Fluvial Flood Risk Report for AESC Plant 3 site

Final

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This report describes work commissioned by SYSTRA, on behalf of AESC UK, by an instruction dated 09th May 2023. The Client's representative for the contract was Tim Dawe of SYSTRA. Chulani Herath and Kevin Frodsham of JBA Consulting carried out this work.

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Contents

List of Figures

List of Tables

Abbreviations

1D	One-Dimensional
2D	Two-Dimensional
AEP	Annual Exceedance Probability
AESC Plant 3	Name of Development Site
CC	Climate Change
CSD	Critical Storm Duration
DTM	Digital Terrain Model
FEH	Flood Estimation Handbook
FEP	Flow Estimation Point
FRA	Flood Risk Assessment
IAMP	International Advanced Motoring Park
LIDAR	Light Detection and Ranging (remote sensing data)
LMED	Median Annual Stage (L)
m AOD	metres Above Ordnance Datum
NGR	National Grid Reference
QMED	Median Annual Flow (Q)
ReFH	Revitalised Rainfall-Run Off
URBEXT	Urban Extent (FEH catchment descriptor)

Executive Summary

Introduction

JBA were commissioned by SYSTRA to produce a fluvial flood risk report to inform a prospective new development site (i.e., the AESC Plant 3 site) adjacent to the International Advanced Manufacturing Park (IAMP) near Washington, Tyne and Wear. This information is expected to be used by SYSTRA to prepare a Flood Risk Assessment (FRA) for the site.

The Usworth Burn, a tributary of the River Don (Jarrow), flows along the northern edge of the AESC Plant 3 site. JBA previously modelled the fluvial flood risk from the River Don and Usworth Burn for SYSTRA between 2015 and 2018 to inform the FRA for the IAMP (Stage 1), which has now been implemented. The hydrology and hydraulic modelling that underpinned the IAMP FRA were reviewed and accepted by the Environment Agency in 2017 and the results were used to update their Flood Map locally.

Model and Hydrology Review and Updates

One requirement of the current study was to determine what, if any, updates were needed to the existing IAMP (2017) hydrology and hydraulic model to provide an up-to-date picture of the fluvial flood risk to the AESC Plant 3 site. To this purpose, a high-level review of the hydrology and hydraulic model were undertaken, which led to the following outcomes.

- Hydrology
    - The IAMP (2017) model inflows were retained in the knowledge that they have previously been reviewed and accepted by the Environment Agency and are known to be conservative. The critical storm duration for the Usworth Burn alongside the Plot 2 site was also confirmed to be the same as was used for the IAMP site (i.e., 12 hours).
    - The inflows for climate change scenarios were updated to reflect the current recommended climate change uplifts for the study watercourse over the lifetime of the development. A +34% (Central) allowance should be appropriate for the AESC Plant 3 site, if (as expected) it is categorised as 'Highly Vulnerable'. However, a 1% AEP +42% (Higher Central) uplift has also been modelled in this study to provide design levels should the development be categorised as 'essential infrastructure'.
- Hydraulic Modelling - The following model updates were undertaken.
    - The floodplain and bank crests were updated to reflect the latest LIDAR data (i.e., National LIDAR 2022 composite DTM - flown in 2021). This supersedes the combination of old LIDAR (believed from 2009), topographic survey and proposed IAMP levels that was used in the IAMP (2017) model.
    - The floodplain roughness map was updated to reflect the current state of the IAMP1 development in relation to new buildings, roads, hard standing areas and surface water.

Model Runs and Outcomes

The following model simulations were undertaken.

- Baseline (existing risk) AESC Plant 3 scenario.
    - Present day (i.e., without climate change) - 50%, 3.3%, 1% and 0.1% AEP
    - Future (i.e., with climate change) - 3.3% AEP Central (+34%), 1% AEP Central (+34%) and 1% AEP Higher Central (+42%)
- Undefended (Defence Failure) - 1% AEP Central (+34%) event.
- Site Fully Raised - 1% AEP Central (+34%) event.
- Sensitivity Tests - Storm duration, Flow, Roughness and Downstream Boundary.

The modelled baseline (existing risk) flood outlines predict that only a small area along the north-eastern periphery of the AESC Plant 3 site would be at fluvial flood risk. The baseline peak 1% AEP with climate change (+34%) flood levels modelled in the Usworth Burn alongside the site range from 38.43m AOD in the west to 35.76m AOD in the east.

The undefended model predicts that failure of the local (relatively low-level) earth embankments would not increase the flood risk to the AESC Plant 3 site.

The 'site fully raised' scenario predicts that there would be off-site impacts in a 1% AEP with climate change (+34%) event, should the whole of the development site be raised above flood levels.

Implications for Development

Most of the site remains dry in 0.1% AEP event so there would be no fluvial flood risk constraints on developing these parts of the site (providing that excavation is not undertaken to below the modelled flood levels). By contrast, there will be constraints on developing those parts of the site that are modelled to be at fluvial flood risk. The outcome of the 'site fully raised' scenario shows that raising these areas out of the flood zones would lead to adverse off-site impacts so our recommendation would be to avoid any development (including ground level changes) across these areas or else some additional flood mitigation measures would likely be needed to avoid an Environment Agency objection. From a set of proposed development platform levels that were supplied to JBA by SYSTRA in July 2023, the site could be safely developed as planned without having any off-site impacts, but the platform elevations would need to be tapered sharply down to existing levels along the eastern edge of the Giga 3 platform.

There would be no residual risk to the site from defence failure or blockage along the Usworth Burn and River Don. However, one might want to consider whether it would be appropriate to build in resilience to an extreme (0.1% AEP) flood event within any critical parts of the site.

There would be no emergency access/egress issues for the site as dry access would be possible along the A1290 in all events.

Recommendations

The main recommendation from this study would be to ensure that no development takes place within the modelled area of the 1% AEP with climate change (+34%) flood outline. This would ensure that the site was suitably safe and would have no adverse off-site impacts. If ground levels are to be changed across this area, then further work may be needed to quantify the impacts and deliver appropriate mitigation. An alternative approach would be undertake fresh hydrology that would seek to downscale the importance of the Hylton Bridge adjustment factor that underpins the current model hydrology and has led to what is expected to be a conservative assessment of the flood risk.

Limitations

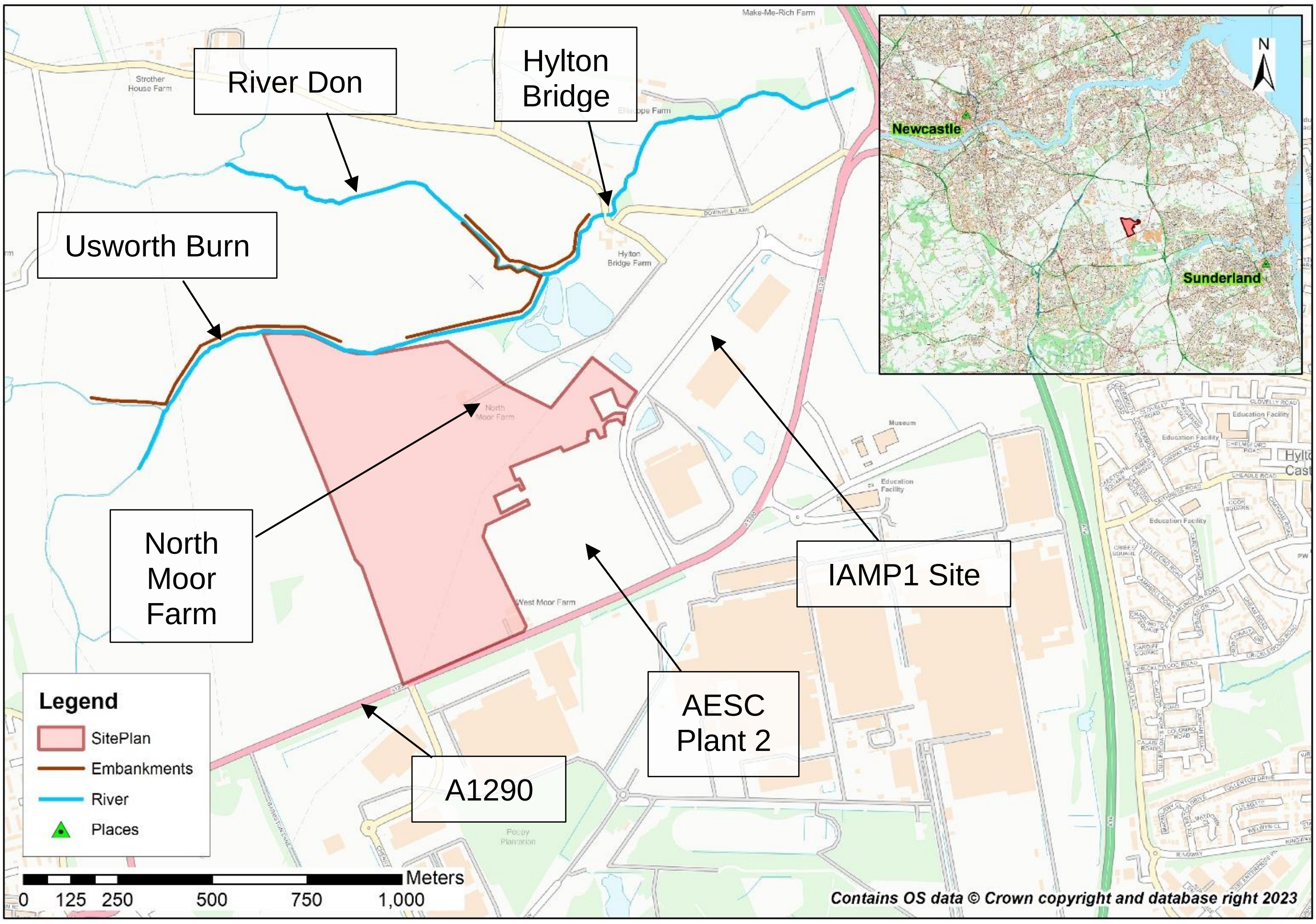
The flood risk presented in this report is based on a model with only minor updates to an existing model that was previously reviewed and accepted by the Environment Agency in 2017. However, the Environment Agency will still likely seek to review the hydraulic model and hydrology after a Flood Risk Assessment has been submitted before removing any objection to the development. There is therefore a risk that the Environment Agency review may require a response that would require further work, which could include a request to update the hydrology or certain parts of the hydraulic model.

1 Introduction

SYSTRA is assisting with the potential development of a commercial (AESC Plant 3) site, which is located between the A1290 and a watercourse called the Usworth Burn near the town of Washington, Tyne and Wear (Figure 1-1). The AESC Plant 3 development site is immediately to the west of the initial stages of the IAMP (International Advanced Motoring Park) development site[1], for which JBA previously assisted SYSTRA between 2015 and 2018 in relation to the fluvial flood risk. The AESC 3 site will be sited alongside the AESC Plant 2, which is now already under construction as part of the IAMP development.

The Usworth Burn is a tributary of the River Don (Jarrow) that flows along the northern edge of the AESC Plant 3 site. There is, therefore, a potential fluvial flood risk to the site that needs to be quantified so that the magnitude of any flood mitigation measures that may be needed can be determined before submitting a site-specific Flood Risk Assessment (FRA) to planning.

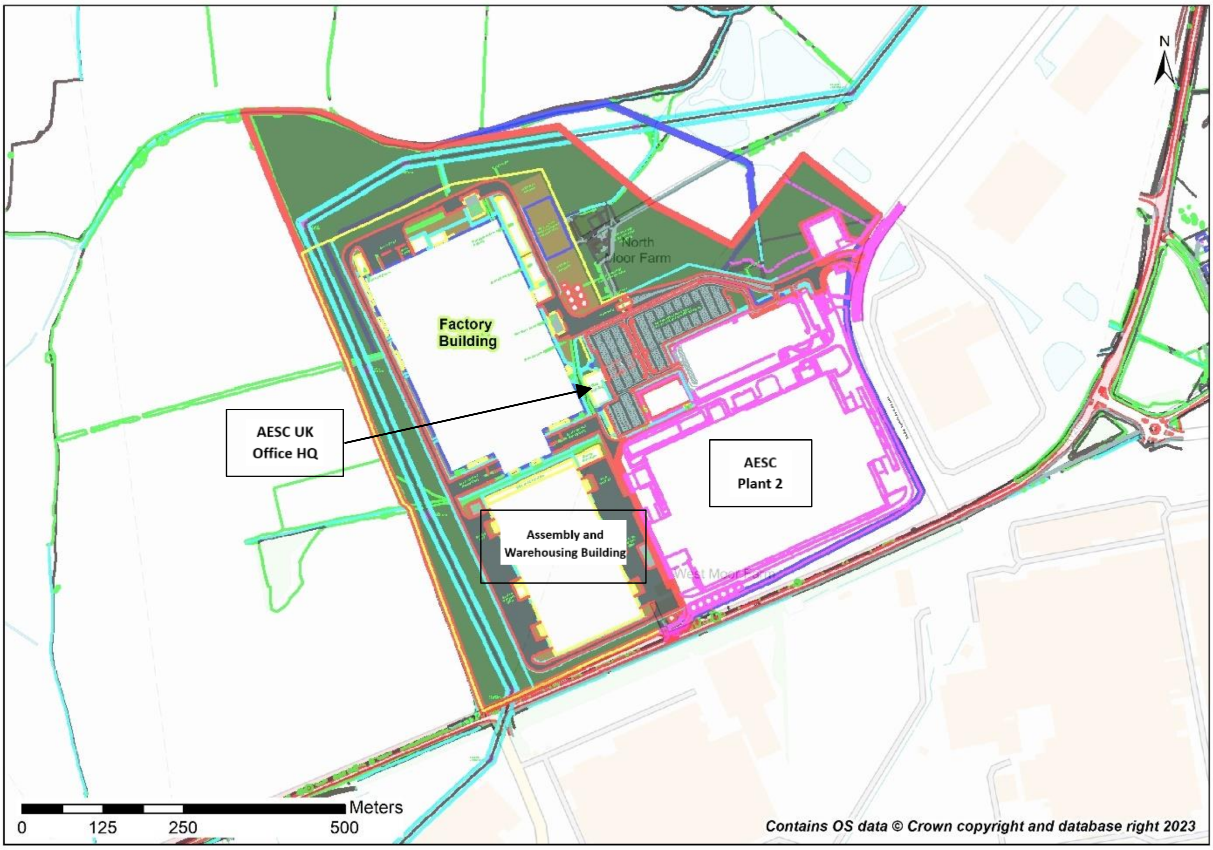
Figure 1-1: Planning Boundary for AESC Plant 3 and location



[1] https://iampnortheast.co.uk/

The proposed site layout is shown in Figure 1-2. The main components of the site design are a large factory building, a large assembly and warehousing building, and a smaller office building. These buildings would be partly surrounded by hardstanding areas (grey on Figure 1-2) with a retaining wall separating this from green space (green on Figure 1-2). The main access to the site is planned to be from International Drive to the east alongside the AESC Plant 2. It is expected that North Moor Farm will be demolished by a third party.

