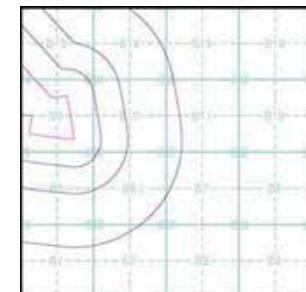
General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Slice
- Map ID

BGS Geological Indicators of Flooding

- Coastal
- Inland
- Bodies of Water

BGS Flood Data Map - Slice B

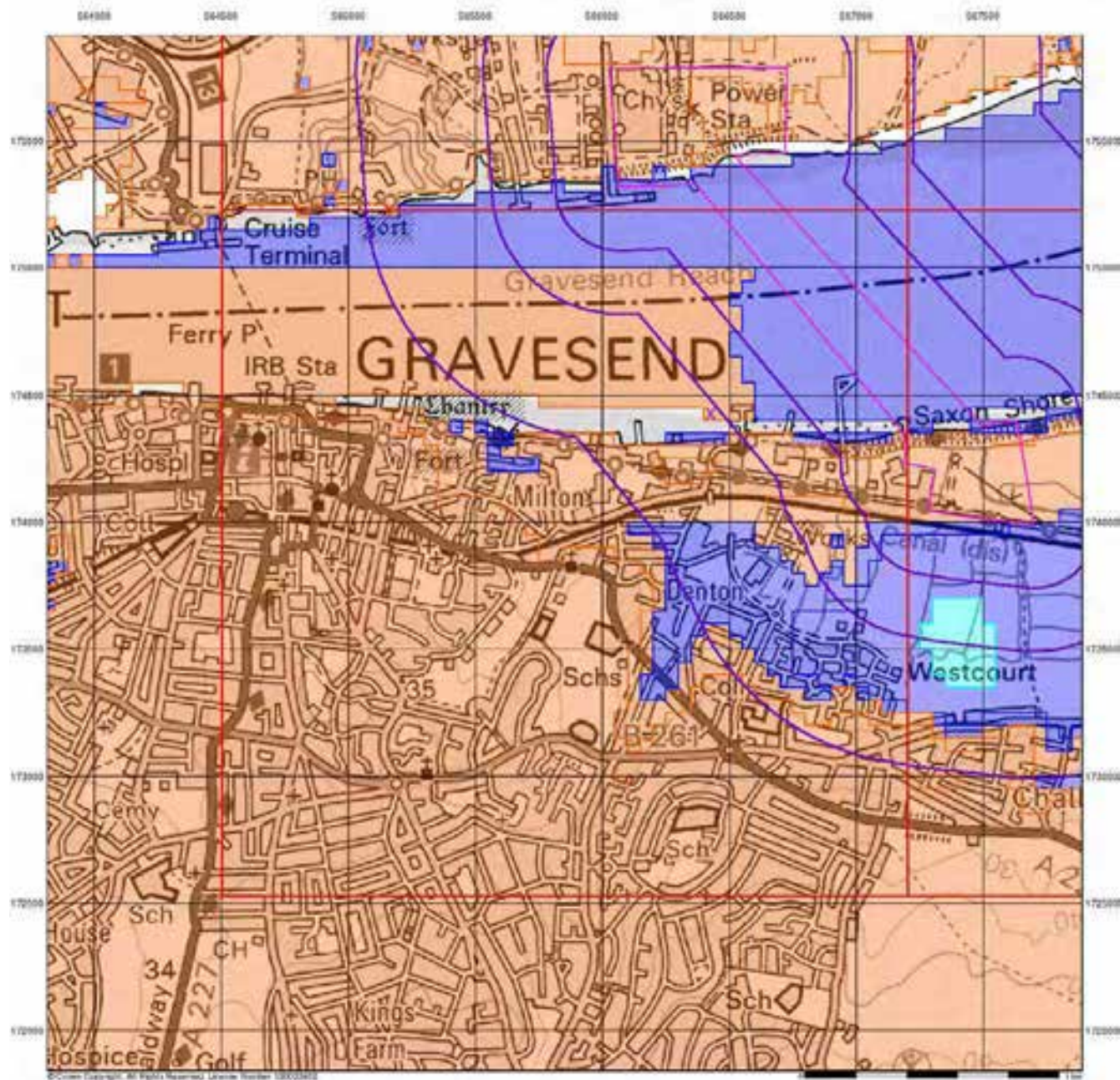


Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock



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BGS Flood GFS Data

General

- Specified Site
- Specified Buffer(s)
- Missing Reference Point
- Slice

Agency and Hydrological (Flood)

- Limited Potential for Groundwater Flooding to Occur
- Potential for Groundwater Flooding of Property Situated Below Ground Level
- Potential for Groundwater Flooding to Occur at Surface

Site Sensitivity Context Map - Slice A



Order Details

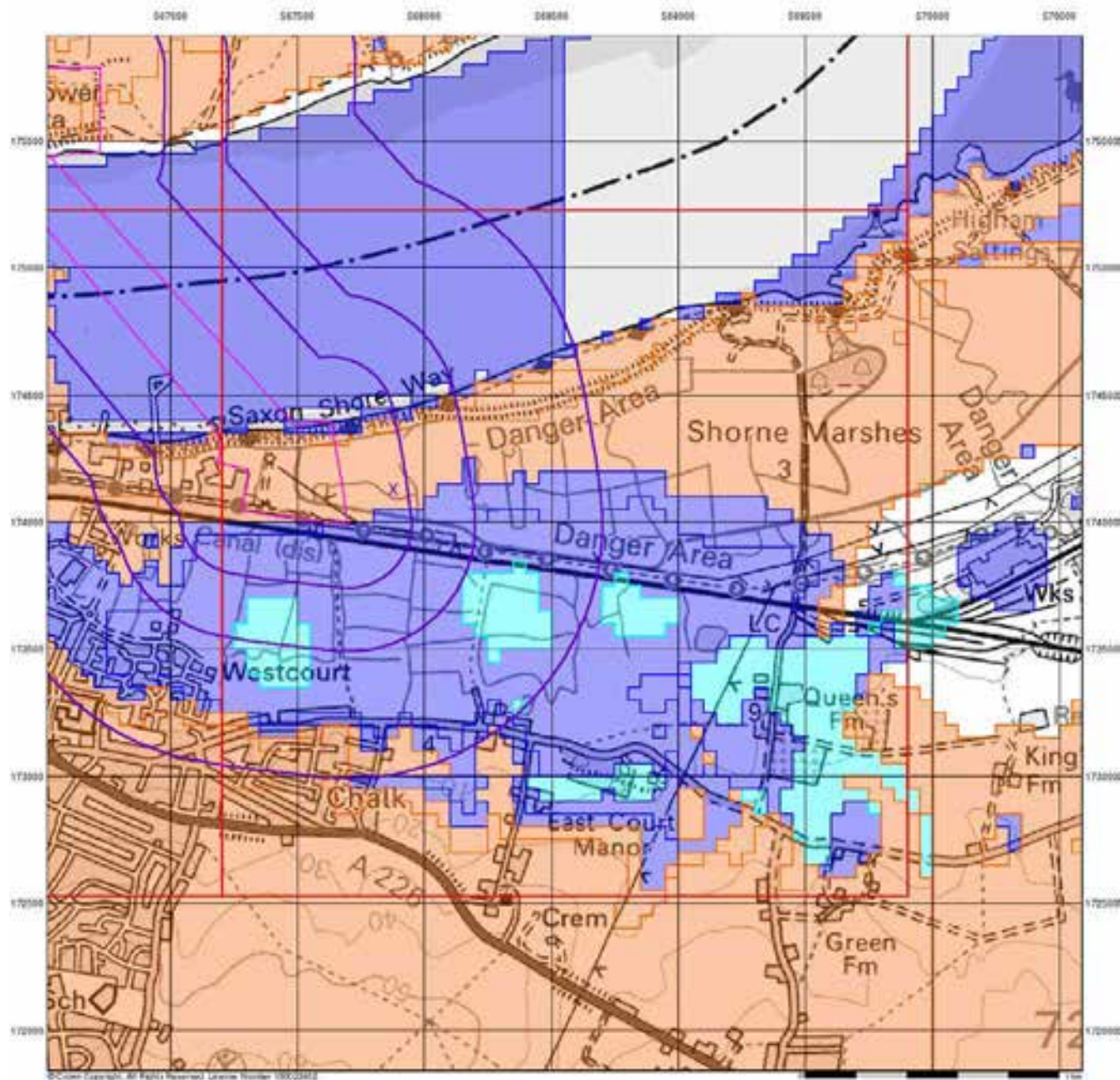
Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566430, 174430
 Slice: A
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

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 Web: www.envirocheck.co.uk



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BGS Flood GFS Data

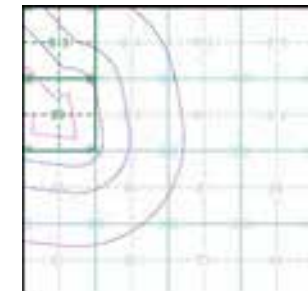
General

- Specified Site
- Specified Buffer(s)
- Missing Reference Point
- Slice

Agency and Hydrological (Flood)

- Limited Potential for Groundwater Flooding to Occur
- Potential for Groundwater Flooding of Property Situated Below Ground Level
- Potential for Groundwater Flooding to Occur at Surface

Site Sensitivity Context Map - Slice B



Order Details

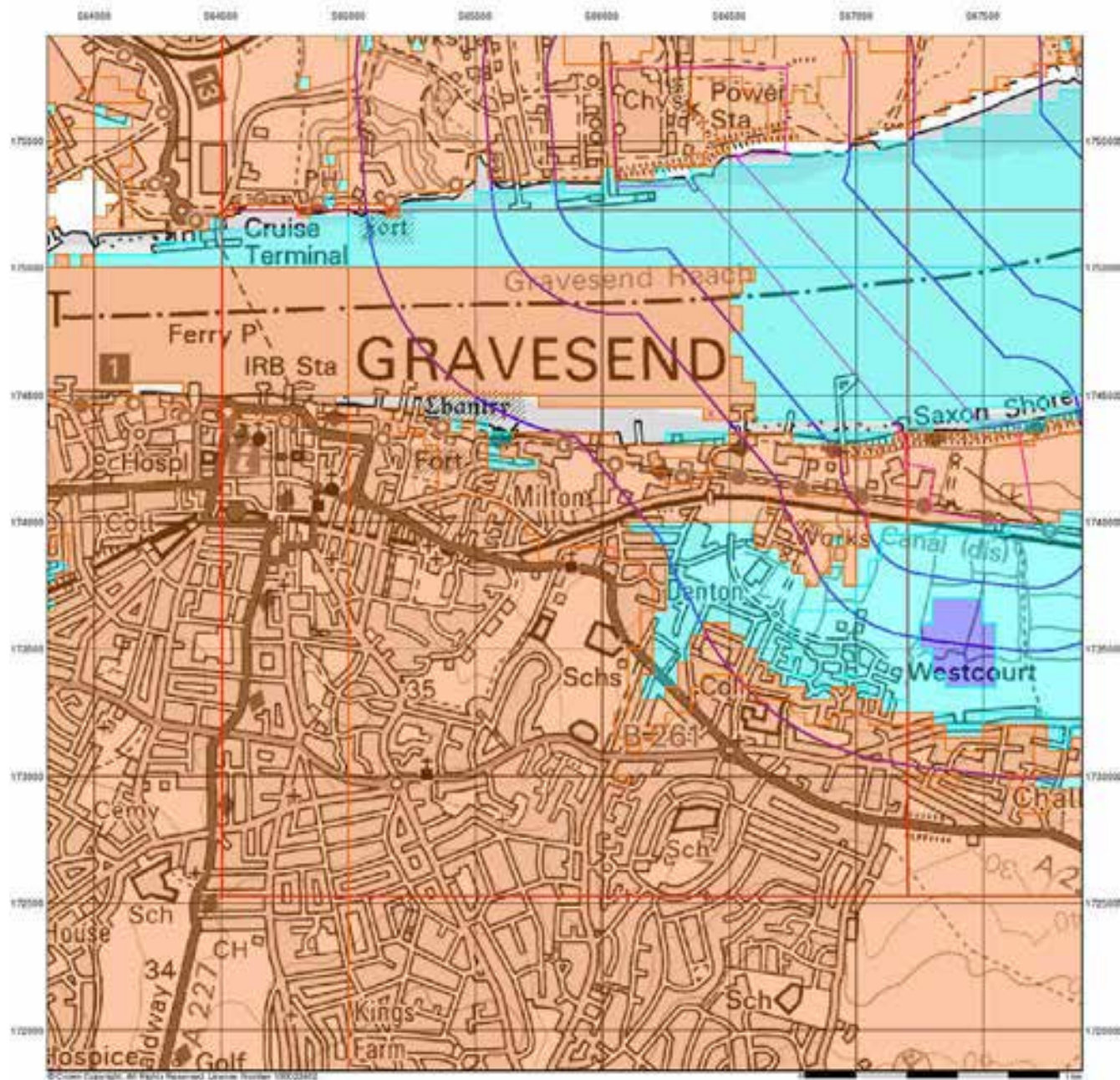
Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

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 Fax: 0844 844 9951
 Web: www.envirocheck.co.uk



BGS Flood Data (1:50,000)

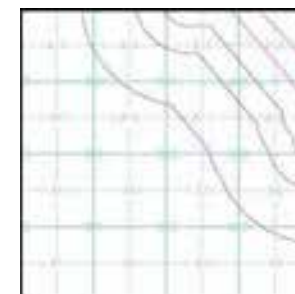
General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Slice
- Map ID

BGS Groundwater Flooding Susceptibility

- Potential for Groundwater Flooding to Occur at Surface
- Potential for Groundwater Flooding of Property Situated Below Ground Level
- Limited Potential for Groundwater Flooding to Occur

BGS Flood Data Map - Slice A

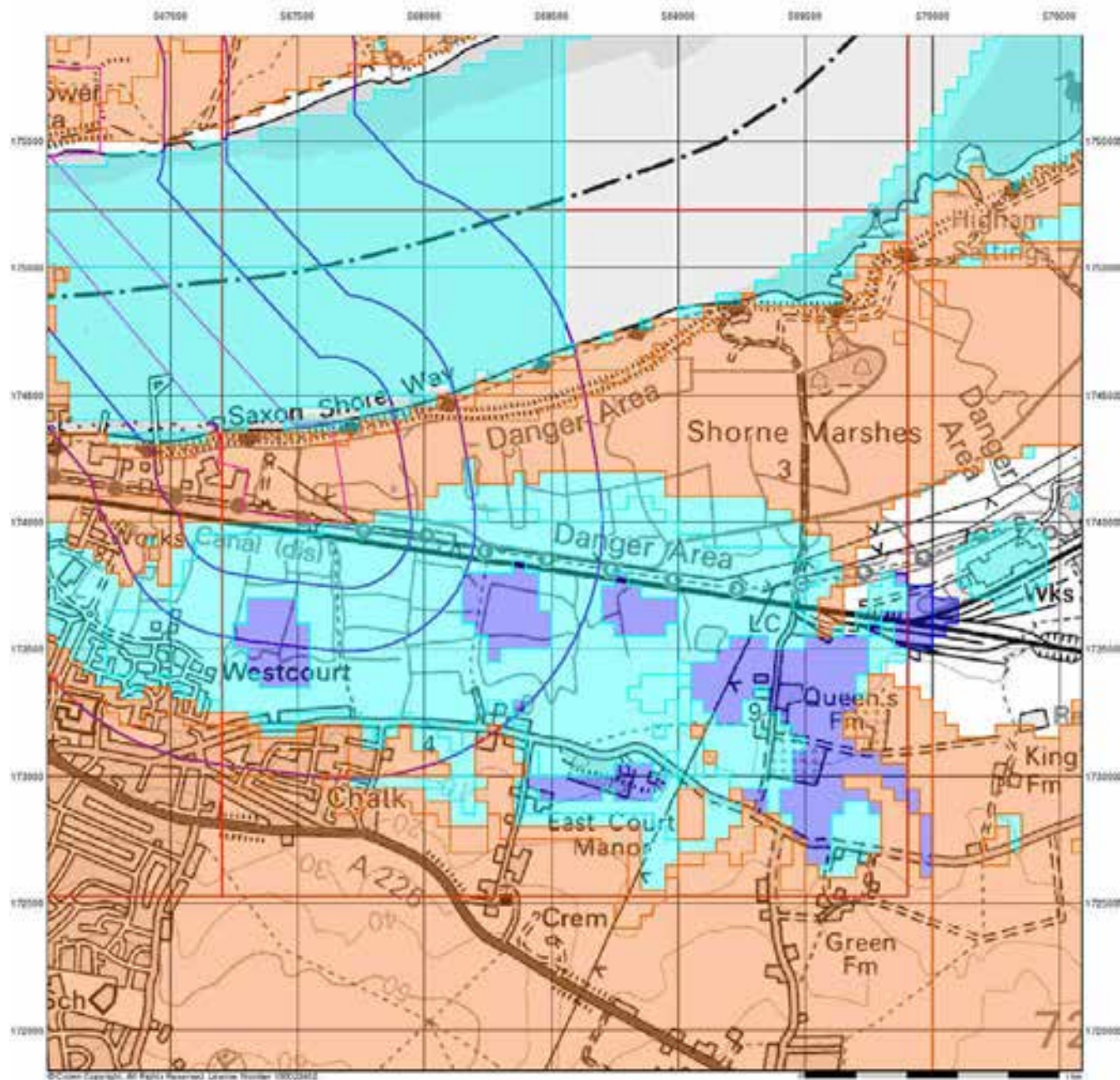


Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566430, 174430
 Slice: A
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock



BGS Flood Data (1:50,000)

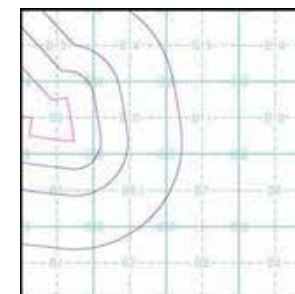
General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Slice
- Map ID

BGS Groundwater Flooding Susceptibility

- Potential for Groundwater Flooding to Occur at Surface
- Potential for Groundwater Flooding of Property Situated Below Ground Level
- Limited Potential for Groundwater Flooding to Occur

BGS Flood Data Map - Slice B

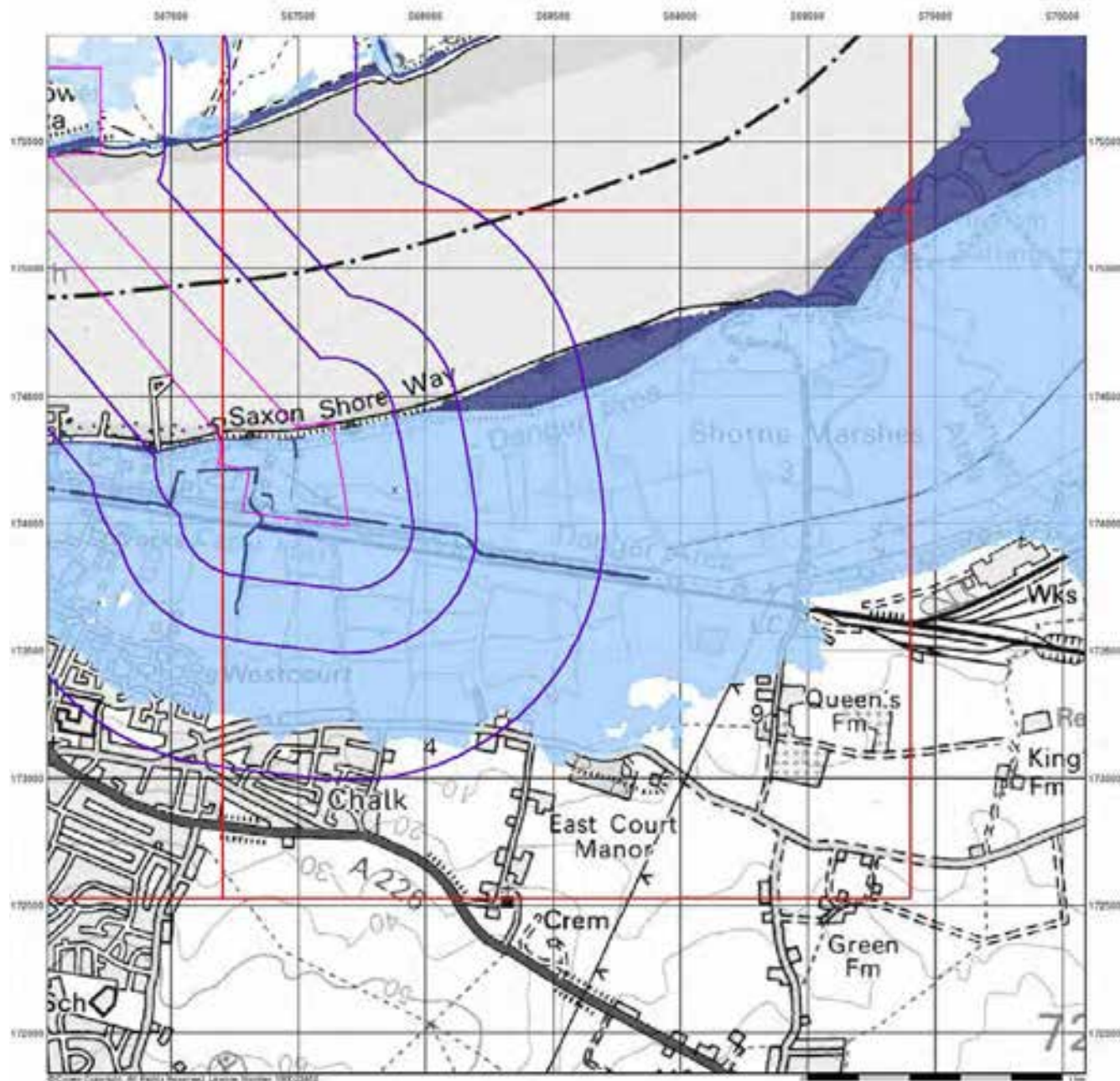


Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock



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EA/NRW RoFRS Data (1:50,000)

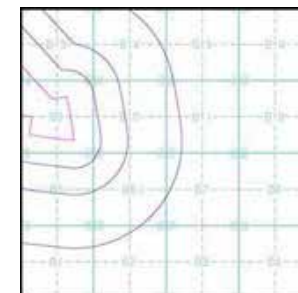
General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point
- Slice
- 8 Map ID

Risk of Flooding from Rivers and Sea (RoFRS)

- High Risk
- Medium Risk
- Low Risk
- Very Low Risk

EA/NRW RoFRS Data Map - Slice B



Order Details

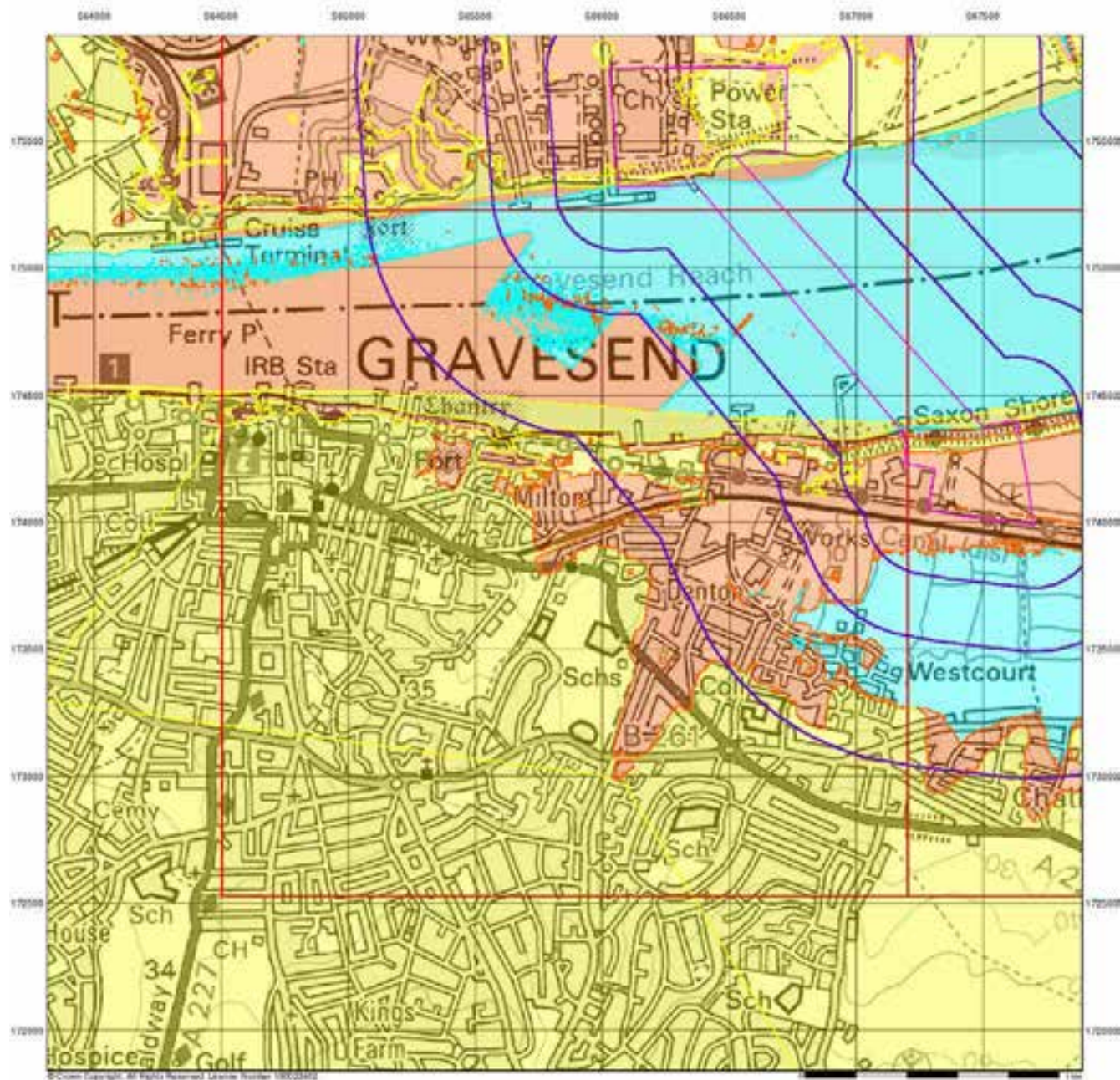
Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

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 Fax: 0844 844 9951
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GeoSmart Information Groundwater Flood Map (1:50,000)

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Slice

GeoSmart Information Groundwater Flooding Risk

- High Risk
- Moderate Risk
- Low Risk
- Negligible Risk

GeoSmart Information Groundwater Flood Map - Slice A



Order Details

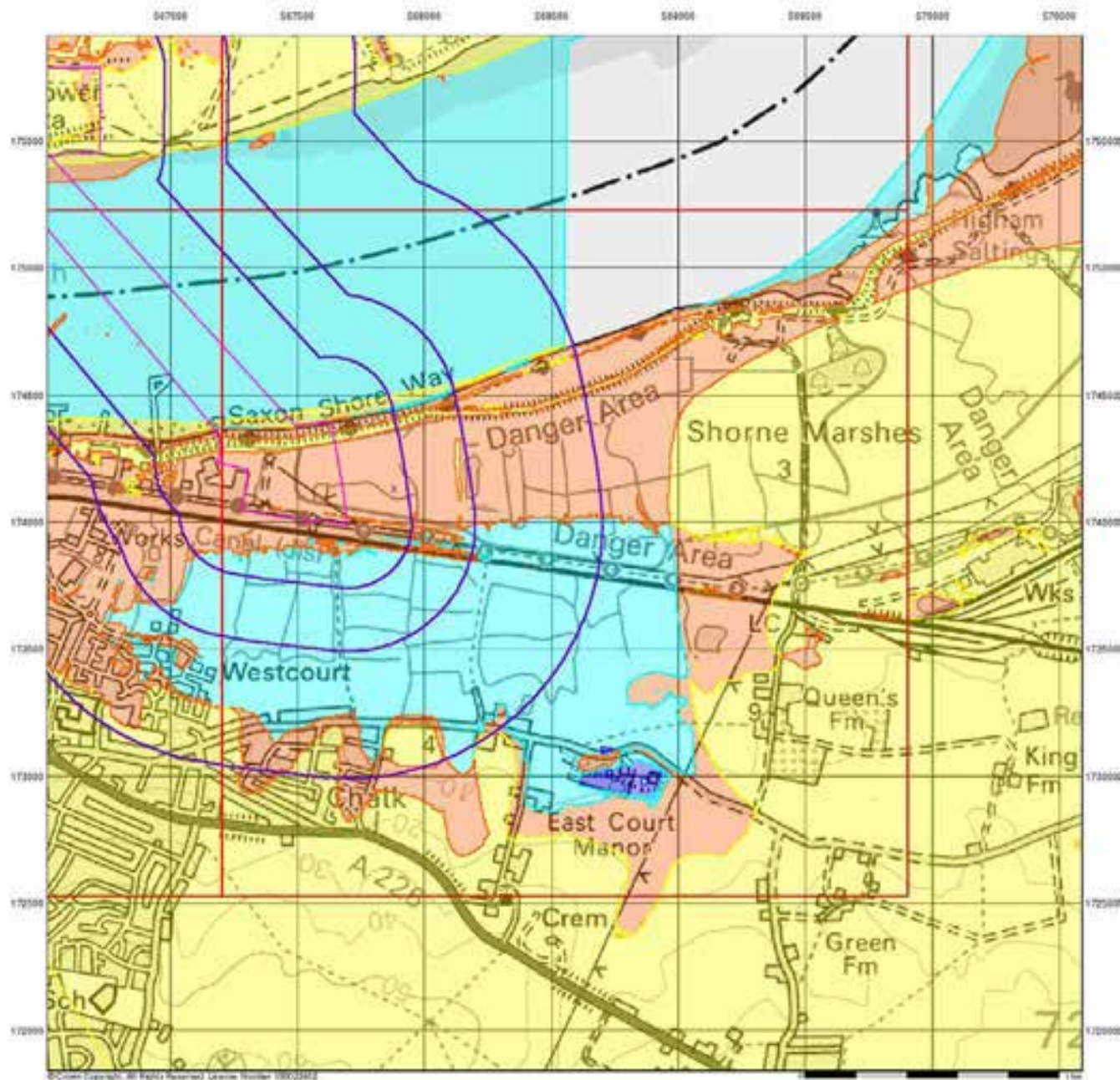
Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 566430, 174430
 Slice: A
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

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 Fax: 0844 844 9951
 Web: www.envirocheck.co.uk



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GeoSmart Information Groundwater Flood Map (1:50,000)

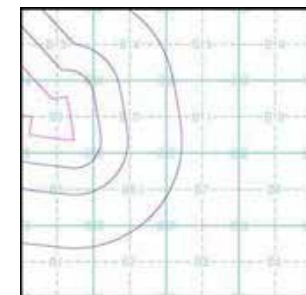
General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point
- Slice

GeoSmart Information Groundwater Flooding Risk

- High Risk
- Moderate Risk
- Low Risk
- Negligible Risk

GeoSmart Information Groundwater Flood Map - Slice B



Order Details

Order Number: 302366136_1_1
 Customer Ref: 500199 TKRE
 National Grid Reference: 567880, 174130
 Slice: B
 Site Area (Ha): 72.49
 Search Buffer (m): 1000

Site Details

Site at, Tilbury, Thurrock

Landmark[®]
 LANDMARK INFORMATION GROUP

Tel: 0844 844 9952
 Fax: 0844 844 9951
 Web: www.envirocheck.co.uk

Flood map for planning

Your reference
Gravesend

Location (easting/northing)
567427/174139

Created
21 Mar 2023 16:24

**Your selected location is in flood zone 3
– an area with a high probability of flooding.**

This means:

- you may need to complete a flood risk assessment for development in this area
- you should ask the Environment Agency about the level of flood protection at your location and request a Flood Defence Breach Hazard Map (You can email the Environment Agency at: enquiries@environment-agency.gov.uk)
- you should follow the Environment Agency's standing advice for carrying out a flood risk assessment (find out more at www.gov.uk/guidance/flood-risk-assessment-standing-advice)

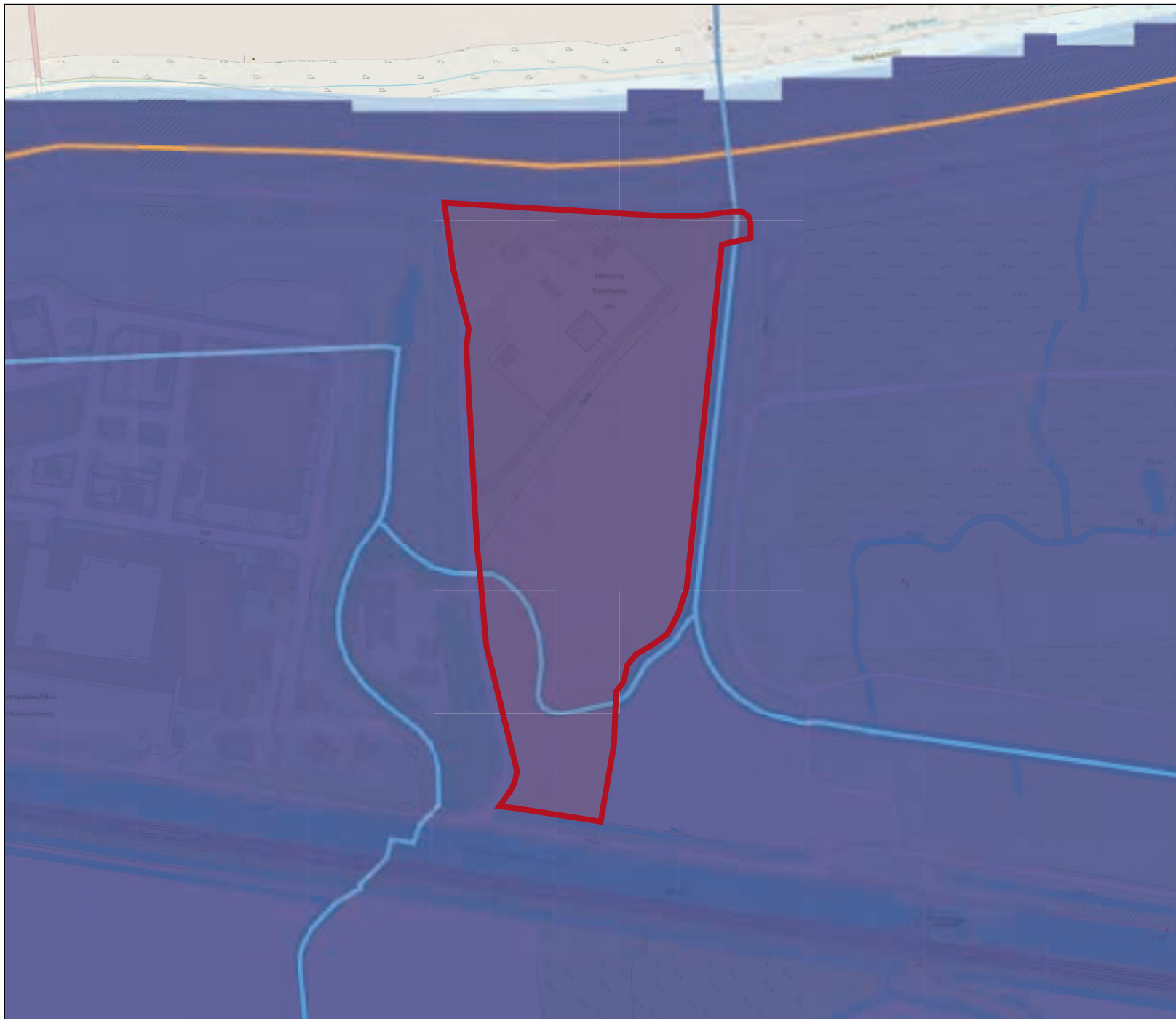
Notes

The flood map for planning shows river and sea flooding data only. It doesn't include other sources of flooding. It is for use in development planning and flood risk assessments.

