Flood Risk Assessment and Drainage Strategy

Thatch Cottage, Pond Lane, Worthing

Drew Bailey

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Issue P01










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Executive Summary

Hilson Moran has been commissioned by Drew Bailey (the 'Client') to undertake a Flood Risk Assessment (FRA) and Drainage Strategy for the proposed development at Thatch Cottage, Pond Lane, Worthing, BN13 2RH. This document constitutes a formal National Planning Policy Framework (NPPF) compliant FRA, Drainage Strategy, Sequential Test and Exception Test, appropriate to the scale and nature of the development and risk involved.

The proposed development is approximately 0.1 ha in size, and is located within a residential area in Durrington, a suburb to the north west of Worthing Town Centre. The site comprises a fire-damaged Listed building and surrounding, overgrown soft landscaping. Because of the existing building within the site, this development is classified as brownfield. Directly adjacent to the north of the site is Pond Lane, with residential buildings and Pond Lane Recreation Ground beyond. To the east of the site is overgrown greenfield land, and to the south and west are residential properties.

The development proposals are for the restoration of the existing fire-damaged Listed building, the erection of 2 no. semi-detached dwellings to the west side of the existing property, and provision of cycle storage and car parking via existing access on land to the east of the existing property.

The general topography of the site gently slopes towards the east, with one noticeable feature: a shallow pit located southwest of the site. The highest ground levels are in the east of the site where the existing Thatch Cottage is located, at around 10.63 above Ordnance Datum (AOD), whilst the lowest area is recorded to be *circa* 9.74m AOD, located at the pit in the southwest.

The Environment Agency (EA) Flood Map for Planning has identified that the site is wholly within fluvial Flood Zone 1 (low risk), with no flooding of the site in the current or future defended or undefended scenarios.

The EA Risk of Flooding from Surface Water Maps shows that the site is at "High Chance" of surface water flooding. This means that there is more than 3.3% probability of flooding from surface water sources in any given year (>3.3% AEP). The extent of the surface water flooding within the area is not limited to the site only but also affects the entire eastern half of Pond Lane (local street). The surface water within this area is shown to follow a flood flow route that originates from Salvington Road (200 m to the northeast of the site), towards Pond Lane, and terminates by Long Croft Park (*circa* 500 m southwest of the site).

However, the EA's Risk of Flooding from Surface Water (RoFSW) maps classify the site as having a High Chance (>3.3% AEP) of surface water flooding, primarily due to local topography causing ponding and flow routes originating from Salvington Road and terminating near Long Croft Park.

The EA's Long-Term Flood Risk Map predicts surface water flooding depths up to 30 cm across most of the site, with deeper flooding (up to 90 cm) confined to the southwest depression. Climate change (CC) allowances were using Upper End scenarios, comprise +40% for the 1-in-30-year event and +45% for the 1-in-100-year event.

To refine the EA surface water flood mapping, site-specific TUFLOW pluvial modelling was undertaken using EA LiDAR data and ReFH2.3 rainfall inputs. Scenarios included:

- Baseline: 1-in-30, 1-in-100, 1-in-1000-year events (with CC uplifts).
- Post-development: same events plus hazard mapping using the UK Hazard Formula (depth × velocity + debris factor).

Key findings comprised:

- Flooding occurs across the site in all scenarios, with the southwest depression experiencing depths up to 1.60 m during the 1-in-100-year + CC event.
- Around Thatch Cottage, depths range from 0.25–0.50 m (1-in-30-year) to 0.75–1.00 m (1-in-100-year + CC).

Although a flood exclusion strategy cannot be achieved for the existing Thatch Cottage due to listing constraints, flood exclusion can be achieved for the two new dwellings, even for the 1 in 1000-year event, by setting the ground floor Finished Floor Levels (FFL) at 10.89 m AOD.

For Thatch Cottage, raising ground floors is impractical due to its Listed status. Instead, a flood entry strategy is recommended, accompanied by the following measures:

- Use of water-resistant materials within heritage constraints;
- Install sealed doors/windows and non-return valves in drainage systems, where practical.
- Elevate electrical systems, meters, and appliances above predicted flood levels.
- Avoid ground-floor sleeping accommodation; with the first floor providing safe refuge.

This FRA demonstrates that:

a) Flood risk from the site only comprises current and future surface water flood risk;

b) With the adoption of the proposed layout, design, and mitigation measures presented in this document, occupiers of the site will remain safe from the current and future surface water flood risk;

c) The proposals do not result in an increase in flood risk elsewhere.

Consequently, with reference to Planning Practice Guidance (PPG), there is no requirement for the scheme to pass either the Sequential Test or the Exception Test. Nevertheless, the Sequential Test is satisfied because:

- Restoration of Thatch Cottage is only viable if funded by the two new dwellings on the same site.
- No alternative sites can accommodate this requirement.

The Exception Test is passed because:

- Community benefits: The scheme restores a historic building, improves visual amenity, and contributes to housing supply.
- Safety: This FRA demonstrates occupiers remain safe for the development’s lifetime, with refuge on upper floors and safe egress routes to higher ground within 85 m.
- No increased flood risk elsewhere: TUFLOW modelling shows negligible off-site impacts (max depth increase 10–25 mm), with no significant change in hazard classification or risk beyond the site boundary.

With regard to the Drainage Strategy, the scheme reduces permeable surfaces from 90.5% to 53.8%. Without mitigation, runoff would increase; therefore, a SuDS-based strategy is proposed, comprising:

- Attenuation storage: 18 m^3 for Thatch Cottage catchment; 13 m^3 for new dwellings.
- Discharge limited to 0.9 l/s via control structures.
- Porous car park surfaces and geocellular storage units (*e.g.*, Permavoid) to provide required capacity.
- Design includes 45% CC uplift for future-proofing.

In conclusion, this FRA and SuDS Strategy demonstrates that:

- The site is at low fluvial risk but high surface water risk, mitigated through design and resilience measures.
- The proposed development is safe for its lifetime, without increasing flood risk elsewhere.
- The drainage strategy complies with DEFRA 2025 SuDS standards, within the constraints of the site and the listed building status of Thatch Cottage, to provide betterment compared to the existing situation.
- The development delivers significant heritage and housing benefits, justifying approval under NPPF.

Overall, the principle of development is acceptable on flood risk grounds, subject to implementation of the recommended mitigation and drainage measures.

1. Introduction

1.1. Instruction

Hilson Moran Partnership Ltd ('Hilson Moran') has been commissioned by Drew Bailey (the 'Client') to undertake a Flood Risk and SuDS Strategy of Thatch Cottage, Worthing (the 'site'). The assessment was undertaken in connection with the proposed restoration of a listed cottage and construction of two residential dwellings.

The red line boundary for the site is shown as **Figure 1-1** below.

Figure 1-1. Site red line boundary (source: Manorwood).

This report will constitute the Flood Risk Assessment (FRA) and Sustainable Drainage Systems (SuDS) Strategy.

1.2. Purpose

The purpose of the FRA and SuDS Strategy is to provide formal support for the planning application. The National Planning Policy Framework (NPPF)[i] requires that developments which have a size greater than 1 ha and/or are located in a Flood Zone 2 or 3, along with the change of use of the land to a more vulnerable classification, will require a FRA.

The FRA and SuDS recommendations are appropriate to the scale and nature of the development and risks involved and address the surface water drainage requirements of the Lead Local Flood Authority (LLFA), West Sussex County Council (WSCC)[ii], and Local Planning Authority (LPA), Adur and Worthing Councils[iii].

1.3. Scope

This document comprises a full FRA and SuDS Strategy, using relevant information and up-to-date methodologies available.

The remainder of this document describes the legislative context of WSCC LLFA's guidance for SuDS strategies and sewer adoptions, demonstrates the flood risk status of the site from all sources of flooding, presents surface water runoff calculations, proposes a Surface Water Drainage Strategy for the scheme, and finally presents a summary and conclusions relating to this report.