Figure 1-2: Current site layout for the AESC Plant 3 site.



An initial inspection of the results of the previous work on the IAMP site would suggest that the fluvial flood risk to the AESC Plant 3 site is likely to be low. Therefore, the initial commission between JBA and SYSTRA is limited to quantifying the existing fluvial flood risk to the site, which would be needed to present the baseline risk within a Flood Risk Assessment (FRA). Should the existing (baseline) risk be found to place significant constraints on the development, then further work may be needed to identify mitigation measures and quantify their impact.

For the purposes of understanding the existing risk to the site and planning a site-specific flood risk assessment (FRA), up-to-date hydraulic modelling will be required for the AESC Plant 3 site and the outcomes of the following fluvial flood events are required to help inform the fluvial risk and site drainage strategy.

- 1-year, 30-year, 100-year, 1,000-year and 30-yr & 100-yr+climate change.

The climate change (CC) allowances must follow the latest guidance on developing in flood zones[2], which has changed since the IAMP models were last edited.

Any fluvial hydraulic modelling that is used to underpin an FRA will likely be reviewed by the Environment Agency before an objection to development on flood risk grounds is removed. Since the IAMP model and hydrology were previously reviewed and accepted by the Environment Agency in 2017, it is not expected that significant issues will be raised in response to re-using the existing model and flows (updated, as necessary, with the latest climate change allowances). However, if there have been any changes to hydraulic modelling or hydrology best practices since 2017, or, if any new information has become available since 2017 that could call into question the accuracy of the existing model, then some model updates might be required before the Environment Agency is able to sign off the modelling work. Therefore, before re-running the models, a high-level review of the existing IAMP (2017) model and hydrology was undertaken to see what (if any) improvements could be made to the existing hydraulic model. These reviews are documented in Section 2 of this report. The methodology for quantifying the fluvial flood risk to the AESC Plant 3 site is then discussed in Section 3 before the modelling outcomes are presented in Section 4, together with some commentary on the resulting development constraints. Some limitations of the study are listed in Section 5.

This report has been written to summarise the existing fluvial risk to the site to a standard that can be presented as a modelling Appendix to a Flood Risk Assessment.

[2] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

2 Model and Hydrology Review

2.1 Hydraulic Modelling History

The River Don is situated in Tyne and Wear and flows from a source in Washington to the River Tyne at Jarrow. The Usworth Burn is a short tributary of the Don that originates in Usworth and flows into the Don alongside the IAMP1 development. Prior to 2015 there were no detailed hydraulic models of either the River Don or Usworth Burn. Therefore, to assess the risk from these watercourses to the IAMP development, a detailed model was developed by JBA under commission from SYSTRA between 2015 and 2017, which ultimately informed the Flood Risk Assessment (FRA) for the IAMP1 site. The outputs from that model were subsequently used by the Environment Agency to update part of the Flood Zones between Usworth and the A19 (Washington Road). The model was subsequently updated by JBA in October 2018 to reflect a further potential phase of development (IAMP2) but these features have not been implemented so the IAMP1 model represents the most suitable starting point for any existing risk modelling. JBA were involved in a further phase of modelling of the Don and Usworth Burn for South Tyneside Council in 2018/19 as part of a fluvial modelling study for a small number of sites along the River Don. However, this later study merely appended the IAMP1 model into upstream and downstream extensions of the River Don so did not contain any model improvements that could influence the AESC Plant 3 site (other than a fresh set of hydrology calculations).

This chapter documents the development of these flood risk models in a little more detail leading to a more detailed review of the latest model and hydrology.

2.1.1 IAMP1 model

JBA Consulting were originally commissioned by SYSTRA (via JMP) in 2015 to undertake a flood risk modelling study of the fluvial flood risk from the River Don in Washington. The study was used to support the outline planning application for the initial stages of the International Advanced Manufacturing Park (IAMP) development on undeveloped land upstream of the A19.

The study required the production of a hydrology report to define the model inflows and the creation of a new-build hydraulic model of the River Don and Usworth Burn to define the fluvial flood risk.

The hydraulic model is a linked 1D-2D (ISIS-TUFLOW) model that includes a 2.6-kilometre reach of the River Don and a 1.4-kilometre reach of the Usworth Burn (Figure 2-1). The upstream modelled extents on these watercourses are located at Strother House Farm Bridge on the River Don (NGR 432354, 559708) and approximately 600 metres upstream of the upstream extent of the AESC Plant 3 site on the Usworth Burn (NGR 432130, 558907). The downstream model extent is located approximately 500 metres downstream of the A19 (at NGR 431525, 559646), at which point the River Don drains a catchment area of around 17km^2.

Figure 2-1: IAMP1 Model Schematic

Some of the key data components of the model are as follows.

- **Survey** - Topographic survey to underpin the IAMP model was collected by Academy Geomatics in November 2015 and March 2017. This included 38 cross sections along the River Don and Usworth Burn that were used to define the channel geometry and structures within the 1D component of the hydraulic model. Bank height information and floodplain levels were also surveyed.
- **LIDAR** - 1m DTM tiles (believed to have been flown in 2009) were used in combination with topographic survey to define the floodplain topography within the 2D domain of the model.

Both baseline (existing risk) and post-development model scenarios were created as part of the IAMP modelling.

The model was reviewed and accepted by the Environment Agency following a model review undertaken in June 2017. The modelled flood outlines adjacent to the IAMP development were then used to update the Environment Agency's Flood Maps.

2.1.2 IAMP2 modelling - October 2018

This phase of modelling was undertaken in response to the following potential changes that were being considered as a subsequent stage (2) of the IAMP development.

- The inclusion of a new access bridge
- The inclusion of a new hotel platform (raised above flood levels)
- The removal of the Elliscope Farm Access Bridge.

No changes were made to the IAMP1 model inflows at this stage.

None of the studied measures have yet been implemented. Furthermore, none of the modelled changes was predicted to have any impacts when evaluated against the IAMP1 post development model. Therefore, the IAMP1 model would still seem to be the more appropriate baseline model for assessing the baseline (existing risk) to the AESC Plant 3 site.

2.1.3 River Don - South Tyneside Council

This study added both up and downstream extensions to the IAMP1 mode so that the model extended from Northumberland Avenue (A195) to downstream of New Road (B1298) in East Boldon. However, the 1D model remained effectively unchanged through the IAMP model and the 2D model component required a larger (4 metre) cell size because of the increased model extent. In addition, to our knowledge, the model was never received by the Environment Agency. Therefore, the IAMP1 model would still appear to be the best model to use to assess the flood risk to the AESC Plant 3 site. However, a fresh hydrology calculation record was undertaken for the Don (STC) study that is potentially relevant to the AESC Plant 3 site assessment.

2.2 Hydrology Review

2.2.1 IAMP methodology

The IAMP1 and IAMP2 models both utilised the inflows that had been calculated for the IAMP1 study in 2017. Flood estimates were limited to the IAMP model extents as shown in Figure 2-2. Both FEH Statistical and (Urban) ReFH peak flows were estimated for these locations, and the final model inflows were derived as ReFH hydrographs that were scaled (as necessary) to match the FEH Statistical peak flows shown in

Table 2-1. One key assumption of the IAMP hydrology was that the (discontinued) gauge record from Hylton Bridge was appropriate for deriving a donor adjustment factor for the FEH Statistical peak flow estimates. The inclusion of this donor factor more than doubled the peak flows relative to those based on catchment descriptors alone (with or without donor factors from other, more distant, gauges). Hence, the IAMP FRA was undertaken in the expectation that the modelled flows were likely quite conservative.
The IAMP hydrology was signed off by the Environment Agency along with the IAMP model in 2017. Therefore, this review is aimed at checking whether the original IAMP flows are still appropriate for undertaking an FRA for the AESC Plant 3 site in 2023. Given the short

time between the two studies, they should still be appropriate subject to the following checks.

1. The age of the data underpinning the hydrology (i.e., has any new data become available since the IAMP1 model).
2. Hydrology guidance (i.e., has anything changed in terms of standards that could mean that some changes are needed to the original hydrology method).
3. Are any changes needed because the primary fluvial risk to the western extension will be from the Usworth Burn rather than the River Don.

Figure 2-2: Flow Estimation Points (FEPs) for the IAMP study

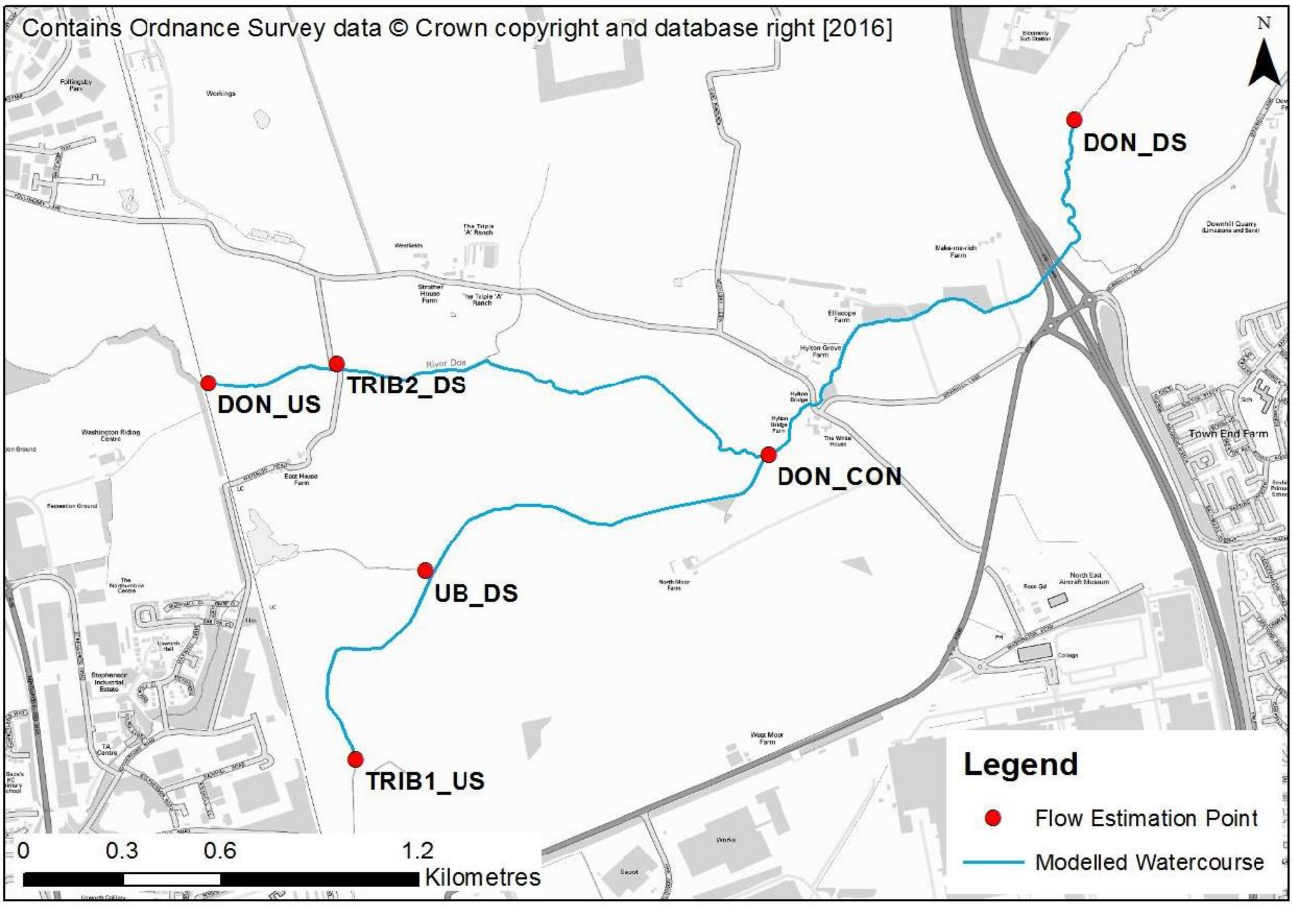


Table 2-1: Final lumped peak flow estimates from the IAMP (2017) study

Flow Estimation Point	Flood peak (m³/s) for the following AEP events (%)									
	50	20	10	5	3.33	2	1.33	1	0.5	0.1
DON_US	2.8	4.1	4.9	5.7	6.2	6.8	7.3	7.6	8.5	10.5
UB_DS	1.6	2.2	2.6	3.0	3.3	3.6	3.9	4.1	4.7	6.1
TRIB1_US	0.7	0.9	1.1	1.2	1.3	1.5	1.6	1.7	1.9	2.5
TRIB2_DS	1.4	1.9	2.3	2.7	2.9	3.2	3.5	3.6	4.0	5.0
DON_CON	7.6	10.8	13.0	15.1	16.4	18.1	19.4	20.3	22.6	28.3
DON_DS	8.4	11.9	14.4	16.8	18.2	20.0	21.4	22.4	25.0	31.0

Issues related to the age of the data

The Hylton Bridge gauge was only operational between October 2005 and June 2014. Therefore, there is no new gauge data within the catchment that could be used to improve the Hylton Bridge donor adjustment that underpins the peak flows used by the IAMP model. If the Hylton Bridge donor factor were to be disregarded, then one would potentially have to resort to using one of the other three gauges (outside the catchment) that were listed in the IAMP Calculation Record as a donor. There may be up to five more years data from these other potential donor sites, but five years additional data is unlikely to induce any significant change to these other donor factors which were all previously either close to or lower than 1.0. An additional five years of data could influence the pooling groups that were used to estimate the growth curves but a major change in the growth curve in relation to this length of additional record is considered unlikely.