This information relates to the selected location and is not specific to any property within it. The map is updated regularly and is correct at the time of printing.

Flood risk data is covered by the Open Government Licence which sets out the terms and conditions for using government data. <https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>

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Flood map for planning

Your reference

Gravesend

Location (easting/northing)

567427/174139

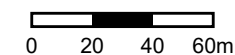
Scale

1:2500

Created

21 Mar 2023 16:24

-  Selected area
-  Flood zone 3
-  Flood zone 2
-  Flood zone 1
-  Flood defence
-  Main river
-  Water storage area



Flood map for planning

Your reference
Gravesend

Location (easting/northing)
567427/174139

Created
21 Mar 2023 16:27

**Your selected location is in flood zone 3
– an area with a high probability of flooding.**

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Notes

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Flood map for planning

Your reference
Gravesend

Location (easting/northing)
567427/174139

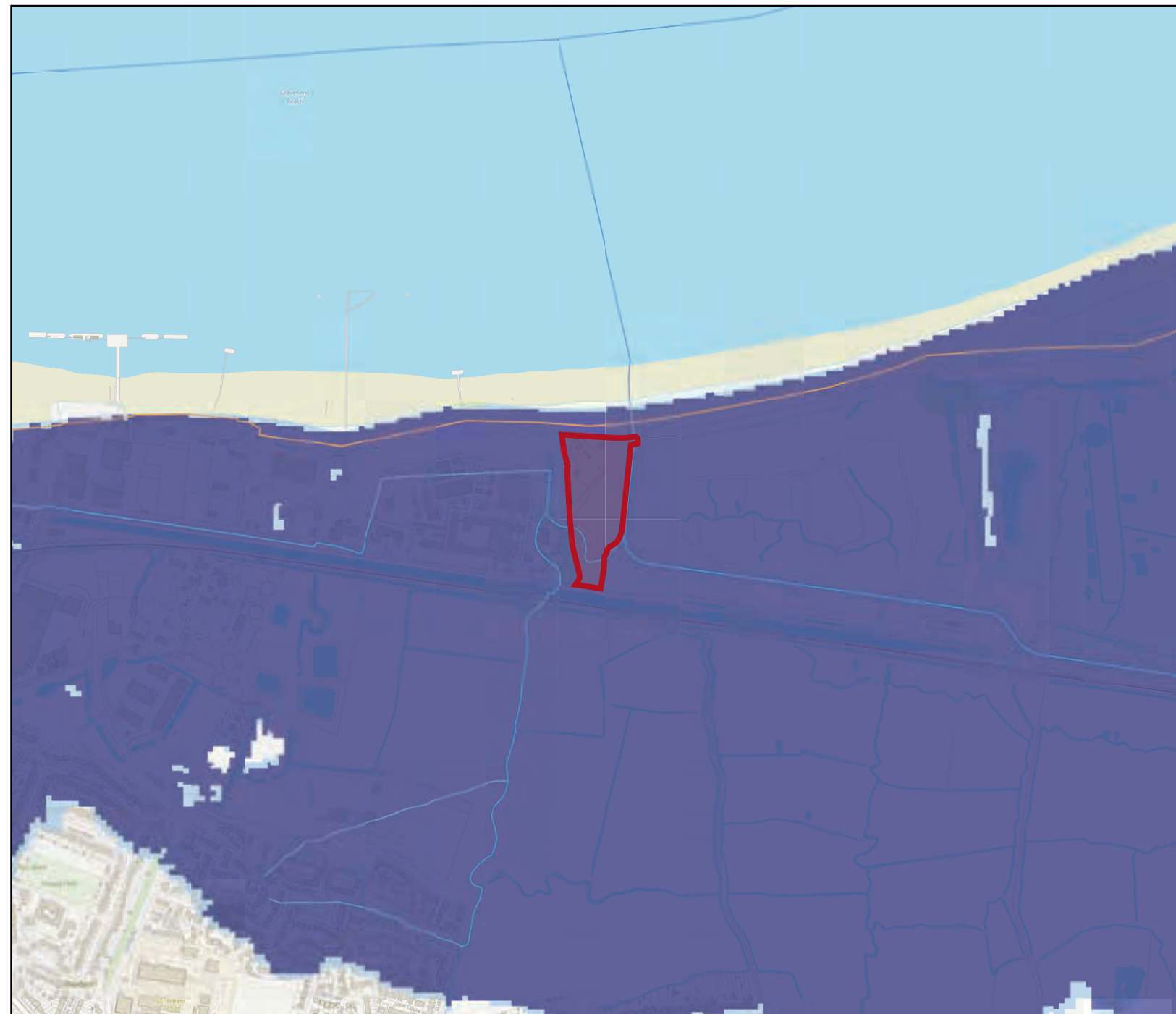
Scale
1:10000

Created
21 Mar 2023 16:27

-  Selected area
-  Flood zone 3
-  Flood zone 2
-  Flood zone 1
-  Flood defence
-  Main river
-  Water storage area

0 100 200 300m

Page 2 of 2



Hill, Nigel (MSES)

From: KSL PSO SE London & North Kent <PSO.SELondonandNKent@environment-agency.gov.uk>
Sent: 06 April 2023 20:01
To: Hill, Nigel (MSES)
Cc: KSL Enquiries
Subject: RE: NR305781 RL: Gravesend Shaft

Dear Nigel,

Re: NR305781 RL: Gravesend Shaft

Thank you for your enquiry which was received on 23 March 2023.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

You have requested a Product 4, 5, 6, 7 and 8, please see Appendix 1 below detailing each product.

Your request for a Product 4 and 8 falls under the exemption in provision 6(1)(a) and (b) of the Environmental Information Regulations 2004 (EIR), and on this occasion we are not providing the information in the requested format, but in an alternative format. Further detail of the provisions under the EIR can be found in Appendix 2.

Please find below the link containing the Product 5 and 6

Thames Tidal Downriver Breach Inundation Modelling 2018 <https://defra.sharefile.com/d-s7fa7e1d01734d5a9>

Product 8 data can be derived using the depth (d) velocity (v) and hazard (ZKU0) 2D grids which are provided in the Product 6 dataset

We have also enclosed Thames Estuary 2100 information.

We are licensing the supplied data to you under the [Environment Agency Conditional Licence](#), details of which are included in the ShareFile link. You must first check this supporting information, to determine if the conditions of use are suitable for your purposes. If the conditions for use are not suitable for your purposes, this information is not provided with a licence for use, and the data is provided for the right to read only.

The information provided in the ShareFile link is based on the best data available as of the date of this letter. You may feel it is appropriate to contact us at regular intervals, to check whether any amendments/ improvements have been made to the data for this location. Should you re-contact us after a period of time, please quote the above reference in order to help us deal with your query.

Requests for flood products in Kent, South London and East Sussex

Please note that we changed our process in December 2019 for responding to flood product data requests. Where appropriate, we supply the data in its raw form (Product 6), as opposed to in the Product 4 and/or 8 PDF format. This is to improve efficiency within our area of the Environment Agency, and to provide customers with a more rapid and flexible response. Where customers are unable to use the Model Output Data (Product 6), or if the data is particularly complex, we will continue to produce Product 4 and 8 formats.

The Product 4 and 8 itself is not a direct requirement in the planning process, but the data that goes into the Product 4 and 8 is required to inform your Flood Risk Assessment. This data can be extracted from the Product 6 data provided in the ShareFile link and in open data sources listed below. Instructions on how to use the appropriate data are provided on the ShareFile link.

Other flood data sources

The Flood Map for Planning is available to view and export maps for your site at: <https://flood-map-for-planning.service.gov.uk/>

Flood Zone 3 <https://data.gov.uk/dataset/flood-map-for-planning-rivers-and-sea-flood-zone-3>

Flood Zone 2 <https://data.gov.uk/dataset/flood-map-for-planning-rivers-and-sea-flood-zone-2>
Historic Flood Map <https://data.gov.uk/dataset/historic-flood-map1>

Please note that our historic flood event maps may not be comprehensive. We would therefore advise that you make further enquiries locally with specific reference to flooding at your location. You should consider contacting the relevant Local Planning Authority and/or water/sewerage undertaker for the area.

Please be aware that flooding can come from different sources. Examples of these are:

- from rivers or the sea
- surface water (i.e. rainwater flowing over or accumulating on the ground before it is able to enter rivers or the drainage system)
- overflowing or backing up of sewer or drainage systems which have been overwhelmed
- groundwater rising up from underground aquifers

Currently the Environment Agency can only supply flood risk data relating to the chance of flooding from rivers or the sea. The Lead Local Flood Authority is responsible for surface water flooding issues. Please contact them for further information or for details on groundwater flood risk.

Defence Information

Asset type / Description – Natural High Ground

Location – Gravesend Shaft

Maintainer – Environment Agency

Design Standard of protection – 5

Asset protection type – Fluvial

Condition – 4

Build date – 21/11/2012

Environment Agency planning guidance and pre application service.

- Planning practice guidance - provides information about planning considerations in areas at risk of flooding <https://www.gov.uk/guidance/flood-risk-and-coastal-change>
- Planning applications: assessing flood risk - information about completing flood risk assessments <https://www.gov.uk/planning-applications-assessing-flood-risk>
- Site specific flood risk assessment checklist - a checklist to help ensure you have considered all the relevant factors in your flood risk assessment <http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/site-specific-flood-risk-assessment-checklist/>
- Climate change allowance guidance - <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

We recommend that you discuss your proposals with the Local Planning Authority at the earliest opportunity. They will be able to advise you on a wide range of planning matters in addition to flood risk.

Please see our website for details on how to get planning advice from the Environment Agency, including charged-for discretionary advice <https://www.gov.uk/guidance/developers-get-environmental-advice-on-your-planning-proposals#when-to-consult>. Our planning team can be contacted at kslplanning@environment-agency.gov.uk

If you have a new enquiry or would like us to review the information we have provided under the Freedom of Information Act 2000 and Environmental Information Regulations 2004 please contact us within two months by email at KSLE@environment-agency.gov.uk

Regards,

Layo Oluwole

Flood & Coastal Risk Management Officer

Partnership & Strategic Overview - South East London & North Kent

Kent, South London and East Sussex Area

Environment Agency | Orchard House, London Road, Addington, West Malling, ME19 5SH

PSO.SELondonandNKent@environment-agency.gov.uk



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Appendix 1

Product 4	Detailed Flood Risk Assessment Map, including flood zones, defences and storage areas, areas benefiting from defences, statutory main river designations, historic flood event outlines and more detailed information from hydraulic models (including model extents and 2D flood level data for specific points)
Product 5	Reports, including flood modelling reports, model user logs and guides, hydrology reports, etc
Product 6	Model Output Data, including product 5. • flood outlines usually provided in shapefile format • 2D grids (level (h), depth (d) velocity (v) and hazard ZKU0) usually provided in ASCII or GeoTIFF format • 1D flow and level data Requires GIS software such as ArcGIS, MapInfo, QGIS or similar.
Product 7	Calibrated and Verified Model Input Data (CaVMID), including product 5. Enables customer to re-run and/or make changes to a hydraulic model. Requires specific hydraulic modelling software such as Flood Modeller, TUFLOW, or ICM InfoWorks.
Product 8	Breach Hazard Map Provides a hazard map of breaches in PDF format including, maximum flood depth, maximum flood velocity and maximum flood hazard. Please note product 8 is not available for fluvial models.

Appendix 2

The exemption in provision 6(1)(a) and (b) of the Environmental Information Regulations 2004 (EIR) states that

‘.....6.—(1) Where an applicant requests that the information be made available in a particular form or format, a public authority shall make it so available, unless—

(a) it is reasonable for it to make the information available in another form or format; or

(b) the information is already publicly available and easily accessible to the applicant in another form or format.....’

On this occasion we are not providing the information in the requested format, for the following reasons:

- Complying with the preference would incur a significant cost, which the public authority [The Environment Agency] cannot pass on to the requester;
- Using a Product 5/6/7 allows us to make the information available at a lower cost; and
- The impact on the available resources of the public authority [The Environment Agency], of supplying a Product 5/6/7, is therefore much less.

From: Hill, Nigel (MSES) <Nigel.Hill2@morgansindall.com>

Sent: 23 March 2023 14:31

To: Enquiries, Unit <enquiries@environment-agency.gov.uk>

Subject: ref: 230331/KT10 - Request for a Flood Defence Breach Hazard Map and information

To whom it may concern.

I would like to request two flood defence breach hazard maps centred around the following coordinates for the construction of shafts for a cable tunnel across the Thames river. I would be good to have the maps to include at least a 500m radius from these coordinates as to include the shoreline and flood defences.

The areas are located in flood zone 3 so we would be interested in receiving your products

- flood zone 3 choose from products 4, 5, 6, or 7
- flood zone 3 in an area behind raised flood defences use product 8

as described in your Guidance Flood risk assessments if you're applying for planning permission
<https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications#contact>

Shaft	X (Easting)	Y (Northing)
-------	-------------	--------------

Tilbury Shaft	566288.1	175840.6
---------------	----------	----------

Gravesend Shaft	567445.7	174136.6
-----------------	----------	----------

Screen shots with coordinate location and boundary outlines are included below and attached

Can you please let me know when you might be able to send them across.





Kind Regards,

Nigel Hill MSc

Design Engineer

Morgan Sindall Engineering Solutions

M 078 0574 5260 nigel.hill2@morgansindall.com



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Morgan Sindall Engineering Solutions Limited

210 Euston Road

King's Cross

London, NW1 2DA

T 020 7078 0570

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Thames Estuary Breach Assessment

Thames Barrier to Gravesend and Linford

Methodology Report

Environment Agency

May 2018

Contains *private* information



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Atkins assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

This document has 22 pages including the cover.

Document history

Job number: 5143189			Document ref: 001			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	Issue	Rob Fulton	Rob Millington			

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1. Introduction

1.1. Background

London is a city that is constantly growing, and having a streamlined planning process to enable safe development is key to ensuring its sustainable growth. Any proposed development located within the Environment Agency's Flood Zone 2 and 3 needs to demonstrate that it has considered the flood risk to the development site. This evidence is expected to be provided within a Flood Risk Assessment, which considers all sources of flooding, to prove there will be no increase in flood risk to the site or elsewhere. A significant amount of London is sited on the floodplain of the River Thames, and therefore located within Flood Zones 2 and 3. The source of this flood risk is from both fluvial and tidal sources, with many areas in London being at a greater risk from the tidal source.

London benefits from a significant number of defences, which include the Thames Barrier and flood defence embankments upriver of the Barrier. There are also defences downriver of the Thames Barrier, protecting large areas of the floodplain along the tidal estuary.

As noted however, all sources of flooding need to be considered and there is a residual risk of failure of a flood defence asset. If a failure were to occur during a flood event, the impacts could be devastating resulting in rapid inundation and extensive flooding. The residual risk of a breach of the defences therefore must be considered within a site-specific Flood Risk Assessment (FRA) for any proposed development.

The Environment Agency reviews hundreds if not thousands of Flood Risk Assessments on an annual basis. A significant proportion of these need to consider the residual risk of a breach, as they are within Flood Zones 2 or 3 and in an area benefitting from a defence. It would not be practical to either request every developer to undertake their own individual breach modelling, or review every model that would have to be provided alongside an FRA. As a result of this, breach modelling has previously been commissioned by the Environment Agency to quantify the results of a breach at key locations along the Thames defences. These locations were pre-defined as, at the time of the previous studies, model run times were around 6 hours per scenario and it was not practical to model every individual location. As a result, that only specific areas in London have had quantification of the results of a breach of the defences.

Using the existing breach modelling, the Environment Agency provide site specific flooding information to developers in the format of a Product 4 request. A developer will be expected to use this information to inform their site specific FRA and to allow the residual risk of a breach to be mitigated (by for example increasing finished floor levels above the maximum breach level). Queries and concerns however can arise during this process, specifically when the site is located outside of a modelled breach extent.

This discrepancy was noted by members of the Environment Agency South East London and North Kent, and South West London and Mole Partnership and Strategic Overview (PSO) teams. A solution was proposed where all breach locations along the Thames downriver are equitably modelled, to ensure a consistent approach across London. This study has completed breach modelling at every location between the Thames Barrier and Gravesend on the south bank and Linford on the north bank. Recent technological advancements in hydraulic modelling and computer GPU processing speed have been exploited to enable this. The objectives of this study are listed below, and the study area of where the breach modelling has been undertaken is in Figure 2-1 below.

1.2. Objectives

The objectives of the Thames Estuary Breach Inundation Assessment study are as follows:

- Model individual breaches of the Thames defence line, to cover the entire extent between the Thames Barrier and Gravesend and Linford (see Figure 2-1 below);
- Use the previous Thames Tidal Breach Modelling Study (CH2M, 2015) as a framework to inform the methodology of an individual breach taken in this study;
- Undertake breach modelling for two return period events for two epochs to consider current and future hydrological conditions of the River Thames, namely the 2005 epoch 0.5% AEP and 0.1% AEP events, and the 2115 epoch 0.5% AEP and 0.1% AEP events;
- Use computer scripting and GIS data processing to automate the generation of breach scenarios;
- Use computer scripting to automatically simulate the individual breach scenarios and export the outputs to include maximum flood extent, depth, hazard and velocity for each breach scenario; and

- Combine the individual breach scenario outputs to generate a single maximum flood extent, depth, hazard and velocity outputs that can be used for future planning in London.

The tidal influence along the River Thames dominates for a large proportion of London including the whole study area for this assessment. The defences in London are designed for extreme tidal events and have not been designed against extreme fluvial events.

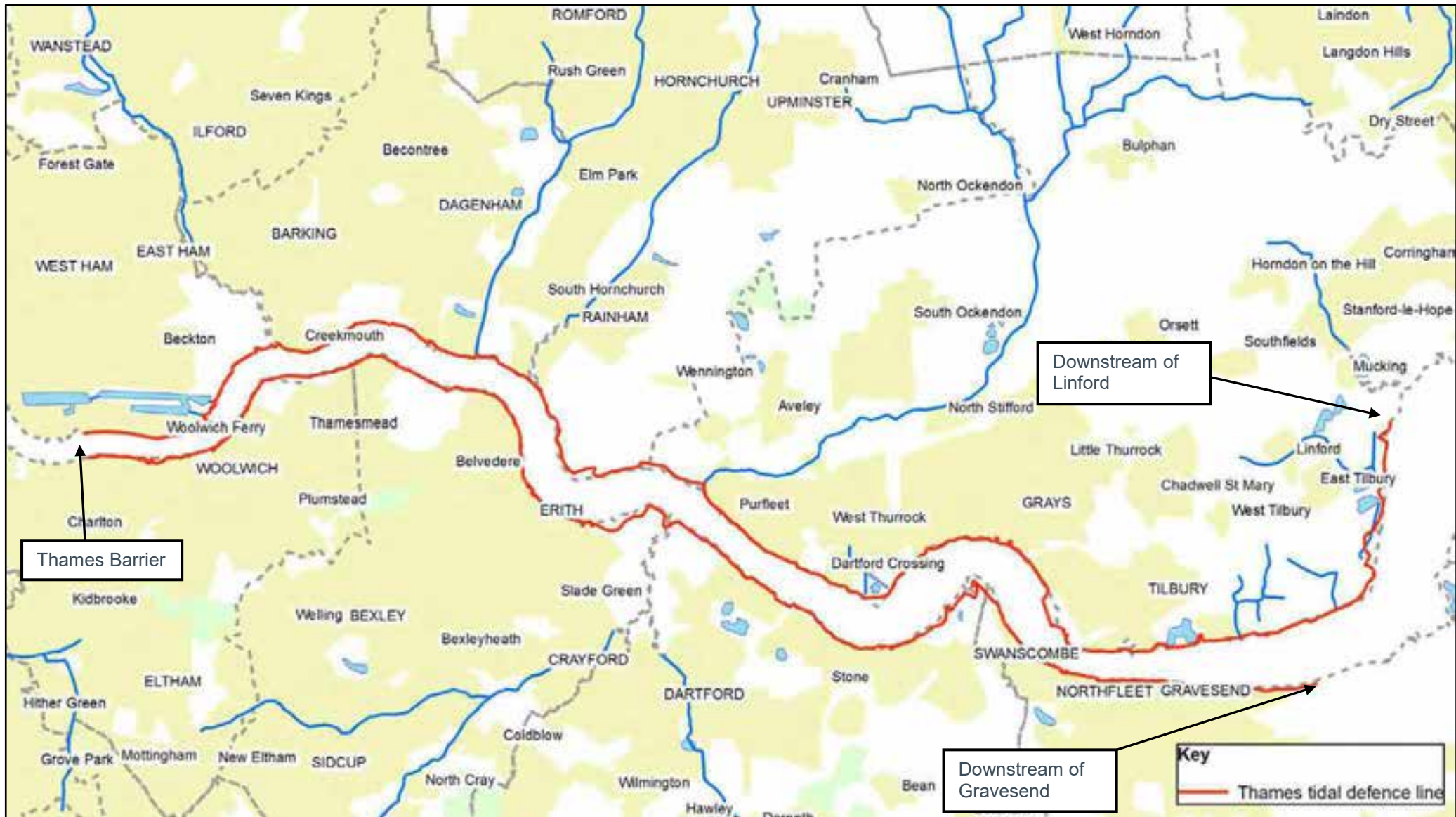
1.3. This report

This report describes the work undertaken to develop a modelling framework to automatically generate and simulate individual breaches of the Thames tidal defences, between the Thames Barrier and Gravesend and Linford. This report outlines the methods that were used, the results and provides recommendations for future applications of the work including what opportunities the outputs bring.

2. Study area

The study area of this project is shown in Figure 2-1, which highlights the extent of Thames tidal defence line considered in the breach modelling. The extent is from the Thames Barrier (considering defences both sides of the Thames) to Gravesend on the south bank, and to Linford on the north bank. The study considers the impact of a breach occurring during a tidal event in the linear defences that protect the floodplain from high tidal levels downstream of the Thames Barrier.

There has been no modelling of a breach of any defences along the incoming tributaries of the River Thames as part of this study. This is because there are tidal barriers (including the Dartford Barrier) that act as defences against a tidal surge. However, as these barriers effectively form part of the tidal Thames defences, these are considered in the breach modelling.



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Figure 2-1 Study area for the breach modelling undertaken as part of this assessment: Thames Barrier to Gravesend (south bank) and Linford (north bank).

3. Available data

3.1. Introduction

This section of the report describes and outlines the data that was available to develop the InfoWorks ICM breach model. InfoWorks ICM is the modelling system developed by Innovyze for integrated catchment modelling, which includes fluvial, pipe and floodplain drainage. The following data were obtained for this assessment:

- LiDAR terrain data;
- TE2100 Maximum Likely Water Level (MLWL) hydrographs;
- Ordnance Survey MasterMap® Data (OSMM); and
- Thames Tidal Defence Line.

3.2. LiDAR terrain data

Light detection and ranging (LiDAR) data at 1m resolution was downloaded in May 2017 from the Environment Agency data share catalogue (Environment Agency, 2017). This LiDAR information has a vertical height accuracy of +/- 15cm and a horizontal accuracy of +/- 40cm. Further information on the LiDAR accuracy is available in the Environment Agency LiDAR data Technical Note (Environment Agency, 2017). A review of the LiDAR was undertaken, including a check against the prior DTM that was used as part of the Thames Tidal Breach Modelling Study (CH2M, 2015) to ensure gaps under bridges etc. were represented within the digital terrain model (DTM) within the ICM. The extent of the 1D LiDAR data covered the entire study catchment, ensuring a full representation of the modelled breach flood extents.

3.3. TE2100 Maximum Likely Water Level hydrographs

Thames Tidal water level profiles were obtained from the existing Thames 1D ISIS River Model (version 11), covering the extent from Teddington Weir down to Southend-on-Sea. An extract from the Thames Tidal Breach Modelling Study (CH2M, 2015) is provided below that provides a summary of the methodology for these water level profiles:

Tide profiles are generated along the estuary using a separate 1D model (the Thames Barrier's operational model – version 11). The model has a fluvial flow-time (QT) boundary just upstream of Teddington and a tidal head-time (HT) boundary at Southend-on-Sea. The fluvial QT boundary is a constant (steady state) inflow, with the discharge depending upon the scenario being modelled (see below). A steady state fluvial flow is considered to be a reasonable assumption, as any change in flow over a 24 hour period at Teddington is generally gradual, reflecting the size of the catchment at this point (c. 10,000 km²). The tidal HT boundary is unsteady, meaning that the flood and ebb of each tide are dynamically modelled.

The HT boundary is prepared using a spreadsheet called the 'extreme tide generator'. The spreadsheet is the same as that applied to the TE2100 modelling, and combines a Mean High Water Spring (MHWS) tide with a scaled 1953 surge to achieve the target water level at Southend.

Once the 1D model has been run for each scenario (see below), the resulting tidal hydrographs are scaled to match the TE2100 peak water levels along the Thames Estuary, to ensure an exact match. The exception is for the 1 in 200 year water levels downriver of the Thames Barrier, as TE2100 did not publish these water levels, so they have been generated using a 1 in 200 year boundary at Southend, but with no subsequent scaling (as there are no TE2100 levels to match exactly to). Where they existed, the Environment Agency provided the TE2100 water levels, referring in turn to the 'B0' results reported in table A1 of the TE2100 report "EX6158-Implementation Guidance_R2-0.pdf".

Note also that the 2065 Southend Boundary was interpolated from the TE2100 2050 and 2080 boundaries, as reported in Table A1 within 'TN_Model_Boundaries.doc' (see Appendix F).

Model boundaries upstream of the Thames Barrier

Downstream of the Thames Barrier, 1 in 200 and 1 in 1000 year breach water levels are derived from a water level with an equivalent return period at Southend-on-Sea. For all six scenarios, a constant inflow of 52 m³/s is assumed at the upstream end of the model. Barrier closure is represented by all

gates closing simultaneously when water levels reach 1m AOD at Node 3.1 - Silvertown (just downstream of the Thames Barrier). This closure timing was selected to be consistent with that used in TE2100, but is noted to differ from operational closures, where closure of the gates will be staggered. A staggered closure has been shown (through modelling) to result in slightly higher water levels downstream of the barrier (see Appendix G).

Resulting hydrographs were scaled to match exactly with the TE2100 peak water levels along the Estuary.

Given the Thames Estuary does not benefit from being protected by the Thames Barrier, peak water level predictions were extended using the latest National Planning Policy Framework (NPPF) guidance (Environment Agency, 2017). The existing 2100 peak levels were extended to 2115, using an increase of 1.21m from the 1990 peak tidal levels applied at the downstream boundary of the ISIS model. The 2115 epoch was chosen as this is the latest prediction of peak level increase that is available with National Planning Policy Framework (NPPF) (Environment Agency, 2017), with the primary purpose of this modelling to support future Flood Risk Assessments.