1.4. Limitations

This report has been prepared on behalf of and for the exclusive use of Drew Bailey, the Client, for whom the services were undertaken and is subject to and issued in connection with the provisions of the agreement set out by Hilson Moran Partnership Ltd. Hilson Moran Partnership Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party. Furthermore, this report is subject to the following limitations:

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- Hilson Moran Partnership Ltd has not taken any steps to update this report since it was produced, and it accepts no liability for any part of this report that has or may become inaccurate as a result of circumstances that have occurred or arisen in relation to the project after the date of this report.

2. Policy Framework and Regulation

2.1. Planning Policy and Guidance

2.1.1. National

National Planning Policy Framework

The NPPF sets out policies that apply to the preparation of local plans, and development management decisions. This framework sets out the Government's economic, environmental, and social planning policies for England. Taken together, these policies articulate the Government's vision of sustainable development, which should be interpreted and applied locally to meet local aspirations.

The NPPF states that flood risk and surface water disposal are material considerations for Local Planning Authorities (LPAs) when determining individual land-use planning proposals.

The NPPF reinforces the importance that the Government attaches to the management and reduction of flood risk in the land-use planning process, whilst also adopting a precautionary approach and fully accounting for the effects of climate change. The NPPF states how flood risk should be considered at all stages of planning and development, in an attempt to reduce future loss of life and damage to property.

The NPPF also states that surface water disposal is a material consideration for LPAs when determining individual land-use planning proposals and that SuDS should be incorporated into a development wherever practical development "unless there is clear evidence that this would be inappropriate. The systems used should:

a) take account of advice from the lead local flood authority;

b) have appropriate proposed minimum operational standards;

c) have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and

d) where possible, provide multifunctional benefits."

The NPPF is supported by Planning Practice Guidance[iv], which provides further information on key issues in the implementation of policies identified in the NPPF.

2.1.2. Local

Local Planning Policy is provided by Worthing Borough Council Local Plan Policy DM20 – Flood Risk and Sustainable Drainage. Policy DM20 is outlined below:

Policy DM20 – Flood Risk and Sustainable Drainage

"a) The Council will work with relevant bodies to ensure that flood risk in Worthing is managed and reduced. Development should be directed away from areas of highest risk of flooding from any source and opportunities should be taken to reduce flooding through sustainable drainage systems and natural flood management to deliver multi-functional benefits for people and wildlife.

Flood Risk Assessment

b) A site specific Flood Risk Assessment must be submitted with planning applications for:

i. *sites of 1 hectare or greater in Flood Zone 1;*

ii. *all new development (including minor development and change of use) in Flood Zones 2 and 3;*

iii. *development that would introduce a more vulnerable class on land at increased flood risk in future or subject to other sources of flooding identified by the Strategic Flood Risk Assessment.*

c) The Flood Risk Assessment should be proportionate to the degree of flood risk and appropriate to the scale, nature and location of development. It will need to demonstrate that:

i. *the site has passed the sequential test (this has already been undertaken for all sites allocated in the Local Plan) and within the site the most vulnerable development is located in areas at lowest flood risk from any source unless there are overriding reasons for not doing so;*

ii. *Where required by national policy, demonstrate both parts of the exception test have been passed:*
   - *the development would provide wider sustainability benefits to the community that outweigh the flood risk; and*
   - *the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*

iii. *current and future flooding from all sources including in-combination and cumulative effects, and any residual risk can be safely managed;*

iv. *ensure safe access and egress to and from the development, where necessary as part of an agreed flood warning and evacuation plan;*

v. *development will not increase flood risk elsewhere, and where possible will reduce the overall level of flood risk; and*

vi. *development should be appropriately flood resistant and resilient so in the event of a flood it can be quickly brought back into use without significant refurbishment.*

Surface Water Drainage

d) The surface water drainage scheme should use Sustainable Drainage Systems, unless there is clear evidence that this would be inappropriate, and be designed to:

i. *limit runoff to greenfield 1 year rates for events up to and including the 100 year plus climate change event where possible, and always ensure no increase in flows as a result of development;*

ii. *follow natural drainage flow paths and work with existing site topography;*

iii. provide adequate capacity for the 30 year plus climate change event to be contained within the drainage system, and demonstrate that the development is safe for the 100 year plus climate change event scenario and does not increase in flood risk off site;

iv. incorporate green infrastructure and maximise multi-functional benefits ensuring adequate treatment of surface water prior to discharge to ensure that the quality of local water is not adversely affected;

v. be sensitively located and designed to promote an enhanced landscape/ townscape and good quality spaces that improve public amenity;

vi. discharge run-off according to the following hierarchy: (1) into the ground (infiltration), (2) to a surface water body, (3) to a surface water sewer, (4) to a combined sewer. Surface water connections to the public sewerage network should only be made with prior agreement of the relevant sewerage undertaker and where it can be demonstrated that there are no feasible alternatives (this applies to new developments and redevelopments) and where there is no detriment to existing users.

e) Clear management arrangements and funding for their ongoing maintenance over the lifetime of the development should be proposed. Planning conditions or obligations will be used to secure these arrangements."

The Worthing Local Plan[v] is based on the following requirements:

Runoff rates

Limit runoff to greenfield 1 year rates for events up to and including the 100 year plus climate change event, where possible, and always ensure no increase in flows as a result of development;

Storage Volumes

All design storms must include a climate change allowance on stored volumes or rainfall intensity. Infiltration structures must cater for the critical 1 in 10 year storm event, (plus 40%) between the invert of the entry pipe to the soakaway and the base of the structure. The design must also have provision to ensure that there is capacity in the system to contain the critical 1 in 100 year storm event (plus 45%) on site.

All developments to provide adequate capacity for the 30 year plus climate change event to be contained within the drainage system, and demonstrate that the development is safe for the 100-year-plus climate change event scenario and does not increase in flood risk off site.

SuDS Hierarchy

The following destinations must be considered for surface runoff in order of preference:

(1) into the ground (infiltration), (2) to a surface water body, (3) to a surface water sewer, (4) to a combined sewer.

2.2. Legislation

2.2.1. Building Regulations Part H: Drainage and Waste Disposal (2010)

Building Regulations Approved Document Part H3[vi] provides guidance on the hierarchy of options for surface water removal from a development site. The document states that, where feasible, the first choice for surface water removal should be to discharge such waters to an adequate soakaway or infiltration system. If this is not reasonably practicable then discharge should be to a watercourse, with discharge to an existing sewer being the least favoured option. Infiltration techniques should therefore be applied wherever they are feasible.

Building Regulation H3 stipulates that "...[Infiltration devices should not be built] *where the presence of any contamination in the run-off could result in the pollution of a groundwater source or resource*". This is reaffirmed in the SuDS Manual, which states that "*in areas containing contaminated soils or contaminated groundwater, soakaways are not acceptable*".

2.2.2. Water Industry Act (1991)

Legislation covering connection to a public sewer is contained in Section 106 to Section 109 of the Water Industry Act 1991 (the Act)[vii]. Section 106 of the Act stipulates that the owner or occupier of any premises may have their drains or private sewer connected to the public sewers of the sewerage undertaker.

In accordance with the Act, the following types of connection may (subject to approval) be made to the public sewerage system. The type of connection you make will depend on the sewerage system in the area of the required connection.

a. Foul water into a foul sewer (e.g. from toilets, sinks, showers, and baths);

b. Surface water into a surface water sewer (e.g. roof and paved area drainage);

c. Foul and surface water into a combined water sewer (both a. and b. above); and

d. Other types of connections may be permitted in exceptional circumstances, but they would be considered at the time of application.

2.2.3. Environmental Protection Act (1990)

Part II of the Environmental Protection Act 1990[viii] states that "*contaminated land is any land which appears to be in such a condition, because of substances in, on or under the land, that:*

- *significant harm is being caused or there is a significant possibility of such harm being caused; or,*
- *pollution of controlled waters is being or is likely to be caused*".