Issues related to changes in guidance

In recent years, flow estimation guidelines have shifted from recommending ReFH to using ReFH2 when applying a rainfall run-off method. Therefore, any new calculation record would be expected to list the ReFH2 calculated flows instead of ReFH. However, the peak IAMP model inflows are based on the FEH Statistical method so any update of the ReFH2 flows would likely only have a relatively small influence on the IAMP inflows[3]. If one were to abandon the original preference for generating peak flows via the FEH Statistical approach to generating them via the ReFH2 method, this would bring about an overall reduction in flows because of the magnitude of the Hylton bridge adjustment factor.

It is noted that the local sewer network data was not used in the IAMP study. It was, therefore, assumed that there was no significant transfer of water in or out of the topographic catchments via the sewers. This is a fair assumption for an FRA, for which sourcing the sewer network data would be potentially problematic. However, given the extent of upstream urbanisation, there is a risk that some run-off may be diverted either in or out of the study catchments.

The IAMP hydrology was based on the following software: FEH CD-ROM v3.01, WINFAP-FEH v3.0.0032 and ISIS v3.7 (for urban ReFH). These products have all subsequently been updated, which could lead to changes in any fresh hydrology calculations. However, it is considered highly unlikely that these would lead to a significantly more conservative assessment of the IAMP flows.

Issues related to Usworth Burn being the primary source of risk

The IAMP FRA documents the outcome of storm duration testing, which justified the use of a 12-hour storm for modelling the risk to the IAMP site, which is situated close to the Don / Usworth Burn confluence. However, Table 2-2 (reproduced from the IAMP 2017 report) hints that a shorter storm may be critical along the Usworth Burn. Therefore, the AESC

[3] Via a subtly changed hydrograph shape and/or altered 1%:0.1% AEP ratio, which is used to derive the 0.1% AEP inflows. In addition, the IAMP study made use of the Urban ReFH approach, which represented an improvement over earlier ReFH approaches.

Plant 3 study should seek to confirm the critical storm duration for the site before running design events (see Section 4.4.1).

Table 2-2: Peak river levels modelled in response to different 1% AEP storm durations (reproduced from the IAMP 2017 reporting)

Location	Peak river levels (m AOD) for the following storm durations				
	4 hr	8 hr	12 hr	14 hr	16 hr
US extent of River Don	37.15	37.21	37.19	37.18	37.16
US extent of tributary	40.76	40.73	40.70	40.69	40.67
DS of confluence	34.45	34.59	34.60	34.59	34.58
US face of Hylton Bridge	33.96	34.09	34.10	34.09	34.08
US face of A19 road bridge	32.19	32.42	32.46	32.45	32.43
DS extent of River Don	29.99	30.06	30.07	30.07	30.07

2.2.2 River Don STC Study

Whereas the IAMP study was restricted to the upper reaches of the Don, the STC study undertaken undertook a more holistic assessment to the River Don hydrology to inform three separate models at various regions within the Don catchment, one of which was the extended IAMP model (listed in Section 2.1.3). The detail of this more recent calculation record is not reviewed in detail here partly because it was undertaken for another client and partly because it is mainly referenced to provide a ballpark comparison with the previous IAMP model approach.

The STC calculation record considered donor adjustments based on the same gauges as the IAMP study and concluded that the value of QMED, derived via the Hylton Bridge gauge record, was simply too different without any additional supporting evidence to be used as a donor site. The STC study favoured an adjustment to the initial FEH Statistical flow estimates based on the Team Valley gauge. However, the hydrology report ultimately recommended that the design flows should be derived on the basis of a distributed unscaled (Urban) ReFH approach. This was largely based on the observation that the (Urban) ReFH derived peak flows were (a little) more conservative than the flows generated by the FEH Statistical method[4]. In addition, the urban component of the ReFH approach had been studied in more detail than for the IAMP study, giving increased confidence in the results. The resulting flows appeared to produce reasonable results when assessed against the recent flood history along the River Don suggesting that any widespread donor adjustment based on Hylton Bridge would likely lead to an overestimate of flows.

[4] Note that the difference between FEH Statistical and ReFH derived flows was much smaller than for the IAMP hydrology, so the two approaches led to broadly similar peak flows.

2.2.3 Re-assessment of Hylton Bridge QMED flow

The QMED derivation process used in the IAMP study has been re-examined as part of this study to assess whether there is any evidence of why the IAMP analysis led to such a high donor adjustment.

The previous QMED assessment at the Hylton Road gauge derived an LMED value of 1.635m ALD (Above Level Datum) from the POT series, which, when appended to the supplied Environment Agency datum of 32.081m AOD, produces an LMED value in m AOD of 33.716m AOD. The equivalent QMED flow was then read from the IAMP model rating (Figure 2-3) to be 7.0m^3/s. This contrasted with a value of 2.6m3/s that had been derived from catchment descriptors alone, which ultimately led to QMED donor adjustment factors (when adjusted for both URBEXT and centroid distance) of between 2.0 and 2.5[5] at all FEPs (flow estimation points) within the IAMP model.

One concern with the original LMED/QMED conversion process was the accuracy of the gauge datum, which could not be checked when surveyors visited the watercourse in 2017 with an instruction to check the gauge datum because the gauge board had been removed. The following paragraph details some new information on the datum issue that was not examined in the IAMP study.

The recorded baseflow level in the Hylton Bridge gauge record is around 32.3m AOD based on the supplied Environment Agency datum (Figure 2-4). By contrast, the water levels recorded in two different river surveys at the upstream and downstream faces of Hylton Bridge that were undertaken for the IAMP study in November 2015 and March 2017 were 32.15 and 32.14m AOD, respectively. In addition, both surveys recorded a channel invert level in the order of 31.95m AOD and flow conditions on the day of both surveys were relatively benign. This suggests that there is likely a discrepancy of at least 0.16 metres between the surveyed and gauged (low flow) water levels at the gauge location. This might be due to issues with the gauge and/or survey datums or the fact that the downstream cross-section at the bridge is not sufficiently close to the gauge location. In any case this re-analysis would suggest that the previously calculated LMED value of 1.635m ALD should be added to a datum that is at least 0.16 metres lower than the Environment Agency gauge datum. When this is done, the outcome is an LMED value of 33.556m AOD, which from the model rating would arise from a reduced QMED flow of 5.6m^3/s (Figure 2-3). This represents an approximate 25% reduction in the 7.0m^3/s flow that was used to inform the IAMP hydrology.

Although this reassessment of QMED is perhaps lacking in the certainty needed to rubber stamp a fresh calculation record with reduced flows, it is a further line of evidence that the IAMP model inflows will likely lead to a conservative assessment of the site risk. Therefore, we can be confident that, even if the Environment Agency were to request an updated hydrology report for the FRA, it would be lower than the fluvial flood risk that arises from the existing IAMP model inflows. Hence, the **minimum** design levels provided in this report

[5] Note that a donor factor of 2.2 was derived for the Usworth Burn.

from running the IAMP inflows are considered very unlikely to have to be raised should any fresh hydrology calculations be undertaken in future.

Figure 2-3: Model rating at the gauge location on the downstream face of Hylton Bridge

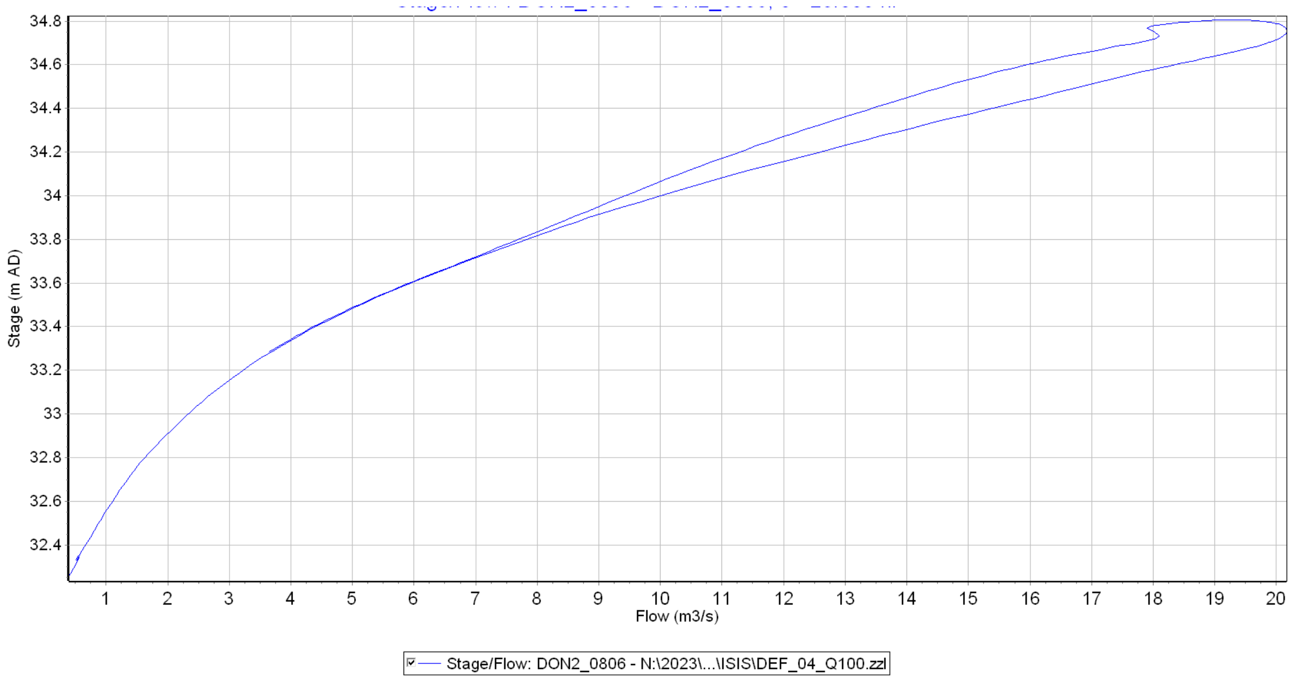
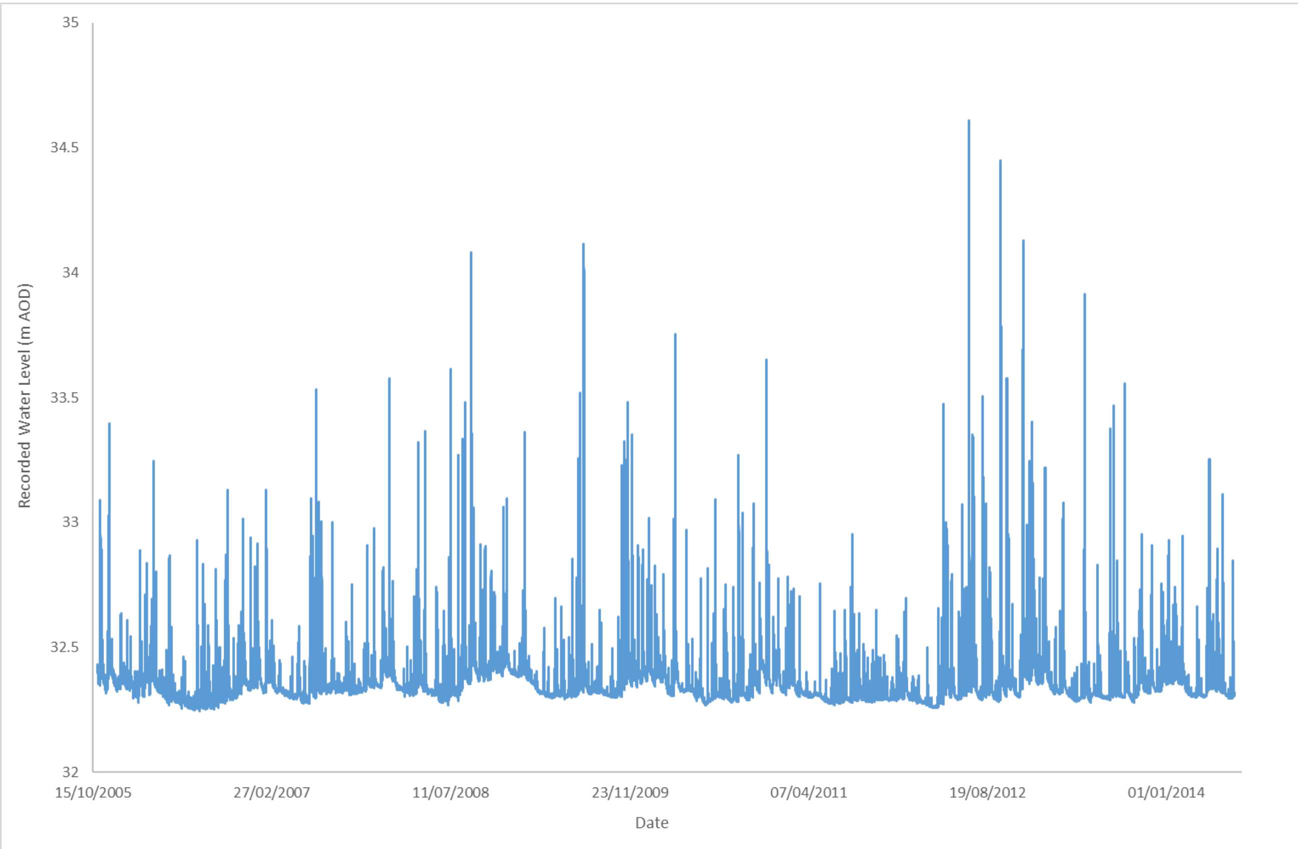


Figure 2-4: Hylton Bridge gauge record (m AOD based on the supplied Agency datum)



2.2.4 Hydrology Approach

The outcome of the hydrology review is that it is recommended that the following approach should be taken towards deriving the model inflows for the AESC Plant 3 site.

