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Author	Arup
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Abbreviations

Abbreviation	In Full / Term
AEP	Annual Exceedance Probability
AGI	Above Ground Infrastructure
ASU	Air Separation Unit
CHP	Combined Heat and Power
DCO	Development Consent Order
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
ES	Environmental Statement
FRA	Flood Risk Assessment
FRAP	Flood Risk Activity Permit
mAOD	Metres Above Ordnance Datum
NSIP	Nationally Significant Infrastructure Project
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
MaGIC	Multi-Agency Geographic Information for the Countryside
NPPF	National Planning Policy Framework
NPPG	National Planning Policy Guidance
NPS	National Planning Statement
NRBD	Northumbria River Basin District
PDP	PD Ports (the Statutory Harbour Authority for Teesport)
PFRA	Preliminary Flood Risk Assessment
PINS	Planning Inspectorate
RCBC	Redcar and Cleveland Borough Council
RUA	Residual Uncertainty Allowance
SAF	Sustainable Aviation Fuel
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection
SoS	Secretary of State
STBC	Stockton-on-Tees Borough Council
SuDS	Sustainable Drainage Systems

Executive Summary

1.1.1 This Flood Risk Assessment (FRA) has provided an assessment of flood risk of the Proposed Development based on the design at the time of DCO application submission and confirmation of flood risk parameters based on existing hydraulic modelling outputs.

1.1.2 The FRA addresses comments received from the Environment Agency (EA) including considering a 75 year development lifetime and a 100 year assessment to consider long term implications of land raising. While these longer periods have been assessed in the FRA, a 30-year operational life has generally been adopted as a reasonable worst case scenario for the Proposed Development.

1.1.3 The FRA has been informed by hydraulic modelling, following a method statement agreed in advance with the EA.

1.1.4 The FRA has considered flooding from fluvial and tidal, surface water, groundwater, and artificial sources.

1.1.5 The Main Site (in North Tees) lies predominantly within Flood Zone 1, indicating low baseline risk, although certain access routes and pipeline corridors (within the Wider Site), and the proposed quay fall within Flood Zones 2 and 3a. There are no areas of Flood Zone 3b mapped in the vicinity of the site. Climate change projections suggest that parts of the Site may experience increased flood risk over the operational life and assessed time period.

1.1.6 Section 10 sets out the approach to site resilience. To maintain resilience within the Main Site, a tiered approach to flood mitigation is proposed. Components have been classed as to whether they can be readily adapted to address future climate change (e.g. raised, or flood proofed), and or whether they are less (e.g. water retaining structures) or more vulnerable (e.g. sensitive / critical electrical plant) to flood risk. The tiered approach sets general ground levels at a minimum of 5.08m Above Ordnance Datum (mAOD); adaptable and / or less vulnerable components at a minimum of 5.38mAOD; and less adaptable / more vulnerable assets a minimum of 5.68mAOD. The quay will be constructed to a minimum level of 5.65mAOD. Table 10.1 identifies adaptable and vulnerable components in greater detail.

1.1.7 Hydraulic modelling identifies that the proposed general ground level is effectively the 0.5% Annual Exceedance Probability (AEP) 2105 Higher Central flood level + 0.23m Residual Uncertainty Allowance (RUA). A 0.23m RUA corresponds to a 99% chance of non-exceedance in this scenario, above the industry standard.

1.1.8 Adaptable and vulnerable components would have 0.27m and 0.57m freeboard levels above the modelled 0.5% AEP 2105 Upper End Central flood level, again giving over a 99% chance of non-exceedance in that scenario.

1.1.9 A risk is noted due to wave hazard, however there are elements of conservatism in the assessment of hazard. The wave hazard shall be assessed in greater detail through the detailed design process, and wave protection designed to manage the pedestrian environment within the Proposed Development's 30-year operational life. Wave protection identified as being necessary beyond the operational life shall be dealt with on a managed adaptive basis, through development of appropriate measures in an Operational Flood Warning and Evacuation Plan (FWEP) or through physical intervention.

1.1.10 Hydraulic modelling shows that the Proposed Development does not result in any material increase in flood risk elsewhere.

1.1.11 The findings of the Framework Drainage Strategy (Annex C) confirm that the Proposed Development will manage surface water runoff in a controlled manner and will not result in an increase in flood risk on-site or elsewhere.

1.1.12 A Flood Risk Activity Permit (FRAP) will be required for the construction of the quay, which will effectively move the defence line to the riverside of the quay.

1 Introduction

1.1 Overview

1.1.1 This **Flood Risk Assessment (Application Document Ref. 5.7)** has been prepared by Ove Arup and Partners Limited (Arup) on behalf of LGF Projects Limited (the Applicant), to support an application (the Application) seeking development consent for the construction, operation, maintenance and decommissioning of the Lighthouse Green Fuels (LGF) project (the Proposed Development) on land within the administrative boundaries of Stockton-on-Tees Borough Council (STBC) and Redcar and Cleveland Borough Council (RCBC).

1.1.2 The Order limits for the Proposed Development are made up of the Main Site and Wider Site, together 'the Site'. A more detailed description of the Site is set out at section 2.4.

1.1.3 The Application has been submitted to the Planning Inspectorate (PINS), and the decision whether to grant a Development Consent Order (DCO) will be made by the Secretary of State (SoS) for Energy Security and Net Zero pursuant to the Planning Act 2008 (the PA 2008) [Ref 1].

1.1.4 The Proposed Development comprises a commercial-scale second generation Sustainable Aviation Fuel (SAF) production facility and associated infrastructure.

1.2 The Applicant

1.2.1 The Applicant is wholly owned by Alfanar Energy Limited (Alfanar). Alfanar is part of a global project development, manufacturing, and engineering group headquartered in Saudi Arabia. Alfanar has developed significant in-house feedstock-to-SAF expertise. This experience will be utilised to construct and operate the Proposed Development.

1.3 Overview of the Proposed Development

1.3.1 The Proposed Development is anticipated to be the UK's first commercial-scale second generation SAF production facility.

1.3.2 The Proposed Development includes the construction, operation, maintenance and decommissioning of a commercial-scale facility that will produce approximately 180 million litres of advanced SAF and approximately 30 million litres of renewable naphtha each year.

1.3.3 The Proposed Development includes the following elements (the location of each Work No. is shown on the **Works Plans (Application Document Ref. 2.4)**):

Table 2.1 Works Description Summaries

Work Number:	
Work No. 1	SAF production facility comprising: • 1A - feedstock pre-treatment facility including flue gas treatment and stack • 1B - SAF processing facility including thermal oxidiser, flue gas treatment, and stack • 1C - up to two flare structures
Work No. 2	Combined heat and power (CHP) generating station comprising: • 2A - boilers and steam turbine generators • 2B - flue gas treatment and stack
Work No. 3	Feedstock and intermediate and final product handling and storage
Work No. 4	Cooling infrastructure for SAF production facility and CHP plant
Work No. 5	Bridge and culvert crossings of existing infrastructure
Work No. 6	Marine infrastructure comprising: • 6A - construction of permanent quay • 6B - permanent quay • 6C - capital and maintenance dredging
Work No. 7	Electrical connection works comprising: • 7A - underground and overground cable connections to the existing North Bank Supply Point • 7B - electrical connection works
Work No. 8	Modified or new natural gas connection and above ground infrastructure (AGI)
Work No. 9	Supply of industrial gases: Only one of Work No. 9A or Work No. 9B would be developed; • 9A - industrial gases connection works comprising installation of new and repurposing of oxygen and nitrogen pipeline connections, and connection to existing low pressure nitrogen supply • 9B - air separation unit (ASU) facility and connections to Work No. 1
Work No. 10	Modification or removal and replacement of industrial wastewater pipeline connection works
Works No. 11	• Export connection works:11A - pipeline(s) for the export of SAF and renewable naphtha • 11B or 11C - a pipeline for the export of carbon dioxide (CO_2) connecting to AGI by others (being either AGI C1 or C2 of the Northern Endurance Partnership (NEP) transport and storage pipeline) Only one of Work No. 11B or Work No. 11C would be developed
Works No. 12	Surface water attenuation, and drainage and discharge works
Works No. 13	Laydown areas comprising: • 13A - temporary construction compounds and laydown areas • 13B - permanent laydown and storage

Work No. 14	Access works and private street improvements

1.3.4 In addition a range of associated development, both specified and unspecified, is proposed in relation to the above.

1.3.5 The new quay on the River Tees (**Work No. 6**) will allow delivery of modular plant and construction materials by ship during construction and biomass and waste wood feedstock during operation, reducing reliance on road transport. Feedstock will be stored (**Work No. 3**) then pre-treated at the Main Site and processed into SAF through gasification and gas-to-liquids processes (**Work No.1**).

1.3.6 The Proposed Development berth pocket will be dredged to a maintained depth of -14m Chart Datum (CD) (**Work No.6C**). An approach channel between the existing turning circle and the Proposed Development berth pocket would be dredged to a maintained depth of -10.4m CD.

1.3.7 Dredging would remove up to 800,000 m^3 of material. This includes a 0.5m allowance for re-accumulation of sediment. Dredged material is to be disposed of at the Marine Management Organisation (MMO) licenced site at Tees Bay A (TY150), located approximately 6-7 nautical miles offshore.

1.3.8 Maintenance dredging (i.e. cyclical dredging activity when the Proposed Development is operational) is not considered as part of this FRA due to it being an operational activity routinely managed and overseen by PD Ports (PDP) in its role as statutory harbour authority.

1.3.9 Nonetheless, a marine process modelling study has been undertaken by ABPmer on behalf of the applicant (Lighthouse Green Fuels: Coastal Process Modelling. Modelling Report). This study estimates the rate of reaccumulation of sediment at 0.13m/yr, but notes relatively high uncertainty in such an estimate. It is therefore estimated that the required frequency of maintenance dredging would be once every 3-5 years.

1.3.10 To support operations, the Proposed Development will include a biomass and waste wood-fired CHP plant (**Work No. 2**) with an electrical output capacity of up to 200 megawatts electrical (MWe), providing a low-carbon energy supply for the SAF process. Cooling infrastructure (**Work No. 4**) will be required for the SAF process and the CHP plant. Connections will provide electricity for start-up and to maintain ancillary site supplies (**Work No. 7**), natural gas for start-up and as auxiliary fuel for some processes during operation (**Work No. 8**), and oxygen and nitrogen which will either be delivered to the Site via pipelines or produced by a new ASU in the Main Site (**Work No. 9A or 9B** respectively). Waste materials, including off-specification materials will be exported from the Main Site by road. Finished

products (SAF, and a secondary product of the process, renewable naphtha) will be transferred via pipeline(s) (**Work No. 11A**) to local marine loading facilities for marine export or export by road. CO_2 from the acid gas removal unit in Work No. 1B will be exported via pipeline (**Work No. 11B or Work No. 11C**) subject to a suitable agreement to connect to one of two proximate AGIs in the NEP project.

1.3.11 The Proposed Development will include bridges and culvert crossings of existing infrastructure (**Work No.5**). However the Proposed Development does not include bridges or culvert crossings of any watercourses.

1.3.12 The Proposed Development will also include replacement and new wastewater pipeline connection works (**Work No. 10**), surface water drainage systems (**Work No. 12**) and access and street improvements (**Work No. 14**). Space within the Wider Site is identified for temporary construction and laydown and space within the Main Site identified for permanent laydown and storage areas (**Work No. 13**).

1.3.13 The preliminary layout of the Proposed Development is shown on Indicative **General Arrangement Plan (Application Document Ref. 2.5.1)** and **Indicative General Arrangement Isometric (Application Document Ref. 2.5.2)**.

1.4 The Site

1.4.1 The Site location and boundary (which is also known as the 'Order limits') are shown on **Site Location Plan (Application Document Ref. 2.1)**. The Site is located in Teesside on land to the north and south of the River Tees with connection corridors crossing the Tees.

1.4.2 The Main Site is located in the industrial area of Seal Sands approximately 5km east of Billingham town centre and 4km north-east of Middlesbrough town centre, on the north bank of the River Tees in the borough of Stockton-on-Tees). The majority of the Main Site lies south of Seal Sands Road and largely comprises previously developed land formerly used as a chemical plant from the early 1970s. It was last operated by INEOS Nitriles.

1.4.3 The Main Site comprises the main SAF facility development area of the Site, lying to the south and north sides of Seal Sands Road and bounded by the proposed quay in the River Tees, with the River Tees to the east.

1.4.4 The eastern boundary of the Main Site is formed by the River Tees, where existing jetties will be demolished and a new quay developed.

1.4.5 The Wider Site comprises the connection corridors, including land required for road access, pipelines (including under the River Tees), dredging near to

the Main Site, and utility connections and construction laydown in both North Tees and (in the borough of Redcar and Cleveland) South Tees.

1.5 The DCO Process

1.5.1 Part 3 of the PA 2008 defines which projects constitute a nationally significant infrastructure project (NSIP). Once classed as an NSIP, development consent (in the form of a DCO) is required under Part 4 of the PA 2008.

1.5.2 In legislative terms the Proposed Development comprises both a SAF production facility and a CHP generating station together with development associated with the SAF production facility and the CHP generating station.

1.5.3 The construction and operation of the main SAF production facility does not automatically fall within the definition of an NSIP. Therefore, on 12 August 2025, the Applicant formally requested a direction by the SoS for Energy Security and Net Zero, pursuant to section 35(1) of the PA 2008, that the following elements be treated as one for which development consent is required. The Section 35 direction request was made in respect of: a main gasification facility to process sustainably sourced biomass; feedstock pre-treatment, syngas clean-up apparatus; Fischer-Tropsch process units; refining units; feedstock, intermediates and finished product storage; quayside with ship loading/ offloading infrastructure; supporting infrastructure and utility connections (hereafter called the 'Specified Elements').

1.5.4 The SoS for Energy Security and Net Zero issued a direction under Section 35 of the PA 2008 [Ref 1] on 08 September 2025 to confirm that the Specified Elements of the Proposed Development, together with any matters/ development associated with them, should be treated as development for which development consent under the PA 2008 is required.

1.5.5 The CHP plant (**Work No. 2**) surpasses the 50 Megawatt (MW) threshold for generating stations defined in Section 15 of the PA 2008 and is therefore a NSIP in its own right.

1.5.6 An application for development consent for the Proposed Development has been submitted to PINS acting on behalf of the SoS. Subject to the Application being accepted, PINS will then examine it and make a recommendation to the SoS who will then decide whether to grant a DCO.

1.5.7 The application for development consent for the Proposed Development supersedes a previous application that was being progressed by Lighthouse Green Fuels Limited centred on a site off Huntsman Drive in Seal Sands, TS2 1TT (PINS ref. EN010150). Statutory consultation on that

application took place between 16 May 2024 and 20 June 2024. As shown on the PINS website[1], that application is discontinued.

1.6 The Purpose and Structure of this Document

1.6.1 This **Flood Risk Assessment (Application Document Ref. 5.7)** has been prepared to support the Application to be made to the SoS for Energy Security and Net Zero seeking development consent for the construction, operation, maintenance and decommissioning of the Proposed Development.

1.6.2 The location and extent of the Proposed Development is shown in **Figure 1.1: Site Location and Figure 1.2: Proposed Development Boundary (ES Volume II, Application Document Ref. 6.2)**. The elements of the Proposed Development and the Site are described in **Chapter 4: The Proposed Development (ES Volume I, Application Document Ref. 6.1) and Chapter 3: Site and Surrounding Area (ES Volume I, Application Document Ref. 6.1)** respectively.

1.6.3 This FRA identifies flood risk from all sources, including the River Tees, considers the nature of the Proposed Development and the suitability of the Proposed Development against local and national planning policy relating to flood risk. This FRA outlines how the Proposed Development satisfies the Sequential and Exception tests, and identifies required flood risk mitigation; for example, design elevations.

[1] https://national-infrastructure-consenting.planninginspectorate.gov.uk/projects/EN010150

2 Assumptions and limitations

2.1.1 The following assumptions and limitations apply:

- The FRA is based on the design at the time of writing;
- The FRA has been prepared using publicly available information to inform desk-based assessment. It is assumed that the information provided from public sources is correct and accurately reflects baseline conditions;
- Site-specific modelling has been undertaken for the DCO submission due to the Site's location and the requirement to build within the River Tees, and the report updated to reflect the results; and
- The construction activities, including management of temporary site drainage during construction, will be managed through a Construction Environmental Management Plan (CEMP). A **Framework CEMP (fCEMP)** is provided at **Appendix 5A of the ES Volume I (Application Document Ref. 6.3)**. A Flood Risk Activity Permit (FRAP) will be secured, which will include a construction-specific FRA. As such, this FRA only considers permanent impacts associated with the operational phase of the Proposed Development.

3 Consultation

3.1.1.1 Consultation was undertaken with statutory consultees to inform the Water Environment Chapter of the ES. A summary of comments relevant to Flood Risk is set out in Table 3.1.

3.1.1.2 A meeting was also held with the EA's Sustainable Places and Data, Digital and Evidence teams on 15 April 2026.

Table 3.1 Summary of consultation feedback relevant to flood risk

Stakeholder	Date	Summary of consultee comment	Summary of response
Environment Agency (EA)	Scoping Opinion (November 2025)	Summary of the FRA response: The FRA must confirm Flood Zone classification (3a or 3b), define vulnerability under NPPF Annex 3, and demonstrate compliance for essential infrastructure—ensuring it remains operational during flooding, does not reduce floodplain storage, and does not increase flood risk elsewhere. Highly vulnerable uses are generally unsuitable in Flood Zone 3. The FRA should include site layouts overlaid on flood maps, apply a sequential approach to prioritize lower-risk areas, and consider climate change impacts. It must reference key guidance (NPPF, Planning Practice Guidance (PPG), Shore Management Plan) and address technical issues such as reservoir risk, culverts, pipelines, quayside works, and watercourse crossings. Culverting should be avoided unless temporary, and pipeline crossings must prevent debris accumulation. The Environmental Statement should show floodplain interactions and access routes, while DCO documents must include pipeline and crossing details. The design life is unclear; PPG recommends assuming at least 75 years for non-residential developments to inform future flood extent assessments. The FRA must state climate change allowances and epochs. For essential infrastructure, assess higher central and upper end allowances for river flow and sea	This FRA details the work that has been prepared in support of this application. The FRA states the parts of the Proposed Development that are within Flood Zones. The FRA has followed the NPPF Annex F guidance and considers the impacts of climate change. The FRA outlines how the Proposed Development will interact with the flood risk receptors. Hydraulic modelling has been agreed with the EA and undertaken to inform the FRA. This FRA includes the site layout overlaid on flood maps and applies a sequential approach to prioritize lower risk areas. Operational period of the Proposed Development is expected to last 30 years. The FRA has considered a 75-year development lifetime in accordance with EA climate change guidance. A 100 year period is also assessed so that the long-term implications of ground raising can be assessed. Regardless of the length of the design life, decommissioning of the site will not result in ground levels being reinstated to current levels.

Stakeholder	Date	Summary of consultee comment	Summary of response
		level rise, with sensitivity tests including H++. In line with EN-1, the development must remain operational during the design flood and consider the credible maximum scenario to ensure resilience.	The FRA states the climate change allowances and epochs considered. The FRA considers the resilience of the site in the credible maximum scenario.
		The Scoping Report proposes a 1km study area with potential to extend beyond to capture potential impacts to receptors beyond the 1km buffer. The Inspectorate considers that the ES should clearly define the study area based on the ZoI, the hydrology of the site and potential for significant effects. Consideration of upstream receptors should also be included where appropriate.	The zone of influence (ZoI) for surface water receptors has been increased to 2km from the Main Site, due to the nature of the works proposed and the designated sites within the area.
EA	Statutory Consultation Response (January 2026)	**Outline Drainage Strategy for Construction and Operation** The PEIR states that site drainage systems will collect surface water and direct it to attenuation ponds where it will be tested prior to being discharged to the River Tees. In the event of contamination, the water can be directed to the onsite treatment plant for further processing before export by pipeline to Bran Sands Wastewater Treatment Works (WwTW). The Outline Drainage Strategy should be updated to include the following information: • full details on how surface water will be collected, treated, and discharged during construction and operation; • how the proposed drainage strategy will be managed and maintained throughout the operational phase; • how contaminated water will be contained, treated and removed to prevent pollution; and	The Framework Drainage Strategy (Annex C of this document) has been produced in support of this application as well as the Water Environment Regulations (**WER) Assessment (Application Document Ref. 5.10)** Surface water will be discharged to the Tees via a new extension of the existing outfall which will be incorporated into the new quay. Construction drainage has been addressed in the fCEMP and a construction surface water management plan will be submitted to the local planning authority for approval prior to the commencement of construction in accordance with Requirement 4 (Construction Environment Management) of the **draft DCO (Document Reference 3.1)**.

Stakeholder	Date	Summary of consultee comment	Summary of response
		• further details of the onsite treatment plan, including a development layout plan. Is this an interim treatment process before wastewater is taken to Bran Sands WwTW? Clarification is required on this matter. We note the choice of a new surface water outfall versus use of the existing outfall to the River Tees is still under consideration. The potential impact on the receiving watercourse should be assessed in the Water Framework Directive (WFD) Assessment.	
		Flood Risk The Flood Risk Assessment (FRA) should include the following: • details of all the defences within the study area, including their condition, crest level and standard of protection. The EA requires a 16m setback from any flood defence assets wherever possible. Where this cannot be achieved, it must be demonstrated that unrestricted access to defences is retained to enable their maintenance, repair, operation, and replacement, as necessary. Any proposed structures proposed in the River Tees must be structurally independent from any flood defence assets; • an assessment of residual flood risk, taking into account the risk of flooding should defences be breached; • details of all proposed watercourse crossings. Crossings should be minimised wherever possible, and opportunities to consolidate existing and proposed crossings should be explored. The impact	This FRA includes characterisation of flood defence infrastructure within the study area, an assessment of residual flood risk including breach scenarios. The Proposed Development does not include any new watercourse crossings. Utilities make use of existing infrastructure to pass under the Tees. The FRA, while noting that the Site's impact on flood risk is insensitive to the presence of dredging, identifies the quantum of dredging, its destination and the frequency of maintenance dredging.

Stakeholder	Date	Summary of consultee comment	Summary of response
		of on flood risk and hydrogeomorphology from the proposed dredging activities. The FRA should specify the volume of material to be dredged, the destination of the dredged material, and the anticipated frequency of maintenance dredging.	
		Hydraulic modelling We acknowledge the Applicant's intention to undertake site-specific modelling to further assess the flood risks associated with the proposed development and to inform any necessary flood risk mitigation. Any modelling submitted in support of the DCO application will need to be reviewed by the Environment Agency and confirmed as suitable for use. The hydraulic modelling should be undertaken in accordance with the following guidance: • https://www.gov.uk/guidance/using-modelling-for-flood-risk-assessments • https://www.gov.uk/government/publications/river-modelling-technical-standardsand-assessment/river-modelling-standards-who-theyre-for-and-how-to-use-them • https://www.gov.uk/government/publications/river-modelling-technical-standards-and-assessment We would advise that any modelling be undertaken as soon as possible to allow sufficient time for model reviews to take place and for any issues to be resolved.	The approach to hydraulic modelling in this FRA was agreed in consultation with the EA and undertaken in accordance with suggested guidance.

Stakeholder	Date	Summary of consultee comment	Summary of response
Environment Agency	Targeted Consultation Response (May 2026)	Limited information on the proposed on-site treatment works and drainage strategy in the PEIR.	A Framework Drainage Strategy (Annex C to the FRA (Application Document Ref. 5.7) has been produced in support of this application.
		There are no additional flood risk concerns arising from the proposed changes to the development, and no comments are raised in relation to the PEIR Addendum. However, several points previously raised during the January 2026 PEIR consultation require reiteration.	No further comments.

4 Planning policy context

4.1.1.1 A review of relevant national, regional and local planning legislation, policy and guidance has been conducted to inform understanding of the potential impacts of the Proposed Development in terms of flood risk (see Table 4.1). The Proposed Development is located within the administrative boundaries of Stockton-on-Tees Borough Council (STBC) in North Tees and Redcar and Cleveland Borough Council (RCBC) in South Tees (see FRA Figure 1 in Annex A).

Table 4.1 Summary of key legislation, policy and guidance

Legislation, policy and guidance	Summary
Legislation	
Environmental Protection Act 1990 [Ref 2]	This Act makes provision to control pollution arising from industrial and other processes for waste management. This is relevant to the identification and control of pollution potentially arising from construction and operation of the Proposed Development.
The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 [Ref 3]	These Regulations provide a statutory framework for the protection and restoration of the water environment. The Regulations require the preparation and publication of River Basin Management Plans (RBMPs). This is pertinent to the protection of the River Tees.
Flood and Water Management Act 2010 [Ref 5]	This Act gives the EA a strategic overview of the management of flood and coastal erosion risk in England. In accordance with the Government's Response to the Pitt Review, it also gives upper tier local authorities in England responsibility for preparing and putting in place strategies for managing flood risk from groundwater, surface water and ordinary watercourses in their areas.
Reservoirs Act 1975 [Ref 34]	This Act establishes requirements for large raised reservoirs to prevent catastrophic flooding. The Act requires registration and regular inspections by qualified engineers to ensure safety. The Act focuses on reservoirs where failure could endanger life, linking directly to flood risk by mandating preventive measures and reservoir flood plans to minimise the impact of potential breaches.
Policy	
The Overarching National Policy Statement (NPS) for Energy (EN-1) (2025) [Ref 7]	The NPS EN-1, Section 4.12 (Pollution control and other environmental regulatory regimes) considers discharges and emissions including indirect and direct impacts to terrestrial and freshwater onshore environments. It notes that before consenting any potentially polluting developments, it should be

Legislation, policy and guidance	Summary
	confirmed that the relevant pollution control authority is satisfied that potential releases can be adequately regulated under the pollution control framework. It should also be confirmed that the effects of existing sources of pollution in and around the Site are not such that the cumulative effects of pollution when the proposed development is added would make that development unacceptable, particularly in relation to statutory environmental quality limits. The NPS EN-1, Section 5.8 (Flood Risk) addresses the assessment and management of flood risk for energy infrastructure projects. It mandates that a comprehensive Flood Risk Assessment (FRA) be conducted to evaluate potential impacts under both current and future conditions. The Sequential Test must be applied to prioritize locating projects in areas with the lowest flood risk. If this is not feasible, the Exception Test may be used. When seeking development consent on a site allocated in a development plan through the application of the Sequential Test, informed by a strategic flood risk assessment, applicants need not apply the Sequential Test, provided the proposed development is consistent with the use for which the site was allocated and there is no new flood risk information that would have affected the outcome of the test. Developers are required to propose mitigation measures, such as flood defences and sustainable drainage systems, to manage and reduce flood risk. Additionally, assessments must consider climate change impacts, including increased rainfall and sea level rise, to ensure long-term sustainability and resilience. Consultation with relevant authorities, including the Environment Agency, is essential to ensure compliance with national and local flood risk policies. The Proposed Development must be designed to mitigate the impact of flooding and must be completed in line with the requirements outlined in this policy.
National Policy Statements for Renewable Energy Infrastructure (EN-3) [Ref 40]; for Natural Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4) [Ref 41]; for Electricity Networks Infrastructure (EN-5) [Ref 42]	These National Policy Statements all reference NPS EN-1 for considerations to be taken into account for flood risk and climate change.
National Planning Policy Framework (2026) [Ref 6] - Section 18 and Annex F in relation to flood risk and climate change	The NPPF states that when determining planning applications, local planning authorities should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a

Legislation, policy and guidance	Summary
	site-specific FRA. Development should only be allowed in areas at risk of flooding where, in light of this assessment (and the Sequential and Exception tests, as applicable), it can be demonstrated that: • within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location; • the development is appropriately flood resistant and resilient; • it incorporates Sustainable Drainage Systems (SuDS), unless there is clear evidence that this would be inappropriate; • any residual risk can be safely managed; and • safe access and escape routes are included where appropriate, as part of an agreed emergency plan. It can be demonstrated that flood risk will not be increased elsewhere Applications which could affect drainage on or around the site should incorporate SuDS. The systems used for major development should: • take account of advice from the Lead Local Flood Authority (LLFA); • be designed in accordance with the National Standards for Sustainable Drainage Systems; • have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and • where possible, provide multifunctional benefits. The Proposed Development is located within areas of flood risk, as well as having the potential to impact water quality. This document is therefore relevant to the assessment. The FRA has followed the methodology outlined in the NPPF.
Stockton-on-Tees Borough Council (STBC) Local Plan (2019) [Ref 8]	Requires development to avoid flood-prone areas and incorporate SuDS, reducing pressure on watercourses. Protects water resources through policies on green infrastructure and climate resilience.
Stockton-on-Tees Local Flood Risk Management Strategy (2016) [Ref 9]	Surface water drainage strategies are a key consideration for major development, where the proposals must not increase the risk of surface water run-off or the risk of flooding to neighbouring sites or downstream of the development.
Stockton-on-Tees Strategic Flood Risk Assessments: Level 1 (2018) [Ref 10] Level 2 (2018) [Ref 11]	A Strategic Flood Risk Assessment (SFRA) has been produced by STBC. The SFRA includes a Level 1 SFRA, an SFRA review, a Level 2 Stage 1 SFRA and a Level 2 Stage 2 SFRA. They provide the evidence

Legislation, policy and guidance	Summary
	base to support a review of the STBC local plan and have an ongoing purpose in providing guidance to developers on flood risk management. The Level 1 SFRA includes guidance to developers on flood risk identification, management and mitigation, flood risk regulatory compliance (including obtaining necessary permits), and community engagement. The Level 2 Stage 1 SFRA includes further guidance to developers on site-specific flood risk identification and mitigation, Sequential and Exception Tests for flood risk assessment, and emergency planning. It also includes further guidance to developers on flood defence infrastructure, flood hazard mapping, residual risk management, and the alignment of development proposals with local and national flood risk policies.
Stockon-on-Tees Preliminary Flood Risk Assessment (n.d.) [Ref 12]	The Preliminary Flood Risk Assessment (PFRA) is a high-level screening assessment that identifies areas where flood risk is significant (known as Flood Risk Areas). It considers the risk of flooding from local sources, namely Ordinary Watercourses, surface water and groundwater. No areas in Stockon-on-Tees were identified as meeting the national thresholds to be classed as a Flood Risk Area.
Redcar and Cleveland Local Plan (2018) [Ref 13]	The plan integrates flood risk management with coastal protection measures to safeguard communities and critical infrastructure from tidal and fluvial flooding. It places strong emphasis on preserving marine and estuarine environments, ensuring that development does not compromise ecological integrity or water quality. Policies encourage water-sensitive urban design, including SuDS and green infrastructure, to manage surface water, reduce runoff, and maintain healthy aquatic ecosystems. The strategy aligns with climate resilience objectives, promoting adaptive approaches to protect biodiversity and support sustainable growth along the coast.
Redcar and Cleveland Borough Council (RCBC) Preliminary Flood Risk Assessment (2011) [Ref 14]	The PFRA is a high-level screening assessment that identifies areas where flood risk is significant (known as Flood Risk Areas). It considers the risk of flooding from local sources, namely Ordinary Watercourses, surface water and groundwater. No areas in Redcar and Cleveland were identified as meeting the national thresholds to be classed as a Flood Risk Area.
Redcar and Cleveland Borough Council Strategic Flood Risk Assessments: Updated Level 1 (2016) [Ref 15]	A Level 1 SFRA and a Level 2 SFRA have been produced by RCBC. They provide the evidence base to support a review of the RCBC local plan and have an ongoing purpose in providing guidance to developers on flood risk management.

Legislation, policy and guidance	Summary
Level 2 (2010) [Ref 16]	The Level 1 SFRA includes guidance to developers on flood risk identification, management and mitigation, flood risk regulatory compliance (including obtaining necessary permits), and community engagement. The Level 2 Stage 1 SFRA [Ref 16] includes further guidance to developers on site-specific flood risk identification and mitigation, Sequential and Exception Tests for flood risk assessment, and emergency planning. It also includes further guidance to developers on flood defence infrastructure, flood hazard mapping, residual risk management, and the alignment of development proposals with local and national flood risk policies.
Redcar and Cleveland Borough Council Local Flood Risk Management Strategy (2017) [Ref 17]	The Strategy notes a flood event (2013) was as a result of surface water run-off and sewer flooding rather than from river sources. Work has subsequently been undertaken with Northumbrian Water to improve the surface water drainage system within the borough. Sustainable drainage is critical to achieving effective surface water management, and the Authority is developing its policy in this area. All major planning applications now must include proposals on drainage and flood risk reduction. Surface water drainage strategies are a key consideration for major development, whereby the proposals must not increase the risk of surface water run-off or the risk of flooding to neighbouring sites or downstream of the development.
Guidance	
Environment Agency (EA)'s Climate Change Allowance Guidance (2022) [Ref 18]	Outlines when and how local authorities, developers, and their agents should use climate change allowances in flood risk assessments to ensure that developments are resilient to future climate change. It promotes an adaptive planning approach to managing flood risk, ensuring that all potential risks are identified and mitigated, thereby protecting communities and infrastructure. The guidance will inform design and the identification of mitigation measures to manage the impact of climate change on flood risk. This guidance also sets out when and how risk management authorities should use climate change allowances for flood and coastal risk projects, schemes, and strategies. It promotes an adaptive approach to managing flood risk, enabling the development of projects that can adapt to a range of future climate change scenarios. By using climate change allowances to assess and plan for future flood risk, the guidance ensures that potential risks are identified and mitigated, and that projects are designed to be resilient to future climate change

Legislation, policy and guidance	Summary
	impacts. The guidance will inform design and the identification of mitigation measures to manage the impact of climate change on flood risk.
Planning Practice Guidance, Flood risk and coastal change [Ref 32]	A proportionate approach should be taken to the sequential test. If a site-specific FRA shows that the proposed layout, design, and mitigation will keep occupiers safe from current and future surface water flood risk for the development's lifetime, without increasing flood risk elsewhere, then the sequential test need not be applied. For applications subject to the sequential test, the search area should reflect local circumstances, the development type, and the needs it addresses. The catchment area must be appropriate to the proposal's scale and the settlement it serves.

5 Available information

5.1 Summary

5.1.1 Key sources of information that have been used in the production of this FRA include:

- EA Flood map for Planning [Ref 19];
- EA Long term flood risk for an area in England, for rivers and sea, surface water, reservoirs and groundwater [Ref 20];
- Department for Environment Flood and Rural Affairs (Defra) National 1m Light Detection and ranging (LiDAR) Programme DTM [Ref 21];
- Defra Multi-Agency Geographic Information for the Countryside (MAGiC) online Mapping [Ref 22];
- British Geology Survey (BGS) data [Ref 23];
- The National Planning Policy Framework (NPPF) [Ref 6];
- National Planning Policy Guidance (NPPG): Flood Risk and Coastal Change Planning Practice (FRCC-PPG) [Ref 18];
- Stockton-on-Tees Local Flood Risk Management Strategy [Ref 9];
- Stockton-on-Tees Level 1 Strategic Flood Risk Assessment [Ref 10];
- Stockton-on-Tees Level 2 Strategic Flood Risk Assessment [Ref 11];
- Stockon-on-Tees Preliminary Flood Risk Assessment [Ref 12];
- RCBBC PFRA [Ref 14];
- RCBC Level 1 SFRA [Ref 15];
- RCBC Level 2 SFRA [Ref 16];
- RCBC Local Flood Risk Management Strategy [Ref 17]; and
- Tees Catchment Flood Management Plan (CFMP) [Ref 29].

6 Hydrological context

6.1 Hydrology

6.1.1 The River Tees (a Main River) is located to the south and east of the Main Site. The Proposed Development includes use of existing infrastructure crossing under the Tees for connection to South Tees. The River Tees is an estuary in this location, and is tidally influenced as far upstream as the Tees Barrage in Stockton on Tees, 12km to the south west.

6.1.2 There are numerous other watercourses located in the vicinity of the Proposed Development. These include:

- several unnamed land drains;
- Dabholm Gut (an Ordinary Watercourse[2]) is located adjacent to Bran Sands Waste Water Treatment Works (WwTW);
- Mill Race (an Ordinary Watercourse) intersects the Trunk Road at the eastern extent of the Proposed Development in South Tees;
- The Fleet (an Ordinary Watercourse) located approximately 200m north of the Proposed Development in South Tees;
- Holme Fleet (a Main River) located approximately 120m south west of the Proposed Development (through the Saltholme Nature Reserve) in North Tees;
- Knitting Wife Beck (an Ordinary Watercourse) located approximately 300m south west of the eastern extent of the Proposed Development (Tees Dock roundabout) in South Tees; and
- Greatham Creek (a Main River) located approximately 1.5km north of the Main Site.

6.1.3 In addition, there are several other surface water features:

- Dorman's Pool, plus water bodies within RSPB Saltholme Nature Reserve, including Saltholme East Pool, Saltholme West Pool and several unnamed ponds to the west of the Main Site; and
- Saltholme Brine Reservoirs located approximately 600m west of the Proposed Development.

[2] An Ordinary Watercourse is defined as any stream, river, ditch, drain, culvert, or other channel where water flows that is not designated as a Main River.

6.2 Land use

6.2.1 Currently, the land use within the boundary of the Main Site includes a historic and revegetated landfill site to the west and undeveloped land to the north. The Main Site south of Seal Sands Road was used for chemical manufacturing from the 1970s, with operations most recently undertaken by INEOS Nitriles. These industrial activities have since ceased operation; the facility has been decommissioned, demolished, and the Main Site cleared leaving hardstanding and comprises mainly brownfield land. There are two existing redundant jetties located on the River Tees within the Proposed Development boundary.

6.2.2 Land use in the surrounding area is predominantly industrial including Navigator Terminals and SABIC amongst others all being located in proximity to the Main Site (see FRA Figure 2 in Annex A). The nearest residential properties are at Port Clarence and Cowpen Bewley, approximately 2.8km south west and 3.5km north west, respectively. The wider area also includes various commercial buildings, such as the Asda and Tesco distribution centres in South Teesside.

6.3 Geology and Groundwater

6.3.1 The Main Site and connection corridors are underlain by made ground (including dredged material in North Tees and ash and slag in South Tees). The underlying superficial depots are Tidal Flat Deposits (estuarine and marine alluvium) composed of sand, silt, and clay, which in turn overlie as Glaciolacustrine Deposits (clay and silt) and Glacial Till.

6.3.2 The superficial deposits are Secondary (undifferentiated) unproductive (Tidal Flat Deposits) and Secondary A aquifers (Glaciolacustrine Deposits).

6.3.3 The BGS Geology Viewer [Ref 23] shows the bedrock beneath the Main Site is the Mercia Mudstone Group which generally exhibits low permeability. The Mercia Mudstone (a Secondary B aquifer) is underlain by the Sherwood Sandstone Group (a Principal Aquifer) which also subcrops beneath superficial deposits to the west of the Main Site.

6.3.4 This indicates that the aquifers can provide local water supplies and may contribute significantly to river baseflow, with some horizontal groundwater movement occurring through permeable layers. The Sherwood Sandstone is abstracted for drinking water supply approximately 9km to the north east of the Main Site.

6.3.5 At a local scale, the groundwater flow within the superficial deposits and made ground will generally be towards the River Tees. However, this flow direction can vary due to local changes in topography, aquifer structure (such as the presence of clay or fine-grained sediments), rainfall patterns,

and artificial features (e.g. drainage systems). The River Tees is likely to be hydraulically connected to the shallow groundwater contained within the superficial (Tidal Flat) deposits.

6.4 Existing topography

6.4.1 The Site is characterised by relatively flat topography (FRA Figure 3, Annex A). According to LiDAR levels within the Main Site, the lowest parts of the Main Site are approximately in the range of 4.6 to 4.8 metres Above Ordnance Datum (mAOD) located adjacent to the existing revetment of the Tees. The rest of the Main Site is generally 5mAOD.

6.4.2 Ground levels along the Linkline pipeline corridor along the southern edge of the Main Site range between approximately 4mAOD and 8mAOD, while those in South Tees are around 4mAOD.

6.5 Existing drainage

6.5.1 Much of the existing drainage infrastructure on the Main Site has been abandoned and filled in, although a remaining drain that runs to a pumping station adjacent to the River Tees is believed to still be operational.

6.5.2 During a site visit, the location of an existing outfall was identified in the south eastern part of the Main Site. This piped outfall is fitted with a flap valve. This outfall is understood to form part of the former surface water drainage system associated with the previous industrial use of the Site.

6.5.3 Pre-construction utility survey and verification works will be undertaken at the detailed design stage to confirm the location and condition of all existing services.

6.6 Flood defences

6.6.1 The EA asset management website [Ref 24] identifies several flood defences in Seal Sands near the Main Site (FRA Figure 5, Annex A). These are not ‘formal’ flood defences, i.e. they are not defined as assets and features that are formally maintained by risk management authorities (namely the EA).

6.6.2 Asset ID 395472 (5149.5m in length) extends along the left (north) bank of the River Tees through the Main Site, where the proposed quay will be built, and extending 200m to the south, and 319m to the north. Where the asset passes through the Main Site, this feature is a revetment, and does not retain higher ground. As such it does not provide flood protection.

6.6.3 Asset ID 395472 is however considered to be a flood defence asset by the EA. As the quay will be constructed along its line, the quay will replace the revetment as a flood defence asset. The EA will require access for inspection and maintenance but will not place maintenance obligations on the client provided the structure is safe and lasts for the proposed lifetime. A FRAP will be required for the construction of the quay, which will effectively move the defence line to the riverside of the quay.

6.6.4 North of the Main Site, Asset ID 395472 features sections of raised embankment that may offer some level of protection to neighbouring sites. This does not provide any protection to the location of the Tees services tunnel, as the embankment ends at this location, and would be bypassed by flooding from the north.

6.6.5 Assets ID 183041 (2214.74m in length) and 29649 (2615.15m in length) extend along the right hand (south) bank of the River Tees. These features are providing partial protection against tidal flooding of South Tees from the River Tees (FRA Figure 5 Annex A).

6.6.6 Flood defences within the area surrounding the Main Site are understood to be maintained by private third parties (i.e. not the EA). Accordingly, the EA asset dataset [Ref 29] contains no recorded information on its ownership, operator, condition, design characteristics, or standard of protection (see B.4). It is also noted that these assets are not included within the EA Flood Map for Planning. The presence of such flood defences is not, therefore, reflected in the published flood zone extents (see B.1.2).

6.6.7 The closest ‘formal’ (i.e. EA owned and/or maintained) flood defences to the Proposed Development are located >4km upstream along the River Tees (near Port Clarence) and approximately 2km downstream along the banks of the Greatham Creek.

6.7 Historical flooding

6.7.1 STBC holds no records of historical flooding within the vicinity of the Site.

6.7.2 Historical flooding has been recorded within the RCBC SFRA [Ref 16], as well as the EA maintained database (see Annex B.1.2), which records the flood outlines historical events caused by rivers, the sea, groundwater and surface water. Historic flood outlines are shown in the EA recorded flood outlines dataset (FRA Figure 6, Annex A).

6.7.3 Within the boundary of RCBC, historical flooding has predominantly arisen from sources such as surface water sewers, combined sewer systems, and smaller ordinary watercourses and drains. All major urban areas within RCBC have experienced localised flooding. Across Redcar and Cleveland, nearly 800 flooding incidents have been documented by multiple data

holders, affecting approximately ten key locations. The RCBC SFRA identifies Eston, Guisborough, and Redcar as the principal local flood risk areas, designating them as Critical Drainage Areas (CDAs).

6.7.4 Historical flood records sourced from the BHS Chronology of British Hydrological Event [Ref 30] and the RCBC SFRA and EA (including the Final report of the Holme Fleet Realignment Model [Ref 35]), are summarised in Table 6.1.

Table 6.1 Records of historical flooding

Date	Flooding source	Summary
1953	Tidal	A deep low-pressure system combined with north westerly winds and a high spring tide generated a major tidal surge, flooding Port Clarence to 1.2m depth. Peak water level reached 4.01mAOD on the River Tees. Two breaches occurred on Greatham Creek embankments near the A178, with additional impacts at Billingham Reach Industrial Estate, Tees Marshalling Yard, and other low-lying areas along the tidal Tees.
1978	Tidal	A breach occurred on both the north and south embankments of Greatham Creek, downstream of the A178.
1983	Tidal	A breach of the Greatham Creek Southern flood defence embankment both upstream and downstream of the A178, with a peak tide level of 3.65mAOD.
1999	Fluvial	Heavy rainfall and restricted peak flows caused substantial flooding when the Holme Fleet culvert north of Port Clarence became blocked by debris within its access chambers.
2000	Fluvial	An intense storm hit the area of Port Clarence. Approximately 16 properties suffered from internal flooding with flood water reaching ground floor level, caused by a combination of overtopping from Holme Fleet, blockage of key structures, storm overflow and sewer network capacity being exceeded. The Holme Fleet culvert is reported to have been blocked at the time.
Unknown	Groundwater	Flooding to the south of Marske, directly below Errington Wood.
2012	Fluvial and surface water	24-hours of persistent heavy rain followed the wettest summer on record, resulting in fluvial and surface water flooding of several communities. The most severely affected were those along Lustrum Beck, and those in Norton near Billingham Beck. Traffic disruption also occurred following flooding of the A19/A66 trunk road. The report estimates that 150 properties and businesses were flooded internally
2013	Tidal	A high spring tide combined with a low-pressure system caused a tidal surge reaching 4.09mAOD, exceeding previous records. Flooding affected 32 homes and 20 businesses in Port Clarence, Billingham Reach Industrial Estate, and Seal Sands. (There was no know contribution from the Holme Fleet to the Port Clarence flooding).

Date	Flooding source	Summary
		Significant infrastructure damage included closure of the A19 Portrack interchange and partial closure of the A66. Breaches at Greatham Creek inundated large areas of land.
2017	Fluvial/Surface water/Drainage Infrastructure	Cross Beck (Eston) and Spencer Beck (Teesville) catchments were affected after one week's rainfall fell in an hour, confirmed by the Met Office. Northumbrian Water reported this as a 1-in-197-year storm. Dry antecedent conditions accelerated runoff, and the rainfall intensity overwhelmed all drainage systems.
2021	Fluvial/Surface water/Drainage Infrastructure	Flooding to community allotments and private gardens in Port Clarence in Feb 2021. A section of the Holme Fleet culvert was 100% blocked, and not passing any flow until partially cleared, causing overtopping from Holme Fleet and surface water following persistent rainfall. No reported flooding to properties.

7 Baseline Flood Risk Assessment

7.1 Overview

7.1.1 This section provides a baseline assessment of flood risk at the Site, from all sources including fluvial, tidal (coastal), surface water, groundwater, and artificial sources such as infrastructure failure. Following this, potential changes to flood risk due to climate change are discussed. Finally, flood risk management measures to protect the Proposed Development over its design life are set out.

7.2 Fluvial and tidal/coastal flooding

7.2.1 The EA classifies flood risk into three main Flood Zones, defined as follows:

- Flood Zone 1 (Low Probability): Land assessed as having less than a 0.1% annual probability of fluvial flooding (i.e. less than a 1 in 1,000 chance in any given year);
- Flood Zone 2 (Medium Probability): Land assessed as having between a 0.1% and 1% annual probability of fluvial flooding (i.e. between a 1 in 1,000 and 1 in 100 chance in any given year); and
- Flood Zone 3 (High Probability): Land assessed as having a 1% or greater annual probability of fluvial flooding (i.e. a 1 in 100 or greater chance in any given year).

  The flood mapping underlying the above Flood Zones assumes that flood defences are not present.

7.2.2 Flood Zone 3 is further subdivided into Flood Zones 3a and 3b, where 3b is the functional floodplain, commonly defined as having a 3.3% or greater annual probability of fluvial flooding (i.e. a 1 in 30 or greater chance in any given year). The definition of Flood Zone 3b does take account of the effect of defences. Flood Zone 3a is the remaining component of Flood Zone 3.

7.2.3 The majority of the Main Site falls within Flood Zone 1 and is at low fluvial and tidal flood risk (Flood Zone 1), under baseline conditions.

7.2.4 Within the Main Site, areas along the line of the Tees revetment (east boundary of the Main Site) fall within Flood Zone 3a. Along the south boundary of the Main Site, a thin (3-6m) strip falls within Flood Zone 2, but this is likely due to the definition of LiDAR at this location.

7.2.5 Within the Wider Site, some areas south of the Main Site fall within Flood Zone 2. Utility crossings of the Tees fall within Flood Zone 3a, and the utility corridor along the north bank of the Dabholm Gut falls mostly within Flood Zone 2, but with some areas of Flood Zone 3a. Existing access routes

connecting to the Seaton Carew road along the west side of the Wider Site fall within Flood Zone 3a.

7.2.6 Without any changes to flood defences, EA Flood Zone mapping predicts all of Main Site may become Flood Zone 2 and/or 3 by 2070, when accounting for climate change (FRA Figure 7, Annex A). The EA Flood Map for Planning plus Climate Change [Ref 33] does not account for the benefits of any existing flood defences.

7.2.7 Furthermore, several sections of the Site are situated within higher-risk areas classified (Flood Zones 2 and 3) under baseline conditions. These include: the initial 800m of Seal Sands Road east of Seal Sands Roundabout; the intertidal area along the River Tees; and areas along the north bank of Dabholm Gut in South Tees.

7.2.8 The flood zone mapping of the STBC and RCDC SFRAs have been reviewed. There are no areas of Flood Zone 3b at, adjacent to, or in the vicinity of the site.

7.3 Hydraulic modelling

7.3.1 The tidal hydraulic model (Greatham and Port Clarence model update (2020)) [Ref 36] for the Tees Estuary has been updated for this project to allow assessment of flood risk to the proposals and the impact of the Proposed Development.

7.3.2 The model has been updated to reflect latest available LiDAR and bathymetry. Boundary conditions for extreme sea levels and projected future sea-level rise have been updated in accordance with climate change guidance [Ref 18]. All known formal and informal flood defences, including recent structures at Greatham and Port Clarence, are represented within the defended model.

7.3.3 Under NPPF Annex F [Ref 6], essential infrastructure located in high flood risk areas must be designed to remain operational and safe during at least the 1-in-200-year flood event.

7.3.4 Whilst the operational life of the Proposed Development will be at least 25 years, it could be longer, subject to market conditions. 30 years has been adopted as the reasonable operational life. EA guidance [Ref 27] requires the Flood Risk Assessment to consider a minimum 75-year development lifetime. Construction of the Proposed Development is anticipated to commence in 2028 and the Proposed Development is expected to be operational by 2031. The proposals include ground raising that will not be removed on decommissioning of the Main Site. As such, the legacy flood risk impact of the Main Site has been assessed for a 100-year design life.

7.3.5 To reflect the above timelines, the project has been assessed for climate change epochs to the years 2030, 2080, 2105 and 2130. These have been assessed against the Higher Central Sea Level Rise assumptions. The 2105 period has been assessed against the Upper End and H++ climate change scenarios (albeit the latter will not be subject to explicit hydraulic modelling).

7.3.6 Climate change scenarios are defined in greater detail in Section 9.

7.4 Modelled baseline flood risk

7.4.1 Modelled flood maps can be found in Annex D Attachment E “Hydraulic modelling figures”. Details of the hydraulic modelling can be found in Annex D “LGF Hydraulic modelling report”.

7.4.2 In the baseline conditions, the following areas are potentially affected by tidal flooding.

- Southern section of the Main Site, in the existing Linkline pipeline corridor, where existing above ground pipelines are located, and where the SAF export pipeline will likely be routed. The area is flooded in the 2030 1-in-200-year flood event.
- Connection Pipeline Corridors and access routes, South Teesside - some areas of pipeline corridor are flooded in the 2030 1-in-10-year flood event
- Sabic site electricity sub-station (proposals connect to this existing substation) - flooded in the 2080 1-in-200-year flood event but not flooded in the 1-in-1000-year 2030 flood event.
- Marine Assessment Area (including the proposed new quay) - flood levels at the location of the quay are as shown in Table 7.1. Low ground immediately adjacent to the quay are noted as being at 4.55mAOD.

7.4.3 The baseline modelling has identified flood levels at the location of the quay as shown in Table 7.1.

Table 7.1 Baseline flood levels at proposed quay location (mAOD)

AEP (%)	Epoch	Sea Level Rise assumption	Baseline (mAOD)
1	2030	Central	4.05
0.5	2030	Central	4.15
0.1	2030	Central	4.40
0.5	2080	Central	4.56
0.5	2105	Central	4.85
0.5	2105	UE	5.11
0.5	2130	Central	5.13

7.4.4 Flood levels are very flat along the Tees, and the above levels are less than 0.015m higher than at the model's tidal boundary, 5.5km downstream. This indicates that the area is expected to be highly insensitive to the impact of the proposals, and also that the above flood levels are representative of flood levels throughout the Site.

7.5 Breach risk

7.5.1 Two breach scenarios have been modelled, representing breach to the Greatham Creek defences immediately to the east of the Tees Road, and breach to the Port Clarence defences, beside the Transporter Bridge. The Greatham Creek breach was modelled in the Greatham and Port Clarence model and reflects the account of a breach event in December 2013 at Greatham Creek. The Port Clarence breach has been modelled in recognition of the potential risk of failure from a raised defence at this location.

7.5.2 The resulting flood levels are shown in Table 7.2

Table 7.2 Breach levels adjacent to Seal Sands Road access to site

Breach location	Event	Peak water level (mAOD)
Greatham Creek	2100 0.5% AEP Higher Central	3.71
	2100 0.5% AEP Upper End	3.83
Port Clarence	2100 0.5% AEP Higher Central	2.30
	2100 0.5% AEP Upper End	2.84

7.5.3 A flood level of 3.83mAOD still leaves approx. 1m of freeboard to the lowest existing ground levels at the Main Site, and the proposals intend to raise ground levels higher than this. Hence breach risk is not considered to be of significance to the Main Site itself.

7.5.4 The Greatham Creek breach would imply the destruction of the emergency access road and would flood both the Tees Road and the Seal Sands Road, including the latter flooded up to 0.35m deep (in the Higher Central 2100 1-in-200-year flood event, Seal Sands Road would still be flooded to 0.30m deep). This implies the site would be temporarily isolated in such an event.

7.5.5 While both events have been modelled for a 2100 scenario and not a 2105 scenario, there is only a 0.06m sea level rise between these two scenarios and incorporating this update will not be sufficient to overcome the 1m freeboard identified above. For comparison, the sea level rise between the 0.5% 2100 Higher Central and Upper End scenarios is 0.25m, but only resulted in 0.12m increase in water level at Seal Sands Road. This has therefore not been remodelled for 2105 (see the Hydraulic modelling report in Annex Annex D for more details).

7.5.6 The breach scenarios were not remodelled for the Proposed Development: the resulting flood outlines do not interact with the Proposed Development, and therefore the results would be unchanged. The Proposed Development includes increasing Main Site ground level to a minimum of 5.08mAOD and would therefore increase the level of freeboard to 1.25m.

7.6 Fluvial flood risk

7.6.1 The Holme Fleet was modelled as part of the EA's assessment of local habitat creation measures [Ref 34]. A "Do Nothing" scenario at the Holme Fleet considered complete blockage of the culvert to the Tees, leaving this watercourse with no means of discharge; flood levels took three months to reach a level of 2.8mAOD in a 1-in-1000-year flood. Flood risk from the Holme Fleet is therefore considered negligible.

7.6.2 The floodplain (and indeed catchment) of the Holme Fleet merge to the east of the Main Site. The volume of the combined fluvial floodplain to the east of the site below the Main Site existing ground level of 4.8mAOD is calculated at 17.75 million m^3. The combined catchment area to this floodplain is calculated at 18.3km^2. Even assuming that the floodplain's outfalls to the Tees were all blocked, it would therefore take 0.97m of run-off from everywhere within the catchment for flood levels to reach the existing ground levels within the Main Site.

7.6.3 For context, the 1% AEP present day 10day rainfall depth is 173.7mm. Applying the Upper End 2070's climate allowance of 45% brings this up to 252mm, which would generate 4.6 million m^3 of run-off – but only if the catchment percentage run-off was assumed to be 100%. This would achieve a level of 3mOD if the outfalls were blocked. In reality of course, run-off would not be 100%, and the outfalls are highly unlikely to be left

blocked for an extended period of time. For context, local road levels are at ~3.4mOD.