An example of the level hydrograph applied in the ICM model for node 3.12 in the ISIS model is provided in Figure 3-1.

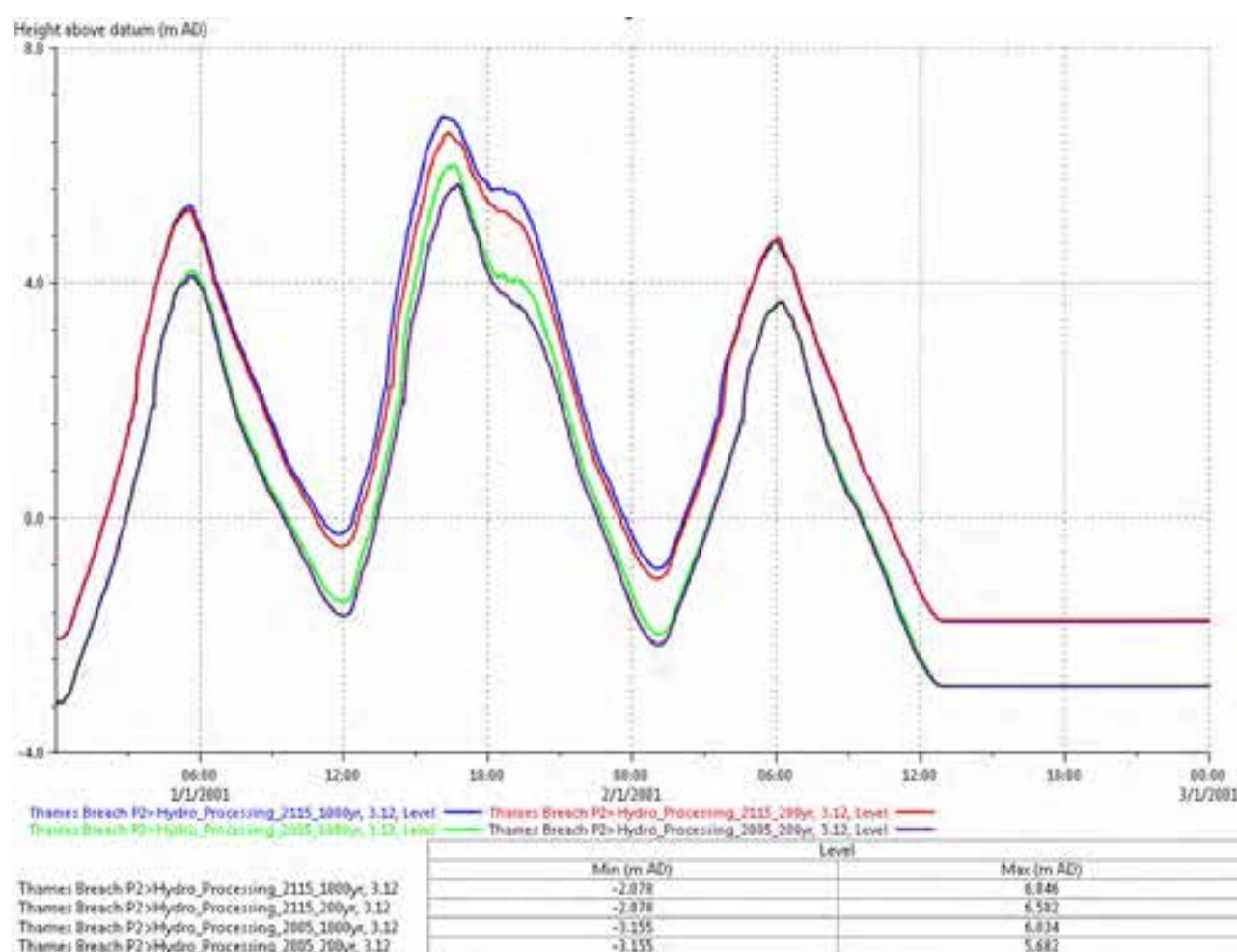


Figure 3-1 Level hydrograph for Node 3.12, showing the 0.1% AEP and 0.5% AEP events for the 2115 and 2005 epochs

3.4. Ordnance Survey MasterMap®

Ordnance Survey MasterMap® (OSMM) data were obtained in ESRI shapefile format from the Environment Agency Partner Data Catalogue (Environment Agency, 2017). This data has been used to inform the building outlines for the hydraulic modelling, which is further described in Section 4.3.2.

3.5. Thames Tidal Defence Line

The NAFRA Thames Tidal defence line was obtained from the Environment Agency AIMS database in ESRI shapefile format. A detailed review of this defence line was undertaken against the LiDAR data and available aerial imagery, to ensure the line was located on the crest of the defences. Consultation was undertaken with the Environment Agency, including the issue of the final proposed defence line for review with the relevant Environment Agency teams. Modifications were undertaken to the defence line, to ensure it fitted to the LiDAR data (so not to be located within the river at low ground levels) and gave a realistic representation of the defence crest. A shapefile of the final Thames Tidal defence line has been provided as part of this study.

Defence levels are not included in the current modelling, as the current study considers breaching rather than overtopping. The method by which the breach level is derived is described in Section 4.1.2.

4. Methodology

The following sections describe the methodology that was applied for the specific aspects of a breach scenario. The overall approach to the breach definition is presented first, followed by an explanation of how the relevant components were represented in the ICM. The Thames Tidal Breach Modelling Study (CH2M, 2015) methodology was used as a basis of defining an individual breach. Modifications however have been conducted when comparing to the original methodology, and the key changes are described in Section 4.5.

4.1. Breach definition

4.1.1. Breach width definition

The Thames Tidal defence line was used to define the breach locations. The defence line between the Thames Barrier and Gravesend was considered in the breach location definition (as shown in Figure 2-1). Firstly the defence line was split into 'hard' and 'soft' defence types, using the attribute definitions within the edited NAFRA Thames Tidal defence line. For this purpose, a hard defence is considered to be a concrete wall, structure or composite embankment, whilst only earth embankments are considered to be a soft defence. As with the previous methodology (CH2M, 2015), a hard defence was defined as a 20m wide breach, with a soft defence as a 50m wide breach.

Figure 4-1 below shows a section of the Thames tidal defences that were split into individual 'hard' 20m breach sections.

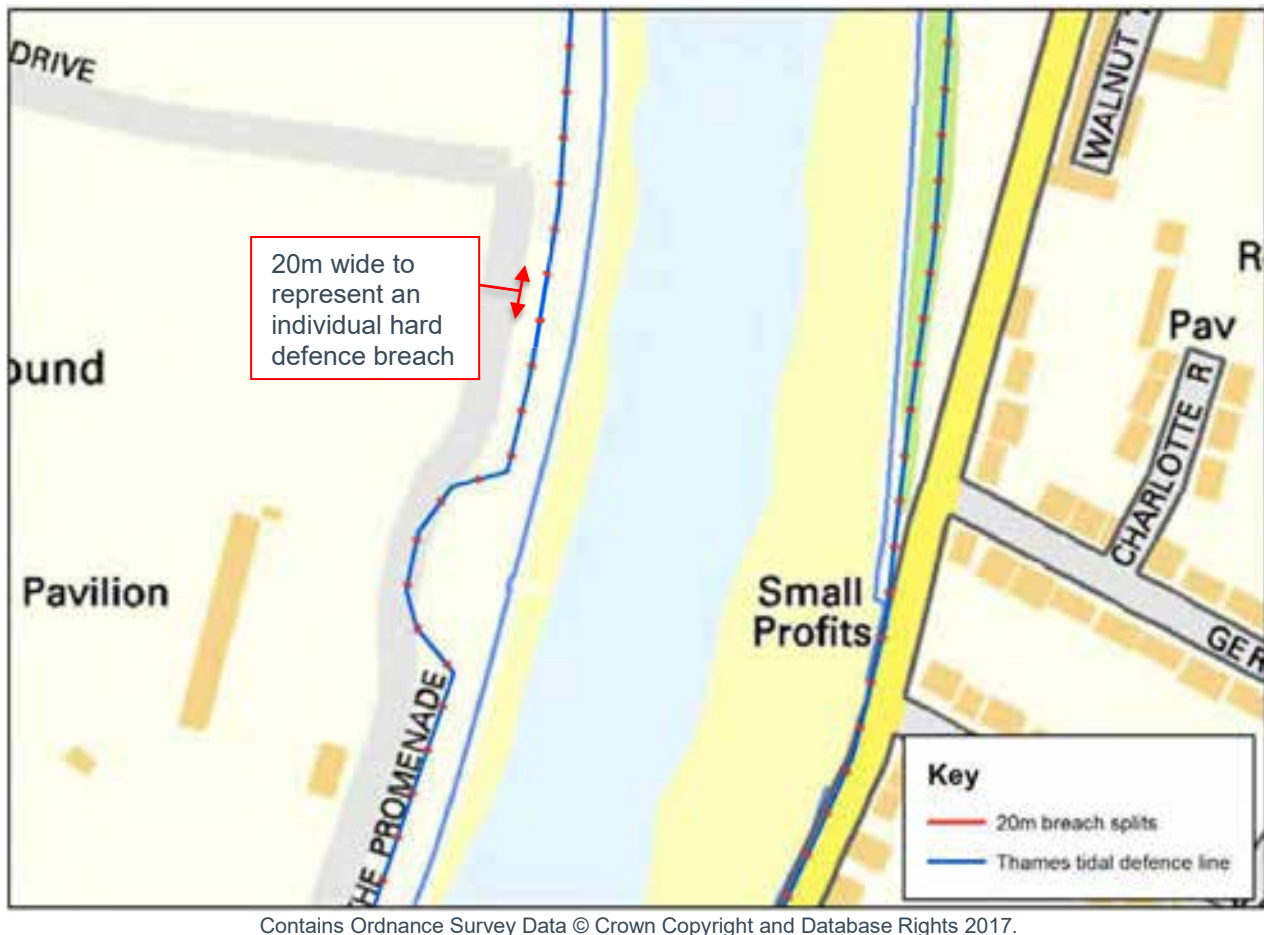


Figure 4-1 Individual 20m lines representing a breach width that will be individually modelled

Given that the hard and soft defence lines were not exact multiples of either 20m or 50m, there were residual lengths at the end of the defence lines, as shown in Figure 4-2. Where these short lines occurred, they were extended back to either 20m or 50m, so overlapping another breach line. This ensured consistency across the study area so that all breaches were either 20m or 50m wide (some edges were modified to fit the defence line so not precisely 20m or 50m).

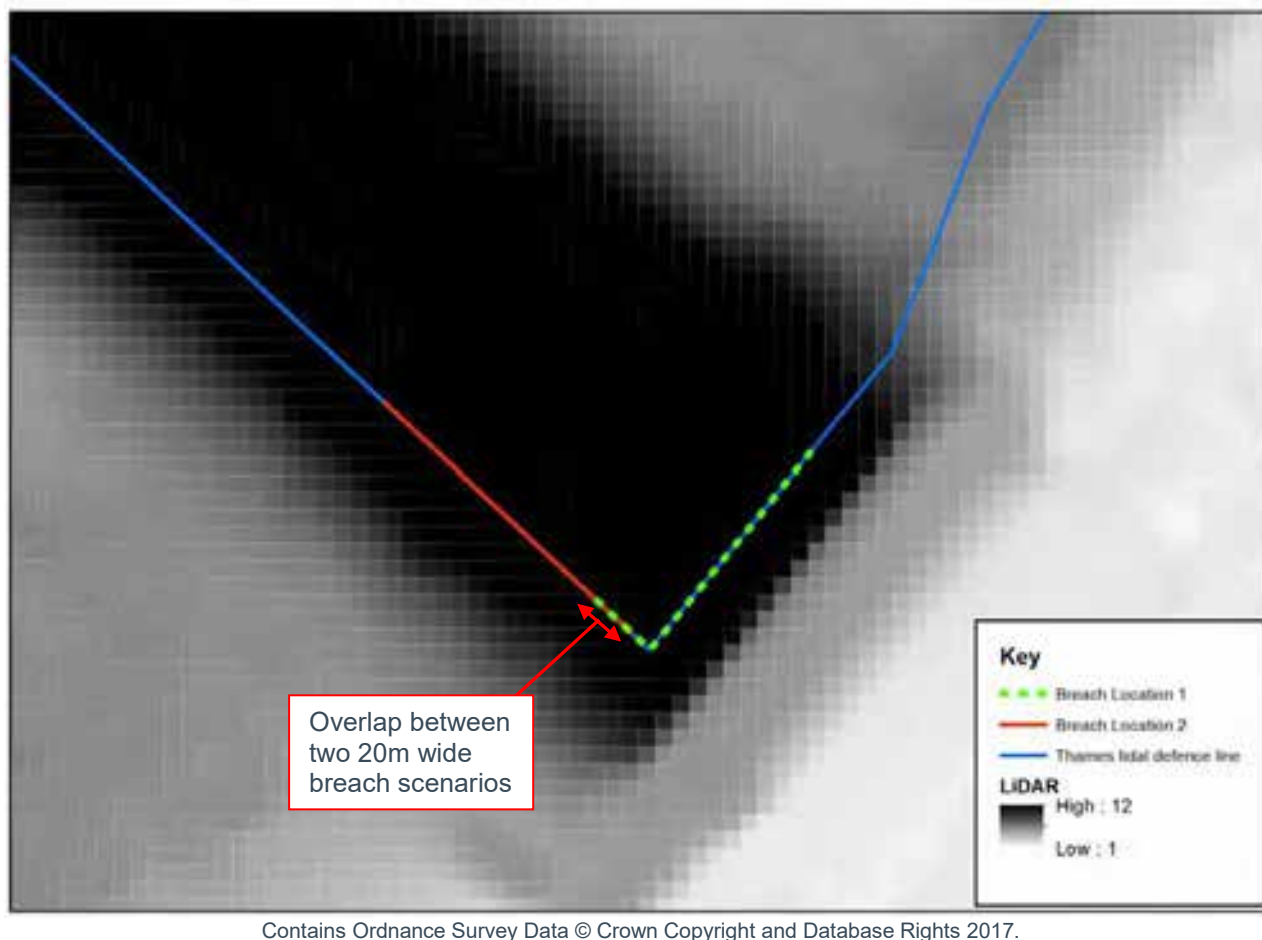


Figure 4-2 Overlap between two 20m wide separate breach scenarios

For soft defence breaches, where splits resulted in lengths of less than 10m at the end of the soft defence line, these were added to the next closest soft defence breach. This resulted in 32 breach widths being between 50 – 60m wide. For hard defence breaches, a similar approach was used, however as the breach widths were shorter the greatest difference of a breach width at 19.8m. These widths will cause minor changes to the hydraulics and resultant flood extents for those individual breach scenarios. However, given the entire defence line (within the study area) was tested for an individual breach, these impacts are likely to be negligible.

The result of the above GIS task generated a total of 3149 potential breach locations (the number per epoch were further refined as described in Section 4.2.2). This was a total of 2634 hard defence breaches and 515 soft defence breaches.

4.1.2. Breach sill level and scour zone definition

Given the Thames Tidal defence line is represented within the DTM, a sill level is required to lower the ground model to represent the breaching of the defence and resultant scouring that would occur. During discussions with the Environment Agency, it was agreed to repeat the prior methodology that was undertaken to define the breach sill level and scour zone.

Figure 4-3 shows the location of a single 20m (hard defence line) breach location that has been conducted as part of this assessment. GIS analysis was undertaken to generate a semicircle, the radius of which is the width of the breach itself from the centroid of the breach line (20m for hard defences and 50m for soft defences).

The lowest ground elevation within the semicircle was identified, and all levels within the semicircle were then lowered to that level for the respective breach scenario. This lowering represents the occurrence of the breach and the resultant scour. This lowering of the ground model was represented within the model at the start of the simulation, and so assumes that the failure of the defence occurs before the water fully abuts the defence line. Having the defence line failed/breached at the start of the event is the same approach taken from the prior methodology (CH2M, 2015). Figure 4-3 shows an example of a generated breach scour zone from a 20m hard defence breach line. This line and scour zone combination is what has been used to model an individual breach i.e. during a breach event water will flow through the breach width inland into the scour zone and then further

inland.

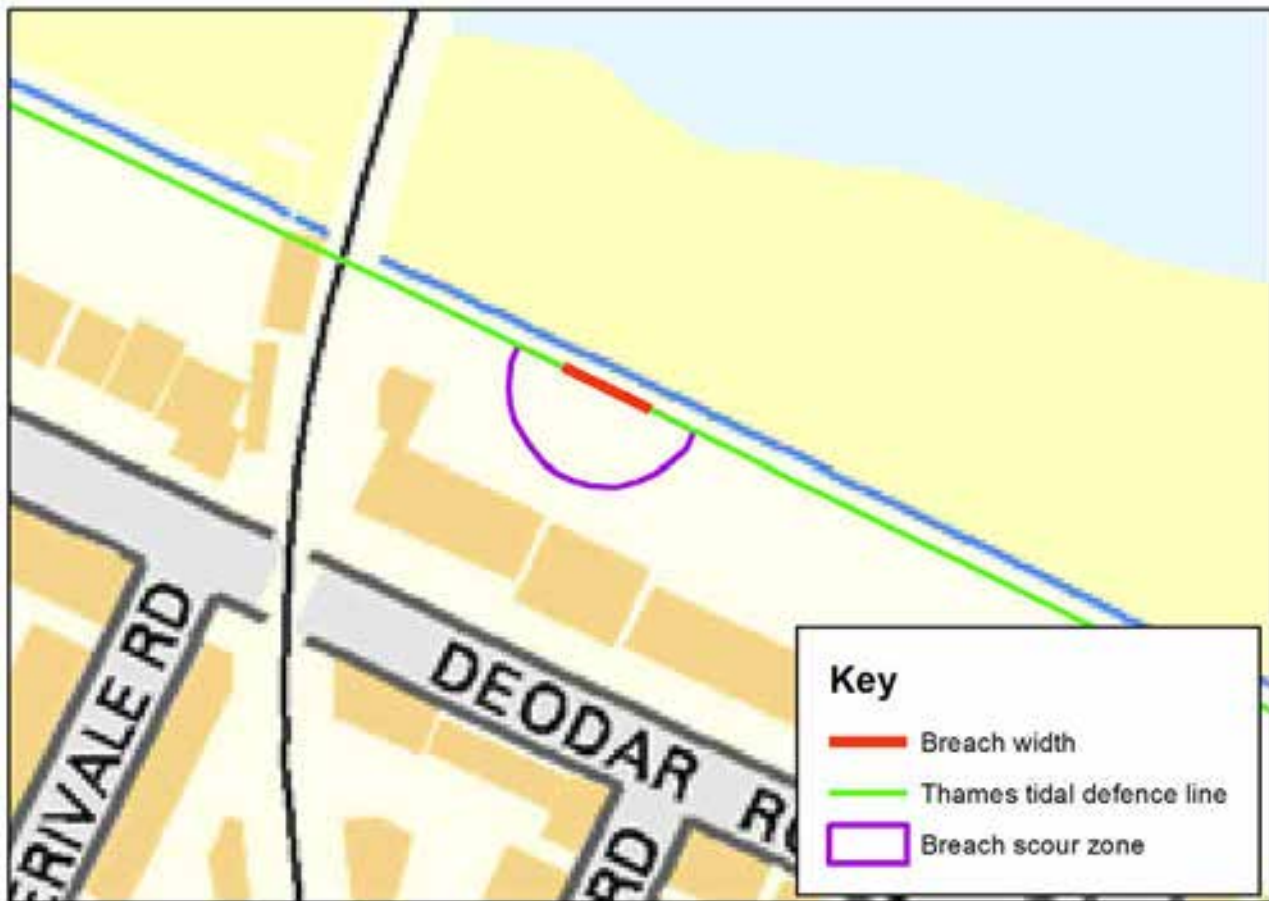


Figure 4-3 A 20m wide hard defence breach including the scour zone identified for this breach

As noted previously, a review of the Thames Tidal defence line was undertaken to ensure the line represented the crest of the defence and not the river. This was to ensure the correct sill level was identified and the river levels in the DTM were not used, which were likely to yield far lower ground levels for the scour zones.

4.2. Hydrology and modelled epochs

4.2.1. Hydrology

As noted in Section 3.3, the existing 1D ISIS Thames model has been used to extract the water level time series hydrographs. In total 47 hydrographs were available, covering the ISIS nodes from the Thames Barrier to Southend-on-Sea. Given there were 31 hydrographs across the study area, breach locations were grouped and hydrographs were allocated to the groups. Starting from upstream, the breach locations were allocated to the closest hydrograph until another node location was crossed, to which the next set of breach locations were then allocated. The relevant breach location and allocated hydrograph is provided in the hydraulic model, breach location ESRI shapefile and model build spreadsheet (provided with the ICM model).

For each breach scenario, three tidal cycles were included. This differs from the Thames Tidal Upriver Breach modelling (Atkins, 2017) where only one tidal cycle was included due to the benefit of the Thames Barrier. Three tidal cycles were included in the Thames Estuary based on the assumption of a worst-case scenario, where the timing taken to provide a temporary repair would allow three tidal cycles to propagate through the breach. An example of a breach hydrograph is shown in Figure 3-1; models were run for a duration of 40 hours to allow three tidal cycles along the Thames Estuary and sufficient time for the flood wave to propagate across the floodplain.

4.2.2. Modelled epochs

Given this study is for informing current and future planning in London, two epochs were modelled for each individual breach location, being the 2005 epoch 0.5% AEP and 0.1% AEP events, and the 2115 epoch 0.5% AEP and 0.1% AEP events. The 2005 epoch scenarios were already modelled within the 1D ISIS Model of the

Thames and were the same used in the Thames Tidal Breach Modelling Study (CH2M, 2015). The 2100 epoch scenarios were however extended to 2115, which is the furthest future prediction provided using NPPF guidance associated with Flood Risk Assessments (Environment Agency, 2017). The revised tide curve at Southend-on-Sea for these events was calculated using the Extreme tide estimator spreadsheet provided by the Environment Agency. This was then applied in the ISIS model of the Thames Estuary to generate level hydrographs for the reach between the Thames Barrier and Gravesend.

No review of the underlying methodology in modelling the tidal hydrographs for the relevant epochs was undertaken as part of this assessment.

A sense check was undertaken against the hydrographs for both epochs against the identified breach sill levels. The purpose of this check was to identify areas of high land that the MLWL did not exceed. These areas do not need to be modelled, as even with the identified sill level the ground is too high for water levels to spill over.

4.3. Hydraulic model representation

The following section details the technical representation of the components of a breach scenario within the hydraulic model. This study used Infoworks ICM v7.5.5 utilising the ICM Exchange module to automate the model build and simulation process.

4.3.1. Individual breach, sill and scour area

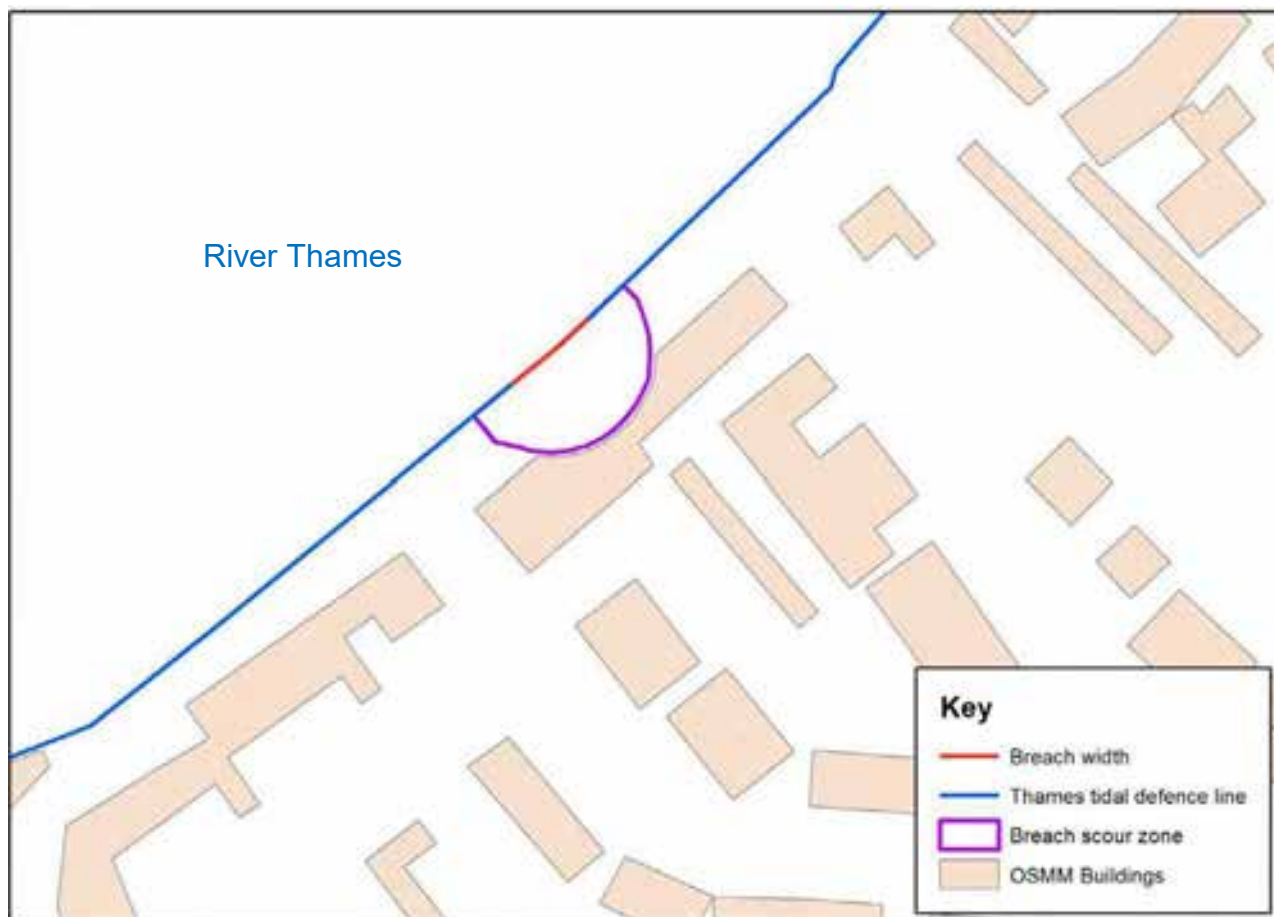
Section 4.1 describes how GIS data processing was undertaken to generate individual breach widths and related scour zones. Three further GIS shapefiles were generated from the breach width line, which were required for the hydraulic model build process. A line shapefile was generated that intersected the individual breach widths, with two point shapefiles generated at the vertices of these lines. These shapefiles were imported into Infoworks ICM as the relevant hydraulic model component types as described in Section 4.4.1. The sill identified as described in Section 4.1.2 defined the scour zone ground level.

This methodology relates to the previous approach that was undertaken as part of the Thames Tidal Breach Modelling Study (CH2M, 2015). There are however notable differences between the two approaches, which are described in Section 4.5.

4.3.2. Topographic features

Ordnance Survey MasterMap® data was used to represent building outlines within the model DTM. The previous study (CH2M, 2015) used the approach of adding 5m threshold on the building outlines. This approach was considered to be an overestimate, as storage of water within buildings would occur following a breach. The approach taken for this study was to represent building outlines within the model, setting a 300mm threshold to the building outlines. A porosity of 0.1 was set to give the buildings some permeability, allowing water to flow through.

Where a breach scour area was located either on or part on a building, the building area that was within the scour area was removed, as shown in Figure 4-4. This ensured consistency across the breach scenarios and allowed the representation of part collapse of a building following a breach event. The removed area was set to be 1m away from the edge of the scour area, to prevent the formation of very small mesh elements that can generate model instabilities.



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Figure 4-4 Example of removal of the building section overlapping the scour zone of a breach

Manning's values were allocated on the mesh using OSMM land use categories as described below. Buildings were not allocated a Manning's value, instead using porous polygons as described in section 4.3.2.

Table 4-1 Allocated Manning's 'n' values using OSMM categories

OSMM description	Manning's 'n' value applied
General Surface	0.035
Landform	0.05
Natural Environment	0.06

4.4. Automation of ICM

Ruby scripting has been used alongside Infoworks ICM to automate the generation of all breach scenarios, simulating the individual scenarios, and extracting the results. This approach has never previously been undertaken for breach modelling within the UK, and has resulted in substantial benefits for the Environment Agency. This section describes the processes where Ruby scripting was used, and the manual adjustments made.

4.4.1. Model build

All individual breach scenarios were generated using a GIS data processing (as described in Section 4.1), generating a total of 15,745 individual model components. Each breach scenario contained 5 unique components, namely:

- A bank line to represent the breach width sill level;
- A mesh zone to represent the breach scour zone;
- An inline bank to connect to the bank line as defined above;
- An outflow node to connect the 1D breach component to the 2D mesh; and

- A break node to connect the 1D breach to the relevant hydrograph.

A common ID was retained across the five individual shapefiles that related to an individual breach scenario. This common ID was stored within an Excel spreadsheet that also defined the required attributes for the individual breach scenario including:

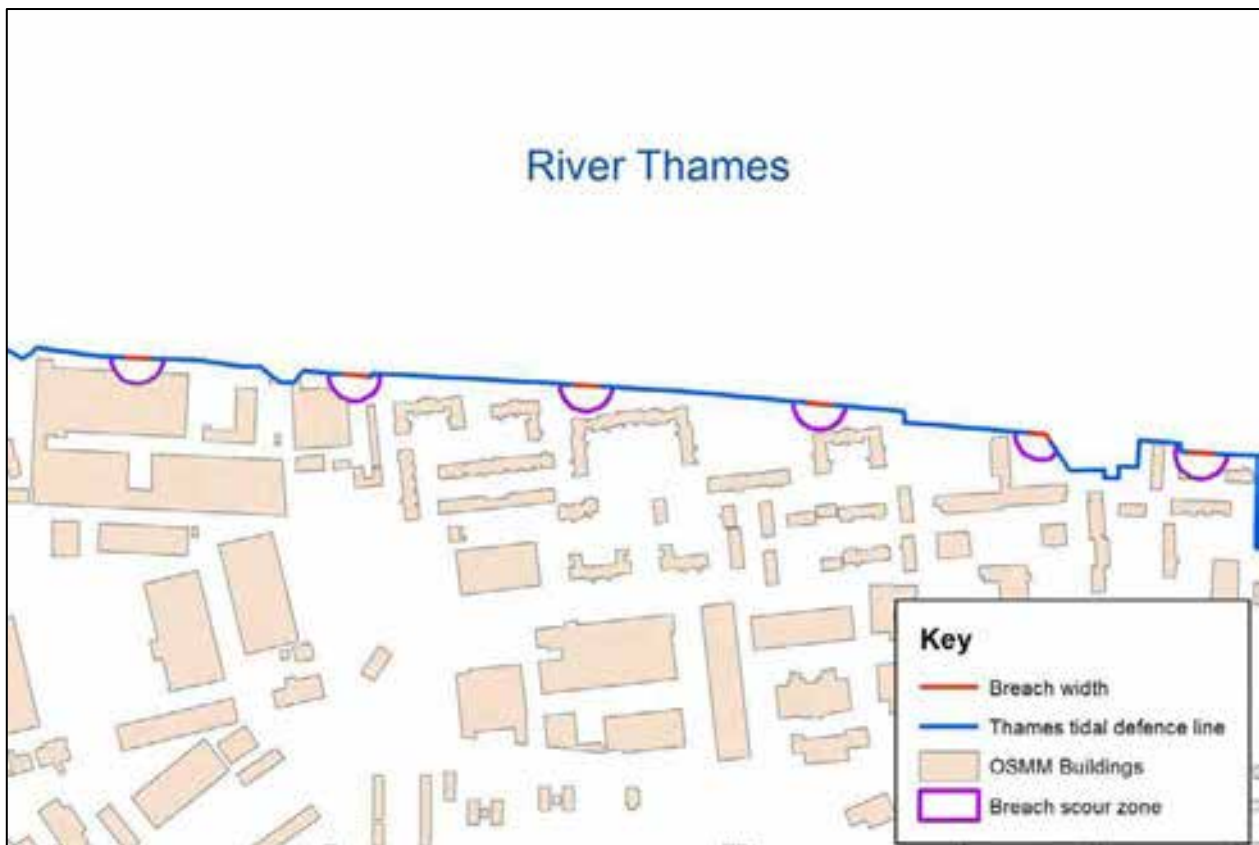
- Relevant shapefile names plus ID (Node_001, Inline Bank_001 etc.);
- Breach sill level (as defined in the GIS assessment);
- Model start time;
- Model duration (end time to be 24 hours from the peak of the hydrograph);
- Allocated hydrograph node ID; and
- Allocated model network (see Section 4.4.2).