- The IAMP derived peak flows should be retained.
- The critical storm for the Usworth Burn alongside the AESC Plant 3 site should be tested and, if necessary, the IAMP model inflows should be adjusted to the modelled critical storm duration.

The main limitation of this approach is that the Environment Agency could request a full hydrology update due to uncertainties in the previous approach. If this were to be the case, then the Hylton Bridge donor adjustment would come under more scrutiny than in the previous IAMP hydrology calculations with the likelihood that the model inflows would ultimately be reduced, whether based on the FEH Statistical approach (with alternative donor factor) or unscaled ReFH2.

2.3 Hydraulic Model Review

Section 2.1 noted the history of flood modelling at this site. Given that the IAMP1 development has now been implemented but none of the works simulated by the IAMP2 model have yet been constructed, the more appropriate starting point for baseline (existing risk) modelling at the AESC Plant 3 site would be the post-development IAMP1 model scenario[6]. The Don STC model contains a larger reach of the River Don than the IAMP models but the Usworth Burn in the STC model is a straight copy of the Usworth Burn representation in the IAMP models. Therefore, given that the IAMP1 model has previously been signed off by the Environment Agency, uses a more conservative hydrology and has a higher floodplain definition, the IAMP1 model is considered more appropriate than the STC model for assessing the risk to the AESC Plant 3 site.

As the IAMP1 model was signed off by the Environment Agency in 2017, it should still be appropriate for assessing the risk to the AESC Plant 3 site subject to the following checks.

- The age of the data underpinning the model (i.e., has any new data become available since the IAMP1 model was produced).
- Floodplain development (i.e., have there been any changes on the floodplain since the IAMP1 model was produced).
- Modelling Standards (i.e., has anything changed in terms of standards that could mean that some changes are needed to the original modelling process e.g., new software versions, modelling techniques etc).
- Are any changes needed because the primary fluvial risk to the western extension will be from the Usworth Burn rather than the River Don.

[6] Note that because the IAMP2 model predicted that the post-development IAMP1 and IAMP2 river levels along the Usworth Burn would be identical (i.e., there would be no impacts along the Usworth Burn due to the IAMP2 development), the risk to the western extension from any subsequent IAMP2 development should also be covered by the IAMP1 model.

2.3.1 Topographic Data

- **River Survey** - The majority of the river channel survey in the IAMP model was collected by Academy Geometrics in November 2015. This was supplemented by some additional river survey downstream of Hylton Bridge that was collected in March 2017. The river survey is less than 10 years' old so should still be appropriate for evaluating the baseline site risk to a site in 2023 without the need for check survey.
- **LIDAR** - The original model used a combination of LIDAR DTM and topographic survey to define the floodplain topography. Topographic survey was used across the southeastern corner of the model because the available LIDAR did not cover the full extent of the modelled flood outlines. it is believed that the LIDAR that was used in the IAMP1 model was flown in 2009.
  1m composite LIDAR DTM now covers the whole of the model domain. This has been downloaded and cross-checked against the existing model topography, which shows that fresh LIDAR is available for the whole of the 2D model domain (i.e., the latest composite does not seem to contain any of the 2009 data). A check on LIDAR flight dates implies that the latest LIDAR was flown in 2021 as part of the National LIDAR programme.
- **Topographic Survey** - A large topographic survey was undertaken in 2015 that covers the whole of the IAMP1 and AESC Plant 3 sites. Since development has occurred across the IAMP1 site but not the Plot 2 site, then this topographic survey should still be relevant to the Plot 2 site but not for the developed parts of the IAMP1 site.

2.3.2 Recent Development

The main ground level changes to the floodplain associated with the IAMP1 site were implemented prior to 2017 so would have been in place by the time of the National LIDAR overflights in 2021. Therefore, subject to some checks (presented in Section 3.3), the 2021 LIDAR is expected to present an accurate picture of present-day floodplain elevations. This implies that the model can be safely updated with the latest LIDAR and that there is now no need to include the topographic patches that were used to define the proposed ground level changes that were read into the IAMP1 post-development scenario.

2.3.3 Modelling Standards

There have been no major changes in modelling guidelines that could impact on the suitability of the IAMP model. There have, however, been incremental improvements to the software. The IAMP1 model was previously run with ISIS v3.7 and TUFLOW 2016-03-AD-w64, whereas the updated model ought to be run with more recent versions of both software packages.

[7] Some works are still ongoing, but these are outside of the floodplain so should not influence the fluvial flood modelling results.

2.3.4 Usworth Burn Risk

The only factor that might need to be changed as a consequence of the AESC Plant 3 site being located further upstream in the Usworth Burn relative to the main part the IAMP1 site is that the critical storm duration along the Usworth Burn might be shorter than along the River Don. Therefore, it is recommended that storm duration testing is carried to verify if the 12-hour storm used for the IAMP1 model is still appropriate for the AESC Plant 3 site. This is reported in Section 4.4.1.

2.3.5 Other issues noted during the model review.

- The 1D (channel) bed and bank roughnesses were previously accepted for the IAMP FRA modelling and seem reasonable so will be maintained for this study. Sensitivity testing of the roughness will be carried out to demonstrate the model sensitivities and to inform the Agency review.
- There are no structures in the model that could influence the risk along the Usworth Burn. Therefore, any modification of the existing structures would not influence the current study.
- The 2D domain is based on a cell size of 2 metres so there would be little benefit from reducing the cell size further to increase the model definition.
- The bank crests are currently based on the topographic survey that was undertaken in November 2017. This seems reasonable but, because it is recommended to update the floodplain to reflect the latest (2021) LIDAR DTM, it would also be appropriate to update the bank crests likewise. The 1 metre definition of the LIDAR should ensure that the crest height of the earth embankments is represented in the model to a reasonable level of accuracy, although ultimately the local embankments were previously shown to have little impact during major flood events.
- There will have been changes in roughness across the IAMP development area so a local update to the floodplain roughness will be needed. Floodplain roughness was previously determined by drawing a set of polygons around buildings, roads etc as depicted on an Open Source map background and this approach should be adequate to incorporate recent changes across the IAMP site.
- An HQ boundary was previously placed along part of the southern edge of the 2D domain to avoid undue ponding of water against the edge of the 2D domain in an 0.1% AEP event. This was necessary because there was no further topographic data (LIDAR or topo survey) available in this area. This could be rectified in the current study because the LIDAR is more extensive. However, because this floodwater was already within the adjacent catchment and will have no impact on the western extension, there is no necessity to update the model hereabouts.
- The IAMP currently contains several stability fixes (roughness patches and a Boundary Viscosity Factor = 2) to control 1D-2D oscillation. An updated model run with more recent software version may enable these stability fixes to be reduced in scale.

3 Methodology

3.1 Hydrology Updates

Section 2.2 provided a detailed summary of the status of the IAMP model hydrology and led to the following recommended approach for the assessing the risk to the AESC Plant 3 site.

- The peak flows derived for the IAMP study should be retained.
- The critical storm duration (CSD) along the Usworth Burn should be tested and, if necessary, a new set of inflow (IED) files should be created and run for the relevant CSD.
- Up to date climate change factors should be applied.

Section 4.4.1 lists the outcome of the storm duration testing, which verifies that the same 12-hour storm as was used for the IAMP assessment is still appropriate for the AESC Plant 3 site. Therefore, the only modification needed to the IAMP model inflows was to apply the updated uplifts for the climate change simulations (see Section 3.2).

The above approach is considered appropriate for an FRA at the AESC Plant 3 site, but the following potential limitations are noted.

- The inflows are likely to be conservative (based on the discussions in Section 2).
- The IAMP hydrology was calculated in 2017. The Environment Agency could request a fresh hydrology, but it is considered that the current hydrology is defensible on the grounds that it is relatively recent and likely to be conservative.

3.2 Climate change uplifts

The climate change uplifts required of an FRA are dependent on the nature of the development. The climate change guidance in relation to fluvial flows has changed across England since uplifts of +20, +25 and +50% were previously modelled for the IAMP study.

For the AESC Plant 3 site, it is expected that the site will be classified as 'highly vulnerable' because of the storage of certain hazardous materials that will be required to be used in the battery manufacturing process. An FRA for a 'highly vulnerable' development site would require an assessment of the ‘Central’ emissions climate change scenario, which evaluates to a +34% uplift for watercourses in the Tyne catchment. In addition to the 'Central' emissions scenario, the 'Higher Central' climate change allowance of +42% has also been modelled in this study to provide a steer should the Environment Agency wish to see the impact of development at this level of climate change uplift, which would normally only be required for developments categorised as 'essential infrastructure'. Hence, both uplifts have been modelled in conjunction with the 1% AEP event for this study. The central uplift was also run at the client's request for a 3.3% event

3.3 Data Checks

The original IAMP model grid was based primarily on the latest available LIDAR (1m DTM tiles) that was available at the time[8] but with some topographic survey included where the LIDAR was absent. The proposed IAMP mitigation measures (platform raising and additional floodplain storage) were then included as topographic adjustments to this underlying ground level model.

A model should ideally use the most up-to-date available data (of suitable quality) and it is evident that LIDAR has been re-flown since the IAMP model was created. Therefore, the 1m LIDAR DTM (2022) composite across the IAMP model extent was downloaded in June 2023[9]. However, before updating the model to include for the most recent LIDAR, some checks were undertaken against the topographic datasets that had been used in the original IAMP model. This was to check for consistency between the datasets and highlight areas where ground level changes had taken place between the different data collections.

3.3.1 LIDAR (2023) vs LIDAR (2009)

The difference in elevation between the two LIDAR datasets is shown in Figure 3-1. This illustrates that, beyond the extent of the IAMP development, the two LIDAR datasets are generally consistent in that elevations are typically within ±0.1 metres of one another but there is a tendency for the most recent LIDAR DTM to be higher than the previous LIDAR[10]. This observation could help explain why the original study found some discrepancies between the (old) LIDAR and topographic survey across some areas (most notably on the left bank of the River Don downstream of Hylton Bridge). Across the IAMP development, there are clear differences between the two LIDAR datasets, which reflect the fact that the old LIDAR was flown before the IAMP development took place whilst the most recent LIDAR was flown after development. Hence the new LIDAR is higher across the raised platform of the IAMP site and lower across the areas where additional floodplain storage was created.

3.3.2 LIDAR 2023 versus 2015 topographic survey

An extensive topographic survey was collected by Academy Geomatics for the initial IAMP study in November 2015. Figure 3-2 shows a comparison between the elevations in the topographic survey and the 2022 LIDAR DTM. This was created by point inspecting the

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[8] From checking the LIDAR 'time stamped' extents at https://environment.data.gov.uk/DefraDataDownload/, this data would appear to have been flown in 2009.

[9] The DEFRA website states that the composite dataset is derived from a combination of the 'time stamped' archive and 'National LIDAR Programme', and that where repeat surveys have been undertaken the newest, best resolution data is used. A look at the 'time stamped' and 'National' LIDAR coverage would, therefore, imply that the 2022 composite should be wholly (subject to no poor data quality defects) based on the 2021 National LIDAR across the IAMP model extent.