7.6.4 The Main Site is therefore not at risk from fluvial flooding in the 1% Upper End 2070's scenario even in its baseline condition. The proposals to raise the Main Site therefore do not displace fluvial floodwater and compensatory floodplain storage is not necessary.

7.7 Surface water flood risk (pluvial flooding)

7.7.1 Surface water flooding, also referred to as pluvial flooding, occurs when intense or prolonged rainfall generates surface runoff that cannot be absorbed by the ground or conveyed by the local drainage system.

7.7.2 The EA Risk of Flooding from Surface Water (RoFSW) mapping categorises surface-water flood risk according to the following annual probabilities:

- High risk: >3.3% AEP (greater than 1 in 30 chance each year);
- Medium risk: 1% – 3.3% AEP (between 1 in 100 and 1 in 30);
- Low risk: 0.1% – 1% AEP (between 1 in 1000 and 1 in 100); and
- Very low risk: <0.1% AEP (less than 1 in 1000).

7.7.3 The EA RoFSW mapping identifies several small, linear, and discrete areas within the Site at risk of flooding, ranging from low to high chance of flooding from surface water within the Main Site. They are mostly in the central and eastern parts of the Main Site (FRA Figure 14, Annex A). These are likely to be associated with low ground where water would pond after intense or prolonged rainfall event.

7.7.4 The EA Long-Term Flood Risk Map [Ref 20] indicates that there is predominantly a low chance of surface water flooding to depths of approximately 20–30cm along the northern boundary of the Main Site, with some minor areas exhibiting a medium chance of flooding. This potential surface-water risk is associated with Seal Sands Road, and the immediately surrounding areas.

7.7.5 Overall, the Site is associated with a variable but predominantly low to medium risk of surface-water flooding. Notwithstanding, there are isolated areas of higher risk which are likely linked to localised low-lying ground and sections of the access route and associated corridors.

7.7.6 A surface water drainage strategy will be developed at detailed design stage. Surface water runoff will be collected and directed to on-site attenuation features prior to controlled discharge. The current design includes attenuation via balancing ponds, with discharge via an outfall

integrated with the proposed quay. Water quality will be monitored, with provision for treatment or diversion where required.

7.7.7 Overall, surface water flood risk is considered secondary to tidal influences at the Site. However, localised ponding in low-lying areas may occur during high-intensity rainfall events.

7.7.8 A surface water management strategy will be developed at the detailed design stage to ensure that runoff from the Proposed Development is appropriately managed and does not increase flood risk elsewhere. This is expected to include the use designed in accordance with relevant guidance and incorporating climate change allowances.

7.8 Groundwater flood risk

7.8.1 The Main Site is underlain at depth by Mercia Mudstone which is of low permeability and is underlain by the high permeability Sherwood Sandstone Group Principal Aquifer. The bedrock is overlain by superficial deposits including Tidal Flat deposits underlain by glacial deposits. The superficial deposits are also predominantly of lower permeability that may store and yield limited amounts of groundwater.

7.8.2 At a local scale, groundwater within superficial deposits and made ground generally flows toward the River Tees, which is likely hydraulically connected to shallow groundwater in the Tidal Flat deposits.

7.8.3 Both the RCBC Level 1 SFRA [Ref 15] and PFRA [Ref 14] state that the overall risk of groundwater flooding in Redcar and Cleveland is low. It is noted in these assessments, that the majority of the borough may be subject to very wet ground conditions as a result of winter waterlogging. STBC hold no records of groundwater flooding problems in their area.

7.8.4 The Tees CFMP Catchment Flood Management Plan [Ref 29] states that there is little documented evidence of groundwater flooding in the Tees catchment and groundwater flooding is not known to be a major problem due to the geology of the catchment.

7.8.5 It is anticipated that any localised, emergent groundwater seepages would be managed by the new or updated drainage system. The detailed design for the Proposed Development will also need to ensure foundation design does not adversely affect (and is not adversely affected by) changes in groundwater elevation in made ground (Main Site) and underlying superficial deposits (River Tees).

7.9 Reservoir flood risk

7.9.1 Reservoir flooding is categorised as flooding from an artificial source, typically resulting from the overtopping, structural failure, or breach of a

reservoir or its associated outfall structures. The likelihood of such events is considered very low, owing to stringent regulatory and inspection regimes. However, the consequences of a breach can be severe, making reservoir flooding a residual but high-impact risk.

7.9.2 The EA Reservoir Flood Map indicates that the Main Site is not directly at risk of flooding from reservoirs (FRA Figure 15 Annex A). However, the Main Site lies adjacent to areas identified as being at potential risk of flooding from this source; under both normal river conditions and combined fluvial–reservoir flood scenarios.

7.9.3 The reservoir flood map indicates a flood level of 3.5-3.6mAOD associated with the “Wet Day” failure. As such, the Main Site has significant freeboard against failure from reservoirs. The only proposals within the reservoir floodplain are the access routes and existing pipeline corridors. The reservoir flood risk floodplain already includes residential properties, and as such, the reservoirs behind the floodplain will be Category A under the Reservoirs Act [Ref 34] and shall not need to change category because of the proposals.

7.10 Canal and artificial flooding

7.10.1 The residual risks associated with canal flooding are primarily influenced by the location and nature of any potential structural failure.

7.10.2 There are no canal systems within the Site or the surrounding area (as noted in the STBC and RCBC SFRAs). On this basis, there is no risk of canal flooding to the Site.

7.11 Flood risk from utilities

7.11.1 A detailed utility survey and verification exercise has been undertaken to confirm the location**,** condition, and capacity of all existing underground services, including water mains and drainage infrastructure. No flood risk issues were identified for the site.

8 Sequential and Exception Tests

8.1 Development type and vulnerability classification

8.1.1 The NPPF classifies all types of developments in accordance with their vulnerability to flood risk [Ref 8], which allows more vulnerable developments to be steered into areas of lowest flood risk. The vulnerability classification has a specific meaning under the flood risk assessment guidance to inform the Sequential and Exception tests and determine the selection of the appropriate climate change allowance for design flood levels (see Table 8.1 and Table 8.2). Developments can be classified as Essential Infrastructure, Highly Vulnerable, More Vulnerable, Less Vulnerable or Water-Compatible. Note that the flood receptor vulnerability classification under NPPF does not imply the degree of susceptibility to damage or disruption during flood events.

Table 8.1 Flood risk vulnerability and compatibility (based on Table 2 of the NPPG)

Flood Zone	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Flood Zone 1	✓	✓	✓	✓	✓
Flood Zone 2	✓	Exception test required	✓	✓	✓
Flood Zone 3a	Exception test required	✗	Exception test required	✓	✓
Flood Zone 3b “Functional Floodplain”	Exception test required	✗	✗	✗	✓

Table 8.2 Flood risk vulnerability classification

Vulnerability classification	Description
Essential infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including for electricity generation and storage, electricity network infrastructure, telecommunications infrastructure, water supply reservoirs and water treatment works that need to remain operational in times of flood. • Wind turbines. • Solar farms. • Hydrogen production facilities. • Carbon Capture, distribution and storage facilities. • Heat networks.

Vulnerability classification	Description
	• Data Centres. • Electric vehicle charging stations.
Highly vulnerable	• Police and ambulance stations, fire stations and command centres. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent or which fall under The Control of Major Accident Hazards Regulations 2015. Where there is a demonstrable need for such installations – including bulk storage associated with port or similar facilities, and energy infrastructure and carbon capture or storage – to be located at coastal, water-side, or other high flood risk areas, they should be classified as 'Essential Infrastructure'. • Installations requiring a radioactive substances regulations permit for disposal to landfill or dedicated near-surface disposal by burial.
More vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses (including floating/rising designs), student halls of residence, drinking establishments, nightclubs and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less vulnerable	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for: shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place. • Car parks. • Land-raising (unless part of or enabling a development with a higher vulnerability classification).

Vulnerability classification	Description
Water-compatible development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • Ministry of Defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.

8.1.2 The primary function of the Proposed Development is to produce, store and export SAF, which will require hazardous substance consent, an environmental permit and a COMAH licence. The Proposed Development needs to be located in a water-side location to receive feedstock by ship and in proximity to existing third party marine export facilities. By reference to

8.1.3 Table 8.2, development proposals requiring hazardous substance consent are classified as Highly Vulnerable, but the need to locate this proposal at a water-side location that is subject to flood risk classifies the Proposed Development, including the quay, as “Essential Infrastructure”.

8.1.4 The Section 35 Direction issued by the Secretary of State for Energy Security and Net Zero (dated 8 September 2025) confirms that the Specified Elements of the Proposed Development should be treated as development for which development consent under the PA 2008 is required. The CHP plant is an NSIP in its own right.

8.2 Sequential Approach

8.2.1 The NPS requires a sequential approach to be taken to site selection to avoid inappropriate development in areas at risk of flooding from all sources and to steer new development to areas with the lowest risk of flooding.

8.2.2 The sequential approach prioritises development in low-risk flood areas over higher risk ones, considering all sources of flooding. Avoiding flood risk through the Sequential Test is the most effective method to do this.

8.2.3 The sequential approach follows a sequential, risk-based method to direct new development towards areas with the lowest flood risk, considering all sources of flood risk and climate change.

8.2.4 If development cannot be located in low-risk areas, the Sequential Test should compare reasonably available sites:

- first, within medium risk areas; and
- then, if no reasonable sites are available in both low and medium risk areas, within high-risk areas.

8.2.5 The NPS also notes “When seeking development consent on a site allocated in a development plan through the application of the Sequential Test, informed by a strategic flood risk assessment, applicants need not apply the Sequential Test, provided the proposed development is consistent with the use for which the site was allocated and there is no new flood risk information that would have affected the outcome of the test.”

8.2.6 STBC Level 1 SFRA states “*Planning should seek to avoid inappropriate development in areas at risk of flooding by directing development away from areas at highest risk and ensuring that all development does not increase risk and where possible can help reduce risk from flooding to existing communities and development*.”

8.2.7 The STBC Local Plan [Ref 8] identifies policies SD4 and EG4 as applying to the Main Site, albeit that they do not cover the entire site as the plan dates from 2019, when the Main Site was in use by its previous occupier. The Local Plan was informed by the STBC Level 1 SFRA.

8.2.8 Policy SD4 identifies support for redevelopment of previously developed land. The Seal Sands area is noted as one of three main growth locations for ‘Specialist Uses’, including hazardous installations and energy generation.

8.2.9 Policy EG4 builds on Policy SD4, identifying the need for an FRA for such development.

8.2.10 As stated in previous sections, the Main Site is located in Flood Zone 1, while sections of existing pipeline and access routes within the Wider Site located within Flood Zone 2 and 3. The quay is located in Flood Zone 3.

8.2.11 It is the nature of the connecting pipelines within the Wider Site that they connect to existing third party generation, use, treatment or transmission locations within Teesside. To reduce their collective impact, such pipelines are routed along existing shared corridors. The location of these pipelines within Flood Zone 2 or 3 is therefore as much a function of these corridors and connection points as it is a function of the proposed site location. Their presence within Flood Zones 2 and 3 is therefore not considered material to the Sequential Test.

8.2.12 The Main Site requires access to quayside facilities for delivery of resilient fuel supplies avoiding reliance on road transport, and an area that is large enough to accommodate the infrastructure of the Main Site and on site power generation. Furthermore, the infrastructure needs to be within proximity to a WwTW and with access to existing utilities and CO_2 transport and storage proposals and transport access routes (marine, road & rail). This greatly limits the number of sites available; most available quayside sites are likely to subject to similar, if not greater levels of flood risk.

8.2.13 The consideration of alternative sites is presented in **Chapter 6: Alternatives (ES Volume I, Application Document Ref. 6.1.).** Three alternative sites were considered on Teesside.

8.2.14 A previous site was under consideration at the former Air Products TV1/TV2 site in North Tees ("the Huntsman Drive site") located to the southwest of the current Main Site of the Proposed Development. However, a significant portion of that site was at a lower level than the current Main Site, and therefore at higher flood risk. The previous site did not have direct access to the River Tees and was, therefore deemed less suitable for delivery of construction modules and feedstock. The previous site was also smaller in size, which would have meant that the biomass feedstock pre-treatment would have had to be undertaken off-site.

8.2.15 A second site was under consideration in South Tees; however the quay for this site is subject to a recent and live planning application for use of the existing quay, which would leave insufficient space for the construction and operation of the Proposed development. The site also had no access to third party liquid export infrastructure, and no viable route for developing a crossing under the Tees to reach existing export facilities in North Tees. The creation of export facilities on site would conflict with the existing planning permission and quay access for space.

8.2.16 These important technical reasons contributed to the decision to change the location of the SAF Production Facility to the Main Site.

8.2.17 No other alternative sites have been identified that are both available and suitable, in accordance with the requirements outlined above. Considering these factors, the Site is considered to comply with the principles of the Sequential Test.

8.3 Exception Test

8.3.1 According to Table 8.1, Essential Infrastructure located within a high-risk flood zone (Flood Zone 3) is also required to satisfy the Exception Test. The Exception Test necessitates that the Proposed Development demonstrates both sustainability benefits and appropriate flood risk mitigation. The

Proposed Development meets the Exception Test criteria through the following measures:

- Sustainability Benefits: The Proposed Development represents a £2 billion strategic investment in a biomass-to-SAF facility in Teesside (see Section 4), delivering measurable environmental and socio-economic gains. The facility will convert biomass feedstock into advanced SAF and renewable naphtha, directly supporting the UK's Net Zero and circular economy objectives. The inclusion of low-carbon energy infrastructure, comprising a biomass and waste wood-fired CHP plant enhances the Site's energy autonomy. These outcomes strengthen national energy resilience, reduce greenhouse gas emissions, positioning Teesside as a key node in the UK's green energy transition. **Chapter 7: The Proposed Development (ES Volume I, Application Document Ref. 6.1), and the Planning Statement** describe the main planning and energy policies of relevance to the Proposed Development and how those policies support the need for the Proposed Development.
- Flood Resilience and Safety: Flood-resilient measures will be embedded into the design to ensure effective management and mitigation of flood risk. The majority of the Main Site is located within Flood Zone 1 (low risk), where the SAF production infrastructure and other critical assets are located. The Proposed Development is classed as Essential Infrastructure and under NPPF Annex F, must be designed to remain operational and safe during at least the 1-in-200-year flood event.

8.3.2 No cumulative impact on flood risk elsewhere: Hydraulic modelling has been undertaken to demonstrate no increase in flood risk in areas of Flood Zone 2 and 3, or creation of new areas of flood risk, as a result of the Proposed Development.

9 Climate change

9.1 Climate Change allowance

9.1.1 Climate change is expected to, and likely already does, influence key hydrological and coastal parameters including peak river flows, rainfall intensity, sea level rise, offshore wind speeds, and extreme wave heights. These changes are anticipated to increase both the frequency and magnitude of flooding, heightening risks in areas already susceptible to flood events and potentially introducing new areas to flood risk to areas that are currently unaffected [Ref 25].

9.1.2 There are two principal approaches to incorporating climate change into design:

- the precautionary approach, which entails implementing mitigation measures at the outset to account for potential climate change impacts;
- the managed adaptive approach, which allows for mitigation measures to be introduced in the future, once there is greater certainty regarding the scale and nature of climate change effects on factors such as river flows and rainfall;
- the proposals have adopted the precautionary approach for still water flood risk, albeit that there is scope to raise defences at a later date, given the scale of the Main Site. The managed adaptive approach is considered appropriate for managing a low residual risk from wave impacts; and
- whilst the operational life of the Proposed Development will be at least 25 years, it may be longer, subject to market conditions. 30 years has been adopted as the reasonable worst case operational life. EA guidance [Ref 27] requires the Flood Risk Assessment to consider a 75-year development lifetime. Construction of the Proposed Development is anticipated to commence in 2028 and is expected to be operational from 2031. The Proposed Development includes raising of ground levels which will not be reinstated when the Proposed Development is decommissioned. Flood modelling therefore assesses a 100 year period to check against permanent change to the floodplain.

9.1.3 The NPPF and NPS outlines how the planning system should reduce vulnerability and enhance resilience to climate change impacts. The EA's climate change allowances for flood risk assessments provide guidance for designers and developers on assessing and accommodating these impacts. The applicable climate change allowances for different sources of flooding at the Site are presented under the following sub-sections.

Peak river flow allowance

9.1.4 Peak river flow allowances have been developed for management catchments across the UK using data from the UK Climate Projections, produced by the UK Centre for Ecology and Hydrology. These allowances represent anticipated changes in peak river flows due to climate change across a series of future time epochs - the 2020s, 2050s, and 2080s - for each catchment area.

9.1.5 For each time period, a range of percentile-based allowances has been derived to reflect varying degrees of potential change, as follows:

- Central allowance: 50th percentile;
- Higher Central allowance: 70th percentile; and
- Upper end allowance: 95th percentile.

9.1.6 Table 9.1 summarises the peak river flow allowances applicable to the Tees Management Catchment [Ref 29].

Table 9.1 Peak river flow allowances for the Tees Management Catchment

Epoch	Central	Higher	Upper
2020s	19%	23%	32%
2050s	21%	27%	41%
2080s	32%	40%	61%

9.1.6.1 The epochs in the EA climate change guidance [Ref 18] represent future time periods used to apply allowances for peak river flow. For the Tees Management Catchment, they are:

- 2020s: applies to developments with a lifetime up to 2035 (short-term);
- 2050s: applies to developments with a lifetime between 2036 and 2065 (medium-term); and
- 2080s: applies to developments with a lifetime between 2066 and 2125 (long-term).

Sea level rise allowance

9.1.7 Sea level rise allowances have been established for each River Basin District and future flood epoch, using percentile-based projections (Higher Central and Upper End). The allowances for the Northumbria River Basin District (NRBD) are presented in Table 9.2.

Table 9.2 Sea level allowances* for the NRBD

Allowance/ Epoch	2000 to 2035 (mm**)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise from 2000 to 2125 (metres)
Higher Central	4.6 (161)	7.5 (225)	10.1 (303)	11.2 (336)	1.03
Upper End	5.8 (203)	10 (300)	14.3 (429)	16.5 (495)	1.43

* Sea level rise estimates are provided as mm rise for each year, based on a 1981 to 2000 baseline. **Total sea level rise for each flood epoch is presented in brackets.

9.1.8 Sea level rise for the Higher Central allowance has been calculated for the years 2030, 2080, 2105 and 2130.

9.1.9 In addition to sea level rise, wave heights may also vary due to increased ocean energy and potential changes in the frequency, duration, and intensity of storm events. The guidance regarding consideration of wave heights specifically relates to offshore wave height determination and (by agreement with the Environment Agency) has not been applied to the Site's more sheltered context.

Peak rainfall allowance

9.1.10 Allowances for changes in peak rainfall intensity have been developed for defined management catchments across the UK. These allowances are intended for use in site-specific assessments, such as drainage design, surface water mapping within small catchments (less than 5 km²), and assessments in urbanised catchments. Alternative methodologies are available and more appropriate for larger catchments.

9.1.11 The peak rainfall intensity allowances applicable to the Tees Management Catchment are summarised in Table 9.3.

9.1.12 Climate change is likely to increase the frequency and/or magnitude of rainfall events/storms, which will relatively increase risk of flooding from this source for the Site.

Table 9.3 Peak Rainfall Climate change allowances for the Tees Management Catch

AEP and Epoch	Central	Upper
3.3% AEP (2050s)	20%	35%
3.3% AEP (2070s)	30%	40%
1% AEP (2050s)	25%	40%
1% AEP (2070s)	30%	45%

* Use '2050s' for development with a lifetime up 2060 and use the 2070s epoch for development with a lifetime between 2061 and 2125

9.2 Future flood risk accounting for climate change

Fluvial and tidal/coastal flooding

9.2.1 Allowances for sea level rise have been incorporated to the hydraulic modelling as appropriate. While flood levels are noted as being extremely insensitive to changes in flow, climate change has also been applied to the flow boundary in the hydraulic model.

Surface water flooding and drainage

9.2.2 Climate change is expected to increase the frequency and intensity of rainfall events, which may heighten the risk of surface water flooding. Future climate surface water maps have been reviewed, and no significant changes to the flooding mechanism are anticipated.

9.2.3 As the detailed drainage design is not yet developed, assessment of this risk remains preliminary; however, the final drainage strategy will incorporate appropriate climate change allowances in accordance with EA and LLFA guidance.

Groundwater flooding

9.2.4 In the absence of site-specific data, professional judgement has been applied to assess the potential future flood risk from groundwater sources. Climate change is anticipated to increase rainfall, which may enhance infiltration rates and subsequently raise groundwater levels within underlying aquifers. As a result, a slight increase in groundwater flood risk relative to baseline conditions may occur.

9.2.5 Overall, the Site is considered to be at low risk of groundwater flooding. It is recommended that the Flood Emergency and Evacuation Plan also account for potential groundwater flooding to maintain safe access and egress over the operational lifetime of the Proposed Development.

Artificial flood sources (sewer flooding, canals and reservoirs)

9.2.6 In the absence of detailed data, professional judgement has been applied to evaluate the potential future flood risk from artificial sources. Climate change may increase the frequency and intensity of rainfall events, potentially leading to a slight rise in flood risk from sewer systems, although this remains a residual risk under baseline conditions.

9.2.7 There remains no risk from canal failure under future climate conditions.

9.2.8 While future climate conditions may increase the likelihood of reservoir failure, the management of this risk will remain tightly controlled. The potential magnitude of coincident floods in the “wet day” conditions may be increased by future climate conditions, but the overall volume of reservoir

water released in any incident would remain the same. As such the future flood risk from reservoirs is considered low.

H++ sensitivity assessment

9.2.9 The H++ scenario is a plausible, high-impact, low-likelihood “credible maximum” extreme future scenario, required to be assessed for NSIPs by the NPPG guidance on climate change allowances [Ref 18].

9.2.10 The H++ climate change scenario has not been explicitly modelled due to the Proposed Development being situated within a hydraulically insensitive area where flood mechanisms are not materially altered. Instead, a qualitative assessment has been undertaken by comparing extreme water levels with LiDAR-derived ground levels.

9.2.11 The Proposed Development includes raising Main Site levels to a minimum of 5.08mAOD, providing inherent resilience to tidal flooding.

9.2.12 30 years has been adopted as the reasonable worst case operational life for the Proposed Development (from 2031). Environment Agency guidance requires assessment over a 75-year development lifetime. Accordingly, the assessment adopts a precautionary approach using late-century climate change allowances which is a more precautionary and extreme scenario than the client’s requirements.

9.2.13 Access to the Main Site is the provided via Seal Sands Road, with connections to the wider road network via the A1185. Secondary emergency access routes are also included within the Site. Under extreme flood conditions, there is potential for localised flooding along access routes, which may temporarily restrict access and egress during peak events. However, the Proposed Development will incorporate an on-site refuge in the form of a control building designed as a place of safety, along with designated muster points, ensuring that risks associated with temporary isolation are appropriately managed.

10 Proposed development flood risk

10.1 Approach to site flood resilience.

10.1.1 Outline design of the Proposed Development has been informed by hydraulic modelling of the proposals. The assessment considers potential changes in flood risk, including climate change, over the lifetime of the Proposed Development. The available modelling outputs were used to inform design flood levels for the Site.

Main Site

10.1.2 A tiered approach to setting design levels is applied in the Main Site. The general existing ground level of approximately 5.08mAOD already provides a Standard of Protection (SoP) equivalent to the 2105 Higher Central 0.5% event + 0.23m allowance. Residual Uncertainty Assessment identifies that a 0.23m allowance achieves a 99% probability of non-exceedance, which is a conservative allowance. It is therefore proposed to adopt a minimum of 5.08mAOD for the site ground levels, and raise any low ground above this. Threshold levels of adaptable and less vulnerable components are proposed to be set to a minimum of 2105 Higher Central 0.5% event + 0.53m (5.38mAOD). Vulnerable or hard-to-adapt components are proposed to adopt a higher minimum level of 5.68mAOD, which corresponds to a 2105 Upper End 0.5% event + 0.57m. Threshold levels will also be set to a minimum of 0.30m above ground level (to minimise surface water flood risk).

10.1.3 This tiered approach reflects the varying vulnerability of site components and aligns with EA expectations for essential infrastructure. It ensures that critical infrastructure remains operational during design flood events, while allowing less vulnerable elements to adopt proportionate levels of protection. The limited sensitivity of assessed flood levels, based on existing baseline hydraulic modelling outputs, provides confidence that proposed ground raising and design levels will not materially affect flood behaviour within the wider system. The assumed levels of vulnerability per site component are as per Table 10.1. Without building usage/materials information being known at application stage, a precautionary assumption is made that all buildings are more vulnerable/less adaptable.

Table **10.1** Classification of site components by vulnerability

Component	Less vulnerable/ more adaptable	More vulnerable/ less adaptable
Feedstock Pre-Treatment		X
Flares		X
CHP Plant		X
Bulk SAF and Naphtha Storage		X
Feedstock reception and storage	X	
Cooling towers	X	
Quay	X	
ASU		X
Roads	X	
Electrical equipment		X
Buildings		X

10.1.4 The quay has a cross-fall for drainage which sets the leading edge of the quay to a level of 5.65mAOD. This provides additional protection to the wave environment alongside the quay.

10.1.5 Surface water attenuation and drainage and discharge works inherently will sit below Main Site ground level to enable discharge and attenuation.

10.1.6 To ensure resilience over the lifetime of the Proposed Development against sea level allowances, the H++ scenario has been assessed, representing a total projected rise of 1.9m from the year 2000 by 2100.

Connection corridors

10.1.7 The works in the connection corridors comprise reuse of, or replacement of pipelines within existing pipeline infrastructure (alongside existing live utility infrastructure used by other businesses). It is not reasonably practicable in this context to raise any new pipelines beyond the level of existing infrastructure. As such, any new pipelines or utilities are exposed to the same level of risk as the existing pipelines.

10.1.8 The pipelines themselves will be designed to be resilient to flood conditions in consideration of their metallurgy, surface finishes and corrosion protection, as well as their supports which shall consider flotation and velocity (noting that the expected velocities are modest).

Site design principles

10.1.9 Further mitigation will be developed through site design. The NPPG [Ref 37] states that passive measures should be prioritised, opposed to active

measures, as they are more likely to be more effective and reliable. Avoidance, flood resistance, and flood resilience mitigations shall be applied, including:

- Adoption of sequential approach to the layout of the Proposed Development. While the Main Site is predominantly flat, and therefore flood risk variation within the Main Site is low, such an approach favours the location of feedstock materials and other “less vulnerable” components (see Table 10.1) towards the Tees side of the Main Site, and the location of buildings and plant and other “more vulnerable” components towards the north and west of the Site. The **Indicative General Arrangement Plan (Application Document Ref. 2.5.1)** demonstrates that this principle has been followed (the control buildings are not explicitly labelled on this plan: they are to the south of label 35 in Drawing 5);
- The construction of the quay along the alignment of the existing revetment (listed as a defence on the AIMS database) amounts to a change in the alignment of the flood defence. The quay will be owned by LGF Project Limited, who will be authorised to maintain quay for the duration of their ownership. Where possible, other structures will be set 16m back from the quay to satisfy EA access requirements. Design will be in accordance with the Construction (Design and Management) Regulations [Ref 44] and shall enable safe access for the quay’s maintenance, repair, operation, and replacement as necessary. Such access and operations by the EA would nonetheless need to be by agreement with the site operator,to ensure compliance with relevant Health and Safety, and operational requirements of a quay in an industrial setting;
- Ground floor finishes will be made using durable materials that are less likely to be affected by saline water, such as ceramic/concrete/stone, plastics and/or water-resistant composite woods;
- Any critical infrastructure, machinery and electrical equipment shall be elevated above the predicted design flood levels corresponding to the part of the Site in which they are to be located. Away from wave environments, this will be a minimum level of 5.68mAOD. Within 20m of the site boundaries, where there is a greater chance of an adverse wave environment, electrical fittings and appliances will need to be raised above an indicative minimum level of 5.83mAOD, to be confirmed by more detailed assessment at detailed design;
- All other electrical fittings and appliances (including equipment/machinery) shall be raised as high as practicable above the

ground floor levels, electrical ring mains should be installed above the identified flood levels (or as high as is practicable), with drops to ground floor sockets and switches;

- All water sensitive electrical components for the quay shall be 'contained' within a waterproof protection system to make them flood resilient;
- All other infrastructure that could be damaged by flood waters shall be protected and sealed and/or raised as high as practicable above design flood levels;
- Storage of any stockpiled materials, hazardous materials/waste (e.g. chemicals) shall be elevated as high as practicable above the ground floor levels. Chemical storage may need to be bunded;
- Non-return valves shall be fitted to all water supply, sewerage and drainage infrastructure;
- Wherever possible, construction methods that promote easy draining shall be used;
- Use of sacrificial materials (i.e. materials and fittings that are likely to be damaged in times of flood, but that can be easily replaced) shall also be considered;
- Provision shall be made for safe access, egress and/or refuge to enable evacuation and/or access by emergency services, as part of the detailed design; and

Flood warning and evacuation plan (FWEP)

10.1.10 The Proposed Development workers and users will need to have sufficient warning and notice prior to any flood event inundating the Proposed Development, recognising this is low risk for the Main Site. A site-specific Operational Flood Warning and Evacuation Plan (Operational FWEP) must be prepared for the Site (see Section 7.2). This must account for all sources of flood risk, including the effects of climate change over the lifetime of the Proposed Development. This plan must clearly identify procedures, and roles and responsibilities for staff working at the Proposed Development to ensure safe operation, access and egress in times of flood. The Operational FWEP would be developed separately by the site operator and informed by the Proposed Development final designs.

10.1.11 The CEMP(s) will also include a FWEP which will be approved prior to the commencement of the relevant works. The proposed mitigation would include signing up to the EA's flood warning service to act as an early

warning system. The EA flood warnings can provide advance notice of areas at risk of flooding from rivers, tidal, and groundwater sources.

Safe route of access/egress

10.1.12 Safe evacuation of staff, visitors and vehicles from the Proposed Development will be required in response to an EA Severe Flood Warning.

10.1.13 Breach modelling indicates that sections of the surrounding road network may become inundated during extreme events. However, flooding across the Site and access routes is generally shallow with low flow velocities, reflecting the flat topography.

10.1.14 The primary access road is the extension of the Seal Sands Road connecting from the west end of the Main Site to Seaton Carew Road/A1185 Roundabout.

10.1.15 Safe access and egress is possible to the Main Site via the main access along the Seal Sands Road in events up to and including the 0.5% AEP 2105 Upper End scenario and 0.5% AEP 2130 Higher Central scenario.

10.1.16 Some other roads in the vicinity of the Main Site are flooded in lesser events, with potential impacts on ease of access (without preventing access entirely). Nonetheless, the gradual onset of flooding and generally low hazard conditions mean that safe access and egress can be achieved, given sufficient warning. Flood warning for tidal events is generally deliverable with significant advance notice.

10.1.17 Modelling of breach events show that the Seal Sands Road and connecting A178 Seaton Carew Road/Tees Road would be flooded in a breach at Greatham Creek in a 0.5% AEP 2100 Higher Central scenario or higher, resulting in temporary road loss of access or egress from the Main Site in such an event. The modelled velocities local to the roads are not high, so it is not thought that they would be scoured in a flood event, and it is likely that the Seal Sands Road would be serviceable following the event.

10.2 Surface water (overland) flood flow mitigation

10.2.1 The Main Site is already predominantly at a height above predicted flood levels and largely flat; as such it does not have any existing natural overland flow paths. Raising of the Main Site does not disrupt any flowpaths.

10.2.2 Proposed drainage will be designed in accordance with current regulations and guidance, and as appropriate, incorporating overland flood flow routes for the conveyance of excess floodwater towards areas of low vulnerability land use.

10.3 Framework Drainage Strategy

10.3.1 A Framework Drainage Strategy has been prepared separately to support the Proposed Development (refer to the Framework Drainage Strategy, Annex C). The drainage strategy sets out the proposed approach for the management of surface water across the Main Site, including the collection, conveyance, attenuation, treatment, and discharge of runoff in accordance with relevant national and local policy, Environment Agency guidance, and LLFA requirements.

10.3.2 The Proposed Development may not be considered suitable for infiltration-based SuDS due to ground conditions and potential contamination risks. Pending further review, surface water runoff will be managed close to source by natural infiltration across the Site and paved areas will be generally limited to the process units. All surface water features, including SuDS, will be lined or sealed to prevent contamination.

10.3.3 Attenuation of clean surface water is proposed via retention ponds located on the Main Site. These ponds will be sized to accommodate runoff from the full contributing catchment area(s), based on detailed site hydrology and drainage connectivity at detailed design. The ponds (in combination with any upstream features) will provide sufficient attenuation for events up to and including the 1 in 100-year rainfall event plus climate change. This will ensure flooding during this event is managed within the Proposed Development boundary in accordance with LLFA requirements.

10.3.4 Final attenuation sizing will consider climate change allowances, future development, and additional storage needs such as firewater or process discharges. Storm durations will be tested to identify the critical event to ensure compliance with LLFA guidance and operational resilience.

10.3.5 The proposed retention ponds do not provide primary water quality treatment, and upstream measures will be prioritised to protect the storage function and reduce sediment build-up in the ponds. These include appropriate SuDS and full retention oil-water separators at high-risk locations.

10.3.6 The discharge of surface water from the retention ponds is proposed to be to the River Tees via an outfall in the south-east corner of the Main Site to the south of the new quay (an extension of the existing outfall to the quay). It is recognised that the discharge rate will therefore ultimately be governed by the hydraulic capacity of the existing outfall pipe.

10.3.7 The final discharge rate will be confirmed at detailed design in accordance with LLFA guidance, with flows managed to ensure that there is no increase in flood risk elsewhere, which supports the conclusions of this FRA. The detailed drainage design will be confirmed post-DCO and will be developed

in accordance with the drainage principles, design parameters, and commitments set out within the Framework Drainage Strategy (Annex C).

10.4 Flood Risk Impacts of the Proposals

10.4.1 A hydraulic impact assessment has been undertaken to review the effect of the Proposed Development on flood levels and flood extents within the surrounding area. A full suite of modelled outputs can be found in Annex **Error! Reference source not found.**, but key results are discussed in this report.

10.5 Flood risks to the Site

10.5.1 Table 10.2 compares the baseline and proposed flood levels adjacent to the proposed quay. It can be seen that the difference between water levels in the two scenarios is negligible.

Table 10.2 Tidal flood levels adjacent to the proposed quay

AEP (%)	Epoch	Climate change scenario	Baseline (mAOD)	Proposal (mAOD)	Difference (m)
1	2030	Higher Central	4.05	4.05	0.000
0.5	2030	Higher Central	4.15	4.15	-0.001
0.1	2030	Higher Central	4.40	4.40	0.000
0.5	2060	Higher Central	4.37	4.37	unmodelled
0.5	2080	Higher Central	4.56	4.56	0.000
0.5	2105	Higher Central	4.85	4.85	0.000
0.5	2105	UE	5.11	5.11	0.000
0.5	2130	Higher Central	5.13	5.13	0.000
0.5	2100	H++	5.65	5.65	unmodelled

10.5.2 The 2060 and H++ levels are unmodelled, but given the low head losses in the model, they are readily inferable from the calculated tidal level at the model boundary.

10.5.3 As part of site development, the ground level of the Main Site is intended to be raised to a minimum of 5.08mAOD, which was identified at the PEIR stage as being broadly reflective of the general ground level of the Main Site. A Residual Uncertainty Analysis (RUA) calculation has been undertaken to identify the level of confidence that this ground level provides (see Hydraulic Modelling Report, Annex Annex D).

10.5.4 The analysis identifies that still water flood levels at the Site are only subject to uncertainty from the tidal boundary. 5.08mAOD corresponds to 0.23m uplift on top of the 0.5% AEP 2105 Higher Central flood level of 4.85mAOD.

A 0.23m uplift corresponds to a non-exceedance probability of 99%. This a high level of confidence, in excess of industry standards.

10.5.5 Flood levels at the Site are dominated by the assumed tidal boundary, to the degree that the tidal boundary level explains all but 1cm of the flood level at the Site. It should therefore be understood that local flood risk is not sensitive to the presence or absence of the dredged berth pocket adjacent to the quay. The maintenance of this berth pocket is therefore only of importance to navigation and not to flood risk.

10.5.6 Waves are not explicitly represented in the model, but the associated flows onto the Main Site have been calculated using the EurOtop (2018) methodology and have been considered in terms of potential hazard to Site users.

10.5.7 Within the 30 year operational life, the unmitigated risks to pedestrians are generally acceptable for trained staff, but some areas of higher hazard would be present at the north and south ends of the quays. Subject to vehicles in the vicinity of the quay driving at low speeds during flood events (which can be managed through the Operational FWEP), the hazards to vehicles are acceptable. Buildings and equipment would not be at risk. Some wave protection, which will be ~0.30m high, will be implemented at either end of the quays, to mitigate the risks to pedestrians back to acceptable levels.

10.5.8 Within the Environment Agency's required 75 year assessment period, the risks to pedestrians on the site edge may be significant, as may the risks to vehicles. Provided buildings are not set at the very edge of the site, their exposure to structural damage should be low. Equipment should where possible be set back at least 10m, and may require additional raising or wave protection. It is noted that the quay has rail mounted continuous ship unloaders and a quay crane, which would be approx. 3m from the quay edge. The unloaders and crane themselves will be at significant height above waves: while their travel gear will remain at quay level, they are generally designed for a marine environment with wave spray; the quantum of predicted flow does not indicate significant inundation.

10.5.9 Ultimately, these residual risks are controllable. The risks to pedestrians and vehicles can be controlled through response procedures and restricting access during flood events. The actual exposure can be minimised by setting back development from the Main Site edge, and / or incorporation of low bunding at the edge of the Main Site or beside development. Modelling has demonstrated that raising the ground levels of the site has negligible impact on flood risk to adjacent sites, and this gives the freedom to undertake such measures without concerns for flood displacement.

10.5.10 There is some uncertainty in the understanding of this hazard. The paper used (Allsop et al (2008) [Ref 38]) relates the hazard to an average overtopping flow, but the analyses are based on coastal waves. Coastal waves have a highly randomised behaviour that mean the highest waves within a given wave state may produce far higher overtopping flows than the average waves, and it is these waves which will define a lot of the hazard. In the more sheltered context of the Site, this effect will not be so marked, and hence the hazard will be significantly lower than suggested by the papers.

10.5.11 It is recommended that more detailed wave modelling is carried out as detailed design progresses to support design of mitigation measures for wave hazard, particularly around the north and south ends of the quays, and more detailed identification of the hazard.

10.5.12 Given the uncertainty associated with understanding of the wave hazard (and likely conservatism in the current approach), where the detailed wave modelling does not indicate a wave hazard to be managed within the 30 year operational life of the Proposed Development, it is recommended that the residual risk associated with waves is managed using a managed adaptive approach, i.e. if a physical intervention is confirmed as being required later in the Proposed Development's operational life, it can be implemented or investigated further then.

10.5.13 Such an approach recognises that the results of the modelling indicate extremely low sensitivity to development of the Site, and therefore implementing a physical intervention later in the Proposed Development's operational life would not introduce any notable increase in flood risk to surrounding developments. Design development shall retain the necessary space to implement these measures at a later date.

10.6 Flood hazard

10.6.1 Flood hazard mapping has been reviewed to understand the potential risk to people during a flood event, taking into account both flood depth and flow velocity. The mapping is shown in Annex **Error! Reference source not found.**. The hazards described are as defined by the ZUK0 parameter from FD2321 Flood Risks to People [Ref 39].

10.6.2 The modelling indicates that areas of high hazard are primarily associated with the main river channel and adjacent floodplain, where deeper and faster flowing water is present. These areas are categorised as significant to extreme hazard and are consistent with expectations for tidal/fluvial flooding in this location.

10.6.3 In the Main Site, there is no flood ingress up to and including to the 0.5% AEP 2105 Higher Central design event. Exceedance events have also been assessed (the 0.5% AEP 2105 Upper End, and 0.5% AEP 2130 Higher Central events). These show low hazard within the Main Site.

10.6.4 One part of the Wider Site where hazard is noted as being “Danger for all” (is the location of a 132 kV electrical connection from the Main Site to the existing North Bank Supply Point located to the south of the Main Site. The cables would however be buried at this location and staff would only be exposed to this risk if undertaking maintenance operations at the same time as a flood event, which can be managed through the Operational FWEP.

10.6.5 There is no hazard in the 0.5% AEP 2105 Higher Central design event along the existing road & pipeline corridor running north east from the Main Site. In exceedance events, hazard at the Main Site ranges from “very low hazard” to “danger for some.” The hazard associated with these exceedance events is manageable by an appropriate Operational FWEP.

10.6.6 Overall, the pattern and magnitude of flood hazard are considered to remain broadly consistent with the baseline scenario.

10.7 Residual flood risk

10.7.1 Residual flood risk at the Site has been assessed with reference to exceedance scenarios (the 0.5% AEP 2105 Upper End, and 0.5% AEP 2130 Higher Central events), breach scenarios and potential flood defence failure mechanisms, such as embankment breach or overtopping. These represent conditions beyond the design standard.

Main Site residual risk

10.7.2 It can be seen from Table 10.2 that the two modelled exceedance scenarios are only 0.03m and 0.05m above the proposed Main Site ground level respectively. As such, only shallow flooding is noted in these events, and it is stopped by raised roads or bunded areas within the Main Site. This reduces the likelihood of sudden or high velocity flows developing across the Main Site within this scale of exceedance event.

10.7.3 Residual flood risk associated with embankment failure is considered to be low. Along the River Tees, the Main Site is bounded by an existing sheet piled quay structure rather than a raised earth embankment. The Main Site is therefore not reliant on a conventional flood defence embankment, and residual flood risk is principally associated with extreme exceedance events rather than embankment failure.

10.7.4 The relatively flat nature of the Main Site limits the potential for rapid flow, and as a result, floodwater spreads gradually with limited hazard.

10.7.5 Residual risks remain associated with more extreme events exceeding the design standard, as well as the potential for exceedance or blockage of drainage infrastructure. However, these risks are not considered to be materially different from the baseline scenario and are typical of sites located within the floodplain.

Wider Site residual risk

10.7.6 Within the Wider Site, the Proposed Development makes use of existing shared utility corridors or roads, and it is not reasonably practicable to locate utilities outside of the floodplain or above flood water to provide flood alleviation. This is because utilities within these corridors share existing infrastructure with other third party utilities, and / or connect to existing treatment, distribution, generation or receiving points. Nonetheless, the risks are low, as follows.

10.7.7 Work No. 9a (Industrial Gases Connection Works) runs northeast from the Main Site underground along the existing pipe corridor. Works No. 10 (Replacement and new wastewater pipeline connection works) run above ground along the road in parallel with them. Within this length, the pipes sit outside the 0.5% AEP 2105 Higher Central floodplain.

10.7.8 The pipes turn east towards the Tees and pass under the Tees through existing pipeline (Work No. 9a) and tunnel infrastructure (Work No. 10) under the Tees. The wastewater pipeline enters the northern tunnel without passing through any areas of the 0.5% AEP 2105 Higher Central floodplain, and the entrance to the west bank tunnel sits outside this floodplain. The route of the industrial gases pipelines would flood over a 45m length near the Tees by 0 – 0.12m depth in the 0.5% AEP 2105 Higher Central event albeit that the pipelines are underground, would be fully welded (i.e. no flanges) and designed against flotation.

10.7.9 The proposed wastewater pipeline exits the tunnel on the northside of Dabholm Gut. It runs along the north side of the Dabholm Gut, where it will be raised 0.45m or more above ground levels, giving it a minimum invert level of approximately 4.27mAOD. It is afforded a slightly higher level of protection by a wall beside the Gut, and high ground (4.35mAOD) on the Tees side of the basin to its north. In 2030, this pipeline would have approximately a 0.1% AEP frequency of flooding. In 2060, this pipeline would be subject to approximately a 0.5% AEP frequency of flooding. In 2080, this would be approx. a 2% AEP of flooding, and by 2105, a 16% AEP.

10.7.10 While high velocities are noted in the vicinity in the model results, closer inspection shows that this only occurs at low depths of flow just as the

location initially floods. At depths high enough for water to make contact with the pipeline, velocities are low.

10.7.11 The materials and finishes of the wastewater pipe, and its corrosion protection will be selected according to the carried fluid and exposure environment and ground conditions; supports would be designed according to hydraulic forces in this location. As such, this pipeline is considered appropriately flood resilient for its location.

10.7.12 A new high-pressure nitrogen pipeline system will be buried underground along the south side of Dabholm Gut. At this location, flood risk to local ground levels (4.25mAOD) would be 0.25% AEP in 2030, and approximately 4% in 2080; it would be as high as 33% in 2105.

10.7.13 The materials and finishes of the Nitrogen pipeline, and its corrosion protection will be selected according to the carried fluid and exposure environment and ground conditions. Pipework would be fully welded (i.e. no flanges) and designed against flotation. As such, this pipeline is considered appropriately flood resilient for its location. Safety systems would monitor the pressure of pipeline against any breach. As such, this pipeline is considered appropriately flood resilient for its location.

10.7.14 Oxygen will be supplied through an existing pipeline which may need upgrading in sections. Nitrogen and oxygen pipes make use of existing pipeline and tunnel infrastructure under the Tees.

10.7.15 The Proposed Development includes an off-site 132 kV electrical connection to be constructed from the Main Site to the existing North Bank Supply Point located to the south of the Main Site. The Supply Point is at a ground level of 4.53mOD, and is subject to minimal (<0.2% AEP) flood risk at the end of the 30 year operational life. Within the period of assessment, the supply point would be subject to a 0.5% AEP flood frequency in 2080 and a 4% AEP flood frequency in 2105. The electrical connection is only required to provide power for startup and in the event that the on-site CHP plant is not operational. The Proposed Development is not therefore wholly dependent on this connection.

10.7.16 The connections themselves would be either underground (and therefore flood resilient), or above ground, in which case they would be raised to a minimum of the “more vulnerable” level of 5.68mAOD.

The H++ Scenario

10.7.17 The H++ Credible Maximum Future Climate scenario assumes a flood rise of 1.90m over the period 2000-2100. Adjusting for the base year of 2017 from the Coastal Flood Boundary Extreme Sea Levels, this gives sea level rise of 1.58m to the year 2100. This is sufficient that the flooding to the Main

Site would have an annual probability of 30%. Road based evacuation would be impacted in a ~7% AEP event. In a 2100 0.5% AEP H++ event, the flood level would be 5.65mAOD. The Main Site would be nearly entirely flooded, with land-based evacuation being possible only on foot through the Sabic site and along the railway line at Port Clarence. Sensitive components of the Main Site (at a minimum level of 5.68mAOD) would have a 2% AEP standard of protection (assuming comparable levels of RUA).

10.7.18 The Proposed Development incorporates on-site refuge in the form of a control building designed as a place of safety, along with designated muster points, ensuring that risks associated with temporary isolation are appropriately managed.

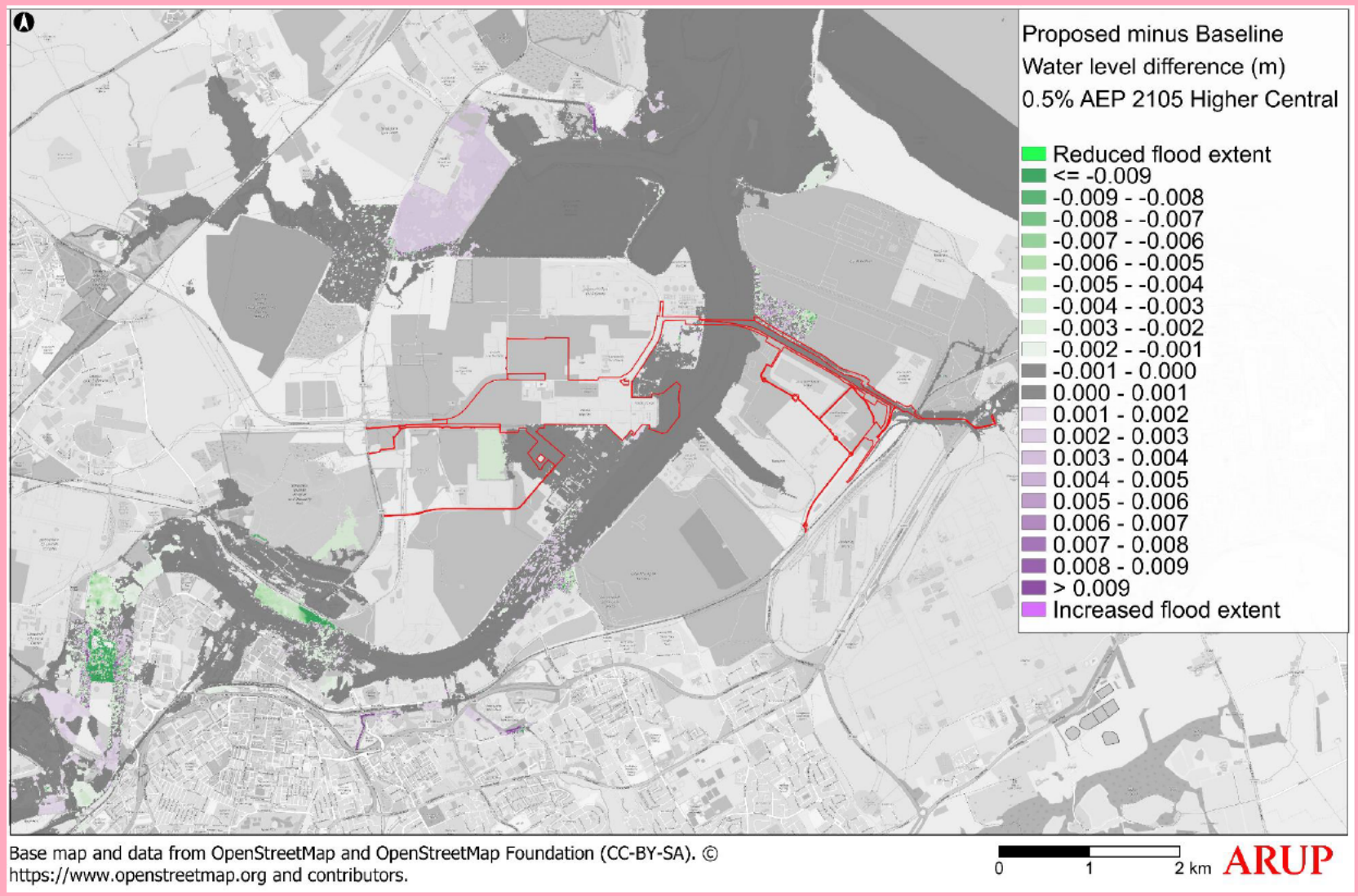
10.7.19 To retain a 0.5% AEP 2105 standard of protection (SoP) to the Main Site with the same 0.23m RUA, it would need an approximately 1.2m high defence along much of its boundary, however for the Site to remain viable would require a significant level of modification to also protect the associated access, and the facilities that it connects to.

10.7.20 Making the Site viable over shorter periods of time would require less effort and it is noted that (assuming the same RUA), the proposed ground level would have a better than 0.3% AEP SoP for 25 years, or a better than 0.67% AEP SoP for the reasonable worst case operational life of 30 years, or a better than 10% AEP SoP for 50 years. Even over a 50 year period, more vulnerable components would retain a 0.2% SoP or better.

10.7.21 Therefore, while an H++ scenario may render the Site unviable in the long term, it would retain viability in the short term (0-30 years) as designed, or in the medium term (30-50 years) with some level of modification.

10.8 Off Site flood risk impacts

10.8.1 Inset 10.1 shows the impact of the Proposed Development in the 0.5% AEP 2105 Higher Central design event. In the majority of locations, the difference in modelled flood level is <1mm (dark grey). There are some locations where higher differences are noted remote from the Site (e.g. around the Venator Greatham works), and these are believed to reflect model instability rather than the influence of the Site itself. This is more obvious around areas where the model results exhibit a mottled water surface of alternating increases and decreases in water surface. There are no increases in floodplain extent.



Inset 10.1 Difference of proposed and baseline water levels, 0.5% AEP 2105 Higher Central event.

10.8.2 Inset 10.2 shows the impact of the Site proposals in the 0.5% AEP 2130 Higher Central event. This is the event in which the proposals exhibited the most impact on the local water levels, although as can be seen, in the majority of locations, the difference in modelled flood level is <1mm (dark grey). Areas along the edges of the Main Site exhibit some low increases, generally <3mm (A & C). Their immediate proximity to reductions in water levels (D) suggest these could, again, be due to some low level instability in the model. They do not indicate any increase in flood frequency to these areas, and the affected areas are already flooded in this magnitude of event in the baseline.

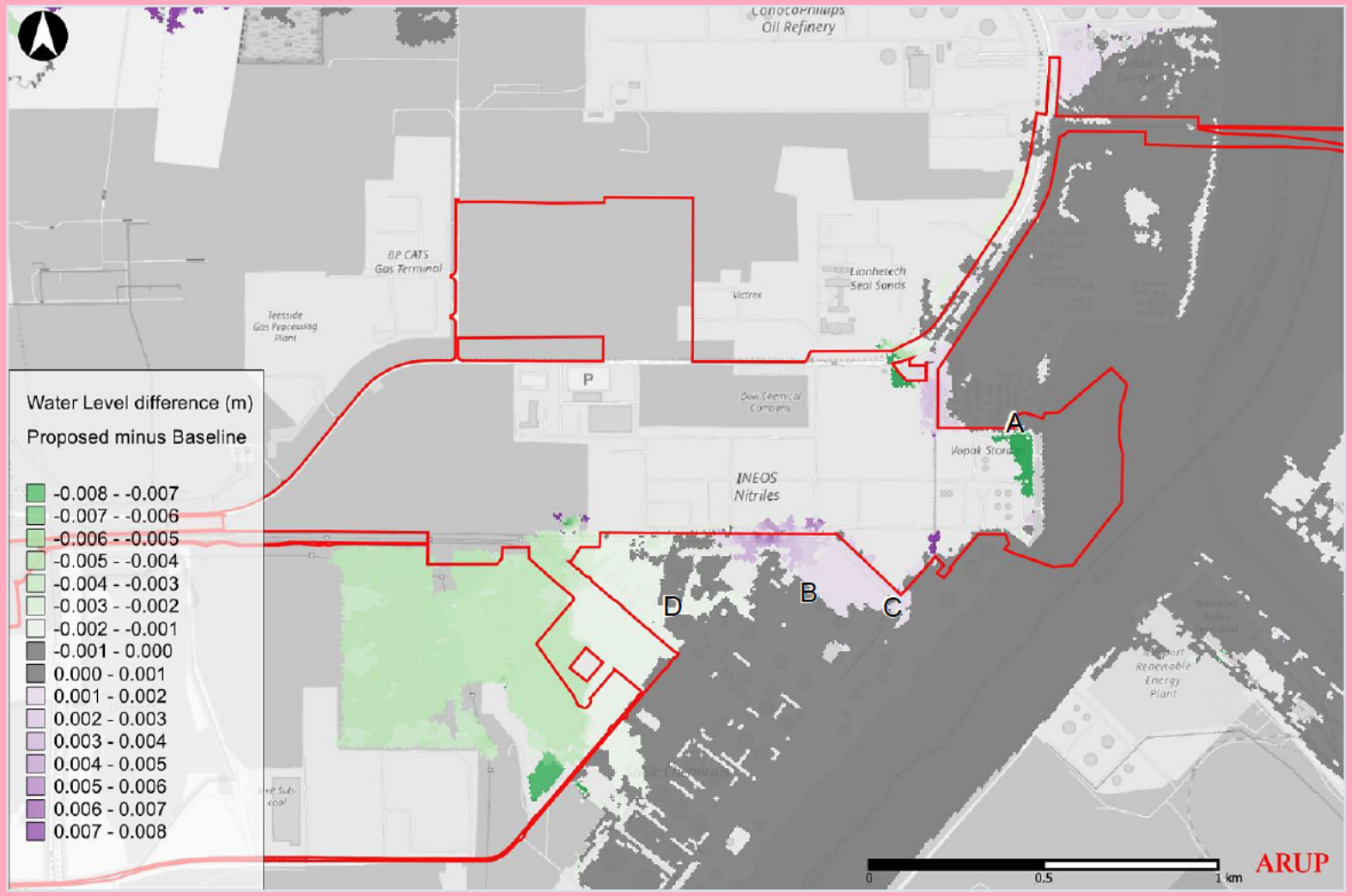
10.8.3 Area B is discussed in greater detail as it exhibits an 8mm increase in water level.