All shapefiles were imported into a single model network in ICM representing the relevant breach model component. Further model components were generated common to all breach scenarios, these being a 2D zone to define the ground model (levels obtained from LiDAR - see Section 3.2), and porous polygons to represent buildings (see Section 4.3.2). A further outfall node and weir unit were also used for hydrograph allocation purposes, as defined in Section 4.4.3.

4.4.2. Model networks and mesh zone refinement

Within the current version of Infoworks ICM (v7.5.5), the 2D mesh required for floodplain modelling must be created manually. Because of this, the individual breach scenarios were split into the fewest possible number of models to minimise this part of the model creation process. The scenarios are split into 10 geographical areas, with each area containing 1 in 10 of the breaches in that area. This gives rise to a total of 90 models within which all 3149 breach scenarios are created. Figure 4-5 shows part of one of the sub-models, showing how every 9th breach is included in each sub-model.

This approach means that the scour zones for a number of inactive breaches are included in the model of any particular breach scenario. This potentially results in a small increase in floodplain storage if a modelled inundation floods into an adjacent scour zone. This storage however is considered negligible because of the approach which combines all outputs to produce maximum extents.



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Figure 4-5 Breach scour zones present in the same model network (so mesh lowered in these areas for each individual breach scenario)

Mesh zones were predefined within the model networks. All breach scenarios were first simulated with a coarse mesh (maximum triangle area of 1000m²), to identify the approximate maximum extent of flooding from the breach inundation. The results of this modelling were used to identify the approximate extent of floodplain to be modelled in detail. A detailed mesh at a higher resolution for the detailed breach modelling (with a maximum triangle area of 10m² which is approximately equivalent to a 5m grid size) ensuring that 2D domain was sufficiently large to cover the breach extents identified from the coarse modelling, with an additional 200m buffer applied. A key point in this process was to avoid glass walling (where the flood extent is artificially constrained by the edge of the 2D domain) and a review of the model outputs was also undertaken to identify any glass walling that occurred during any events. This point is discussed further in Section 6.

4.4.3. Hydrograph allocation

Each model network included up to 66 individual breach scenarios. Each breach scenario required the allocation of a specific level hydrograph, and ICM Exchange was used to automate this process, including the creation of the relevant modelling objects used to represent the breach. Each hydrograph boundary was connected to the appropriate breach through a combination of an outfall, weir link and break node.

4.4.4. Simulating and exporting results

ICM Exchange was used to automate the creation and simulation of run files in Infoworks ICM, using the information stored in the spreadsheet described in Section 4.4.1. This approach allowed each model run to be automatically created and populated with the following information for each breach scenario:

- Target model network;
- Target breach scenario;
- Allocated level hydrograph;
- Start time (with respect to the relevant hydrograph); and
- Model run time (end time to be 24 hours from the peak of the hydrograph).

The models were then batched on to multiple workstations hosting dual GPU cards that are supported by InfoWorks ICM for 2D simulations. Once the simulations had completed the maximum 2D mesh results were automatically exported as individual shape files for each epoch and event. These were then post-processed into individual raster images on a 5m grid from which a composite output of the maximum flood depth, elevation, hazard and velocity outputs.

The approach adopted allowed substantial reductions in user input allowing thousands of scenarios to be generated and simulated in a short period of time.

ICM was initially run with a minor change to the momentum and velocity thresholds in the 2D simulation parameters. These were set to 0.01m for momentum and 0.01m/s for velocity which was intended to reduce the computational run time during the run-out phase of each simulation when water was not actively flowing across the mesh. However, testing identified that this change gave inconsistencies between the results for different epochs. This was subsequently identified as resulting from momentum not being reinstated in the simulation when flooding occurred over multiple tidal peaks.

A total of 3149 potential breach locations were identified, with the total number of modelled breaches (ie those where tidal water levels exceeded the derived breach level) as shown in Table 4-2.

Table 4-2 Number of breach simulations by event and epoch

Epoch and event	Number of breaches simulated
2115 epoch, 0.1% AEP	3075
2115 epoch, 0.5% AEP	3009
2005 epoch, 0.1% AEP	2865
2005 epoch, 0.5% AEP	2734

The following outputs were produced for each epoch and event (figures in brackets give the total numbers for the 2115 epoch, 0.1% AEP event):

- Shape files containing the maximum values of all the modelled variables for each simulation (3075);
- Individual raster (.TIF) files containing the maximum values of each modelled variable for each simulation on a 5m grid (12,300);

- A composite raster (.TIF) created by merging the maximum values from the full set of raster files for each epoch and event (4);
- Compressed ICM results files (.7z) for each individual simulation (3075).

The first 3 items have been supplied to the EA on a portable hard disk. The ICM results files have been retained by Atkins for future reference. In addition, the ICM database has also been provided.

4.5. Key changes from prior breach modelling

The following summarises the key differences between the previous Thames Tidal Breach Modelling Study (CH2M, 2015) and this study. There are notable changes which are likely to result in significant differences in the outlines, namely:

- The breach location in the latest study is on the crest of the Thames tidal defence line, the previous study applied the breach width at the lowest point within the scour zone on the landward side of the flood defence;
- Buildings were represented as 5m high in the previous study, essentially removing the building outline for storage. In the latest model, buildings are represented as porous polygons with a porosity of 10% and a threshold level of 300mm;
- 113 breach locations were simulated as part of the previous study. This study considered the entire extent, totalling 3149 breaches; and
- The latest LiDAR information available at the time of model build (November 2017) was used for this assessment. The previous study used the DTM generated for the Updated Flood Map for Surface Water (uFMfSW) available at the time of model build.

5. Assumptions and limitations

There are key assumptions and limitations associated with the modelling that has been undertaken, namely:

- Breach widths for hard defences were set to 20m and soft defences at 50m, uniformly across the study area. The use of different breach widths would result in different flood extents;
- The breach sill levels were set to the lowest ground elevation within the scour zone, with all elevations within this zone set to that identified level. This assumes that everything within this area will be scoured out to the lowest ground level, irrespective of the material;
- Manning's values have been based on OSMM data, as described in 4.3.2. There may be other materials within the catchment that will increase or decrease roughness compared to the defaults applied;
- Buildings have been represented as porous polygons with 10% porosity and a threshold of 300mm. This approach forces most flow around the buildings whilst still allowing storage of water within the building outline (irrespective of the building type). Whilst this has been considered the most appropriate method of building representation, this could overestimate or underestimate storage in some areas;
- A single breach has been modelled in each scenario. There is a risk that a breach may occur in multiple places across a defence line and this could significantly increase the depths and extents of flooding. However, this has not been assessed in this study;
- The hydrology uses the existing 1D ISIS model of the River Thames, with upscaling of the 2100 peak levels to 2115. There has been no review of this hydrology as part of this assessment. The hydrology is consistent with the Thames Tidal Breach Modelling Study (CH2M, 2015);
- The breach has been assumed to be present during the rising limb of the tidal hydrograph. This could overestimate the volume of water entering through the breach, dependent at what stage of the tidal event the breach occurs;
- There has been no sensitivity testing as part of this assessment. The above limitations include components of the modelling that can be tested for their sensitivity, including breach width, number of breaches, breach timing, building representation and floodplain roughness;
- No consideration to flood defence stability or fragility has been considered in this assessment. The method of testing all locations however enables the quantification of the probabilistic and consequential risk of failure of a defence asset;
- The modelling undertaken has only considered breach modelling and no other sources of flooding are considered (such as groundwater or surface water);
- There is no representation of the below ground sewer network in the model. There is a risk that a breach may cause localised sewer flooding (including at locations remote from the breach) due to backing up of the network;

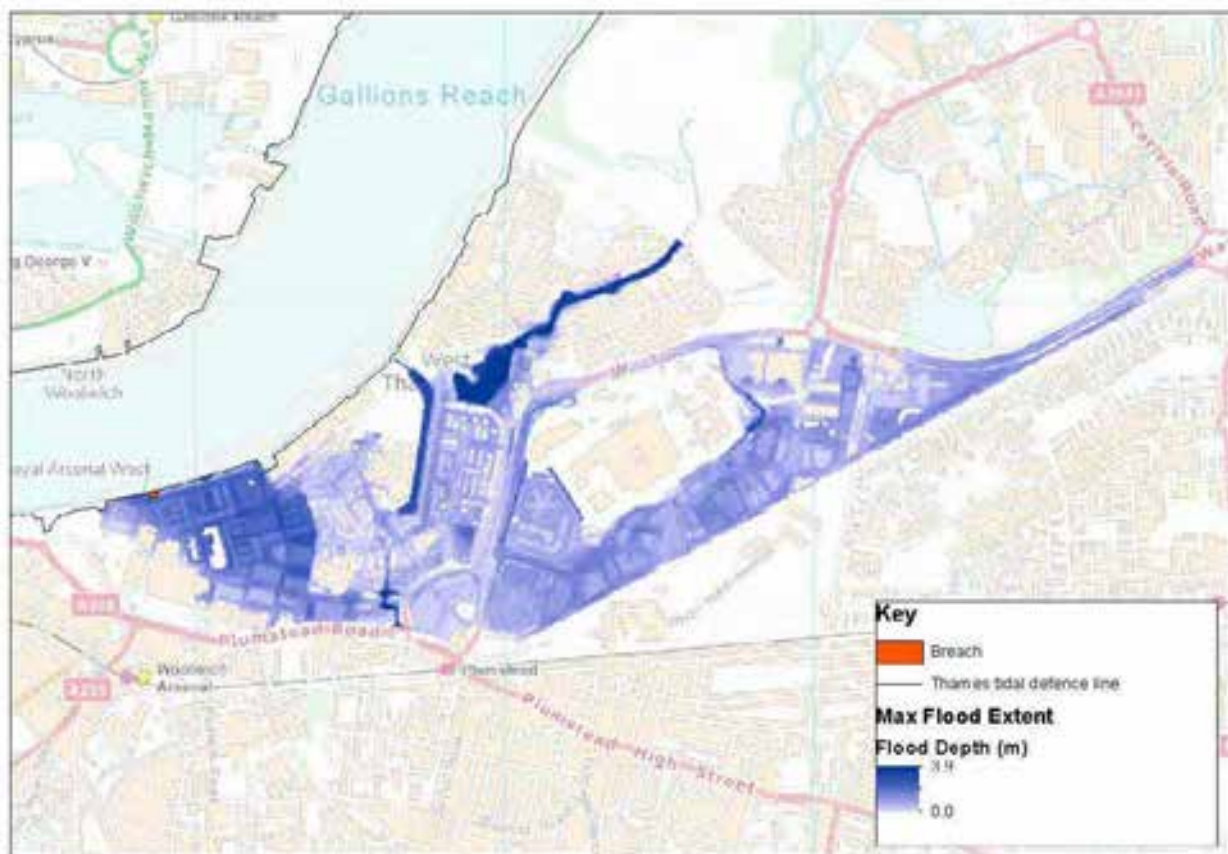
- There is no representation of any other below ground structures, such as entrances to the London Underground network or road tunnels. There is a risk that a breach would cause flooding of a below ground structure which would change the flood dynamics of a breach; and
- As with all hydraulic modelling, models are representations of reality and must be used proportionately and for the original purpose of the modelling study. If other uses of models are desired, the model must be reviewed (and updated as necessary) to ensure it is suitably fit for purpose.

6. Results

6.1. Individual breach output

The individual breach model flood extents have been combined for each epoch, as described below. All of the individual breach outputs have been stored and provided as part of this study. An associated shapefile has been provided which provides the information associated with the specific breach. This shapefile can also be cross referenced to the relevant maximum flood extent shapefile. This allows the breach scenarios to be individually assessed, which may have benefits for other applications, such as emergency response planning and asset management. Some opportunities to further use these outputs are described in Section 7.2.

Figure 6-1 shows the individual breach output for Breach 148 for the 2115 epoch 0.1% AEP event.



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Figure 6-1 Maximum flood extent for Breach 148 for the 2115 epoch 0.1% AEP event

A comparison of the previous modelling has not been undertaken as there are significant differences in the modelling methodology as described in Section 4.5. A review of the flooded extents was undertaken to ensure that glass-walling did not occur due to the flooding reaching the edges of the model domain. Glass walling was identified at a small number of locations on the north bank primarily where the flood wave travelled along the Thames tributaries of the Roding, Beam, Ingrebourne and Mar Dyke. Individual simulations where glass-walling was observed were rerun with an extended model mesh.

6.2. Combining the outputs

The purpose of this study was to identify the maximum likely water level that would be achieved along the Thames tidal defence line if an individual breach were to occur at any point. All modelled breach scenarios for each epoch were extracted from the hydraulic model, and combined taking the maximum values for the modelled variables at each point within the study area, transposed onto a 5m grid. This was undertaken for elevation, depth, velocity and hazard, so generating four key outputs for each epoch which can be used for future planning. It is important to note there are assumptions and limitations associated with the work that has been undertaken, as described in Section 5.

7. Conclusion, Recommendations and Opportunities

7.1. Conclusion

The following summarises the work that has been undertaken:

- Breach modelling has been undertaken on the Thames tidal defences between the Thames Barrier and Gravesend for the south bank, and Linford for the north bank;
- Breach scenarios have been modelled for current and future conditions of the Thames, namely the 2005 epoch 0.5% AEP and 0.1% AEP events, and 2115 epoch 0.5% and 0.1% AEP events. The hydrology has been extracted from the 1D ISIS river model study (as described in Section 3.3); no hydrological assessment has been undertaken as part of this study. The 2100 peak levels however were extended to 2115 using the latest National Planning Policy Framework guidance (Environment Agency, 2017) ;
- A total of 3149 breach locations were identified for this study by splitting hard defences to 20m wide individual breaches and soft defences to 50m wide individual breaches;
- A combination of GIS data processing, InfoWorks ICM modelling and ICM Exchange scripting has been used to automatically generate, simulate and export outputs for the individual breach scenarios. This method has provided substantial benefits and efficiencies, as described below;
- This study has built upon the methodologies applied as part of the Thame Tidal Breach Modelling Study (CH2M, 2015). The key differences between the two studies are described in Section 4.5;
- A single flood output per epoch has been generated that shows the maximum extent that would be achieved if a breach were to occur at any point along the Thames tidal defence line (within the study area, see Section 2). The associated maximum elevation, depth, velocity and hazard values have been provided alongside the maximum extents; and
- The purpose of the outputs is to assist the Environment Agency in future planning decisions for London; all development sites between the modelled extents receive the same information to help inform their FRA.

This work has used a completely new and innovative technique to model breaches of the Thames Tidal flood defences. The following summarises the key efficiencies that have been achieved:

- The hydraulic models have been simulated on high end workstations running dual GPU cards. Using GPU cards, InfoWorks ICM simulations are up to 100x faster than conventional methods. This has enabled the very high number of simulations to be modelled as part of this study;
- With a predefined approach, GIS data processing and computer scripting has automatically generated all of the individual breach scenarios. This has minimised the risk of user error during the model build process. Furthermore, this has also substantially reduced the user time input for a task that would have had to be undertaken manually, driving down the cost for undertaking the work; and
- Global changes to the modelling can be undertaken again with a substantially reduced user input time. If for example updates to hydrology are required, this will involve a small change to the hydrology files, which then the model can again automatically generate the required scenarios, simulate them and export the results.

7.2. Recommendations and opportunities

This section provides recommendations for the work that has been undertaken and the opportunities of how else to make the most of the data that has been generated.

It is recommended that:

- Sensitivity analysis is undertaken to consider the formation and size of a breach, the effect of multiple breach locations and the hydrology used to calculate the MLWL for the relevant epochs. This will enable an uncertainty assessment / threshold to be considered, to gain more confidence in the maximum breach outputs provided as part of this study; and
- Currently only the 200 year and 1000 year events have been modelled. The availability of the models and the automated approach adopted would allow additional events to be modelled to resolve potential flooding at a lower return periods.

The information / methodology generated as part of this assessment has also created opportunities to further this work and other work, namely:

- As noted in the recommendations, the approach for rapid breach model generation and simulation can be undertaken for the defences along the Thames outside of the study area. In fact this methodology can be applied to any location within the UK for large scale breach modelling;
- This methodology that has been used is not only applicable for river breach modelling. The framework that has now been created allows for other multiple scenario simulations to be automatically generated and simulated. An example of this is to test the consequence of a breach of the coastal defences of the UK. The recent tidal surge along the East Coast that issued numerous Severe Flood Warnings could have led to a breach of the defences (Environment Agency, 2017). An assessment using the methodology applied here could quantify the impact of a breach at any given location, allowing the assessments of defences that have a high consequence of failure, optimising the cost of assessing and improving the tidal defences;
- As the individual outputs have been retained, there is an opportunity to undertake a breach priority assessment. This assessment could quantify the areas at greatest risk, considering the probability and consequence of a breach. Emergency planning and response could then be prioritised following the assessment;
- Infoworks ICM is an integrated catchment modelling platform. There are other sources of flooding that can be represented within the hydraulic model, including surface water, ground water and piped network flooding. This provides opportunities to further refine the breach modelling to consider the Thames Water storm water sewer network for example, which creates opportunities for collaboration of a London catchment scale; and
- Other areas for collaboration include identifying other underground infrastructure that are highly vulnerable to flooding following a breach. TfL and the London Underground network is an example of this; the Underground stations at greatest risk can be identified and mitigation measures put in place to reduce the impact following a breach of the defences.

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Technical note

Project:	Thames Estuary Breach Assessment	To:	Environment Agency
Subject:	Model User Guide	From:	Atkins
Date:	June 2018	cc:	

1. Introduction

This document outlines the process and software required to run the Thames Tidal Upriver Breach model. The following software are required to run the model:

- Infoworks ICM (version built in v7.5); and
- Infoworks ICM Exchange.

2. Model User Guide

2.1. Ruby Scripting

Ruby scripting with Infoworks ICM Exchange has been used for this assessment, to undertake 4 main tasks, namely:

1. Creating all required scenarios;
2. Creating the ICM run files;
3. Executing the simulations; and
4. Exporting the results to GIS.

In order to execute the ruby scripting for any of the above tasks, an ICM Exchange licence is required. Before executing the Ruby scripting, firstly all GIS files were imported into a single model network in Infoworks ICM, which were allocated unique IDs that cross reference to an **Excel Control Spreadsheet**

2.2. Excel Control Spreadsheet

The ruby scripting uses an **Excel Control Spreadsheet** to define the model parameters for the individual simulations. This spreadsheet contains the following definitions for a breach scenario:

- Breach sill level;
- Allocated hydrograph node;
- Model start time;
- Model duration; and
- Timestep control.

Given the model scenarios and structure is set up, only the Ruby scripting is required to execute all model scenarios. This means that for example, if future changes to the hydrology of the River Thames is undertaken, it will take substantially reduced user input to update the control spreadsheet and hydrology files, and then to rerun all model scenarios.

2.3. Model build process

A total of 3149 potential breach locations were identified from the initial analysis of the defence line. An initial screening was carried out of the breach and tidal levels to identify any breaches that would not be overtopped and therefore did not require modelling. This reduced the number of simulations for the 2005 and 2115 level sets as follows:

Technical note

Epoch and event	Number of breaches simulated
2115 epoch, 0.1% AEP	3075
2115 epoch, 0.5% AEP	3016
2005 epoch, 0.1% AEP	2868
2005 epoch, 0.5% AEP	2739

A coarse mesh was created for each area/sub-area, generated from the LiDAR dataset, and this was used to determine the approximate flooded area for each breach scenario. These meshes had the following characteristics:

- Full extent of the LiDAR data;
- element size of 1000m²; and
- buildings not included.

The flooded extents from these were subsequently used to identify the extent of the floodplain to be modelled in detail.

2.4. Detailed model

The detailed model for each area / sub-area was created with the following characteristics:

- Extent based on the flooded extents of the coarse model, extended with a buffer and with manual adjustment in areas where the coarse meshing was thought not to have represented the terrain accurately (eg, around channels on the floodplain);
- Buildings incorporated from OS MasterMap® data. Each building was represented using a porous polygon and a mesh zone, which allowed each building to have a porosity of 10% and a threshold of 0.3m for flooding; and
- Element size of 10m².

2.5. Scenario simulation

The process of simulating each scenario was identical for both the coarse and fine models. In each case, a model run was created for each scenario and this was then simulated on a high spec PC equipped with multiple GPU cards. Once run, each scenario was checked to ensure that the following conditions were met:

- No glass-walling, resulting from the model mesh not extending sufficiently far to capture the full flood extent (see comments below);
- Volume balance error less than 5%; and
- No other simulation errors or run failures.

Where any of these criteria were not met, appropriate adjustments were made and the scenarios rerun until the criteria were met. Typically, these adjustments took the form of a combination of:

- adjusting ground levels of the mesh zone and breach;
- rerunning with a shorter timestep (1s compared to 5s); and
- extending the mesh to fully capture the flooded extents.

Following the above process, GIS data processing was undertaken to combine the individual outputs to create combined maximum depth, hazard and velocity extents for the relevant epochs. Individual outputs are also retained for future uses.

Technical note

Project:	Thames Tidal Upriver Breach Assessment	To:	Environment Agency
Subject:	Key outputs description	From:	Atkins
Date:	June 2018	cc:	

1. Introduction

This user note describes the key outputs that have been generated as part of the Thames Estuary Breach Assessment project. It is intended for use by Environment Agency PSO staff to explain how these outputs have been generated, and how to make best use of them. The key outputs of the project are as follows:

- Maximum flood extents for the 2005 epoch 0.5% and 0.1% AEP events, and 2115 epoch 0.5% and 0.1% AEP events;
- Maximum depth and level shapefiles for the 2005 epoch 0.5% and 0.1% AEP events, and 2115 epoch 0.5% and 0.1% AEP events; and
- Maximum hazard shapefiles for the 2005 epoch 0.5% and 0.1% AEP events, and 2115 epoch 0.5% and 0.1% AEP events.

There is existing Thames Breach Mapping that is used to help inform planning decisions in London, and is issued as part of the Product 4 requests. There are however limited breach locations between Thames Barrier, Gravesend (south bank) and Lindford (north bank) that have been modelled to support the existing mapping.

This latest work has simulated breaches at regular intervals along the Thames Tidal defence line between the Thames Barrier, Gravesend (south bank) and Linford (north bank). The following sections will describe how this has been undertaken and how to use the outputs from this latest assessment.

2. Key outputs

2.1. How they have been generated

A brief description of how these modelled extents have been generated is provided below. For full technical details of how the breach modelling was undertaken (including how they differ to the previous modelling), please refer to the Thames Estuary Breach Assessment Methodology Report.

A simple step-by-step process of how this breach modelling has been generated for each epoch and AEP event can be summarised as:

1. Obtain the Thames Tidal defence line between the Thames Barrier, Gravesend (south bank) and Lindford (north bank);
2. Separate the defence line in to 'hard' (such as concrete walls and composite defences) and 'soft' (earth embankment) defences;
3. Split the defence line further into 20m lengths for hard defences, and 50m lengths for soft defences;
4. This totals a maximum of 3149 locations to undertake individual breach modelling;
5. Eliminate scenarios where the maximum water level does not exceed the breach level;
6. Apply the relevant epoch and AEP event level hydrograph to the individual breach length;
7. Extract the relevant results in the form a SHP file containing the maximum values for that scenario;
8. Repeat for each individual breach length;
9. Convert SHP outputs to raster on a 5m grid;
10. Combine individual raster outputs to obtain the maximum extent, depth, level and hazard value for a breach at any point along the Thames Tidal Defences.

Technical note

By undertaking the above process, the outputs generated provide a maximum likely extent, depth, level and hazard value that would be achieved if an individual breach of the Thames Tidal Defence line was to occur at any point.

There are limitations and uncertainties to this modelling, and the user is referred to the relevant sections of the Methodology Report for further detail.

2.2. Project deliverables

The following outputs were produced for each epoch and event:

- Individual shape files containing the maximum values of all the modelled variables for each simulation;
- Individual raster (.TIF) files containing the maximum values for elevation, depth, speed and hazard for each simulation on a 5m grid;
- Composite raster (.TIF) files containing the maximum values for elevation, depth, speed and hazard created by merging the full set of raster files for each combination of variable, epoch and event;
- The ICM database;
- The compressed ICM results files (.7z) for each individual simulation.

Flood Hazard Rating is calculated using the DEFRA Hazard formula presented in technical reports [FD2320/TR2](#) and [FD2321/TR1](#):

$$HR = d \times (v + 0.5) + DF$$

Where:

d = depth of flooding (m); v = velocity of floodwaters (m/s); DF = Debris Factor

Where Debris Factor is assumed to be:

0.5 for depths < 0.25m; 1.0 for depths > 0.25m

2.3. Additional outputs

A GIS polyline shapefile has been provided which details the attributes associated with an individual breach that has been modelled. Each shape within this file represents an individual breach width,

The individual 2D model outputs have also been retained as part of this assessment. The Breach ID within the shapefile relates to the Breach ID within the 2D individual model outputs. These additional outputs provide an opportunity for other uses than the purpose of this study, such as emergency planning. There are further attributes in these 2D model outputs, including:

- Mesh element area;
- Duration;
- element_no;
- Element level;
- Max unit flow;
- Min Depth;
- Min Speed;
- Min unit flow;
- Speed;
- Time to last inundation;
- Total inundation duration;
- Time to first inundation; and
- Time to peak inundation.

Further data processing can generate other useful combined raster grids. An example being to generate a time to inundation grid for Access / Egress to support Flood Risk Assessments.

2.4. Note on use of ICM database and results

The ICM database used to undertake this work was held on the Atkins internal ICM Workgroup Database Server (WDS). This has been copied to a standalone database that is provided supplied on the hard disk

Technical note

containing the project deliverables. This includes the full set of networks, levels, ground model and sims developed for the project. The size of the ICM database and the number of sim objects makes the use of a transportable database impractical, which is the reason that a standalone copy of the database has been supplied.

The full set of model results has been provided on the project hard disk. These have been individually zipped (.7z format) as in uncompressed format the total size of the full set of results files is of the order of 100TB. Each zip file is labelled by epoch, event, model area and scenario. For example, "2005_1000_dp_Runs_Area_011_Run_63.7z" contains the model results for the 2005 epoch, 0.1% AEP event for scenario 63, which is located in Area 011. The files within the individual .7z files are labelled according to the Atkins database sim ID.

A user will be able to access the standalone database within ICM, and rerun any/all sims that are of interest. Use of the existing model results would require the user to unzip the results, and to remap the original SIM id to the SIM id in the standalone database.

KSLES Guidance on using Product 6 data in a Flood Risk Assessment

The Product 6 data can be viewed using several GIS applications such as:

- ArcGIS
- Civil3D
- AutoCad
- Mapinfo
- Qgis

As an example, QGIS is an open source GIS application which is licensed under the General Public License (GNU) and can be freely used for commercial purposes on a wide range of devices.

The flood outlines (usually in shapefile format), along with flood level (h) grids (usually in ASCII, or GeoTIFF format) can be loaded into GIS software for further interrogation.

Please provide a node map and accompanying table in the Flood Risk Assessment similar to the example given below. You should clearly demonstrate the highest and most representative flood levels for your proposed development. For example, if it is a small extension (< 250 square metres) then approximately 5-10 nodes would be sufficient. For larger sites, approximately 10 to 20 nodes would be appropriate.

If you have any further queries regarding how to use the above data please contact the Partnership and Strategic Overview (PSO) team directly by reply email.



1. Outline your site boundary clearly
2. Clearly mark the node points where you are extracting data from
3. Select node points that cover the site, around the site itself, and along the access route to the site to give a representative sample.
- 4 Provide the flood level extracted from the data points in a table, similar to the one below.

Example Flood Level table:

Node	National Grid Reference		Modelled Levels
	Easting	Northing	[insert return periods]
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Advice to Consultants

The data provided in a Flood Risk Assessment will be checked against our records as we review the FRAs when consulted by the Local Planning Authority in our remit as statutory consultee for flood risk from tidal and fluvial sources. We require you to get in touch with us to check for the most up to date model information and FRA checklist. Having the latest data is important, as not having the data will possibly delay us in reviewing your application at planning stage.

Thank you for your enquiry.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004. The information is attached.