2.2.4. Flood and Water Management Act (2010)

The Act states that construction work that has drainage implications may not be commenced unless a drainage system for the work has been approved by an approving body (unitary authority/ County Council)[ix].

In determining an application for approval, the approving body must "*grant it, if satisfied that the drainage system if constructed as proposed will comply with national standards for sustainable drainage; or refuse it if not satisfied*".

The Act therefore removes the automatic right to connect to the public sewer if the proposed drainage strategy does not fully consider the feasibility of sustainable drainage techniques.

As part of the provisions of the Act, Defra released updated 'National standards for sustainable drainage systems (SuDS)[x] in June 2025. The scheme will aim to comply with the Standards within the constraints of the site and the listed building status of Thatch Cottage.

3. Proposed Development

3.1. Site Location

The site is located to the south of Pond Lane, Durrington, Worthing, BN13 2RH, at National Grid Reference 511834, 105052.

The redline boundary of the site bounds an area of approximately 0.1 hectares (ha) (941.4 m^2) and it is situated in a semi-urban residential area. The site is occupied by a fire-damaged Listed building and surrounding soft landscaping, which is overgrown. Because of the existing building within the site, this development is classified as brownfield.

Directly adjacent to the north of the site is Pond Lane, with residential buildings and Durrington Recreation Ground beyond. To the east of the site is overgrown greenfield land, and to the south and west are residential properties (Figure 3-1).

Figure 3-1 Site location and the surrounding area (evidence of fire damage to the existing Thatch Cottage building can also be seen)

3.1.1. Historical Maps

Historical OS maps of Durrington dating from 1875[xi] and 1879[xii] show that Thatch Cottage was located on a raised area directly to the west of a large pond, associated with nearby springs, denoted by "W" on the 1879 map (refer to Figures 3-2 and 3-3 below).

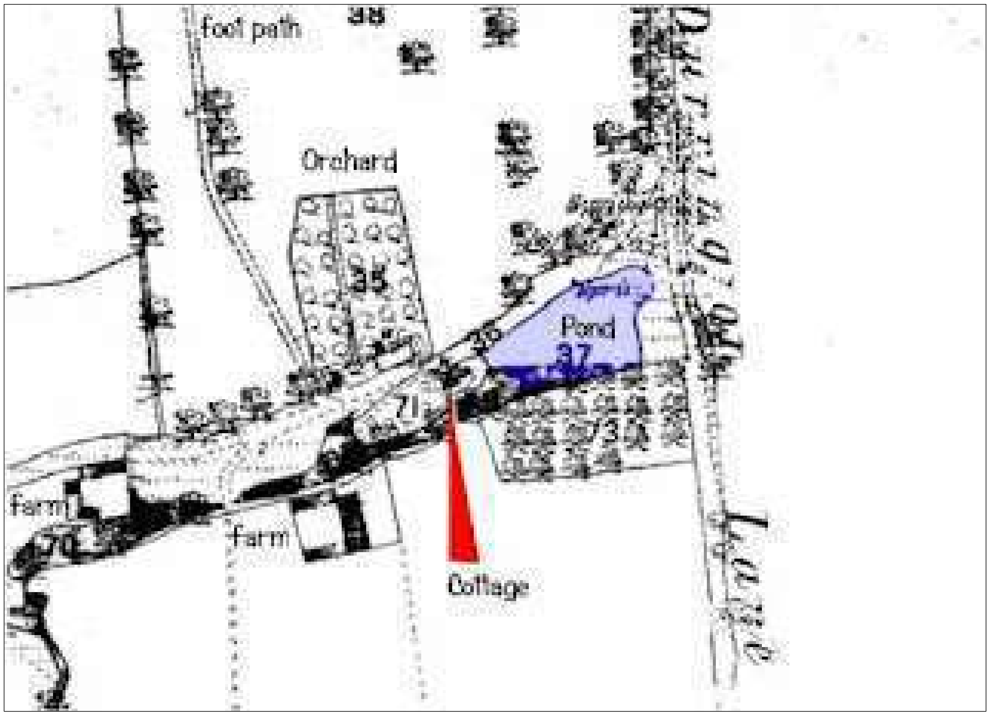


Figure 3-2 1875 OS map showing Thatch Cottage directly west of a large pond

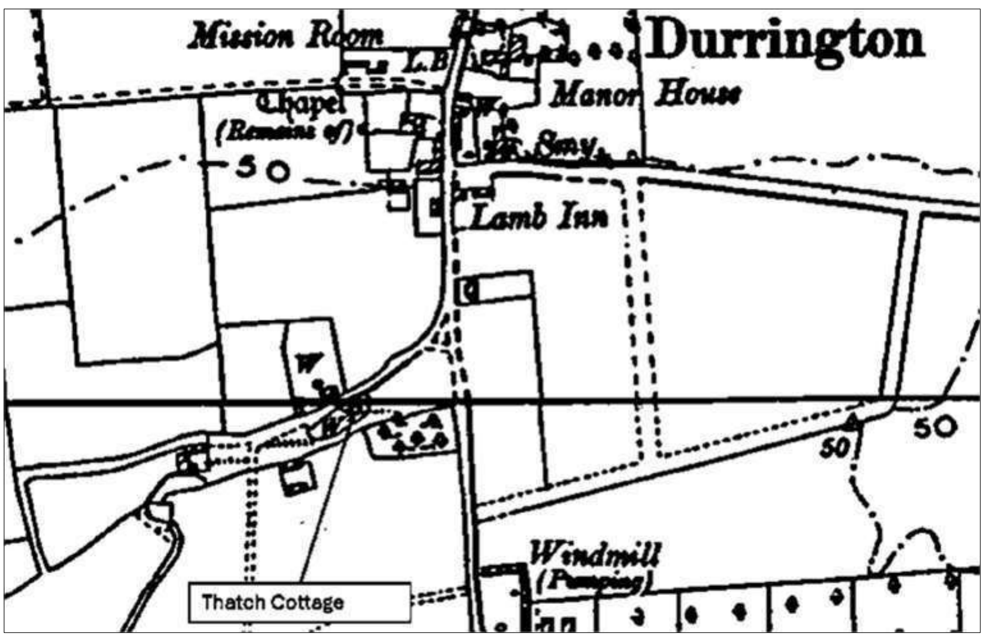


Figure 3-3 1879 OS Map showing nearby springs "denoted by "W".

At the time, Thatch Cottage was called Durringmere; "mere" being an old English term for shallow lake. The building was renamed to Thatch Cottage in the 1960's. There is anecdotal evidence[xii] that the pond was associated with a small watercourse that passed under Edmorton and Romany Road before confluencing with the Ferring Rife to the west and now replaced by the Southern Water 1200 mm⌀ corrugated polyethylene surface water sewer that runs through the southern half of the Thatch Cottage site.

It is reported that the pond was drained by the local authority in 1985, by which time it had become heavily silted and something of a tipping ground.[xiii] The area of the former pond is now overgrown and also forms part of the Council owned land at the junction of Pond Land and Durrington Lane (refer to Figure 3-4 below).

The importance of this pond for local surface water flood storage may well have been overlooked, as it is reported that flooding occurred locally after heavy rains in 1995 and 2000[xii], although improved drainage, including the subsequent construction of a flood storage area on Durrington Recreation Ground, downstream from Thatch Cottage, seems to have overcome the problem.

Nevertheless, it is recommended that Worthing Council explore the benefits of reinstating the former pond, to improve local flood risk and futureproof the area against predicted increases in peak rainfall arising from CC.

Figure 3-4 Area of infilled pond to the west of Thatch Cottage[xii]

3.2. Proposals

Drew Bailey (the 'Applicant') intends to submit a Planning Application for the restoration of the existing fire-damaged Listed building "Thatch Cottage", and the construction of 2 no. semi-detached dwellings to the west side of the existing property, together with the provision of cycle storage and car parking via the existing access on land to the east of the existing property. Refer to Figure 3-5 below for the proposals.