10.8.4 The increase impacts a pipeline corridor adjacent to the south boundary of the site, which sits outside the red line boundary (Inset 10.3). It is noted that this area is also flooded in the baseline event and are not placed at greater frequency of flooding by the proposals. Hazard values are increased by 2%-6% in this location (2.19 to 2.32), but are already noted as “dangerous to all” in the baseline. These high hazard values are driven locally by depth of water rather than velocity.

10.8.5 It can be seen from aerial photography that there is a 4mm increase in the vicinity of some equipment (Inset 10.3). While aerial photography from suggests that the 4mm increase coincides with this equipment, cross-referencing with LiDAR DSM information shows that the assets sit on a raised platform with a level of 5.33mAOD, and are therefore above the local flood level of 5.12mAOD. The area of the 4mm increase is on the access to the location and some open vegetation to the north, not the platform.

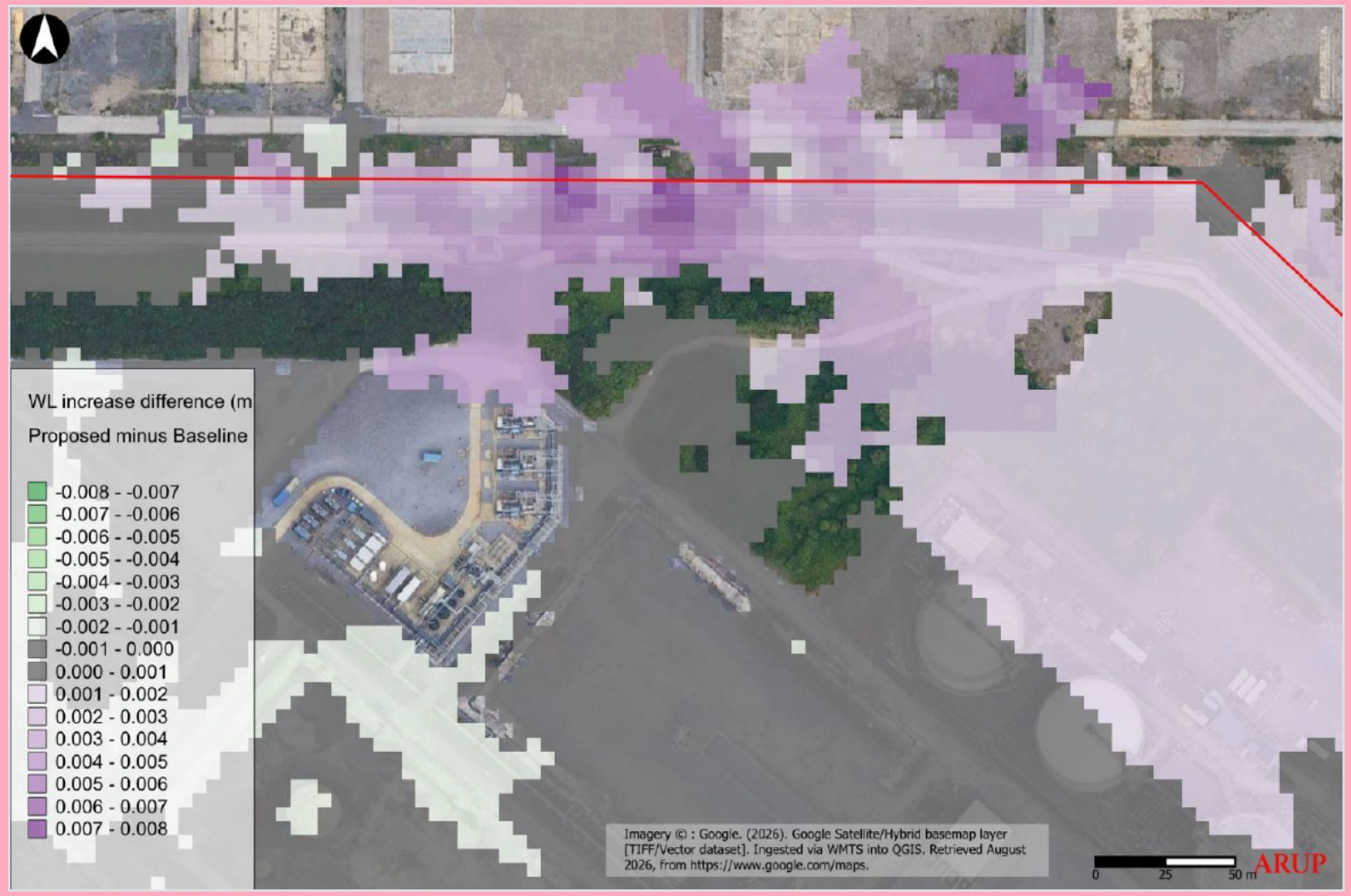
10.8.6 Neither the pipelines nor the equipment access will be detrimentally impacted by such a low increase in flood level. Further detail in this area can be seen in the “Location of interest” section of the modelling outputs in Annex **Error! Reference source not found.**.

10.8.7 No notable increase in flood extent is predicted as a result of the Proposed Development in any of the modelled events. Any isolated areas of change are negligible and do not represent a meaningful alteration to the overall floodplain.



Inset 10.2 Impact of proposals on modelled water levels in the 0.5% AEP 2130 Higher Central scenario

Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors



Inset 10.3 Water level increases at Location B (0.5% AEP 2130 Higher Central event)

Imagery © Google.com/Maps 2026

10.8.8 No notable increase in flood extent is predicted as a result of the Proposed Development. Any isolated areas of change are negligible and do not represent a meaningful alteration to the overall floodplain or flood frequencies.

10.8.9 Overall, the modelling indicates that the Proposed Development does not result in any significant increase in flood risk elsewhere. The minor changes identified are not considered to be hydraulically significant.

10.9 Construction

10.9.1 The construction activities, including management of temporary site drainage during construction, will be managed through a Construction Environmental Management Plan (CEMP). A **Framework CEMP (fCEMP)** is provided at **Appendix 5A of the ES Volume I (Application Document Ref. 6.3)**. A Flood Risk Activity Permit (FRAP) will be secured, which will include a construction-specific FRA. As such, this FRA only considers permanent impacts associated with the operational phase of the Proposed Development.

10.9.2 It is nonetheless noted that all areas of temporary set down are located outside the 2030 Higher Central 0.5% AEP flood outline. Modelling may be required to demonstrate that temporary works conditions associated with piling of the quay do not adversely impact flood risk, but as modelling has already demonstrated high insensitivity of local flood conditions, these are likely to have minimal impact (< 0.01m).

10.10 Decommissioning

10.10.1 Decommissioning of the Development Proposals would return the Main Site to a brownfield condition (albeit with likely retention of below ground elements). Raised ground levels of 5.08mAOD would not be returned to their original height. The quay would remain in situ, but maintenance of the dredging pocket would cease.

10.10.2 Noting the insensitivity of local flood risk to the design proposals, the decommissioned state of the site is expected to have similarly minimal impact on local flood risk.

11 Conclusions

11.1 Overview

11.1.1 This Level 3 FRA has provided an assessment of flood risk of the Proposed Development based on the updated concept design at the time of writing (June 2026) and confirmation of flood risk parameters based on existing hydraulic modelling outputs.

11.1.2 The FRA has considered flooding from fluvial and tidal, surface water, groundwater, and artificial sources.

11.1.3 The Main Site lies predominantly within Flood Zone 1, indicating low baseline risk, although certain access routes, pipeline corridors fall within Flood Zones 2 and 3a. The proposed quay falls with Flood Zone 3a. There are no mapped areas of Flood Zone 3b in the vicinity of the site. Climate change projections suggest that parts of the Site may experience increased flood risk in all assessed periods

11.1.4 To maintain resilience within the Main Site, a tiered approach is proposed: general ground levels at a minimum level of 5.08mAOD, adaptable components at a minimum level of 5.38mAOD, and vulnerable assets up to a minimum level of 5.68mAOD. The quay will be constructed to a minimum level of 5.65mAOD.

11.1.5 The proposed ground level is effectively the 0.5% AEP 2105 Higher Central flood level + 0.23mRUA. A 0.23m RUA corresponds to a 99% chance of non-exceedance in this scenario, above the industry standard.

11.1.6 Adaptable and vulnerable components would have 0.27m and 0.57m freeboard levels above the 0.5% AEP 2105 Upper End flood level, again giving over a 99% chance of non-exceedance in that scenario.

11.1.7 Wave hazard to pedestrians at the Main Site boundary to the north and south ends of the quay will be managed to acceptable levels over the 30 year operational life by a low level (~0.3m) intervention (e.g. a bund or wall). Higher residual wave risks are noted beyond the proposed operational life however there are elements of conservatism in the assessment of hazard,. It is intended therefore to undertake more detailed modelling of wave at detailed design. This would inform design of the interventions and better understand the potential hazard beyond the 30 year operational life. Any physical interventions required beyond the 30 years are proposed to be undertaken on a managed adaptive basis.

11.1.8 Within the Wider Site, connecting pipelines make use of existing utility corridors, and are restricted in their alignments and levels by existing infrastructure in those corridors or at receiving / connecting points. In general, these corridors are either at low flood risk, or pipes are buried where they are at risk. Along the north side of the Dabholm Gut, a wastewater pipe would be at a 0.5% AEP risk of wetting at the end of the 30 year operational life; by 2105, the risk of wetting would be 16% AEP. To the south of the Main Site, the route of an electrical connection to an existing supply point would be subject to minimal (<0.2% AEP) flood risk at the end of the 30 year operational life. Within the period of assessment, the supply point would be subject to a 0.5% AEP flood frequency in 2080 and a 4% AEP flood frequency in 2105. The electrical connection is only required to provide power for startup and in the event that the on-site CHP plant is not operational. The Proposed Development is not therefore wholly dependent on this connection.

11.1.9 Any upgrades required to these utility corridors to retain a higher standard of protection to the utilities beyond the 30 year operational life would need to be addressed on a managed adaptive basis.

11.1.10 Hydraulic modelling shows that the Proposed Development does not result in any material increase in flood risk elsewhere.

11.1.11 The findings of the drainage strategy confirm that the Proposed Development will manage surface water runoff in a controlled manner and will not result in an increase in flood risk on-site or elsewhere.

11.1.12 A FRAP will be required for the construction of the quay, which will effectively move the defence line to the river side of the quay. Proposals will where possible retain a 16m set back from the quay; where not possible, access will be retained for inspection, maintenance, repair or replacement. LGF Projects Limited will own and be authorised to maintain the quay for the duration of their ownership.

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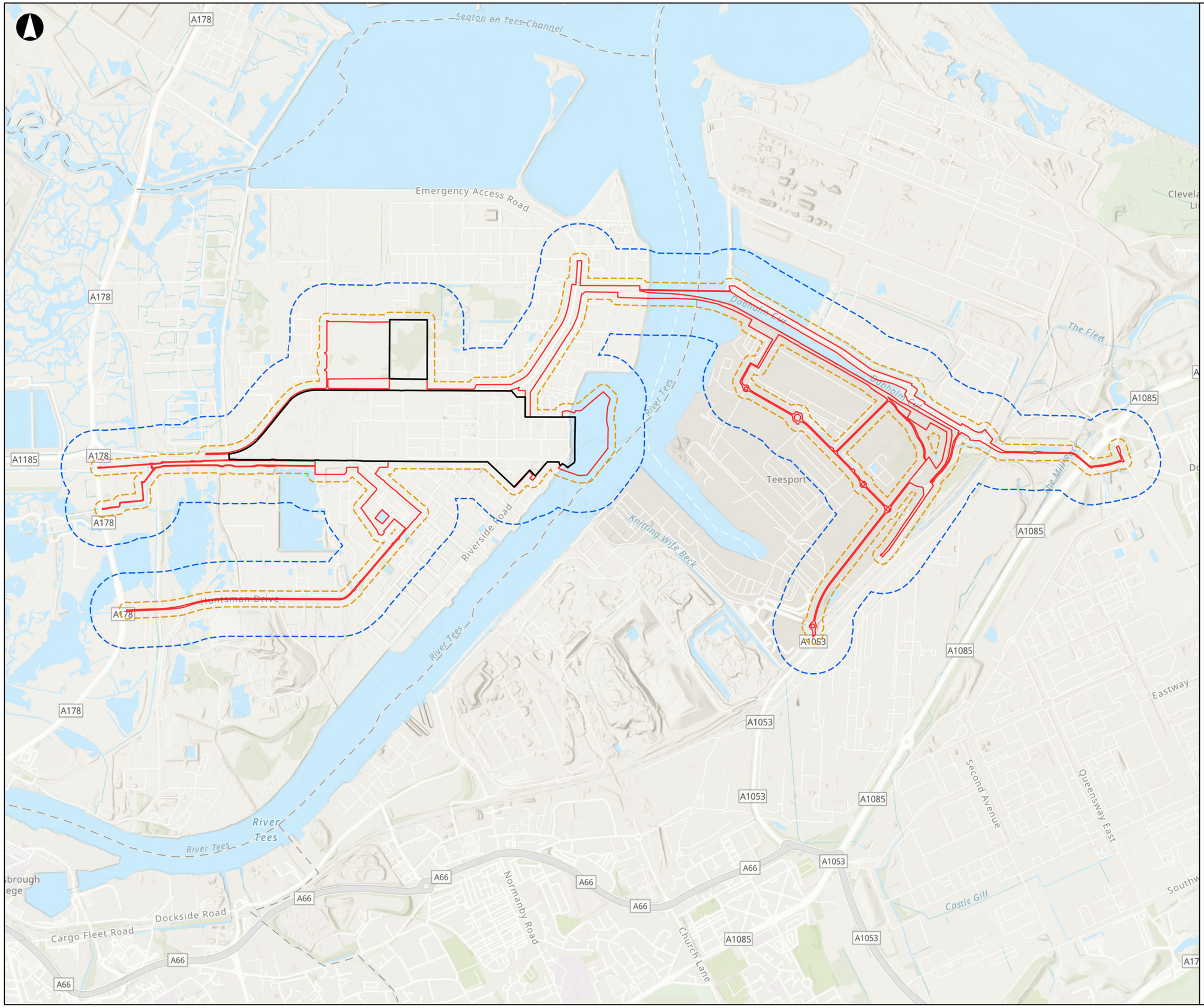
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Annex A FRA Figures



A3

Site Boundary
Main Site
Study Area (50m Site Boundary)
Study Area (250m Site Boundary)

Coordinate System: British National Grid

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ARUP Lighthouse GREEN FUELS

Drawing Title
Figure 1
Proposed Development Boundary

Client
LGF Projects Ltd.

Project Name
Lighthouse Green Fuels

Scale at A3
1:25,000

Project Number
306732-00

Rev
P01

Drawing Number
EN0110025/5.7
APFP Reg. 5(2)(a) and EIA Reg. 14

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Site Boundary
Study Area (50m Site Boundary)
Study Area (250m Site Boundary)

UKCEH Landcover Map 2024

Broadleaved, mixed & yew woodland
Coniferous woodland
Arable horticulture
Improved grassland
Neutral grassland
Calcareous grassland
Acid grassland
Fen, marsh & swamp
Heather
Heather grassland
Bog
Inland Rock
Saltwater
Freshwater
Supra-littoral rock
Supra-littoral Sediment
Littoral Rock
Littoral Sediment
Saltmarsh
Suburban
Urban

Coordinate System: British National Grid

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Drawing Title
Figure 2
Existing Land Use

Client
LGF Projects Ltd.

Project Name
Lighthouse Green Fuels

Scale at A3
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Project Number
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Drawing Number
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Site Boundary
Main Site
Study Area (50m Site Boundary)
Study Area (250m Site Boundary)
DTM Contour 10m

DTM Height (m)
- <1
- 1.001 - 2
- 2.001 - 3
- 3.001 - 4
- 4.001 - 5
- 5.001 - 6
- 6.001 - 7
- >7

Coordinate System: British National Grid

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Lighthouse GREEN FUELS

Drawing Title
Figure 3
Topography

Client
LGF Projects Ltd.

Project Name
Lighthouse Green Fuels

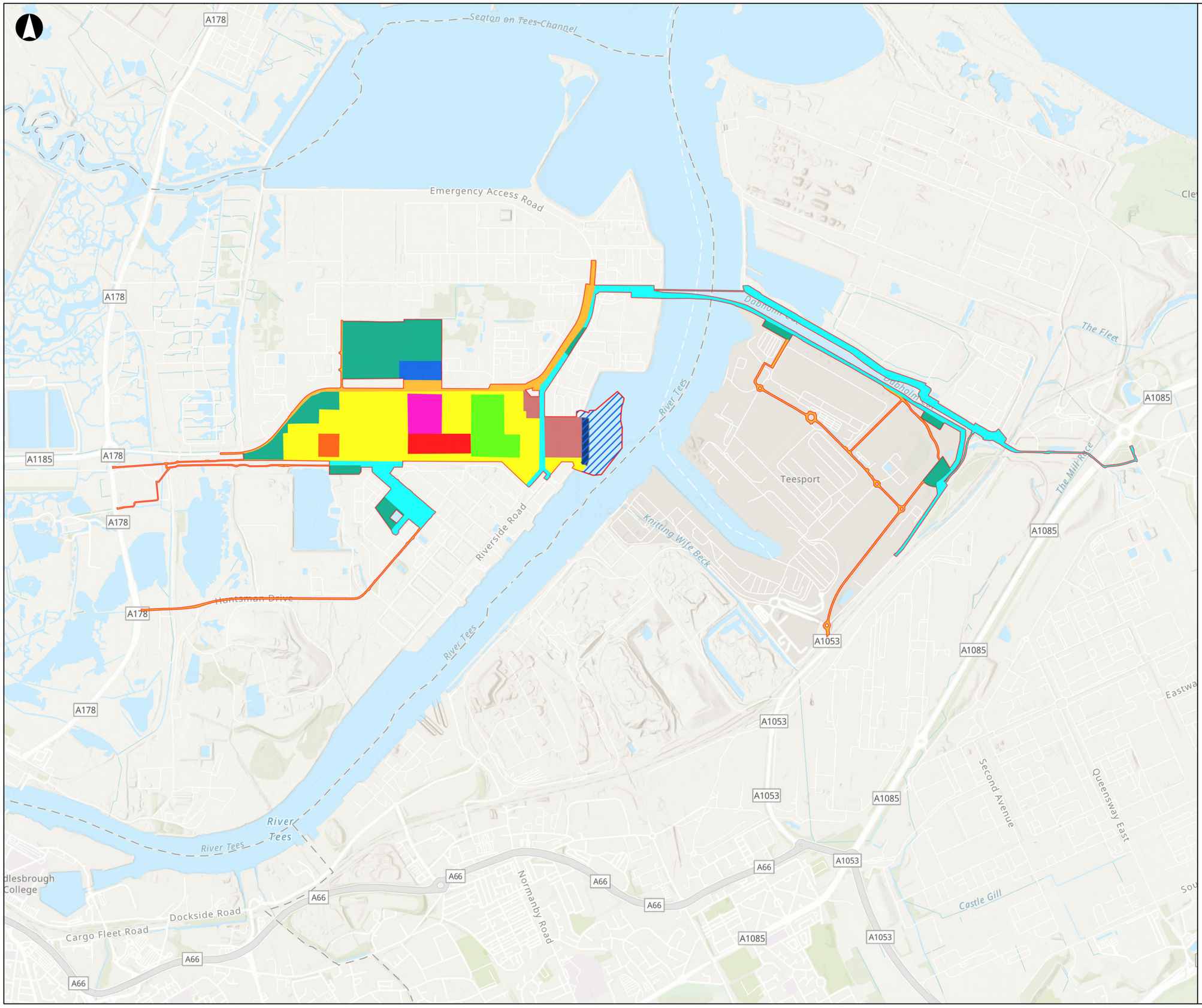
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A3

Site Boundary

Site Layout

- Air Supply Unit
- Access Roads
- Combined Heat & Power Plant
- Construction Laydown
- Feedstock Storage & Handling
- Flare Structure
- Marine Works
- Pipeline & Utility Area
- Product Storage & Export
- SAF Processing
- SAF Pre-Treatment
- Quay

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Drawing Title

Figure 4
Indicative Project Elements

Client

LGF Projects Ltd.

Project Name

Lighthouse Green Fuels

Scale at A3

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Project Number

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Drawing Number

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A3

Site Boundary
Statutory Main River Map

EA Flood Defences

Bridge Abutment
Demountable Defence
Embankment
Engineered High Ground
Natural High Ground
Wall

Greatham
Seaton Snook Drain
Tees Mouth
Seaton on Tees Channel
80960
29643
52942
29170
125914
52943
409532
29172
29171
515411
52933
520352
515966
515361
395539
296649
395472
183041
River Tees
Knitting Wife Beck
183040
The Fleet
Ash Gill
The Mill Race
Mains Dike
Redc
183628
179648
29650
179857
519510
179859
179856
179858
454219
178509
452698
454231
454309
129291
129082
416350
29648
454290
454233
454311
458038
458402
395455
183212
River Tees
183213
46351, 178587
178588, 178593
178589, 178594
178591, 179950
181813
107123, 127810
105717, 127811
Ormesby Beck
107122
107118, 126401
178592, 179951
45827, 155686
181984, 183206
543265
67405
181796
69684
181797
183202
543541
181983
183205
80091
68563
565667
80092
68202
565668
183207
543944
Middlesbrough
Eston
Greystone Road
Castle Gill
Mains Dike
Ash Gill

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Drawing Title
Figure 5
Environment Agency Flood Defences

Client
LGF Projects Ltd.

Project Name
Lighthouse Green Fuels

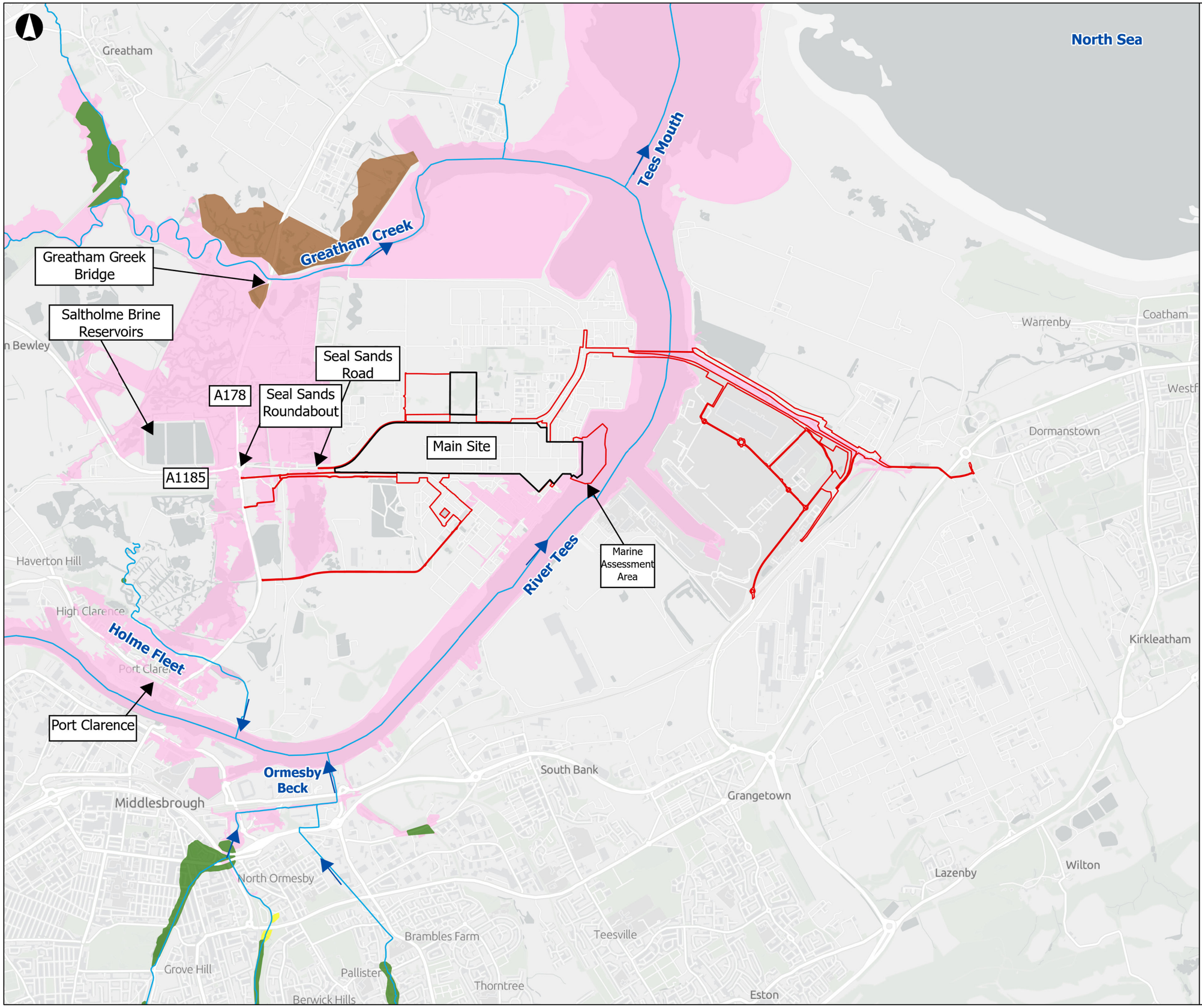
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A3

- Site Boundary
- Main Site
- Statutory Main River Map

Recorded Flood (Flood cause)

- Channel capacity exceeded (no raised defences)
- Local drainage/surface water
- Obstruction/blockage - culvert
- Operational failure/breach of defence
- Overtopping of defences
- Unknown

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Lighthouse GREEN FUELS

Drawing Title

Figure 6
Environment Agency Historical Flooding

Client

LGF Projects Ltd.

Project Name

Lighthouse Green Fuels

Scale at A3

1:35,000

Project Number

306732-00

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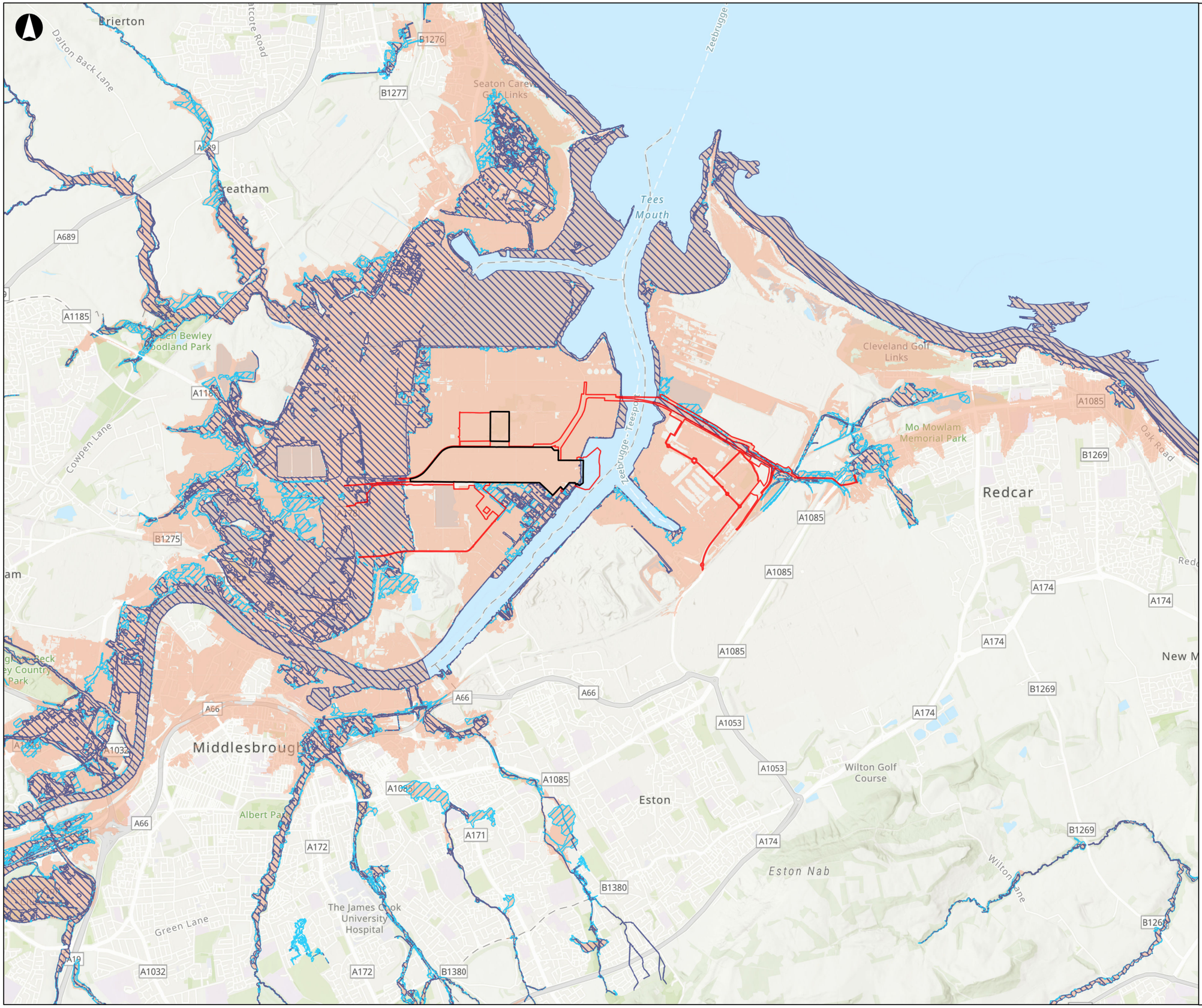
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Site Boundary
Main Site
Flood Zone 2
Flood Zone 3
Flood Zones with Climate Change (2070 to 2125)

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Lighthouse GREEN FUELS

Drawing Title
Figure 7
Environment Agency Flood Zones 2 and 3 (Present Day and Climate Change)

Client
LGF Projects Ltd.

Project Name
Lighthouse Green Fuels

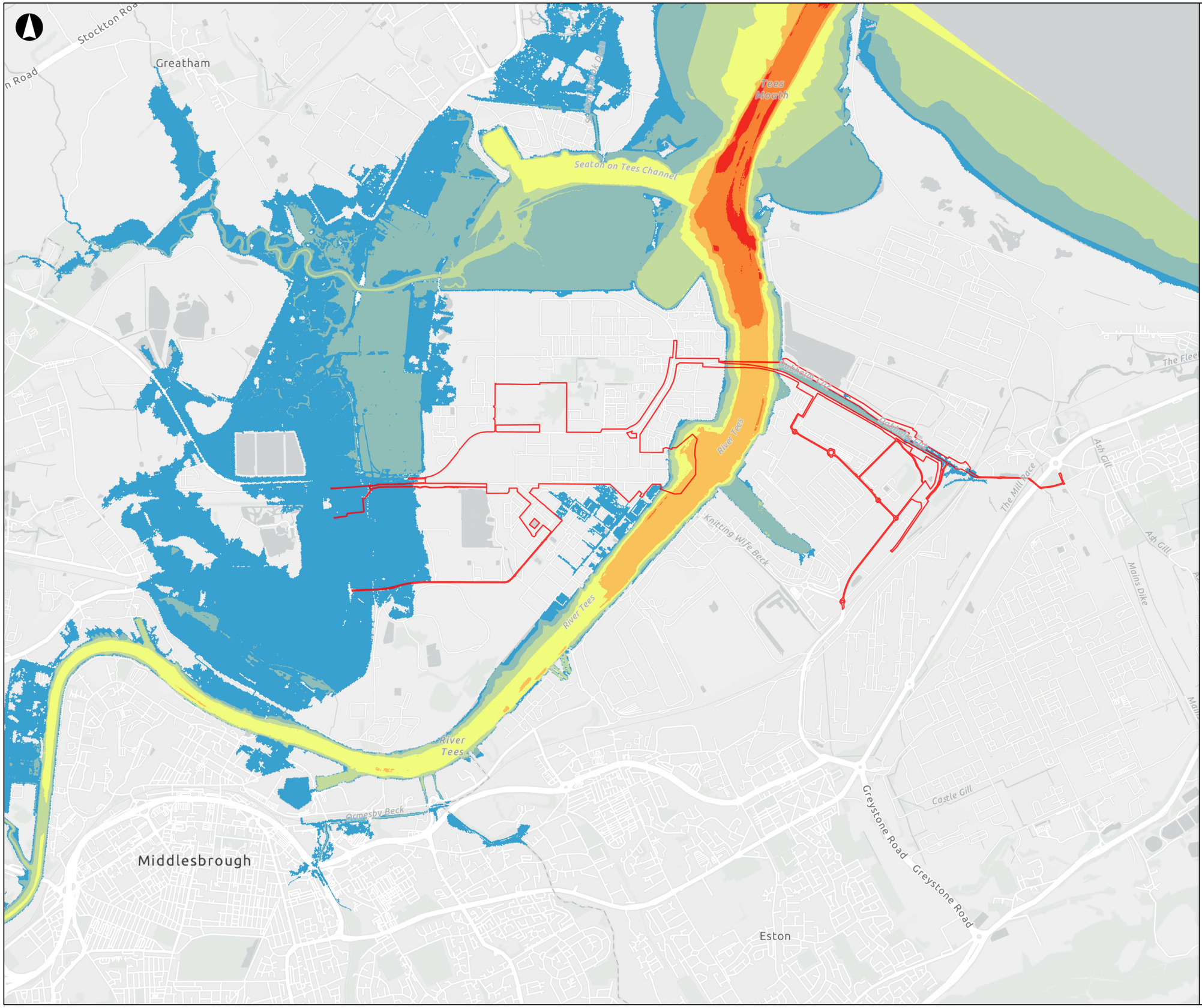
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Site Boundary

Maximum Water Depth (m)

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 22
- 22 - 26

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Lighthouse GREEN FUELS

Drawing Title

Figure 8
Environment Agency Existing Flood Model: Undefended Scenario for 1 in 200 Year (Depths)

Client

LGF Projects Ltd.

Project Name

Lighthouse Green Fuels

Scale at A3

1:35,000

Project Number

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Drawing Number

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Site Boundary

Maximum Water Depth (m)

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 22
- 22 - 26

Coordinate System: British National Grid

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Lighthouse GREEN FUELS

Drawing Title

Figure 8
Environment Agency Existing Flood Model: Undefended Scenario for 1 in 1000 year (Depths)

Client

LGF Projects Ltd.

Project Name

Lighthouse Green Fuels

Scale at A3

1:35,000

Project Number

306732-00

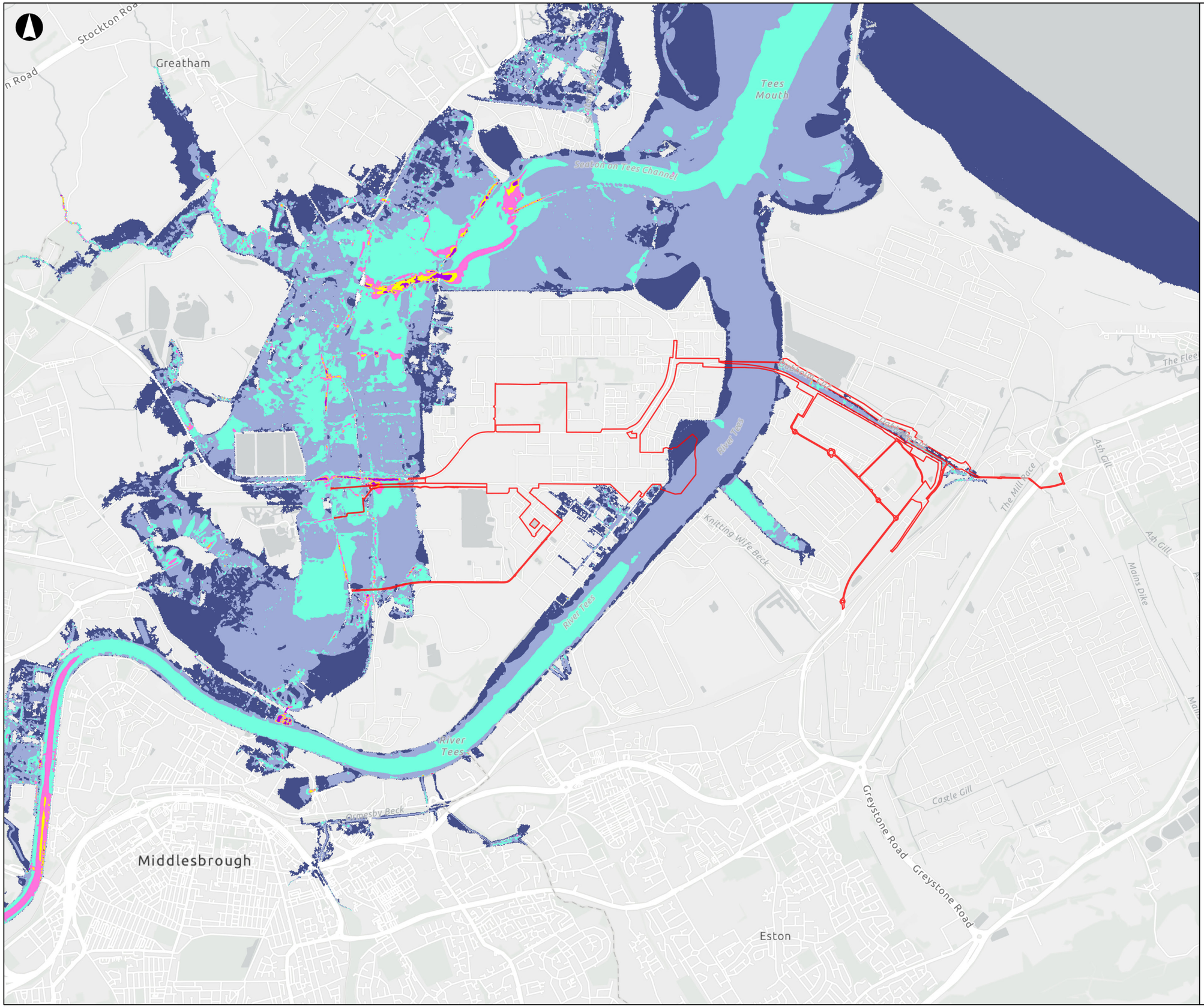
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ARUP Lighthouse GREEN FUELS

Drawing Title
Figure 9
Environment Agency Existing Flood Model: Undefended Scenario for 1 in 200 Year (Velocity)

Client
LGF Projects Ltd.

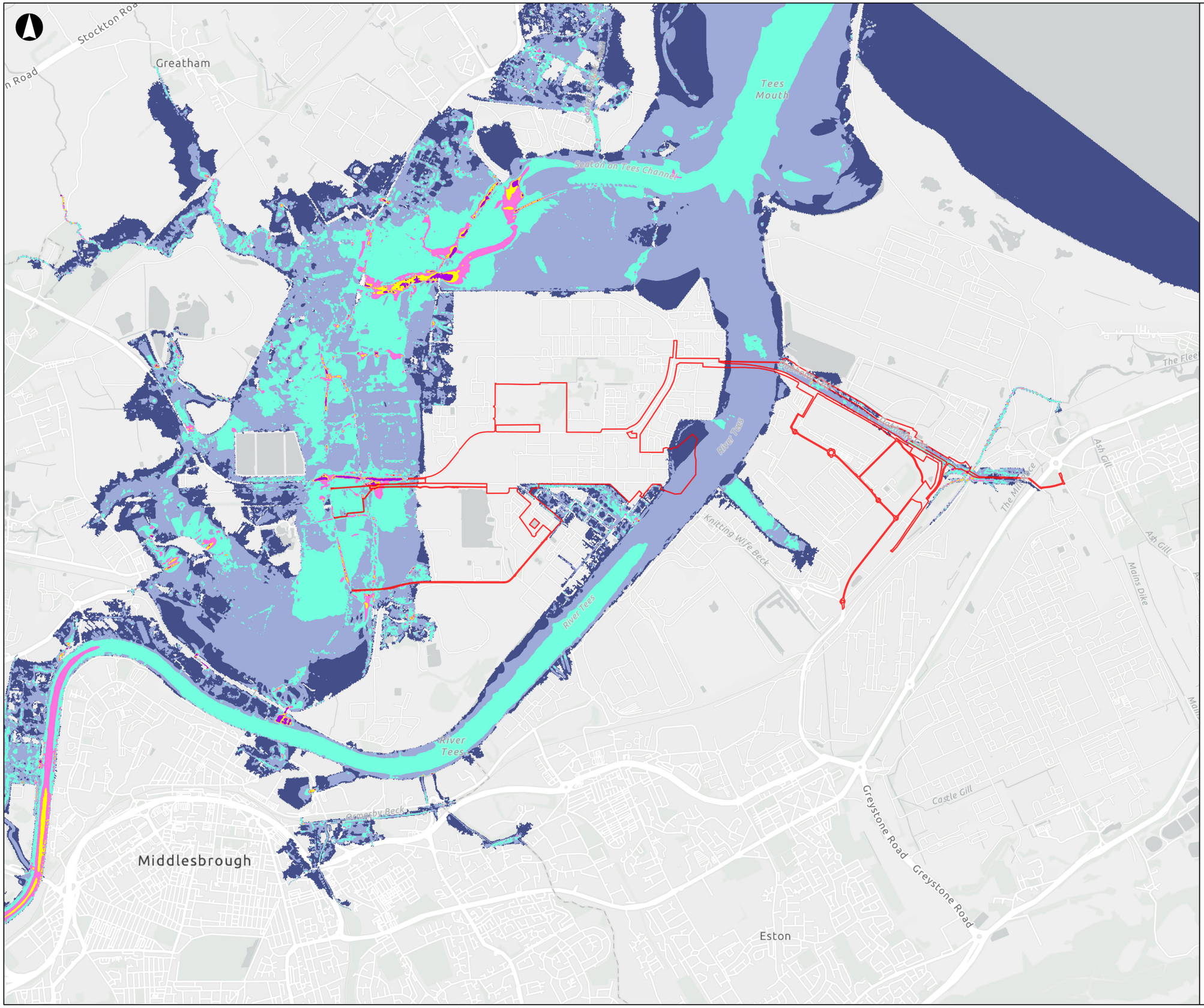
Project Name
Lighthouse Green Fuels

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Project Number	Rev
306732-00	**P01**

Drawing Number
EN0110025/5.7
APFP Reg. 5(2)(a) and EIA Reg. 14

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Site Boundary

Maximum Velocity (m/s)

- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 6
- 6 - 10

Coordinate System: British National Grid

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Kilometres

0 0.5 1



Rev	Date	By	Chkd	Appd	Authd
P01	08/09/26	KRIG	ACAR	LBAL	KCOB

ARUP

Lighthouse GREEN FUELS

Drawing Title

Figure 9
Environment Agency Existing Flood Model: Undefended Scenario for 1 in 1000 year (Velocity)

Client

LGF Projects Ltd.

Project Name

Lighthouse Green Fuels

Scale at A3

1:35,000

Project Number	Rev
306732-00	**P01**

Drawing Number

EN0110025/5.7
APFP Reg. 5(2)(a) and EIA Reg. 14

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A3

Site Boundary

Maximum Water Depth (m)

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 22
- 22 - 26

Coordinate System: British National Grid

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Kilometres

0 0.5 1



Rev	Date	By	Chkd	Appd	Authd
P01	08/09/26	KRIG	ACAR	LBAL	KCOB

ARUP

Lighthouse GREEN FUELS

Drawing Title

Figure 10
Environment Agency Existing Flood Model: Defended Scenario for 1 in 200 Year (Depths)

Client

LGF Projects Ltd.

Project Name

Lighthouse Green Fuels

Scale at A3

1:35,000

Project Number

306732-00

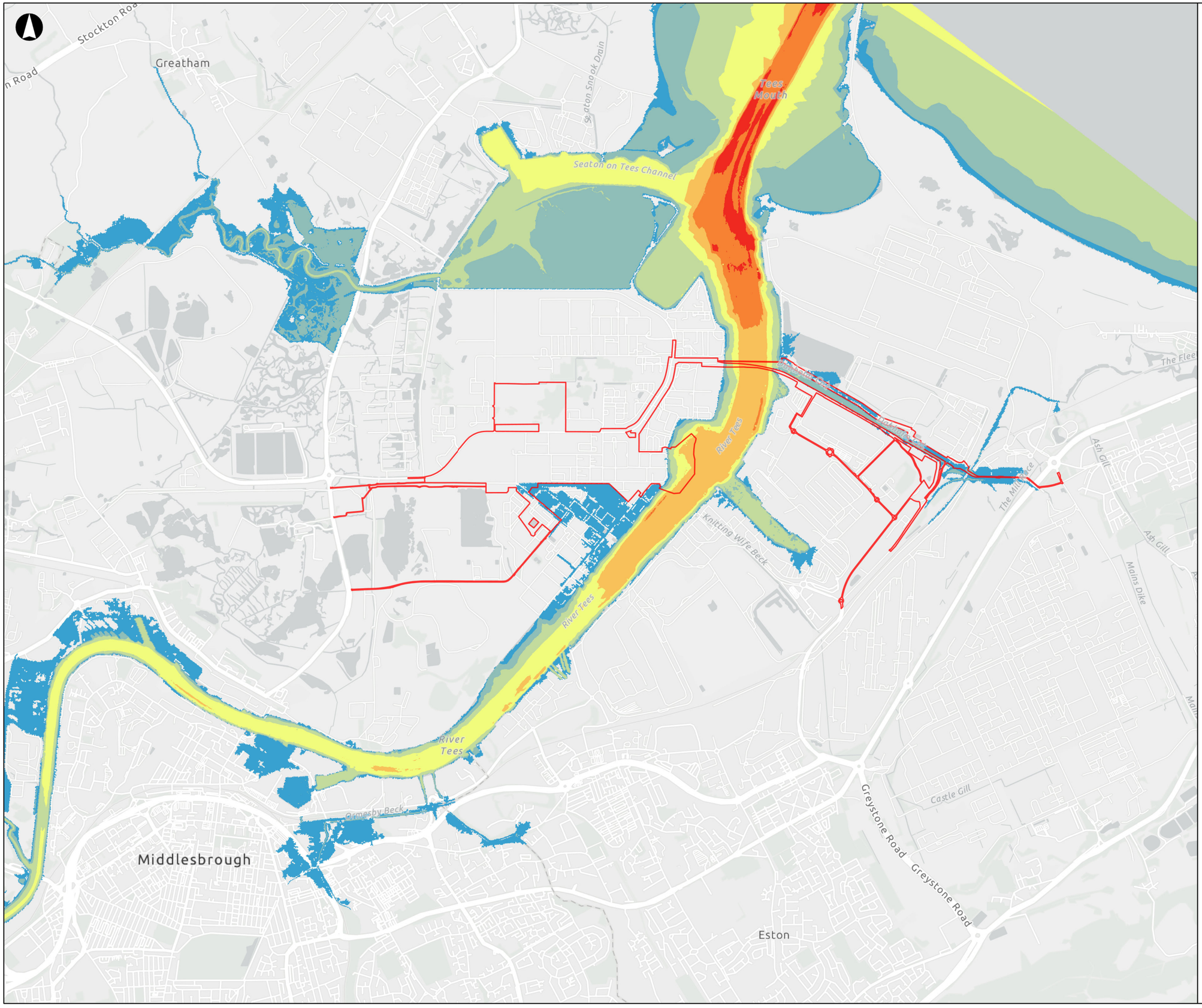
Rev

P01

Drawing Number

EN0110025/5.7
APFP Reg. 5(2)(a) and EIA Reg. 14

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A3

Site Boundary

Maximum Water Depth (m)

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 22
- 22 - 26

Coordinate System: British National Grid

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Kilometres

0 0.5 1



Rev	Date	By	Chkd	Appd	Authd
P01	08/09/26	KRIG	ACAR	LBAL	KCOB

ARUP

Lighthouse GREEN FUELS

Drawing Title

Figure 10
Environment Agency Existing Flood Model: Defended Scenario for 1 in 1000 Year (Depths)

Client

LGF Projects Ltd.

Project Name

Lighthouse Green Fuels

Scale at A3

1:35,000

Project Number	Rev
306732-00	**P01**

Drawing Number

EN0110025/5.7
APFP Reg. 5(2)(a) and EIA Reg. 14

© Arup 2026

A3

Site Boundary

Maximum Velocity (m/s)

- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 6
- 6 - 10

Coordinate System: British National Grid

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Kilometres

0 0.5 1



Rev	Date	By	Chkd	Appd	Authd
P01	08/09/26	KRIG	ACAR	LBAL	KCOB

ARUP

Lighthouse GREEN FUELS

Drawing Title

Figure 11
Environment Agency Existing Flood Model: Defended Scenario for 1 in 200 Year (Velocity)

Client

LGF Projects Ltd.

Project Name

Lighthouse Green Fuels

Scale at A3

1:35,000

Project Number

306732-00

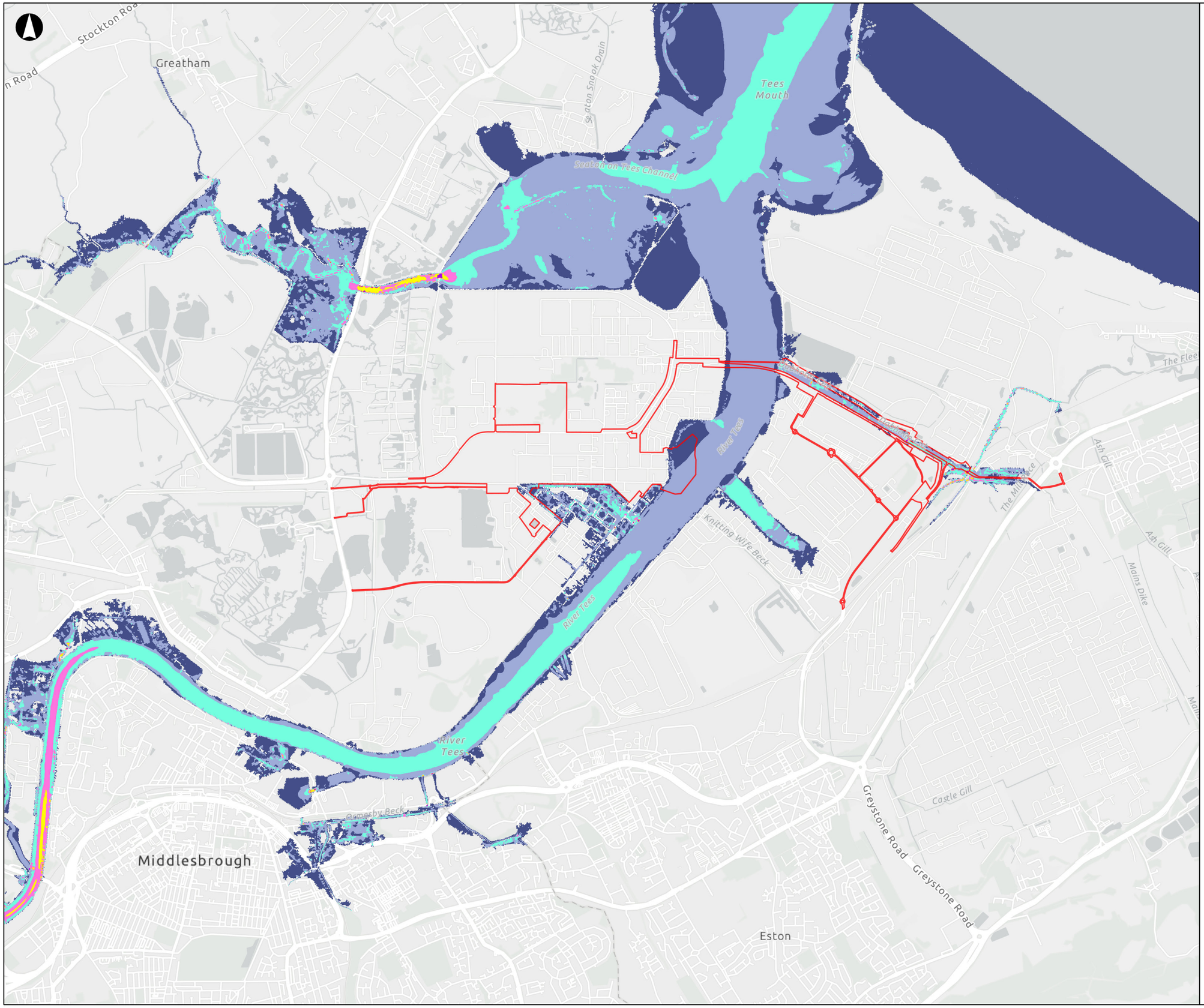
Rev

P01

Drawing Number

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APFP Reg. 5(2)(a) and EIA Reg. 14

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A3

Site Boundary

Maximum Velocity (m/s)

- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 6
- 6 - 10

Coordinate System: British National Grid

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Kilometres

0 0.5 1



Rev	Date	By	Chkd	Appd	Authd
P01	08/09/26	KRIG	ACAR	LBAL	KCOB

ARUP

Lighthouse GREEN FUELS

Drawing Title

Figure 11
Environment Agency Existing Flood Model: Defended Scenario for 1 in 1000 Year (Velocity)

Client

LGF Projects Ltd.