Name	Products 5, 6 and 7
Description	Report names: Thames Estuary Breach Assessment Methodology Report, May 2018, Rev 1.0, by Atkins Thames Estuary Breach Assessment Model User Guide, June 2018, by Atkins Thames Estuary Breach Assessment Outputs User Note, June 2018, by Atkins Model output data for Thames Tidal Downriver Breach Inundation Modelling 2018 Calibrated and Verified Model Input Data for Thames Tidal Downriver Breach Inundation Modelling 2018
Licence	Environment Agency Conditional Licence
Conditions	1.0 You may use the Information for your internal or personal purposes and may only sublicense others to use it if you do so under a written licence which includes the terms of these conditions and the agreement and in particular may not allow any period of use longer than the period licensed to you. 2.0 Notwithstanding the fact that the standard wording of the Environment Agency Conditional Licence indicates that it is perpetual, this Licence has a limited duration of 5 years at the end of which it will terminate automatically without notice. 3.0 We have restricted use of the Information as a result of legal restrictions placed upon us to protect the rights or confidentiality of others. In this instance it is because of third party data. If you contact us in writing (this includes email) we will, as far as confidentiality rules allow, provide you with details including, if available, how you might seek permission from a third party to extend your use rights. 4.1 The Information may contain some data that we believe is within the definition of "personal data" under the Data Protection Act 1998 but we consider that we will not be in breach of the Act if we disclose it to you with conditions set out in this condition and the conditions above. This personal data comprises names of individuals or commentary relating to property that may be owned by an individual or commentary relating to the activities of an individual. 4.2 Under the Act a person who holds and uses or passes to others personal data is responsible for any compliance with the Act and so we have

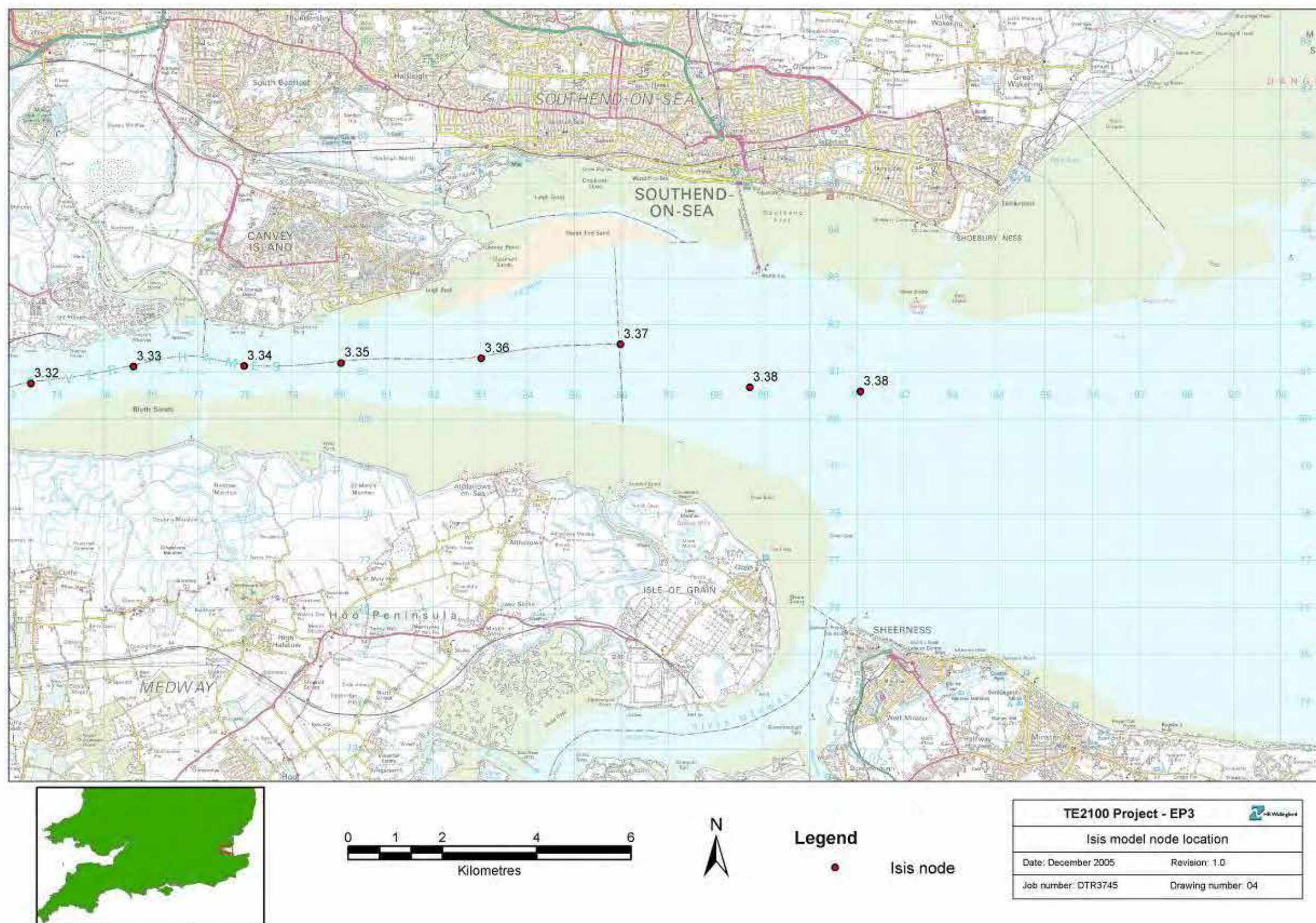
	no option but to warn you that this means you have responsibility to check that you are compliant with the Act in respect of this personal data. 5.0 The location of public water supply abstraction sources must not be published to a resolution more detailed than 1km2. Information about the operation of flood assets should not be published.. 6.1 Where we have supplied model data which may include model inputs or outputs you agree to supply to the Environment Agency copies of any assessments/studies and related outputs, modifications or derivatives created pursuant to the supply to you of the Information, all of which are hereinafter referred to as "the Data". 6.2 You agree, in the public interest to grant to the Environment Agency a perpetual royalty free non-exclusive licence to use the Data or any part thereof for its internal purposes or to use it in any way as part of Environment Agency derivative products which it supplies free of charge to others such as incorporation into the Environment Agency's Open Data mapping products.
Information Warnings	Please be aware that model data is not raw, factual or measured but comprises of estimations or modelled results based on the data available to us.
Attribution	Contains Environment Agency information © Environment Agency and/or database rights. May contain Ordnance Survey data © Crown copyright 2019 Ordnance Survey 100024198.

Data Available Online

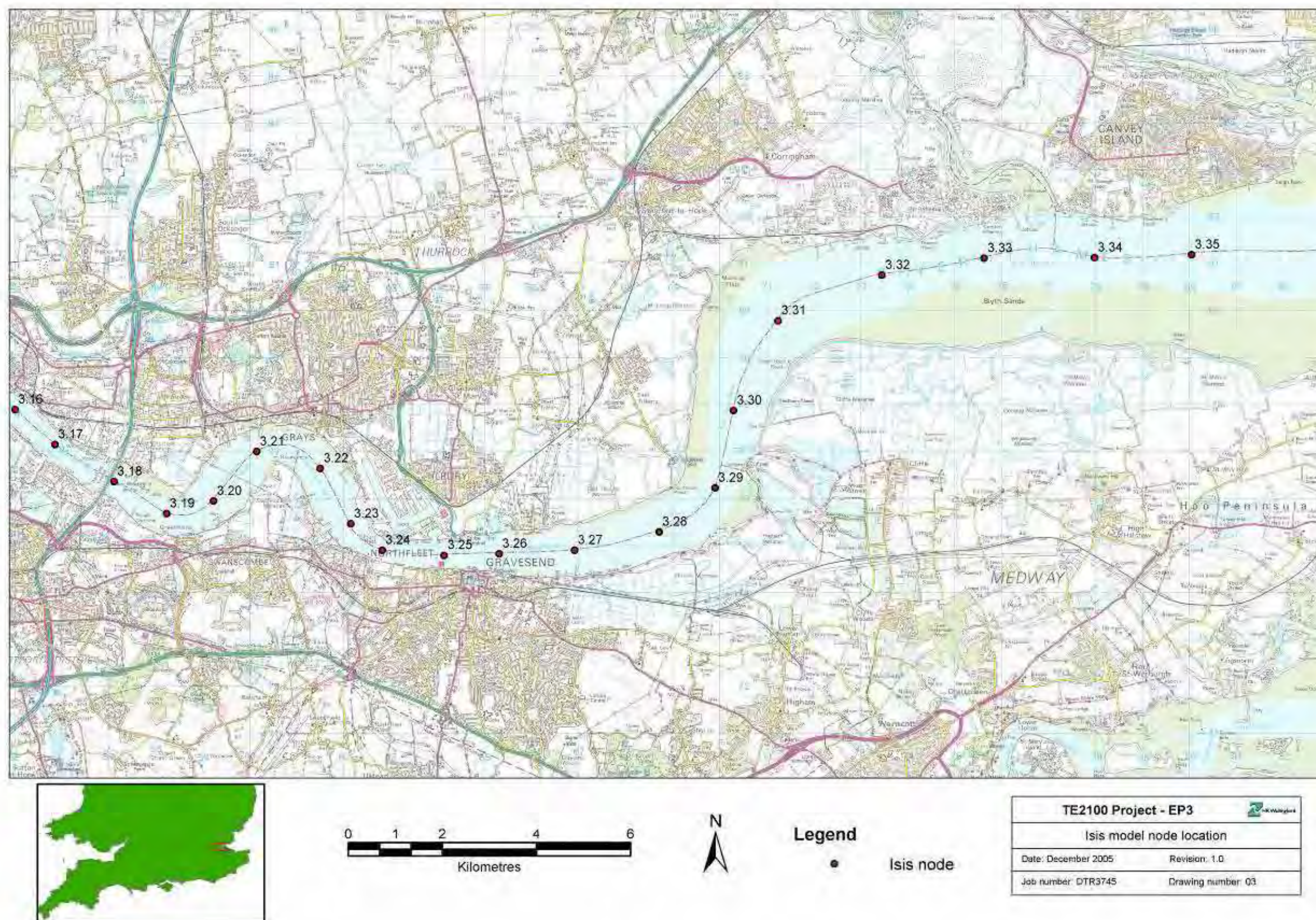
Many of our flood datasets are available online:

- [Flood Map For Planning \(Flood Zone 2, Flood Zone 3 ,Flood Storage Areas, Flood Defences, Areas Benefiting from Defences\)](#)
- [Risk of Flooding from Rivers and Sea](#)
- [Historic Flood Map](#)
- [Current Flood Warnings](#)

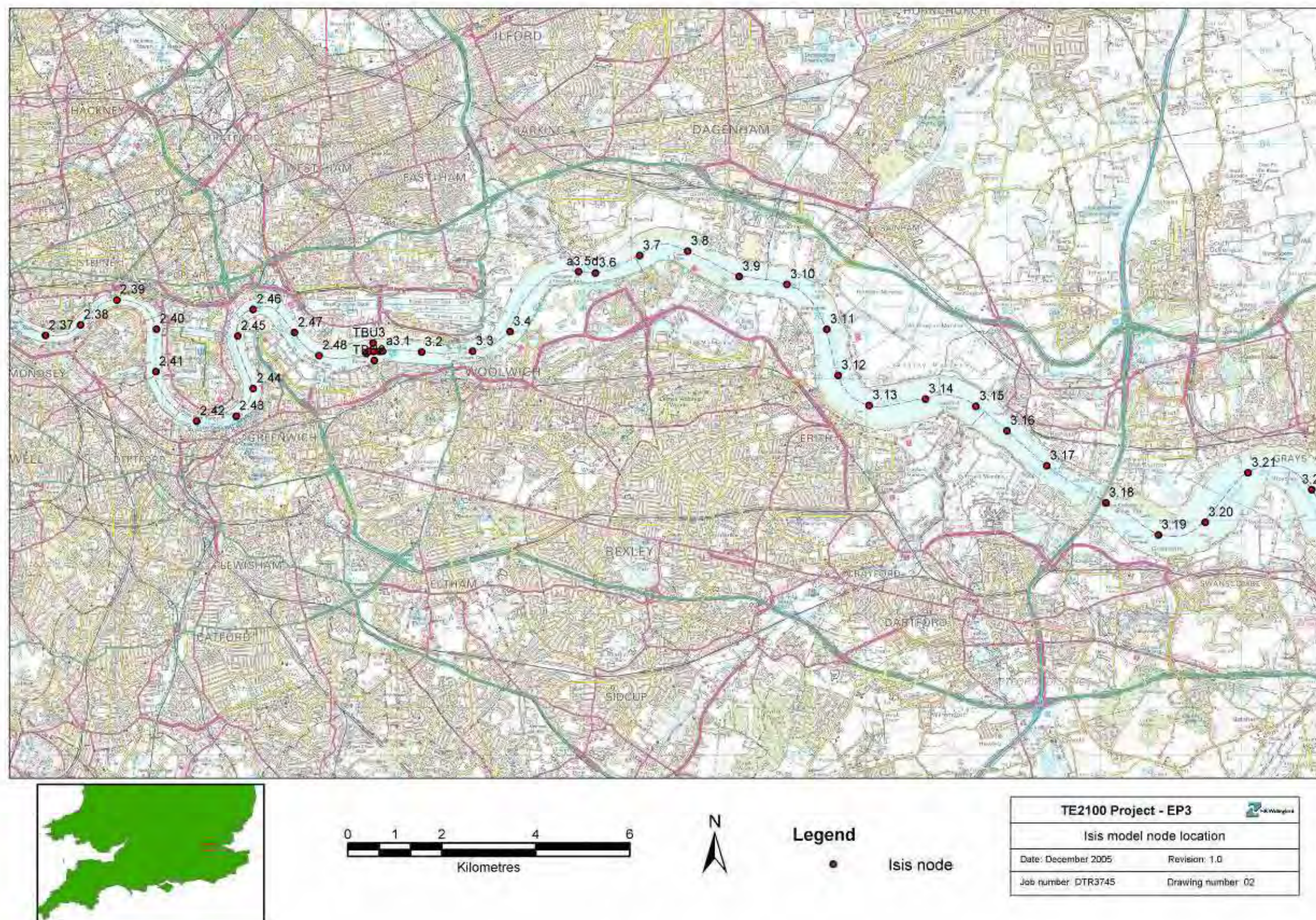
Appendix B Estuary Model Node Location Maps



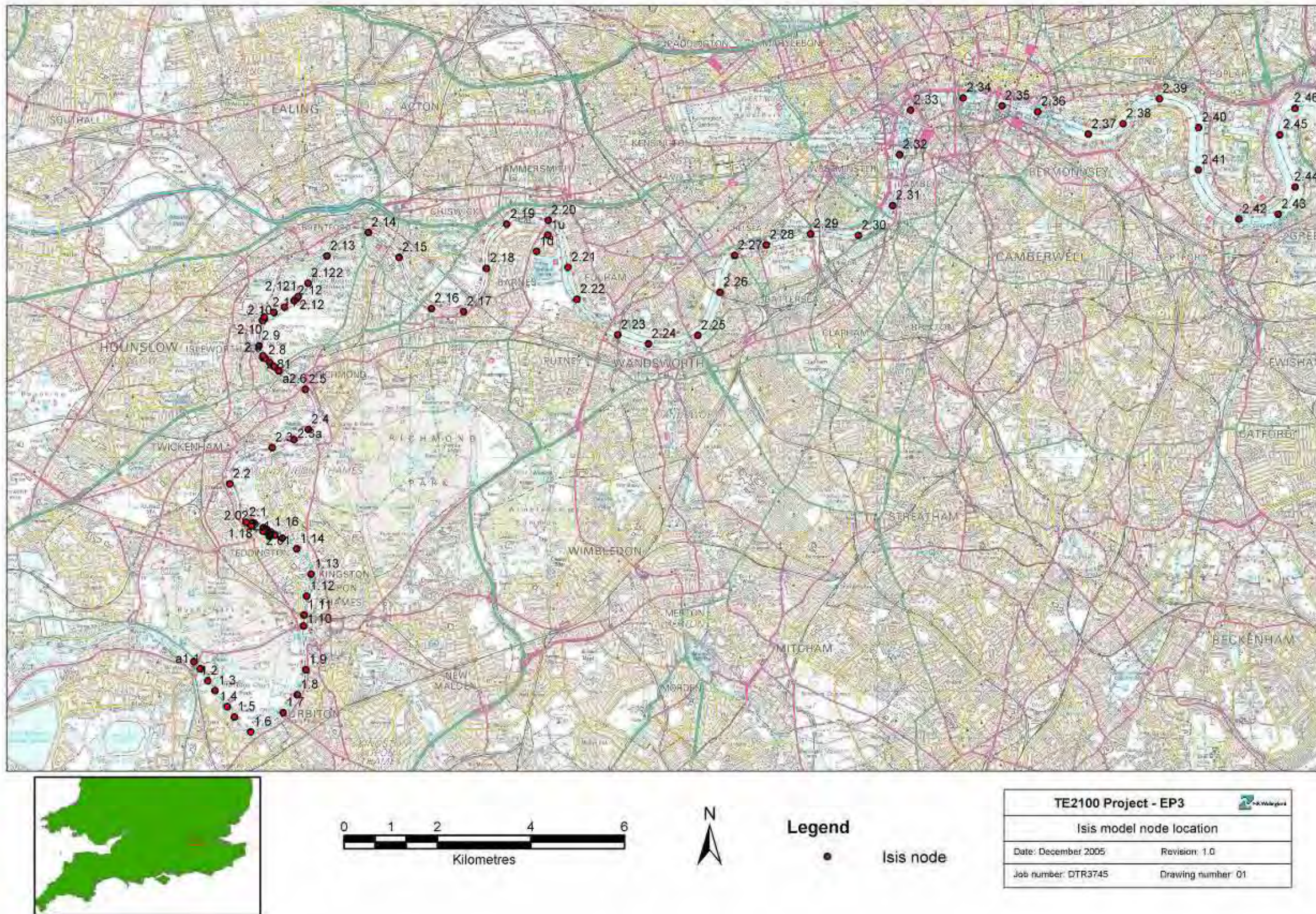
Map 1: Outer estuary



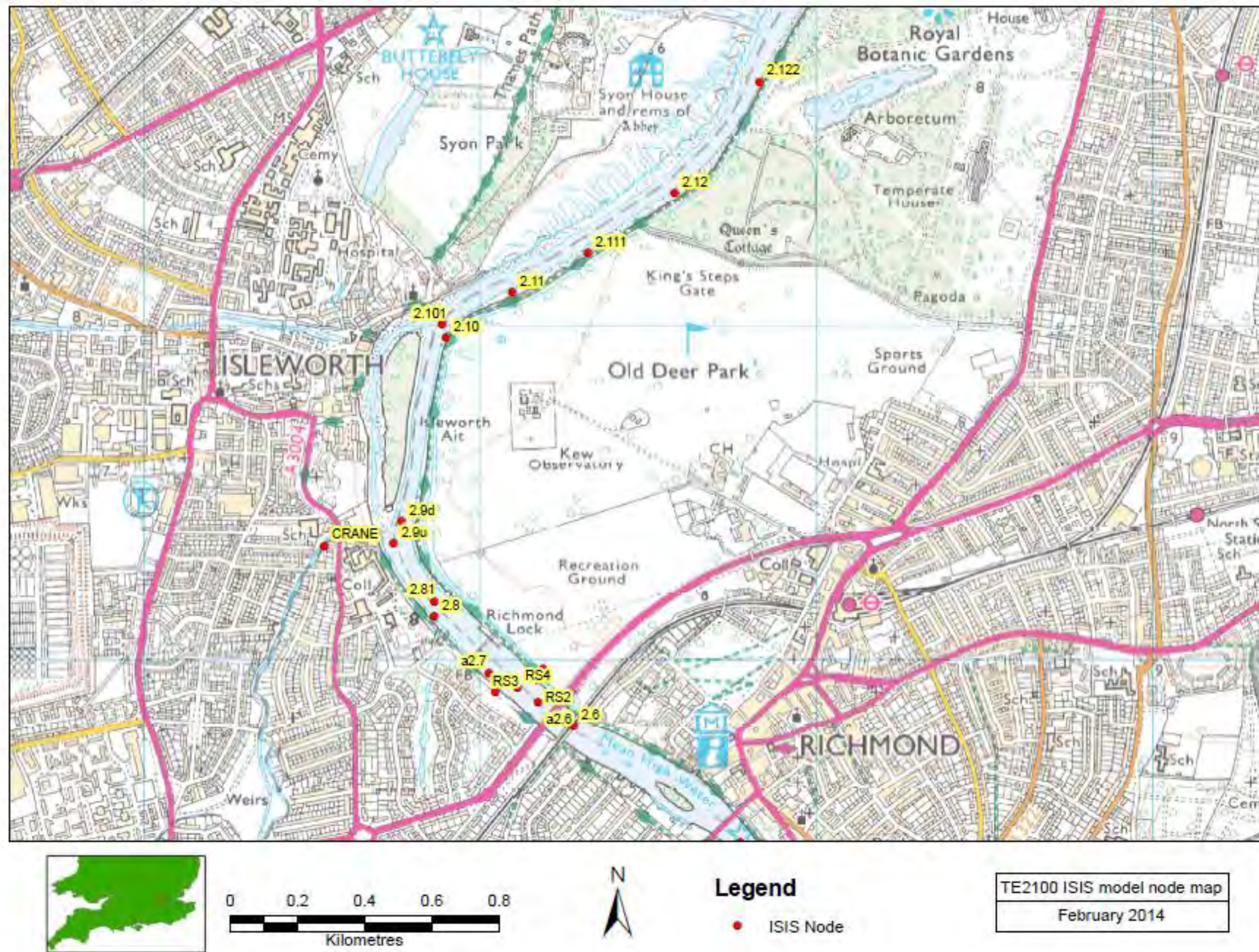
Map 2: Purfleet to Canvey



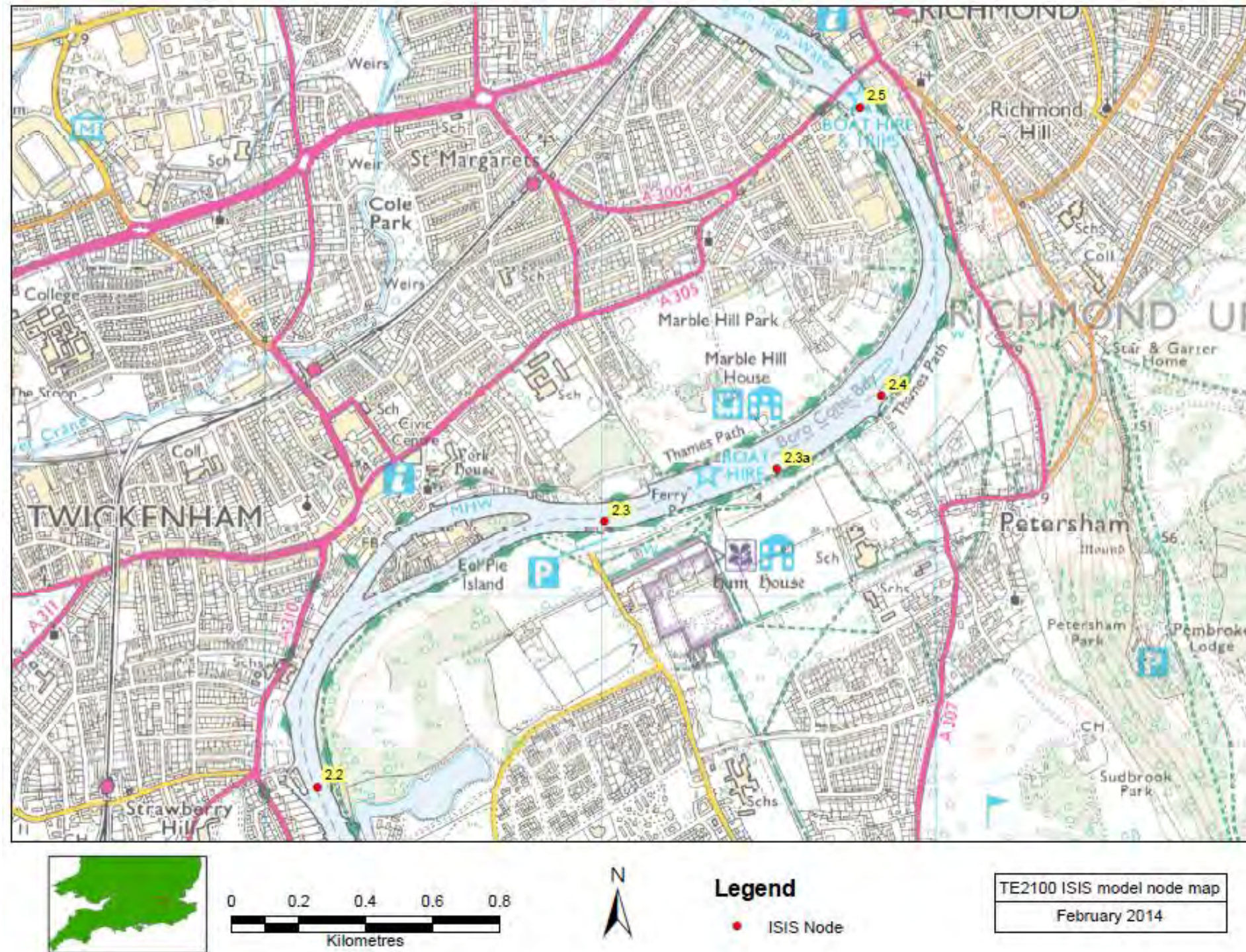
Map 3: Tower Bridge to Grays



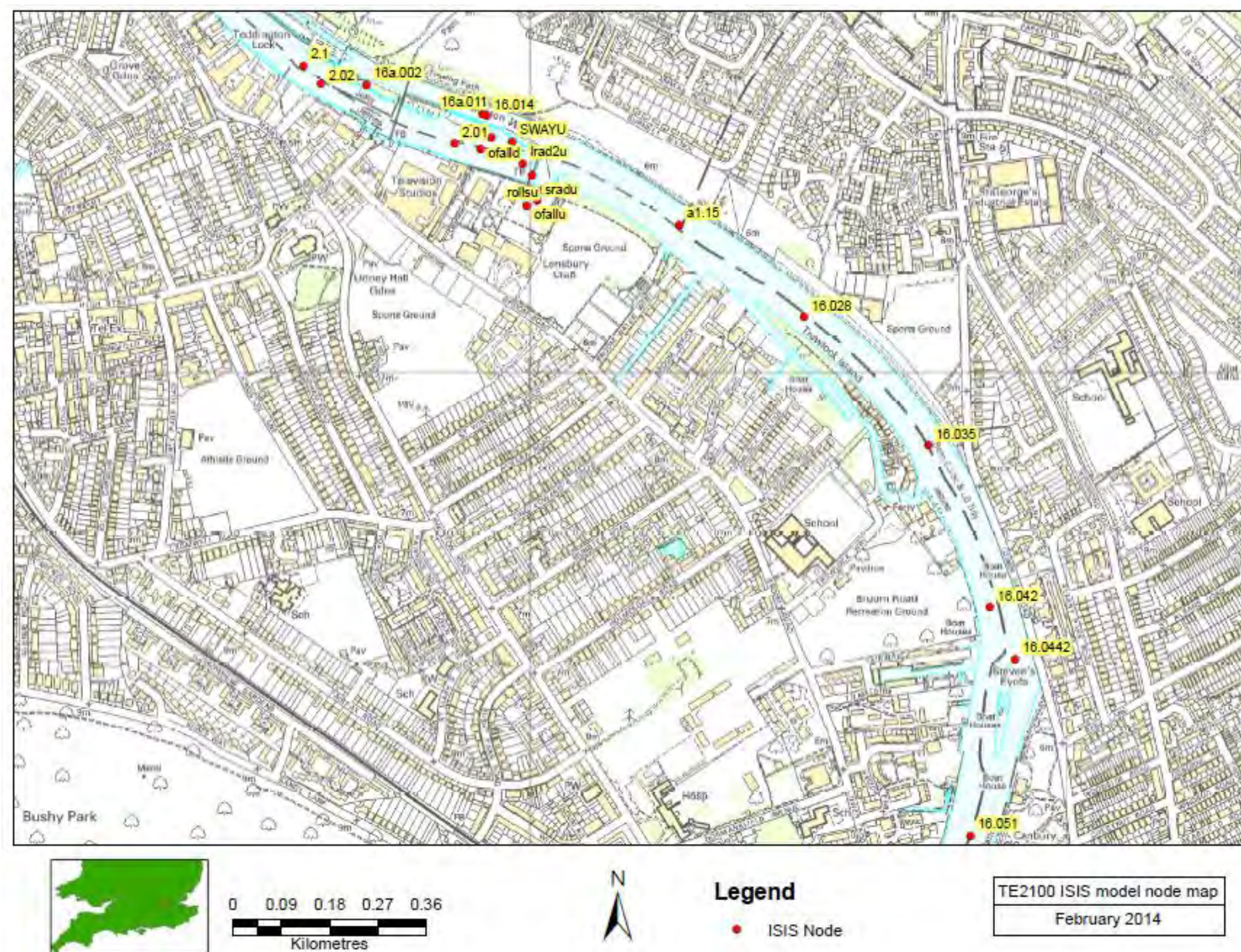
Map 4: Teddington to Greenwich



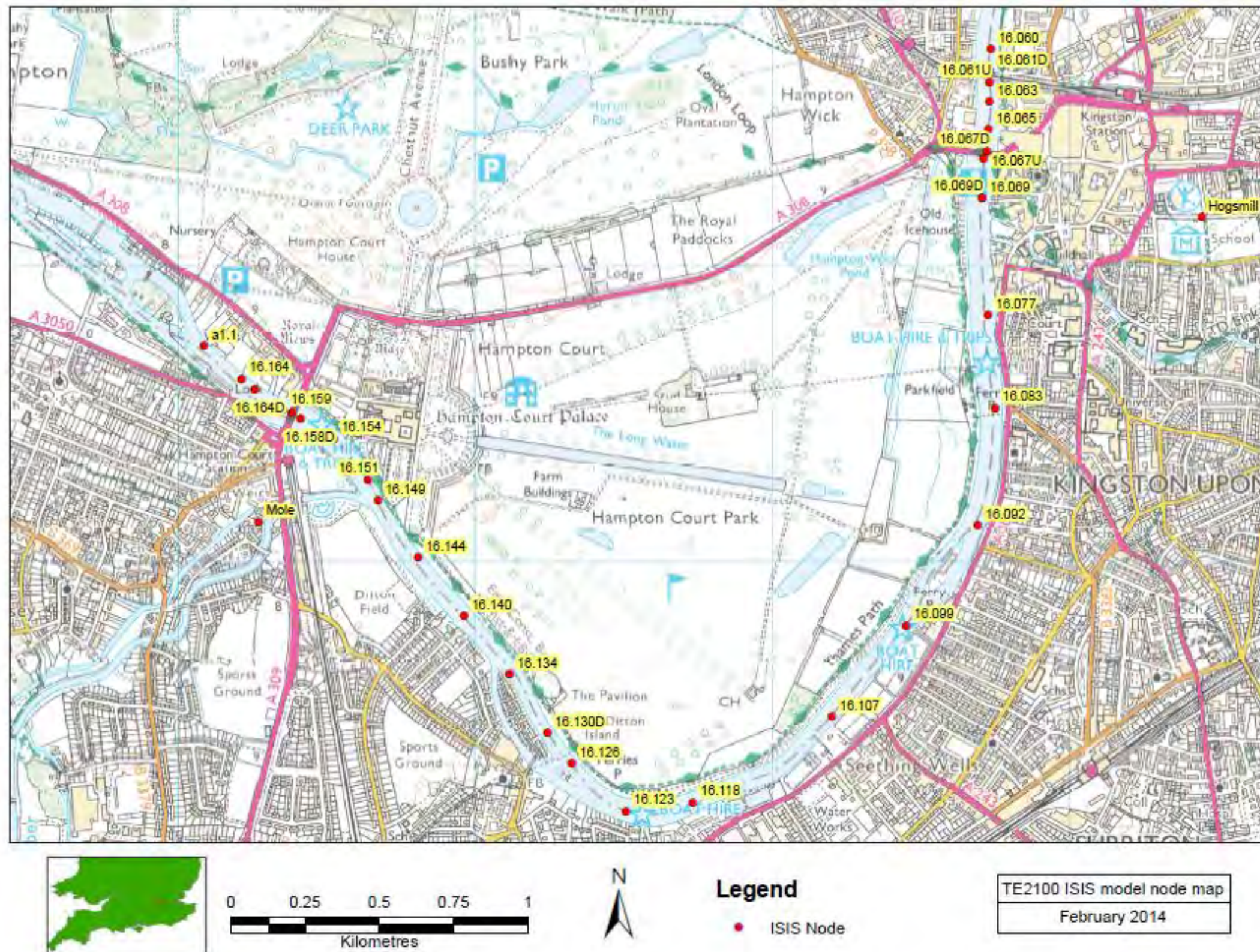
Map 5: Richmond to Kew - detail



Map 6: Twickenham to Richmond – detail



Map 7: Teddington to Kingston (upriver of TE2100 area)



Map 8: Kingston to Molesey (upriver of TE2100 area)

Table 4.7 New Barrier at Tilbury (implemented in 2070, limit in 2135)

Location	Node	Defence Level		Defence Level - Freeboard		Peak Water Level (2140)		Total Defence Raising Required	
		LB	RB	LB	RB	1,000yr	10,000yr	LB	RB
Barrier	a3.1	7.20	7.20	6.50	6.50	5.61	5.61	-	-
	3.2	7.20	7.20	6.50	6.50	5.59	5.59	-	-
	3.3	7.20	7.20	6.50	6.50	5.58	5.58	-	-
	3.4	7.20	7.20	6.50	6.50	5.57	5.57	-	-
Roding	a3.5u	7.20	7.10	6.50	6.40	5.55	5.55	-	-
	a3.5d	7.20	7.10	6.50	6.40	5.55	5.55	-	-
	3.6	7.10	7.10	6.40	6.40	5.54	5.54	-	-
	3.7	7.10	7.10	6.40	6.40	5.53	5.53	-	-
Beam	3.8	7.10	7.10	6.40	6.40	5.51	5.51	-	-
	3.9	7.10	7.10	6.40	6.40	5.49	5.49	-	-
	3.10	7.10	7.10	6.40	6.40	5.48	5.48	-	-
	3.11	7.10	7.10	6.40	6.40	5.46	5.46	-	-
	3.12	6.90	7.00	6.20	6.30	5.45	5.45	-	-
	3.13	6.90	7.00	6.20	6.30	5.43	5.43	-	-
	3.14	6.90	6.90	6.20	6.20	5.42	5.42	-	-
Darent	3.15u	6.90	7.34	6.20	6.64	5.40	5.40	-	-
	3.15d	6.90	7.34	6.20	6.64	5.40	5.40	-	-
	3.16	7.15	6.71	6.45	6.01	5.39	5.39	-	-
	3.17	6.94	6.74	6.24	6.04	5.37	5.37	-	-
	3.18	7.12	6.74	6.42	6.04	5.35	5.35	-	-
	3.19	6.84	6.76	6.14	6.06	5.33	5.33	-	-
	3.20	6.84	6.76	6.14	6.06	5.31	5.31	-	-
	3.21	6.84	6.76	6.14	6.06	5.30	5.30	-	-
	3.22	6.84	6.76	6.14	6.06	5.27	5.27	-	-
	3.23	6.84	6.76	6.13	6.05	5.25	5.25	-	-
	3.24	6.84	6.87	6.11	6.14	5.23	5.23	-	-
	3.25	6.84	7.10	6.10	6.36	5.20	5.20	-	-
Tilbury	3.26	6.63	7.10	5.87	6.34	5.18	5.18	-	-
	3.27	6.63	6.52	5.85	5.74	6.61	7.11	1.26	1.37
	3.28	6.63	6.57	5.83	5.77	6.61	7.11	0	0
	3.29	6.48	6.12	5.66	5.30	6.60	7.10	0	0
Mucking	3.30	6.76	5.91	5.91	5.06	6.60	7.08	0	0
	3.31	6.52	6.10	5.64	5.22	6.59	7.07	0.95	0
	3.32	6.50	5.92	5.59	5.01	6.59	7.07	1.00	0
	3.33	6.60	5.82	5.66	4.88	6.58	7.06	0.92	0
	3.34	6.47	5.75	5.50	4.78	6.57	7.06	1.07	0
Canvey	3.35	6.66	5.82	5.66	4.82	6.57	7.05	0.91	0
	3.36	6.56	5.50	5.56	4.50	6.56	7.05	1.00	0
	3.37	5.30	5.50	4.60	4.50	6.56	7.04	1.63	0
Southend	3.38	5.70	5.50	5.00	4.50	6.55	7.03	1.22	0

Note: Areas shaded in blue are Policy P3, where no defence raising is needed.