Figure 3-5 Masterplan of proposals

4. Baseline Conditions

4.1. Existing Site

The application site comprises approximately 0.1 ha and is occupied by a Grade 2 listed building “Thatch Cottage” and associated soft landscaping. In 2023, this building was badly damaged by a fire[xiv] and was subsequently left disused. From recent satellite images of the site, the surrounding soft landscape has been undermaintained and is overgrown with vegetation.

4.2. Topography

The general topography of the site gently slopes towards the east, with one noticeable feature: a shallow pit located southwest of the site (refer to Topographical Survey in **Appendix H**).

According to the local digital terrain model (DTM), the highest recorded region is in the east of the site where the existing Thatch Cottage is located, at approximately 10.63 m AOD, whilst the lowest area is recorded to be 9.74 m AOD, located within the depression in the southwest. This produces a slope of 0.03 m/m (Figure 4-1 below).

Figure 4-1 Topographical view along with a cross-section showing the general slope of the site

4.3. Geology and Soils

The British Geological Survey's (BGS) Geology of Britain viewer[xv] provides an understanding of the geological formations throughout Great Britain. A review of 1:50,000 scale mapping of the area shows the superficial deposits underlying the site to comprise entirely of Quaternary sedimentary "Head" deposits consisting of clay, silts and gravel (Figure 4-2 below).

Superficial River Terrace Deposits are present *circa* 150 m south of the site.

The bedrock geology underlying the superficial geology of the site comprise entirely of Lambeth Group sedimentary deposits, which are a Paleogene clay, slits, and sands.

Figure 4-2 Superficial deposits underlying the site and surrounding area (source: BGS).

With reference to the National Soil Resources Institute (NSRI) Soilscape[xvi], the soils at the site are shown to consist of freely draining, slightly acid but base-rich soils and border freely draining loamy soils immediately to the south of the boundary, as illustrated in Figure 4-3.

Figure 4-3 Soil map of the site and the surrounding area (source: Soilscape).

Nevertheless, locally the Head deposits can be variable and the unsuitability of using infiltrating SuDS within these strata was confirmed by the neighbouring 2-dwelling development, directly to the west, *circa* 2011 (Planning Ref. WB/10/0759/FUL). Consequently, a precautionary approach has been adopted in this report, where the use of non-infiltrating methods for surface water disposal have been assumed.

4.3.1. Source Protection Zone

Source Protection Zones (SPZs) are defined as areas that contain groundwater that is used to supply drinking water and are protected by the Environment Agency (EA). This includes wells, boreholes, and springs. SPZs are defined as the total area needed to support the abstraction or discharge from the protected groundwater source.

The EA's Magic Map[xvii] identifies that the site is not located within an SPZ, with the closest SPZ (insert SPZ designation) located 200m north, and is a SPZ 2 (Outer Protection Zone). According to the Manual for the Production of Groundwater Source Protection Zones, a SPZ 2 represents the area around a groundwater abstraction source where pollutants may still reach the borehole within 400 days[xviii].

Figure 4-4 Proposed site relative to nearby Source Protection Zone (SPZ) (source: DEFRA Magic Map)

5. Hydrology

5.1. Information Sources

In determining the hydrological conditions across the site and environs, reference has been made to several sources. In particular, information has been brought together from:

- The EA's Flood Map for Planning[xix];
- The EA's Long-Term Flood Risk Map[xx];
- West Sussex County Council (LLFA) Local Flood Risk Management Strategy (LFRMS);
- Adur and Worthing Level 1 Strategic Flood Risk Assessment (SFRA)[xxi].

5.2. Surface Waters

The nearest identified formal watercourse to Thatch Cottage is the Ferring Rife stream, with the nearest section of this stream being around 915 m west of the site. The site is also around 3.2km north of the coast (The English Channel).

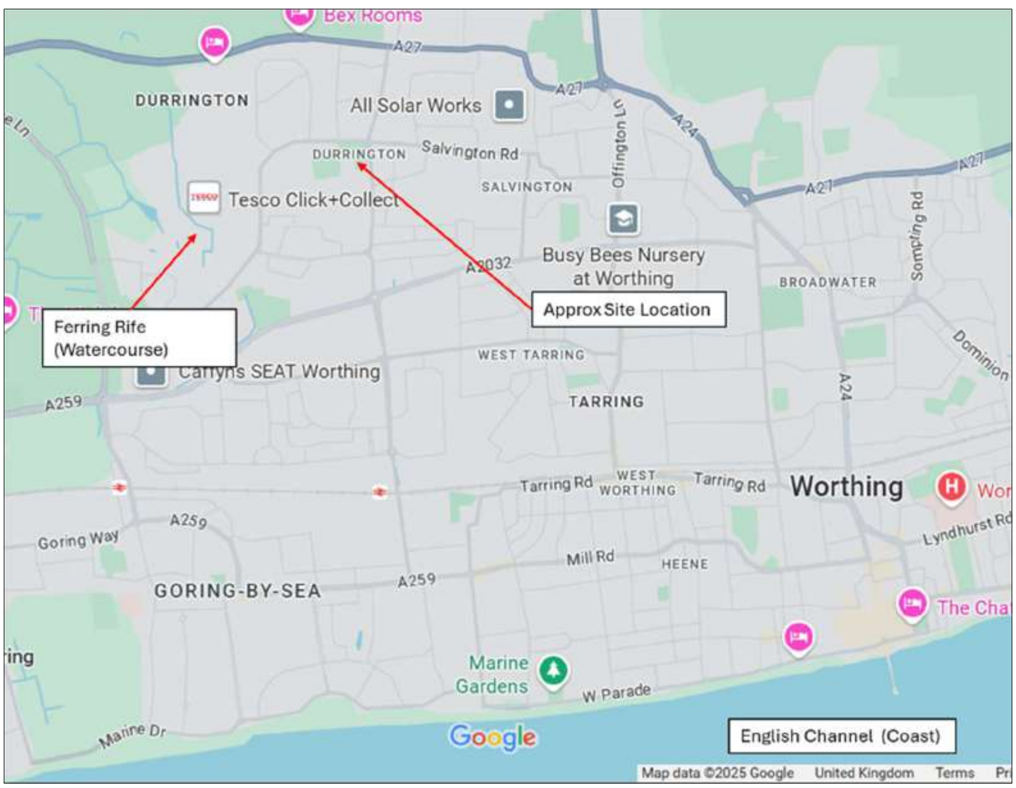


Figure 5-1 Nearest surface waters

Regarding artificial surface waterbodies, the nearest identified to the site is the Swanbourne Lake, located in Arundel (approximately 10.5 km northwest of the site). This is an artificial millpond created in the 11th century.[xxii] The closest identified reservoir is the Ardingly Reservoir, located by Haywards Heath, and is around 32 km to the northeast of the site.

5.3. Fluvial Sources

Fluvial flooding occurs when water levels exceed the banks of a watercourse, causing it to overflow into the surrounding areas. This can be caused by excessive rainfall, snowmelt, or coastal surges. The areas where the water can spill out from the channel are called floodplains, and some have flood-compatible uses such as farming.

The EA Flood Map for Planning indicates that the site is in Fluvial Flood Zone 1 and will have less than 1 in 1000 chance of flooding from fluvial sources in any given year (0.1% Annual Exceedance Probability, AEP).

The nearest area of Flood Zone 3 "high risk", is located 1.05 km to the west of the site. The site remains at low risk from fluvial flooding in the present day, as well as in future CC undefended scenarios.