Project Name

Lighthouse Green Fuels

Scale at A3

1:35,000

Project Number

306732-00

Rev

P01

Drawing Number

EN0110025/5.7
APFP Reg. 5(2)(a) and EIA Reg. 14

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Annex B Third party data

B.1.1 Detail of recorded floods

Location	Flood source	Flood cause	Start date	End date
Premier Road, Middlesbrough	main river	channel capacity exceeded (no raised defences)	2009-07-17	2009-07-17
High Street, Ormesby	drainage	obstruction/blockage - culvert	2009-07-17	2009-07-17
Grovehill, Mddlesbrough	main river	channel capacity exceeded (no raised defences)	2009-07-17	2009-07-17
1995 Flood Event	unknown	overtopping of defences	1995-01-28	1995-02-04
The Link, Ormesby	main river	channel capacity exceeded (no raised defences)	2009-07-18	2009-07-18
Berwick Hills, Middlesbrough	main river	channel capacity exceeded (no raised defences)	2009-07-18	2009-07-18
Bewick Hills, Middlesbrough	main river	channel capacity exceeded (no raised defences)	2008-08-19	2008-08-19
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Seaton 1978	main river	overtopping of defences	1978-01-11	1978-01-11
Thornaby 1978	main river	overtopping of defences	1978-01-11	1978-01-11
Thornaby 1978	main river	overtopping of defences	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Seaton 1978	main river	overtopping of defences	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11

Location	Flood source	Flood cause	Start date	End date
Thornaby 1978	main river	overtopping of defences	1978-01-11	1978-01-11
Claxton 1978	main river	unknown	1978-01-11	1978-01-11
Stockton 1979	main river	channel capacity exceeded (no raised defences)	1979-03-23	1979-03-23
Stockton 1979	main river	channel capacity exceeded (no raised defences)	1979-03-23	1979-03-23
Autumn 2000 Event	unknown	unknown	2000-10-30	2000-11-15
Autumn 2000 Event	drainage	local drainage/surface water	2000-10-30	2000-11-15
Autumn 2000 Event	unknown	unknown	2000-10-30	2000-11-15
Autumn 2000 Event	unknown	unknown	2000-10-30	2000-11-15
Lustrum Beck	main river	unknown	2000-11-03	2000-11-03
Autumn 2000 Event	unknown	unknown	2000-10-30	2000-11-15

B.1.2 Detail of flood defences within the area

Asset ID	Asset name	Asset type	Primary purpose	Protection type		Water body name	Current condition	Design-return period	Design-AEP (%)	Asset length	Asset maintainer	Asset operator	Asset owner	Include in flood map	Water management	Local authority
105717	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	100	0.01	23.91	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	23/02/2022
107118	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	100	0.01	240.42999	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	05/07/2022
107122	Not Available	Embankment	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Good	2	0.50	10.26	Environment Agency	Unknown	Private individual, Company or Charity	Considered and Rejected	North East	Middlesbrough	22/04/2025
107123	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	2	0.50	68.760002	Private individual, Company or Charity	Unknown	Unknown	Considered and Rejected	North East	Middlesbrough	22/04/2025
125914	Not Available	Natural High Ground	Flood Risk Management	Tidal		Not available	2	0.50	1596.5699	Private individual, Company or Charity	Private individual, Company or Charity	Private individual, Company or Charity	Not Yet Considered	North East	Hartlepool	16/05/2022
126401	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	100	0.01	235.23	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	05/07/2022
127811	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	2	0.50	20.65	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	05/07/2022
127810	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	2	0.50	80.120003	Private individual, Company or Charity	Unknown	Unknown	Considered and Rejected	North East	Middlesbrough	22/04/2025
129082	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal	River Tees	Not available	2	0.50	5673.2998	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	19/05/2022
129291	Not Available	Natural High Ground	Flood Risk Management	Tidal	River Tees	Not available	2	0.50	184.94	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Stockton-on-Tees	27/08/2021
155686	Not Available	Natural High Ground	Flood Risk Management	Fluvial	Middle Beck	Not available	1000	0.00	20.719999	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	27/08/2021
178509	Not Available	Natural High Ground	Flood Risk Management	Fluvial	Holme Fleet	Not available	2	0.50	494.69	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Stockton-on-Tees	18/05/2022
178587	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	2	0.50	122.01	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	18/05/2022
178588	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	2	0.50	103.48	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/04/2022
178589	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	50	0.02	19.75	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/04/2022
178591	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	100	0.01	167.39999	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/04/2022
178592	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	100	0.01	53.119999	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/04/2022
178593	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	100	0.01	72.599998	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/04/2022
178594	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	50	0.02	20.940001	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/04/2022
179648	Not Available	Natural High Ground	Flood Risk Management	Fluvial		Not available	2	0.50	2153.75	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Stockton-on-Tees	18/05/2022
179856	Not Available	Embankment	Flood Risk Management	Fluvial	Holme Fleet	Not available	5	0.20	71.470001	Private individual, Company or Charity	Unknown	Unknown	Considered and Rejected	North East	Stockton-on-Tees	23/06/2025
179857	Not Available	Embankment	other	Fluvial	Holme Fleet	Not available	5	0.20	1326.9	Private individual, Company or Charity	Unknown	Unknown	Considered and Rejected	North East	Stockton-on-Tees	26/06/2025
179858	Not Available	Embankment	Flood Risk Management	Fluvial	Holme Fleet	Not available	5	0.20	431.44	Private individual, Company or Charity	Unknown	Unknown	Considered and Rejected	North East	Stockton-on-Tees	19/06/2025
179859	Not Available	Embankment	Flood Risk Management	Fluvial		Not available	5	0.20	181.83	Private individual, Company or Charity	Unknown	Unknown	Considered and Rejected	North East	Stockton-on-Tees	19/06/2025

Asset ID	Asset name	Asset type	Primary purpose	Protection type		Water body name	Current condition	Design-return period	Design-AEP (%)	Asset length	Asset maintainer	Asset operator	Asset owner	Include in flood map	Water management	Local authority
179950	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	100	0.01	182.88	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/04/2022
179951	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	100	0.01	28.5	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/04/2022
181796	Not Available	Wall	Flood Risk Management	Fluvial	Marton West Beck	Not available	10	0.10	41.5	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	14/03/2025
181797	Not Available	Wall	Flood Risk Management	Fluvial	Marton West Beck	Good	75	0.01	93.089996	Environment Agency	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	14/03/2025
181813	Not Available	Natural High Ground	Flood Risk Management	Tidal	River Tees	Not available	2	0.50	1667.96	Local Authority	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	12/05/2022
181983	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	Marton West Beck	Good	75	0.01	22.01	Environment Agency	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	28/02/2025
181984	Not Available	Bridge Abutment	Flood Risk Management	Fluvial	Marton West Beck	Not available	10	0.10	11.75	Local Authority	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	17/02/2025
183040	Not Available	Natural High Ground	Flood Risk Management	Tidal	River Tees	Not available	2	0.50	1244.39	Local Authority	Unknown	Unknown	Not Yet Considered	North East	Redcar and Cleveland	17/02/2021
183041	Not Available	Natural High Ground	Flood Risk Management	Tidal	River Tees	Not available	2	0.50	2214.74	Local Authority	Unknown	Unknown	Not Yet Considered	North East	Redcar and Cleveland	12/05/2022
183212	Not Available	Natural High Ground	Flood Risk Management	Tidal	River Tees	Not available	2	0.50	2615.8301	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Redcar and Cleveland	17/02/2021
183202	Not Available	Wall	Flood Risk Management	Fluvial	Marton West Beck	Good	75	0.01	15.96	Environment Agency	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	28/02/2025
183205	Not Available	Wall	Flood Risk Management	Fluvial	Marton West Beck	Good	75	0.01	38.32	Environment Agency	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	31/03/2025
183206	Not Available	Bridge Abutment	Flood Risk Management	Fluvial	Marton West Beck	Not available	10	0.10	11.91	Local Authority	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	17/02/2025
183207	Not Available	Engineered High Ground	Flood Risk Management	Fluvial	Marton West Beck	Not available	10	0.10	12.8	Local Authority	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	17/02/2025
183213	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	2	0.50	141.32001	Local Authority	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	18/05/2022
183628	Not Available	Natural High Ground	Flood Risk Management	Fluvial	Holme Fleet	Not available	2	0.50	982.09003	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Stockton-on-Tees	01/12/2021
29170	Not Available	Natural High Ground	Flood Risk Management	Tidal		Not available	2	0.50	344.16	Local Authority	Unknown	Unknown	Not Yet Considered	North East	Hartlepool	16/05/2022
29171	Not Available	Embankment	Flood Risk Management	Tidal	Greatham Creek	Fair	25	0.04	751.89001	Environment Agency	Unknown	Unknown	Considered and Accepted	North East	Hartlepool	25/04/2025
29172	Not Available	Embankment	Leisure and Amenity	Tidal		Not available	30	0.03	340.17001	Private individual, Company or Charity	Unknown	Unknown	Considered and Accepted	North East	Hartlepool	28/09/2021
29643	Not Available	Natural High Ground	Flood Risk Management	Fluvial		Not available	2	0.50	2423.8	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Hartlepool	
29648	Not Available	Embankment	Flood Risk Management	Tidal	River Tees	Fair	200	0.01	297.01001	Environment Agency	Unknown	Local Authority	Considered and Accepted	North East	Stockton-on-Tees	19/06/2025
29649	Not Available	Natural High Ground	Flood Risk Management	Tidal	River Tees	Not available	2	0.50	2615.1499	Local Authority	Unknown	Unknown	Not Yet Considered	North East	Redcar and Cleveland	19/05/2022
29650	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal	River Tees	Not available	2	0.50	2215.06001	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Stockton-on-Tees	19/05/2022
395455	Not Available	Natural High Ground	Flood Risk Management	Tidal	Holme Fleet	Not available	Not available	Not available	2997.8999	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Stockton-on-Tees	12/05/2022
395472	Not Available	Natural High Ground	Flood Risk Management	Tidal	River Tees	Not available	Not available	Not available	5149.48	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Stockton-on-Tees	19/05/2022
395539	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal		Not available	Not available	Not available	3140.3	Private individual, Company or Charity	Private individual, Company or Charity	Private individual, Company or Charity	Not Yet Considered	North East	Stockton-on-Tees	11/05/2022

Asset ID	Asset name	Asset type	Primary purpose	Protection type		Water body name	Current condition	Design-return period	Design-AEP (%)	Asset length	Asset maintainer	Asset operator	Asset owner	Include in flood map	Water management	Local authority
409532	Not Available	Embankment	Flood Risk Management	Fluvial/ Tidal		Fair	Not available	Not available	1304.49	Environment Agency	Environment Agency	Environment Agency	Considered and Accepted	North East	Hartlepool	29/05/2025
416350	Not Available	Embankment	Flood Risk Management	Fluvial/ Tidal	River Tees	Good	Not available	Not available	15.87	Environment Agency	Environment Agency	Environment Agency	Considered and Accepted	North East	Stockton-on-Tees	19/06/2025
46351	Not Available	Natural High Ground	Flood Risk Management	Tidal	Ormesby Beck	Not available	100	0.01	168.97	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/04/2022
452698	Not Available	Embankment	Flood Risk Management	Fluvial/ Tidal	River Tees	Good	200	0.01	108.42	Environment Agency	Private individual, Company or Charity	Private individual, Company or Charity	Considered and Accepted	North East	Stockton-on-Tees	26/06/2025
454219	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	River Tees	Good	200	0.01	88.370003	Environment Agency	Private individual, Company or Charity	Private individual, Company or Charity	Considered and Accepted	North East	Stockton-on-Tees	26/06/2025
454231	Not Available	Embankment	Flood Risk Management	Fluvial/ Tidal	River Tees	Fair	200	0.01	76.419998	Environment Agency	Private individual, Company or Charity	Private individual, Company or Charity	Considered and Accepted	North East	Stockton-on-Tees	26/06/2025
454233	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	River Tees	Good	200	0.01	231.72	Environment Agency	Private individual, Company or Charity	Private individual, Company or Charity	Considered and Accepted	North East	Stockton-on-Tees	26/06/2025
454290	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	River Tees	Fair	200	0.01	57	Environment Agency	Private individual, Company or Charity	Private individual, Company or Charity	Considered and Accepted	North East	Stockton-on-Tees	26/06/2025
454309	Not Available	Demountable Defence	Flood Risk Management	Fluvial/ Tidal	River Tees	Not available	200	0.01	278.48999	Private individual, Company or Charity	Private individual, Company or Charity	Private individual, Company or Charity	Not Yet Considered	North East	Stockton-on-Tees	26/06/2025
454311	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	River Tees	Good		#DIV/0!	9.470003	Environment Agency	Private individual, Company or Charity	Private individual, Company or Charity	Considered and Accepted	North East	Stockton-on-Tees	19/06/2025
458038	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	River Tees	Not available		#DIV/0!	25.040001	Local Authority	Local Authority	Local Authority	Considered and Accepted	North East	Stockton-on-Tees	26/06/2025
45827	Not Available	Natural High Ground	Flood Risk Management	Fluvial	Middle Beck	Not available	1000	0.00	29.73	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	05/07/2022
458402	Not Available	Embankment	Flood Risk Management	Fluvial/ Tidal	River Tees	Not available		#DIV/0!	18.280001	Local Authority	Local Authority	Local Authority	Considered and Accepted	North East	Stockton-on-Tees	27/08/2021
515361	Not Available	Embankment	Flood Risk Management	Fluvial/ Tidal		Good		#DIV/0!	1693.9	Environment Agency	Environment Agency	Private individual, Company or Charity	Considered and Accepted	North East	Stockton-on-Tees	23/05/2025
515411	Not Available	Embankment	Flood Risk Management	Fluvial/ Tidal		Good		#DIV/0!	155.39	Environment Agency	Environment Agency	Private individual, Company or Charity	Considered and Accepted	North East	Stockton-on-Tees	25/04/2025
515966	Not Available	Embankment	Flood Risk Management	Fluvial/ Tidal	Greatham Creek	Fair		#DIV/0!	760.47998	Environment Agency	Environment Agency	Private individual, Company or Charity	Considered and Accepted	North East	Stockton-on-Tees	28/05/2025
519510	Not Available	Engineered High Ground	Flood Risk Management	Fluvial/ Tidal	River Tees	Not available		#DIV/0!	728.19	Private individual, Company or Charity	Private individual, Company or Charity	Private individual, Company or Charity	Not Yet Considered	North East	Stockton-on-Tees	26/06/2025
520352	Not Available	Embankment	Leisure and Amenity	Tidal		Not available		#DIV/0!	457.17001	Private individual, Company or Charity	Unknown	Unknown	Considered and Accepted	North East	Stockton-on-Tees	25/04/2025
52933	Not Available	Embankment	Leisure and Amenity	Tidal		Not available	50	0.02	151.75	Private individual, Company or Charity	Unknown	Unknown	Considered and Accepted	North East	Stockton-on-Tees	25/04/2025
52942	Not Available	Wall	Flood Risk Management	Tidal	Seaton on Tees Channel	Not available	200	0.01	485.92999	Private individual, Company or Charity	Private individual, Company or Charity	Private individual, Company or Charity	Considered and Rejected	North East	Hartlepool	25/04/2025
52943	Not Available	Embankment	Flood Risk Management	Tidal		Poor	153	0.01	2012.75	Environment Agency	Private individual, Company or Charity	Private individual, Company or Charity	Considered and Accepted	North East	Hartlepool	25/04/2025
543265	Not Available	Engineered High Ground	Flood Risk Management	Fluvial/ Tidal	Marton West Beck	Not available		#DIV/0!	18.629999	Unknown	Unknown	Private individual, Company or Charity	Not Yet Considered	North East	Middlesbrough	17/02/2025
543541	Not Available	Engineered High Ground	Flood Risk Management	Fluvial/ Tidal	Marton West Beck	Not available		#DIV/0!	11.21	Unknown	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	01/04/2021
543944	Not Available	Wall	Flood Risk Management	Fluvial	Marton West Beck	Very Good	75	0.01	3.04	Environment Agency	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	01/04/2021
565667	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	Marton West Beck	Fair	75	0.01	73.589996	Environment Agency	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	17/02/2025
565668	Not Available	Wall	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	75	0.01	8.9	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	17/02/2025
67405	Not Available	Wall	Flood Risk Management	Fluvial	Marton West Beck	Good	75	0.01	168.57001	Environment Agency	Unknown	Unknown	Considered and Rejected	North East	Middlesbrough	14/03/2025
68202	Not Available	Natural High Ground	Flood Risk Management	Fluvial	Ormesby Beck	Not available	25	0.04	386.94	Unknown	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/06/2022
68563	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	2	0.50	812.34003	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	05/07/2022

Asset ID	Asset name	Asset type	Primary purpose	Protection type		Water body name	Current condition	Design-return period	Design-AEP (%)	Asset length	Asset maintainer	Asset operator	Asset owner	Include in flood map	Water management	Local authority
69684	Not Available	Engineered High Ground	Flood Risk Management	Fluvial	Marton West Beck	Not available	10	0.10	30.07	Private individual, Company or Charity	Unknown	Unknown	Considered and Rejected	North East	Middlesbrough	14/03/2025
80091	Not Available	Natural High Ground	Flood Risk Management	Fluvial/ Tidal	Ormesby Beck	Not available	2	0.50	823	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	05/07/2022
80092	Not Available	Natural High Ground	Flood Risk Management	Fluvial	Ormesby Beck	Not available	5	0.20	390.64999	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Middlesbrough	21/06/2022
80960	Not Available	Natural High Ground	Flood Risk Management	Fluvial		Not available	2	0.50	2255.3401	Private individual, Company or Charity	Unknown	Unknown	Not Yet Considered	North East	Hartlepool	

Annex C Framework Drainage Strategy report

Lighthouse GREEN FUELS

The Lighthouse Green Fuels Order

Application Reference: EN0110025

Applicant: LGF Projects Limited

Framework Drainage Strategy

Document Reference: 5.7A

Revision: 00

APFP Reg. 5(2)(a) and EIA Reg. 14

Document Title	
Document Ref	
Author	

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Information Classification	Date	Reason

Lighthouse GREEN FUELS

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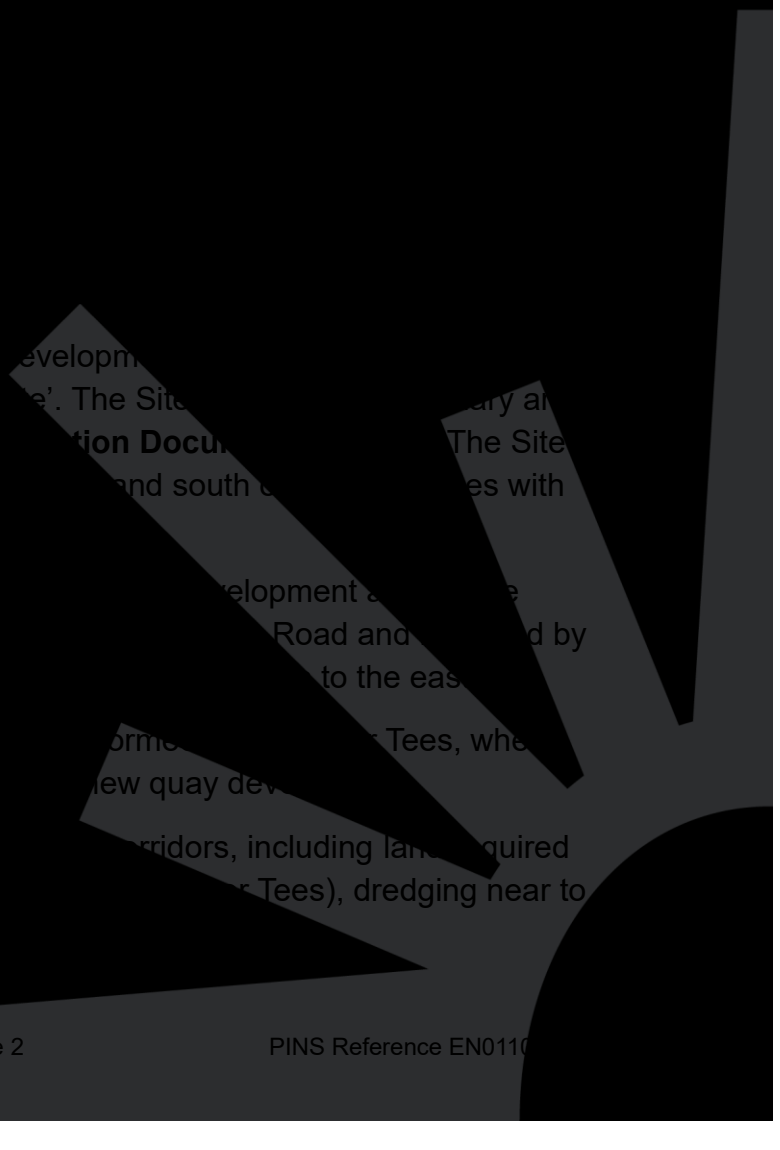
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1.2 Scope of the report

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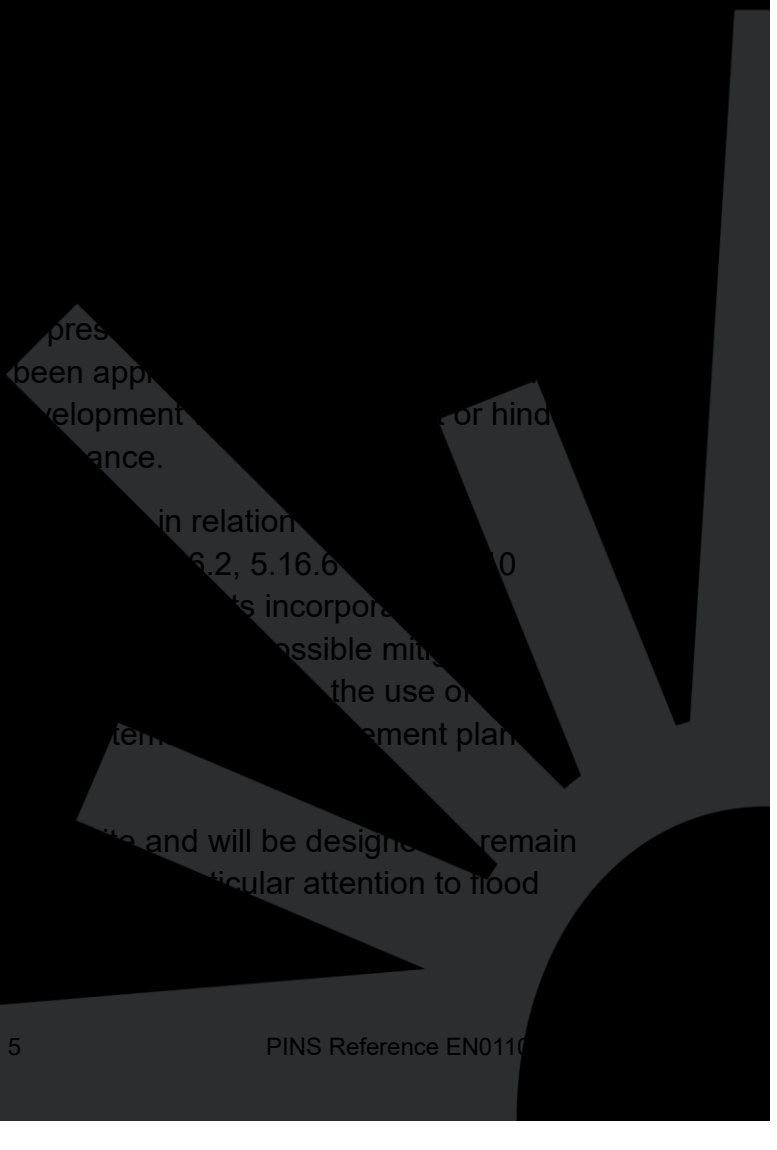
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2 Policy and guidance context

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2.2 National planning requirements



2.3 Local planning requirements

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3 Proposed Development

3.1 Location

3.2 Topography, land use and soil type

3.3 Site layout

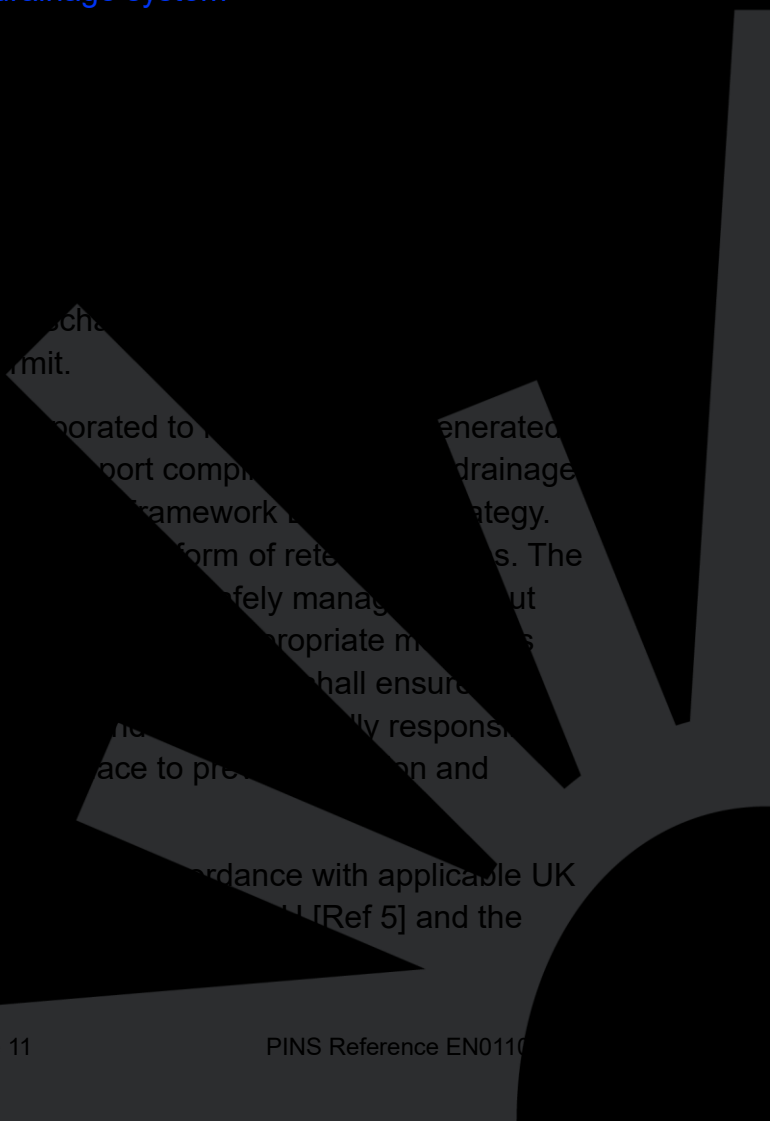
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4 Operational drainage network

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5 Operational drainage strategy

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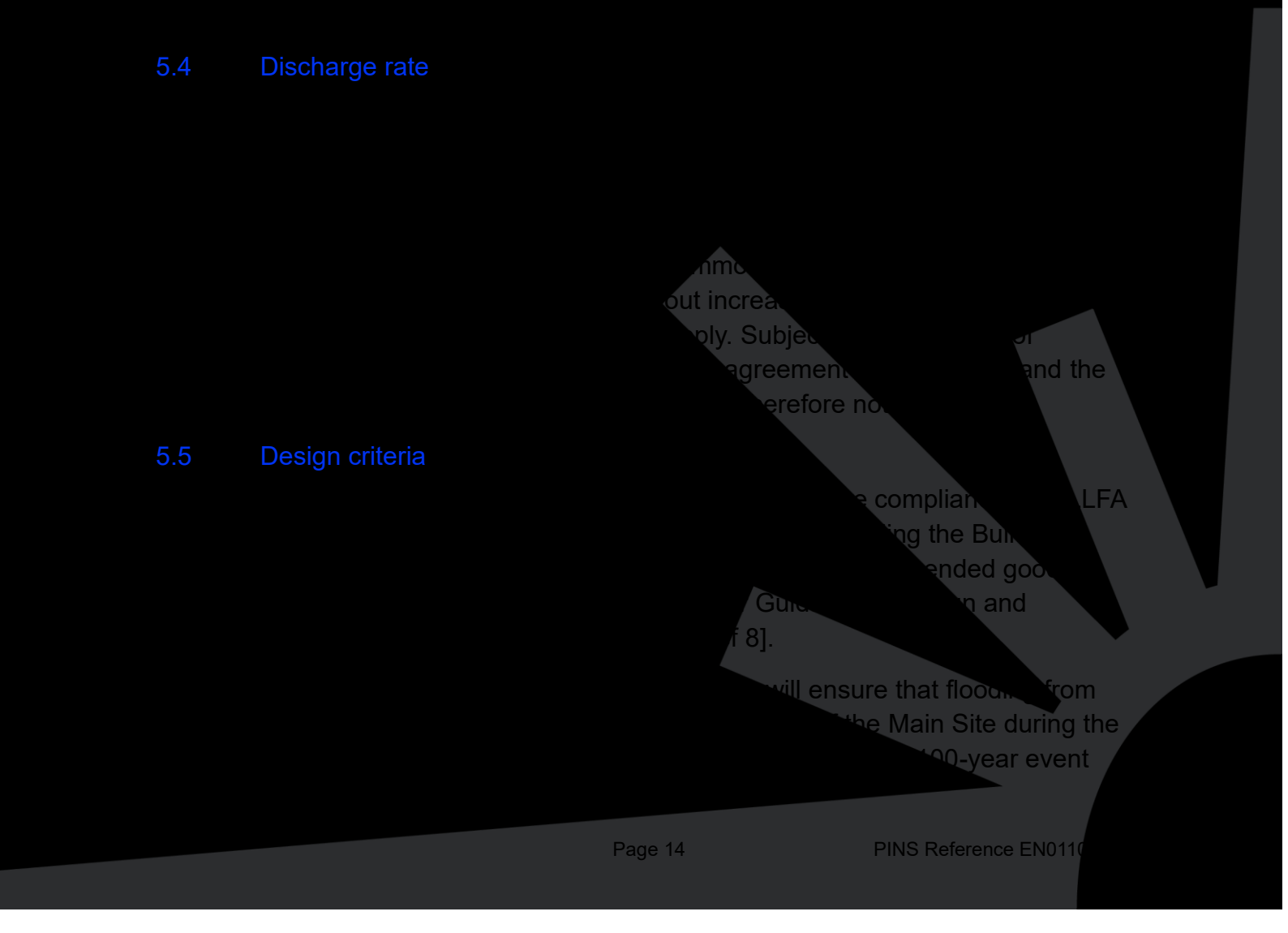
5.2 Discharge hierarchy



5.3 Runoff control

5.4 Discharge rate

5.5 Design criteria



Climate change

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Table 5.1 below

Table 5.1 Tees Management Catchment - peak rainfall allowances

Allowance	3.3% annual exceedance rainfall event	1% annual exceedance rainfall event
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5.6 Attenuation

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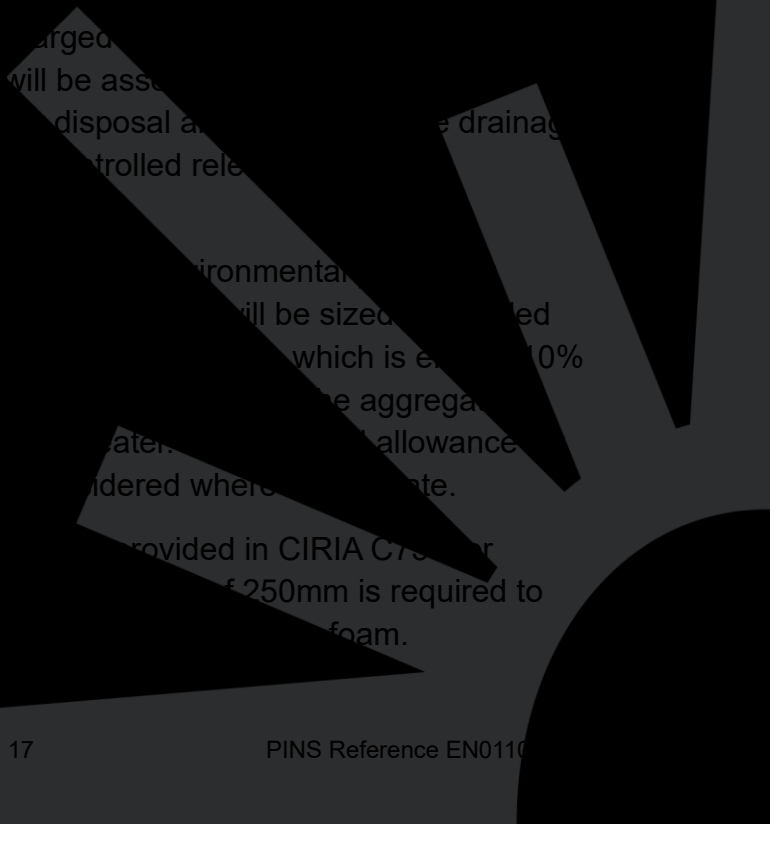
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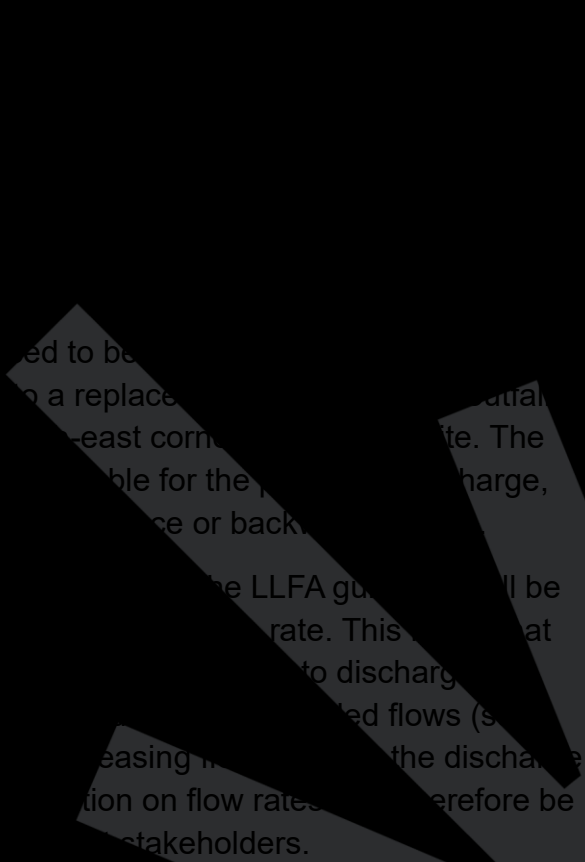
5.8 Sustainable drainage systems

Sustainable Drainage System standards



5.9 Drainage maintenance

6 Conclusion



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Annex D Hydraulic modelling report

Lighthouse GREEN FUELS

The Lighthouse Green Fuels Order

Application Reference: EN0110025

Applicant: LGF Projects Limited

Flood Risk Assessment Annex D: Hydraulic Modelling Report

Document Reference: 5.7 (Annex D)

Revision: 00

APFP Reg 5(2)(e)

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Document Ref	5.7 (Annex D)

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	Date	September 2026

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Abbreviations

Abbreviation	In Full / Term
ASU	Air Separation Unit
CHP	Combined Heat and Power
CO_2	Carbon dioxide
DCO	Development Consent Order
ES	Environmental Statement
km	kilometre
LGF	Lighthouse Green Fuels
MW	Megawatts
MWe	Megawatts electrical
PINS	Planning Inspectorate
RCBC	Redcar and Cleveland Borough Council
SAF	Sustainable Aviation Fuel
SoS	Secretary of State
STBC	Stockton-on-Tees Borough Council

Executive Summary

1.1.1 Flood risk to the Proposed Development Site (the Site) has been modelled using a Flood Modeller Pro - TUFLOW numerical model based on the 2020 update to the Tidal Tees model.

1.1.2 Bathymetry, site topography, LiDAR and tidal boundaries have been updated in the model to use more recent data.

1.1.3 The water levels at the site are highly insensitive to most model parameters other than the tidal boundary.

1.1.4 Breach analyses from the baseline model show that the site is at a high level compared to breach flood levels and would not be at direct risk. Transport links that the site depends on may be flooded, however.

1.1.5 Baseline water levels have been used to identify suitable site design levels, guided by a Residual Uncertainty Assessment.

1.1.6 Site proposals, comprising increased ground levels for the Site, creation of a new quay and dredging of a berth pocket, have been represented in the model and remodelled. These do not lead to significant changes in flood risk; main-channel water levels change by <1mm.

1.1.7 A residual risk is noted due to wave hazard, and this will require wave protection works to the north and south end of the quays to control hazards to acceptable levels within the 30-year operational life of the Proposed Development. It is proposed that for wave hazards that emerge beyond the 30-year operational life that these are dealt with on a managed adaptive basis.

2 Introduction

2.1 Overview

2.1.1 This Hydraulic modelling report **(Annex D of the Flood Risk Assessment, Application Document Ref 5.7)** has been prepared by Ove Arup and Partners Ltd (hereafter referred to as 'Arup') on behalf of LGF Projects Limited (the Applicant), to support an application (the Application) seeking development consent for the construction, operation, maintenance and decommissioning of the Lighthouse Green Fuels project (the Proposed Development) on land (the Site) within the administrative boundaries of Stockton-on-Tees Borough Council (STBC) and Redcar and Cleveland Borough Council (RCBC).

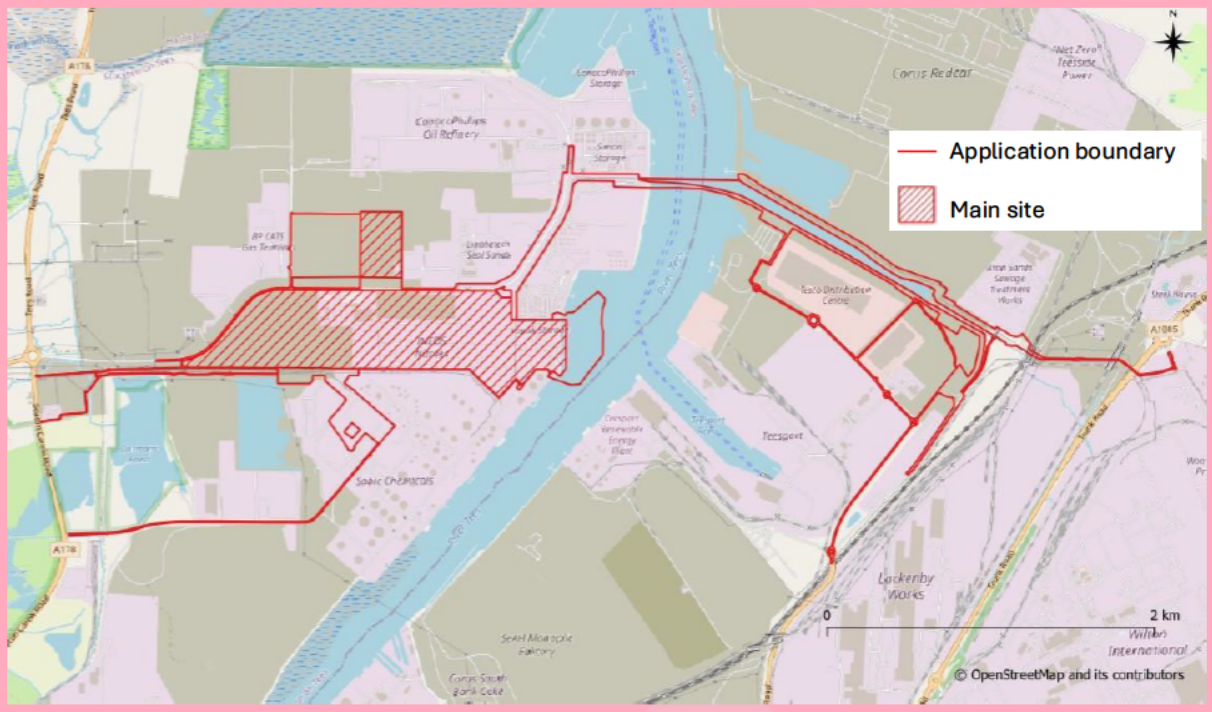
2.1.2 This document is a Hydraulic Model Report to be read in conjunction with the hydraulic model for that work. The model has been used to inform flood risk to the site in support of a Flood Risk Assessment.

3 Overview

3.1 Context

3.1.1 The Main Site is on the left bank of the Tees, and the vast majority of it is located at a level above present-day flood levels.

3.1.2 The Proposed Development will be a sustainable aviation fuel (SAF) plant, and as a site for the storage of a hazardous substance material, the Proposed Development is classified as “Essential Infrastructure” according to Annex 3 of the National Planning Policy Framework (NPPF). While the Site boundary (Inset 3.1) indicates a significant geographic coverage of the site, construction is primarily confined to the “Main Site”; areas extending out of relate to pipeline corridors and access routes.



Inset 3.1 Location and Site boundary of the Proposed Development

Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA).
© https://www.openstreetmap.org and contributors

3.1.3 The design proposals of relevance to flood risk comprise:

- removal of existing jetties and creation of a new quay in advance of the main development, and associated dredging of a berth ‘pocket’. During operation, ships arriving at the quay will supply raw materials biomass for the SAF production process. During construction, they will supply modules and materials; and
- raising ground levels to a minimum of the RUA value above the 0.5% AEP 2080 Higher Central (70%ile) flood level and raising site buildings /

equipment to a minimum of the RUA value above the 0.5% AEP 2105 Upper End (95%ile) flood level.

3.1.4 Given the context of high tidal water levels with an extremely flat sea level locally, it is expected that local flood levels will be largely insensitive to the proposals.

3.1.5 The design life of the SAF production plant is 25 years, but the operational life may be longer (e.g. 30 years). It is recognised that the Environment Agency will require assessment on the basis of a 75-year life. It is also recognised that if the proposals include ground raising and quay building, it cannot be guaranteed that such works would be subsequently removed at the end of the development's life. The assessment therefore also considers the full 100 years to check for any impacts on flood levels.

4 Modelling approach

4.1.1 The proposed approach was consulted with the Environment Agency, and is reproduced as Attachment B of this report, together with the minutes of our consultation meeting. As a high-level summary:

4.1.2 The 2020 Greatham and Port Clarence model update to the Tidal Tees model is the latest model in the area (albeit that the reporting is specifically focussed on those updates). This model has been used for this study and is hereafter referred to as “the received model”.

4.1.3 The model is built in FMP-TUFLOW, but is mostly TUFLOW, with some Estry components that are of little relevance to the site. Following review of the received model, we have:

- generated skew surge tidal boundaries to match key dates appropriate to our study;
- undertaken sensitivity analysis on QMED;
- imported latest LiDAR (assuming the LiDAR and its filtering are of adequate quality);
- imported the latest survey of the site, so that our representation of site interventions is consistent with the rest of the design team; and
- imported the available latest bathymetry of the River Tees.

4.1.4 The model updates are not expected to significantly impact the model’s performance, and because of this it is not proposed to recalibrate the model, or to repeat sensitivity tests undertaken in the 2020 study. Indeed, the 2020 model report notes that no formal calibration was possible with the data available. The dominant influence on flood levels is expected to be the tidal boundary and relative sensitivity to assumed water levels will be apparent from comparison of the range of events to be run (Attachment A0).

4.1.5 We note that extreme events in the model have a modification for stability – omission of a 1D structure. As we are dealing with extreme events throughout this study, and the structure in question is remote from the site of interest, we intend to work with this stabilised version of the model for all scenarios that we run.

4.1.6 We will undertake baseline model runs for comparison with previous model outputs so that we can say how much these updates might have changed results compared to the received model.

4.1.7 The baseline model runs will form the baseline for demonstrating the impact of the proposals, as well as providing initial water levels as the basis for design.

Design update

4.1.8 The design proposals have subsequently been incorporated into the model by modification of the topographic and bathymetric surfaces of the model in the 2D domain. The proposals do not introduce new bridges, and no structures required modification.

4.1.9 The grid size has not been changed to represent the works. The current grid size is 10m and the quay works' smallest dimension is 20m; furthermore, at its narrowest, the river channel is 340m wide. As above, flood levels are expected to be insensitive because of the high tidal boundary; a more detailed grid size will not change this main driver of flood levels.

Scheme resilience

4.1.10 Breach - We will test two breach analyses in the hydraulic model and are expecting to test these against the 1st and final design iterations. The proposed breach locations are at Greatham Creek and Port Clarence. The breaches will be tested against two events. The breaches will be modelled in accordance with LIT56413 Breach of Defences Guidance.

4.1.11 A Residual Uncertainty Assessment (RUA) freeboard analysis will be used to inform design floor and ground levels in accordance with "SC120014 Accounting for Residual uncertainty: updating the freeboard guide".

4.1.12 H++ - While the H++ scenario is noted for sensitivity assessment in the FRA scope, it is not considered necessary to model this scenario. Instead, it is proposed to use the H++ tidal boundary water level (assumed to be the H++ 2100 level) to infer depths of flooding across the site. The basis for this approach is:

- the H++ water levels will be high enough that hydraulic routing effects are unlikely to greatly reduce depths of flooding;
- only a very small proportion of the site is above the H++ flood level; and
- the H++ scenario is theoretical enough that precise modelling is unnecessary – it is an extreme scenario for exploring design sensitivity & robustness.

4.2 Model software

- In-channel model: Flood Modeller version [7.0.0.9977 single precision 64-bit];

- Floodplain model: TUFLOW / ESTRY version [2025.1.2-iSP-w64]; and
- Precision: [single precision – unchanged from the received model].

4.3 Modelled scenarios

4.3.1 The following scenarios have been modelled:

- baseline;
- baseline (breach-1);
- baseline (breach-2); and
- design.

4.4 Model file names

4.4.1 A complete list of model file names is included as Attachment A to this report.

4.5 Simulated events

4.5.1 The following events have been simulated (Table 4.1).

Table 4.1 Simulated events

Event	Fluvial event	Tidal event	Justification	Baseline	Design	Breach 1, Breach 2
1	50% AEP 2030	1% AEP 2030	Indication of change in model due to updates	Y		
	70th %ile	70th %ile				
2	50% AEP 2030	0.1% AEP 2030	Indication of change in model due to updates	Y		
	70th %ile	70th %ile				
3	50% AEP 2030	0.5% AEP 2030	Potential flood conditions by start of project	Y	Y	
	70th %ile	70th %ile				
4	50% AEP 2070	0.5% AEP 2080	Design water level for flood mitigation (Applicant's intent)	Y	Y	
	70th %ile	70th %ile				
5	50% AEP 2105	0.5% AEP 2105	Design water level for flood mitigation (EA requirement)	Y	Y	Y (0.5% AEP 2100 tidal)
	70th %ile	70th %ile				
6	50% AEP 2130	0.5% AEP 2130	Expected max event magnitude required to answer any compensatory floodplain storage questions	Y	Y	
	70th %ile	70th %ile				
7	50% AEP 2105	0.5% AEP 2105	Design water level for flood mitigation (EA requirement), more vulnerable components. Needed for understanding exceedance events.	Y	Y	Y (0.5% AEP 2100 tidal)
	95th %ile	95th %ile				

4.5.2 Breach analyses were carried out early in the analysis on the baseline scenario, and at the time were carried out using the 2100 climate change scenario, not 2105. This has not been re-run, for the following reasons:

- the residual freeboard to the site from the most severe breach scenario identified in the 2100 Upper End scenario is 1.25m; and
- the difference in tidal level between the 2100 Higher Central and 2100 Upper End scenarios is 0.25m, but the difference in the flood levels at the site in the breach scenario run was only 0.12m. The 2105 scenario sea level is only 0.06m higher than 2100, so the expected increase in flood levels at the site is not expected to rise > 1.25m.

4.5.3 It was therefore considered that the modelled breach scenarios gave adequate understanding of the residual risk from this mechanism.

5 Updated baseline model build

5.1 Initial model

5.1.1 The initial model used is the “stability” variant of the ‘received model’ i.e. the 2020 Greatham and Port Clarence model update to the Tidal Tees model, consisting of:

- RTees_DDD_005_Txxxx_YYYY_038_stability_TUFLOW.ief; and
- RTees_010_Txxxx_YYYY_038_stability.tcf and RTees_021_stability.ecf

5.1.2 Modifications have been made to this model as described below to produce the updated baseline model.

5.2 Survey used

5.2.1 The bathymetry of the model has been updated using the latest LiDAR but only for the areas generally above -1.4 mOD. Additionally, bathymetry survey files (named C1.xyz to C13.xyz) from PD Ports (Teesport), surveyed 2025, have been used to update the bathymetry of the River Tees channel and the turning area adjacent to the Main Site.

5.2.2 LiDAR used in the model was updated using the Composite DTM, https://environment.data.gov.uk/survey, year 2022, downloaded on 20 Apr 2026. This dataset does not form a part of this submission. The LiDAR is at 2m resolution.

5.2.3 The two datasets, i.e. the bathymetry extents and the LiDAR data did not overlap, leaving a gap between the two datasets. The baseline topography from the received model was used to bridge the gap between these two datasets, such that the bathymetry survey was used where available, and the LiDAR was used for elevations above -1.4 mOD; the areas between were based on the baseline topography from the received model.

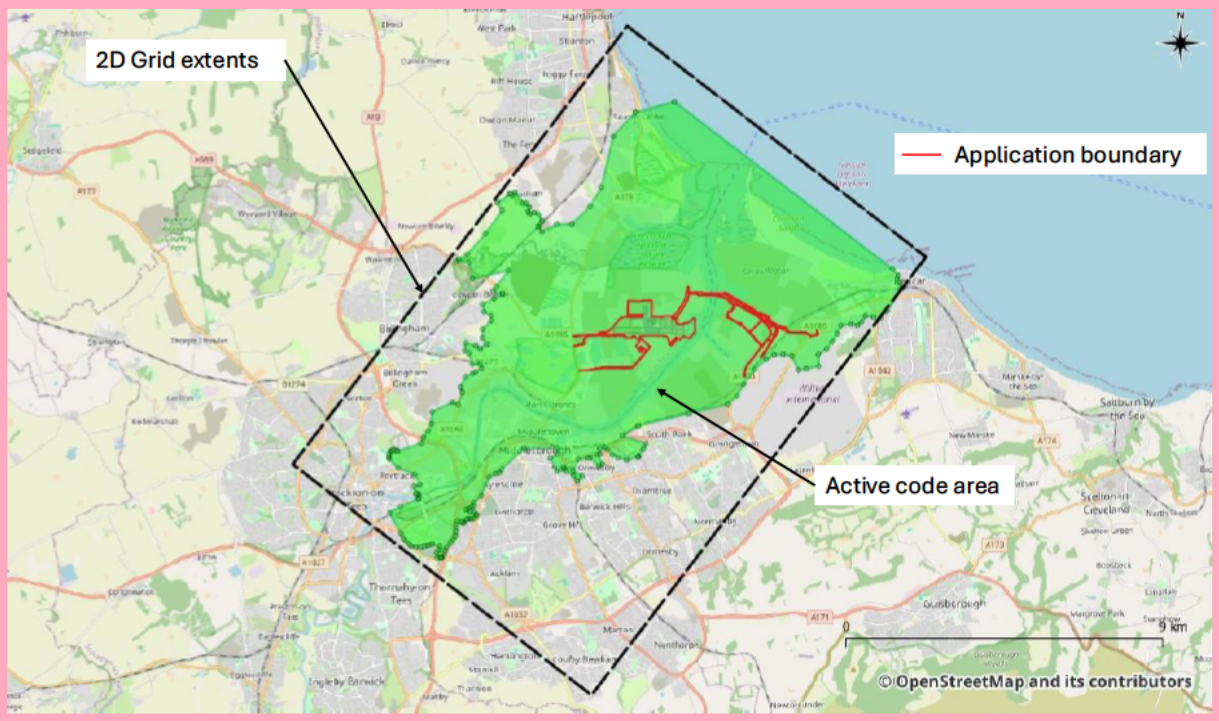
5.3 Grid definition

5.3.1 The orientation and angle of the received model was considered appropriate for use. The bottom left corner of the grid sits at 451191.9, 513434.0, near Rose Wood Primary School. At bearing of 38.17°E the y-axis follows the general direction of the River Tees downstream of Middlesborough (Inset 5.1).

5.3.2 The grid is 10.7 km x 15.6 km and uses a 10m cell size. The grid size of the received model is 10m and the quay works’ smallest dimension is 20m; furthermore, at its narrowest, the river channel is 340m wide. As mentioned in the modelling approach, flood levels are expected to be insensitive

because of the high tidal boundary; a more detailed grid size will not change this main driver of flood levels.

5.3.3 The active code area is cropped to a smaller area than this.



Inset 5.1 2D model domain and spatial extents

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5.4 Definition of downstream boundary

5.4.1 The downstream boundary is a tidal River Tees boundary. No changes have been made to the boundary geometry, but the associated sea levels for the modelled events have been recalculated as described below.

5.4.2 The model report associated with the received model (Greatham and Port Clarence model update, Final Report (Oct 2020)) states that the tidal curve was defined by the High Astronomical Tide (HAT) curve at the mouth of the Tees, and that the storm surge was based on the profile for the North Shields. These were scaled to achieve the peak water levels from the Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels (2018) and uplifted to 2019 using Sea Level Rise allowances from the UKCP18 RCP8.5 Sea level anomalies for marine projections around UK coastline (2007-2100) to derive required future tides.

5.4.3 This method has been assessed as being appropriate. As the guidance has not changed since the 2020 report, the same method has been followed to uplift the Tidal Tees boundaries from 2019 to the target design years. The

rise from 2100 to 2130 has been calculated by using the average rate of rise for 2095-2100 and applying that rate for 2101-2130.

5.4.4 This has resulted in the following peak sea levels (Table 5.1).

Table 5.1 Extreme water levels at tidal boundary

Event	Tidal event	2017 water level from Coastal Flood Boundary Extreme Sea Levels (mAOD)	Sea level rise (m)	Future climate extreme sea level (mAOD)
1	1% AEP 2030	3.97	0.07	4.04
	70th %ile			
2	0.1% AEP 2030	4.32	0.07	4.39
	70th %ile			
3	0.5% AEP 2030	4.07	0.07	4.14
	70th %ile			
4	0.5% AEP 2080	4.07	0.48	4.55
	70th %ile			
5	0.5% AEP 2105	4.07	0.76	4.83
	70th %ile			
6	0.5% AEP 2130	4.07	1.06	5.13
	70th %ile			
7	0.5% AEP 2105	4.07	1.04	5.11
	95th %ile			

5.5 Definition of inflows

5.5.1 The inflows listed in Table 5.2 are used in the model.

Table 5.2 Inflow boundaries

Node name Boundary type	Location	Source
SB_QMED	Spencer Beck, constant QMED, read from RTees_021_stability.ecf file	Original model
BB_QMED	Billingham Beckconstant QMED, read from RTees_021_stability.ecf file	Original model
ORT_QMED	Old River Teesconstant QMED, read from RTees_021_stability.ecf file	Original model
LB_QMED	Lustrum Beckconstant QMED, read from RTees_021_stability.ecf file	Original model
GC_CoBr_QMED	Cowbridge Beck, Greatham QMED flow inflow hydrograph but constant Q, QMED from FEH catchment descriptors, no adjustment, read from RTees_010_ESTRY_020_stability.tbc file	Original model
GC_ClBr_QMED	Greatham Creek, Greatham QMED flow inflow hydrograph but constant Q, QMED from FEH catchment descriptors, no adjustment, read from RTees_010_ESTRY_020_stability.tbc file	Original model
GC_GrHl_QMED	Greatham Beck, Greatham QMED flow inflow hydrograph but constant Q, QMED from FEH catchment descriptors, no adjustment, read from RTees_010_ESTRY_020_stability.tbc file	Original model
FMP node IF30327	River Leven, hydrograph read from RTees_DDD_005.DAT (model report comment: River Leven QMED; peak 14h after Tees as in full model)	Original model
FMP node RT32027	River Tees at Yarm, hydrograph read from RTees_DDD_005.DAT (model report comment: QMED from full model extracted at this location; peak timed to coincide with biggest tide)	Original model

5.5.2 The value of QMED on the River Tees dates from 2010. QMED calculated from the pre-2010 record at the Low Moor gauge (25009) = 401.6m^3/s. QMED for the full record = 410.2m^3/s, a 2% increase. Given the expected low sensitivity to flow at the site, flow boundaries have therefore not been updated.

5.6 Climate change

5.6.1 Climate change allowances for peak river flow have been applied to all ReFH boundaries as below:

- Year 2030 Higher Central 23%;
- Year 2080 Higher Central 40%;
- Year 2105 Higher Central 40%;
- Year 2130 Higher Central 40%; and

- Year 2105 Upper End 61%.

5.7 Roughness

In-channel model

5.7.1 The roughness values in the 1D model (both in the FMP and the Estry) are away from the area of interest and as the flood levels around the site are going to be tidally dominant no updates to the channel roughness values have been undertaken for these model updates.

Floodplain model

5.7.2 The roughness values in the 2D model domain have been updated as per Table 5.3 using the latest OS MasterMap data; the assumptions regarding roughness are standard.

Table 5.3 Hydraulic roughness (Manning's n) values used in the floodplain model

OS MasterMap code	Materials file code	Manning's n	OS MasterMap description	Materials file description
	12	0.05		Default
10123	1	0.03	Manmade, Path,	Gardens, paths, verges
10111	3	0.08	Natural, Natural Environment, Rail, Scrub	Dense mixed vegetation - trees, scrub, marsh
10089	4	0.04	Natural, Inland Water, Watercourse	Tidal land and inland water features
10172	5	0.015	Manmade, Road Or Track,	Roads, tracks
10054	7	0.025	Manmade, General Surface, Step	Pavements, unknown surfaces
10119	7	0.025	Manmade, Path, Step	Pavements, unknown surfaces
10053	10	0.017	Multiple, General Surface, Multi Surface	General manmade surface
10056	10	0.017	Multiple, General Surface, Multi Surface	General manmade surface
10096	11	0.02	Manmade, Landform, Rail, Slope	Rail network
10167	11	0.02	Manmade, Rail,	Rail network
10093	12	0.05	Natural, Landform,	Scrub and rock
10021	18	0.3	Manmade, Building,	Buildings as rough patch
10183	5	0.015	Manmade, Roadside,	Roads, tracks
10185	18	0.3	Manmade, Structure,	Buildings as rough patch
10193	10	0.017	Manmade, Structure, Pylon	General manmade surface

OS MasterMap code	Materials file code	Manning's n	OS MasterMap description	Materials file description
10203	6	0.048	Natural, Natural Environment, Tidal Water, Foreshore, Mud, Sand	Marsh
10210	6	0.048	Natural, Tidal Water,	Marsh
10217	10	0.017	Unclassified, Unclassified,	General manmade surface

5.8 Structures

In-channel model

5.8.1 The structures in the 1D model (both in FMP and Estry) are away from the area of interest and as the flood levels around the site are going to be tidally dominant, no review or changes to the structures in the 1D model component of the received model have been undertaken.