Table 4.8 New Barrier at Long Reach (implemented in 2070, limit in 2135)

Location	Node	Defence Level		Defence Level - Freeboard		Peak Water Level (2140)		Total Defence Raising Required	
		LB	RB	LB	RB	1,000yr	10,000yr	LB	RB
Barrier	a3.1	7.20	7.20	6.50	6.50	5.61	5.61	-	-
	3.2	7.20	7.20	6.50	6.50	5.59	5.59	-	-
	3.3	7.20	7.20	6.50	6.50	5.58	5.58	-	-
	3.4	7.20	7.20	6.50	6.50	5.57	5.57	-	-
Roding	a3.5u	7.20	7.10	6.50	6.40	5.55	5.55	-	-
	a3.5d	7.20	7.10	6.50	6.40	5.55	5.55	-	-
	3.6	7.10	7.10	6.40	6.40	5.54	5.54	-	-
	3.7	7.10	7.10	6.40	6.40	5.53	5.53	-	-
Beam	3.8	7.10	7.10	6.40	6.40	5.51	5.51	-	-
	3.9	7.10	7.10	6.40	6.40	5.49	5.49	-	-
	3.10	7.10	7.10	6.40	6.40	5.48	5.48	-	-
	3.11	7.10	7.10	6.40	6.40	5.46	5.46	-	-
	3.12	6.90	7.00	6.20	6.30	5.45	5.45	-	-
	3.13	6.90	7.00	6.20	6.30	5.43	5.43	-	-
	3.14	6.90	6.90	6.20	6.20	5.42	5.42	-	-
Darent	3.15u	6.90	7.34	6.20	6.64	5.40	5.40	-	-
	3.15d	6.90	7.34	6.20	6.64	5.40	5.40	-	-
	3.16	7.15	6.71	6.45	6.01	5.39	5.39	-	-
	3.17	6.94	6.74	6.24	6.04	7.01	7.41	1.17	1.37
	3.18	7.12	6.74	6.42	6.04	7.01	7.41	0.59	0.97
	3.19	6.84	6.76	6.14	6.06	7.00	7.40	0.86	0.94
	3.20	6.84	6.76	6.14	6.06	6.99	7.40	0.85	0.93
	3.21	6.84	6.76	6.14	6.06	6.98	7.39	0.84	0.92
	3.22	6.84	6.76	6.14	6.06	6.96	7.38	0.82	0.90
	3.23	6.84	6.76	6.13	6.05	6.95	7.37	0.82	0.90
	3.24	6.84	6.87	6.11	6.14	6.93	7.35	0.82	0.79
	3.25	6.84	7.10	6.10	6.36	6.90	7.33	0.80	0.54
Tilbury	3.26	6.63	7.10	5.87	6.34	6.88	7.30	1.01	0.54
	3.27	6.63	6.52	5.85	5.74	6.85	7.28	1.00	0
	3.28	6.63	6.57	5.83	5.77	6.83	7.26	0	0
	3.29	6.48	6.12	5.66	5.30	6.79	7.23	0	0
Mucking	3.30	6.76	5.91	5.91	5.06	6.75	7.18	0	0
	3.31	6.52	6.10	5.64	5.22	6.72	7.15	1.08	0
	3.32	6.50	5.92	5.59	5.01	6.70	7.13	1.11	0
	3.33	6.60	5.82	5.66	4.88	6.68	7.11	1.02	0
	3.34	6.47	5.75	5.50	4.78	6.65	7.09	1.15	0
Canvey	3.35	6.66	5.82	5.66	4.82	6.63	7.08	0.97	0
	3.36	6.56	5.50	5.56	4.50	6.60	7.06	1.04	0
	3.37	5.30	5.50	4.60	4.50	6.57	7.05	1.64	0
Southend	3.38	5.70	5.50	5.00	4.50	6.55	7.03	1.22	0

Note: Areas shaded in blue are Policy P3, where no defence raising is needed.

Table 6.1 Defence levels upriver of the Thames Barrier

DEFENCE LEVELS Upriver of Barrier			Defence crest levels					
			Statutory		Levels required in 2065 (for the period to 2100)		Levels required in 2100 (for the period to 2135)	
Location	Node	Chainage (m)	LB	RB	LB	RB	LB	RB
Teddington	2.01	7419	6.10	6.10	6.45	6.45	6.90	6.90
	2.1	8084	6.10	6.10	6.45	6.45	6.90	6.90
	2.2	9104	6.10	6.10	6.45	6.45	6.90	6.90
		9544	6.10	6.10	6.45	6.45	6.90	6.90
	2.3	10124	6.02	6.02	6.45	6.45	6.90	6.90
	2.3a	10549	6.02	6.02	6.45	6.45	6.90	6.90
		10950	6.02	6.02	6.45	6.45	6.90	6.90
	2.4	10974	6.02	6.02	6.35	6.35	6.80	6.80
		11353	6.02	6.02	6.35	6.35	6.80	6.80
		11727	6.02	6.02	6.35	6.35	6.80	6.80
	2.5	12014	6.02	6.02	6.35	6.35	6.80	6.80
	2.6	12764	5.94	5.94	6.35	6.35	6.80	6.80
	a2.6	13027	5.94	5.94	6.35	6.35	6.80	6.80
		13041	5.94	5.94	6.35	6.35	6.80	6.80
	a2.7	13314	5.94	5.94	6.35	6.35	6.80	6.80
Richmond sluice		13324	5.94	5.94	6.35	6.35	6.80	6.80
		13580	5.94	5.94	6.35	6.35	6.80	6.80
	2.8	13594	5.94	5.94	6.25	6.25	6.70	6.70
	2.9	13844	5.94	5.94	6.25	6.25	6.70	6.70
	2.10	14174	5.94	5.94	6.25	6.25	6.70	6.70
	2.13	16314	5.94	5.94	6.25	6.25	6.70	6.70
		16840	5.94	5.94	6.25	6.25	6.70	6.70
		16850	5.94	5.94	6.10	6.10	6.55	6.55
	2.17	20354	5.94	5.94	6.10	6.10	6.55	6.55
		20840	5.94	5.94	6.10	6.10	6.55	6.55
		20850	5.94	5.94	6.00	6.00	6.40	6.40
		22642	5.94	5.94	6.00	6.00	6.40	6.40
		22651	5.54	5.94	6.00	6.00	6.40	6.40
	2.20	23394	5.54	5.94	6.00	6.00	6.40	6.40
		24420	5.54	5.94	6.00	6.00	6.40	6.40
	2.21	24434	5.54	5.94	5.90	5.90	6.30	6.30
		25503	5.54	5.94	5.90	5.90	6.30	6.30
		25552	5.54	5.54	5.90	5.90	6.30	6.30
	2.23	26424	5.54	5.54	5.90	5.90	6.30	6.30
		26509	5.54	5.54	5.90	5.90	6.30	6.30
		26520	5.41	5.41	5.90	5.90	6.30	6.30
	2.24	27424	5.41	5.41	5.90	5.90	6.30	6.30
	2.25	28424	5.41	5.41	5.90	5.90	6.30	6.30
		30260	5.41	5.41	5.90	5.90	6.30	6.30
		30270	5.41	5.41	5.80	5.80	6.30	6.30
	2.29	32004	5.41	5.41	5.80	5.80	6.30	6.30
	2.33	36174	5.41	5.41	5.80	5.80	6.30	6.30
	2.35	38204	5.41	5.41	5.80	5.80	6.30	6.30
		38418	5.41	5.41	5.80	5.80	6.30	6.30
		38430	5.28	5.28	5.80	5.80	6.30	6.30
	2.36	38904	5.28	5.28	5.80	5.80	6.30	6.30
		40050	5.28	5.28	5.80	5.80	6.30	6.30
		40060	5.28	5.28	5.70	5.70	6.20	6.20
	2.38	40964	5.28	5.28	5.70	5.70	6.20	6.20
		41364	5.28	5.28	5.70	5.70	6.20	6.20
		41415	5.28	5.28	5.70	5.70	6.20	6.20
		41430	5.23	5.23	5.70	5.70	6.20	6.20
	2.39	41984	5.23	5.23	5.70	5.70	6.20	6.20
	2.43	46064	5.23	5.23	5.70	5.70	6.20	6.20
		46100	5.18	5.18	5.70	5.70	6.20	6.20
		46400	5.18	5.18	5.70	5.70	6.20	6.20
		46410	5.18	5.18	5.60	5.60	6.10	6.10
	2.47	50144	5.18	5.18	5.60	5.60	6.10	6.10
Thames Barrier	a2.49	52029	5.18	5.18	5.60	5.60	6.10	6.10
Notes								
Defence levels are shown at ISIS model nodes. Policy Units are not indicated.								

Table 7.1 Defence levels downriver of the Thames Barrier

DEFENCE LEVELS downriver of Barrier		Existing defence levels (2009)		OPTIONS 1.4 & 3.2 Defence levels required in 2040 (for period 2040 to 2070)		OPTION 1.4 Defence levels required in 2070 (for period 2070 to 2120)		OPTION 1.4 Defence levels required in 2120 (for period 2120 to 2170)		OPTION 3.2 Defence levels required in 2070 (for period 2070 to 2170)	
Location	Node	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
Barrier	a3.1	7.20	7.20	7.20	7.20	8.30	8.30	8.80	8.80	6.20	6.20
	3.2	7.20	7.20	7.20	7.20	8.30	8.30	8.80	8.80	6.20	6.20
	3.3	7.20	7.20	7.20	7.20	8.30	8.30	8.80	8.80	6.20	6.20
	3.4	7.20	7.20	7.20	7.20	8.30	7.70	8.80	8.20	6.20	6.20
Roding	a3.5u	7.20	7.10	7.20	7.20	8.30	7.70	8.80	8.20	6.20	6.20
	a3.5d	7.20	7.10	7.20	7.20	7.70	7.70	8.20	8.20	6.20	6.20
	River Roding	R5.80	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3.6	7.30	7.10	7.20	7.20	7.70	7.70	8.20	8.20	6.10	6.10
	3.7	7.30	7.10	7.20	7.20	7.70	7.70	8.20	8.20	6.10	6.10
	3.8	7.30	7.10	7.20	7.20	7.70	7.70	8.20	8.20	6.10	6.10
Beam	3.9	7.20	7.10	7.10	7.10	7.70	7.70	8.20	8.20	6.10	6.10
	3.10	7.10	7.10	7.10	7.10	7.60	7.60	8.10	8.10	6.10	6.10
	3.11	7.05	7.10	7.10	7.10	7.60	7.60	8.10	8.10	6.10	6.10
	3.12	6.90	7.00	7.10	7.10	7.60	7.60	8.10	8.10	6.10	6.10
	3.13	7.00	7.00	7.10	7.10	7.60	7.60	8.10	8.10	6.10	6.10
	3.14	7.00	6.90	7.10	7.10	7.60	7.60	8.10	8.10	6.10	6.10
	3.15u	7.05	6.90	7.10	7.10	7.60	7.60	8.10	8.10	6.10	6.10
	3.15d	7.05	6.90	7.10	7.10	7.60	7.60	8.10	8.10	6.10	6.10
	River Darent	N/A	R5.30	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3.16	7.15	6.70	7.10	7.10	7.60	7.60	8.10	8.10	6.10	6.10
	3.17	6.85	6.74	7.00	7.00	7.60	7.60	8.00	8.00	8.50	8.50
	3.18	6.90	6.35	7.00	7.00	7.50	7.50	8.00	8.00	8.50	8.50
	3.19	6.85	6.75	7.00	7.00	7.50	7.50	8.00	8.00	8.50	8.50
	3.20	6.85	6.28	7.00	7.00	7.50	7.50	8.00	8.00	8.50	8.00
	3.21	6.90	7.05	7.00	7.00	7.50	7.50	8.00	8.00	8.50	8.00
	3.22	6.85	7.05	7.00	7.00	7.50	7.50	7.90	7.90	8.00	8.00
	3.23	6.85	6.75	7.00	7.00	7.50	7.50	7.90	7.90	8.00	8.00
	3.24	6.50	6.73	6.90	6.90	7.40	7.40	7.90	7.90	8.00	8.00
	3.25	6.95	6.87	6.90	6.90	7.40	7.40	7.90	7.90	8.00	8.00
	3.26	6.65	6.75	6.90	6.90	7.40	7.40	7.90	7.90	8.00	8.00
	3.27	7.00	6.35	6.90	6.35	7.40	6.35	7.90	6.35	8.00	6.35
	3.28	7.00	6.57	7.00	6.57	7.00	6.57	7.00	6.57	7.00	6.57
	3.29	6.48	6.12	6.48	6.12	6.48	6.12	6.48	6.12	6.48	6.12
	3.30	6.75	5.91	6.75	5.91	6.75	5.91	6.75	5.91	6.75	5.91
Mucking	3.31	6.90	6.10	6.90	6.10	7.50	6.10	8.10	6.10	8.10	6.10
	3.32	6.50	5.90	6.90	5.90	7.50	5.90	8.10	5.90	8.10	5.90
	3.33	6.60	5.80	6.80	5.80	7.50	5.80	8.10	5.80	8.10	5.80
	Vange Creek	R4.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Canvey	3.34	6.80	5.75	6.70	5.75	7.40	5.75	8.10	5.75	8.10	5.75
	3.35	6.75	5.82	6.70	5.82	7.40	5.82	8.10	5.82	8.10	5.82
	3.36	6.65	Cliff	6.70		7.40		8.10		8.10	
	EH Creek	R4.20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hadleigh Marsh	R6.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3.37	4.75	5.30	6.00	5.30	6.70	5.30	7.40	5.30	7.40	5.30
Southend	3.38	5.70	5.50	6.00	5.50	6.70	5.50	7.40	5.50	7.40	5.50
	Grain east	N/A	5.70	N/A	6.30	N/A	7.00	N/A	7.70	N/A	7.70
Key		Notes									
P5 (1:10,000)		Defence levels are shown at ISIS model nodes. Policy Units are not indicated.									
P4 (1:1,000)		Representative levels are shown using the prefix 'R' for defences									
P4 (1:200)		not represented by ISIS nodes.									
P3											

If staff are requested to provide data to developers in P3 areas downriver of the Barrier, including at Hadleigh Marshes, North Kent Marshes and Isle of Grain, they must contact the TE2100 implementation team as early as possible, to ensure they use the best available data on design levels. The TE2100 Plan assumed that the existing defence crest levels would be maintained in P3 areas downriver of the Barrier but did not calculate the specific design levels required for such sites. These may need to be calculated to support such a data request.

Source: Reference 29 (*Phase 3 Set 2 Estuary Wide Options – Hydraulic Modelling*). Some minor adjustments were subsequently made to simplify the level information.

Table 7.2 Defence levels for Policy Units downriver of the Thames Barrier

Recommendations are given in the right hand column for the allowances for future raising that should be included in new defence designs when defences are replaced.

Policy Unit	Bank	Defence levels (m AOD)				Comment and Recommendations
		Existing (2009 data)	2070	2170	2170	
			Implement in 2040	See Table 7.1 for implementation dates		
				Option 1.4	Option 3.2	
Greenwich, Royal Docks	R L	7.2	7.2	8.8	6.2	Downriver Thames Barrier. Allow future raising to 8.8m AOD
Barking & Dagenham	L	7.2	7.2	8.2	6.1	Allow future raising to 8.2m AOD
Rainham	L	6.9 – 7.1	7.1	8.1	6.1	Allow future raising to 8.1m AOD
Thamesmead	R	7.0 – 7.1	7.1 – 7.2	8.1 – 8.2	6.1	Allow future raising to 8.2m AOD
Dartford & Erith:						
- U/R new barrier	R	6.7 – 7.0	7.1	8.1	6.1	Allow future raising to 8.1m AOD
- D/R new barrier	R	6.7	7.0	8.0	8.5	Allow future raising to 8.5m AOD
Swanscombe & Northfleet	R	6.3 – 7.1	6.9 – 7.0	7.9 – 8.0	8.0	Allow future raising to 8.0m AOD
Purfleet, Grays & Tilbury:						
- U/R new barrier	L	7.1	7.0 - 7.1	8.0 - 8.1	6.1	Allow future raising to 8.1m AOD
- D/R new barrier to Grays	L	6.8 – 6.9	7.0	8.0	8.5	Allow future raising to 8.5m AOD
- D/R Grays	L	6.5 – 6.9	6.9 – 7.0	7.9	8.0	Allow future raising to 8.0m AOD
East Tilbury	L	6.4 – 6.9	6.4 – 6.9	6.4 – 6.9	6.4 – 6.9	APF will be 5% by 2100. Consider secondary defence for East Tilbury.
Shellhaven & Fobbing	L	6.5	6.8 – 6.9	8.1	8.1	Allow for future raising of existing tidal defences to 8.1m AOD in the southern half of the policy unit (i.e. from Mucking Sluice to Fobbing Barrier) to protect critical infrastructure, including London Gateway Port.
Bowers	L	6.5	6.7	8.1	8.1	Allow future raising to 8.1m AOD for primary defence on Holehaven Creek.
Canvey	L	6.6 – 6.8	6.7	8.1	8.1	Allow future raising to 8.1m AOD
Hadleigh	L	6.0	6.0	6.0	6.0	
Southend	L	4.7 – 5.7	6.0	7.4	7.4	Allow future raising to 7.4m AOD
North Kent west	R	6.1 - 6.5	6.1 - 6.5	6.1 - 6.5	6.1 - 6.5	
North Kent east	R	5.8 – 6.1	5.8 – 6.1	5.8 – 6.1	5.8 – 6.1	
Grain west	R	5.5	5.5	5.5	5.5	No defence raising proposed for Allhallows and Grain Marshes. Protection needed for access routes to Grain east.
Grain east	R	5.7	6.0 – 6.3	7.4 – 7.7	7.4 – 7.7	Industrial areas. Allow future raising to 7.4m or 7.7m AOD depending on location.

Notes:

Green shading:

Policy P3 - No change in levels

Orange shading:

Increase in defence levels

D/R: Downriver

U/R: Upriver

If staff are requested to provide data to developers in P3 areas downriver of the Barrier, including at Hadleigh Marshes, North Kent Marshes and Isle of Grain, they must contact the TE2100 implementation team as early as possible, to ensure they use the best available data on design levels. The TE2100 Plan assumed that the existing defence crest levels would be maintained in P3 areas downriver of the Barrier but did not calculate the specific design levels required for such sites. These may need to be calculated to support such a data request.

11. Appendix C – Flood Defence Information

RECORD DRAWING No		RECORD DRAWING No	DESCRIPTION	RECORD DRAWING No	DESCRIPTION	RECORD DRAWING No	DESCRIPTION
15/1	Location Plan	15/12	<u>O.C.L.</u> O.C.L. - Plan & Sections Sheet 1 of 2	15/29	<u>TIDAL BASIN</u> Tidal Basin - Sandfill Embankment	15/52	<u>TILBURY POWER STATION</u> Tilbury A Power Station - Concrete Walls - Schedule
15/2	<u>GRAIN TERMINAL</u> Grain Terminal - Schedule of Bays	15/13	O.C.L. - Plan & Sections Sheet 2 of 2	15/30	Tidal Basin - Location Plan	15/53	Tilbury A Power Station - Key Plan & Schedule
15/3	Grain Terminal - Plan & Sections		<u>TILBURY NESS</u> Tilbury Ness - Transition of Western End	15/31	Tidal Basin - Concrete Walls - Plan & Sections - Sheet 1 of 7	15/54	Tilbury A Power Station - Concrete Walls Plan & Sections
15/4	New Botney Sluice - Sheet Piles - Plan & Sections	15/14	Tilbury Ness - Plan & Sections	15/32	Tidal Basin - Concrete Walls - Plan & Sections - Sheet 2 of 7	15/55	Tilbury A Power Station - Plan & Sections
15/5	New Botney Sluice - Ground Anchor Details	15/15	Tilbury Ness - P.L.A. 300mm dia Drainage Pipe Crossing	15/33	Tidal Basin - Concrete Walls - Plan & Sections - Sheet 3 of 7	15/56	Tilbury A Power Station - Amendments to Original Piled Wall
15/6	New Botney Sluice - Details	15/16		15/34	Tidal Basin - Concrete Walls - Plan & Sections - Sheet 4 of 7	15/57	Tilbury A Power Station - Ground Beam Details at Bays K43-K45
15/7	Grain Terminal - Concrete Wall Details		<u>CUSTOMS HOUSE</u> Customs House No 40 - Plan & Sections Sheet 1 of 2	15/35	Tidal Basin - Concrete Walls - Plan & Sections - Sheet 5 of 7	15/58	Tilbury A Power Station - Details of Ground Anchor Chamber at Gate No.13
15/8	Grain Terminal Jetty - Concrete Details	15/17	Customs House No 40 - Plan & Sections Sheet 2 of 2	15/36	Tidal Basin - Concrete Walls - Plan & Sections - Sheet 6 of 7	15/59	Tilbury A Power Station - Berm Details at Bays K54-K56 & K88-K90
15/9	Grain Terminal - Precast Customs Fence Details	15/18	Customs House No 40 - General Arrangement Pipe Diversion Details	15/37	Tidal Basin - Concrete Walls - Plan & Sections - Sheet 7 of 7	15/60	Tilbury Power Station Jetty - Details
15/10	Grain Terminal - Sheet Piling - Plan & Sections	15/19	Customs House No 40 - Air & Latex Pipe Diversion Details	15/38	Tidal Basin - Roll-on Roll-off Jetty - General Arrangement	15/61	Tilbury Power Station Jetty - Sections & Details
15/11	Grain Terminal - Sheet Piling Alignment Details	15/20	Customs House No 40 - Fire Main Diversion	15/39	Tidal Basin - Walkway Details	15/62	Tilbury Power Station Jetty - Asphalt Ramp & Kerb Details
		15/21	<u>RIVER THAMES SHIP REPAIRERS LTD</u> River Thames Ship Repairers Ltd - Plan & Sections Sheet 1 of 2	15/40	<u>BAGGAGE HALL & RIVERSIDE STATION</u> Riverside Station & Baggage Hall - Location Plan	15/63	Tilbury B Power Station - Concrete Walls - Schedule
		15/22	River Thames Ship Repairers Ltd - Floodwall Details Sheet 2 of 2	15/41	P.L.A. Baggage Hall - Floodwall Details	15/64	Tilbury B Power Station - Concrete Walls - Plan & Sections
		15/23	River Thames Ship Repairers Ltd - Diversions of Main Pipe Lines	15/42	Riverside Station - Floodwall Details	15/65	Tilbury B Power Station - Plan & Sections
		15/24	River Thames Ship Repairers Ltd - Diversions of Cables & Water Supply Pipe Line	15/43	Riverside Station - Eastern Concourse Details - Sheet 1 of 2	15/66	Tilbury B Power Station - Details at Manhole No.1
		15/25	River Thames Ship Repairers Ltd - Raising of Bailey Bridges - Pier Details	15/44	Riverside Station - Eastern Concourse Details - Sheet 2 of 2	15/67	Tilbury B Power Station - Details at Cooling Water Outfall
		15/26	River Thames Ship Repairers Ltd - Outfall Pipework Details	15/45	Riverside Station - Modifications to Car Park	15/68	Tilbury B Power Station - Manhole & Drainage Details
		15/27	River Thames Ship Repairers Ltd - Pipe Bridge to No.1 Repair Jetty	15/46	Baggage Hall & Riverside Station - Steelwork Details	15/69	West Tilbury Marshes - Termination Details
		15/28		15/47	Baggage Hall & Riverside Station - Gate & Latch Details		<u>MISCELLANEOUS DETAILS</u> Steps & Ladder Details - Sheet 1 of 2
				15/48	Riverside Station - Junction with Tilbury Fortlands	15/70	Steps & Ladder Details - Sheet 2 of 2
				15/49	<u>TILBURY FORTLAND</u> Tilbury Fortland - Plan & Sections - Sheet 1 of 2	15/71	Handrailing, Typical Ladder & Step Details
				15/50	Tilbury Fortland - Plan & Sections - Sheet 2 of 2	15/72	Concrete Floodwall, Movement Joints Drainage & Concrete Block Details
				15/51	Tilbury Fortland - Footpath Steps	15/73	Movement Joints & Service Crossing Details
						15/74	Tilbury A Power Station - Ground Anchor Details - Sheet 1 of 2
						15/75	Tilbury A Power Station - Ground Anchor Details - Sheet 2 of 2
						15/76	

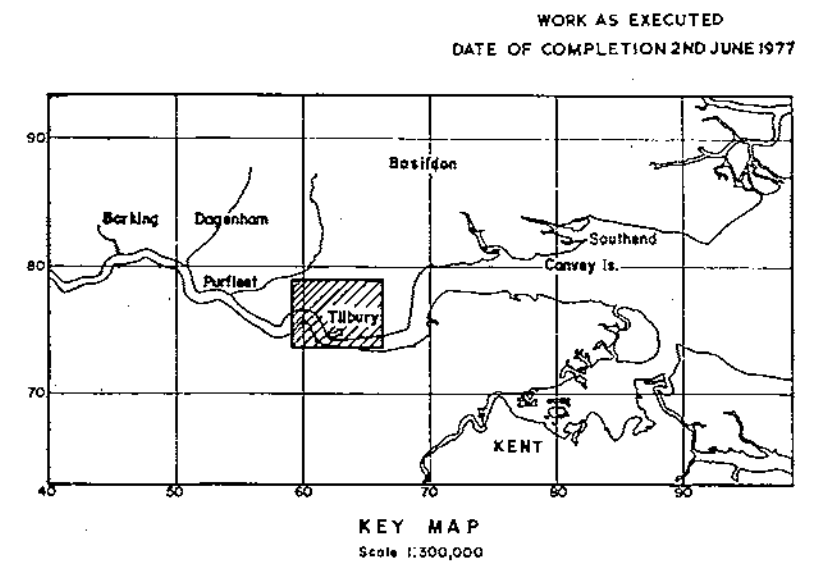
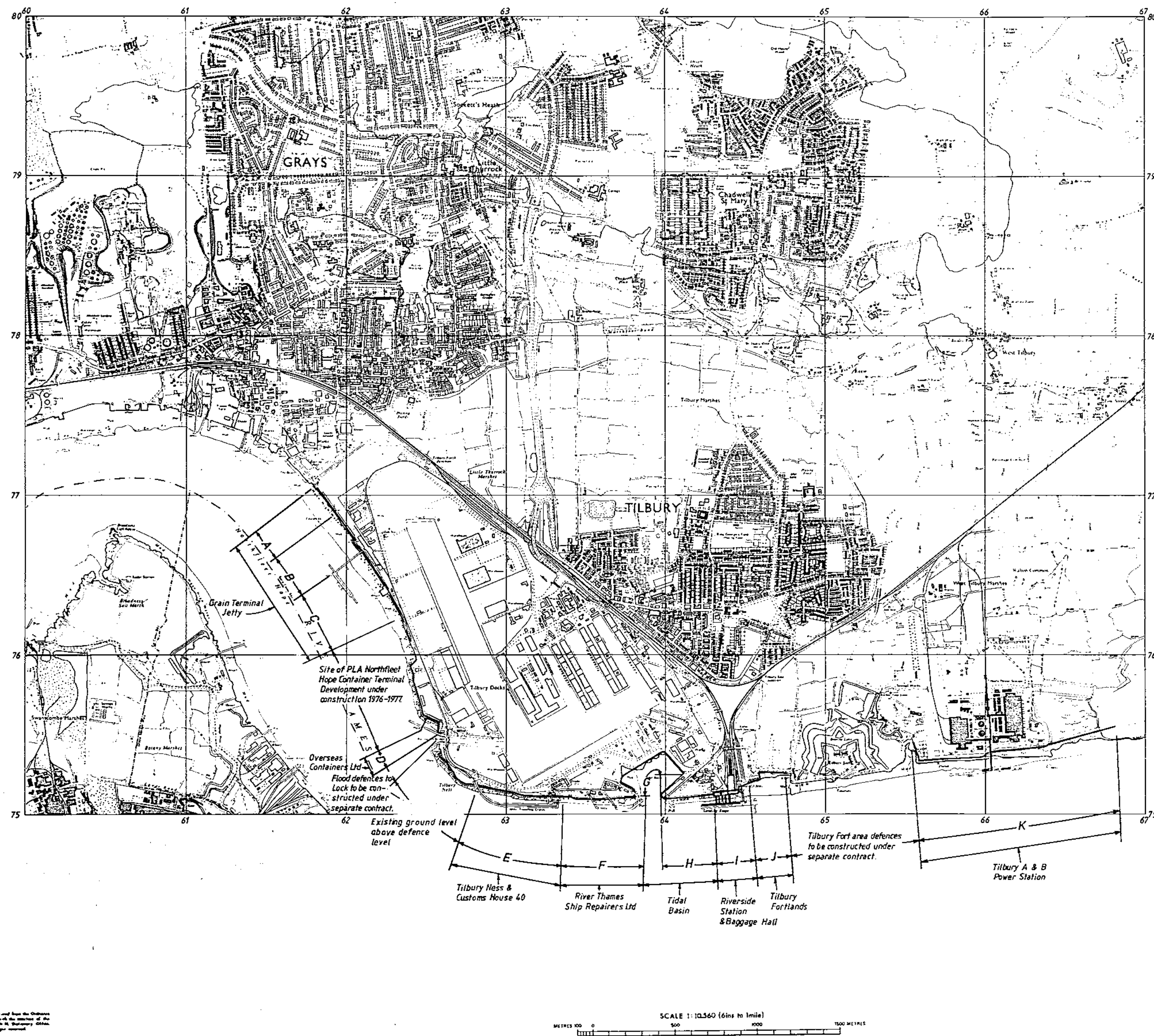
ANGLIAN WATER AUTHORITY
THAMES TIDAL DEFENCES