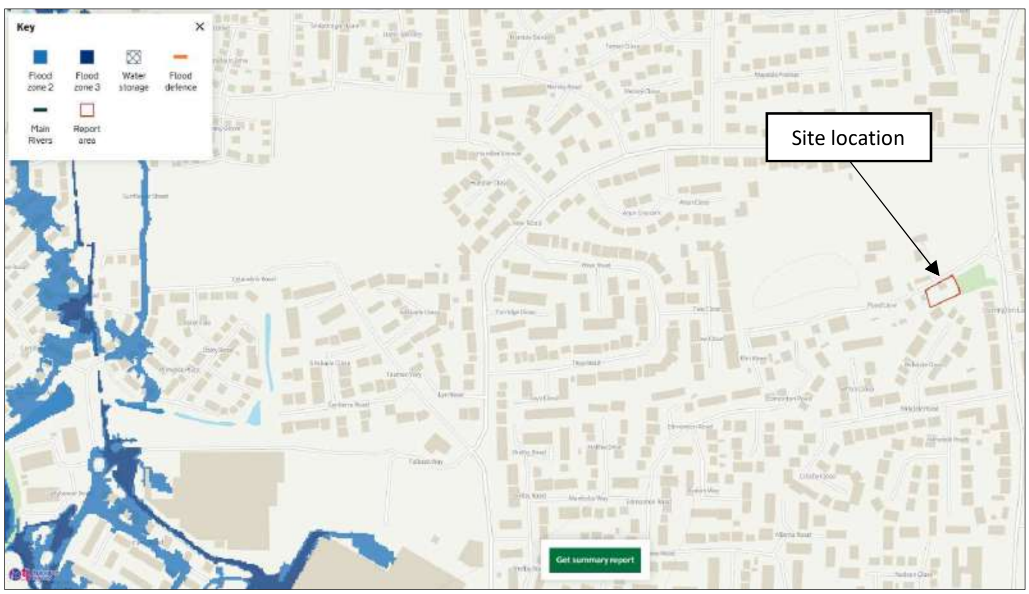


Figure 5-2 EA Flood Map for Planning showing that the site is within Flood Zone 1 (source: EA).

5.4. Groundwater

Groundwater flooding occurs when water from underground emerges above the surface. Depending on the underlying geology and superficial geology of the area, flooding from this source usually occurs after a particularly heavy storm when the infiltrated rainfall raises the local water table, causing the flows to flood the surface. Flooding from groundwater is generally more common in winter months and in areas that are in low-lying areas, where the water table is likely to be shallow.

The “Areas More Prone to Groundwater Flooding” Map from the West Sussex SFRA, is relatively low resolution and shows that the whole of Worthing is considered to have “High” potential for groundwater flooding, with a large area being within groundwater emergence zones.

However, a more detailed groundwater flood risk map was produced by JBA Consulting for the Adur and Worthing Councils, to support their SFRA, which focuses closely on the two council boroughs. This higher-resolution map shows that the site lies in an area that is classified as “No risk” of groundwater flooding (refer to Figure 5-3 below).

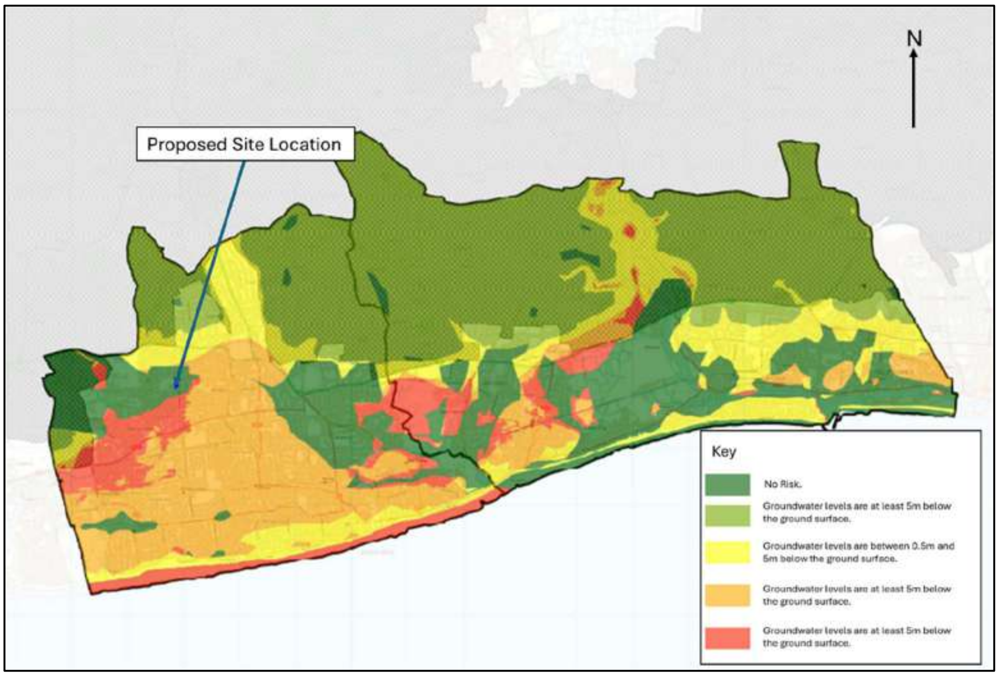


Figure 5-3 Adur and Worthing Groundwater Flooding Risk Map

5.5. Surface Water Flooding (Pluvial)

Surface water flooding occurs when intense, often short-duration, precipitation events are unable to enter a drainage system due to blockages, breakages in water pipes, or when the drainage capacity has been exceeded. This may be caused by a combination of factors, including site topography, rainfall exceeding the capacity of local surface water/ combined systems, or blockages to the sewer systems.

The site is classified as brownfield due to the existing Thatch Cottage listed building within the boundary, but the majority of the site consists of soft landscaping and is overall heavily vegetated. The topographical information shows that the site slopes gently to the east, but there is a basin feature located in the southwest of the site. In terms of the wider area, the site lies at the bottom of a topographical slope.

The EA Risk of Flooding from Surface Water Maps shows that the site is at “High Chance” of surface water flooding. This means that there is more than 3.3% probability of flooding from surface water sources in any given year (>3.3% AEP). The extent of the surface water flooding within the area is not limited to the site, but also affects the entire eastern half of Pond Lane, as the site lies within a local surface water flow route (Figure 5-3).

The surface water within this area is shown to follow a flood flow route that originates near Salvington Road (200 m to the northeast of the site), flowing towards Pond Lane, and terminating by Long Croft Park (approximately 500 m southwest of the site).

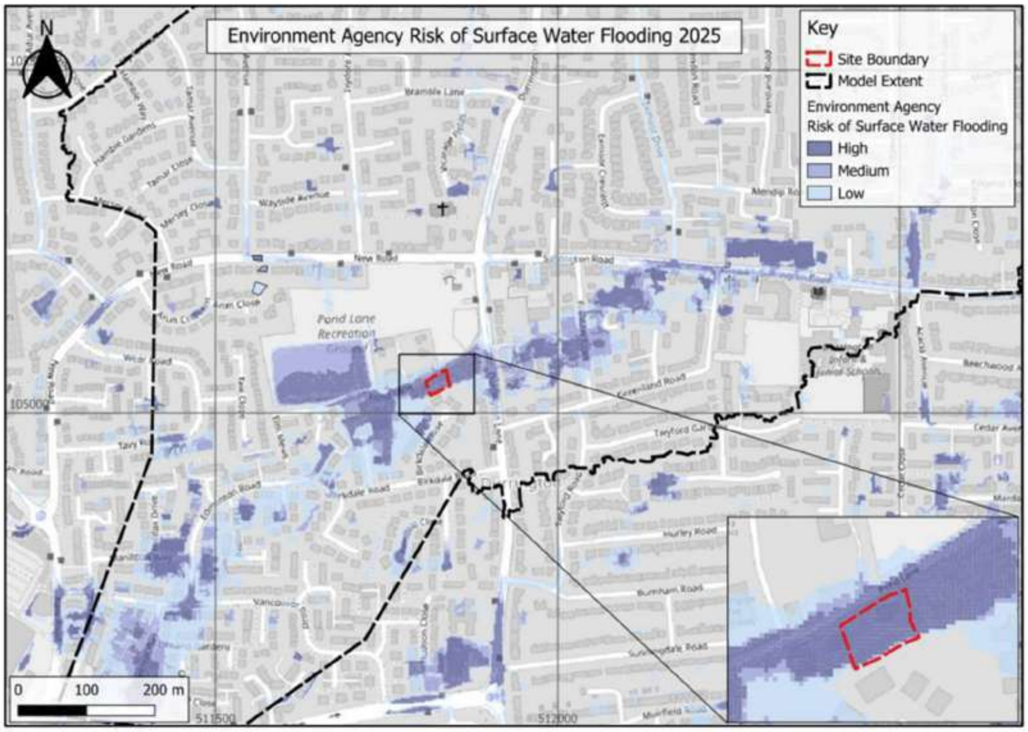


Figure 5-3 EA Surface Water Flood Map

The extent of the surface water flooding that affects the site and the surrounding area is due to the combination of fairly steep topography in the north, in the vicinity of Salvation Road where the flow route originates, which then flows downhill towards Pond Lane. This area, as described in Section 4.2 above, is topographically shallow, which increases the risk of ponding.