5.8.2 Negative conveyance is noted at bridge units RDBU, RWB1 and RWB3, but not considered to impact on the assessment of flood risk at the site.

Floodplain model

5.8.3 There are a number of culvert structures in the 2D portion of the received model in the area of the Seaton Carew Road and Seal Sands roads. These have been reviewed to confirm that their sizes are reasonable. Ultimately, these are only used in the breach event modelling, and as the most onerous modelled breach event overtops the Seal Sands Road but retains 1.25m freeboard to the level of the site, the breach modelling outcomes are insensitive to the representation of the culverts.

5.9 Defences representation

5.9.1 No updates to the defences have been undertaken as the model is a recent model and no new defences have since been built.

5.10 Representation of buildings

5.10.1 No additional buildings have been added but the hydraulic roughness coefficient values have been updated to represent them as roughness patches, see Table 5.3.

6 Breach model build

6.1 Initial model

6.1.1 The initial model used is the Updated baseline model described in Section 5.

6.2 Scenario description

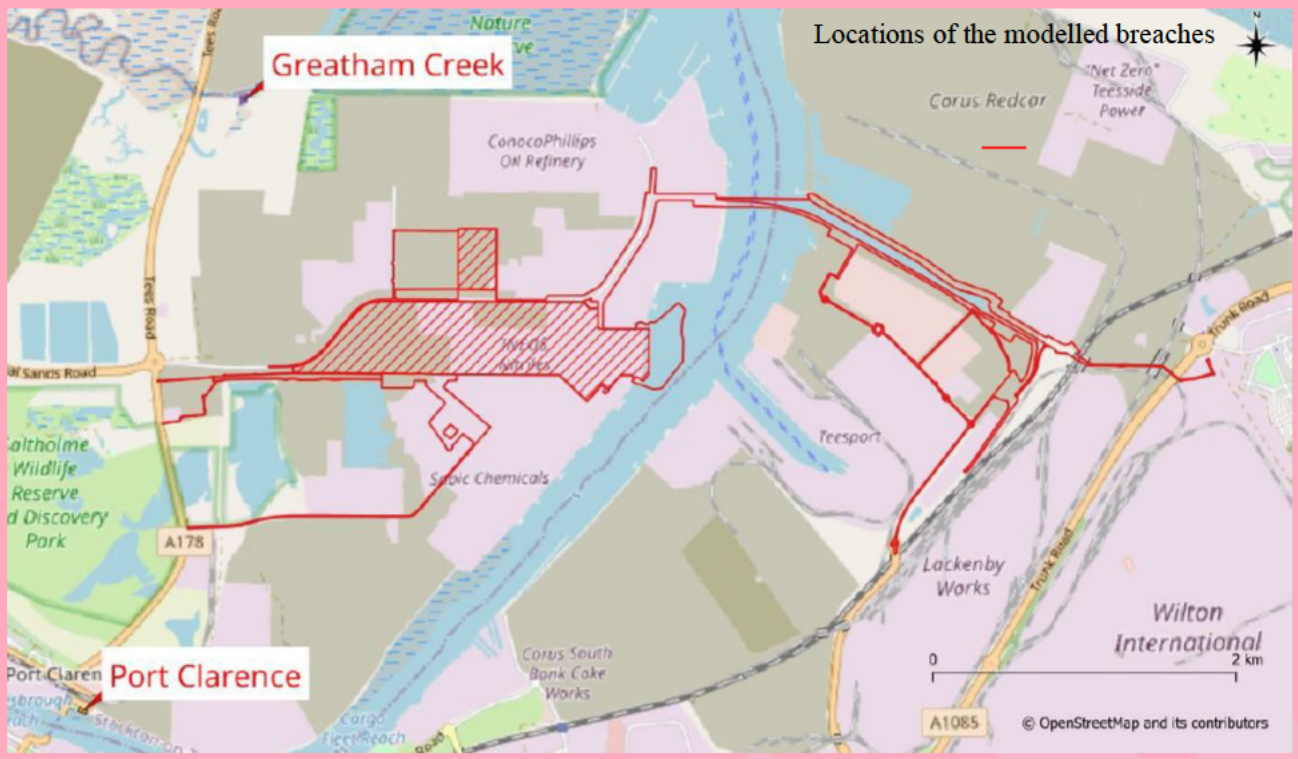
6.2.1 Modifications have been made to the initial model to produce breach models.

6.2.2 The changes do not require any changes to the in-channel model. Hence the model updates relate to only the floodplain model.

6.3 Location of breaches

6.3.1 The latest (on 12 May 2026) Environment Agency AIMS Spatial Flood Defences database was downloaded and locations from breach modelling assessed by following the EA's Breach of defences guidance LIT 56413 (published 29/06/2021).

6.3.2 Two flood defences were identified for breach modelling, see Inset 6.1 and Table 6.1.



Inset 6.1 Locations of modelled breach locations

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Table 6.1 Identified flood defences for breach modelling

id	Port Clarence Site Spatial_Flood_Defences_Including_Standardised_Attributes.78298	Greatham Creek Site Spatial_Flood_Defences_Including_Standardised_Attributes.104506
asset_id	29648	515966
asset_sub_	Embankment	Embankment
primary_pu	Flood Risk Management	Flood Risk Management
alternativ	Flood Risk Management	
alternat_2	Erosion Protection	
asset_leng	297.01001	760.47998
protection	Tidal	Fluvial/Tidal
asset_main	Environment Agency	Environment Agency
asset_oper	Unknown	Environment Agency
asset_owne	Local Authority	Private individual, Company or Charity
current_co	3	3
target_con	3	3
current_so	10	
current__3	27/04/2017	
design_sop	200	
design_s_2	Unchecked	
design_ucl	4.83	
year_last_	2015	
last_inspe	12/12/2025	20/04/2026
next_inspe	07/06/2026	13/10/2026
asset_star	01/03/2017	21/01/2019
actual_dcl	4.9299998	
actual_d_2	crest_level_dqf_2	
actual_ucl	4.586	
actual_u_2	crest_level_dqf_2	
design_dcl	4.83	
bank	Left	Right
effective_	4.9200001	
effectiv_2	crest_level_dqf_4	
include_in	Considered and Accepted	Considered and Accepted
water_mana	North East	North East

id	Port Clarence Site Spatial_Flood_Defences_Including_Standardised_Attributes.78298	Greatham Creek Site Spatial_Flood_Defences_Including_Standardised_Attributes.104506
local_auth	Stockton-on-Tees	Stockton-on-Tees
frms_code	FR/07/S001	FR/07/S001
water_cour	River Tees	Greatham Creek
Top_EL (for breach modelling)	4.830	4.830
Toe_EL (for breach modelling)	2.100	-1.667
Defence_Height (calculated for breach modelling)	2.730	6.497
3/4 Defence height (calculated for breach modelling)	2.048	4.873
Trigger_EL (calculated for breach modelling)	4.148	3.206

6.4 Breach parameters

6.4.1 EA's Breach of defences guidance LIT 56413 (published 29/06/2021) also provides recommended breach parameters (width and time to close) to be applied for different types of defences, which differ for urban and rural areas, see Table 6.2.

Table 6.2 Environment Agency's recommended breach parameters

Source	Defence Type	Breach Width (m)	Time to close – urban (hrs)	Time to close – rural (hrs)
Estuary/Tidal River	Earth Bank	50	30	30
	Reinforced Concrete	20	18	18
Open Coast	Earth Bank	200	44	56
	Earth Bank with facing	100	44	56
	Dunes	100	44	56

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

6.4.2 As the breach locations fall under the first category, Estuary/Tidal River, the 'Time to close' or the 'Restore period' parameter has been set to 30 hours, and as these are earth banks, the breach widths have been set to 50 m. The duration of breach or the 'Period' parameter has been set to 0.25 hrs.

6.4.3 The breaches have been set to fail when the floodwater level reaches ¾ of the flood defence height. The calculations relevant to the breach trigger levels are presented in the bottom four rows of Table 6.2.

6.5 Breach modelling outcomes

6.5.1 The breach modelling results are shown below in Inset 6.2 to Inset 6.4.

6.5.2 Breach 1 causes no flooding to the application boundary in the 0.5% AEP 2100 Higher Central design scenario event, although it would impact the Seaton Carew Road to a shallow depth south of the main access route, with potential temporary disruption impacts to transport. In the 0.5% AEP 2100 Upper End scenario, it causes some flooding to one of the pipeline corridors. The maximum water level in the vicinity of the site would be 2.82mAOD in this exceedance event, well below the proposed site ground level.

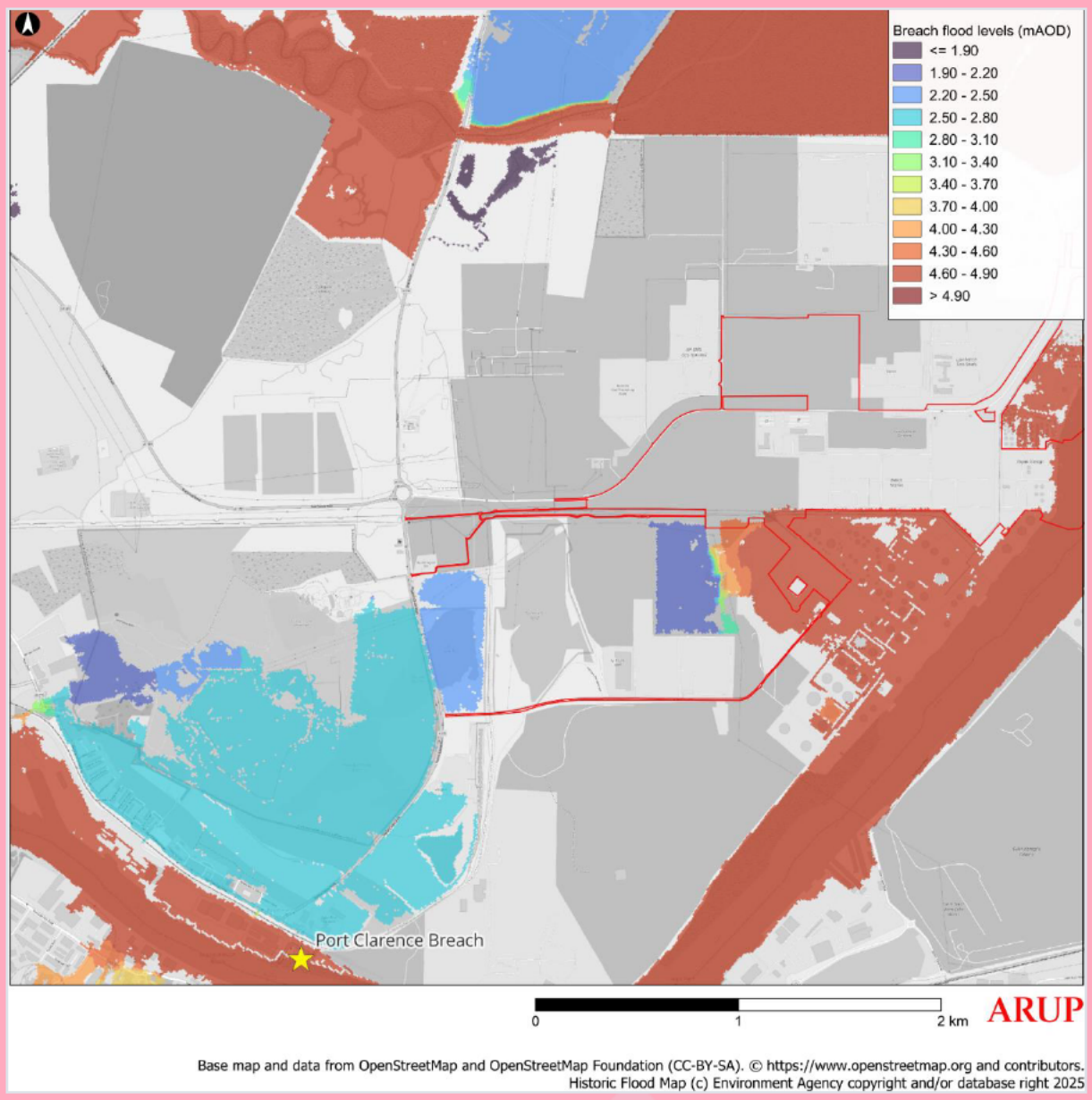
6.5.3 Breach 2 is the worst case of the two scenarios. In the 0.5% AEP 2100 Higher Central design scenario event, it causes flooding over the Seaton Carew Road, Tees Road and the Seal Sands Road. The Emergency Access Road to the north would also be disrupted by this event (albeit not by the breach itself), so the site would be isolated. The peak water level adjacent to the site would be 3.71mAOD. In the 0.5% AEP 2100 Upper End scenario, the consequences would be broadly the same, but the peak flood depth is higher. The maximum water level in the vicinity of the site would be 3.83mAOD, leaving 1.25m freeboard to the proposed site ground level of 5.08mAOD.

6.5.4 Breach analyses were carried out early in the analysis on the baseline scenario, and at the time were carried out using the 2100 climate change scenario, not 2105. This has not been re-run, for the following reasons:

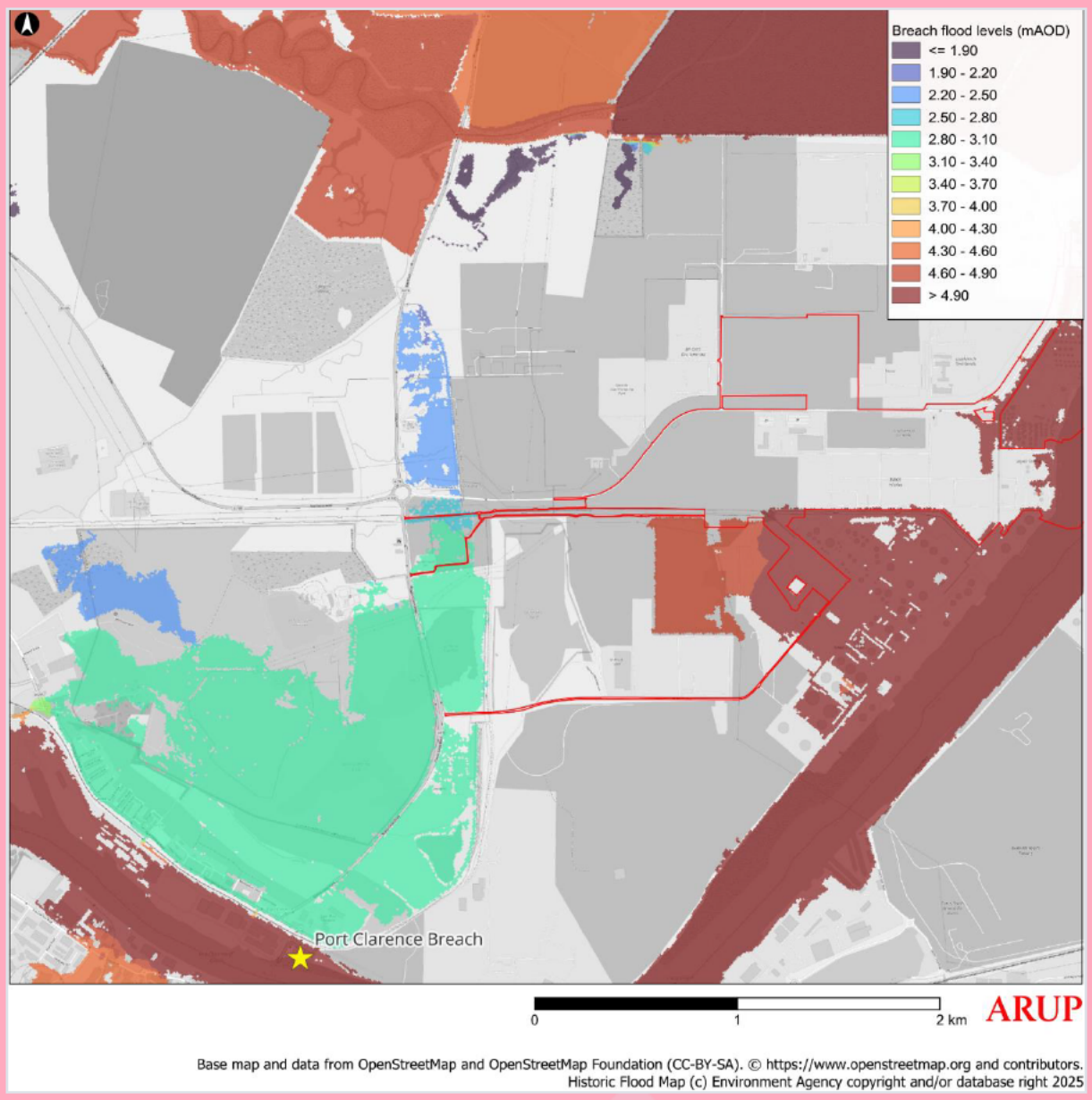
6.5.5 The residual freeboard to the site from the most severe breach scenario identified in the 2100 Upper End scenario is 1.25m.

6.5.6 The difference in tidal level between the 2100 Higher Central and 2100 Upper End scenarios is 0.25m, but the difference in the flood levels at the site in the breach scenario run was only 0.12. The 2105 scenario sea level is only 0.06m higher than 2100, so the expected increase in flood levels at the site is expected to be comfortably less than 1.25m.

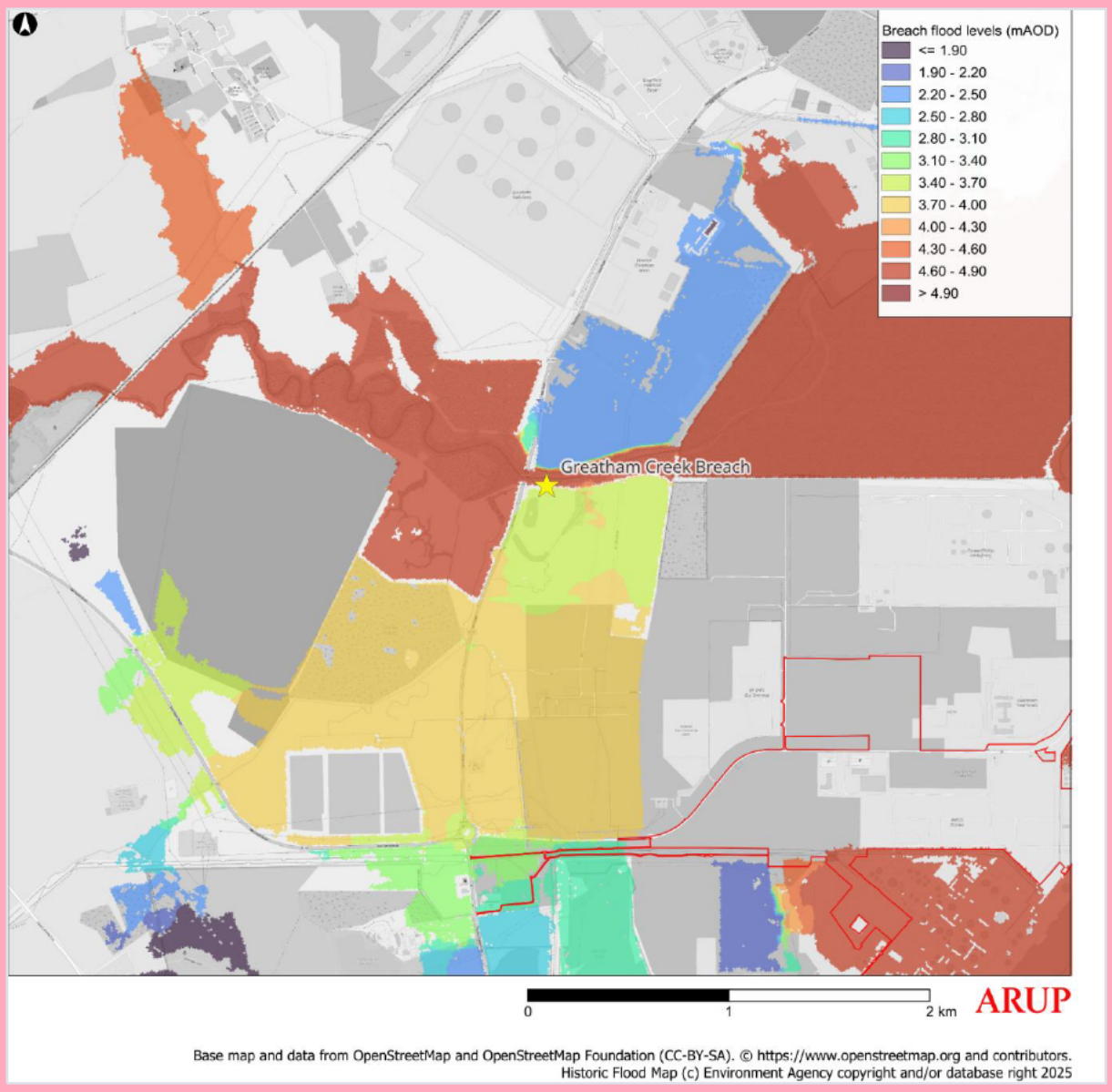
6.5.7 It was therefore considered that the modelled breach scenarios gave adequate understanding of the residual risk from this mechanism.



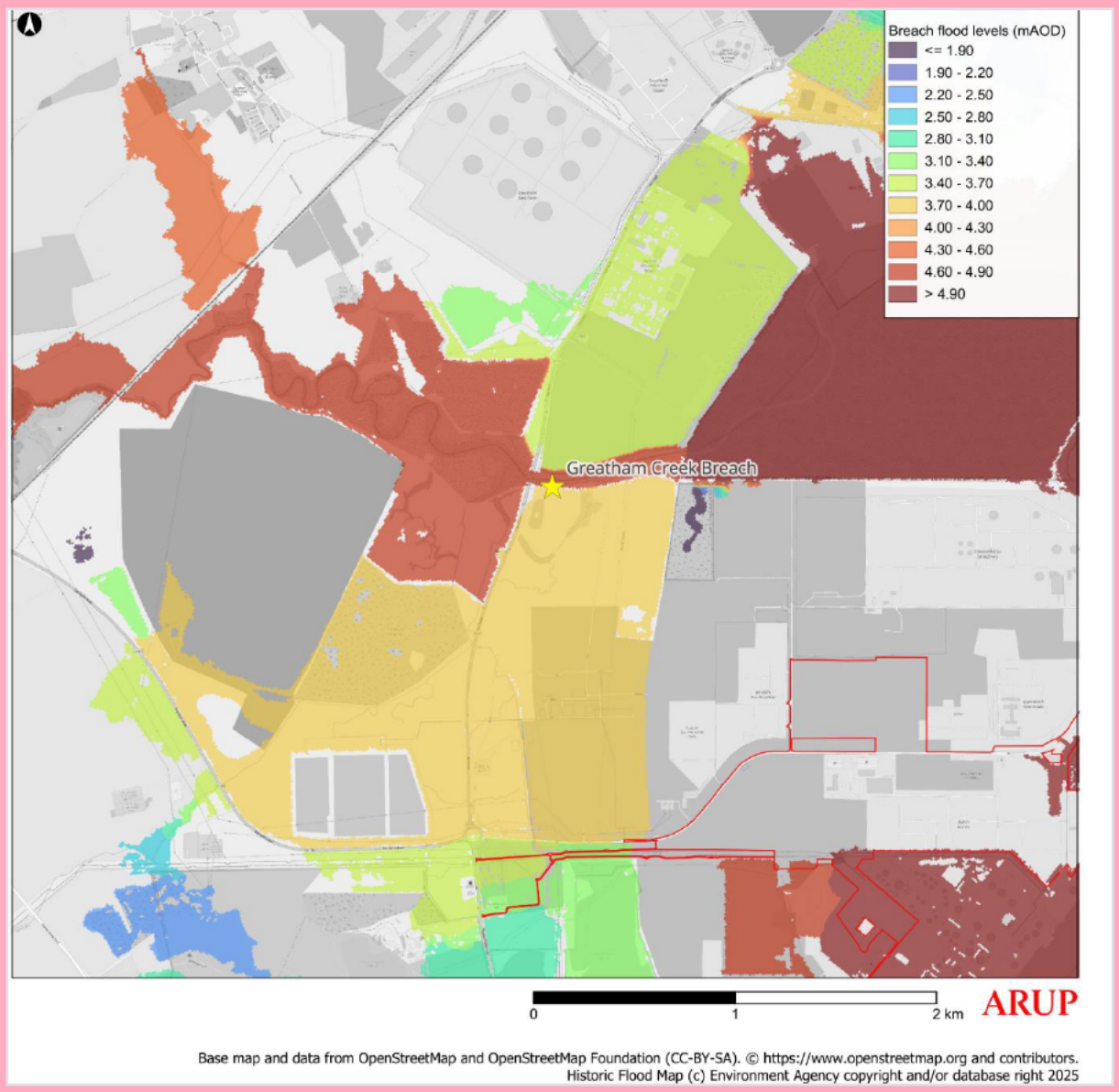
Inset 6.2 Breach 1 flood levels, 0.5% AEP 2100 Higher Central event



Inset 6.3 Breach 1 flood levels, 0.5% AEP 2100 Upper End event



Inset 6.4 Breach 2 flood levels, 0.5% AEP 2100 Higher Central event



Inset 6.5 Breach 2 flood levels, 0.5% AEP 2100 Upper End event

7 Development model build

7.1 Initial model

7.1.1 The initial model used is the Updated baseline model described in Section 5.

7.2 Scenario description

7.2.1 Modifications have been made to the initial model to configure a 'Development model'. This scenario represents the proposed development components in the model, these being:

- proposed removal of the existing jetties and creation of a new quay, and associated dredging of a berth 'pocket';
- proposed raising of the ground levels; and
- proposed built development components, such as buildings and bunds.

7.2.2 The model updates do not require any changes to the 1D model. As such only the TUFLOW model has been updated.

7.3 Details of model updates

DTM/bathymetry:

7.3.1 The proposed removal of the existing jetties and creation of a new quay, and associated dredging of a berth 'pocket' have been achieved by updating the terrain made available by the relevant design team for these components. The river side edge of the quay has a level of 5.65mOD in the design, falling to 5.08mAOD at its landward edge due to a cross-fall for drainage. In the model, the level of 5.65mAOD has been applied for the full width of the quay.

7.3.2 An explicit spatial drawing of the proposals has not been received; however, the general works area of the site, and some concept drawings have been received together with the maximum areas associated with individual components. Using this information, a speculative layout of site components has been drawn up (Inset 7.1). The proposed main site level from PEIR (5.08mAOD) has been retained, and components of the site have been raised relative to this level (see Table 7.1).

7.3.3 The resulting ground surface for the site is considered to represent a "Rochdale envelope" of the possible displacement of flood water from the site.

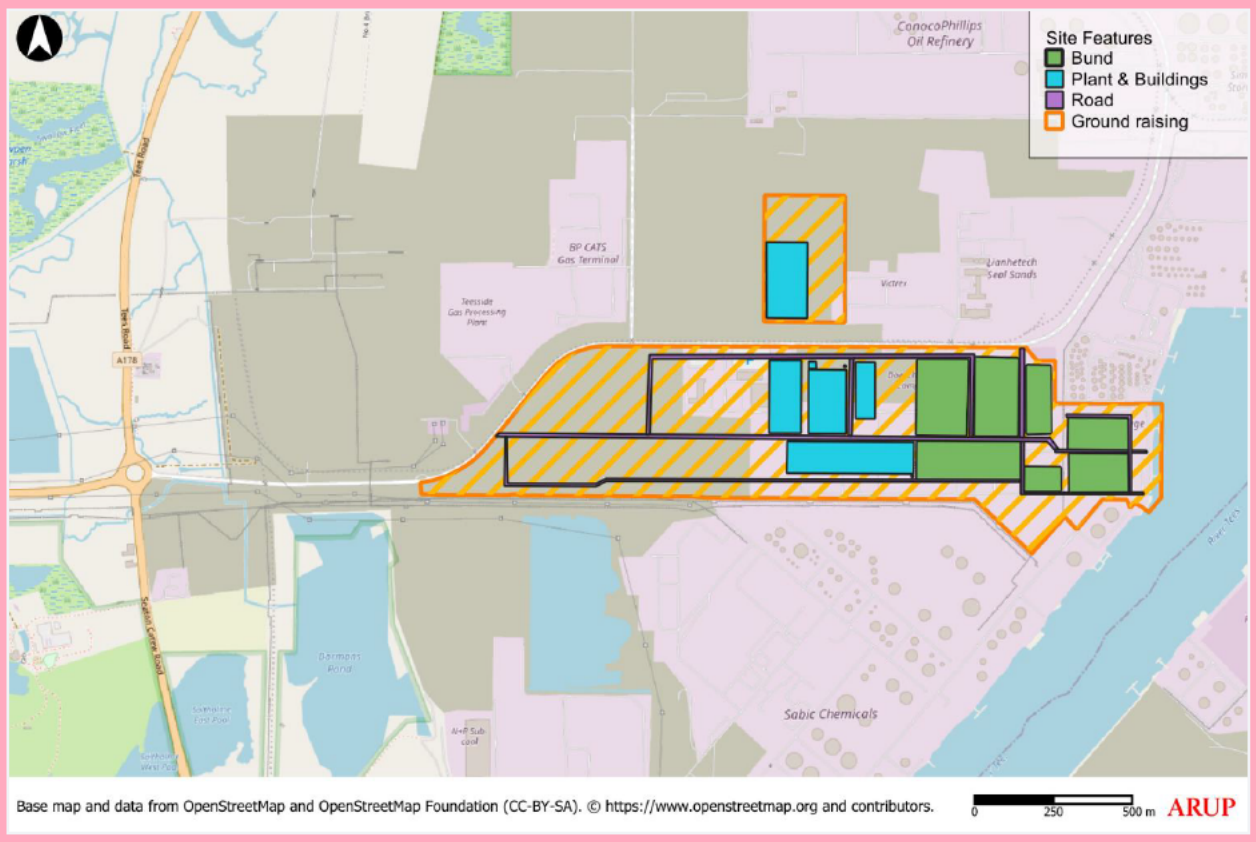
7.3.4 Note: the PEIR distinguished between less vulnerable and more vulnerable site features, suggesting levels of 5.38mAOD and 5.68mAOD. This

distinction has not been made in the modelling because of the coarseness of the received site plans. Furthermore, as the highest modelled water level at the site ended up being 5.13mOAD, the detail of modelling features to different levels would have made no difference to the results.

Table 7.1 Levels of the Proposed Development

Development component	Elevation (mAOD)	Height above Main Site (m)
Main site	5.08	0
Roads	5.23	0.15
Buildings and plant	5.68	0.6
Containment bunds	5.88	0.8

7.3.5 The ground levels in the model have been raised to the listed levels only where the existing ground level is lower than the proposed ground level. The ground levels of the containment bunds have been represented as a terrain modification. This is achieved by raising the terrain of the area enclosed by the bunds to the proposed level. The same procedure is followed to represent the buildings and plants.



Inset 7.1 Assumed Site Layout for modelling purposes

1.2 Roughness

1.2.1 The main site, roads, and bunds have been assigned appropriate material values, these being: 5, 18 and 10 respectively. The corresponding Manning's roughness coefficient values are listed in Table 5.3.

1.3 Proposed development modelling results

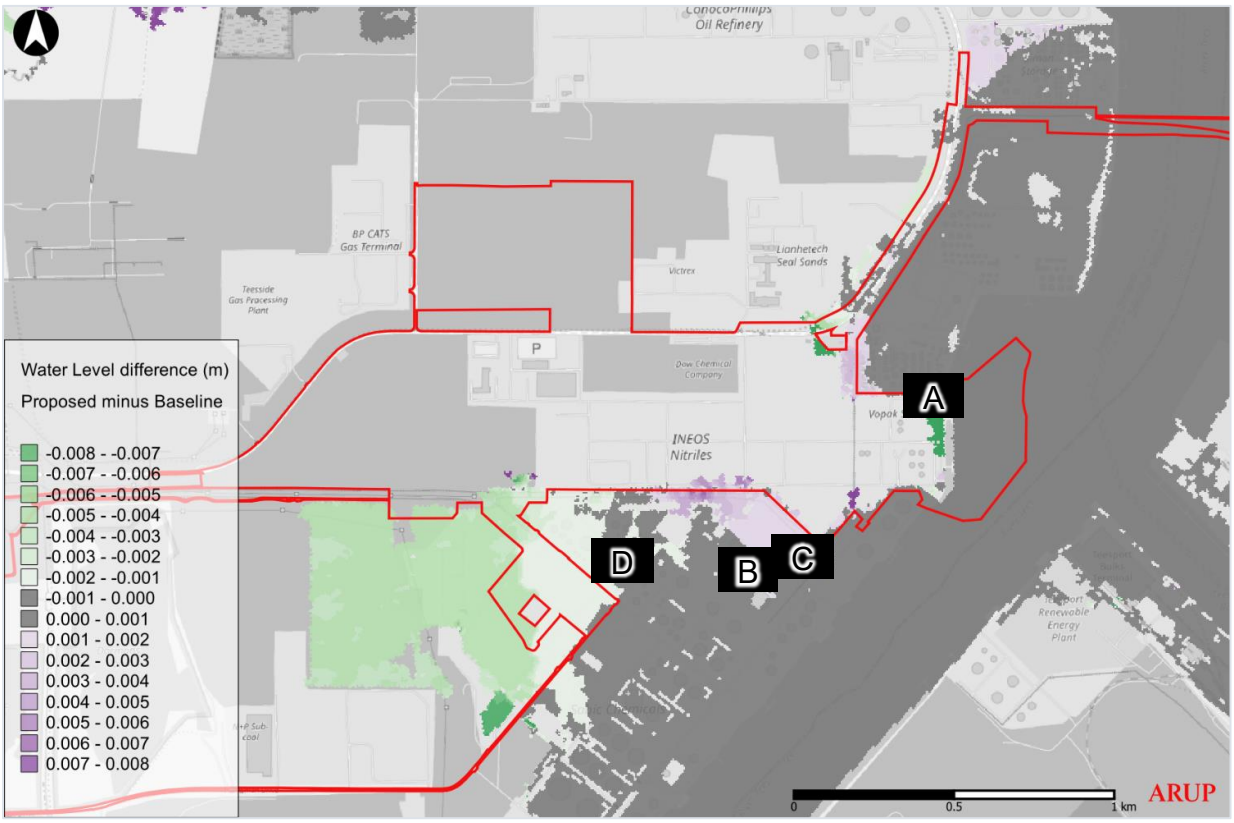
1.3.1 Table 7.2 compares the flood levels adjacent to the proposed quay. It can be seen that the difference between water levels in the two scenarios is negligible.

Table 7.2 Flood levels adjacent to the proposed quay

AEP (%)	Epoch	Climate change scenario	Baseline (mAOD)	Proposal (mAOD)	Difference (m)
1	2030	Higher Central	4.050	4.049	0.001
0.5	2030	Higher Central	4.151	4.151	0.000
0.1	2030	Higher Central	4.403	4.403	0.000
0.5	2080	Higher Central	4.563	4.563	0.000
0.5	2105	Higher Central	4.847	4.847	0.000
0.5	2105	UE	5.131	5.131	0.000
0.5	2130	Higher Central	5.145	5.145	0.000

7.3.6 Inset 7.2 shows the impact of the site proposals in the 0.5% AEP 2130 Higher Central event. This is the event in which the proposals exhibited the most impact on the local water levels, although as can be seen, in the majority of locations, the difference in modelled flood level is <1mm (dark grey. Areas along the south edge of the site exhibit some low increases, generally <3mm (C). Their immediate proximity to reductions in water levels (D) suggest these could, again, be due to some low level instability in the model. They do not indicate any increase in flood frequency to these areas, and the affected areas are already flooded in this magnitude of event in the baseline.

7.3.7 Area B is discussed in greater detail below.



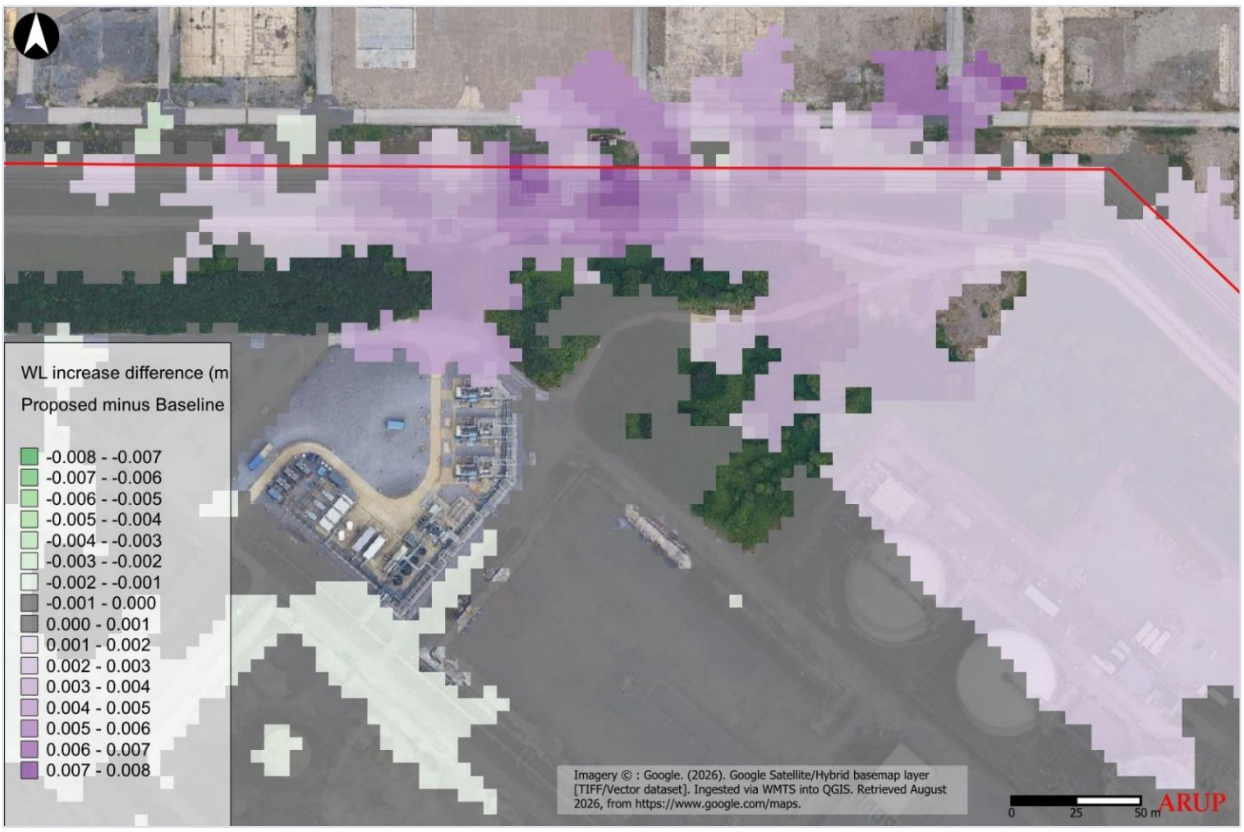
Inset 7.2 Impact of proposals on modelled water levels in the 0.5% AEP 2130 Higher Central event

Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA).
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7.3.8 Area B is assessed in greater detail as it exhibits an 8mm increase in water level.

7.3.9 The increase impacts the pipeline corridor, which sits outside the red line boundary (Inset 7.3). It is noted that this area is also flooded in the baseline event and are not placed at greater frequency of flooding by the proposals. The pipelines will not be detrimentally impacted by such a low increase in flood level. Hazard values are increased by 2%-6% in this location (2.19 to 2.32), but are already noted as “dangerous to all” in the baseline. These high hazard values are driven locally by depth of water rather than velocity.

7.3.10 It can be seen from aerial photography that there is a 4mm increase in the vicinity of some equipment (Inset 7.3). While aerial photography from suggests that the 4mm increase coincides with this equipment, cross-referencing with LiDAR DSM information shows that the assets sit on a raised platform with a level of 5.33mAOD, and are therefore above the local flood level of 5.12mAOD. The area of the 4mm increase is on the access to the location and some open vegetation to the north, not the platform.



Inset 7.3 Water level increases at Location E (0.5% AEP 2130 Higher Central event)

7.4 Residual Uncertainty Analysis

7.4.1 The ground level of the main site is intended to be raised to a minimum 5.08mAOD, which was identified at PEIR as being broadly reflective of the general ground level of the site. A Residual Uncertainty Analysis (RUA) calculation has been undertaken to identify the level of confidence that this ground level provides (Attachment C)

7.4.2 The analysis identifies that stillwater flood levels at the site are only subject to uncertainty from the tidal boundary. 5.08mAOD corresponds to 0.23m uplift on top of the 0.5%AEP 2105 Higher Central flood level of 4.85mAOD. A 0.23m uplift corresponds to the 97.5% confidence interval, a non-exceedance probability of 99%. This a high level of confidence, in excess of industry standards.

7.4.3 Waves are not explicitly represented in the model, but the associated flows onto the site have been calculated using EurOtop (2018), and have been considered in terms of potential hazard to site users.

7.4.4 Within the Applicant's proposed Design Life (the 2060 Higher Central allowance), the risks to pedestrians are generally acceptable for trained staff. Some wave protection is necessary at ground levels either side of the quays to further reduce the hazard, and sufficient space exists within the

site to implement such protection, which would need to be >0.30m high. Overtopping is limited to a low enough flow that the only concern would be safety to vehicles driving at a moderate to high speed. This would not be expected behaviour in the context of an industrial site. Buildings and equipment would not be at risk.

7.4.5 Within the Environment Agency's required assessment period (to 2105), the risks to pedestrians on the site edge may be significant, as may the risks to vehicles. Provided buildings are not set at the very edge of the site, their exposure to structural damage should be low. Equipment should be set back at least 10m and may require additional raising or wave protection.

7.4.6 Where assets are not immediately sited on the edge of the Main Site, they will benefit further from reduction of the waves caused by the low depths of flooding. Even allowing 0.23m for uncertainty on top of the 0.5% AEP 2130 Higher Central exceedance event, flood depths over the minimum ground level of 5.08mAOD would be a maximum of 0.28m. This would limit significant wave heights to 0.15m high, which would pose no risk to buildings raised to the More Vulnerable threshold level.

7.4.7 Ultimately, these residual risks are controllable. Risks to pedestrians and vehicles can be controlled through response procedures and restricting access during flood events. The actual exposure can be minimised by setting back development from the site edge, and / or incorporation of low bunding at the edge of site or beside development. Modelling has demonstrated that raising the ground levels of the site has negligible impact on flood risk to adjacent sites, and this gives the freedom to undertake such measures without concerns for flood displacement.

7.4.8 There is some uncertainty in the understanding of this hazard. The papers used relate the hazard to an average overtopping flow, but the analyses are based on coastal waves. Coastal waves have a highly randomised behaviour that mean the highest waves within a given wave state may produce far higher overtopping flows than the average waves, and it is these waves which will define a lot of the hazard. In the more sheltered context of the site, this effect will not be so marked, and hence the hazard will be significantly lower than suggested by the papers.

7.4.9 It is recommended that more detailed wave modelling is carried out as detailed design progresses to support design of mitigation measures for wave hazard, particularly around the north and south ends of the quays, and more detailed identification of the hazard.

7.4.10 Given the uncertainty associated with understanding of the wave hazard (and likely conservatism in the current approach), where the detailed wave

modelling does not indicate a wave hazard to be managed within the 30 year worst case operational life of the proposed development, it is recommended that the residual risk associated with waves is managed using a managed adaptive approach, i.e. if a physical intervention is confirmed as being required later in the proposals' operational life, it can be implemented or investigated further then.

7.4.11 Such an approach recognises that the results of the modelling indicate extremely low sensitivity to development of the site, and therefore implementing a physical intervention later in the proposal's design life would not introduce any notable increase in flood risk to surrounding developments.

8 Model Sensitivity

8.1.1 The site is 5.5km from the Teesmouth breakwater, and as such, flood levels are dominated by the tidal boundary. For instance, the flood level at the tidal boundary for the 0.5% AEP 2105 Higher Central event is 4.835 mAOD, and the flood level at the site is 4.847mAOD, a 0.01m rise over 5.5km. This is a strong indicator of how insensitive levels at the site will be to change in modelling parameters, as essentially it says that the tidal boundary explains all but 1cm of the flood levels.

8.1.2 Because of this, sensitivity analysis of parameters other than the downstream boundary are highly unlikely to result in significant changes in water levels at the proposed development.

8.2 Downstream boundary

8.2.1 By comparison of the 0.5%AEP 2105 Higher Central and Upper End modelling results, it can be seen that modelling a 0.275m increase in the tidal boundary results in a 0.296m increase at the site.

8.3 Flow

8.3.1 A 10% increase in QMED was run in the baseline scenario as confirmation of model insensitivity. This resulted in increases in water level of 2-3mm at the site. Note that (per Section 5.5), only a 2% increase in QMED on the Tees was noted between 2010 and 2024.

9 Model proving

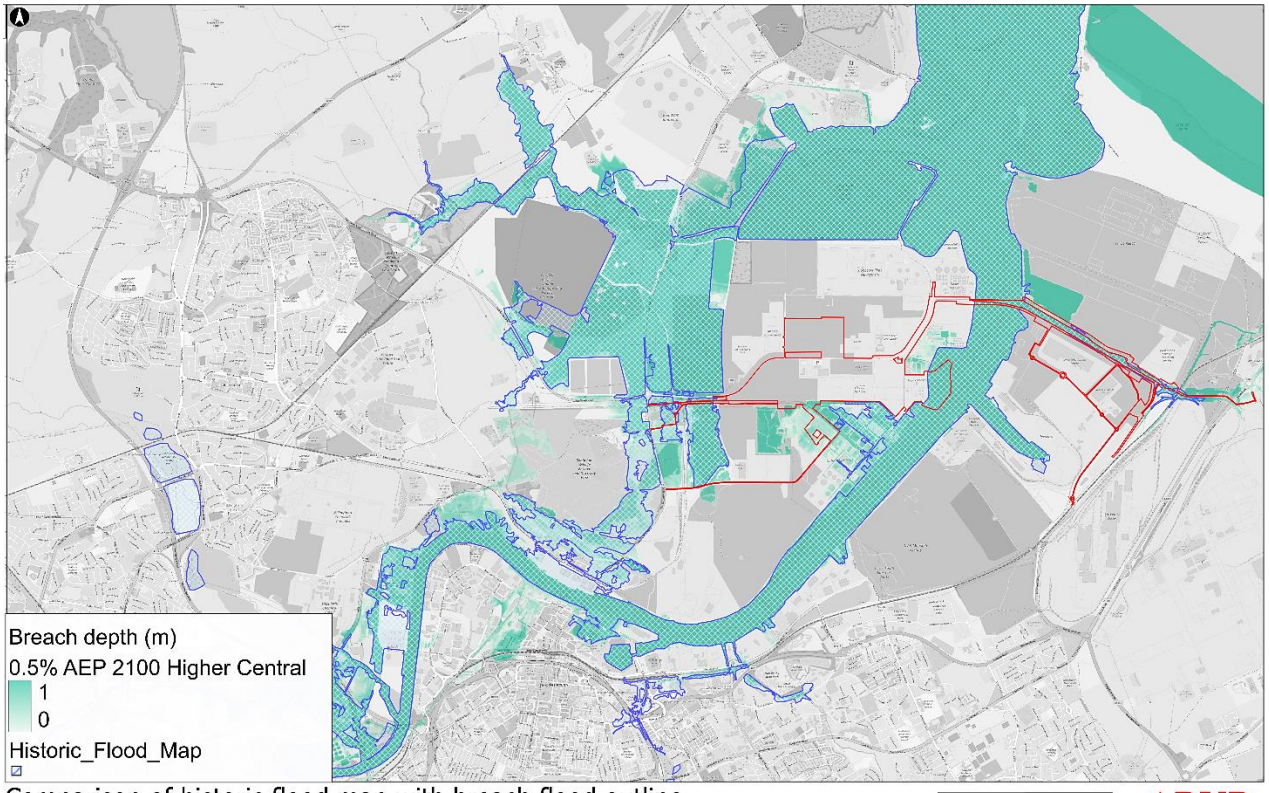
9.1 Hydrological and hydraulic calibration

9.1.1 The site is 5.5km from the downstream boundary, and flood levels are dominated by the tide. For instance, in the 0.5% AEP 2105 event, the peak flood level at the tidal boundary is 4.835mAOD, and the flood level at the site is 4.847mAOD, a 0.012m rise over 5.5km. This is a strong indicator of how insensitive levels at the site will be to change in modelling parameters, as essentially it says that the tidal boundary explains all but 1cm of the flood levels.

9.1.2 This implies that hydraulic and hydrological calibration will result in negligible change to flood levels at the site. The model updates are not expected to significantly impact the model's performance and cannot change the tidal boundary. It is therefore not proposed to recalibrate the model, or to repeat sensitivity tests undertaken in the 2020 study. Indeed, the 2020 model report noted that no formal calibration was possible with the data available.

9.2 Validation & Verification

9.2.1 Similarly, there is little technical merit to validation or verification for this site, although it is noted that the breach outline for Greatham Creek is closely comparable to the Dec 2013 recorded flooded outline, which was also due to a breach event at Greatham Creek (Inset 9.1).



Comparison of historic flood map with breach flood outline

Historic Flood Map data (c) Environment Agency copyright and/or database 2025. All rights reserved
Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors.

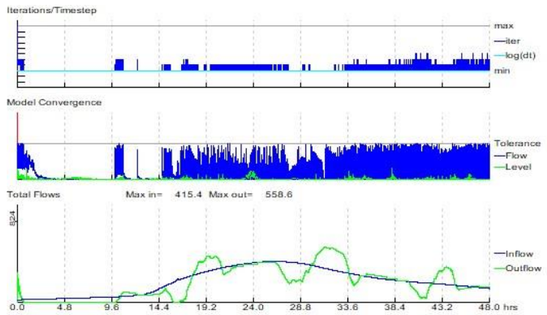
Inset 9.1 Comparison of historic flood map with Greatham Creek breach event

9.3 Model stability

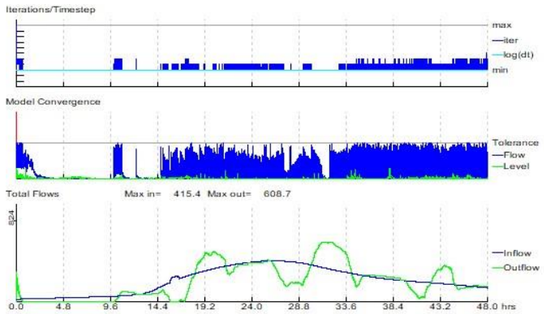
Stability

9.3.1 Convergence bitmaps from the model runs are shown overleaf. These show good convergence over the durations of all the model runs.

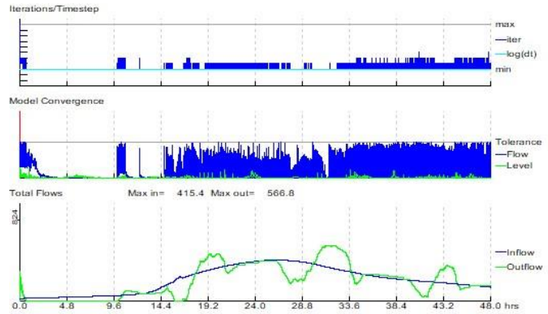
9.3.2 Figures in the following section show the model stability diagnostic parameters. With only the breach scenarios showing up to five unconverged timesteps in the FMP and no negative Estry depths, the simulations demonstrate excellent numerical stability.