FLOODWALLS: TILBURY
INDEX TO RECORD DRAWINGS

RECORD DRAWING No. 15/00

BINNIE & PARTNERS
Consulting Engineers
Artillery House Westminster S.W.1

DATE
FEBRUARY 1979
REGISTER No
1041-15-ROOO



- NOTES**
- This drawing to be read in conjunction with Record Drawings Nos.
 - 15/2 Grain Terminal - Schedule of Bays
 - 15/12 D.C.L. - Plan & Sections
 - 15/15 Tilbury Ness - Plan & Sections
 - 15/18 Customs House No 40 - Plan & Sections
 - 15/22 River Thames Ship Repairers Ltd - Plan & Sections
 - 15/30 Tidal Basin - Location Plan
 - 15/40 Riverside Station & Baggage Hall - Location Plan
 - 15/49 Tilbury Fortland - Plan & Sections
 - 15/52 Tilbury A Power Station - Concrete Walls - Schedule
 - 15/63 Tilbury B Power Station - Concrete Walls - Schedule

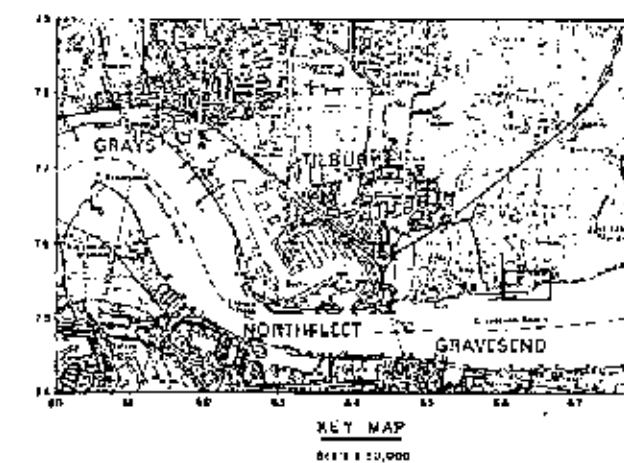
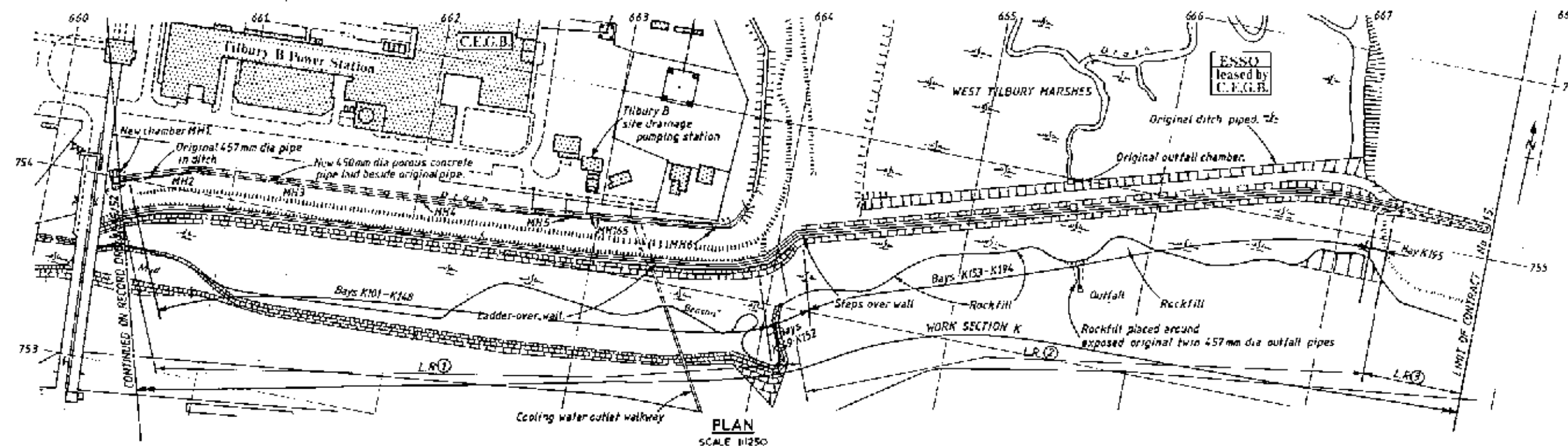
ANGLIAN WATER AUTHORITY
THAMES TIDAL DEFENCES

FLOODWALLS : TILBURY
LOCATION PLAN

RECORD DRAWING No. 15/1

BINNIE & PARTNERS
Consulting Engineers
Artillery House Westminster S.W.1

J. H. Eldridge
DATE
FEBRUARY 1979
REGISTER No
1041-15-ROO1



Bay No.	Type of bay	Length of bay	Cross Section	No. of bays	Remarks
Work Section K					
101 to 148	Straight	2.50	A-A	48	For cross sections A-A, B-B & D-D see Record Drawing No 15/65
149	Bend	6.00	A-A	1	
150 to 151	Straight	2.50	Transition	2	Transition section between Bays K149 and K150.
152	Bend	6.00	D-D	1	
153-156	Straight	7.50	B-B	4	
157-194	Straight	7.50	B-B	39	
195	Straight	7.00	B-B	1	Cut off omitted

Loading Restrictions (L.R.)		
Max Surcharge KNm^2		Limits of Surcharge
L.R. ①	10	Landward for a width of 3.0m
	6	Riverward
L.R. ②	10	Landward for a width of 3.0m
	6	Riverward
L.R. ③	9	Landward & riverward for a width of 10m each side
		Limits measured from face of wall to stem

NOTES

- This drawing to be read in conjunction with Record Drawings Nos 15/61 1:10500 Location Plan
- 15/64 Concrete Walls - Plans & Sections
- 15/65 Pbn & Sections
- 15/66 Details at M.H. No 1
- 15/67 Details at Cooling Water Outfall
- 15/68 Manhole & Drainage Details
- 15/69 West Tilbury Marshes Drainage Details

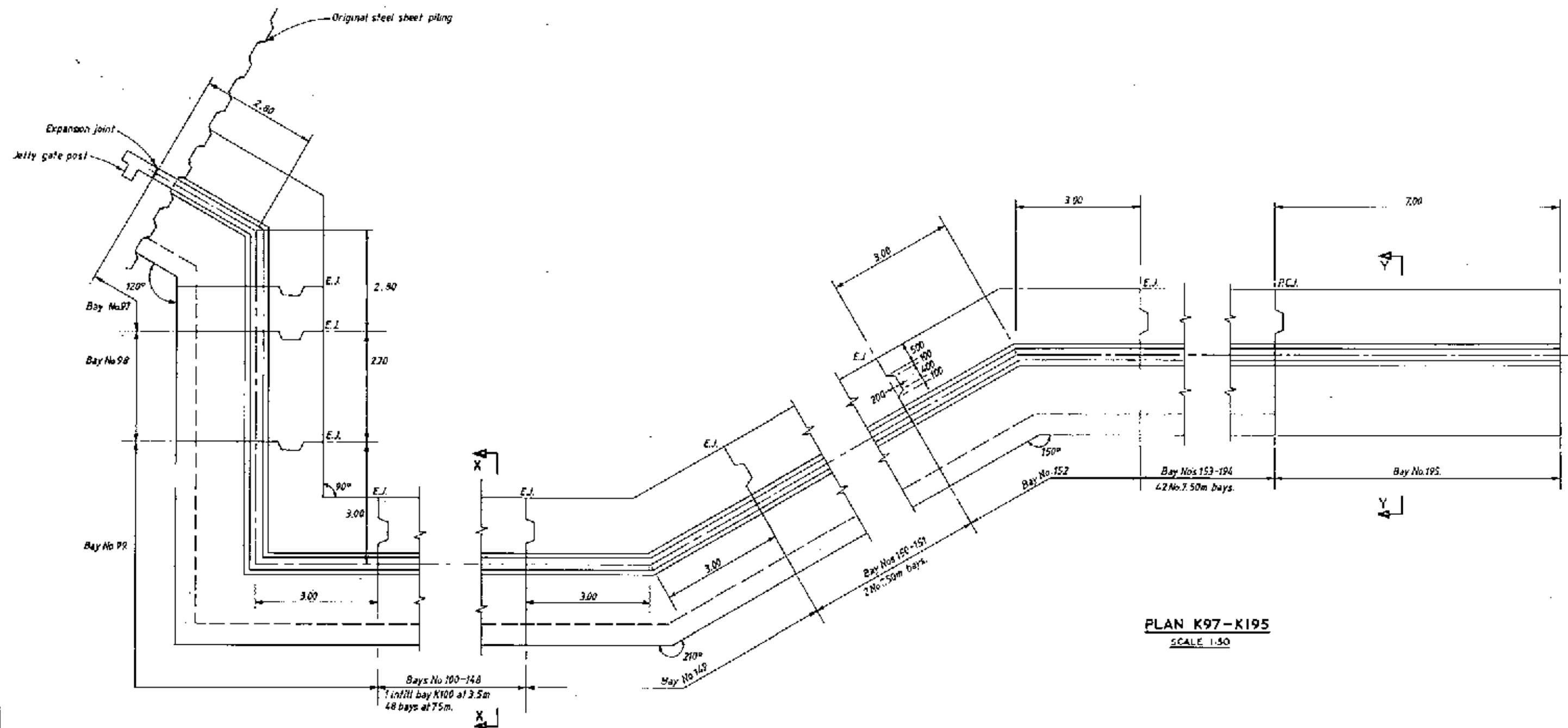
ANGLIAN WATER AUTHORITY
THAMES TIDAL DEFENCES

FLOODWALLS : TILBURY
TILBURY B POWER STATION
CONCRETE WALLS - SCHEDULE

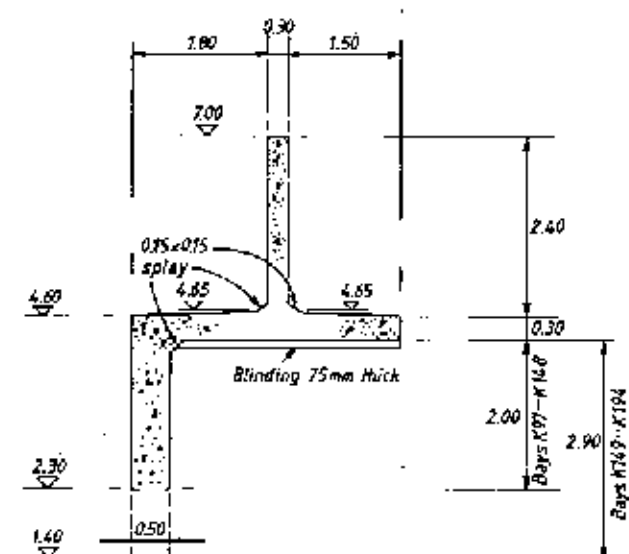
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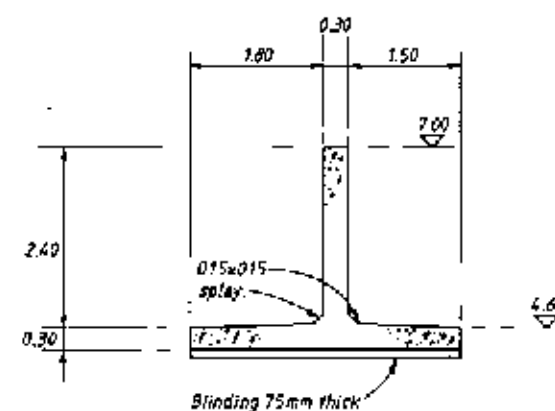
G. J. Eldridge
DATE
FEBRUARY 1979
REGISTER NO
1041-15-RO63



PLAN K97-K195
SCALE 1:50



SECTION X-X
SCALE 1:50



SECTION Y-Y (Bay No. 195 only)
SCALE 1:50

NOTES

- 1 All levels are in metres and refer to Ordnance Datum (Newlyn). All dimensions are in metres unless otherwise stated.
- 2 This drawing to be read in conjunction with Record Drawings Nos 15/63 Concrete Walls & Schedule 15/65 Plan & Sections.

ANGLIAN WATER AUTHORITY
THAMES TIDAL DEFENCES

FLOODWALLS : TILBURY
TILBURY 'B' POWER STATION
CONCRETE WALLS PLAN & SECTIONS

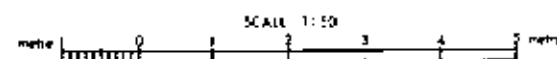
RECORD DRAWING No. 15/64

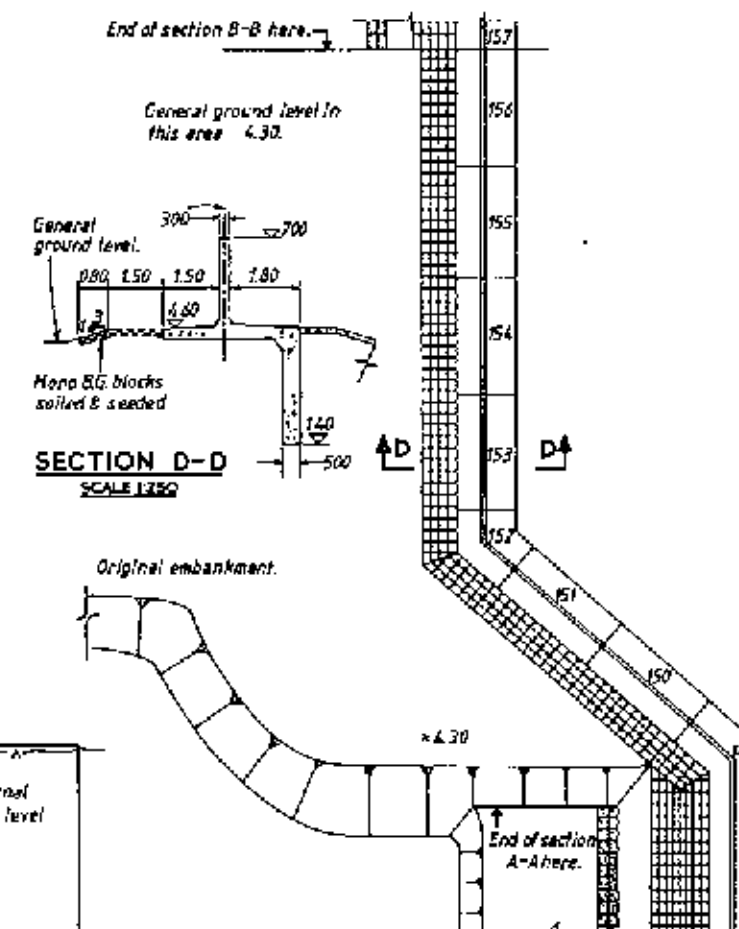
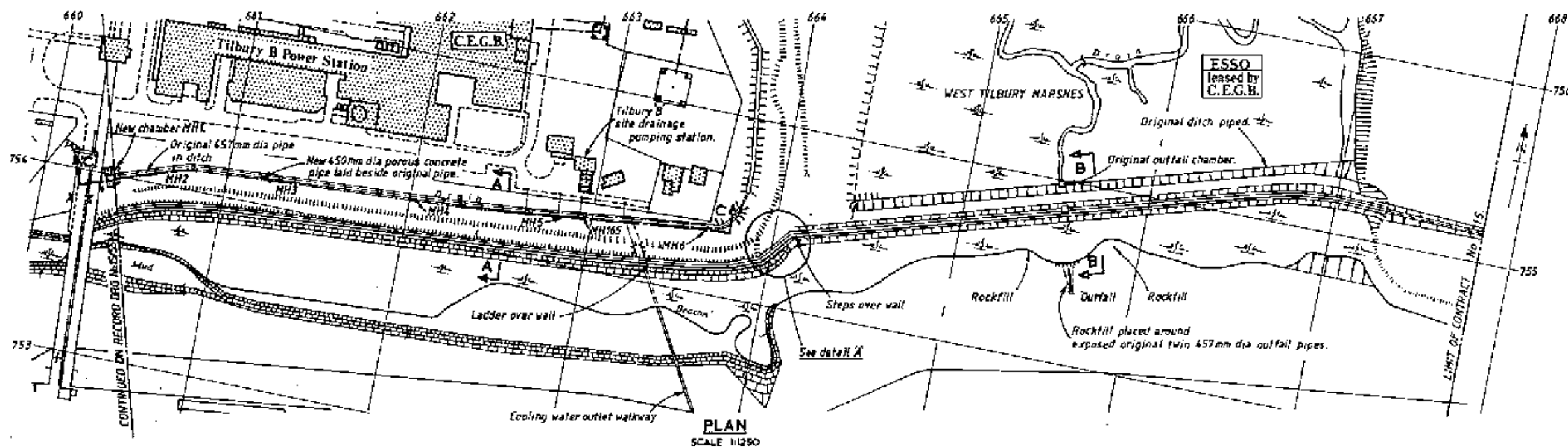
BINNIE & PARTNERS
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Artillery House Westminster S.W.1

J. C. Aldridge

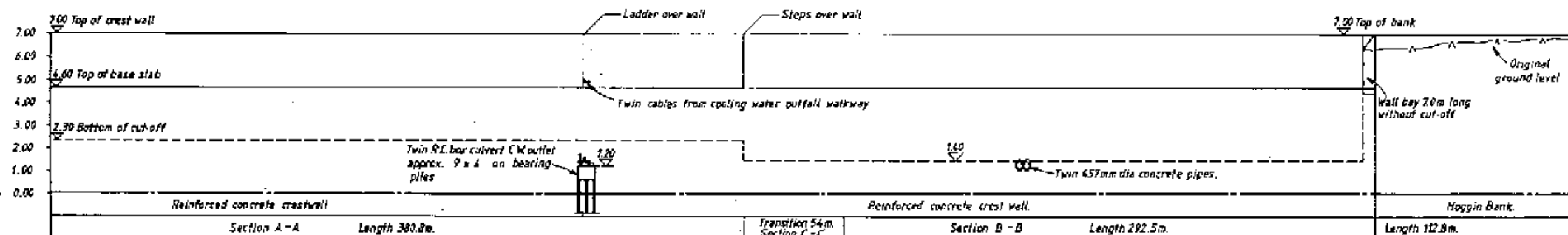
DATE
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REGISTERED
1041-15-RO64

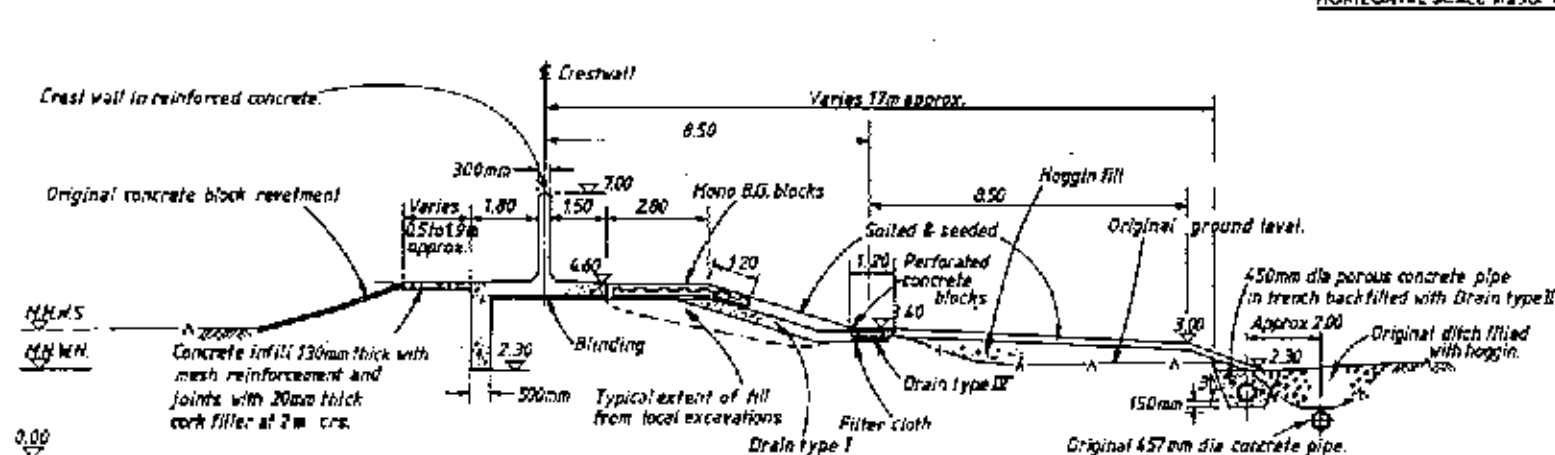




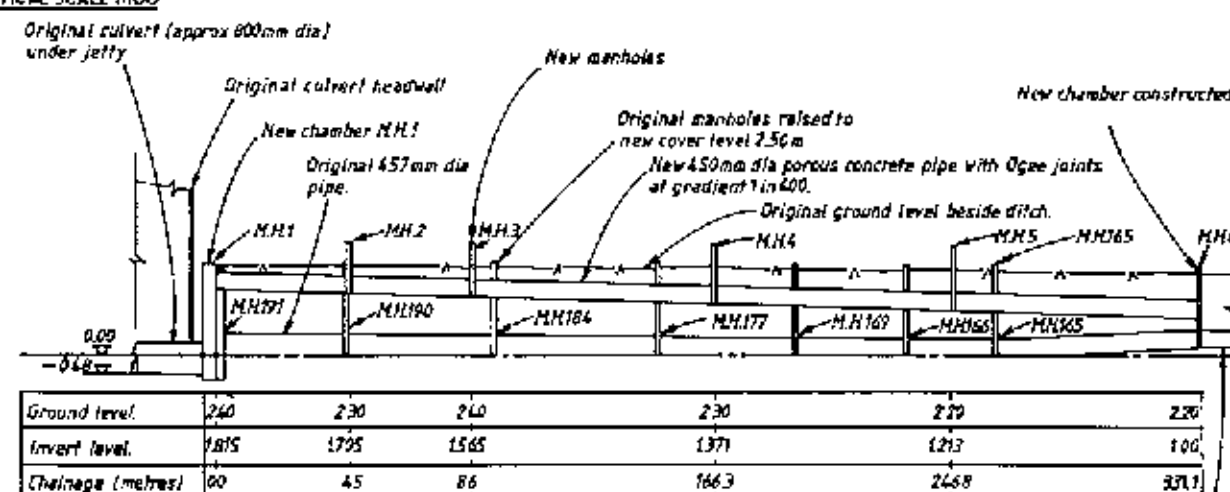
DETAIL A AT TRANSITION
SCALE 1:250



LONGITUDINAL SECTION
HORIZONTAL SCALE 1:1250 VERTICAL SCALE 1:100



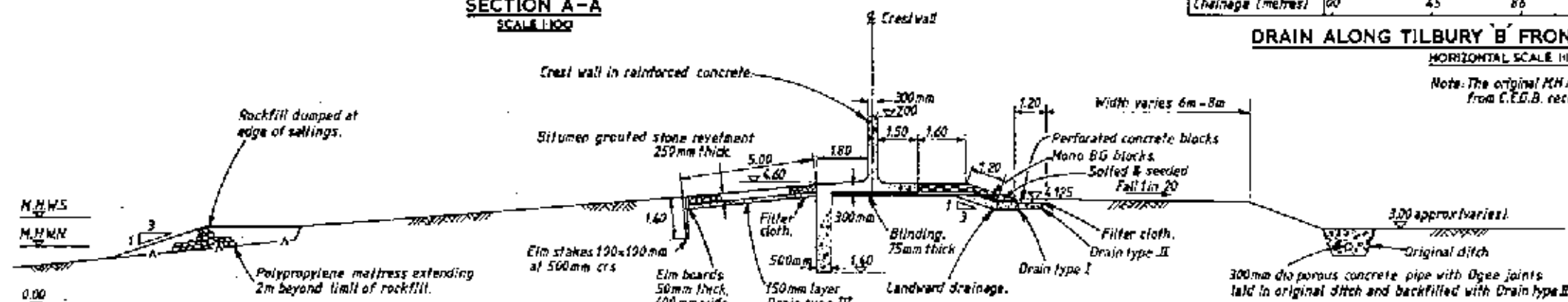
SECTION A-A
SCALE 1:100



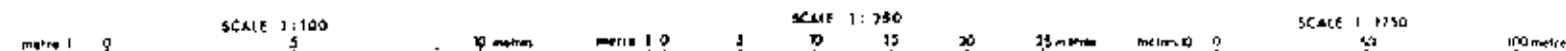
DRAIN ALONG TILBURY B FRONTAGE LONGITUDINAL SECTION C-C
HORIZONTAL SCALE 1:1250 VERTICAL SCALE 1:100

Note: The original M.H. nos M.H.1 to M.H.5 were taken from C.E.G.B. records.

- NOTES**
- All levels are in metres and refer to Ordnance Datum (Newlyn).
 - All dimensions are in metres unless otherwise stated.
 - This drawing to be read in conjunction with Record Drawings Nos:
 - 15/63 Concrete Walls - Schedule
 - 15/64 Concrete Walls - Plan & Sections
 - 15/66 Details at Manhole No. 1
 - 15/67 Details at Cooling Water Outfall
 - 15/68 Manhole & Drainage Details
 - 15/69 West Tilbury Marshes - Termination Details



SECTION B-B
SCALE 1:100



ANGLIAN WATER AUTHORITY
THAMES TIDAL DEFENCES

FLOODWALLS: TILBURY
TILBURY B POWER STATION
PLAN & SECTIONS

RECORD DRAWING No 15/65

BINNIE & PARTNERS

Consulting Engineers

Artillery House

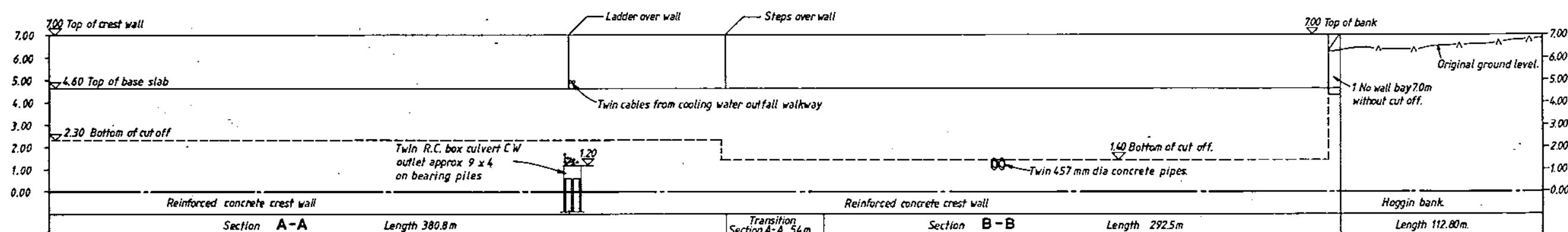
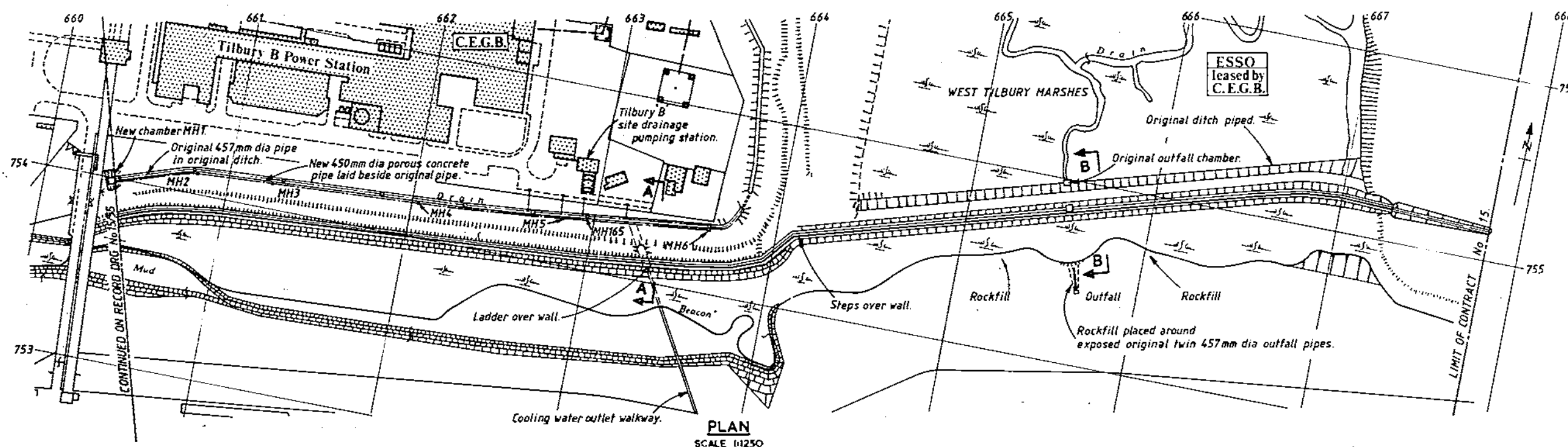
Westminster S.W.1