The EA's Long Term Flood Risk (LTFR) Map indicates a "High Chance" of surface water flooding (more than 3.3% chance of flooding each year) up to 30 cm deep across the site, bar a small area on the north of the boundary which has been classified as "Medium Chance" of flooding up to 30 cm in depth (between 1% and 3.3% chance each year).

The majority of the site, including the existing Thatch Cottage, has a "Low Chance" of flooding up to 60 cm (0.1% and 1% chance each year), with the lowest parts of the site along the southern boundary (in the vicinity of the basin feature) having High to Medium Chances (refer to Figure 5-4 below).

In the highest depth scenario (up to 90 cm) only the deepest part of the basin has a High Chance of flooding to this depth, with this depth scenario not predicted to be reached for the rest of the site.

Figure 5-4 Long-Term Flood Risk Map: Surface water showing that parts of the south of the site has a "High Chance" of flood depths of up to 60cm

Given the significance of the flooding predicted by the EA LTFR Map, additional detailed site-specific TUFLOW pluvial flood modelling has been commissioned by the Applicant using the EA's LiDAR dataset for the DTM, and is compliant with the latest EA Flood Estimation Guidance.

With regard to CC, the "Upper End" allowance was assessed in the study, to reflect the anticipated 100-year lifetime of the residential scheme (40 % CC uplift for the 1 in 30-year event and 45 % uplift for the 1 in 100-year event).

For the rainfall data, ReFH2.3 was used, together with a range of Manning coefficients to reflect the different surfaces within the model extent, spatially varied using OS open data and checked against aerial imagery. A number of scenarios were modelled and outputs provided including:

i. Baseline scenarios: comprising 1 in 30-year, 1in 30-year +40% CC, 1 in 100-year, 1 in 100-year + 45 % CC and 1 in 1,000 year events (outputs: max flood extent, max flood depths, max velocity);

ii. Post-development scenarios: comprising 1 in 30-year, 1in 30-year +40% CC, 1 in 100-year, 1 in 100-year + 45 % CC and 1 in 1,000 year events (outputs: max flood extent, max flood depths, max velocity, depth difference compared to baseline);

iii. Hazard mapping for baseline and post-development scenarios, based on the UK Hazard Formula, which is a function of depth and velocity with a debris factor included. The UK Hazard Formula is based on the UK publication DEFRA R&D Outputs: Flood Risks to People Phase Two Draft FD2321/TR1 and TR2.[xxiii]

A number of sensitivity scenarios, analysing the impact of varying roughness values and rainfall were also run.

The methodologies and inputs to the model are described in detail in the "*Hydraulic Model Report*" presented in **Appendix A** of this document.

The following conclusions were drawn from the modelling:

- A comparison between the modelled extents and the EA's Risk of Flooding from Surface Water (RoFSW) Mapping for the 1 in 100-year and 1 in 1000-year events (refer to Figure 5-3 above) showed that the extents from the TUFLOW modelling were found to be slightly larger than the EA's "Medium" risk (equivalent to the 1 in 100-year event) and "Low" risk (equivalent to the 1 in 1000-year event) extents (refer to Figure 5-5 below).

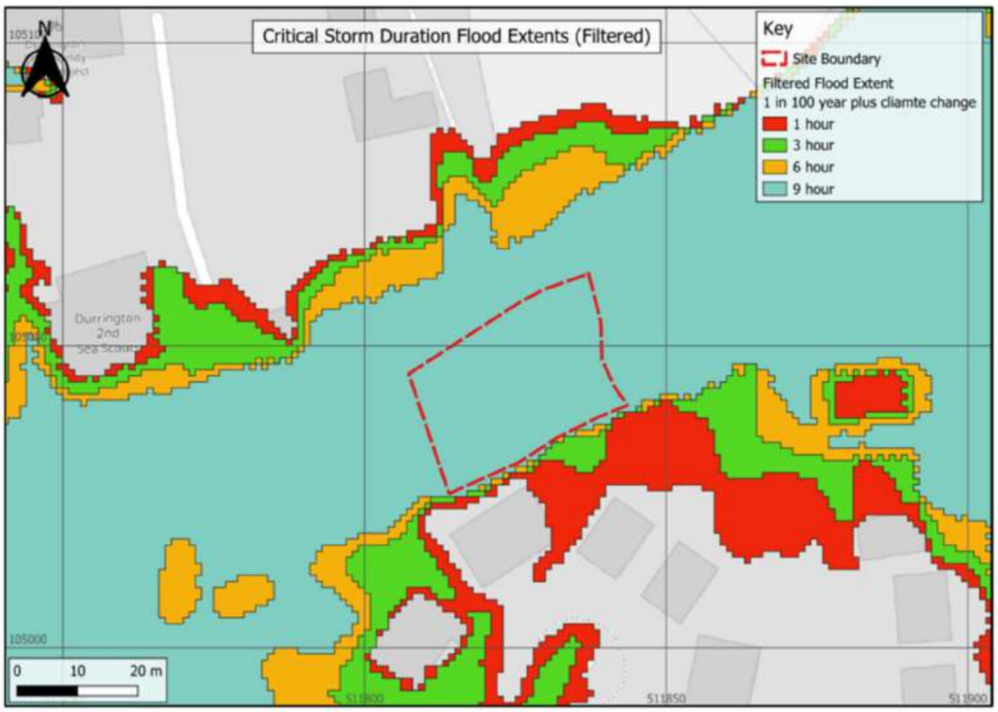
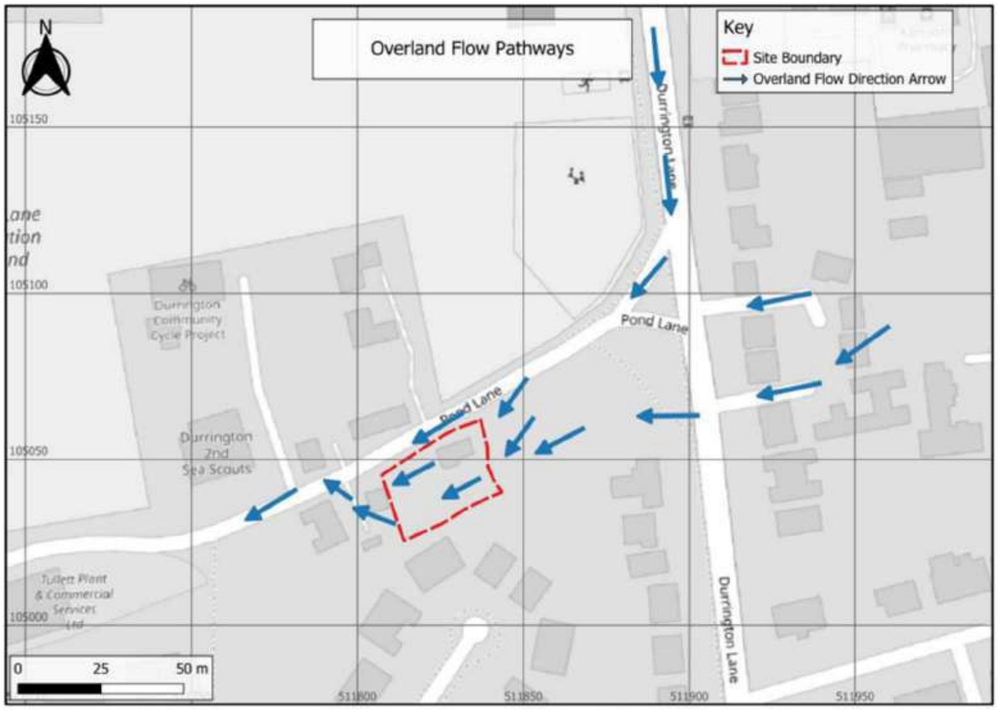