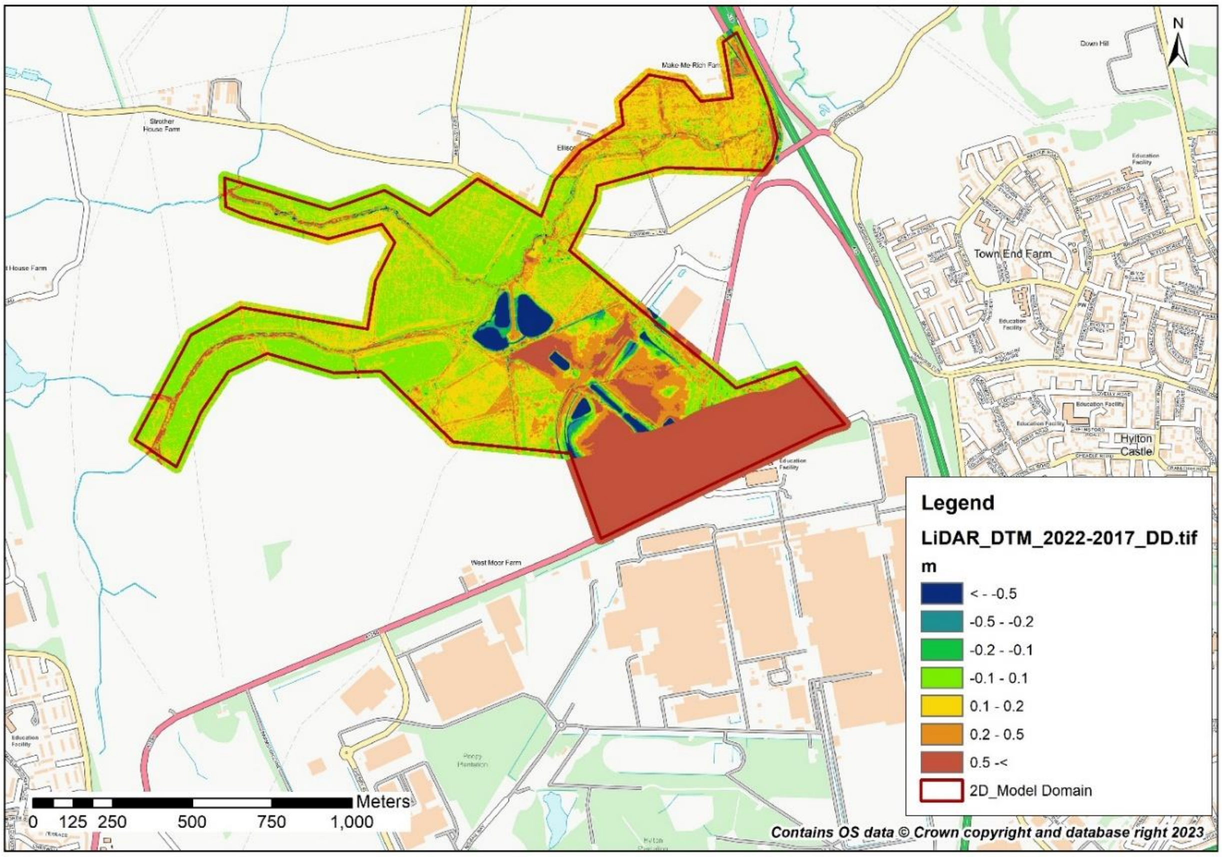
[10] Note that the old LIDAR did not cover the south-eastern edge of the IAMP site, which is why the comparison figure exhibits a uniform colour across this region.

LIDAR at all points in the topographic survey, calculating the differences between the two datasets and creating a raster grid of these differences. This plot reveals a very similar pattern to the LIDAR comparison.

Because the 2015 topographic survey predated the IAMP development, significant topographic differences are again evident within the developed areas of the IAMP site. However, elsewhere the levels between the two datasets are generally consistent but with some evidence for the LIDAR tending to be slightly higher rather than lower than the topographic survey. Hence, Figure 3-2 shows that the LIDAR across most of the Plot 2 site is between 0.1 metres lower and 0.2 metres higher than the topographic survey yet no development has taken place across the area of Plot 2 site since the topographic survey.

It should be noted that the river survey was largely carried out at the same time as the site topographic survey so the fact that there is a reasonable consistency between the LIDAR and top of bank levels in the topographic survey suggests that there should also be consistency between the LIDAR with river cross-sections[11].

Figure 3-1: LIDAR comparison (2015 DTM composite versus 2022 DTM composite)



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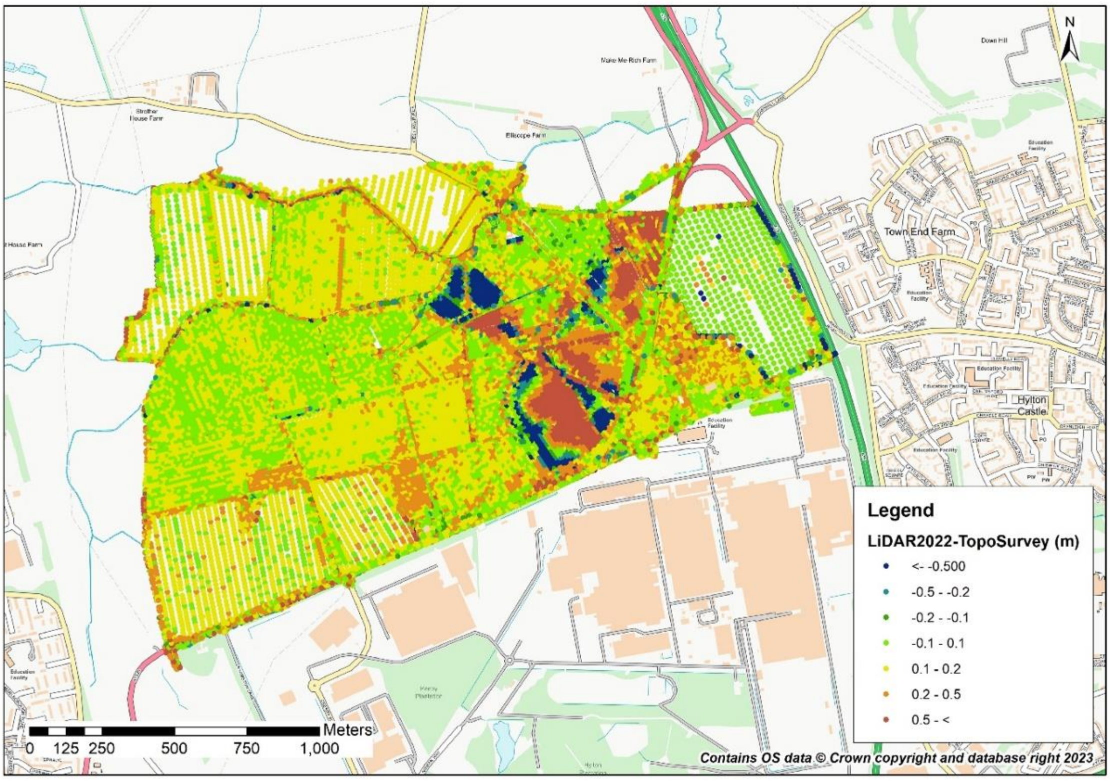
[11] Note that the LIDAR cannot be trusted with the in-channel geometry as it will be reflected from the water surface and the immediate banks are often lined with thick vegetation.

Figure 3-2: LIDAR 2022 DTM composite versus topographic survey (2015)



3.3.3 Summary of topographic checks

Given the relatively low magnitude of differences between the latest LIDAR and previous topographic datasets across the AESC Plant 3 site and the facts that the LIDAR is the most recent dataset and captures the post-development ground levels changes that have so far been involved across the IAMP site, it would seem reasonable to update the model topography to be based on the new LIDAR.

3.4 Hydraulic Model Updates

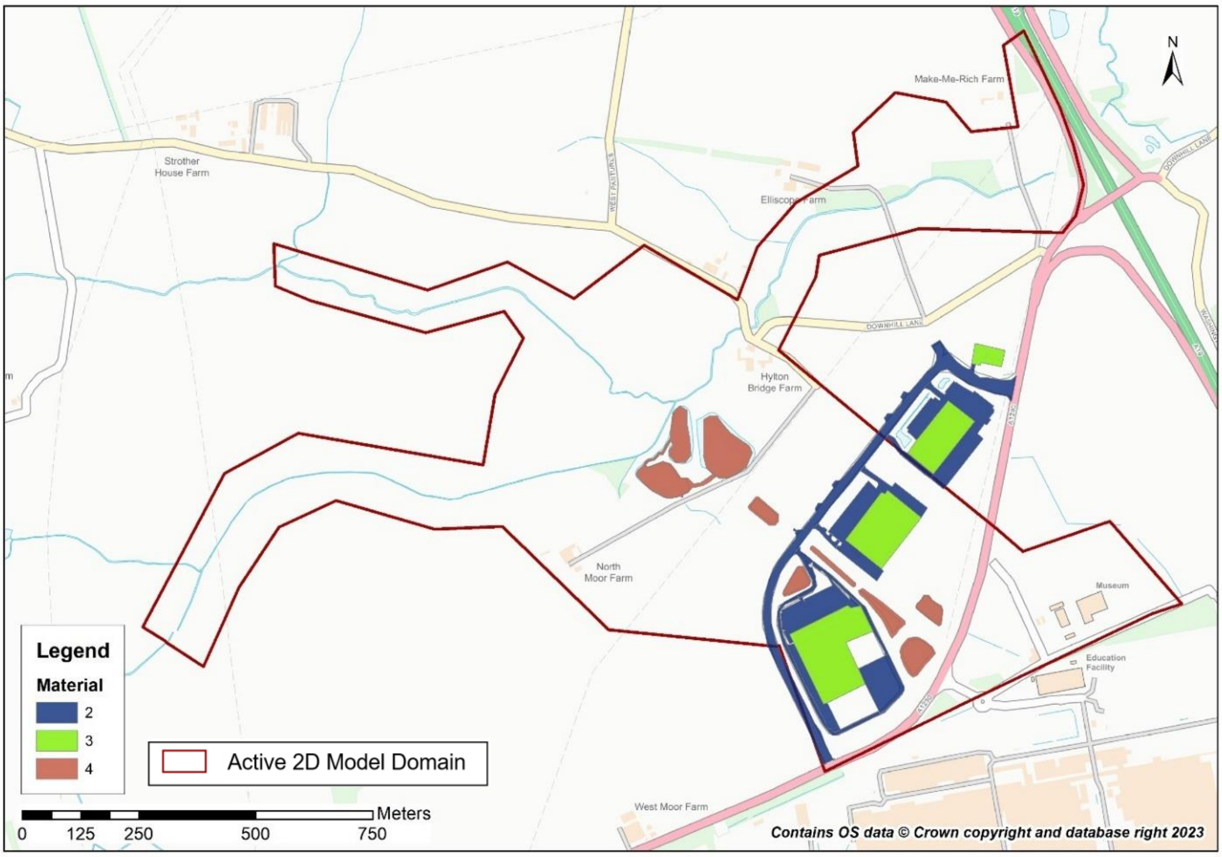
The following updates to the IAMP model were undertaken following the model review (summarised in Section 2.3) and data checks (summarised in Section 3.3).

- The entire floodplain topography was updated from the combination of sources (old LIDAR, local topographic survey and proposed ground level changes) that had been used to model the IAMP post-development scenario to the 1m composite (2022) LIDAR DTM, (believed based solely on National LIDAR Programme 2021 flights).
- The bank crest levels alongside the Usworth Burn and River Don were updated to reflect the elevations in the 1m composite (2022) LIDAR DTM.
- The floodplain roughness map was updated to reflect the current state of the IAMP1 development by stamping the polygons shown in Figure 3-3 to the general floodplain roughness of 0.05 that had previously been applied to this area of the IAMP baseline model. As with the previous model, these polygons (representing

obvious buildings, roads, hard standing areas and surface water) were traced from open-source maps.

Note that because no floodwater is modelled to flow towards the site from the upstream reaches of the Usworth Burn, there was no need to extend the active model domain from the existing model to cover the whole of the AESC Plant 3 site. Hence, the active extent of the model domain as shown in Figure 3-3 remains the same as that of the 2018 model. Extending the domain across the AESC Plant 3 site would have just created a larger model that would have taken longer to run.

Figure 3-3: Updates to the floodplain roughness map across the IAMP site



2= Hardstanding Area, 3 = Building, 4 = Surface Water

3.5 Model Simulations

Once the relevant changes to the model inflow files (listed in Section 3.1) and model (listed in Section 3.4), had been made, the following model simulations were undertaken.

- Baseline (existing risk) AESC Plant 3 scenario (see Section 4.1).
  - Present day (i.e., without climate change) - 50%, 3.3%, 1% and 0.1% AEP
  - Future (i.e., with climate change) - 3.3% AEP Central (+34%), 1% AEP Central (+34%) and 1% AEP Higher Central (+42%)
- Undefended (Defence Failure) - 1% AEP Central (+34%) event (see Section 4.2). The low-level 'defence' embankments alongside the Don and Usworth Burn (see Figure 1-1 for location) were removed from the model by re-using the defence

removal GIS layer that had previously been used to examine the impact of defence failure for the IAMP study.

- (AESC Plant 3) Site Fully Raised - 1% AEP Central (+34%) event (see Section 4.3). The entire Plot 2 site polygon (as shown in Figure 1-1) was raised to above flood levels to quantify the likely worst-case impact of development if the whole site were to be removed from the floodplain.

- Sensitivity Tests (see Section 4.4) - A small number of sensitivity tests were run to justify the current model configuration and enable the model to pass an external review.
  - Storm duration - The updated model was tested against the five (4, 8, 12, 14 and 16-hour), unscaled ReFH, 1% AEP storms that had been created for the original model.
  - Flow ±20%
  - Roughness (channel and floodplain) ±20%
  - Downstream Boundary (steeper and gentler gradient).