DATE

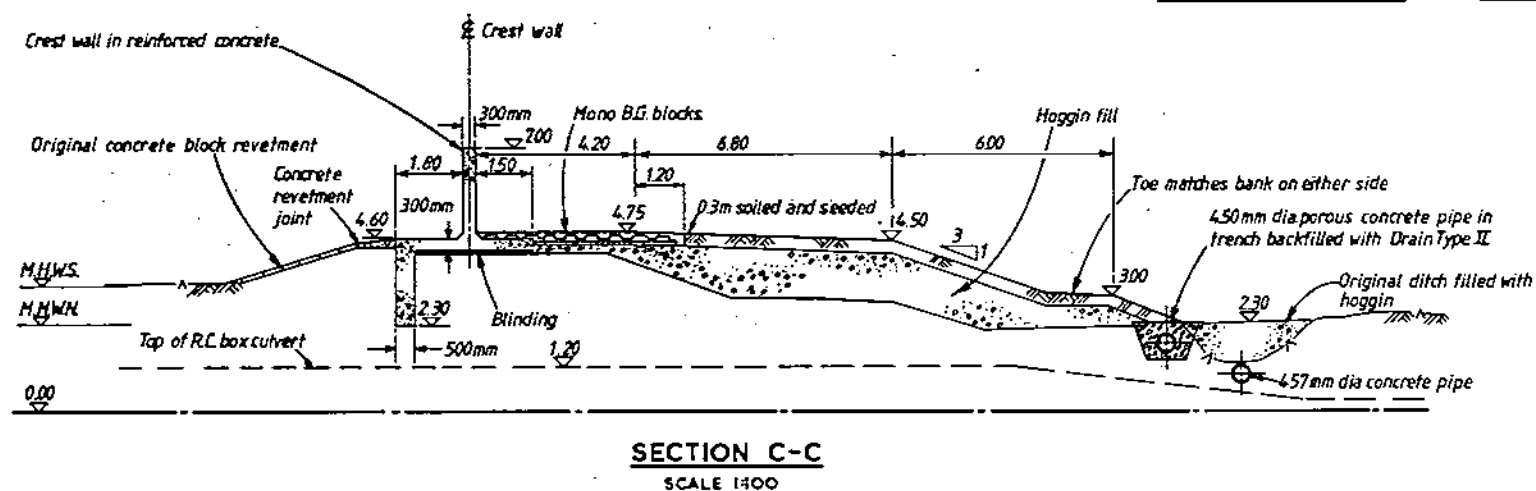
FEBRUARY 1979

REGISTER No

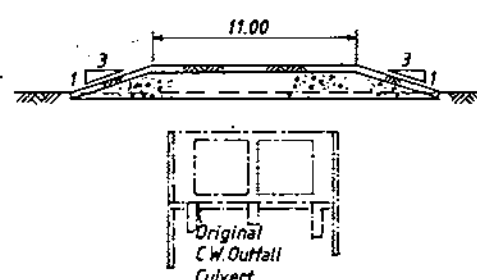
1041-15-RO65



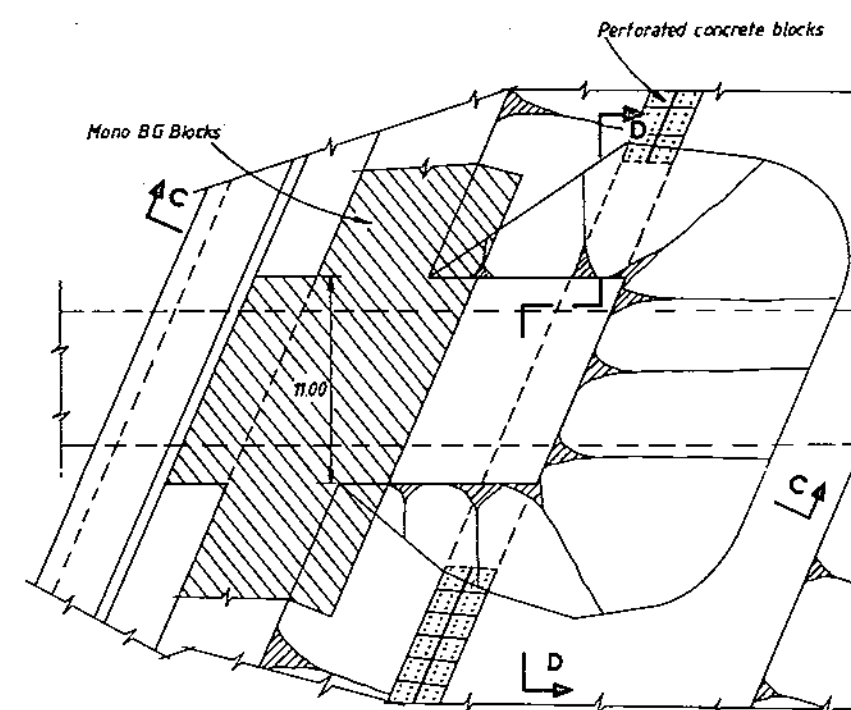
LONGITUDINAL SECTION
HORIZONTAL SCALE 1:1250 VERTICAL SCALE 1:100



SECTION C-C
SCALE 1:400



SECTION D-D
SCALE 1:200



EMBANKMENT DETAIL AT COOLING WATER OUTFALL
SCALE 1:200

NOTES

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- 3 This drawing to be read in conjunction with Record Drawings Nos 15/63 Concrete Walls - Schedule 15/65 Plans & Sections

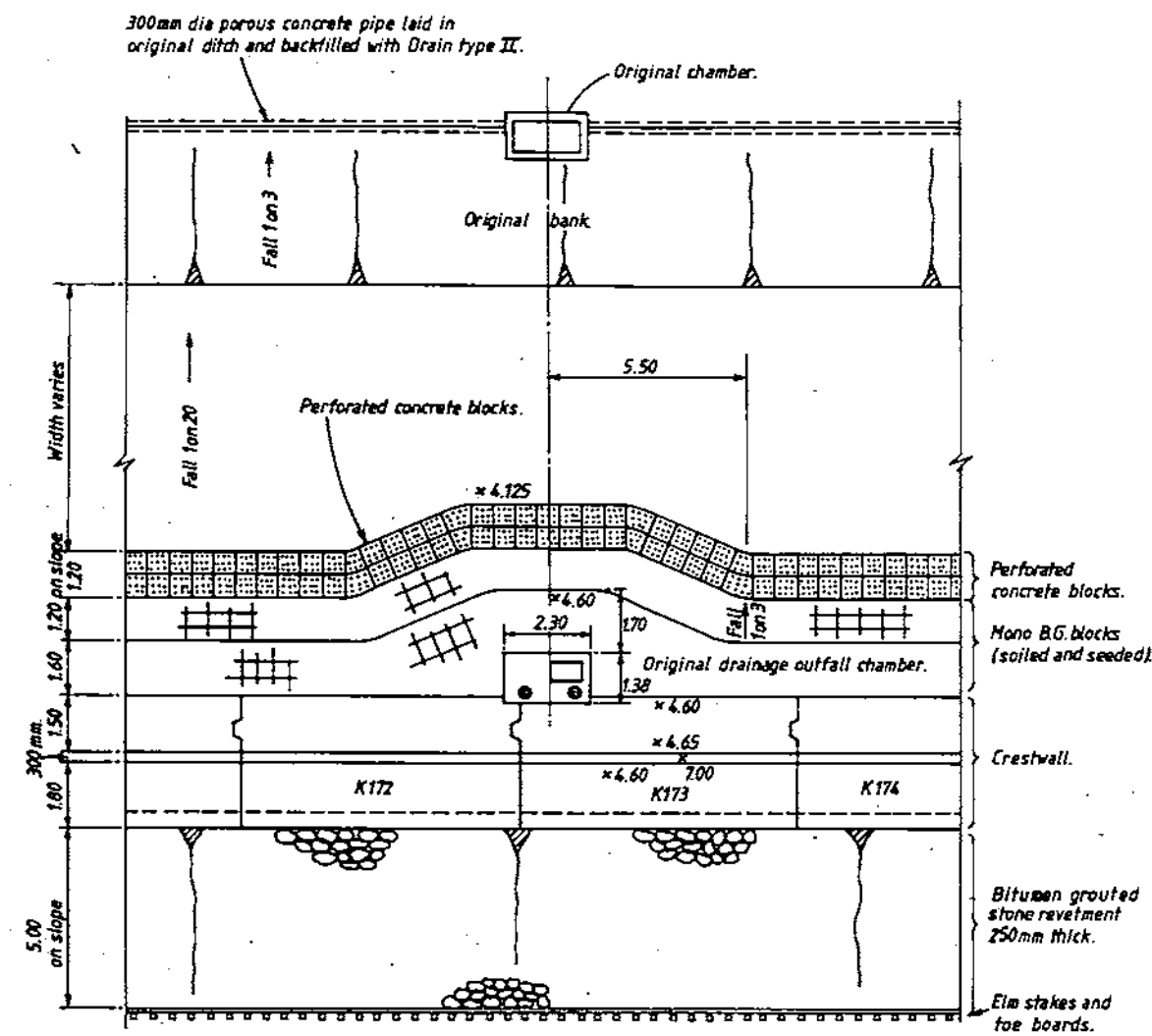
ANGLIAN WATER AUTHORITY
THAMES TIDAL DEFENCES

FLOODWALLS : TILBURY
TILBURY 'B' POWER STATION
DETAILS AT COOLING WATER OUTFALL

RECORD DRAWING No.15/67

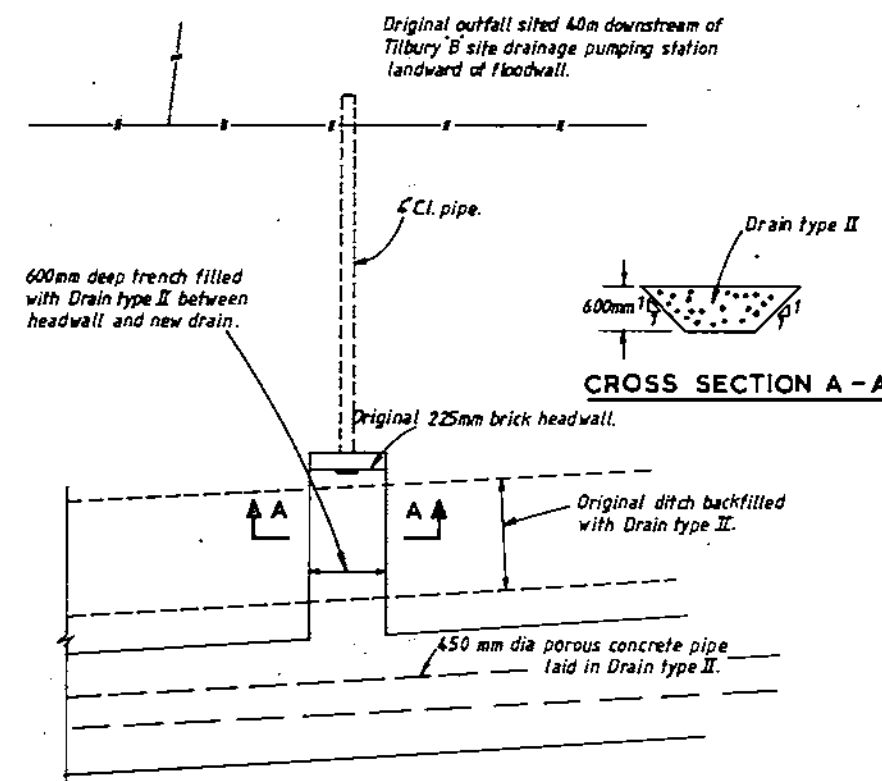
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Artillery House Westminster S.W.1

DATE
FEBRUARY 1979
REGISTER No
1041-15-RO67



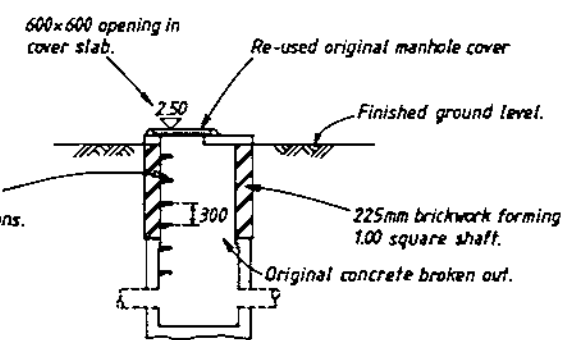
PLAN AT WEST TILBURY MARSH DRAINAGE OUTFALL CHAMBER

SCALE 1:100



DRAINAGE DETAIL AT GULLY 'C' AND ORIGINAL 100mm OUTFALL

SCALE 1:50

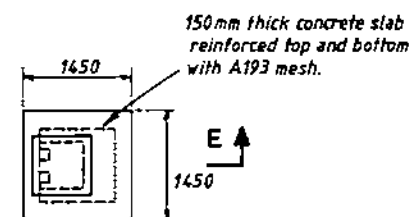


CROSS SECTION E-E

DETAIL AT CEBB MANHOLE No.165

Dimensions in millimetres

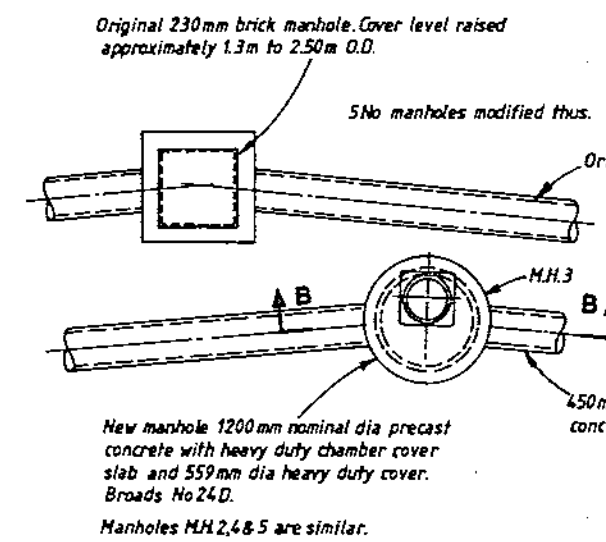
SCALE 1:50



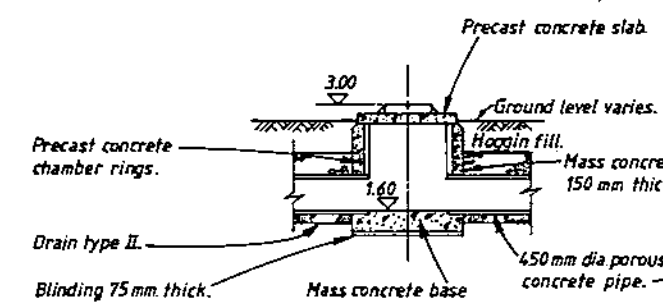
DRAINAGE DETAIL AT GULLIES A, B & D

Dimensions in millimetres

SCALE 1:50



PLAN

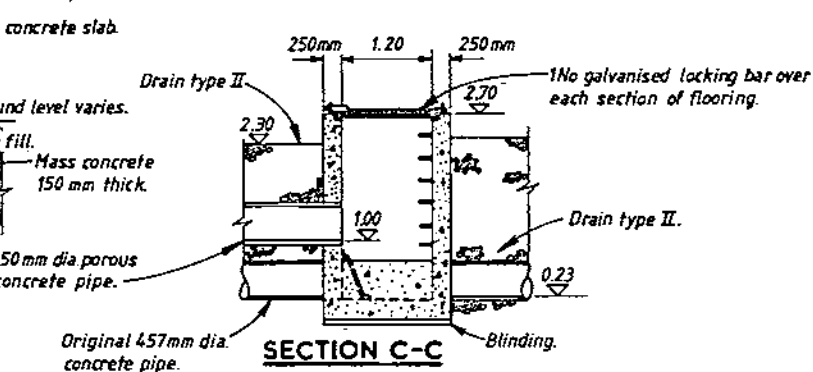


SECTION B-B

DETAILS OF DRAIN ALONG TILBURY B

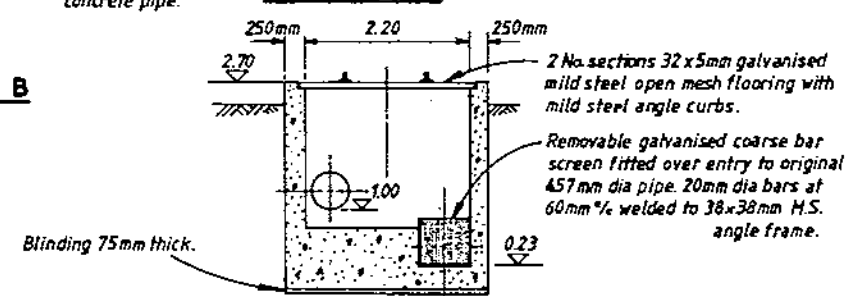
POWER STATION FRONTAGE

SCALE 1:50



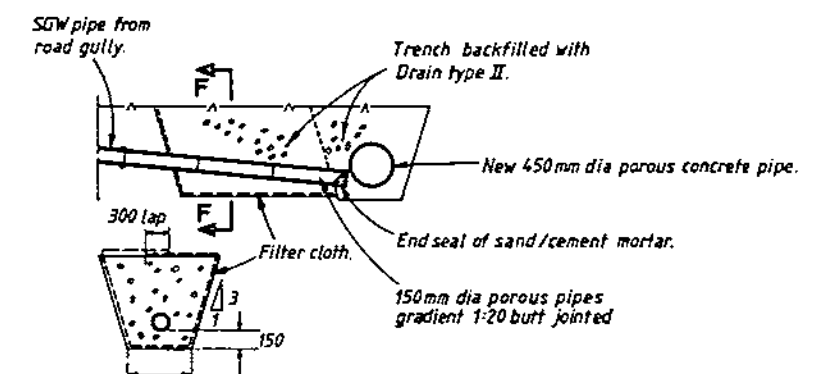
SECTION C-C

DETAILS OF M/H No.6



SECTION D-D

DETAILS OF M/H No.6



CROSS SECTION F-F

NOTES

- 1 All levels are in metres and refer to Ordnance Datum (Newlyn). All dimensions are in metres unless otherwise stated.
- 2 This drawing to be read in conjunction with Record Drawings Nos. 15/63 Concrete Walls - Schedule 15/65 Plan & Sections

ANGLIAN WATER AUTHORITY
THAMES TIDAL DEFENCES

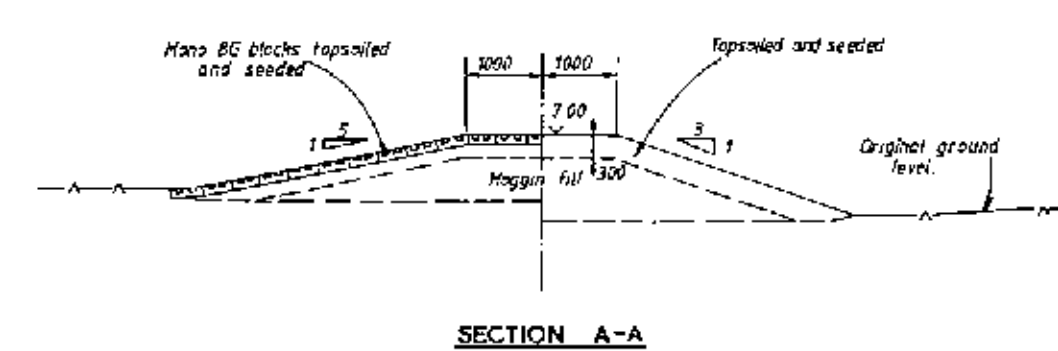
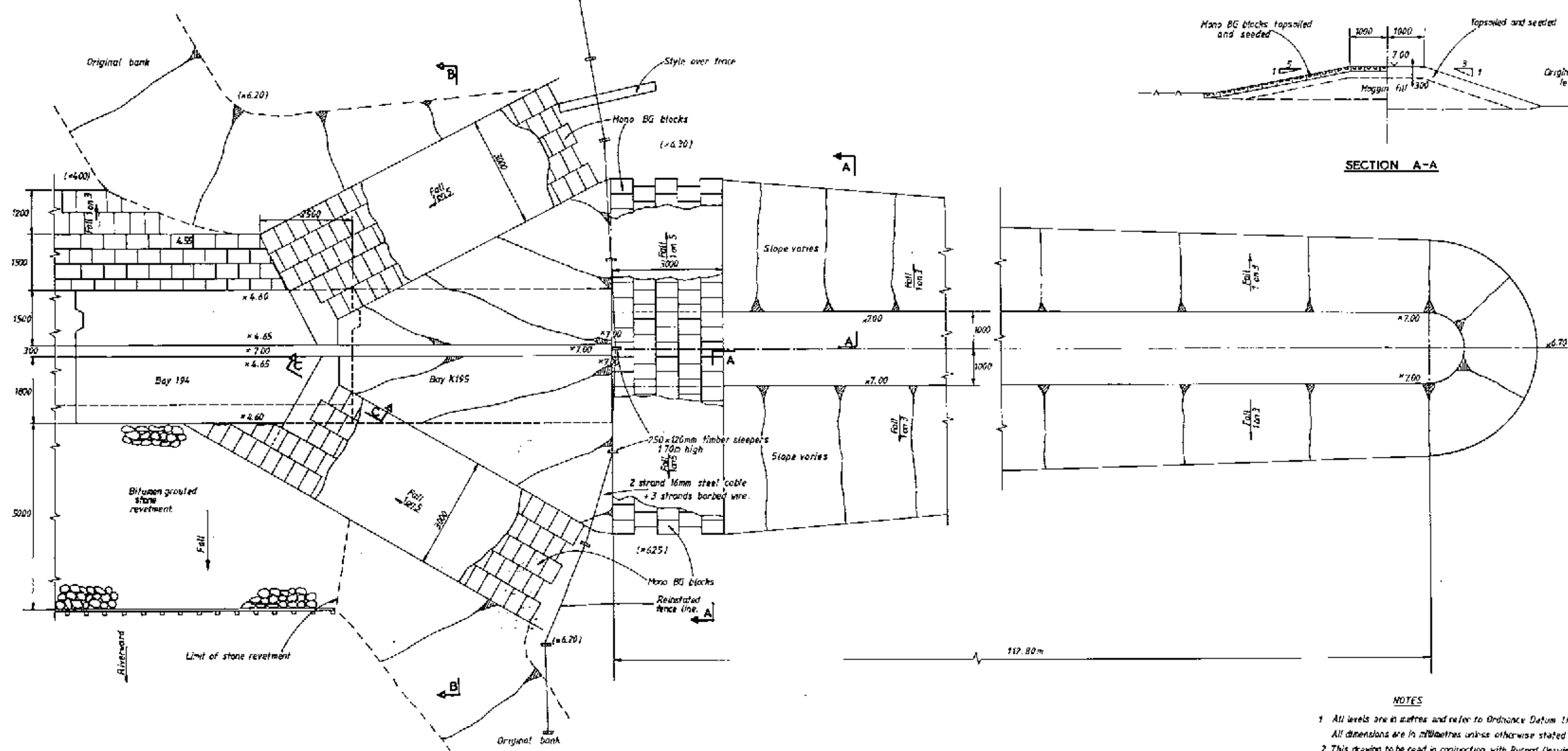
FLOODWALLS : TILBURY
TILBURY 'B' POWER STATION
MANHOLE & DRAINAGE DETAILS

RECORD DRAWING No.15/68

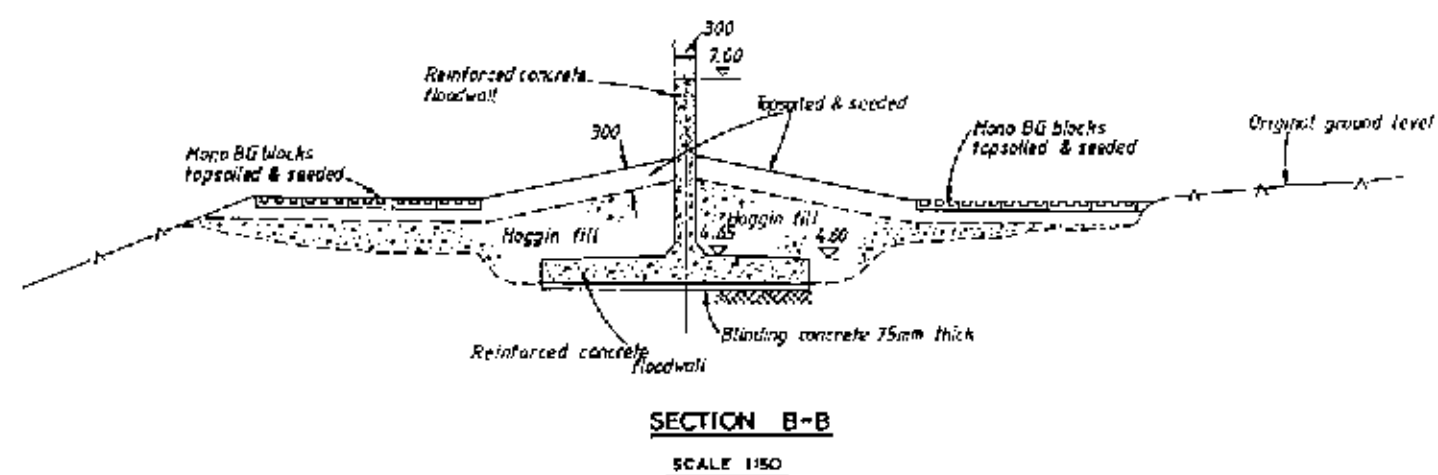
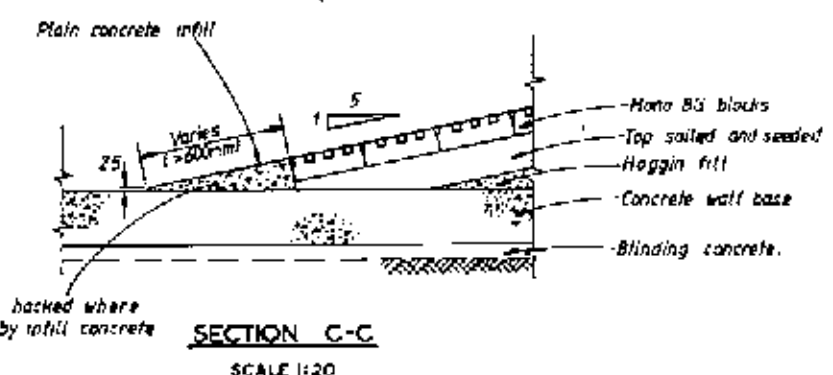
BINNIE & PARTNERS
Consulting Engineers
Artillery House Westminster S.W.1

J. G. Eldridge
DATE
FEBRUARY 1979
REGISTER No
1041-15-R068





- NOTES**
- 1 All levels are in metres and refer to Ordnance Datum (Newlyn)
 - 2 All dimensions are in millimetres unless otherwise stated
 - 3 This drawing to be read in conjunction with Record Drawings Nos 15/63 Concrete Walls - Schedule 15/65 Plan & Sections



ANGLIAN WATER AUTHORITY THAMES TIDAL DEFENCES	
FLOODWALLS : TILBURY WEST TILBURY MARSHES TERMINATION DETAILS	
RECORD DRAWING No. 15/69	DATE 1 FEBRUARY 1979
BINNIE & PARTNERS Consulting Engineers Auriliary House Westminster S.W.1	REGISTER No 1041-15-R069

Datasheet Reference: EAN/2022/282815



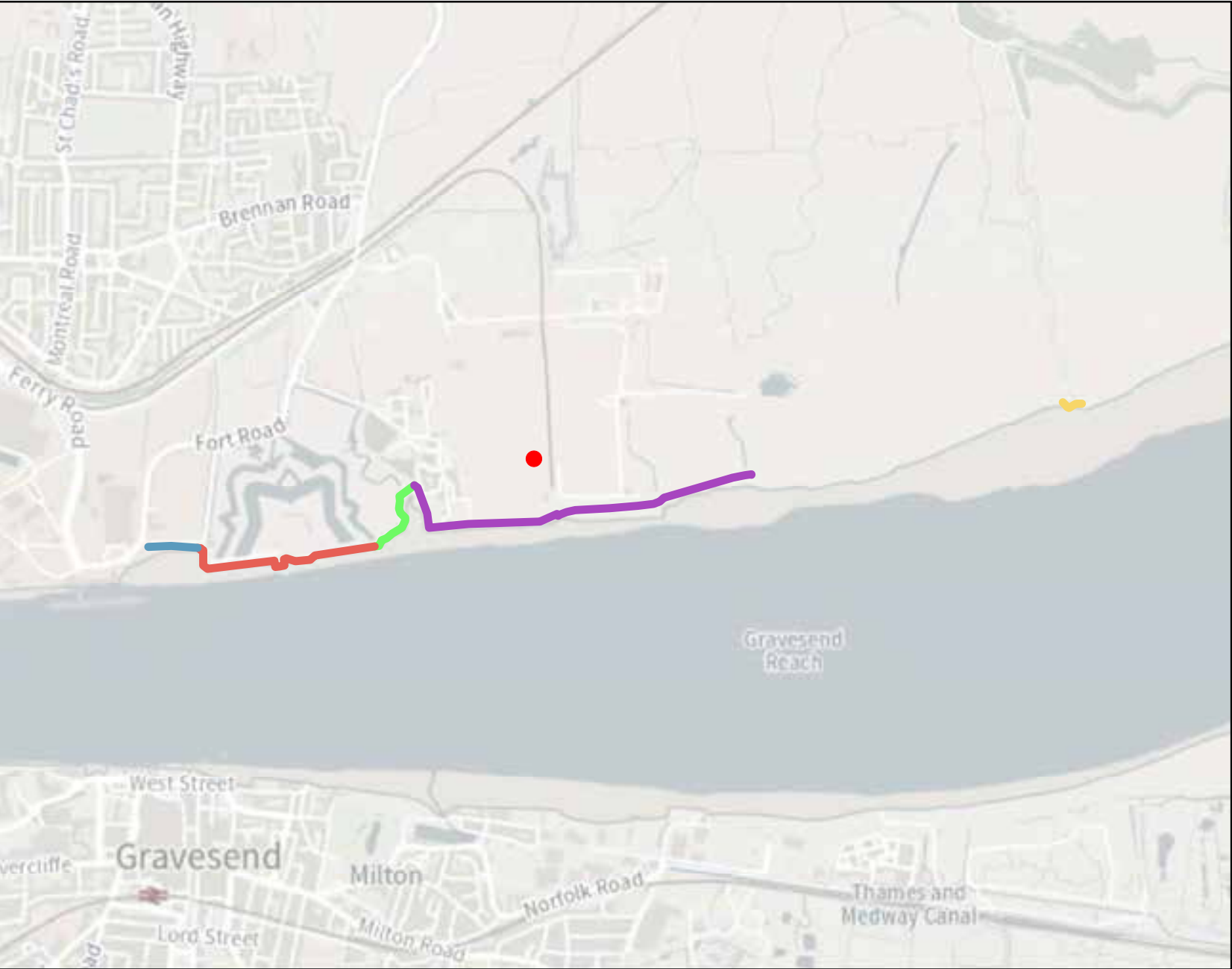
Defence Information

Asset Reference	Maintainer	Asset Type	Asset Description	Overall Condition Grade	Crest Level
109494	Environment Agency	Wall	typical TTD Wall with embankment and Essex Block revetment	3 - Fair	6.72
475722	Environment Agency	Wall	Concrete Wall	3 - Fair	6
109493	Environment Agency	Wall		4 - Poor	6.67
109492	Environment Agency	Wall		4 - Poor	6.7
152988	Environment Agency	Wall		3 - Fair	6.48

Report

Grade	Rating	Description
1	Very Good	Cosmetic Defects that will have no effect on performance.
2	Good	Minor defects that will not reduce the overall performance of the asset.
3	Fair	Defects that could reduce performance of the asset
4	Poor	Defects that would significantly reduce the performance of the asset. Further investigation.
5	Very Poor	Severe defects resulting in complete performance failure.

Flood Defence Location Map for former Tilbury Power Station site
Ref: EAN/2022/282815



Legend
Defences
AIMSID

- 109492
- 109493
- 109494
- 152988
- 475722





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