Figure 5-5 TUFLOW Modelled flood extents for the 1hr, 3hr , 6hr and 9hr duration for the 1 in 100 year + CC storm event

- As the TUFLOW modelled extents incorporate a higher resolution DTM and a higher horizontal resolution grid, the site-specific results are considered more reliable and take precedence over the national-scale approach.
- Surface water flow pathways within close proximity to the Site were found to be conveyed down Durrington Lane to the northeast of the Site, and flowing south west (refer to Figure 5-6 below).



https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

Figure 5-6 Overland flow pathways within close proximity to the site

- Flooding of the site is observed during all scenarios, with inundation observed across the whole of the site during the 1 in 30-year event and all other modelled events (Figure 5-5 above).
- The deepest flooding observed on-Site during baseline scenarios is invariably located within the depression in the southwest corner of the Site. Maximum modelled flood depths within this depression ranged from 1.19 m during the 1 in 30-year baseline event to 1.60 m during the 1 in 100-year +45% CC baseline event. Minimum on-Site flood levels ranged from 0.20 m during the 1 in 30-year baseline event to 0.60 m during the 1 in 100-year +45% CC baseline event.
- Baseline flood depths around the façade of the existing Thatch Cottage are typically within the 0.25 to 0.50 m range on the northern and western facades and within the 0.50 to 0.75 m range on the eastern and southern facades during the 1 in 30-year event, with a maximum depth of 0.53 m predicted on any facade. As standard modern day building fabrics can typically withstand up to 0.6 m depth of external floodwaters before ingress, then a flood exclusion strategy will be achievable for the current 1 in 30-year event (refer to Section 6.2.7.1 below).
- However, for the 1 in 30-year +40% CC and 1 in 100-year events, baseline flood depths around the Thatch Cottage façade are typically within the 0.50 to 0.75 m range on the northern and western facades and within the 0.75 to 1.00 m on the

eastern and southern facades. Maximum predicted flood depths on any façade for these events are 0.76 and 0.70 m, respectively.

- During the 1 in 100-year + 45% CC and 1 in 1000-year events, baseline flood depths around the existing façade are typically within the 0.75 to 1.00 m range on all facades, with maximum predicted flood depths on any façade for these events predicted to be 0.96 and 0.97 m, respectively.

5.6. Sewer Flooding

Sewer flooding occurs when flows overload the capacity of the sewers. This can be from intense rainfall, but blockages and sewer failures can also lead to flooding downstream of the network.

Sewer records obtained from Southern Water and presented in **Appendix G** of this document demonstrate that:

1. The sewer network within the vicinity of the area includes a 1200 mm ⌀ corrugated polyethylene surface water sewer, which runs through the back garden of Thatch Cottage in a southwesterly direction.
2. The closest surface water Manhole (MH) to Thatch Cottage is MH 8053, which has a cover level and invert level of 10.37 mAOD and 7.70 mAOD, respectively.
3. The nearest record of a Southern Water adopted foul sewer is MH 7004 (57m west of the site) that connects to a 150 mm ⌀ vitreous clay pipe that flows southwards.

The Adur and Worthing SFRA indicates that the Southern Water Sewer Incident Report Form (SIRF) database reported that there was a total of 309 recorded flood events between 01/2013 and 05/2023, within Worthing Boroughs and Adur Districts. Within the local postcode to the site (BN13), 70 recoded flood incidents have been recorded, although the resolution of the records do not report if any of the records were local to Thatch Cottage.

It is noted that this address covers a significant portion of north Worthing, which spans from Durrington-on-Sea Station (*circa* 2 km south of the site) to Kithurst Hill (*circa* 9.10 km north of the site) (Figure 5-6). The flooding reported from the site may have since been reduced in some locations by capital investment to increase the capacity of the local network.

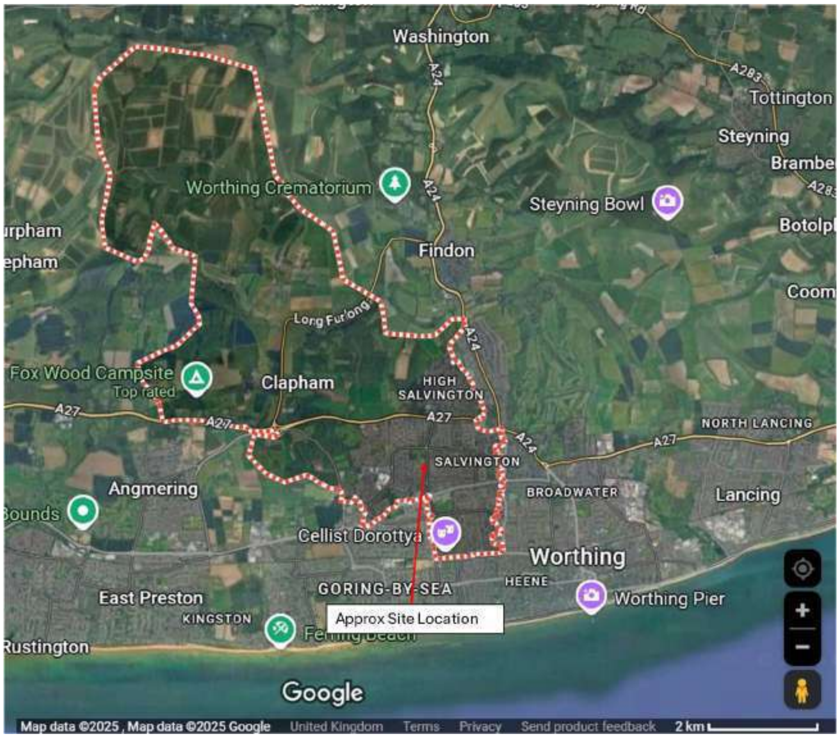


Figure 5-6 Extent of the BN13 postcode area

5.7. Reservoirs and Artificial Waterbodies

A reservoir is a large natural or artificial lake that is designed to collect and store water. Flooding from reservoirs is extremely unlikely. An area is considered at risk if peoples' lives could be threatened in the event of a dam or reservoir failure. The SFRA states that in the National Risk Mapping, reservoir breaches have been found to impact Adur and Worthing. The EA flood risk map shows that the nearest area that is highlighted to be at risk of reservoir flooding is from Swanbourne Lake by Arundel, approximately 10.5 km to the northwest of the site (Figure 5-7).

Consequently, the site is considered to be at a negligible risk of flooding from reservoirs, canals, and/or other artificial sources.