4 Outcomes

4.1 Baseline (Existing) Flood Risk

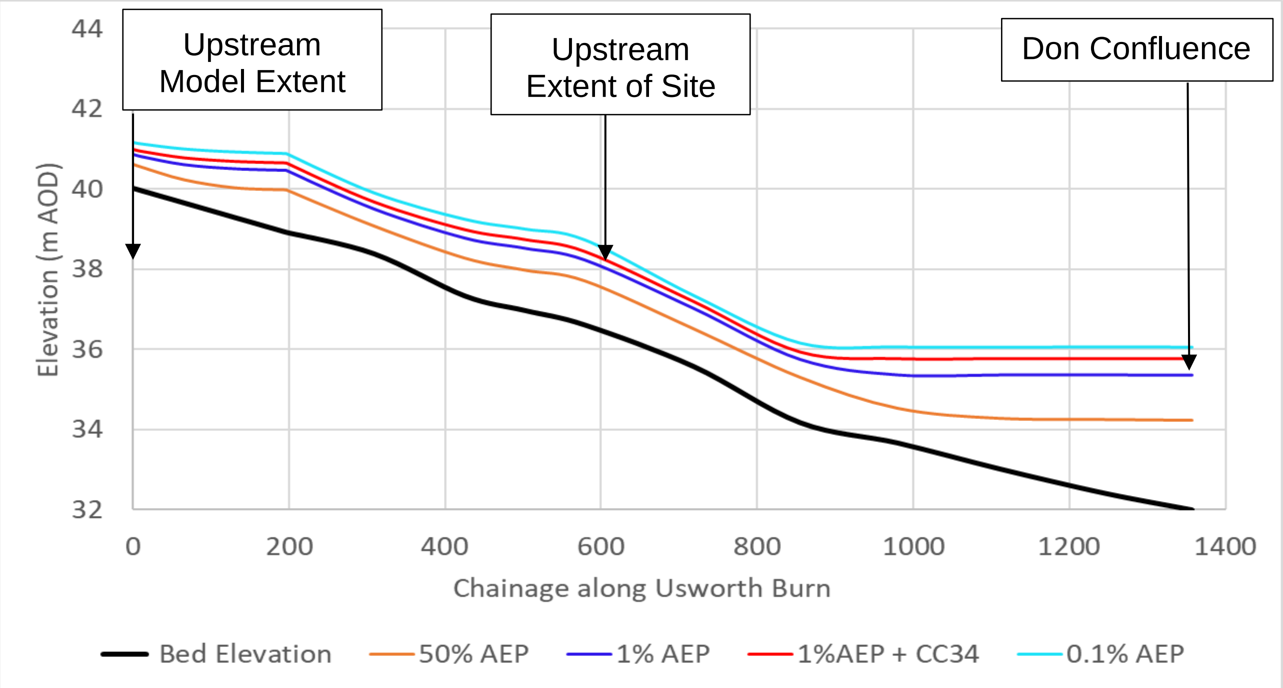
The modelled peak river levels in the Usworth Burn for a select number of 1D model nodes alongside the site are shown in Table 4-1. These illustrate that whereas there is a quite a steep gradient in the peak river levels alongside the upstream part of the site, the peak river level gradient along the Usworth Burn flattens out downstream of the North Moor Farm (i.e., around node TRIB_0377). This pattern largely reflects the backwater influence of the River Don as can be seen in a long section profile of the Usworth Burn for a select number of the modelled flood events in Figure 4-1.

Table 4-1: Modelled peak river levels (m AOD) along the Usworth Burn for specified nodes

Model Node	Annual Exceedance Probability (%)						
	50	3.3	3.3+CC34%	1	1+CC34%	1+CC42%	0.1
TRIB_0855i	37.97	38.35	38.55	38.52	**38.74**	38.79	39.00
TRIB_0778	37.70	38.06	38.26	38.22	**38.43**	38.49	38.72
TRIB_0639	36.51	36.89	37.05	37.01	**37.19**	37.22	37.34
TRIB_0502	35.32	35.63	35.76	35.74	**35.93**	36.00	36.15
TRIB_0377	34.53	35.12	35.47	35.35	**35.76**	35.86	36.05
TRIB_0000	34.23	35.10	35.47	35.34	**35.76**	35.86	36.05

See Figure 4-2 for node locations.

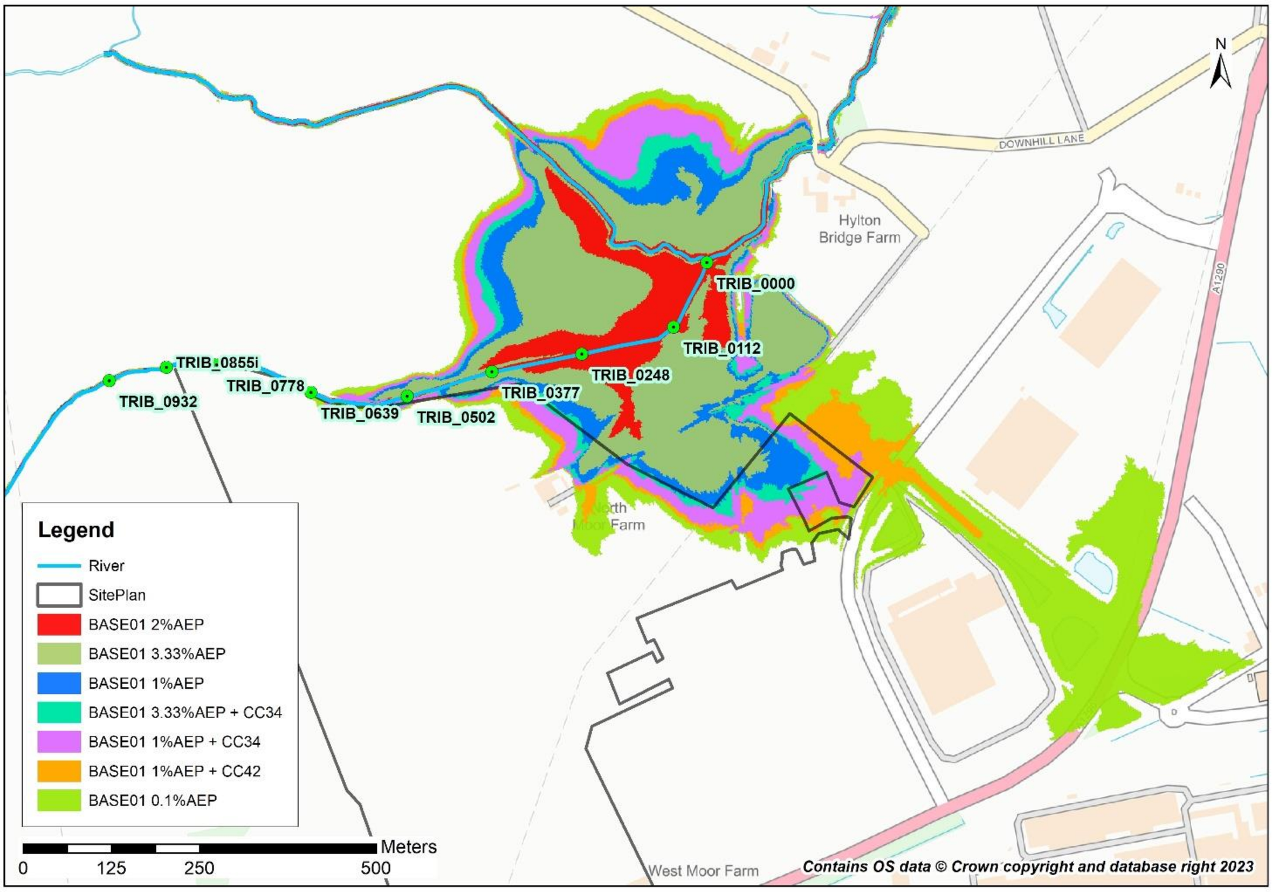
Figure 4-1: Modelled long section event profiles along the Usworth Burn



NB 1% AEP + 42% omitted for clarity.

The modelled flood outlines in the vicinity of the site are shown in Figure 4-2. These illustrate that only a very small area of the site between North Moor Farm and International Drive is modelled to be at fluvial flood risk. This implies that there will be some fluvial flood risk constraints on development on parts of the site but that development across most the site will not be constrained by fluvial flood risk (assuming that excavation below the modelled flood levels is not being planned).

Figure 4-2: Modelled Flood Outlines adjacent to the IAMP site extension.



The design levels for the development proposed in an FRA would generally need to be based on the 1% with climate change (+34%) flood levels with resilience levels based on the 0.1% AEP flood levels. In addition, any off-site impacts would also need to be judged against the 1% with climate change (+34%) and lower events.

4.2 Defence Failure

The IAMP study demonstrated that the flood defence embankments that are depicted on the Environment Agency's Flood Maps (see Figure 1-1 for location) play no significant flood defence role. They are primarily low-lying earth embankments that were presumably constructed with the aim of reducing the frequency of flooding to some of the agricultural land adjacent to the River Don and Usworth Burn. Hence, Figure 4-2 shows that the embankments around the Don confluence are already modelled to be overtopped and/or bypassed in the 50% AEP event.

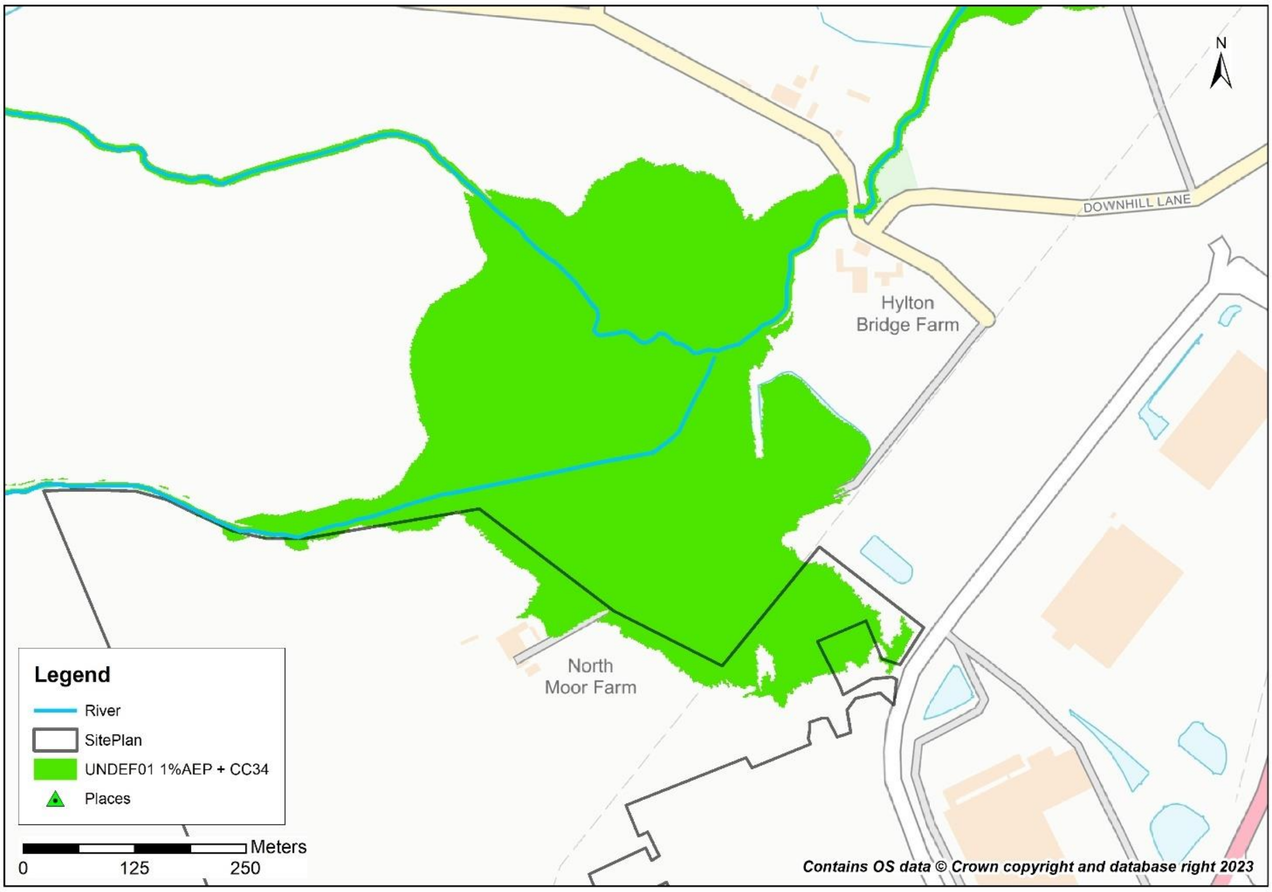
To confirm that the AESC Plant 3 site was not at increased risk from defence failure, a 1% AEP + 34% design event was run through an undefended version of the model (i.e., with embankment crests reduced to ground levels). The main outcomes of this model run are shown in Table 4-2 and Figure 4-3. Table 4-2 shows that defence failure would lead to some small, localised variations in the peak 1% AEP (+34%) river level alongside the Plot 2 site. Figure 4-3 shows that the undefended 1 % AEP (+34%) flood outline is almost identical to the defended flood outline (shown in Figure 4-2). This confirms the findings of the IAMP study that the residual risk from failure of the local earth embankments would not obviously increased relative to the existing (baseline) site risk.

Table 4-2: Modelled impact of removing the defence embankments on peak 1% AEP (+34%) river levels (m AOD)

Scenario	Model Node					
	TRIB_0778	TRIB_0639	TRIB_0502	TRIB_0377	TRIB_0000	DON2_0813*
Baseline	38.44	37.19	35.92	35.76	35.76	35.48
Undefended	38.40	37.24	35.92	35.73	35.72	35.53

* Hylton Bridge

Figure 4-3: Modelled undefended 1% AEP (+34%) flood outline.