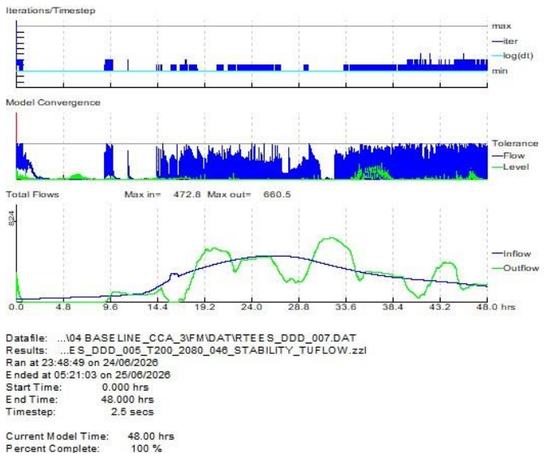
Baseline: 1% AEP 2030, 70th %ile (T100 Tidal)
(RTees_DDD_005_T100_2030_046_stability_TUFLOW.ief)



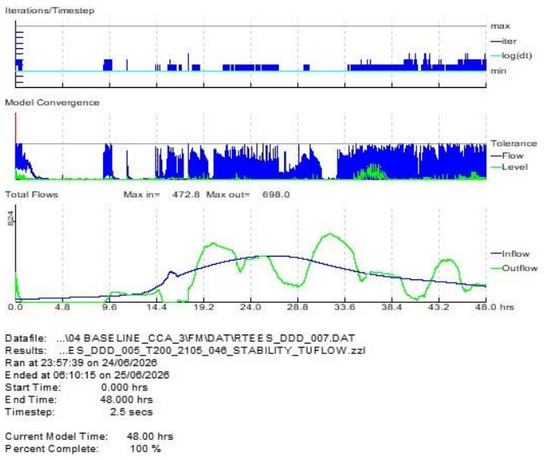
Baseline: 0.1% AEP 2030, 70th %ile (T1000 Tidal)
(RTees_DDD_005_T1000_2030_046_stability_TUFLOW.ief)



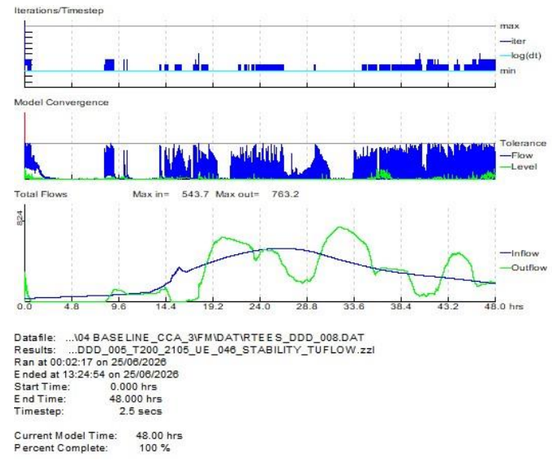
[redacted]



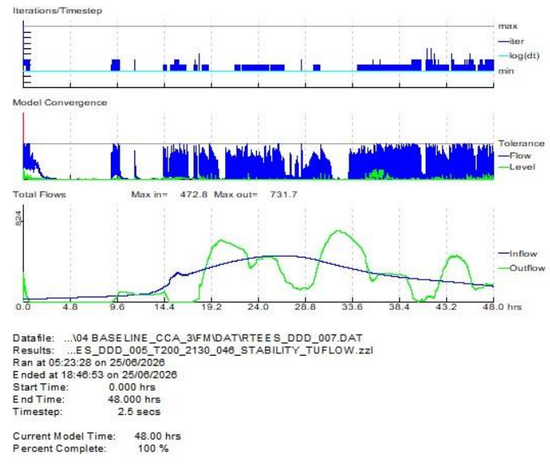
Baseline: 0.5% AEP 2080, 70th %ile (T200 Tidal)
(RTees_DDD_005_T200_2080_046_stability_TUFLOW.ief)



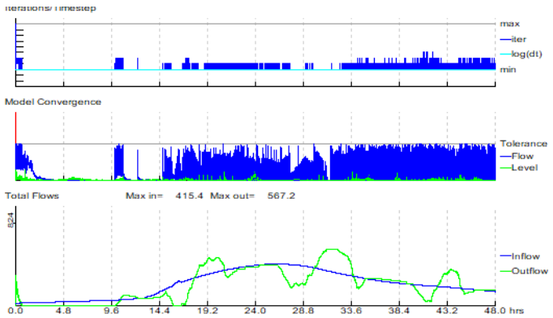
Baseline: 0.5% AEP 2105, 70th %ile (T200 Tidal)
(RTees_DDD_005_T200_2105_046_stability_TUFLOW.ief)



Baseline: 0.5% AEP 2105, 95th %ile (T200 Tidal)
(RTees_DDD_005_T200_2105_UE_046_stability_TUFLOW.ief)



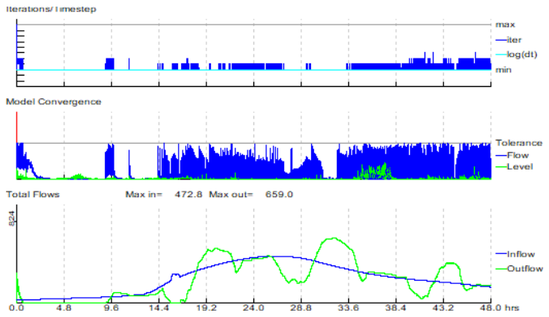
[redacted]



Datafile: ...\07 DEV4_CCA_3\FM\DAT\RTEES_DDD_006.DAT
Results: ...ES_DDD_005_T200_2030_048_STABILITY_TUFLOW.zzl
Ran at 18:39:38 on 07/08/2026
Ended at 00:04:12 on 08/08/2026
Start Time: 0.000 hrs
End Time: 48.000 hrs
Timestep: 2.5 secs

Current Model Time: 48.00 hrs
Percent Complete: 100 %

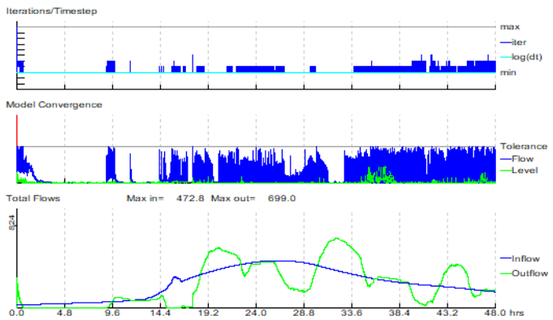
Design: 0.5% AEP 2030, 70th %ile (T200 Tidal)
(RTees_DDD_005_T200_2030_048_stability_TUFLOW.ief



Datafile: ...\07 DEV4_CCA_3\FM\DAT\RTEES_DDD_007.DAT
Results: ...ES_DDD_005_T200_2080_048_STABILITY_TUFLOW.zzl
Ran at 18:41:17 on 07/08/2026
Ended at 00:25:18 on 08/08/2026
Start Time: 0.000 hrs
End Time: 48.000 hrs
Timestep: 2.5 secs

Current Model Time: 48.00 hrs
Percent Complete: 100 %

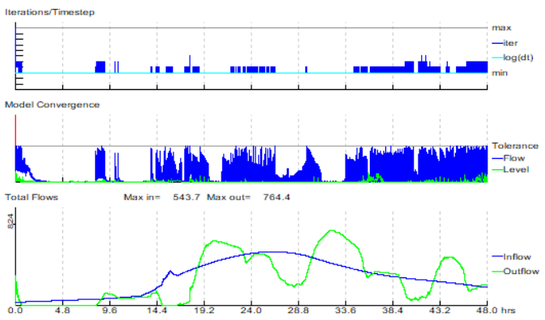
Design: 0.5% AEP 2080, 70th %ile (T200 Tidal)
(RTees_DDD_005_T200_2080_048_stability_TUFLOW.ief



Datafile: ...\07 DEV4_CCA_3\FM\DAT\RTEES_DDD_007.DAT
Results: ...ES_DDD_005_T200_2105_048_STABILITY_TUFLOW.zzl
Ran at 00:03:04 on 08/08/2026
Ended at 06:09:29 on 08/08/2026
Start Time: 0.000 hrs
End Time: 48.000 hrs
Timestep: 2.5 secs

Current Model Time: 48.00 hrs
Percent Complete: 100 %

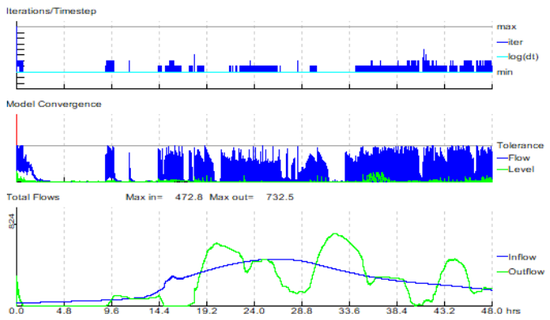
Design: 0.5% AEP 2105, 70th %ile (T200 Tidal)
(RTees_DDD_005_T200_2105_048_stability_TUFLOW.ief



Datafile: ...\07 DEV4_CCA_3\FM\DAT\RTEES_DDD_008.DAT
Results: ...DDD_005_T200_2105_UE_048_STABILITY_TUFLOW.zzl
Ran at 00:05:28 on 08/08/2026
Ended at 13:13:19 on 08/08/2026
Start Time: 0.000 hrs
End Time: 48.000 hrs
Timestep: 2.5 secs

Current Model Time: 48.00 hrs
Percent Complete: 100 %

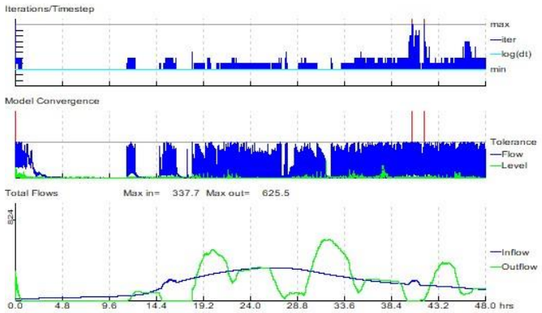
Design: 0.5% AEP 2105, 95th %ile (T200 Tidal)
(RTees_DDD_005_T200_2105_UE_048_stability_TUFLOW.ief



Datafile: ...\07 DEV4_CCA_3\FM\DAT\RTEES_DDD_007.DAT
Results: ...ES_DDD_005_T200_2130_048_STABILITY_TUFLOW.zzl
Ran at 00:26:49 on 08/08/2026
Ended at 13:47:07 on 08/08/2026
Start Time: 0.000 hrs
End Time: 48.000 hrs
Timestep: 2.5 secs

Current Model Time: 48.00 hrs
Percent Complete: 100 %

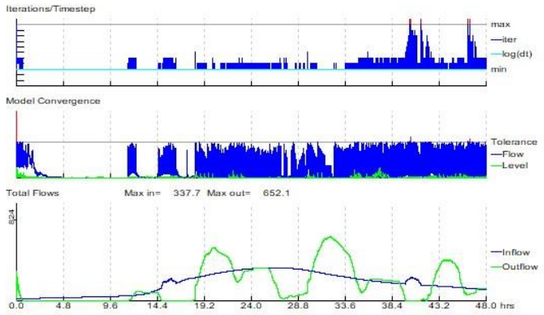
Design: 0.5% AEP 2130, 95th %ile (T200 Tidal)
(RTees_DDD_005_T200_2130_048_stability_TUFLOW.ief



Datafile: ...\05 DEV1BREACH1\FM\DAT\RTEES_DDD_005.DAT
Results: ...ES_DDD_005_T200_2100_040_STABILITY_TUFLOW.zzl
Ran at 18:53:30 on 13/05/2026
Ended at 00:49:34 on 14/05/2026
Start Time: 0.000 hrs
End Time: 48.000 hrs
Timestep: 2.5 secs

Current Model Time: 48.00 hrs
Percent Complete: 100 %

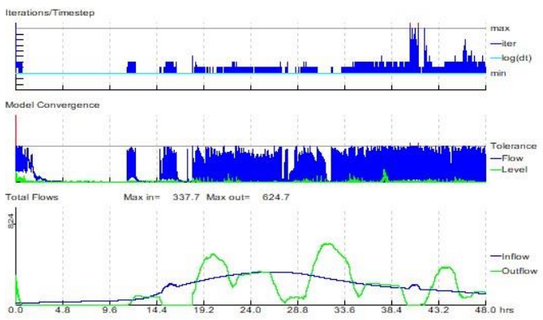
Breach-1: 0.5% AEP 2100 70th %ile (T200 Tidal)
RTees_DDD_005_T200_2100_040_stability_TUFLOW.ief



Datafile: ...\05 DEV1BREACH1\FM\DAT\RTEES_DDD_005.DAT
Results: ...DDD_005_T200_2100_UE_040_STABILITY_TUFLOW.zzl
Ran at 18:56:06 on 13/05/2026
Ended at 07:05:18 on 14/05/2026
Start Time: 0.000 hrs
End Time: 48.000 hrs
Timestep: 2.5 secs

Current Model Time: 48.00 hrs
Percent Complete: 100 %

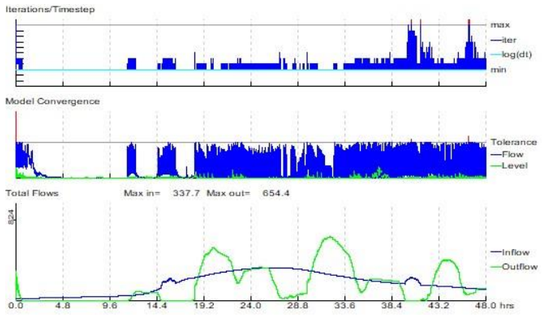
Breach-1: 0.5% AEP 2100 95th %ile (T200 Tidal)
RTees_DDD_005_T200_2100_UE_040_stability_TUFLOW.ief



Datafile: ...\05 DEV1BREACH2\FM\DAT\RTEES_DDD_005.DAT
Results: ...ES_DDD_005_T200_2100_042_STABILITY_TUFLOW.zzl
Ran at 10:12:08 on 14/05/2026
Ended at 16:33:44 on 14/05/2026
Start Time: 0.000 hrs
End Time: 48.000 hrs
Timestep: 2.5 secs

Current Model Time: 48.00 hrs
Percent Complete: 100 %

Breach-2: 0.5% AEP 2100 70th %ile (T200 Tidal)
RTees_DDD_005_T200_2100_042_stability_TUFLOW.ief



Datafile: ...\05 DEV1BREACH2\FM\DAT\RTEES_DDD_005.DAT
Results: ...DDD_005_T200_2100_UE_042_STABILITY_TUFLOW.zzl
Ran at 10:08:19 on 14/05/2026
Ended at 23:09:10 on 14/05/2026
Start Time: 0.000 hrs
End Time: 48.000 hrs
Timestep: 2.5 secs

Current Model Time: 48.00 hrs
Percent Complete: 100 %

Breach-2: 0.5% AEP 2100 95th %ile (T200 Tidal)
RTees_DDD_005_T200_2100_UE_042_stability_TUFLOW.ief

Table 9.1 Model stability diagnostic parameters

Epoch	Event	FMP unconverged timesteps	FMP mass balance error (of peak system volume)	FMP mass balance error (of boundary inflow volume)	TUFLOW 1D (Estry) negative depths	TUFLOW 2D negative depths	TUFLOW cumulative ME
Baseline scenario							
2030	1% 0.5% 0.1%	0 0 0	-0.61% -0.60% -0.41%	-0.12% -0.12% -0.09%	0 0 0	0 4 7	-0.02% -0.02% -0.03%
2080	0.5%	0	-0.51%	-0.10%	0	16	-0.06%
2105	0.5%	0	-0.41%	-0.09%	0	271	-0.14%
2105_UE	0.5%	0	-0.38%	-0.08%	0	0	-0.23%
2130	0.5%	0	-0.43%	-0.10%			-0.23%
Development scenario							
2030	0.5%	0	-0.60%	-0.12%	0	0	-0.02%
2080	0.5%	0	-0.51%	-0.10%	0	17	-0.06%
2105	0.5%	0	-0.48%	-0.10%	0	281	-0.14%
2105_UE	0.5%	0	-0.39%	-0.08%	0	0	-0.23%

Epoch	Event	FMP unconverged timesteps	FMP mass balance error (of peak system volume)	FMP mass balance error (of boundary inflow volume)	TUFLOW 1D (Estry) negative depths	TUFLOW 2D negative depths	TUFLOW cumulative ME
2130	0.5%	0	-0.42%	-0.10%	0	0	-0.23%
Breach-1 scenario							
2100	0.5%	5	-0.34%	-0.09%	0	284	-0.11%
2100_UE	0.5%	5	-0.42%	-0.12%	0	0	-0.19%
Breach-2 scenario							
2100	0.5%	2	-0.43%	-0.12%	0	351	-0.11%
2100_UE	0.5%	4	-0.41%	-0.12%	0	0	-0.19%

9.4 Mass balance

1D Mass Balance

9.4.1 For the Baseline scenarios, the 1D mass balance error (of peak system volume) ranges from -0.38% to -0.61%. The range is slightly shorter for the Development scenarios as -0.38% to -0.60%. For the Breach scenarios, it ranges from -0.34% to -0.41%.

9.4.2 For the Baseline scenarios, the 1D mass balance error (of boundary inflow volume) ranges from -0.08% to -0.12%. The range remains the same for the Development scenarios. For the Breach scenarios, it ranges from -0.09% to -0.12%.

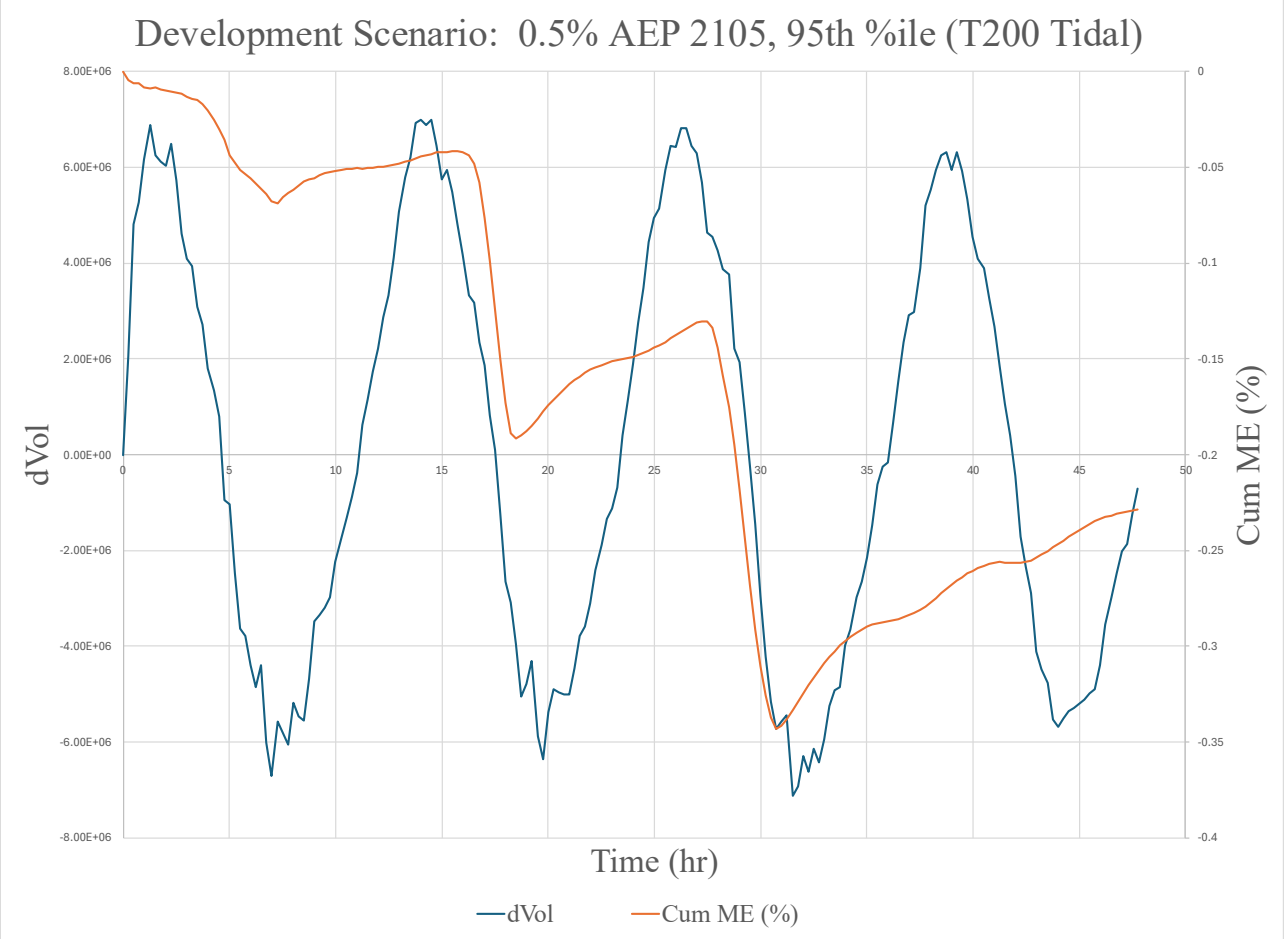
9.4.3 The 1D mass balance errors for all the simulations are substantially below ±0.5%, thus demonstrating excellent numerically stable model simulations.

2D Mass Balance

9.4.4 With up to 351 negative depths in TUFLOW and up to -0.14% of cumulative mass error for the corresponding simulations; and with the rest of the simulations resulting in cumulative mass errors of up to -0.23%, the cumulative mass balance errors are substantially below ±0.5%, thus demonstrating excellent numerically stable model simulations.

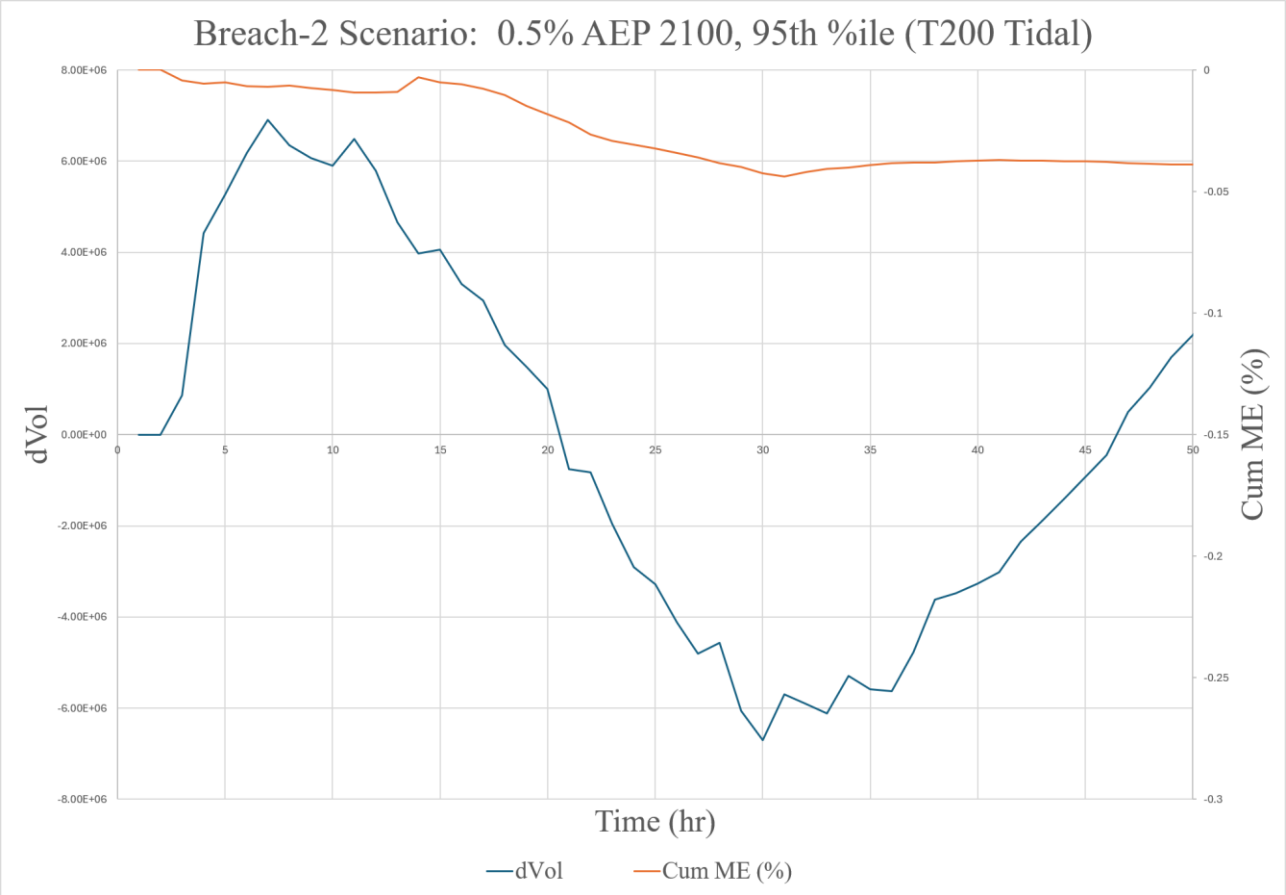
Cumulative Mass Error & Volume Change plots

9.4.5 Presented here are two plots of cumulative mass error (ME%) and volume change (dVol) plots, the first for the 0.5% AEP 2105, 95th %ile (T200 Tidal) Development scenario (Figure 12), and the second for the 0.5% AEP 2100, 95th %ile (T200 Tidal) breach scenario for Breach-2, (Inset 9.2).



Inset 9.2 Cumulative mass error and volumetric changes, 0.5% AEP 2105 Upper End scenario

9.4.6 The plot for the Development scenario shows cyclical volume changes consistent with a tidal model. The mass balance error keeps on falling and improving. Given the low value of CE at -0.23% relative to the volume exchanges, the model results can be treated as meeting industry standards.



Inset 9.3 Cumulative mass error and volumetric changes, Breach 2 0.5% AEP 2105 Upper End scenario

9.4.7 The plot for the breach scenario shows comparatively lesser fluctuations in CE with it being comparatively lower at -0.19%. The volume exchange behaviour remains consistent with the earlier relevant observation.

9.5 Changes to default parameters

Table 9.2 1d Run Parameters

Parameter	Value	Difference to normal	Justification
Start	0 hours	N/A	Unchanged from the inherited model
Finish	48 hours	N/A	Unchanged from the inherited model
Timestep	2.5 second	N/A	See Section 9.6
Dflood	3	--	All non-standard parameters were included in the model as inherited. These were already set to default values.
Minitr	3	--	
Maxitr	11	--	
NewMatrixDummy	0.1	--	
PivotalChoice	0.1	--	
MatrixDummy	0	--	

Table 9.3 2D Run Parameters

Parameter	Value	Difference to normal	Justification
Timestep	5 or 2.5 second (TUFLOW) 1 second (ESTRY)	N/A	See Section 9.6
Boundary Viscosity Factor	1	--	Default

9.6 Timestep

9.6.1 The 1D time step is 2.5 second. The grid size selected (10m) was based on balancing accuracy with model run time. A 2D timestep of 20-50% of the magnitude of the grid cell size is required, and 5 second is 50% of this, which is within the correct range. The 2D timestep must be an integer multiple of the 1D timestep (including a multiple of 1), and consequently 5 second was chosen as a balance between run time and accuracy. However, for improving stability, two simulations have been run with 2D timestep of 2.5 second.

10 Limitations of modelling

10.1.1 Noting the very low sensitivity of flood levels at the site to modelling parameters other than the tidal boundary, and the high levels of residual confidence to the modelled breach scenarios, there is high confidence to be had from this modelling for the Lighthouse Green Fuels site.

10.1.2 Other locations within the model may not be subject to the same level of confidence.

10.1.3 Wave calculations used in the assessment wave hazard are based on a desk study approach, and more detailed modelling is recommended to support assessment at detailed design.

11 Conclusions

11.1.1 Flood risk to the Lighthouse Green Fuels site has been modelled using a Flood Modeller Pro - Tuflow numerical model based on the 2020 update to the Tidal Tees model.

11.1.2 Bathymetry, site topography, LiDAR and tidal boundaries have been updated in the model to use more recent data.

11.1.3 The water levels at the site are highly insensitive to most model parameters other than the tidal boundary.

11.1.4 Breach analyses from the baseline model show that the site is at a high level compared to breach flood levels and would not be at direct risk. However, transport links that the site depends on may be flooded.

11.1.5 Baseline water levels have been used to identify suitable site design levels, guided by a Residual Uncertainty Assessment.

11.1.6 Site proposals, comprising increased ground levels for the site, creation of a new quay and dredging of a berth pocket, have been represented in the model and remodelled. These do not lead to significant changes in flood risk; main-channel water levels change by <1mm.

11.1.7 A residual risk is noted due to wave hazard, which during the Applicant's proposed 30-year operational life can be managed by wave protection to ground levels at the north and south ends of the quays, and should be assessed in greater detail at detailed design. Beyond the 30-year operational life, wave hazards will develop at other locations, and it is proposed that these can be managed on a managed adaptive basis.

12 Model Log

The model log is included as part of this modelling submission as Attachment D.

Attachment A List of model files

A.1 1D model files

Geometry files

A.1.1 Baseline scenario

- RTees_DDD_006.DAT – 23% fluvial CCA
- RTees_DDD_007. DAT – 40% fluvial CCA
- RTees_DDD_008. DAT – 61% fluvial CCA

A.1.1 Development Scenario

- RTees_DDD_006. DAT – 23% fluvial CCA
- RTees_DDD_007. DAT – 40% fluvial CCA
- RTees_DDD_008. DAT – 61% fluvial CCA

A.1.1 Breach-1 & 2 Scenarios

- RTees_DDD_005.DAT – No CCA

A.1.1 Event and Scenario Files

- N/A. Inflows are read from DAT file and Estry+TUFLOW files

Run Files

A.1.1 Baseline scenario

- RTees_DDD_005_T100_2030_046_stability_TUFLOW.ief
- RTees_DDD_005_T200_2030_046_stability_TUFLOW.ief
- RTees_DDD_005_T1000_2030_046_stability_TUFLOW.ief
- RTees_DDD_005_T200_2080_046_stability_TUFLOW.ief
- RTees_DDD_005_T200_2105_046_stability_TUFLOW.ief
- RTees_DDD_005_T200_2105_UE_046_stability_TUFLOW.ief
- RTees_DDD_005_T200_2130_046_stability_TUFLOW.ief

A.1.1 Development Scenario

- RTees_DDD_005_T100_2030_048_stability_TUFLOW.ief
- RTees_DDD_005_T200_2030_048_stability_TUFLOW.ief
- RTees_DDD_005_T1000_2030_048_stability_TUFLOW.ief

- RTees_DDD_005_T200_2080_048_stability_TUFLOW.ief
- RTees_DDD_005_T200_2105_048_stability_TUFLOW.ief
- RTees_DDD_005_T200_2105_UE_048_stability_TUFLOW.ief
- RTees_DDD_005_T200_2130_048_stability_TUFLOW.ief

A.1.1 Breach-1 Scenario

- RTees_DDD_005_T200_2100_041_stability_TUFLOW.ief
- RTees_DDD_005_T200_2100_UE_041_stability_TUFLOW.ief

A.1.1 Breach-2 Scenario

- RTees_DDD_005_T200_2100_041_stability_TUFLOW.ief
- RTees_DDD_005_T200_2100_UE_041_stability_TUFLOW.ief

A.2 2D Model Files

TUFLOW Control Files

A.2.1 Links to TUFLOW Geometry Control, TUFLOW Boundary Control, TUFLOW Materials Files, and the 1D-2D definition shapefiles. Also sets file output locations and control parameters, including some non-default values.

A.2.1 Baseline scenario

- RTees_010_T100_2030_046_stability.tcf
- RTees_010_T200_2030_046_stability.tcf
- RTees_010_T1000_2030_046_stability.tcf
- RTees_010_T200_2080_046_stability.tcf
- RTees_010_T200_2105_046_stability.tcf
- RTees_010_T200_2105_UE_046_stability.tcf
- RTees_010_T200_2130_046_stability.tcf

A.2.1 Development Scenario

- RTees_010_T200_2030_048_stability.tcf
- RTees_010_T200_2080_048_stability.tcf
- RTees_010_T200_2105_048_stability.tcf
- RTees_010_T200_2105_UE_048_stability.tcf
- RTees_010_T200_2130_048_stability.tcf

A.2.1 Breach-1 Scenario

- RTees_010_T200_2100_041_stability.tcf
- RTees_010_T200_2100_UE_041_stability.tcf

A.2.1 Breach-2 Scenario

- RTees_010_T200_2100_042_stability.tcf
- RTees_010_T200_2100_UE_042_stability.tcf

TUFLOW Geometry Control

A.2.1 Links to all topographical and roughness definition shapefiles, including setting the grid cell size and grid size. May contains control logic to read in the correct set of formal and informal defences by scenario and epoch.

- **Baseline scenario:** RTees_010_ISISESTRY_040_CC_stability.tgc
- **Development Scenario:** RTees_010_ISISESTRY_046_CC_stability.tgc
- **Breach-1 Scenario:** RTees_010_ISISESTRY_041_CC_stability.tgc
- **Breach-2 Scenario:** RTees_010_ISISESTRY_042_CC_stability.tgc

TUFLOW Boundary Control

A.2.1 Links to 1D-2D boundary definition shapefiles only.

- **All scenarios:** RTees_010_ESTRY_020_stability.tbc

TUFLOW Materials File

A.2.1 Comma-separated file linking MasterMap land-use codes to Manning's n roughness values for the roughness coverage shapefiles.

- **All scenarios:** materials3.tmf

Geospatial Data

A.2.1 The new model files created in the course of this project are tabulated below.

Category	Filename	Purpose
2D Topography	EA_2022_LiDAR_downloaded_on_20Apr2026_2x2.tif	LiDAR elevation surface
2D Topography	Retain_prev_DTM_clipped_2.tif	Existing terrain model
2D Topography	26-4-13_PD_baseline_bathy_OrdnceDatum_1x1_v2.tif	Bathymetry surface
2D Topography	26-05-06_BaselineBathy_1x1.tif	Additional bathymetry surface covering channel between site and the ship turning semi-circle
2D Topography	T250658-DR-T-001-011_clipped.tif	Scheme terrain surface
2D Topography	Dev1_merged_v2_clipped.tif	Quay design DTM
2D Topography modifications	2d_zsh_wing_walls_Dev1_L.shp and 2d_zsh_wing_walls_Dev1_P.shp	Quay wing walls
2D Topography modifications	2d_zsh_Quay_Dev1_R.shp and 2d_zsh_Quay_Dev1_P.shp	Quay
2D Topography modifications	2d_zsh_Main_Site_Dev4_v2_R.shp	Site at elevation 5.08 mAOD
2D Topography modifications	2d_zsh_Roads_Dev2_R.shp	Roads at elevation 5.23 mAOD (0.15m) higher
2D Topography modifications	2d_zsh_Bunds_Dev3_R.shp	Containment bunds as platforms at elevation 5.88 mAOD (0.8m higher)
2D Topography modifications	2d_zsh_Buildings_Dev3_R.shp	Buildings and plants at elevation 5.68 mAOD (0.6m higher)
2D Materials	2d_mat_OSM2026.shp	OSM-derived roughness layer
2D Materials	2d_mat_Dev1.shp	Manning's n values for Quay
2D Materials	2d_mat_Dev4_Main_Site.shp	Manning's n values for the main site
2D Materials	2d_mat_Dev3.shp	Manning's n values for development components
Breach-1	2d_vzsh_Port_Clarence_R.shp and 2d_vzsh_Port_Clarence_P.shp	For Port Clarence embankment breach model
Breach-2	2d_vzsh_LGF_Greatham_Creek_R.shp and 2d_vzsh_LGF_Greatham_Creek_P.shp	For Greatham Creek embankment breach model

A.2.1 Other inherited geospatial data model files are tabulated below.

Category	Filename
2D TIN	2d_ztin_RTees_def_GCN_001.MIF
2D TIN	2d_ztin_RTees_def_GCS_001.MIF
2D TIN	2d_ztin_RTees_PCbund_001.MIF
2D Elevation Modifiers	2d_zsh_RTees_GC_Estuary_003.MIF
2D Elevation Modifiers	2d_zsh_RTees_OB_002.MIF
2D Elevation Modifiers	2d_zln_RTees_Def_NFCDD_005.MIF
2D Boundary Conditions	2d_bc_RTees_002.MIF
2D Boundary Conditions	2d_bc_RTees_GC_003.MIF
2D Boundary Conditions	2d_bc_RTees_Barr_006.MIF
2D HX/SX Links	2d_bc_hx_RTees_SB_003_KB.MIF
2D Materials	2d_mat_RTees_Naturalpatch_001.MIF
2D Materials	2d_mat_RTees_Natural_003.MIF
2D Materials	2d_mat_RTees_Manmade_003.MIF
2D Materials	2d_mat_RTees_Bldg_002_CROP.MIF
Flow Constrictions	2d_fcsh_RTees_constrict_002.MIF
Flow Constrictions	2d_fcsh_RTees_ISISPatch_001.MIF
1D Network	1d_nwk_RTees_SB_003_KB.mif
1D Network	1d_nwk_RTees_BB_001_PC.mif
1D Network	1d_nwk_RTees_ORT_003D.mif
1D Network	1d_nwk_RTees_LB_002_PC.mif
1D Network	1d_nwk_RTees_FlowLink_006.mif
1D Cross Sections	1d_xs_RTees_SB_003.mif
1D Cross Sections	1d_xs_RTees_BB_001.mif
1D Cross Sections	1d_xs_RTees_ORT_003D.mif
1D Cross Sections	1d_xs_RTees_LB_002.mif
1D Boundaries	1d_bc_RTees_SB_003.mif
1D Boundaries	1d_bc_RTees_BB_002.mif
1D Boundaries	1d_bc_RTees_ORT_001.mif
1D Boundaries	1d_bc_RTees_LB_001.mif
FMP–TUFLOW Link	1d_x1d_isis_nodes_RTees_002.MIF

A.2.1 The files in the TUFLOW boundary database are listed below.

- bc_dbase_RTees_001.csv
- bc_dbase_RTees_002_23per_CCA.csv
- bc_dbase_RTees_002_40per_CCA.csv
- bc_dbase_RTees_002_61per_CCA.csv
- flist.txt
- T1000_2030.csv
- T100_2030.csv
- T200_2030.csv
- T200_2080.csv
- T200_2105.csv
- T200_2105_UE.csv
- T200_2130.csv

Attachment B Proposed approach to modelling consulted with Environment Agency

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Proposed modelling approach for FRA

Lighthouse Green Fuels

15/04/2026

ARUP

Contents

- Site proposals and context
- FRA assumptions
- Baseline updates
- Design updates
- Resilience checks

Context

Site proposals

- NSIP
- Sustainable aviation fuel manufacture
- Essential Infrastructure

- 25yr design life

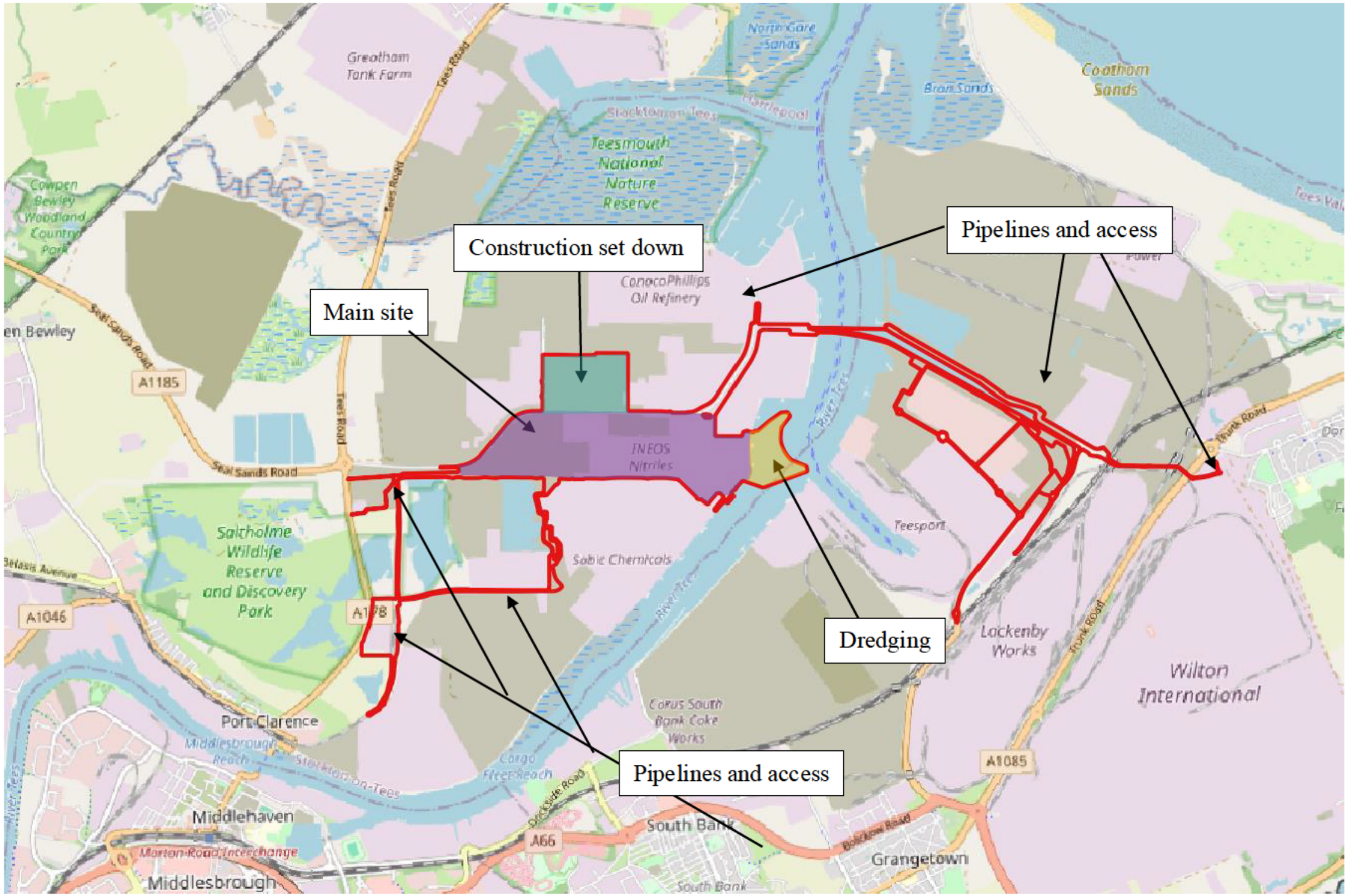
- Quay construction and dredging
- Ground raising or riverside flood defence

Highly vulnerable

- Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding.
- Emergency dispersal points.
- Basement dwellings.
- Caravans, mobile homes and park homes intended for permanent residential use.
- Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure'.)

Context

Site proposals



Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors

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Context

Site proposals

- Jetty removal

- Quay
- for bringing components in construction phase
- for bringing feedstock in operational phase

- Berth pocket for ships

- More flood resilient
- quay may not be required to function during a flood event

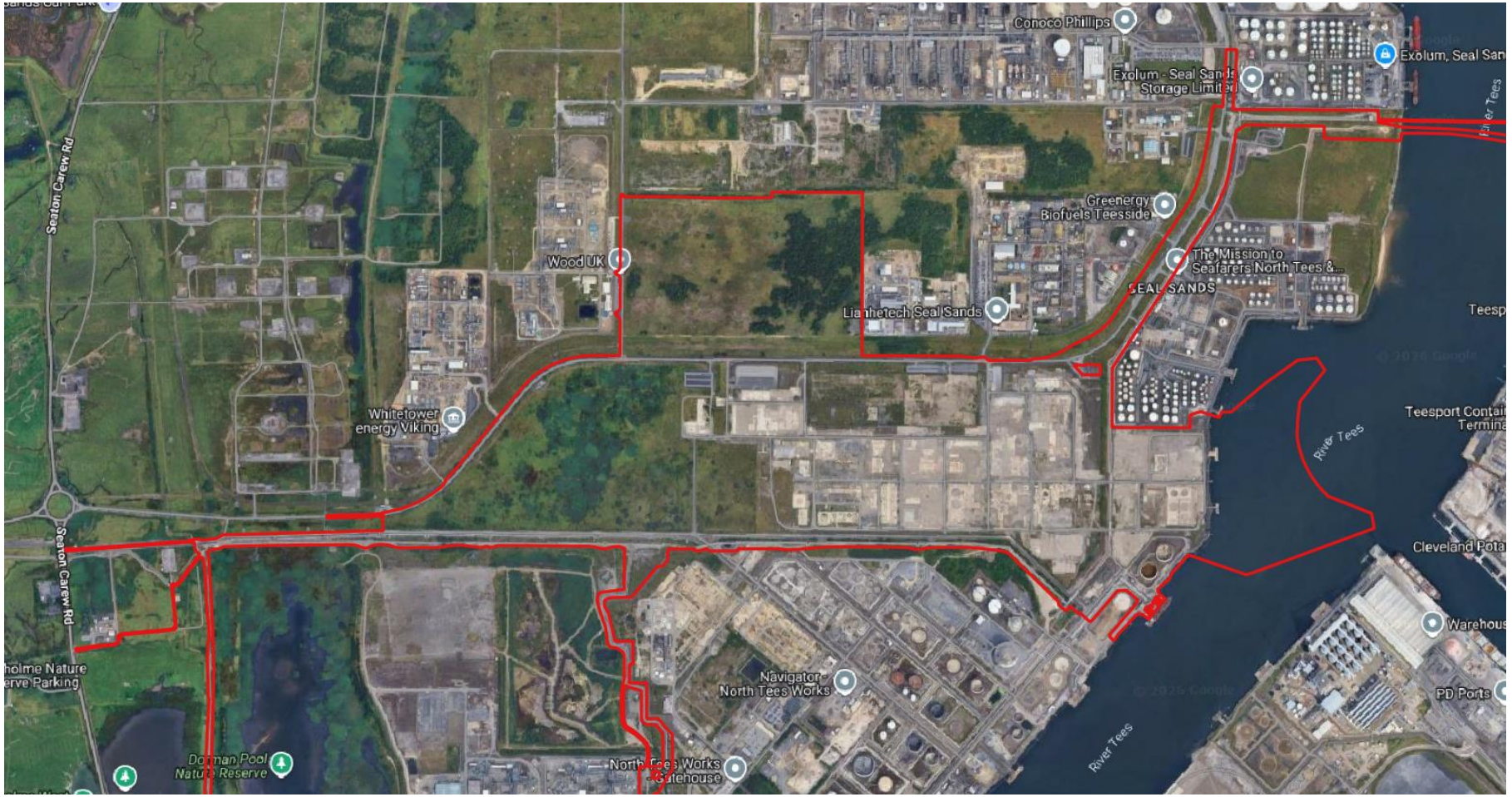


Imagery © Google.com/Maps 2026

Context

Site proposals

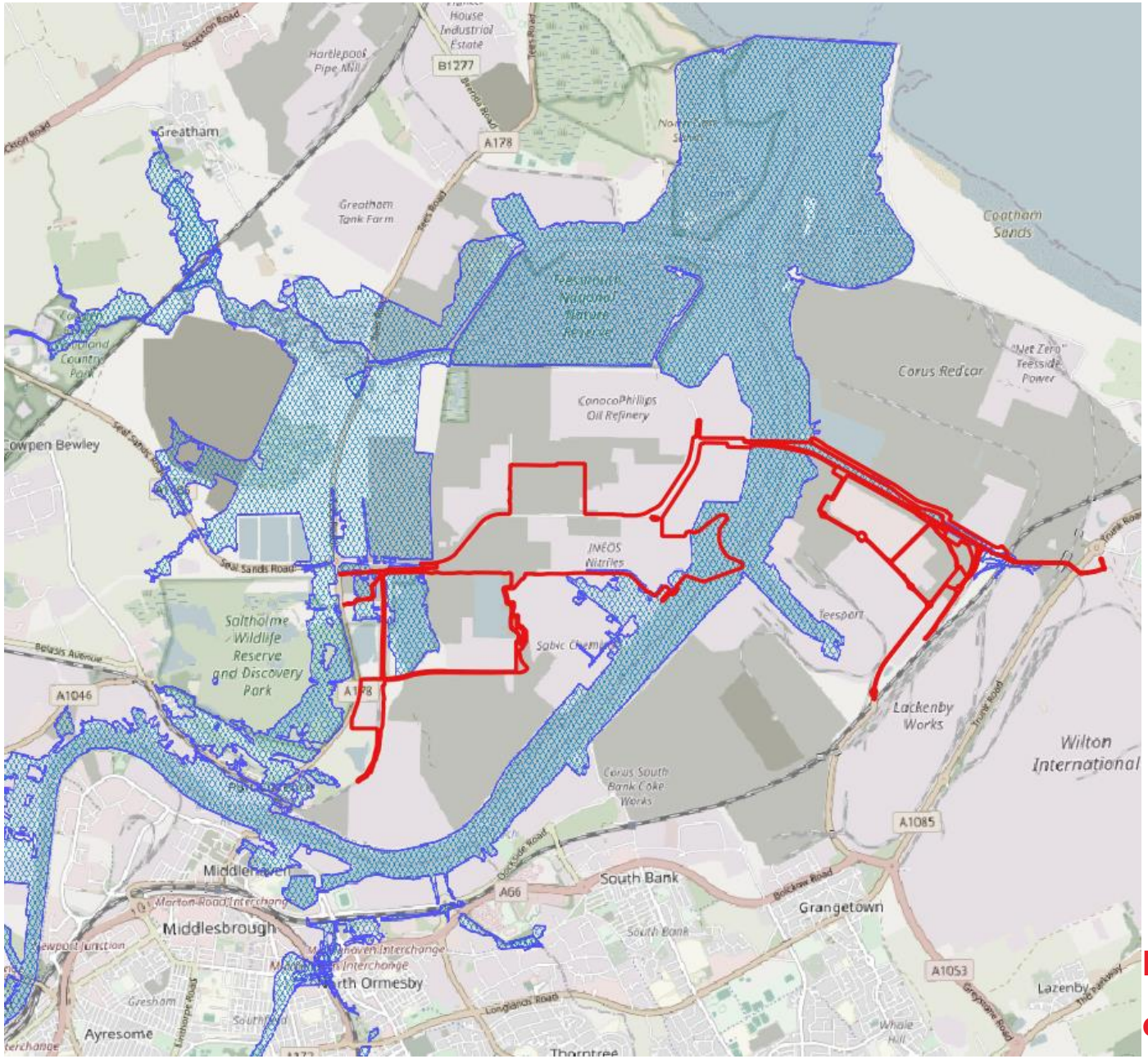
- Ground pipe corridors
- Biomass generating plant for site as a primary user.



Context

Site proposals

Low risk from surface water or ground water flooding



Recorded flood outline

Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors

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Tiered approach from PEIR

Raise ground levels	5.08mOD	200yr 2100 higher central +0.30m
Adaptable / less vulnerable components	5.38mOD	200yr 2100 higher central +0.60m
Fixed / vulnerable components	5.68mOD	200yr 2100 upper end +0.60m
Sensitivity scenario	5.86mOD	200yr H++ 2100

Potential alternative – quayside flood defence

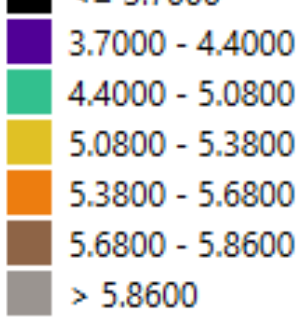
While site is all classed as essential infrastructure, not all components need to remain operational in a flood, some elements are inherently flood resilient. Are the EA open to differentiation of standards of protection?

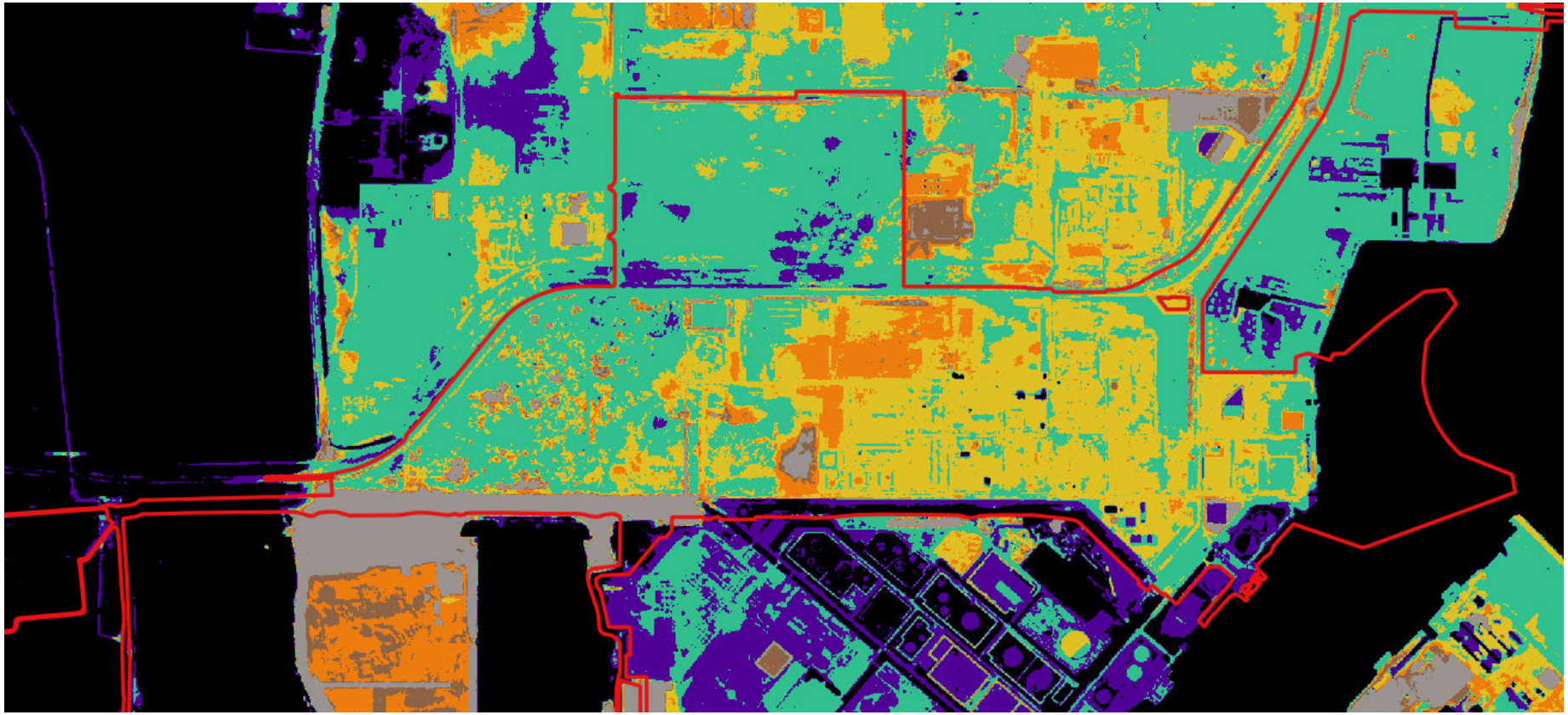
LiDAR Ground elevations

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Site elevation

Raise ground levels	5.08mOD	200yr 2100 higher central +0.30m
Adaptable / less vulnerable components	5.38mOD	200yr 2100 higher central +0.60m
Raise vulnerable / fixed components	5.68mOD	200yr 2100 upper end +0.60m
Sensitivity scenario	5.86mOD	200yr H++ 2100



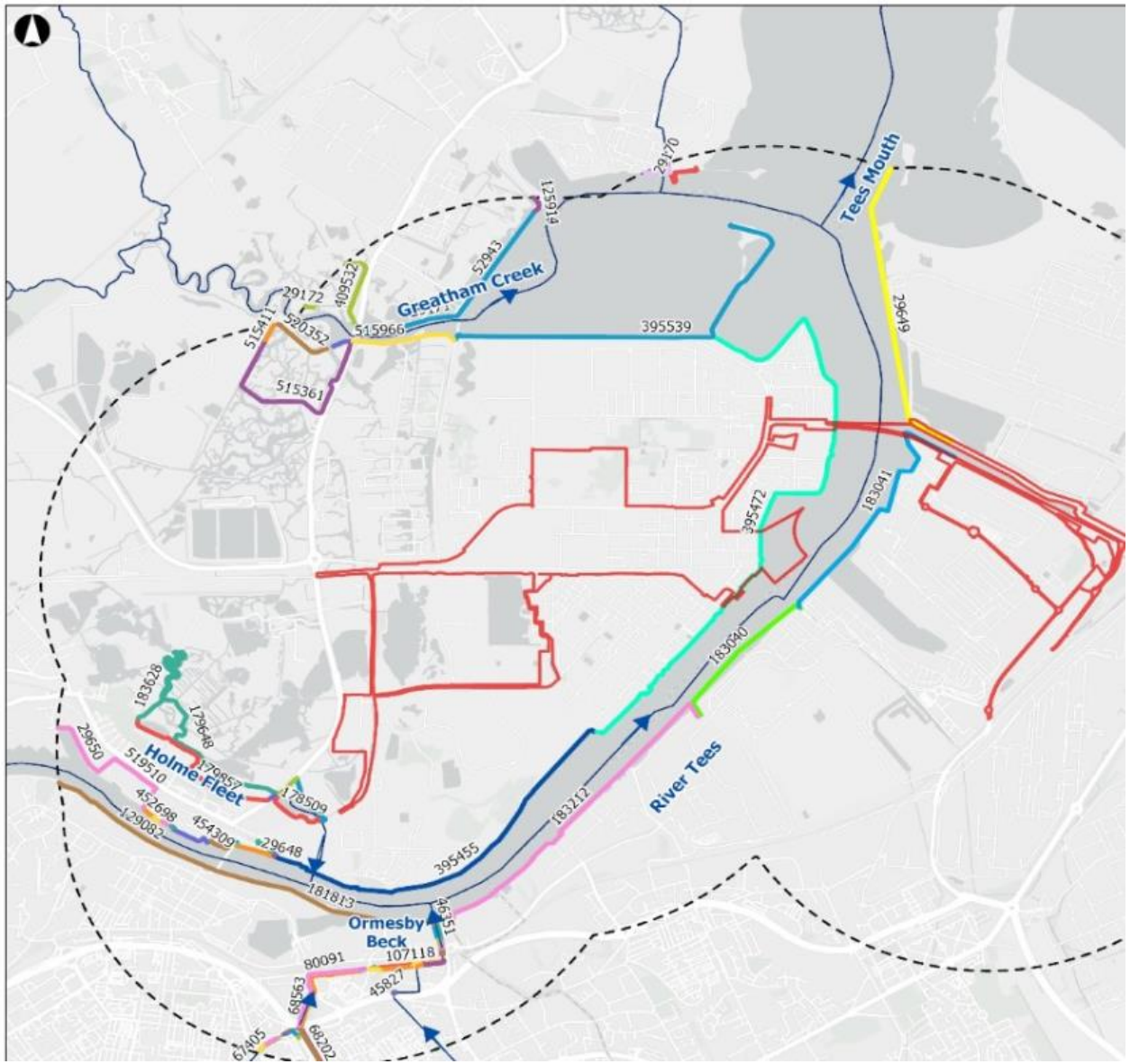


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LiDAR Ground elevations

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“Defences”, but…



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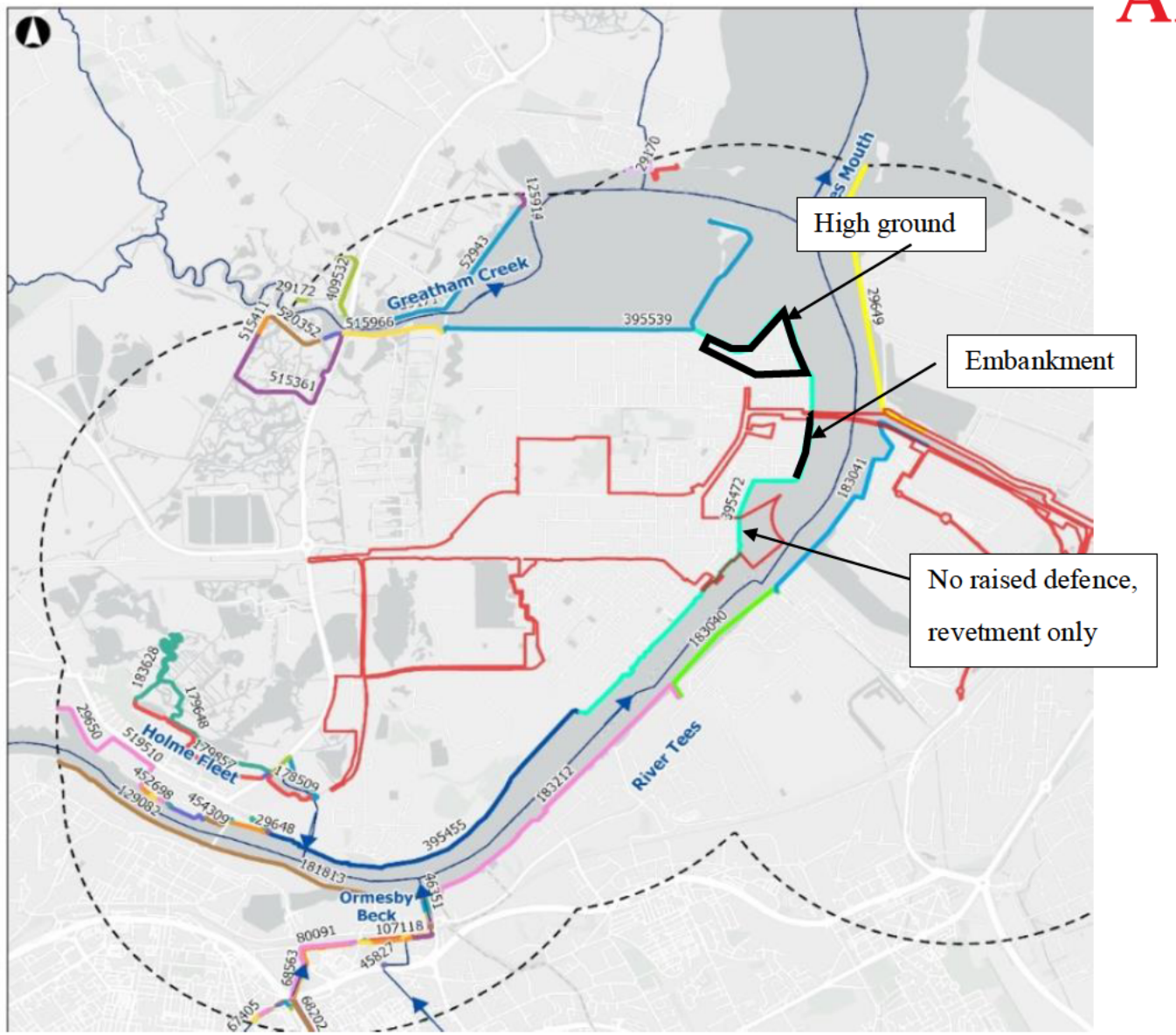
AIMS data © Environment Agency copyright and/or database right 2025. All rights reserved

FRA

Defences, but…

- Revetment is listed in EA Flood Defence Asset dataset, but does not provide a defence function

❖ Does 16m set back & unrestricted access for defences still apply?