4.3 Impact of Fully Land Raising

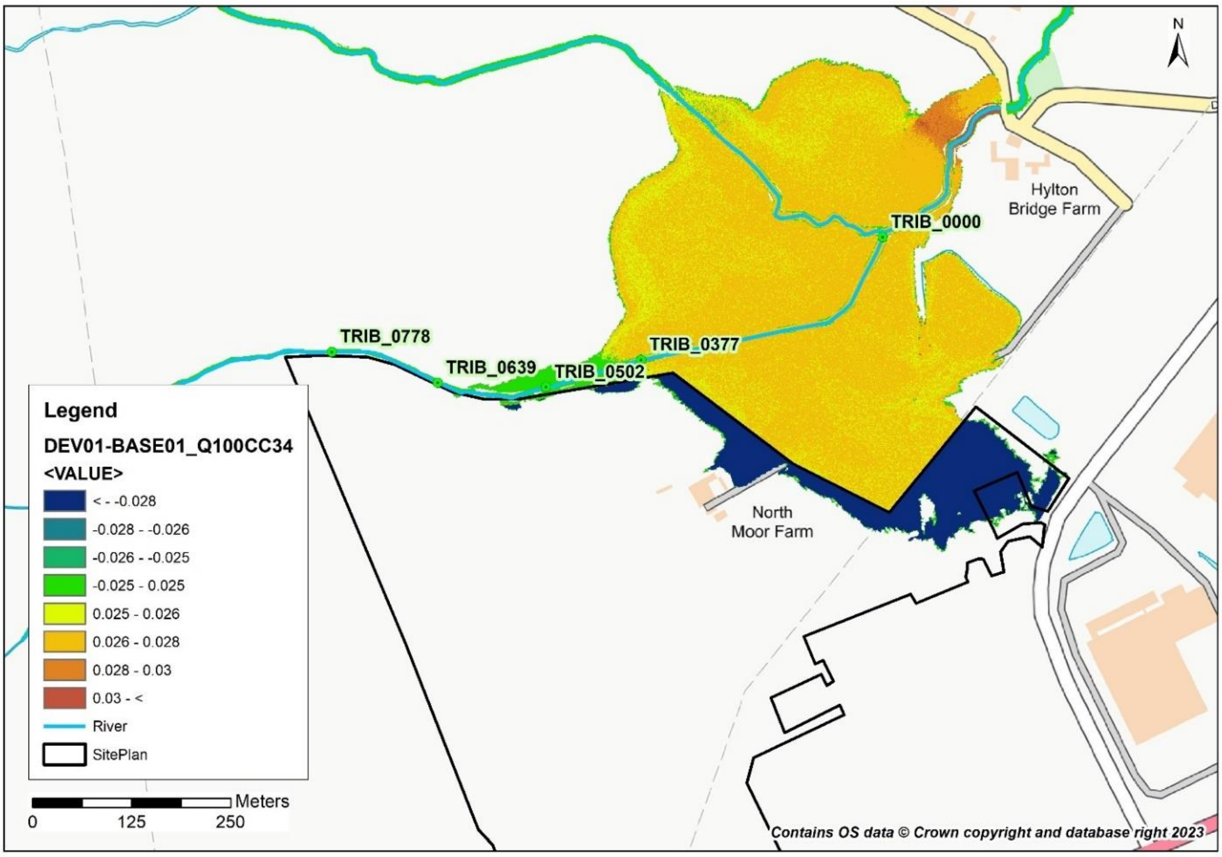
The impact of fully raising the AESC Plant 3 site polygon above all modelled flood levels is illustrated by reference to the changes in peak river level and flood outlines. Table 4-3 illustrates that the impact of fully raising the site would increase river levels by up to 0.03 metres downstream of North Moor Farm. Impacts are modelled to continue beyond Hylton Bridge to the downstream extent of the model where a 0.1 metre increase in the peak river level is modelled downstream of the A19. Figure 4-4 shows that the model predicts that the displaced floodwater would increase the peak flood depth across the nearby floodplain by between 0.025 and 0.03 metres.

Table 4-3: Modelled impact of fully raising the Plot 2 site on peak 1% AEP (+34%) river levels (m AOD)

Scenario	Model Node					
	TRIB_0778	TRIB_0639	TRIB_0502	TRIB_0377	TRIB_0000	DON2_0813*
Baseline	38.44	37.19	35.92	35.76	35.76	35.48
Site Raised	38.44	37.19	35.94	35.79	35.78	35.51

* Hylton Bridge

Figure 4-4: Impact of fully raising Plot 2 site on peak 1% AEP (+34%) floodplain depths.



This map was obtained by subtracting the flood depths from the 'baseline' scenario from the those from the 'fully raised' scenario.

4.4 Sensitivity testing

Sensitivity testing for the AESC Plant 3 site was carried out to demonstrate that the updated model sensitivities have been tested in readiness for any Environment Agency review of the model. Hence the results of the sensitivity test are presented here with little commentary.

4.4.1 Storm Duration

The results of the storm duration testing revealed that an 8-hour storm produces the highest river levels on the Usworth Burn upstream of North Moor Farm but that a 12-hour storm produces the highest river levels downstream of that location (Table 4-4)[12]. The modelled flood outlines (Figure 4-5) also show that a 12-hour storm led to the largest outline (albeit only subtly so) of the tested storms. Given that inundation of the floodplain is limited to the reach downstream of North Moor Farm, it was, therefore, considered appropriate to model design events for the AESC Plant 3 site based on the 12-hour storm, which is also consistent with the critical storm previously modelled for the IAMP site.

Table 4-4: Modelled peak river levels (m AOD) along the Usworth Burn for specified 1% AEP storm durations,

Model Node	Storm Duration				
	4	8	12	14	16
TRIB_0855i	38.17	**38.18**	38.15	38.13	38.11
TRIB_0778	37.86	**37.87**	37.85	37.83	37.82
TRIB_0639	36.69	**36.72**	36.70	36.69	36.68
TRIB_0502	35.47	**35.48**	35.45	34.44	35.42
TRIB_0377	34.66	34.73	**34.74**	34.74	34.73
TRIB_0000	34.39	34.59	**34.60**	34.59	34.58

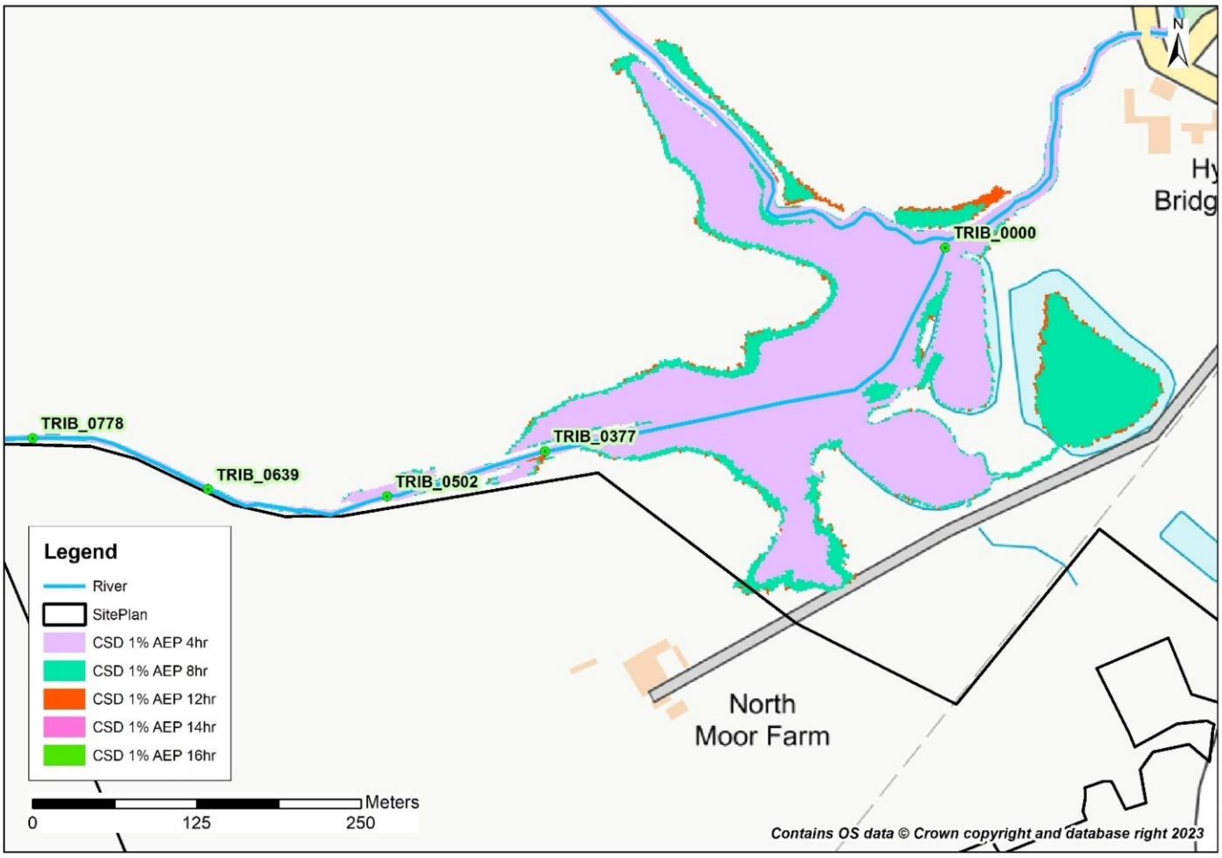
4.4.2 Other Tests

Note that the sensitivity tests were carried out on the 1% AEP (CC+34%) event because this is the key design event for an FRA so the outcomes of these tests show how the design levels and outlines might change in response to moderate changes to some of the model parameters.

The downstream boundary tests demonstrated that, because the boundary is downstream of the A19, there would be no downstream boundary impacts on the flood risk at the AESC Plant 3 site. Hence the modelled levels and outlines from this test were unchanged from those shown in Table 4-1 and Figure 4-2.

[12] Note that the storm duration testing was carried out on the (unscaled) 1% AEP event. Hence, the levels reported in Table 4-4 are noticeably lower than the design levels reported in Table 4-1, which were generated from the final design flows in which the ReFH hydrographs were scaled to match the estimated FEH Statistical peak flows.

Figure 4-5: Modelled flood outlines arising from storm duration testing.



Note that the 14- and 16-hour outlines are hidden behind the 12-hour outline because they are both smaller.

The flow and roughness tests did produce some observable changes to both the 1% AEP (CC+34%) peak river levels and outlines adjacent to the AESC Plant 3 site. The peak river levels are shown in Table 4-5, which shows that the model sensitivity to flow and roughness are generally quite similar with levels varying between ± 0.2 metres in response to the ±20% change in parameters.

Table 4-5: Modelled peak river levels (m AOD) along the Usworth Burn from sensitivity tests

Model Node	Baseline	Flow +20%	Flow -20%	Roughness +20%	Roughness -20%
TRIB_0855i	**38.74**	38.86	38.61	38.90	38.58
TRIB_0778	**38.43**	38.56	38.31	38.62	38.28
TRIB_0639	**37.19**	37.27	37.08	37.30	37.04
TRIB_0502	**35.93**	36.09	35.79	36.03	35.77
TRIB_0377	**35.76**	35.96	35.53	35.88	35.62
TRIB_0000	**35.76**	35.96	35.52	35.88	35.62

The flood outlines arising from the flow and roughness sensitivity tests are illustrated in Figure 4-6 and Figure 4-7, respectively. These demonstrate that the extent of inundation would not be greatly changed in response to changes in these model parameters with the at-risk area still limited to the north-eastern edge of the AESC Plant 3 site.

Figure 4-6: Impact of flow testing (±20%) on the 1% AEP (+34%) flood outline.