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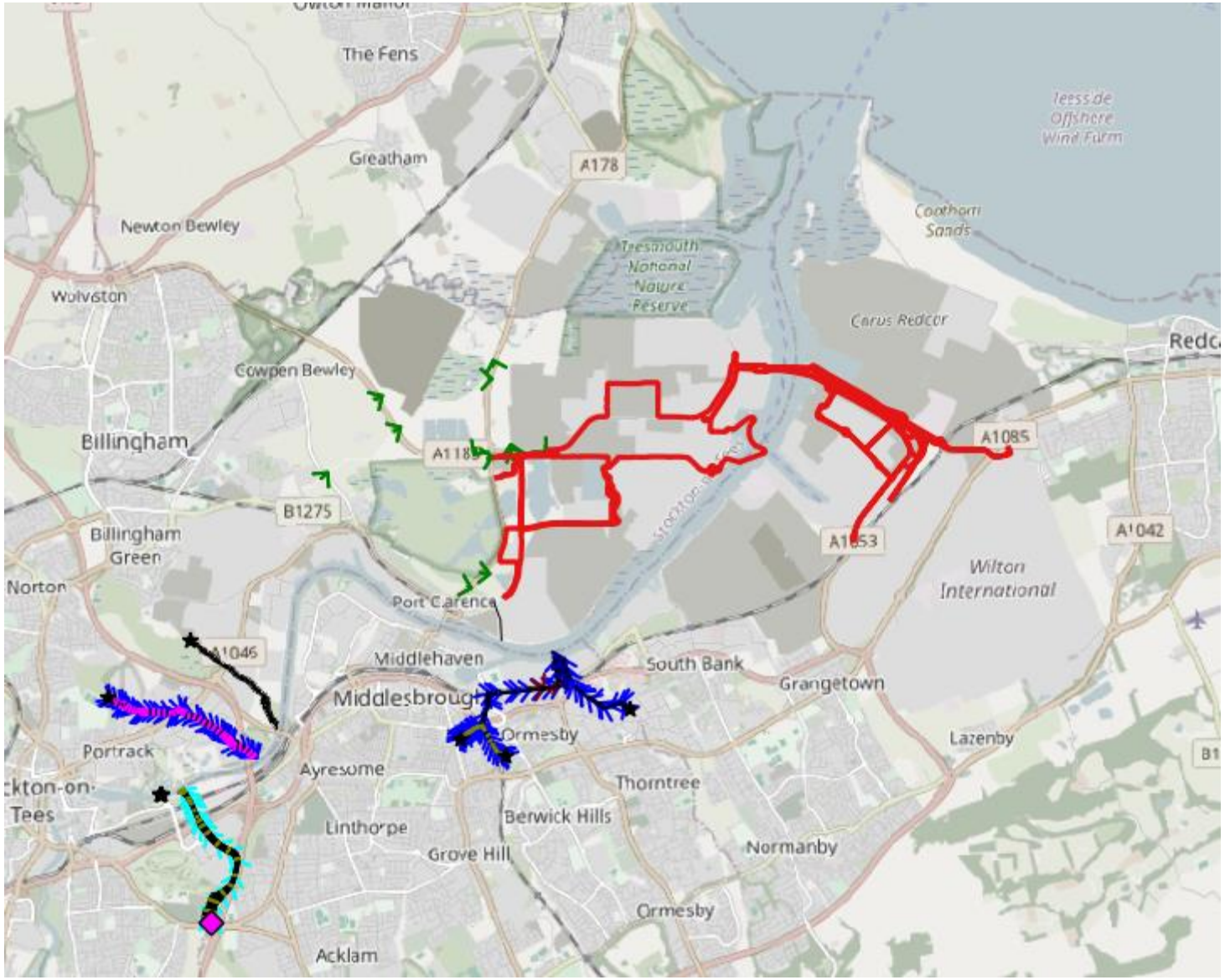
ARUP

Baseline Model

Incoming model

2020 Greatham and Port Clarence model update to the Tidal Tees

FMP-Tuflow, but minimal 1D of relevance to site.



1D model elements

Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors

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Baseline Model

Incoming model

2020 Greatham and Port Clarence model update to the Tidal Tees



2D model elements

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Baseline Model

Low sensitivity of water levels

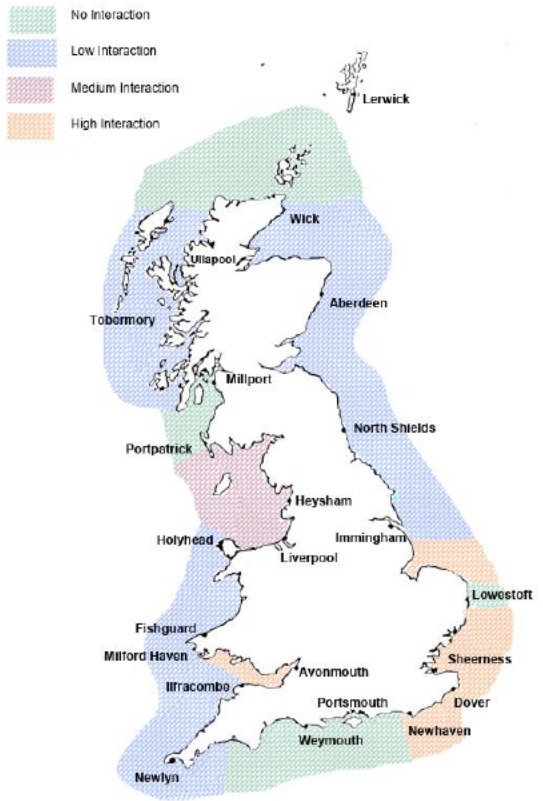
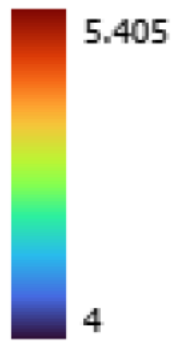
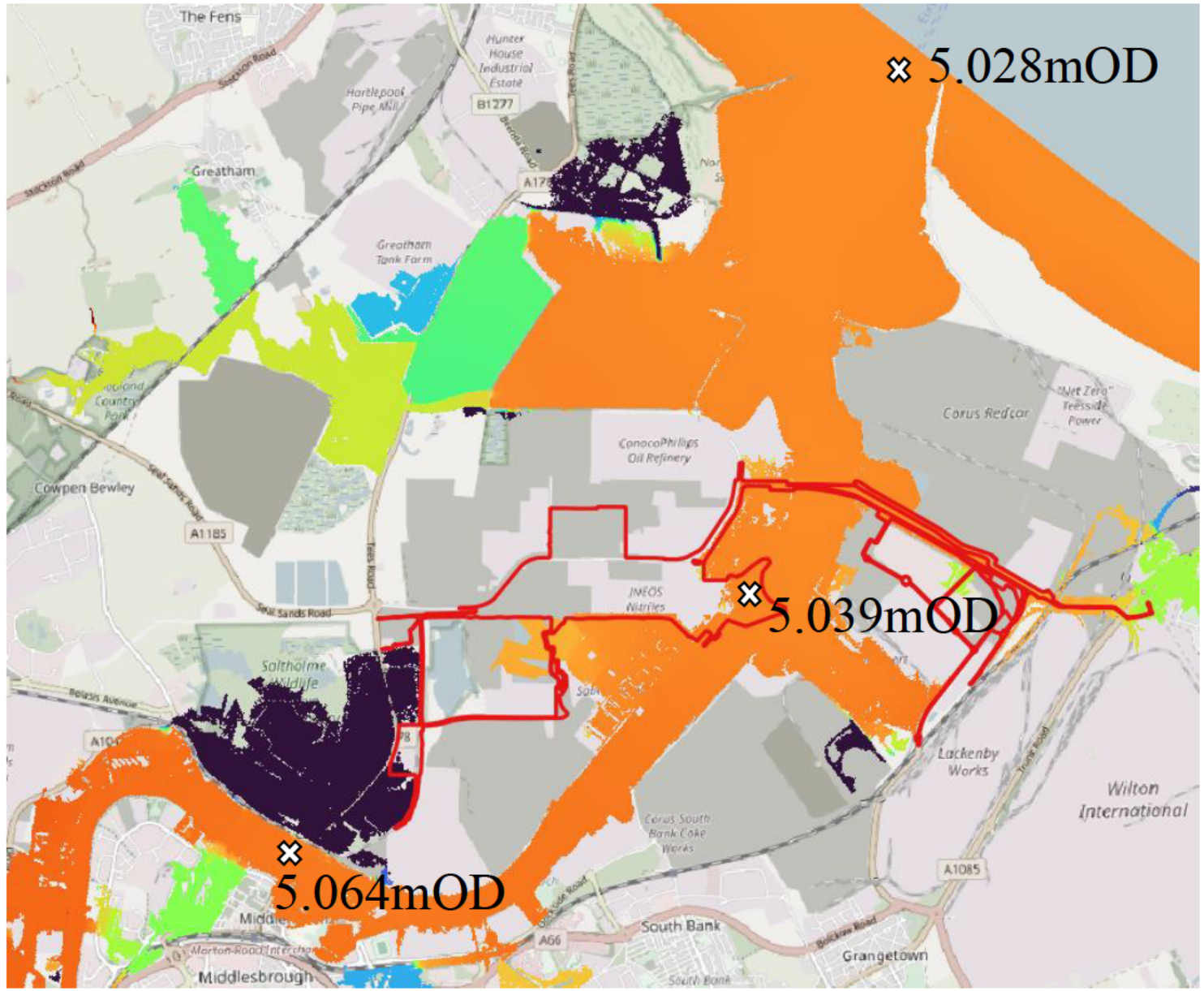


Figure 4.16 Relative levels of tide-surge interaction

Tees flow coinciding with surge at peak of tide: chi = 0.04

For a 200yr event, should coincide with a flow that is exceeded 3 times a year





200yr 2100 event peak water levels

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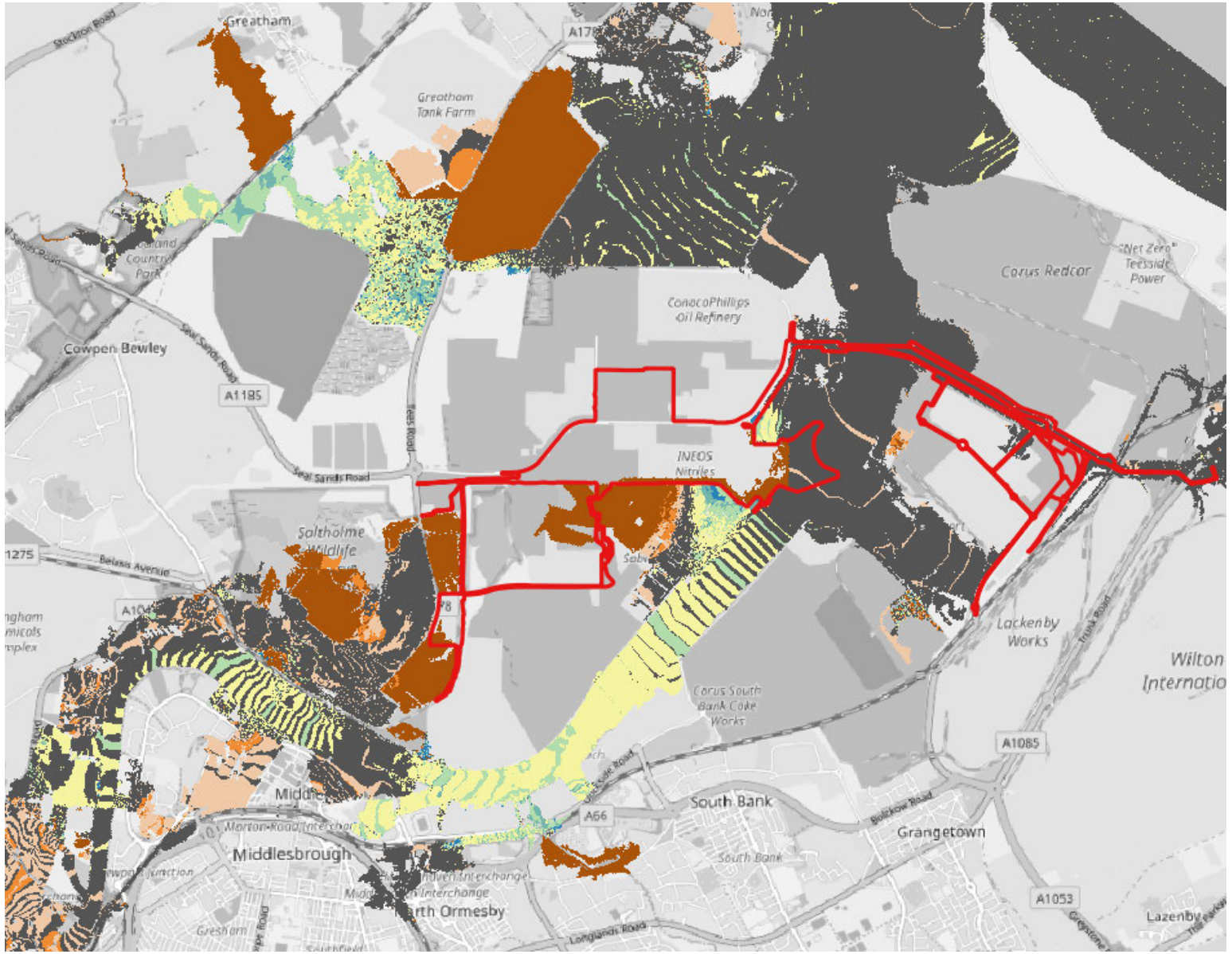
Baseline Model

Low sensitivity of water levels

200yr 2100 event

Site raised (crudely) to 5.08mOD





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Baseline Model

Expected updates

- Use the extreme events “stability” modification
- Generate skew surge tidal boundaries to match key dates
- Update the QMED inflows (although noted 10% increase = 2-3mm increase in WL)
- Import latest LiDAR & bathymetry
- Import latest survey on the site

❖ Not intended to recalibrate

❖ Not intended to re-run sensitivity

❖ No change in grid size (currently 10m)

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Baseline Model

Climate change

Table 8-1 Peak river flow allowances for the Tees Management Catchment

Epoch	Central	Higher	Upper
2020s	19%	23%	32%
2050s	21%	27%	41%
2080s	32%	40%	61%
2020s	19%	23%	32%

Table 8-2 Sea level allowances* for the NRBD

Allowance/Epoch	2000 to 2035 (mm**)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise from 2000 to 2125 (metres)
Higher central	4.6 (161)	7.5 (225)	10.1 (303)	11.2 (336)	1.03
Upper end	5.8 (203)	10 (300)	14.3 (429)	16.5 (495)	1.43

* Sea level rise estimates are provided as mm rise for each year, based on a 1981 to 2000 baseline. **Total sea level rise for each flood epoch is presented in brackets.

Table 8-3 Offshore wind speed and extreme wave height allowances for the English coast

Variable	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%

* Offshore wind speed and extreme wave height are relative to a 1990 baseline.

❖Is it necessary to assess climate change uplifts on wave / wind, as not offshore conditions?

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Design Model

Expected updates

- Modify 2D domain to represent change in topographic and bathymetric surfaces

- Wave study (by others) to give fetch limited wave height / period calculations
  - ❖ Not proposed to assess climate change uplifts on wave / wind

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Scheme resilience

Expected updates

- 2 breaches to be tested (in accordance with LIT56413)

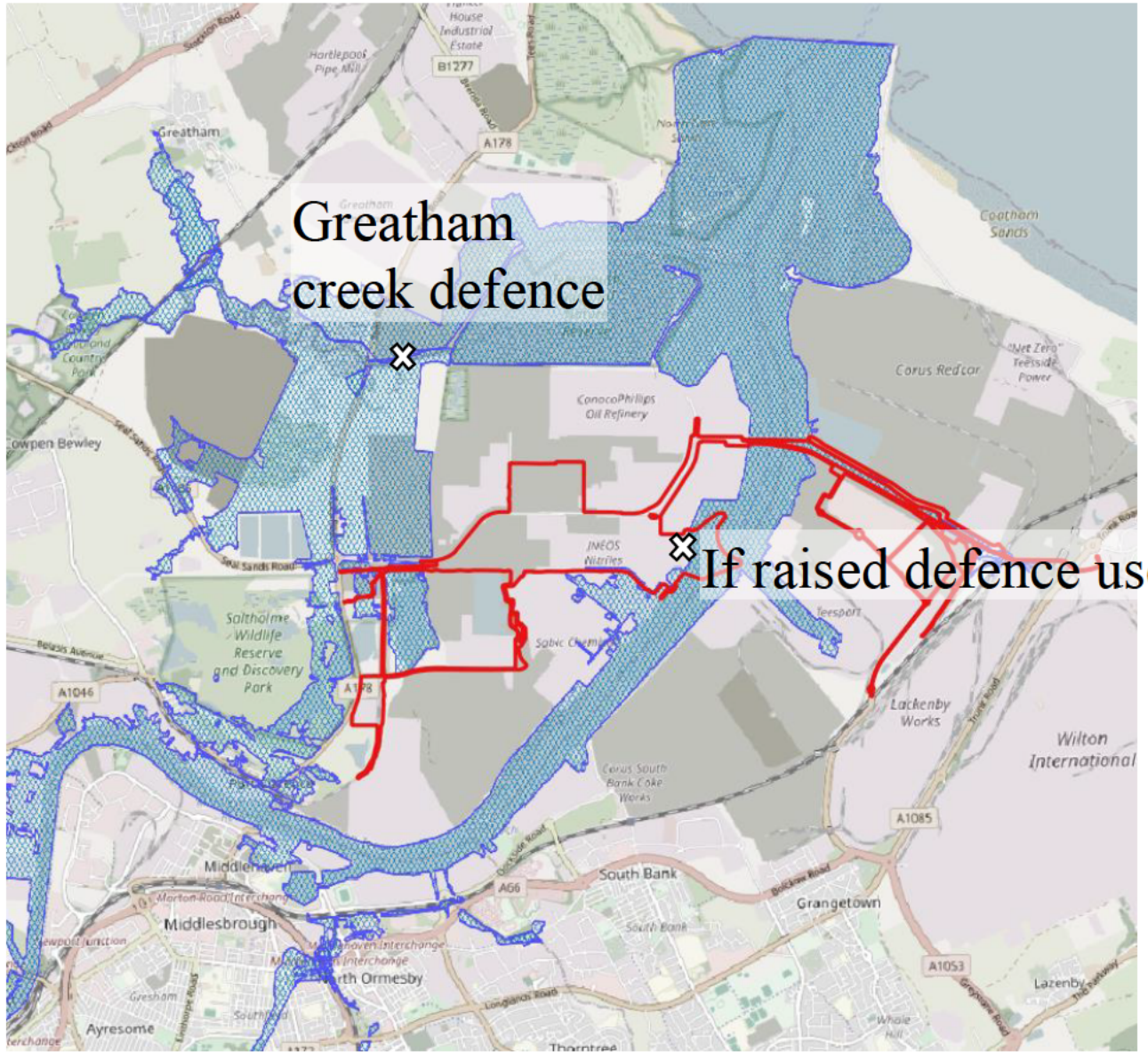
- RUA to inform freeboard / ground levels

❖ Not intended to model H++ 2100 (but level would be readily interpreted)

❖ Cumulative impact – works not expected to have detrimental impact up to the 200yr 2130 70th percentile. Do EA require modelling of a cumulative impact scenario?

Scheme resilience

Proposed breach locations



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Events for assessment

Event	Fluvial event	Tidal event	Justification	Baseline	Design (x 3 iterations)	Breach (x 2 locations, at two different stages in design)	Cumulative impact check
1	50% AEP 2030 70th %ile	1% AEP 2030 70th %ile	Indication of change in model due to updates	Y			
2	50% AEP 2030 70th %ile	0.1% AEP 2030 70th %ile	Indication of change in model due to updates	Y			
3	50% AEP 2030 70th %ile	0.5% AEP 2030 70th %ile	Potential flood conditions by start of project	Y	Y		
4	50% AEP 2070 70th %ile	0.5% AEP 2070 70th %ile	Design water level for flood mitigation (client's intent)	Y	Y		
5	50% AEP 2100 70th %ile	0.5% AEP 2100 70th %ile	Design water level for flood mitigation (EA requirement)	Y	Y	Y	
6	50% AEP 2130 70th %ile	0.5% AEP 2130 70th %ile	Expected max event magnitude required to answer any compensatory floodplain storage questions	Y	Y		Y
7	50% AEP 2100 95th %ile	0.5% AEP 2100 95th %ile	Design water level for flood mitigation (EA requirement), more vulnerable components. Needed for understanding exceedence events.	Y	Y	Y	Y

25yr

75yr

100yr

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Attachment C Residual Uncertainty Analysis

A.3 RUA Executive Summary

A.3.1 A Tier 1 Residual Uncertainty Allowance (RUA) calculation has been undertaken to define design levels at the Lighthouse Green Fuels Site. From consideration of the local hydraulics, it is noted that water levels drop just 1cm in the 5.5km between the site and the tidal boundary of the model. This indicates extreme insensitivity to any factor other than the downstream boundary.

A.3.1 The 97.5% confidence interval for uncertainty in the tidal boundary can be achieved with a 0.23m uplift.

A.3.1 The site is protected solely by raising its ground level and its flood resilience is not vulnerable to collapse due to wave overtopping an erodible defence. Formally therefore it does not require a wave allowance for freeboard. Nonetheless, the front of the quay is raised 0.57m above the general site level, and this value corresponds exactly to the allowance required to protect against a mean annual wave state on top of the design flood plus an allowance for the 97.5% confidence interval.

A.3.1 A potential residual wave hazard to the site is noted for the site. This is not significant within the worst case 30 year operational life, but would need mitigation and control if the site was still operational within the 75 year assessment period required by the Environment Agency.

A.3.1 There is some conservatism in the assessment of the wave hazard. The guidance used is for direct coastal waves, and in the more sheltered environment of the proposed development, the potential hazards are expected to be reduced. Furthermore, the mitigating effects of development either side of the site would also be expected to reduce the strength of incoming waves, but are not taken into account.

A.3.1 It is therefore recommended that the wave hazard is dealt with on a managed adaptive approach.

A.4 Introduction

A.4.1 This note describes the assessment of uncertainty within the modelled flood levels for the design of floor levels as part of the DCO for the Lighthouse Green Fuels Site, Teesside. It summarises the magnitude of residual uncertainties and how they have been assessed. By combining the allowance for residual uncertainty with an allowance for physical processes, an overall defence freeboard has been calculated.

A.4.1 The proposals are Essential Infrastructure, and need to be built above the 0.5% AEP event, with a Higher Central allowance for climate change to 2105.

A.5 Freeboard

A.5.1 The RUA assessment has been used together with an allowance for physical processes affecting the proposed defences to define a freeboard allowance in their design.

Sources of Residual Uncertainty

A.5.1 Options for the site have been assessed hydraulically using Flood Modeller Pro-TUFLOW.

A.5.1 The site is 5.5km from the model's tidal boundary, and as such, flood levels are dominated by the tidal boundary. For instance, the flood level at the tidal boundary for the 0.5% AEP 2105 higher central event is 4.835 mOAD, and the flood level at the site is 4.845mOAD, a 0.01m rise over 5.5km. This is a strong indicator of how insensitive levels at the site will be to potential sources of uncertainty, as essentially it says that the tidal boundary explains all but 1cm of the flood levels. Any uncertainty from sources other than the tidal boundary can therefore only impact on that 1cm.

A.5.1 With this in mind, uncertainty assessment has focussed on the tidal boundary.

Modelled Sources of Residual Uncertainty.

Approach

A.5.1 The approach adopted by Arup is a "Tier 1 – First order error analysis". This approach:

- Identifies the components of uncertainty (x,y,z) that are likely to contribute to uncertainty in the primary variable (in this case, the peak water level at the wet side of the defences)
- Estimates the change in the primary variable (dR) for a small change in the component of uncertainty (dx, or dy or dz)
- Estimates the uncertainty in the secondary variable (xunc or yunc or zunc).
- Estimates the total uncertainty in the primary variable Runc through a weighted summation of independent contributions.

A.5.1 The primary uncertainty Runc is calculated using the formula:

$$R_{unc} = \sqrt{\left[\left(\frac{\partial R}{\partial x}\right)x_{unc}\right]^2 + \left[\left(\frac{\partial R}{\partial y}\right)y_{unc}\right]^2 + \left[\left(\frac{\partial R}{\partial z}\right)z_{unc}\right]^2}$$

A.5.1 In this project however, there is only one primary variable being assessed, and this means the above formula simplifies down to:

$$R_{unc} = \left(\frac{\partial R}{\partial x}\right)x_{unc}$$

A.5.1 The “Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels (2018)” dataset publishes both the best estimate and the 97.5% confidence interval extreme sea levels for the site, which are respectively 4.07mOAD and 4.31mAOD for the 0.5% AEP event, a difference of 0.24m.

A.5.1 By comparison of the 0.5% AEP 2105 Higher Central and Upper End modelling results, it can be seen that modelling a 0.275m increase in the tidal boundary results in a 0.267m increase at the site.

A.5.1 Therefore, the primary uncertainty at the 97.5% confidence interval is (0.267/0.275)*0.24 = 0.23m.

Confidence

A.5.1 The amount of freeboard defined by each source of uncertainty is directly influenced by the desired confidence interval for which it is assessed. For example: one standard deviation of estimates corresponding to the 68% confidence interval, or 84.1% chance of non-exceedance, is commonly used as an initial level at which to assess uncertainty.

A.5.1 Table C.1, taken from the latest RUA Guidance[1] illustrates the different confidence intervals as defined by a normal distribution of probability.

[1] Assessment of Residual Uncertainty - Supplementary Technical Guidance (LIT 73536), Environment Agency, April 2024

Table C.1 Probability distribution, confidence intervals and non-exceedance (extract from LIT 73536)

Confidence interval (%)	Standard deviation	Probability of non-exceedance (%)	Probability of non-exceedance (%)
38	0.5	69.1	30.9
55	0.75	77.3	22.7
68	1.0	84.1	15.9
95	2.0	97.7	2.3
99	3.0	99.9	0.13

A.5.1 A 97.5% confidence interval has approximately a 99% chance of non-exceedance. This is higher than industry standards.

A.6 Physical Processes

Superelevation

A.6.1 Superelevation is not applicable to the site as it is not on a river bend.

Settlement

A.6.1 Settlement has not been considered as part of this assessment and should be added on to design allowances by the geotechnical design team where necessary.

Wave overtopping

Approach to wave overtopping

A.6.1 The site proposals are to achieve flood resilience by raising site ground levels. Environment Agency Fluvial Freeboard Guidance only requires wave overtopping to be considered for freeboard to protect against damage to raised, erodible flood defences (such as embankments).

A.6.1 In this case, there are no formal flood defences as such. The proposed quays have a cross fall for drainage, which make the quays a minimum of 0.57m higher than the raised ground level of the site. The quay will be hard surfaced and their frontage will be sheet piled, so, while not designed as such, they form an effective non-erodible defence along their line.

A.6.1 The quays therefore provide a minimum of 0.57m freeboard against waves over and above the 97.5% confidence interval. This will reduce any residual overtopping from waves to the site.

A.6.1 The site is also theoretically exposed to wave overtopping by flooding through adjacent sites. At these locations, the site does not benefit from the protection offered by the quay, but waves would be considerably reduced by obstructions in the adjacent sites. Again, there are no raised defences at

these locations, so the exposure is limited to the residual hazard posed by wave overtopping. Provided assets are not located directly next to the site edge, the high ground levels of the site will absorb much of the potential wave power.

Wave overtopping calculations

A.6.1 The magnitudes of the significant wave height were estimated in the modelling appendix to the **Appendix 12A: Coastal and Estuary Processes (ES Volume III, Application Document Ref. 6.3).** The two worst case estimates of the mean annual significant wave height are given as 0.46m (from the northeast) and 0.64m (from the southwest), as restated in Table C.2.

Table C.2 Restatement of wind and wave values from the marine processes chapter modelling appendix.

Direction sector	Fetch (m)	1yr wind velocity (m/s)	Assumed depth (m)	Derived wave height (m)	Derived wave period (s)
North East	1670	16.5	18.5	0.46	2.00
South West	3600	15.8	15.8	0.64	2.60

A.6.1 The modelling report acknowledges limitations to the analysis, which is a desk-top based study and does not employ formal modelling. In particular, it is noted that the approach used does not take full account of the effects of shallow depths on waves from the southwest. Figures from a more detailed Royal Haskoning study[2] of the same reach of the Tees indicated a 15-20% reduction in wave heights compared to a central channel estimate. The same Royal Haskoning study gives a wave height of 0.5m from the southwest.

A.6.1 Review of the southwesterly reach suggests that the ABPmer calculations should either take greater account of shallow depths within the southwest fetch, or should have applied a more acute angle of attack, giving a shorter fetch of 2350m. Applying these adjustments to the same United States Army Corps of Engineers (USACE) fetch limited wave calculation gives significant wave heights of 0.50 and 0.52m respectively, which is more in line with the Royal Haskoning results. Equally, a 15% reduction in the ABPmer wave height (adjusting from central channel to the edge) gives a wave height of 0.54m.

A.6.1 The wind velocities from the ABPmer report have been used with fetch lengths and depths derived from modelling for the points shown in Figure

[2] Royal HaskoningDHV, (2020). South Bank Quay EIA Report, Document Reference: PC1084-RHD-SB-EN-RP-EV-1100

C.1, resulting in the wave heights shown in Table C.3.

A.6.1 At site boundaries that are set back from the immediate channel of the Tees, waves would need to approach over adjacent sites. The shallow depths over these sites would have a limiting effect on the maximum wave height that could be achieved. This limit has been identified by putting an exaggerated reach length of 100,000m into the USACE fetch-limited wave calculator.

A.6.1 Hence, where there are marked depth differences between channel depth and depth on the floodplain adjacent to the Main Site, waves have been calculated from the lesser of 1) a weighted average of the wave height given by either depth over the total fetch length, and 2) the wave height given by the lower depth over a 100,000m fetch length.

Table C.3 Wave heights used in hazard calculation

Location	Fetch (m)	Assumed depth (m)	1yr wind velocity (m/s)	Derived wave height (m)	Derived wave period (s)
1	1670	18.5	16.5	0.46	2.00
2	2350	15.8	15.8	0.52	2.23
3	574 702	15 0.75	15.8	0.31	1.63
4	348 1028	18.8 0.6	15.8	0.27	1.5
5	1300	14.5	16.5	0.41	1.9
6	1200 300	13.5 0.35	16.5	0.18	2.2
7	750 300	18 0.6	16.5	0.27	2.6

A.6.1 Where assets are not immediately sited on the edge of the Main Site, they will benefit further from reduction of the waves caused by the low depths of flooding. Even allowing 0.23m for uncertainty on top of the 0.5%AEP 2130 Higher Central event, flood depths over minimum ground level of 5.08mAOD would be a maximum of 0.28m. This could limit significant wave heights to 0.15m.

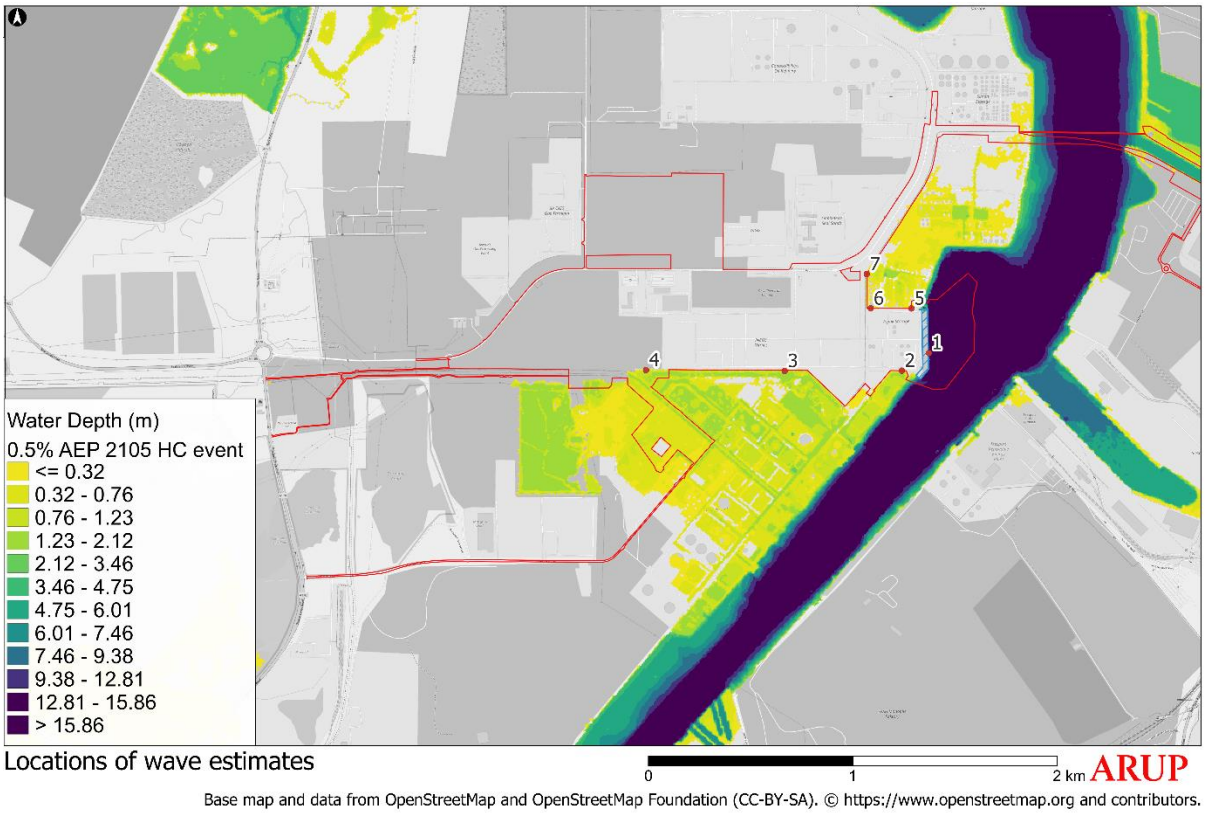


Figure C.1 Locations of wave estimates

Exceedence flows

A.6.1 The magnitudes of wave overtopping have also been assessed in terms of exceedance flows using EurOtop (2018) (incorporating 2019 corrigenda)[3]. These in turn are compared to Table C.4, summarising the potential impacts associated with wave overtopping for different magnitudes of flow.

[3] EurOtop, 2018. "Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application." Van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P. and Zanuttigh, B., www.overtopping-manual.com.

Table C.4 Tolerable limits of wave overtopping (after Allsop et al, 2008)[4]

	Hazard Type and reason	Mean discharge (l/s/m)
Limits of overtopping for pedestrians	Trained staff, well shod and protected, expecting to get wet, overtopping flows at lower levels only, no falling jet, low danger of fall from walkway	1 - 10
	Aware pedestrian, clear view of water, not easily upset or frightened, able to tolerate getting wet, wider walkway	0.1
Limits of overtopping for vehicles	Driving at low speed, overtopping by pulsating flows at low flow depths, no falling jets, vehicle not immersed	10 - 50
	Driving at moderate or high speed, impulsive overtopping giving falling or high velocity jets	0.01 - 0.05
Limits of overtopping for property behind the defence	Building structural elements (NOTE: overtopping defined as being at the building)	1
	Damage to equipment set back 5-10m from defence	0.4
Limits of overtopping for damage to the defence crest or rear slope	Damage to well protected crest and rear slope	50 - 200
	Damage to crest and rear slope of grass covered clay embankment	1 - 10
	Damage to unprotected crest and rear slope	0.1
	Damage to paved or armoured promenade behind seawall	200

A.6.1 It is emphasised that Allsop et al[4] is from an analysis of a coastal environment, and as such the hazard quoted in Table C.4 is a worst-case interpretation of the hazard at the site. This is because coastal waves have less regular patterns of flow – the largest individual waves may produce far higher overtopping flows than the average wave. In the more sheltered context of the site, individual waves will be much closer to the scale of the average wave, and because of this the peak overtopping flow is more representative of the average, and therefore the peak hazard is much lower.

A.6.1 Table C.5 identifies the overtopping flows at the quays in the design event (after 75 years of operational life) and two exceedence events.

[4] Allsop et al (2008). "Direct hazards from wave overtopping – the forgotten aspect of coastal flood risk assessment?"

Table C.5 Overtopping flows at the quays

Event	Water level at + 0.23m uncertainty allowance (mAOD)	Freeboard (m)	Overtopping flow (l/s/m)
0.5% AEP Higher Central 2060	4.60	1.06	0.02
0.5% AEP Higher Central 2105	5.08	0.57	1.6
0.5% AEP Upper End 2105	5.34	0.31	10.8
0.5% AEP Higher Central 2130	5.36	0.29	12.3

A.6.1 Within the 30-year worst case estimate of the operational life, the rates of overtopping at the quay pose no risks.

A.6.1 Within the 75-year assessment period, overtopping could reach thresholds that could be hazardous to inexperienced pedestrians – but the site will mostly be accessible to dock workers, not the general public. Overtopping is limited to a low enough flow that the only concern would be safety to vehicles driving at a moderate to high speed. This would not be expected behaviour in the context of an industrial dock. Equipment within 5-10m of the quay edge would need to be appropriately designed and raised for resilience against waves, and any buildings would similarly need to be set back from the quay edge.

A.6.1 In the exceedance events (2130 Higher Central, or 2105 Upper End climate scenarios), adaptation or mitigation measures may be necessary to maintain staff & vehicular safety and appropriate protection to equipment & buildings within the vicinity of the quays. These events are however well beyond the worst-case estimate of operational life, and it would be appropriate to manage these risks on a managed adaptive basis.

A.6.1 Table C.6 identifies the overtopping flows along the edges of the rest of the Main Site in the design event. These flows do not take account of the mitigating effect of any obstructions in adjacent sites that would reduce the scale of incoming waves.

Table C.6 Overtopping wave flows at identified points around edge of site.

	0.5% AEP Higher Central 2060				0.5% AEP Higher Central 2105			
	Site level	Road level	Less vulnerable	More vulnerable	Site level	Road level	Less vulnerable	More vulnerable
Ground level (mAOD)	5.08	5.23	5.38	5.68	5.08	5.23	5.38	5.68
Freeboard (m)	0.28	0.43	0.58	0.88	0	0.15	0.3	0.6
Location	**Overtopping flow (l/s/m)**							
1	0.02	0.02	0.02	0.02	1.6	1.6	1.6	1.2
2	5.6	2.03	0.68	0.06	63.4	37.4	17.3	2.6
3	0.25	0.03	0.00	0.00	29.2	10.4	2.3	0.06
4	0.08	0.01	0.00	0.00	23.7	6.9	1.1	0.01
5	1.6	0.41	0.09	0.00	44.4	21.6	7.6	0.57
6	0.00	0.00	0.00	0.00	12.9	1.6	0.07	0.00
7	0.08	0.01	0.00	0.00	23.7	6.9	1.1	0.01

A.6.1 Within the Applicant's proposed Design Life (the 2060 Higher Central allowance), the risks to pedestrians are generally acceptable for trained staff. Some wave protection is necessary at Locations 2 and 5 (at either end of the quays), and sufficient space exists within the site to implement such protection, which would only need to be ~0.30m high. Subject to vehicles driving at low speeds, the hazards to vehicles are acceptable. Buildings and equipment would not be at risk.

A.6.1 Within the Environment Agency's required assessment period (to 2105), the risks to pedestrians on the site edge may be significant, as may the risks to vehicles. Provided buildings are not set at the very edge of the site, their exposure to structural damage should be low. Equipment should be set back at least 10m and may require additional raising or wave protection.

A.6.1 Where assets are not immediately sited on the edge of the Main Site, they will benefit further from reduction of the waves caused by the low depths of flooding. Even allowing 0.23m for uncertainty on top of the 0.5% AEP 2130 Higher Central exceedance event, flood depths over the minimum ground level of 5.08mAOD would be a maximum of 0.28m. This would limit significant wave heights to 0.15m high, which would pose no risk to buildings raised to the More Vulnerable threshold level.

A.6.1 Ultimately, these residual risks are controllable. The risks to pedestrians and vehicles can be controlled through response procedures and restricting access during flood events. The actual exposure can be minimised by setting back development from the site edge, and / or incorporation of low bunding at the edge of site or beside development. Modelling has demonstrated that raising the ground levels of the site has negligible impact on flood risk to adjacent sites, and this gives the freedom to undertake such

measures without concerns for flood displacement.

A.6.1 There is some uncertainty in the understanding of this hazard. The papers used relate the hazard to an average overtopping flow, but the analyses are based on coastal waves. Coastal waves have a highly randomised behaviour that mean the highest waves within a given wave state may produce far higher overtopping flows than the average waves, and it is these waves which will define a lot of the hazard. In the more sheltered context of the site, this effect will not be so marked, and hence the hazard will be significantly lower than suggested by the papers.

A.6.1 It is recommended that more detailed wave modelling is carried out as detailed design progresses to support design of mitigation measures for wave hazard, particularly around the north and south ends of the quays, and more detailed identification of the hazard.

A.6.1 Given the uncertainty associated with understanding of the wave hazard (and likely conservatism in the current approach), where the detailed wave modelling does not indicate a wave hazard to be managed within the 30 year worst case operational life of the proposed development, it is recommended that the residual risk associated with waves is managed using a managed adaptive approach, i.e. if a physical intervention is confirmed as being required later in the proposals' operational life, it can be implemented or investigated further then.

A.6.1 Such an approach recognises that the results of the modelling indicate extremely low sensitivity to development of the site, and therefore implementing a physical intervention later in the proposal's design life would not introduce any notable increase in flood risk to surrounding developments.

Attachment D Model Log

Model Log

Log of model input files. Simulations are logged on a separate sheet.
Click on column headers with [?] for further guidance.

File type cell colours: 1d model / data | GIS | 2d control | Other

Project name	Lighthouse Green Fuels	Senior modeller	Frances Dearden	Modelling folder	M \306732-00 LGF\02 Modelling
Project no.	306732-00	Modeller(s)	Deepak Kharat	File naming convention note [?]	
Arup PM	Ian Campbell	Model reviewers			

Last 1d Model ID: 48
Last 2d Model ID: 48

Scenario and sub-scenarios [?]				Milestone [?]	Superseded	Date [?]	Modeller	File type [?]	Model no. [?]	Filename [?]	Preceding file [?]	File location [?]	Comments / changes since preceding file	OPTIONAL Referenced Files [?]			OPTIONAL Quality Assurance columns [?]				
-s1	-s2	-e1	-e2											File type 1	File type 2	File type 3	Check date [?]	Checker [?]	Checked [?]	SM-check actions [?]	Responses to actions [?]
						05/05/2026	Deepak Kharat	1d model	39	RTees_DDD_005_T1000_2030_039_stability_TUFLOW.ief	R e s_DDD_005_T 00_2100_038_st b lity_ UF OW e	odelling\04 baseline_CCA\FM\IEFS	Based on preceding file for baseline runs, refers to new .TCF file							
						05/05/2026	Deepak Kharat	1d model	39	RTees_DDD_005_T100_2030_039_stability_TUFLOW.ief	R e s_DDD_005_T 00_2100_038_st b lity_ UF OW e	odelling\04 baseline_CCA\FM\IEFS	Based on preceding file for baseline runs, refers to new .TCF file							
						05/05/2026	Deepak Kharat	1d model	39	RTees_DDD_005_T200_2030_039_stability_TUFLOW.ief	R e s_DDD_005_T 00_2100_038_st b lity_ UF OW e	odelling\04 baseline_CCA\FM\IEFS	Based on preceding file for baseline runs, refers to new .TCF file							
						05/05/2026	Deepak Kharat	1d model	39	RTees_DDD_005_T200_2070_039_stability_TUFLOW.ief	R e s_DDD_005_T 00_2100_038_st b lity_ UF OW e	odelling\04 baseline_CCA\FM\IEFS	Based on preceding file for baseline runs, refers to new .TCF file							
						05/05/2026	Deepak Kharat	1d model	39	RTees_DDD_005_T200_2100_039_stability_TUFLOW.ief	R e s_DDD_005_T 00_2100_038_st b lity_ UF OW e	odelling\04 baseline_CCA\FM\IEFS	Based on preceding file for baseline runs, refers to new .TCF file							
						05/05/2026	Deepak Kharat	1d model	39	RTees_DDD_005_T200_2100_UE_039_stability_TUFLOW.ief	R e s_DDD_005_T 00_2100_038_st b lity_ UF OW e	odelling\04 baseline_CCA\FM\IEFS	Based on preceding file for baseline runs, refers to new .TCF file							
						05/05/2026	Deepak Kharat	1d model	39	RTees_DDD_005_T200_2130_039_stability_TUFLOW.ief	R e s_DDD_005_T 00_2100_038_st b lity_ UF OW e	odelling\04 baseline_CCA\FM\IEFS	Based on preceding file for baseline runs, refers to new .TCF file							
						05/05/2026	Deepak Kharat	TRD / TCF	39	RTees_010_T1000_2030_039_stability.tcf	RTe s_010_ 00_2100_038_ a ili y. c	g\04 baseline_CCA\TUFLOW\RUNS	changed to TIF output at line 69; refers to updated .ecf, .tgc, .tmf BC event at line 41 & 42 to the current one							
						05/05/2026	Deepak Kharat	TRD / TCF	39	RTees_010_T100_2030_039_stability.tcf	RTe s_010_ 00_2100_038_ a ili y. c	g\04 baseline_CCA\TUFLOW\RUNS	changed to TIF output at line 69; refers to updated .ecf							
						05/05/2026	Deepak Kharat	TRD / TCF	39	RTees_010_T200_2030_039_stability.tcf	RTe s_010_ 00_2100_038_ a ili y. c	g\04 baseline_CCA\TUFLOW\RUNS	changed to TIF output at line 69; refers to updated .ecf							
						05/05/2026	Deepak Kharat	TRD / TCF	39	RTees_010_T200_2070_039_stability.tcf	RTe s_010_ 00_2100_038_ a ili y. c	g\04 baseline_CCA\TUFLOW\RUNS	changed to TIF output at line 69; refers to updated .ecf							
						05/05/2026	Deepak Kharat	TRD / TCF	39	RTees_010_T200_2100_039_stability.tcf	RTe s_010_ 00_2100_038_ a ili y. c	g\04 baseline_CCA\TUFLOW\RUNS	changed to TIF output at line 69; refers to updated .ecf							
						05/05/2026	Deepak Kharat	TRD / TCF	39	RTees_010_T200_2100_UE_039_stability.tcf	RTe s_010_ 00_2100_038_ a ili y. c	g\04 baseline_CCA\TUFLOW\RUNS	changed to TIF output at line 69; refers to updated .ecf							
						05/05/2026	Deepak Kharat	TRD / TCF	39	RTees_010_T200_2130_039_stability.tcf	RTe s_010_ 00_2100_038_ a ili y. c	g\04 baseline_CCA\TUFLOW\RUNS	changed to TIF output at line 69; refers to updated .ecf, .tgc							
						05/05/2026	Deepak Kharat	ECF	21	RTees_021_stability.ecf	RTe s_020_stab l ty cf	g\04 baseline_CCA\TUFLOW\RUNS	added CHECK at line 12 for compatibility with 2018 TUFLOW ver							
						05/05/2026	Deepak Kharat	TGC	39	RTees_010_ISISESTRY_039_CC_stability.tgc	RTees_010_ISISESTRY_0 8_CC_stabi y gc	04 baseline_CCA\TUFLOW\MODEL	Replaces prev terrain with EA LiDAR+site topo+bathy survey; reads new material							
						05/05/2026	Deepak Kharat	other 2d data		EA_2022_LiDAR_downloaded_on_20Apr2026_2 2 t f	New	_CCA\TUFLOW\MODEL\DTM2026	Up to date EA LiDAR							
						05/05/2026	Deepak Kharat	other 2d data		Retain_prev_DTM_clipped_2.tif	New	_CCA\TUFLOW\MODEL\DTM2026	DTM retained between bathy survey and approx -1.4 mAOD							
						05/05/2026	Deepak Kharat	other 2d data		26-4-13_PD_baseline_bathy_OrdnceDatum_1x1 tif	New	_CCA\TUFLOW\MODEL\DTM2026	survey .xyz converted to TIF							
						05/05/2026	Deepak Kharat	other 2d data		T250658-DR-T-001-011_clipped.tif	New	_CCA\TUFLOW\MODEL\DTM2026	site topo from Design Team							
						05/05/2026	Deepak Kharat	SHP / MIF		2d_mat_OSM2026.shp	New	aseline_CCA\TUFLOW\MODEL\Mi	up to date material file based on OSM 2026. See "M \306732-00 LGF\01 modelling input\Materials\materials list.xlsx" for details							
						05/05/2026	Deepak Kharat	other 2d model		materials3.tmf	mate al 2 tmf	04 baseline_CCA\TUFLOW\MODEL	Changed bldg n for matrial 18 from 1 to 0.3 according to the comment in XLS "\\global\europe\Leeds\Modeling_Data\306732-00 LGF\0000_Scope-QA-Logs-Calcs\0050_ReviewsOfIncomingModels\20260417_LIT 17617_Hydraulic_Model_Review_Lighthouse_Green_Fuels.xlsm"							
						05/05/2026	Deepak Kharat	CSV		T1000_2030.csv	T1000 c	baseline_CCA\TUFLOW\BC_DBASE	See CCA calcs at M \306732-00 LGF\0000_Scope-QA-Logs-Calcs\0080_Calcs\2026-01-05_CCA							
						05/05/2026	Deepak Kharat	CSV		T100_2030.csv	T100. v	baseline_CCA\TUFLOW\BC_DBASE	See CCA calcs at M \306732-00 LGF\0000_Scope-QA-Logs-Calcs\0080_Calcs\2026-01-05_CCA							
						05/05/2026	Deepak Kharat	CSV		T200_2030.csv	T 00. v	baseline_CCA\TUFLOW\BC_DBASE	See CCA calcs at M \306732-00 LGF\0000_Scope-QA-Logs-Calcs\0080_Calcs\2026-01-05_CCA							
						05/05/2026	Deepak Kharat	CSV		T200_2070.csv	T 00. v	baseline_CCA\TUFLOW\BC_DBASE	See CCA calcs at M \306732-00 LGF\0000_Scope-QA-Logs-Calcs\0080_Calcs\2026-01-05_CCA							
						05/05/2026	Deepak Kharat	CSV		T200_2100.csv	T 00. v	baseline_CCA\TUFLOW\BC_DBASE	See CCA calcs at M \306732-00 LGF\0000_Scope-QA-Logs-Calcs\0080_Calcs\2026-01-05_CCA							
						05/05/2026	Deepak Kharat	CSV		T200_2100_UE.csv	T 00. v	baseline_CCA\TUFLOW\BC_DBASE	See CCA calcs at M \306732-00 LGF\0000_Scope-QA-Logs-Calcs\0080_Calcs\2026-01-05_CCA							
						05/05/2026	Deepak Kharat	CSV		T200_2130.csv	T 00. v	baseline_CCA\TUFLOW\BC_DBASE	See CCA calcs at M \306732-00 LGF\0000_Scope-QA-Logs-Calcs\0080_Calcs\2026-01-05_CCA							
					Yes	08/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T1000_2030_040_stability_TUFLOW.ief	RTees_DDD_005_T1000_2030_039_ tabil y_ UF OW ef	lling\04 baseline_CCA_2\FM\IEFS\	Updated title, and .TCF ref							
					Yes	08/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T100_2030_040_stability_TUFLOW.ief	RTees_DDD_005_T100_2030_039_s abilit _ UFLOW.i f	lling\04 baseline_CCA_2\FM\IEFS\	Updated title, and .TCF ref							
					Yes	08/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T200_2030_040_stability_TUFLOW.ief	RTees_DDD_005_T200_2030_039_s abilit _ UFLOW.i f	lling\04 baseline_CCA_2\FM\IEFS\	Updated title, and .TCF ref							
					Yes	08/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T200_2070_040_stability_TUFLOW.ief	RTees_DDD_005_T200_2070_039_s abilit _ UFLOW.i f	lling\04 baseline_CCA_2\FM\IEFS\	Updated title, and .TCF ref							
					Yes	08/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T200_2100_040_stability_TUFLOW.ief	RTees_DDD_005_T200_2100_039_s abilit _ UFLOW.i f	lling\04 baseline_CCA_2\FM\IEFS\	Updated title, and .TCF ref							
					Yes	08/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T200_2100_UE_040_stability_TUFLOW.ief	RTees_DDD_005_T200_2100_UE_ 39_sta li _ UF OW	lling\04 baseline_CCA_2\FM\IEFS\	Updated title, and .TCF ref; 2D TS 2.5							
					Yes	08/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T200_2130_040_stability_TUFLOW.ief	RTees_DDD_005_T200_2130_039_s abilit _ UFLOW.i f	lling\04 baseline_CCA_2\FM\IEFS\	Updated title, and .TCF ref; 2D TS 2.5							
					Yes	20/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T200_2105_040_stability_TUFLOW.ief	N w	elling\04 baseline_CCA_2\FM\IEFS\	Used _2100 as basis							
					Yes	20/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T200_2105_UE_040_stability_TUFLOW.ief	N w	elling\04 baseline_CCA_2\FM\IEFS\	Used _2100_UE as basis							
					Yes	20/05/2026	Deepak Kharat	1d model	40	RTees_DDD_005_T200_2080_040_stability_TUFLOW.ief	N w	elling\04 baseline_CCA_2\FM\IEFS\	Used _2070 as basis							
					Yes	08/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T1000_2030_040_stability.tcf	RTees_010_T1000_2030_03 _stabil y. cf	4 baseline_CCA_2\TUFLOW\RUNS	Line 31 refers to updated TGC							
					Yes	08/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T100_2030_040_stability.tcf	RTees_010_T100_2030_039_ tabilit tc	4 baseline_CCA_2\TUFLOW\RUNS	Line 31 refers to updated TGC							
					Yes	08/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T200_2030_040_stability.tcf	RTees_010_T200_2030_039_ tabilit tc	4 baseline_CCA_2\TUFLOW\RUNS	Line 31 refers to updated TGC							
					Yes	08/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T200_2070_040_stability.tcf	RTees_010_T200_2070_039_ tabilit tc	4 baseline_CCA_2\TUFLOW\RUNS	Line 31 refers to updated TGC							
					Yes	08/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T200_2100_040_stability.tcf	RTees_010_T200_2100_039_ tabilit tc	4 baseline_CCA_2\TUFLOW\RUNS	Line 31 refers to updated TGC							
					Yes	08/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T200_2100_UE_040_stability.tcf	RTees_010_T200_2100_UE_ 39_sta li y tc	4 baseline_CCA_2\TUFLOW\RUNS	Line 31 refers to updated TGC; TS 2.5 but note that .ief provides TS							
					Yes	08/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T200_2130_040_stability.tcf	RTees_010_T200_2130_039_ tabilit tc	4 baseline_CCA_2\TUFLOW\RUNS	Line 31 refers to updated TGC; TS 2.5 but note that .ief provides TS							
						08/05/2026	Deepak Kharat	TGC	40	RTees_010_ISISESTRY_040_CC_stability.tgc	RTees_010_ISISESTRY_039_ C_st b i y tg	baseline_CCA_2\TUFLOW\MODEL	Reads at ln 49 file 26-05-06_BaselineBathy_1x1.tif and updated 26-4-13_PD_baseline_bathy_OrdnceDatum_1x1_v2.tif							
						08/05/2026	Deepak Kharat	other 2d data		26-4-13_PD_baseline_bathy_OrdnceDatum_1x1_v2.tif	26-4-13_PD_bas ne_ba h _O dnc Da um_ x1 t f	CCA_2\TUFLOW\MODEL\DTM2026	LAT to OD datum corrected from 2.8 to 2.85							
						08/05/2026	Deepak Kharat	other 2d data		26-05-06_BaselineBathy_1x1.tif	New	CCA_2\TUFLOW\MODEL\DTM2026	New bathymetry information arounf the ship turning semi-circle							
						20/05/2026	Deepak Kharat	CSV		T200_2080.csv	New	seline_CCA_2\TUFLOW\BC_DBASE								
						20/05/2026	Deepak Kharat	CSV		T200_2105.csv	New	seline_CCA_2\TUFLOW\BC_DBASE								
						20/05/2026	Deepak Kharat	CSV		T200_2105_UE.csv	New	seline_CCA_2\TUFLOW\BC_DBASE								
					Yes	20/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T200_2105_040_stability.tcf	Ne	4 baseline_CCA_2\TUFLOW\RUNS								
					Yes	20/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T200_2080_040_stability.tcf	Ne	4 baseline_CCA_2\TUFLOW\RUNS								
					Yes	20/05/2026	Deepak Kharat	TRD / TCF	40	RTees_010_T200_2105_UE_040_stability.tcf	Ne	4 baseline_CCA_2\TUFLOW\RUNS								
						13/05/2026	Deepak Kharat	SHP / MIF		2d_vzsh_LGF_Greatham_Creek_P.shp	New		placed in \MI\Breaches\ of breaches model setups							
						13/05/2026	Deepak Kharat	SHP / MIF		2d_vzsh_LGF_Greatham_Creek_R.shp	New		placed in \MI\Breaches\ of breaches model setups							
						13/05/2026	Deepak Kharat	SHP / MIF		2d_vzsh_Port_Clarence_P.shp	New		placed in \MI\Breaches\ of breaches model setups							
						13/05/2026	Deepak Kharat	SHP / MIF		2d_vzsh_Port_Clarence_R.shp	New		placed in \MI\Breaches\ of breaches model setups							
						13/05/2026	Deepak Kharat	1d model	41	RTees_DDD_005_T200_2100_041_stability_TUFLOW.ief	RTees_DDD_005_T200_2100_040_stab ty_TU LOW ef	lodelling\05 dev1breach1\FM\IEFS	updated reference to TCF							
						13/05/2026	Deepak Kharat	1d model	41	RTees_DDD_005_T200_2100_UE_041_stability_TUFLOW.ief	RTees_DDD_005_T200_2100_UE_040_ ab lit _ UFLOW	lodelling\05 dev1breach1\FM\IEFS	updated reference to TCF							
						13/05/2026	Deepak Kharat	TRD / TCF	41	RTees_010_T200_2100_041_stability.tcf	RTees_010_T200_2100_040_st lity.tc	g\05 dev1breach1\TUFLOW\RUNS	updated ref to updated tgc; In 57 added ZH; updated output and check files locatons							
						13/05/2026	Deepak Kharat	TRD / TCF	41	RTees_010_T200_2100_UE_041_stability.tcf	RTees_010_T200_2100_UE_040_ tabili . f	g\05 dev1breach1\TUFLOW\RUNS	updated ref to updated tgc; In 57 added ZH; updated output and check files locatons							
						13/05/2026	Deepak Kharat	TGC	41	RTees_010_ISISESTRY_041_CC_stability.tgc	RTees_010_ISISE TRY_0 0_CC_stab l ty. gc	h1\TUFLOW\MODEL\MI\Breaches	Added breaches							
						14/05/2026	Deepak Kharat	1d model	42	RTees_DDD_005_T200_2100_042_stability_TUFLOW.ief	RTees_DDD_005_T200_2100_041_stab ty_TU LOW ef	lodelling\05 dev1breach2\FM\IEFS	changed ref to v42 tcf							
						14/05/2026	Deepak Kharat	1d model	42	RTees_DDD_005_T200_2100_UE_042_stability_TUFLOW.ief	RTees_DDD_005_T200_2100_UE_041_ ab lit _ UFLOW	lodelling\05 dev1breach2\FM\IEFS	changed ref to v42 tcf							
						14/05/2026	Deepak Kharat	TRD / TCF	42	RTees_010_T200_2100_042_stability.tcf	RTees_010_T200_2100_041_st lity.tc	g\05 dev1breach2\TUFLOW\RUNS	changed ref to v42 tgc; folder names updated							
						14/05/2026	Deepak Kharat	TRD / TCF	42	RTees_010_T200_2100_UE_042_stability.tcf	RTees_010_T200_2100_UE_041_ tabili f	g\05 dev1breach2\TUFLOW\RUNS	changed ref to v42 tgc; folder names updated							
						14/05/2026	Deepak Kharat	TGC	42	RTees_010_ISISESTRY_042_CC_stability.tgc	RTees_010_ISISE TRY_0 1_CC_stab l ty. gc	h2\TUFLOW\MODEL\MI\Breaches	Activated breach2 instead							
						24/05/2026	Deepak Kharat	other 2d data		Dev1_merged_v2_clipped.tif	New	\TUFLOW\MODEL\DTM2026\Dev1	Created new DTM from Dev1 Quay design							
						24/05/2026	Deepak Kharat	other 2d data		2d_zsh_wing_walls_Dev1_L.shp	New	5 dev1\TUFLOW\MODEL\MI\Dev1	Development proposal							
						24/05/2026	Deepak Kharat	other 2d data		2d_zsh_wing_walls_Dev1_P	New	5 dev1\TUFLOW\MODEL\MI\Dev1	Development proposal							
						24/05/2026	Deepak Kharat	other 2d data		2d_zsh_Quay_Dev1_R.shp	New	5 dev1\TUFLOW\MODEL\MI\Dev1	Development proposal							
						24/05/2026	Deepak Kharat	other 2d data		2d_mat_Dev1.shp	New	5 dev1\TUFLOW\MODEL\MI\Dev1	Development proposal - materials							
						24/05/2026	Deepak Kharat	TGC	43	RTees_010_ISISESTRY_043_CC_stability.tgc	RTees_010_ISISESTRY_040_CC_stabil y tgc	odelling\05 dev1\TUFLOW\MODEL	Dev1 added Quay DTM, quay walls, Quay and materials							
						24/05/2026	Deepak Kharat	TRD / TCF	43	RTees_010_T1000_2030_043_stability.tcf	RTees_010_T1000_2030_040_stabi ity t	Modelling\05 dev1\TUFLOW\RUNS	Refers to updated .tgc (040), check file location updated							
						24/05/2026	Deepak Kharat	TRD / TCF	43	RTees_010_T100_2030_043_stability.tcf	RTees_010_T100_2030_040_stabili .tc	Modelling\05 dev1\TUFLOW\RUNS	Refers to updated .tgc (040), check file location updated							
						24/05/2026	Deepak Kharat	TRD / TCF	43	RTees_010_T200_2030_043_stability.tcf	RTees_010_T200_2030_040_stabili .tc	Modelling\05 dev1\TUFLOW\RUNS	Refers to updated .tgc (040), check file location updated							
						24/05/2026	Deepak Kharat	TRD / TCF	43	RTees_010_T200_2080_043_stability.tcf	RTees_010_T200_2080_040_stabili .tc	Modelling\05 dev1\TUFLOW\RUNS	Refers to updated .tgc (040), check file location updated							
						24/05/2026	Deepak Kharat	TRD / TCF	43	RTees_010_T200_2105_043_stability.tcf	RTees_010_T200_2105_040_stabili .tc	Modelling\05 dev1\TUFLOW\RUNS	Refers to updated .tgc (040), check file location updated							
						24/05/2026	Deepak Kharat	TRD / TCF	43	RTees_010_T200_2105_UE_043_stability.tcf	RTees_010_T200_2105_UE_040_stabili tcf	Modelling\05 dev1\TUFLOW\RUNS	Refers to updated .tgc (040), check file location updated							
						24/05/2026	Deepak Kharat	TRD / TCF	43	RTees_010_T200_2130_043_stability.tcf	RTees_010_T200_2130_040_stabili tc	Modelling\05 dev1\TUFLOW\RUNS	Refers to updated .tgc (040), check file location updated							
						24/05/2026	Deepak Kharat	1d model	43	RTees_DDD_005_T1000_2030_043_stability_TUFLOW.ief	RTees_DDD_005_T1000_2030_040_stabili y_T LOW ef	GF\02 Modelling\05 dev1\FM\IEFS	updated ref to v43 tcf							
						24/05/2026	Deepak Kharat	1d model	43	RTees_DDD_005_T100_2030_043_stability_TUFLOW.ief	RTees_DDD_005_T100_2030_040_stability_ U OW.i	GF\02 Modelling\05 dev1\FM\IEFS	updated ref to v43 tcf							
						24/05/2026	Deepak Kharat	1d model	43	RTees_DDD_005_T200_2030_043_stability_TUFLOW.ief	RTees_DDD_005_T200_2030_040_stability_ U OW.i	GF\02 Modelling\05 dev1\FM\IEFS	updated ref to v43 tcf							
						24/05/2026	Deepak Kharat	1d model	43	RTees_DDD_005_T200_2080_043_stability_TUFLOW.ief	RTees_DDD_005_T200_2080_040_stability_ U OW.i	GF\02 Modelling\05 dev1\FM\IEFS	updated ref to v43 tcf							
						24/05/2026	Deepak Kharat	1d model	43	RTees_DDD_005_T200_2105_043_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_040_stability_ U OW.i	GF\02 Modelling\05 dev1\FM\IEFS	updated ref to v43 tcf							

						24/05/2026	Deepak Kharat	1d model	43	RTees_DDD_005_T200_2105_UE_043_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_UE_040_stabi ity_TUFLOW	GF\02 Modelling\05 dev1\FM\IEFS	updated ref to v43 tcf
						24/05/2026	Deepak Kharat	1d model	43	RTees_DDD_005_T200_2130_043_stability_TUFLOW.ief	RTees_DDD_005_T200_2130_040_stability_ U OW.i	GF\02 Modelling\05 dev1\FM\IEFS	updated ref to v43 tcf
					Yes	08/06/2026	Deepak Kharat	other 2d data		2d_zsh_Main_Site_Dev2_v2_R.shp	N w	6 dev2\TUFLOW\MODEL\MI\Dev2	Dev2 added site, incl green lizard freehold at elevation 5.08 mAOD minimum
					Yes	05/06/2026	Deepak Kharat	other 2d data		2d_zsh_Roads_Dev2_R.shp	N w	6 dev2\TUFLOW\MODEL\MI\Dev2	Dev2 added roads at elevation 5.23 (0.15m) higher
					Yes	05/06/2026	Deepak Kharat	other 2d data		2d_zsh_Bunds_Dev2_R.shp	N w	6 dev2\TUFLOW\MODEL\MI\Dev2	Dev2 added containment bunds at elevation 5.88 (0.8m higher)
					yes	08/06/2026	Deepak Kharat	other 2d data		2d_zsh_Bunds_Dev2_v2_R.shp	2 _ sh_Bu ds_D 2_R shp	6 dev2\TUFLOW\MODEL\MI\Dev2	Dev2 added containment bunds as platforms at elevation 5.88 (0.8m higher)
					Yes	08/06/2026	Deepak Kharat	other 2d data		2d_zsh_Buildings_Dev2_R.shp	N w	6 dev2\TUFLOW\MODEL\MI\Dev2	Dev2 added buidings nad plants at elevation 5.68 (0.6m higher)
					Yes	08/06/2026	Deepak Kharat	other 2d data		2d_mat_Dev2_Main_Site.shp	N w	6 dev2\TUFLOW\MODEL\MI\Dev2	Dev2 materials for main site incl green lizard freehold
					Yes	05/06/2026	Deepak Kharat	other 2d data		2d_mat_Dev2.shp	N w	6 dev2\TUFLOW\MODEL\MI\Dev2	Dev2 Materials for development components
						08/06/2026	Deepak Kharat	TGC	44	RTees_010_ISISESTRY_044_CC_stability.tgc	R e s_010_IS SESTR _043_CC_s bil y tgc	odelling\06 dev2\TUFLOW\MODEL	Dev2 Added main site platform, and roads, bunds & buildings within the main site. Added materials. Changed sequence of Dev1&2 reads. Dev1-Quay devlopment is read later.
						05/06/2026	Deepak Kharat	TRD / TCF	44	RTees_010_T1000_2030_044_stability.tcf	R s_010_T1000_20 0_043_stabil ty t	Modelling\06 dev2\TUFLOW\RUNS	updated ref to v44 tcf and check files to Dev2 folder
						05/06/2026	Deepak Kharat	TRD / TCF	44	RTees_010_T100_2030_044_stability.tcf	R s_010_T100_2030_043_stabi ity tc	Modelling\06 dev2\TUFLOW\RUNS	updated ref to v44 tcf and check files to Dev2 folder
						05/06/2026	Deepak Kharat	TRD / TCF	44	RTees_010_T200_2030_044_stability.tcf	R s_010_T200_2030_043_stabi ity tc	Modelling\06 dev2\TUFLOW\RUNS	updated ref to v44 tcf and check files to Dev2 folder
						05/06/2026	Deepak Kharat	TRD / TCF	44	RTees_010_T200_2080_044_stability.tcf	R s_010_T200_2080_043_stabi ity tc	Modelling\06 dev2\TUFLOW\RUNS	updated ref to v44 tcf and check files to Dev2 folder
						05/06/2026	Deepak Kharat	TRD / TCF	44	RTees_010_T200_2105_044_stability.tcf	R s_010_T200_2105_043_stabi ity tc	Modelling\06 dev2\TUFLOW\RUNS	updated ref to v44 tcf and check files to Dev2 folder
						05/06/2026	Deepak Kharat	TRD / TCF	44	RTees_010_T200_2105_UE_044_stability.tcf	R s_010_T200_2105_UE_043 s b li tcf	Modelling\06 dev2\TUFLOW\RUNS	updated ref to v44 tcf and check files to Dev2 folder
						05/06/2026	Deepak Kharat	TRD / TCF	44	RTees_010_T200_2130_044_stability.tcf	R s_010_T200_2130_043_stabi ity tc	Modelling\06 dev2\TUFLOW\RUNS	updated ref to v44 tcf and check files to Dev2 folder
						05/06/2026	Deepak Kharat	1d model	44	RTees_DDD_005_T1000_2030_044_stability_TUFLOW.ief	RTees_DDD_005_T1000_2030_043_stabi ity_T LOW e	GF\02 Modelling\06 dev2\FM\IEFS	updated ref to v44 tcf
						05/06/2026	Deepak Kharat	1d model	44	RTees_DDD_005_T100_2030_044_stability_TUFLOW.ief	RTees_DDD_005_T100_2030_043_ tabi i y_ U OW.i	GF\02 Modelling\06 dev2\FM\IEFS	updated ref to v44 tcf
						05/06/2026	Deepak Kharat	1d model	44	RTees_DDD_005_T200_2030_044_stability_TUFLOW.ief	RTees_DDD_005_T200_2030_043_ tabi i y_ U OW.i	GF\02 Modelling\06 dev2\FM\IEFS	updated ref to v44 tcf
						05/06/2026	Deepak Kharat	1d model	44	RTees_DDD_005_T200_2080_044_stability_TUFLOW.ief	RTees_DDD_005_T200_2080_043_ tabi i y_ U OW.i	GF\02 Modelling\06 dev2\FM\IEFS	updated ref to v44 tcf
						05/06/2026	Deepak Kharat	1d model	44	RTees_DDD_005_T200_2105_044_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_043_ tabi i y_ U OW.i	GF\02 Modelling\06 dev2\FM\IEFS	updated ref to v44 tcf
						05/06/2026	Deepak Kharat	1d model	44	RTees_DDD_005_T200_2105_UE_044_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_UE_043 s abil ty_TUFLOW	GF\02 Modelling\06 dev2\FM\IEFS	updated ref to v44 tcf
						05/06/2026	Deepak Kharat	1d model	44	RTees_DDD_005_T200_2130_044_stability_TUFLOW.ief	RTees_DDD_005_T200_2130_043_ tabi i y_ U OW.i	GF\02 Modelling\06 dev2\FM\IEFS	updated ref to v44 tcf
						11/06/2026	Deepak Kharat	other 2d data		2d_zsh_Bunds_Dev3_R.shp	n but based on 2d_ sh_Bu d _D v2_v2_R p	7 dev3\TUFLOW\MODEL\MI\Dev3	Dev3 added containment bunds as platforms at elevation 5.88 (0.8m higher)
						11/06/2026	Deepak Kharat	other 2d data		2d_zsh_Buildings_Dev3_R.shp	n but based on 2d_ sh_Bu ld ng _De 2_R.shp	7 dev3\TUFLOW\MODEL\MI\Dev3	Dev3 added buidings and plants at elevation 5.68 (0.6m higher)
						08/06/2026	Deepak Kharat	other 2d data		2d_mat_Dev3_Main_Site.shp	n but based on 2d_mat_Dev2_M n_ t .shp	7 dev3\TUFLOW\MODEL\MI\Dev3	Dev3 materials for main site incl green lizard freehold
						11/06/2026	Deepak Kharat	other 2d data		2d_mat_Dev3.shp	n but based on 2d_m t_Dev shp	7 dev3\TUFLOW\MODEL\MI\Dev3	Dev3 Materials for development components
						11/06/2026	Deepak Kharat	TGC	45	RTees_010_ISISESTRY_045_CC_stability.tgc	R e s_010_IS SESTR _044_CC_s bil y tgc	odelling\07 dev3\TUFLOW\MODEL	Dev3 Has newr layout of bunds, bldgs and mat compared to Dev2. Accordingly, replaced the corresponding shp file commands for these. Dev1-Quay devlopment is read later. Other files from Dev2 have been copied to Dev3 for clarity on what Dev3 represents.
					Yes	11/06/2026	Deepak Kharat	TRD / TCF	45	RTees_010_T1000_2030_045_stability.tcf	R s_010_T1000_20 0_044_stabil ty t	Modelling\07 dev3\TUFLOW\RUNS	updated ref to v45 tcf and check files to Dev3 folder
					Yes	11/06/2026	Deepak Kharat	TRD / TCF	45	RTees_010_T100_2030_045_stability.tcf	R s_010_T100_2030_044_stabi ity tc	Modelling\07 dev3\TUFLOW\RUNS	updated ref to v45 tcf and check files to Dev3 folder
					Yes	11/06/2026	Deepak Kharat	TRD / TCF	45	RTees_010_T200_2030_045_stability.tcf	R s_010_T200_2030_044_stabi ity tc	Modelling\07 dev3\TUFLOW\RUNS	updated ref to v45 tcf and check files to Dev3 folder
					Yes	11/06/2026	Deepak Kharat	TRD / TCF	45	RTees_010_T200_2080_045_stability.tcf	R s_010_T200_2080_044_stabi ity tc	Modelling\07 dev3\TUFLOW\RUNS	updated ref to v45 tcf and check files to Dev3 folder
					Yes	11/06/2026	Deepak Kharat	TRD / TCF	45	RTees_010_T200_2105_045_stability.tcf	R s_010_T200_2105_044_stabi ity tc	Modelling\07 dev3\TUFLOW\RUNS	updated ref to v45 tcf and check files to Dev3 folder
					Yes	11/06/2026	Deepak Kharat	TRD / TCF	45	RTees_010_T200_2105_UE_045_stability.tcf	R s_010_T200_2105_UE_044 s b li tcf	Modelling\07 dev3\TUFLOW\RUNS	updated ref to v45 tcf and check files to Dev3 folder
					Yes	11/06/2026	Deepak Kharat	TRD / TCF	45	RTees_010_T200_2130_045_stability.tcf	R s_010_T200_2130_044_stabi ity tc	Modelling\07 dev3\TUFLOW\RUNS	updated ref to v45 tcf and check files to Dev3 folder
					Yes	11/06/2026	Deepak Kharat	1d model	45	RTees_DDD_005_T1000_2030_045_stability_TUFLOW.ief	RTees_DDD_005_T1000_2030_044_stabi ity_T LOW e	GF\02 Modelling\07 dev3\FM\IEFS	updated ref to v45 tcf
					Yes	11/06/2026	Deepak Kharat	1d model	45	RTees_DDD_005_T100_2030_045_stability_TUFLOW.ief	RTees_DDD_005_T100_2030_044_ tabi i y_ U OW.i	GF\02 Modelling\07 dev3\FM\IEFS	updated ref to v45 tcf
					Yes	11/06/2026	Deepak Kharat	1d model	45	RTees_DDD_005_T200_2030_045_stability_TUFLOW.ief	RTees_DDD_005_T200_2030_044_ tabi i y_ U OW.i	GF\02 Modelling\07 dev3\FM\IEFS	updated ref to v45 tcf
					Yes	11/06/2026	Deepak Kharat	1d model	45	RTees_DDD_005_T200_2080_045_stability_TUFLOW.ief	RTees_DDD_005_T200_2080_044_ tabi i y_ U OW.i	GF\02 Modelling\07 dev3\FM\IEFS	updated ref to v45 tcf
					Yes	11/06/2026	Deepak Kharat	1d model	45	RTees_DDD_005_T200_2105_045_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_044_ tabi i y_ U OW.i	GF\02 Modelling\07 dev3\FM\IEFS	updated ref to v45 tcf
					Yes	11/06/2026	Deepak Kharat	1d model	45	RTees_DDD_005_T200_2105_UE_045_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_UE_044 s abil ty_TUFLOW	GF\02 Modelling\07 dev3\FM\IEFS	updated ref to v45 tcf
					Yes	11/06/2026	Deepak Kharat	1d model	45	RTees_DDD_005_T200_2130_045_stability_TUFLOW.ief	RTees_DDD_005_T200_2130_044_ tabi i y_ U OW.i	GF\02 Modelling\07 dev3\FM\IEFS	updated ref to v45 tcf
						24/06/2026	Deepak Kharat		46	RTees_DDD_006.DAT	RTees_DDD_005.DAT	elling\04 baseline_CCA_3\FM\DAT	Design year 2030 CCA uplift of 23% at nodes RT32027 and IF30327; also added these to the Dat file in the main comment and comments at the nodes
						24/06/2026	Deepak Kharat		46	RTees_DDD_007.DAT	RTees_DDD_005.DAT	elling\04 baseline_CCA_3\FM\DAT	Design years 2080, 2105 and 2130 CCA uplift of 40% at nodes RT32027 and IF30327; also added these to the Dat file in the main comment and comments at the nodes
						24/06/2026	Deepak Kharat		46	RTees_DDD_008.DAT	RTees_DDD_005.DAT	elling\04 baseline_CCA_3\FM\DAT	Design year 2105_UE CCA uplift of 61% at nodes RT32027 and IF30327; also added these to the Dat file in the main comment and comments at the nodes
						24/06/2026	Deepak Kharat	1d model	46	RTees_DDD_005_T100_2030_046_stability_TUFLOW.ief	RTees_DDD_005_T100_2030_0 _ a li _ UFLO\	elling\04 baseline_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_006.DAT
						24/06/2026	Deepak Kharat	1d model	46	RTees_DDD_005_T200_2030_046_stability_TUFLOW.ief	RTees_DDD_005_T200_2030_0 _ a li _ UFLO\	elling\04 baseline_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_006.DAT
						24/06/2026	Deepak Kharat	1d model	46	RTees_DDD_005_T200_2080_046_stability_TUFLOW.ief	RTees_DDD_005_T200_2080_0 0_stability_ UFLO	elling\04 baseline_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_007.DAT
						24/06/2026	Deepak Kharat	1d model	46	RTees_DDD_005_T200_2105_046_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_0 0_stability_ UFLO	elling\04 baseline_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_007.DAT
						24/06/2026	Deepak Kharat	1d model	46	RTees_DDD_005_T200_2105_UE_046_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_U _040_ tabili y_TU	elling\04 baseline_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_008.DAT
						24/06/2026	Deepak Kharat	1d model	46	RTees_DDD_005_T200_2130_046_stability_TUFLOW.ief	RTees_DDD_005_T200_2130_0 _ a li _ UFLO\	elling\04 baseline_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_007.DAT
						24/06/2026	Deepak Kharat	1d model	46	RTees_DDD_005_T1000_2030_046_stability_TUFLOW.ief	RTees_DDD_005_T1000_2030_0 0_stability_TUFLC	elling\04 baseline_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_006.DAT
						24/06/2026	Deepak Kharat	CSV	2	bc_dbase_RTees_002_23per_CCA.csv	bc_dbase_RTees_001.csv	seline_CCA_3\TUFLOW\BC_DBASE	Design year 2030 CCA uplift of 23% same as in RTees_DDD_006.DAT
						24/06/2026	Deepak Kharat	CSV	2	bc_dbase_RTees_002_40per_CCA.csv	bc_dbase_RTees_001.csv	seline_CCA_3\TUFLOW\BC_DBASE	Design years 2080, 2105 and 2130 CCA uplift of 40% same as in RTees_DDD_007.DAT
						24/06/2026	Deepak Kharat	CSV	2	bc_dbase_RTees_002_61per_CCA.csv	bc_dbase_RTees_001.csv	seline_CCA_3\TUFLOW\BC_DBASE	Design year 2105_UE CCA uplift of 61% same as in RTees_DDD_008.DAT
						24/06/2026	Deepak Kharat	TRD / TCF	46	RTees_010_T1000_2030_046_stability.tcf	RTees_010_T1000_2030_040_stability.tcf	4 baseline_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_23per_CCA.csv
						24/06/2026	Deepak Kharat	TRD / TCF	46	RTees_010_T100_2030_046_stability.tcf	RTees_010_T100_2030_040_stability.tcf	4 baseline_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_23per_CCA.csv
						24/06/2026	Deepak Kharat	TRD / TCF	46	RTees_010_T200_2030_046_stability.tcf	RTees_010_T200_2030_040_stability.tcf	4 baseline_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_23per_CCA.csv
						24/06/2026	Deepak Kharat	TRD / TCF	46	RTees_010_T200_2080_046_stability.tcf	RTees_010_T200_2080_040_stability.tcf	4 baseline_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_40per_CCA.csv
						24/06/2026	Deepak Kharat	TRD / TCF	46	RTees_010_T200_2105_046_stability.tcf	RTees_010_T200_2105_040_stability.tcf	4 baseline_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_40per_CCA.csv
						24/06/2026	Deepak Kharat	TRD / TCF	46	RTees_010_T200_2105_UE_046_stability.tcf	RTees_010_T200_2105_UE_040_stability.tcf	4 baseline_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_61per_CCA.csv
						24/06/2026	Deepak Kharat	TRD / TCF	46	RTees_010_T200_2130_046_stability.tcf	RTees_010_T200_2130_040_stability.tcf	4 baseline_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_40per_CCA.csv
					Yes	24/06/2026	Deepak Kharat	1d model	47	RTees_DDD_005_T1000_2030_047_stability_TUFLOW.ief	RTees_DDD_005_T1000_2030_045_stability_ UFLC	/odelling\07 dev3_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_006.DAT
					Yes	24/06/2026	Deepak Kharat	1d model	47	RTees_DDD_005_T100_2030_047_stability_TUFLOW.ief	RTees_DDD_005_T100_2030_0 5_stability_ UFLO	/odelling\07 dev3_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_006.DAT
					Yes	24/06/2026	Deepak Kharat	1d model	47	RTees_DDD_005_T200_2030_047_stability_TUFLOW.ief	RTees_DDD_005_T200_2030_0 5_stability_ UFLO	/odelling\07 dev3_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_006.DAT
					Yes	24/06/2026	Deepak Kharat	1d model	47	RTees_DDD_005_T200_2080_047_stability_TUFLOW.ief	RTees_DDD_005_T200_2080_045_s abili y_ UF O	/odelling\07 dev3_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_007.DAT
					Yes	24/06/2026	Deepak Kharat	1d model	47	RTees_DDD_005_T200_2105_047_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_0 5_stability_ UFLO	/odelling\07 dev3_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_007.DAT
					Yes	24/06/2026	Deepak Kharat	1d model	47	RTees_DDD_005_T200_2105_UE_047_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_UE_0 5_stability_ U	/odelling\07 dev3_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_008.DAT
					Yes	24/06/2026	Deepak Kharat	1d model	47	RTees_DDD_005_T200_2130_047_stability_TUFLOW.ief	RTees_DDD_005_T200_2130_0 5_stability_ UFLO	/odelling\07 dev3_CCA_3\FM\IEFS	Changed DAT file to RTees_DDD_007.DAT
					Yes	24/06/2026	Deepak Kharat	TRD / TCF	47	RTees_010_T1000_2030_047_stability.tcf	RTees_010_T1000_2030_045_stability.tcf	ng\07 dev3_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_23per_CCA.csv
					Yes	24/06/2026	Deepak Kharat	TRD / TCF	47	RTees_010_T100_2030_047_stability.tcf	RTees_010_T100_2030_045_stability.tcf	ng\07 dev3_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_23per_CCA.csv
					Yes	24/06/2026	Deepak Kharat	TRD / TCF	47	RTees_010_T200_2030_047_stability.tcf	RTees_010_T200_2030_045_stability.tcf	ng\07 dev3_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_23per_CCA.csv
					Yes	24/06/2026	Deepak Kharat	TRD / TCF	47	RTees_010_T200_2080_047_stability.tcf	RTees_010_T200_2080_045_stability.tcf	ng\07 dev3_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_40per_CCA.csv
					Yes	24/06/2026	Deepak Kharat	TRD / TCF	47	RTees_010_T200_2105_047_stability.tcf	RTees_010_T200_2105_045_stability.tcf	ng\07 dev3_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_40per_CCA.csv
					Yes	24/06/2026	Deepak Kharat	TRD / TCF	47	RTees_010_T200_2105_UE_047_stability.tcf	RTees_010_T200_2105_UE_045_stability.tcf	ng\07 dev3_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_61per_CCA.csv
					Yes	24/06/2026	Deepak Kharat	TRD / TCF	47	RTees_010_T200_2130_047_stability.tcf	RTees_010_T200_2130_045_stability.tcf	ng\07 dev3_CCA_3\TUFLOW\RUNS	Changed dbase file to bc_dbase_RTees_002_40per_CCA.csv
						07/08/2026	Deepak Kharat	other 2d data		2d_zsh_Main_Site_Dev4_v2_R.shp	New	_CCA_3\TUFLOW\MODEL\MI\Dev4	Update to main site following LGF - RLB change - variation request (06/08/2026)
						07/08/2026	Deepak Kharat	other 2d data		2d_mat_Dev4_Main_Site.shp	New	_CCA_3\TUFLOW\MODEL\MI\Dev4	Update to main site following LGF - RLB change - variation request (06/08/2026)
						07/08/2026	Deepak Kharat	TGC		RTees_010_ISISESTRY_046_CC_stability.tgc	RTees_010_ISISESTRY_045_CC_stability.tgc	\07 dev4_CCA_3\TUFLOW\MODEL	Main site boundary and material updated as per LGF - RLB change - variation request (06/08/2026)
						07/08/2026	Deepak Kharat	1d model	48	RTees_DDD_005_T1000_2030_048_stability_TUFLOW.ief	RTees_DDD_005_T1000_2030_047_stability_TUFLC	/odelling\07 dev4_CCA_3\FM\IEFS	Same as v47 but referring to Dev4 folder, updated ref to v48 TCF
						07/08/2026	Deepak Kharat	1d model	48	RTees_DDD_005_T100_2030_048_stability_TUFLOW.ief	RTees_DDD_005_T100_2030_047_s abili y_ UF O	/odelling\07 dev4_CCA_3\FM\IEFS	--ditto--
						07/08/2026	Deepak Kharat	1d model	48	RTees_DDD_005_T200_2030_048_stability_TUFLOW.ief	RTees_DDD_005_T200_2030_0 7_stability_ UFLO	/odelling\07 dev4_CCA_3\FM\IEFS	--ditto--
						07/08/2026	Deepak Kharat	1d model	48	RTees_DDD_005_T200_2080_048_stability_TUFLOW.ief	RTees_DDD_005_T200_2080_0 7_stability_ UFLO	/odelling\07 dev4_CCA_3\FM\IEFS	--ditto--
						07/08/2026	Deepak Kharat	1d model	48	RTees_DDD_005_T200_2105_048_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_047_s abili y_ UF O	/odelling\07 dev4_CCA_3\FM\IEFS	--ditto--
						07/08/2026	Deepak Kharat	1d model	48	RTees_DDD_005_T200_2105_UE_048_stability_TUFLOW.ief	RTees_DDD_005_T200_2105_UE_0 7_st bi i _ U	/odelling\07 dev4_CCA_3\FM\IEFS	--ditto--
						07/08/2026	Deepak Kharat	1d model	48	RTees_DDD_005_T200_2130_048_stability_TUFLOW.ief	RTees_DDD_005_T200_2130_0 7_stability_ UFLO	/odelling\07 dev4_CCA_3\FM\IEFS	--ditto--
						07/08/2026	Deepak Kharat	TRD / TCF	48	RTees_010_T1000_2030_048_stability.tcf	RTees_010_T1000_2030_047_stability.tcf	ng\07 dev4_CCA_3\TUFLOW\RUNS	Refers to updated TGC;
						07/08/2026	Deepak Kharat	TRD / TCF	48	RTees_010_T100_2030_048_stability.tcf	RTees_010_T100_2030_047_ tabil . f	ng\07 dev4_CCA_3\TUFLOW\RUNS	--ditto--
						07/08/2026	Deepak Kharat	TRD / TCF	48	RTees_010_T200_2030_048_stability.tcf	RTees_010_T200_2030_047_ tabil . f	ng\07 dev4_CCA_3\TUFLOW\RUNS	--ditto--
						07/08/2026	Deepak Kharat	TRD / TCF	48	RTees_010_T200_2080_048_stability.tcf	RTees_010_T200_2080_047_stability.tcf	ng\07 dev4_CCA_3\TUFLOW\RUNS	--ditto--
						07/08/2026	Deepak Kharat	TRD / TCF	48	RTees_010_T200_2105_048_stability.tcf	RTees_010_T200_2105_047_stability.tcf	ng\07 dev4_CCA_3\TUFLOW\RUNS	--ditto--
						07/08/2026	Deepak Kharat	TRD / TCF	48	RTees_010_T200_2105_UE_048_stability.tcf	RTees_010_T200_2105_UE_0 _sta l ty cf	ng\07 dev4_CCA_3\TUFLOW\RUNS	--ditto--

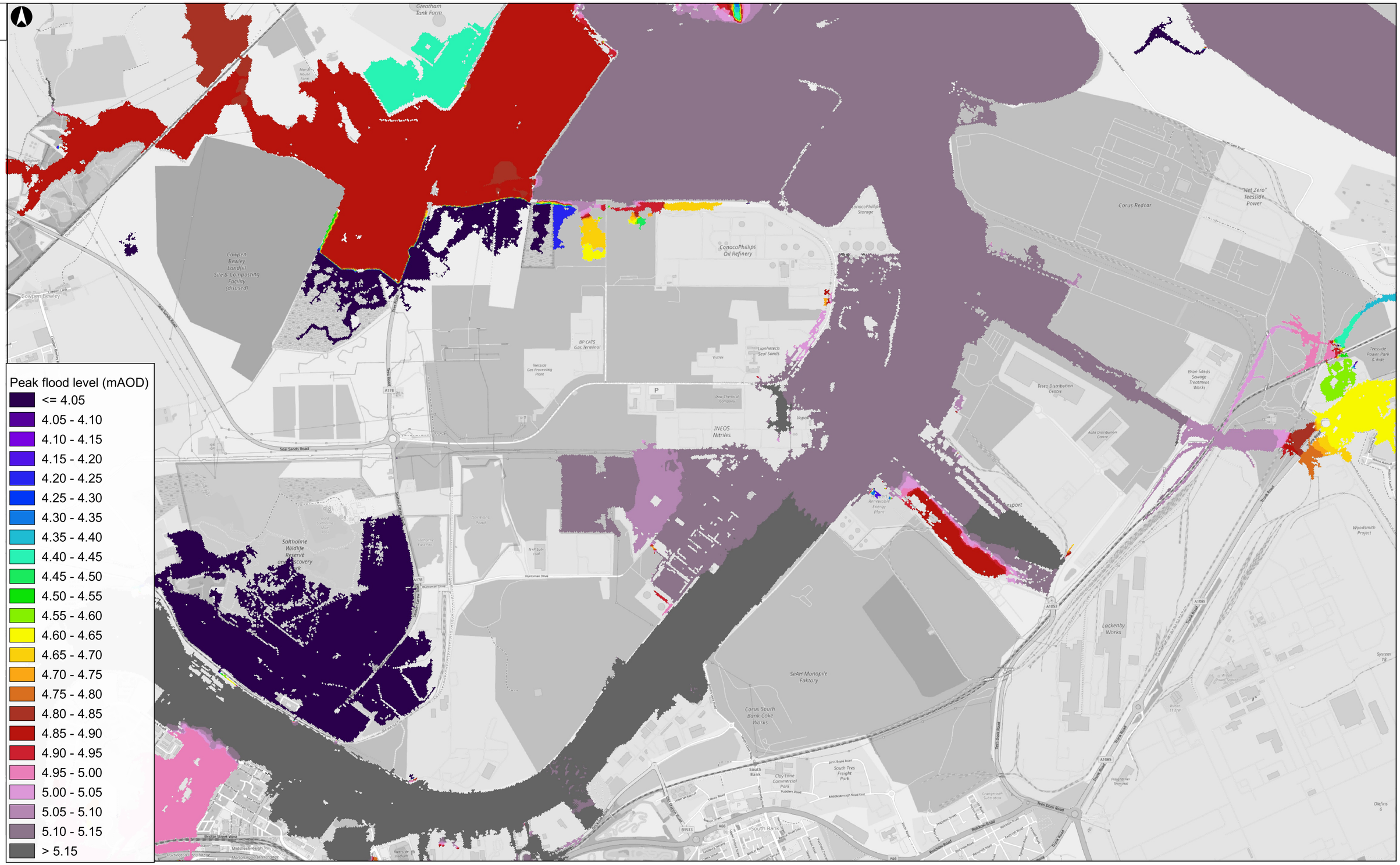
						07/08/2026	Deepak Kharat		TRD / TCF	48	RTees_010_T200_2130_048_stability.tcf	RTees_010_T200_2130_047_stability.tcf	\g\07 dev4_CCA_3\TUFLOW\RUNS	--ditto--									

Attachment E Modelling Figures

Annex E: Hydraulic modelling figures

This is an interactive PDF. Use the layer controls to view events for different results.

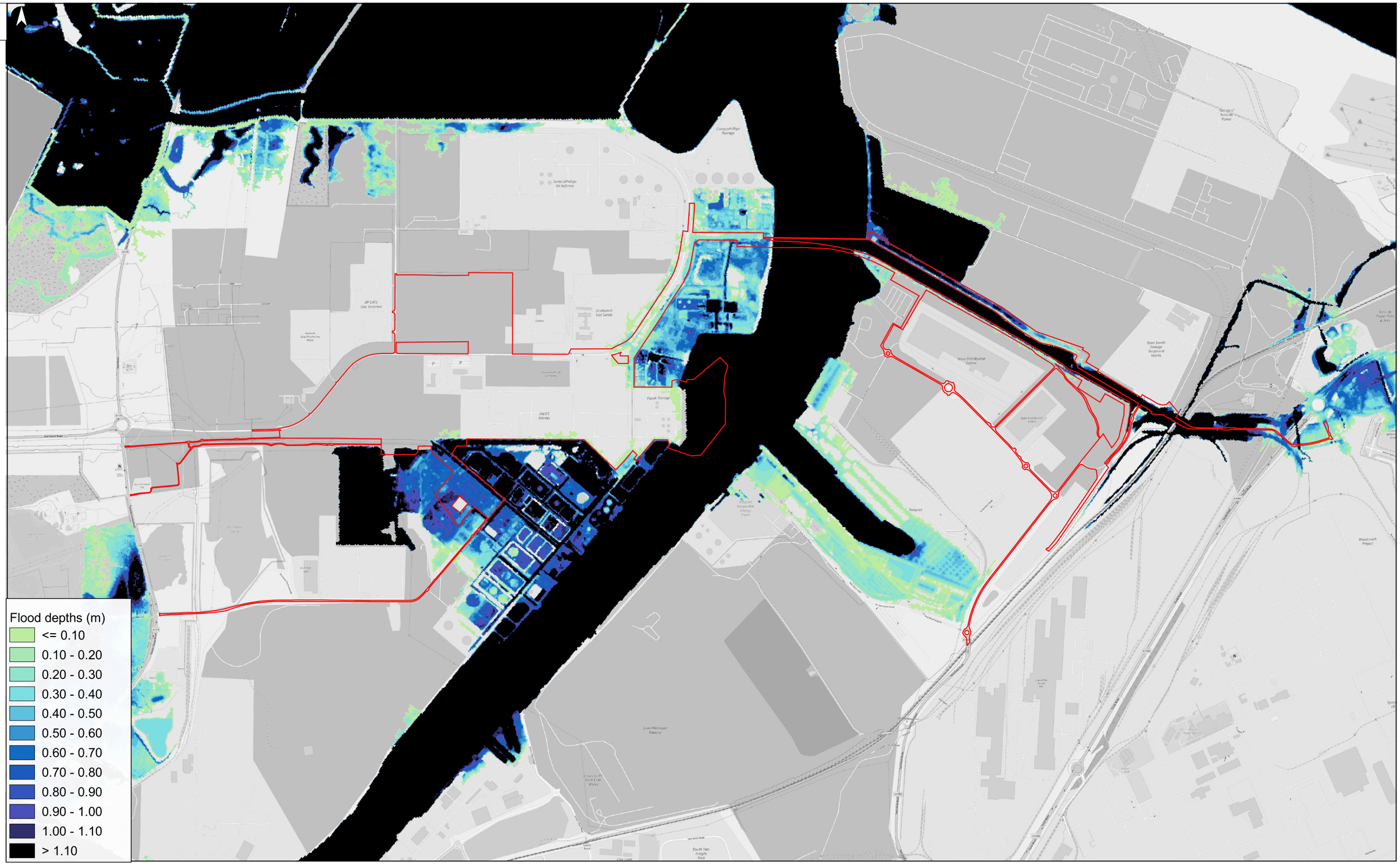
Note: Layers can’t be made exclusive, so care should be taken to view one at a time.



Baseline and Proposed peak water levels

ARUP

Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors.



Baseline and Proposed flood depths

ARUP

Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors.

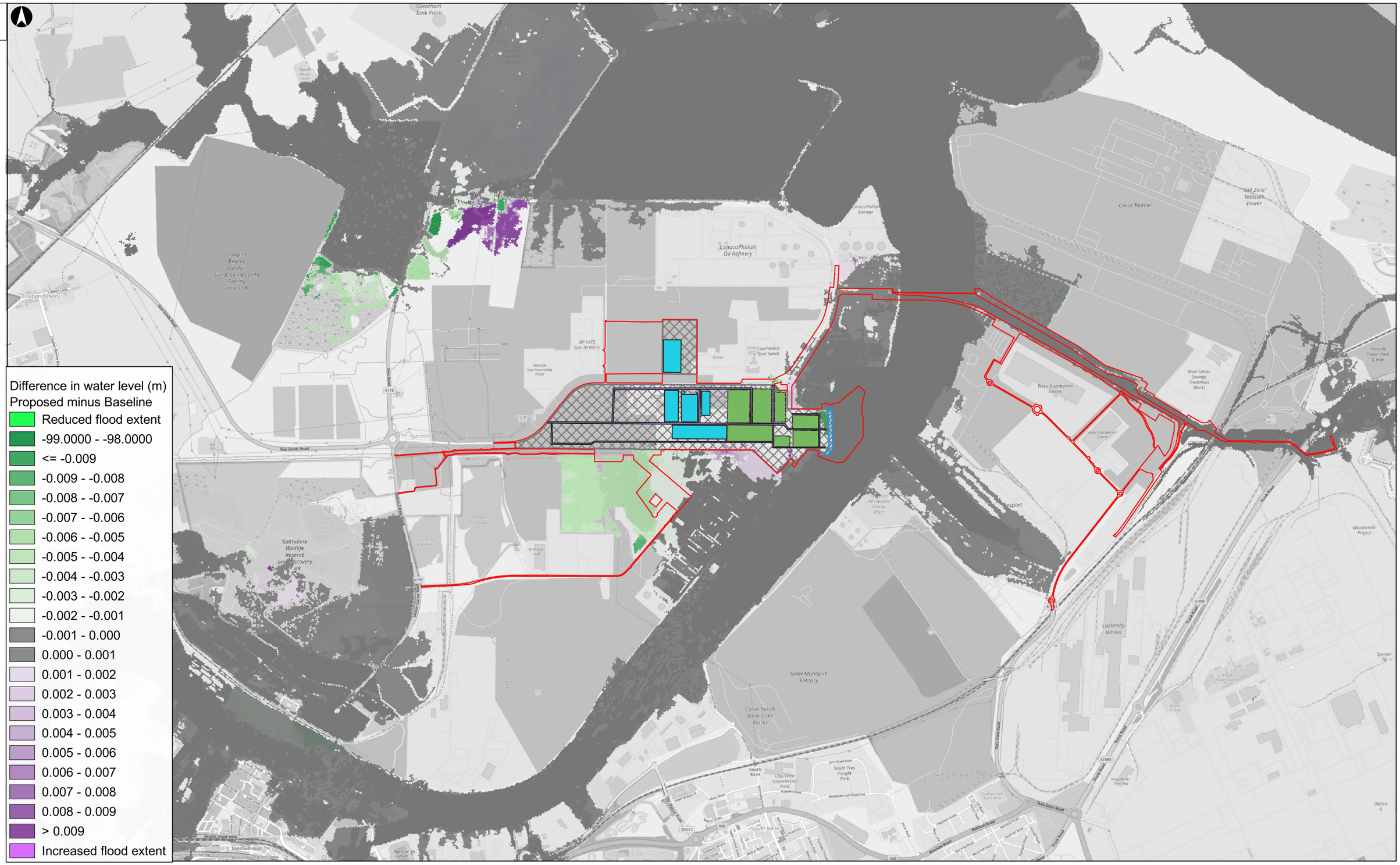
Flood Hazard rating
< 0.75 : Very low hazard
0.75 - 1.25 : Danger for some
1.25 - 2.00 : Danger for most
> 2.00 : Danger for all

Flood Hazard

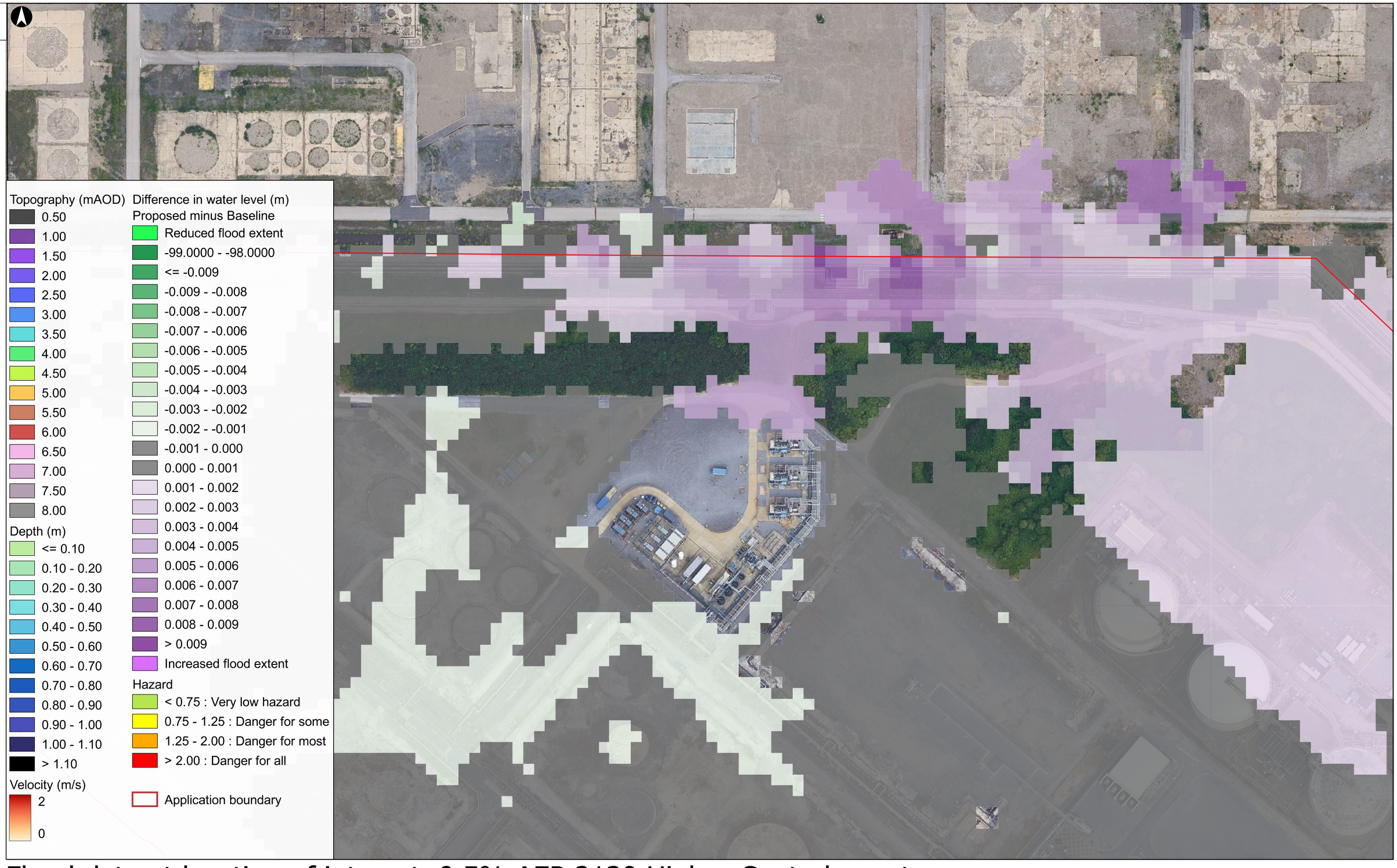
0 1 2 km

ARUP

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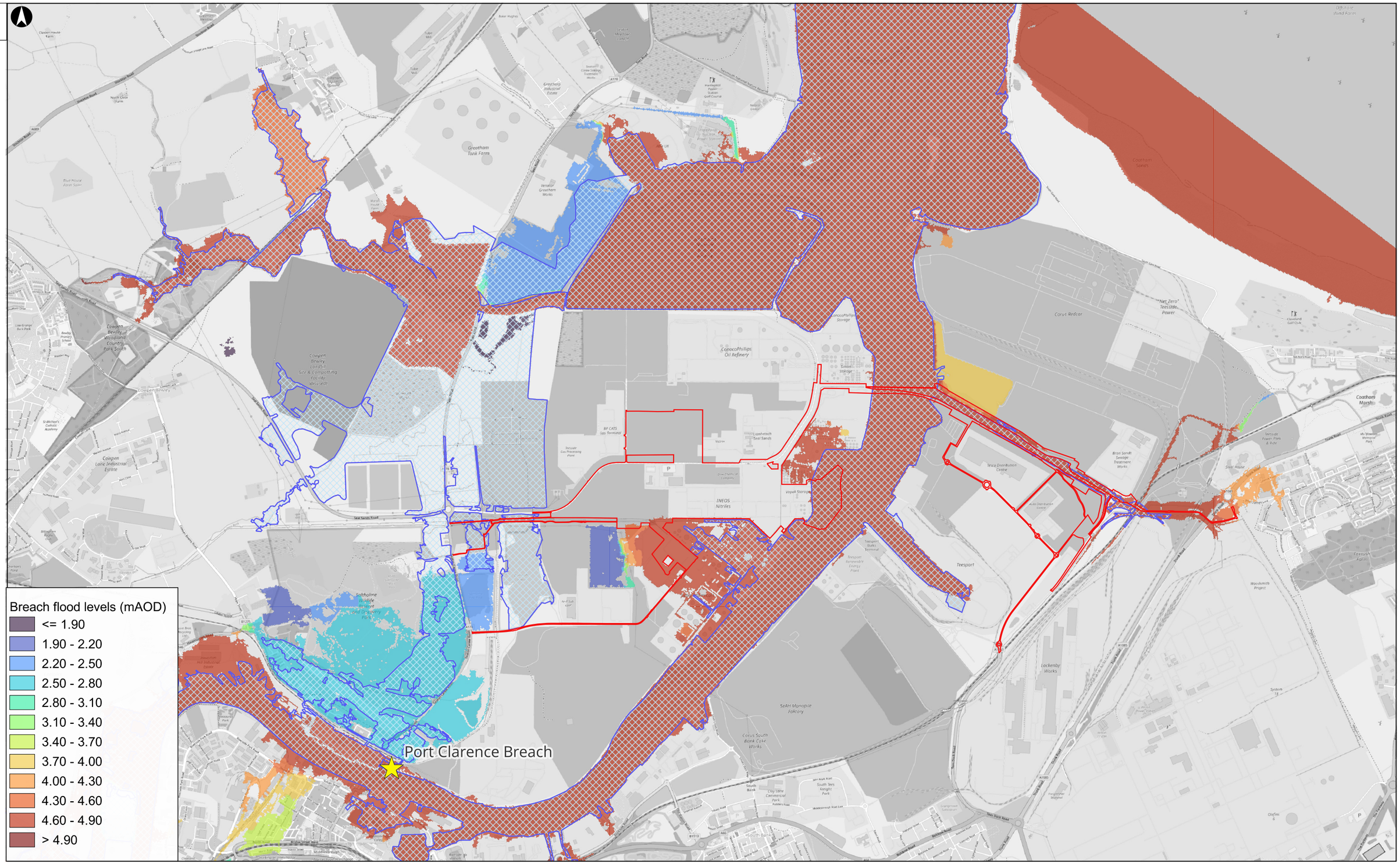


Flood data at location of interest, 0.5% AEP 2130 Higher Central event

0 50 100 m

ARUP

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Imagery (c) Google.com/Maps 2026



Breach flood levels

ARUP

Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors.
Historic Flood Map (c) Environment Agency copyright and/or database right 2025

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