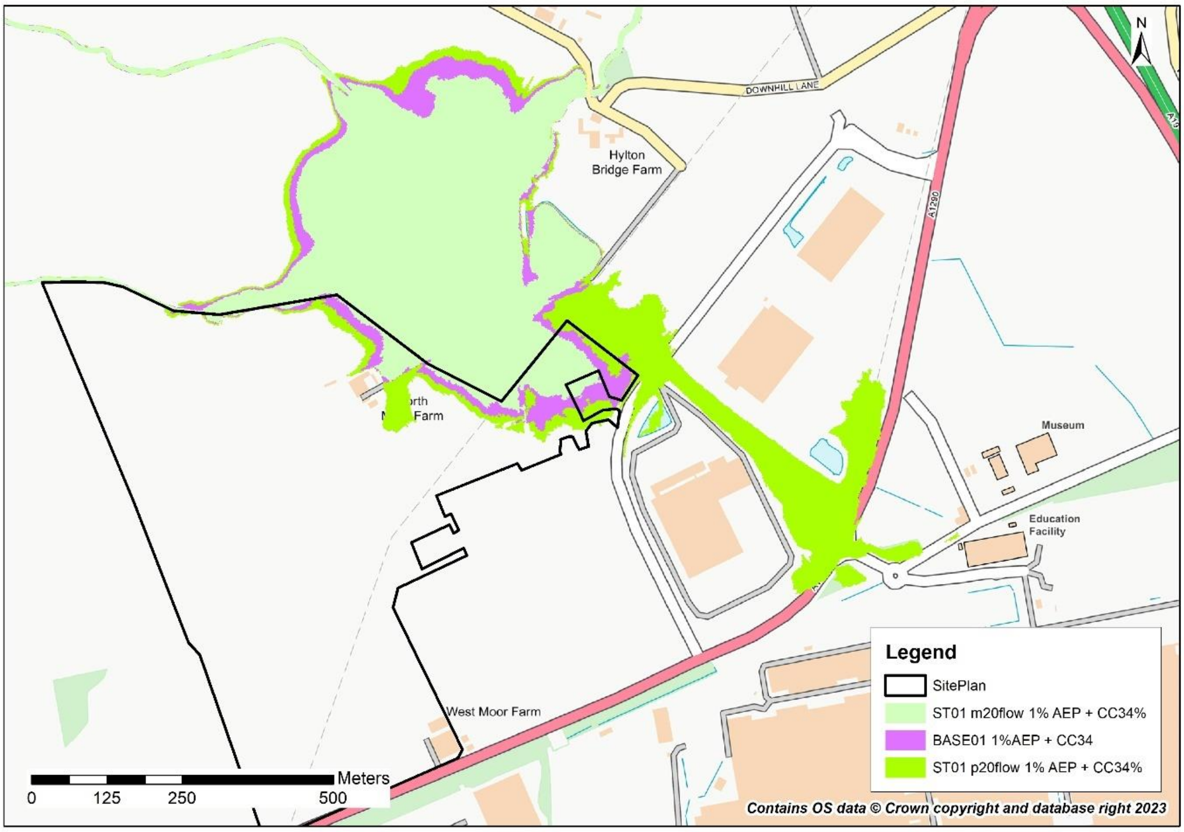
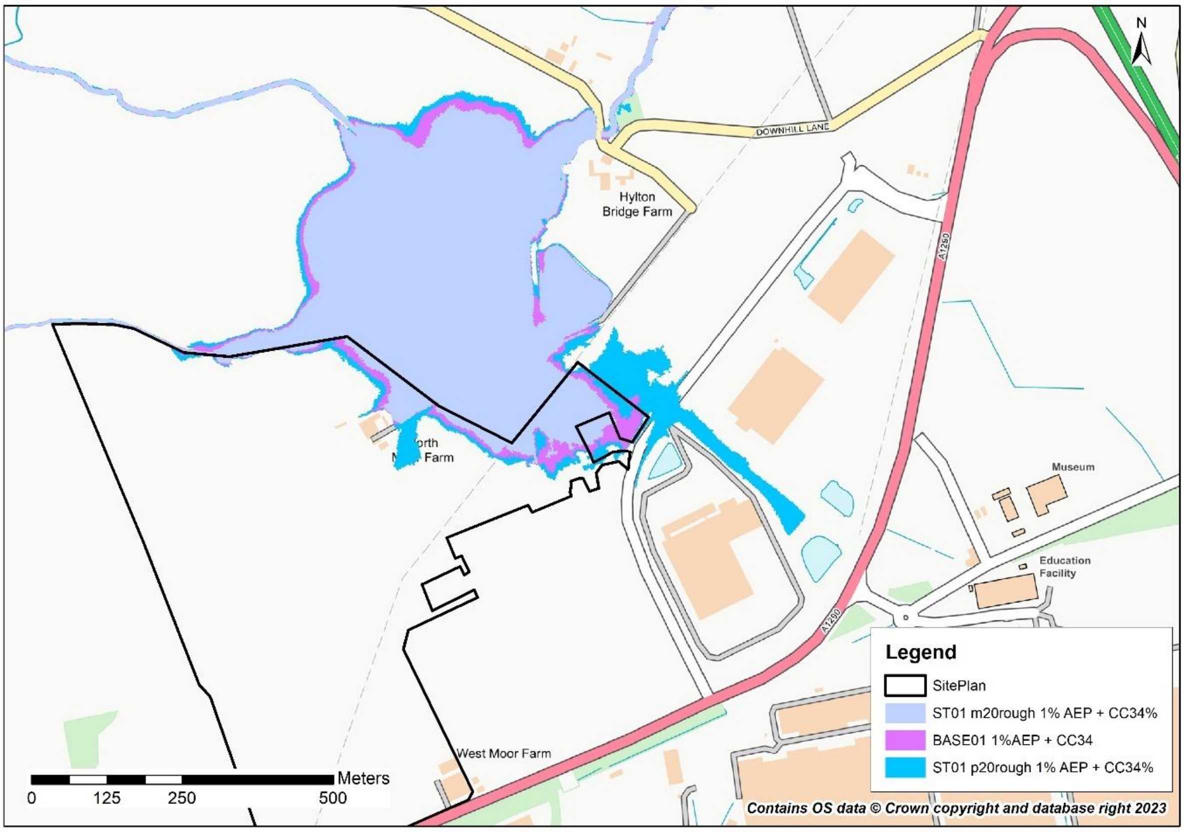


Figure 4-7: Impact of roughness testing (±20%) on the 1% AEP (+34%) flood outline.



In general, the sensitivity tests replicate the sensitivities documented in the IAMP modelling and imply that the flood risk would not be radically changed in response to moderate changes in the model parametrisation. These sensitivities would be covered by a standard (600mm) freeboard allowance.

4.5 Summary of modelling results and implications for development

The baseline (existing risk) model results predict that the majority of the AESC Plant 3 site would be at low risk of fluvial flooding (i.e., outside of Flood Zone 2). Therefore, there should be few fluvial flood risk constraints to development on much of the site. However, the 1% AEP with climate change (+34%) and 0.1% AEP flood outlines are modelled to flood a small part of the site along the north-eastern boundary of the site. There will consequently be some local constraints on development in these areas in that design floor levels of any buildings would likely need to be set above the 1% AEP with climate change (+34%) flood level (plus a freeboard). However, any ground raising across the flooded area could potentially lead to adverse off-site impacts (e.g., as modelled in Section 4.3).

From the site plan '204-P01-Proposed Site Layout' that was supplied in early July 2023 (Figure 1-2), it would not appear that any significant development features are planned within the areas that are modelled to be at flood risk except for a possible track around the circumference of the site that might be at risk in a major flood event. Therefore, the simplest solution to the modelled fluvial flood risk would be to avoid developing those parts within the site boundary that are within the modelled flood outlines, in which case there would be no off-site impacts from developing the AESC Plant 3 site. If these areas were to be developed, then some mitigation measures would likely be needed. However, an alternative approach before considering mitigation measures, would be undertake a fresh hydrology that would seek to downscale the importance of the Hylton Bridge adjustment factor that underpins the current model hydrology and has led to what is expected to be a conservative assessment of the flood risk.

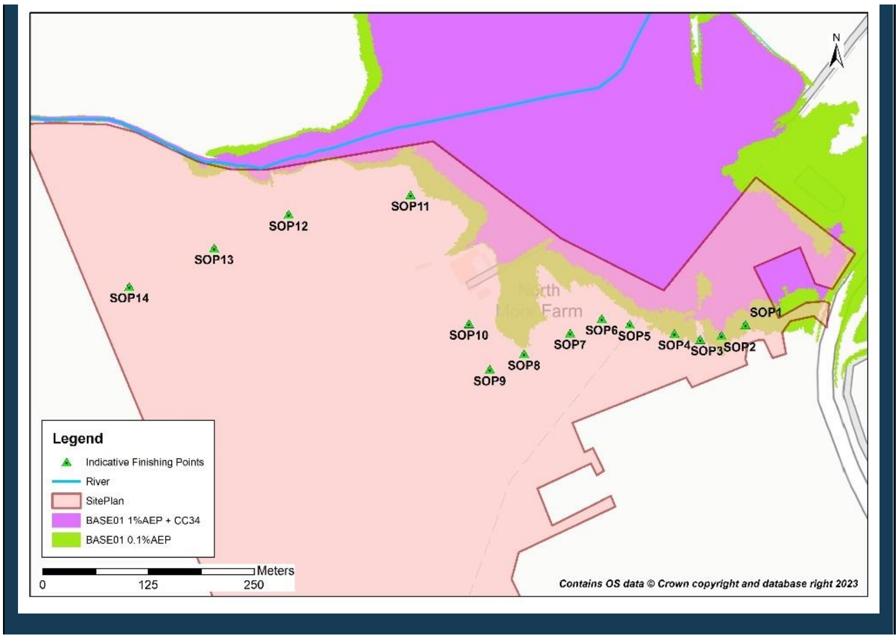
4.5.1 Proposed Site Levels

Further detail of the site plan with some prospective site levels was supplied in mid-July 2023[13]. This shows that some of the proposed levels are close to the edge of the modelled flood outlines (Figure 4-8). The table on the right-hand side of Figure 4-8 shows that the proposed site levels grade up from 37.0m AOD in the east to 38.5m AOD in the west. The existing elevations at these locations (as derived from point inspecting the 2022 LIDAR composite DTM) are also shown Figure 4-8 and this shows that most of the points (SOP1 to SOP12) are proposed to be raised (some by up to 1.5 metres) around the north-eastern periphery of the proposed platform. None of these points is currently within the modelled 1% AEP with climate change flood outline but to avoid any offsite impacts from the

[13] ENV3-RPS-ST-XX-SK-A-000086-P01-Northern boundary plateau level concept evaluation for purpose of flood modeling.pdf

development, the proposed ground levels would need to be tapered down to existing ground levels across the area of the modelled 1% AEP with climate change flood outline.

Figure 4-8: Proposed site elevations in the north-east of AESC Plant 3 site.



REF_No	Elevation (Planned)	Elevation (LiDAR_2022)
SOP1	37	35.92
SOP2	37	35.8
SOP3	38	36.38
SOP4	37.5	36.02
SOP5	37.5	36.32
SOP6	37	36.42
SOP7	37	36.45
SOP8	38.1	36.23
SOP9	38.1	37.16
SOP10	38.1	36.72
SOP11	38.5	36.24
SOP12	38.5	37.44
SOP13	38.5	38.56
SOP14	38.5	39.82

By contrast to the more easterly points, Figure 4-8 shows that the two most westerly points on the proposed site plan (SOP13 and SOP14) are proposed to be lowered relative to existing (LIDAR) ground levels. As the proposed levels are above the peak river levels in the adjacent Usworth Burn (Table 4-1), the site would remain safe from fluvial flooding. However, ground levels should not be excavated much lower than proposed because this could place the site at direct risk from the flood levels modelled for the Usworth Burn (as shown in Table 4-1).

4.5.2 Residual Risk

The residual risk to the site from the hydraulic modelling results is assessed as follows.

- **Extreme Event** - the risk from an event more extreme than the design standard 1% AEP with climate change (+34%) event is covered by the results of the baseline 0.1% AEP scenario. This is modelled to place a slightly larger area of the AESC Plant 3 site at risk (Figure 4-2) but the extent is not dramatically increased so the best mitigation against an extreme event would simply be to avoid developing within the modelled 0.1% AEP flood extent. One might also consider making the development flood resilient to a level above the modelled 0.1% AEP level (see Table 4-1) with a suitable freeboard allowance.
- **Defence Failure** - The modelling work has demonstrated that defence failure of the local earth embankments alongside the Usworth Burn and River Don would not noticeably increase the flood risk to the AESC Plant 3 site during a 1% AEP with climate change (+34%) event (see Section 4.2). Hence, the residual risk

from defence failure would be effectively unchanged from the baseline (existing) risk.

- **Blockage** - The residual risk from blockage is not a material concern for this site since there are no structures along the Usworth Burn that could block and any structures on the River Don are too far downstream to have any impact at the AESC Plant 3 site.

4.5.3 Emergency Access/Egress

Dry emergency access and egress via the main site access route onto International Drive and the A1290 is modelled in a 1% AEP with climate change event, which should be sufficient to cover the risk expected of an FRA. However, it should be noted that Figure 4-8 shows that the site access road and International Drive to the north of the site are modelled to flood in a 0.1% AEP event so there is a potential residual risk to the main access route. However, the 0.1% AEP flood depths are modelled to be shallow (less than 0.2 metres) and low velocity on the site access road so there should be little danger for either vehicular and/or pedestrian access from an emergency route along the main site access road and southwards along International Drive in an extreme event. To further minimise the risk, it would also be possible to have an evacuation route from the southern boundary of the site directly onto the A1290. Hence, the fluvial flood risk from the Usworth Burn and River Don should not pose a significant risk to emergency access/egress.

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5 Assumptions and Limitations

This study has built on the existing IAMP1 model that JBA created for SYSTRA between 2015 and 2017. The model was reviewed by the Environment Agency in 2017 and the 1% and 0.1% AEP flood outlines were later subsequently used to update the Environment Agency's Flood Maps. Hence, because the model was considered appropriate for flood mapping and informing a site-specific FRA on the adjacent IAMP1 site as recently as 2017, a simple review and update approach has been taken to inform this report for the AESC Plant 3 site in 2023. However, we recognise that the Environment Agency may request to review the model prior to removing any objection to development on flood risk grounds. Reviews can be subjective so it is possible that the Environment Agency might request further updates to the model and/or hydrology at the review stage.

We would defend the current model for the reasons listed below.

- The IAMP model, which was the starting point for the AESC Plant 3 model, was signed off by the Environment Agency in 2017 so should be a good template for any revised model.
- We are aware that there are significant uncertainties in the hydrology, most notably with the Hylton Bridge donor factor. Having reviewed the previous hydrology calculations for the catchment, we believe that it was appropriate to retain the existing inflows from the IAMP model, given that a review suggests that the existing model inflows are conservative, and their re-use ensures a consistency of approach with the IAMP development. Note that any new hydrology would be faced with the (subjective) decision of whether to retain the Hylton Bridge donor factor, which would likely far outweigh the impacts of any other new hydrological information.
- Since National LIDAR, which was flown in 2021 after the primary IAMP earth movements had been completed, is now available across the whole study area, it was considered appropriate to update the topography of the model floodplain and bank crests to be based on this new LIDAR data. Checks have demonstrated a reasonable level of consistency with the existing (2015) topographic survey across the AESC Plant 3 site and, given that one would expect a greater degree of accuracy from the most recent LIDAR dataset, the replacement of the existing (2009) LIDAR seems justified. Any other model changes were sufficiently low key as to have very little impact on the model results.

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