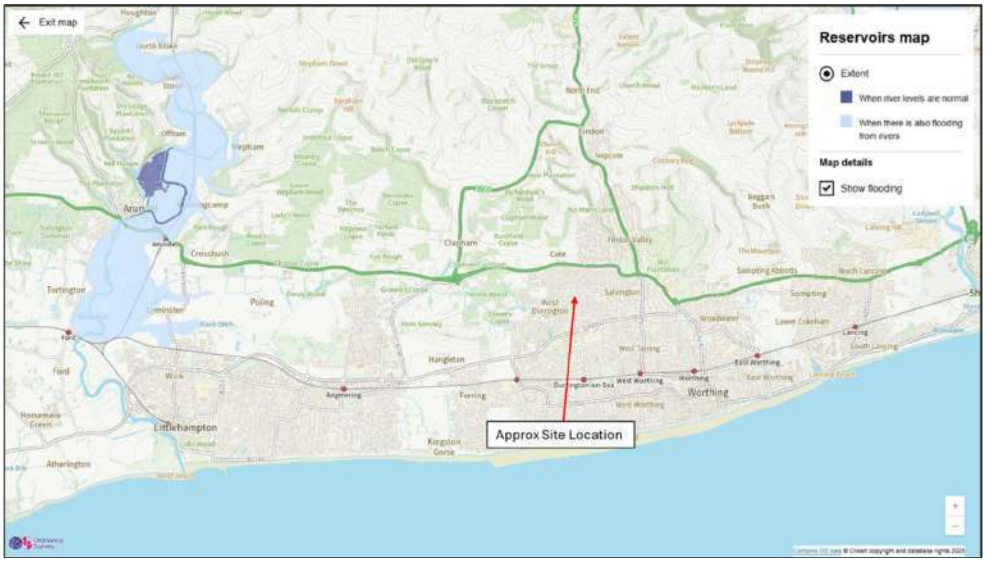


Figure 5-7 EA Reservoir Flood Risk Map

5.8. Records of Historical Flooding

The SFRA has collected historical flooding information from multiple sources, including EA flood records, WSCC's recoded flood incidents, and Southern Water's SIRF data set. The SFRA reports that in Durrington, there have been several recorded incidents, including groundwater flooding, sewer flooding, and surface water flooding. The most notable historical incident of flooding in Durrington have been highlighted to be the following historic event:

- October 1980 – Surface Water flooding following intense rainfall led to widespread flooding in Durrington and Worthing, impacting gardens, roads, and 488 properties.

Furthermore, there is anecdotal evidence of flooding occurring locally after heavy rains in 1995 and 2000[xii] (refer to Section 3.1.1 above) although improved drainage, including the subsequent construction of a flood storage area on Durrington Recreation Ground, downstream from Thatch Cottage, seems to have overcome the problem.

The EA historical flood maps show the maximum extent of recorded flood outlines, showing that there is no historical flooding within the site, but there has been flooding nearby, including flooding across the nearby Durrington Lane highway (70 m east of the site), and a historic flood risk zone 72 m southwest of the site, that spans Sefton Close and Birkdale Close, where records show flooding of properties and the back gardens of several houses (Figure 5-8).

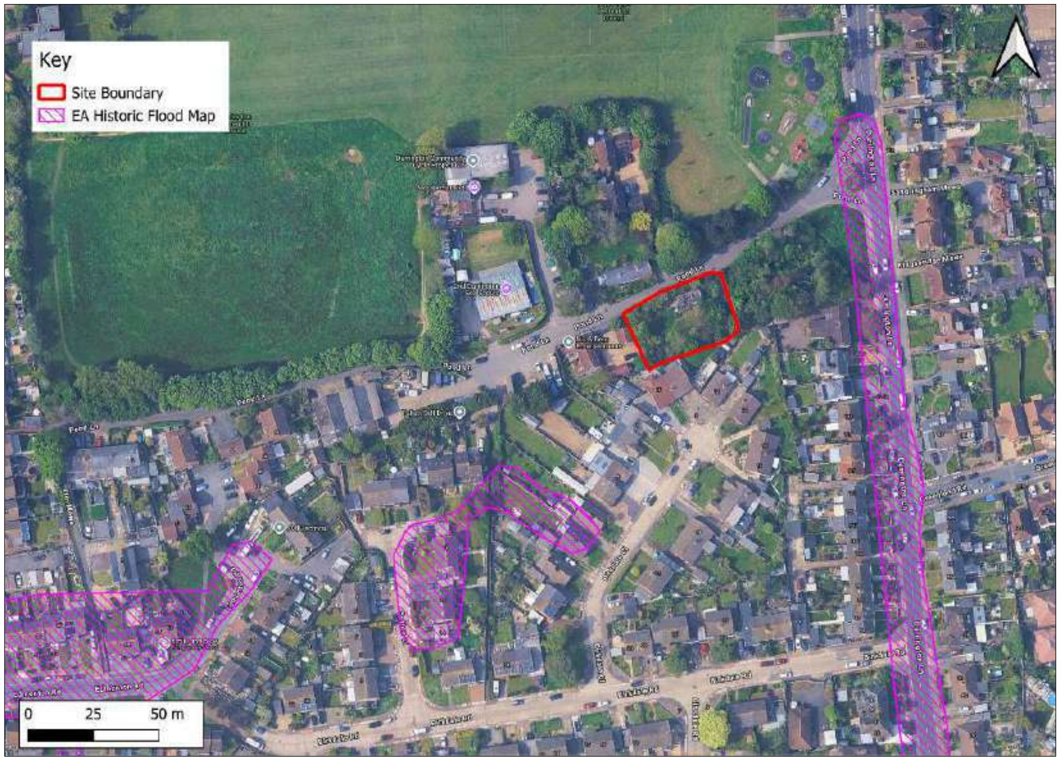


Figure 5-8 EA Historical Flood Map indicating previous reported flood incidents relative to the proposed site.

5.9. Conclusions

The above desk-based study highlights the potential sources of flooding that may affect the site. The EA Flood Map for Planning has identified that the proposed development location is in Flood Zone 1 and has a less than 1 in 1,000 chance of experiencing flooding from fluvial sources in a given year.

EA Surface Water flood mapping has identified the site is at “High” chance of experiencing surface water flooding (3.3% AEP). The extent of the surface water flooding within the area is not limited to the site, but also affects the entire eastern half of Pond Lane, as the site lies within a surface water flow route. In future scenarios, the surface water flood depths are expected to have a “Medium chance” of flooding up to 30cm in the highest parts of the site, with the lowest parts of the site (within the southwestern depression) having a high chance of experiencing flood depths up to 60 cm in depth.

To refine the EA surface water flood mapping, site-specific TUFLOW pluvial modelling was undertaken using EA LiDAR data and ReFH2.3 rainfall inputs. Scenarios included:

- Baseline: 1-in-30, 1-in-100, 1-in-1000-year events (with CC uplifts).
- Post-development: same events plus hazard mapping using the UK Hazard Formula (depth × velocity + debris factor).

Key findings comprised:

- Flooding occurs across the site in all scenarios, with the southwest depression experiencing depths up to 1.60 m during the 1-in-100-year + CC event.
- Around Thatch Cottage, depths range from 0.25–0.50 m (1-in-30-year) to 0.75–1.00 m (1-in-100-year + CC).

Other flooding sources, such as groundwater, sewers, and artificial waterbodies, have also been assessed and are deemed as low-risk.

6. Mitigation & Enhancement

6.1. Background

The NPPF states that the Government's policy is to reduce flood risk. Therefore, the development of the site should be seen as an opportunity for environmental enhancement and a net reduction in flood risk. As such, the development should aim to reduce runoff below the existing runoff rates and volumes. If this is deemed impractical due to various constraints, the proposed development should at least maintain runoff rates and volumes at existing conditions.

To provide betterment and to futureproof the scheme against climate change, the proposals will include the attenuation of surface water runoff rates and volumes from the site, to maintain discharge rates at the pre-existing (Greenfield) rates throughout the lifetime of the scheme, taking into account the impact of climate change.

This will be achieved by incorporating SuDS into the design, and is detailed in the later sections of this chapter.

SuDS can be a combination of both physical structures and techniques used to control surface water runoff as close to its origin as possible before surface water discharges to a watercourse or ground. There is a wide variety of sustainable drainage options available. Specific solutions need to be developed for each site, the choice of which will depend on factors such as the nature of the site, the type of pollutants potentially present, the hydrology of the area, and the presence of Groundwater SPZs.

The implementation of SuDS as an alternative to conventional drainage systems can achieve significant direct and indirect long-term environmental benefits. Depending on the choice of the system these can include:

- Reduction in overall flood risk on-site and downstream from the proposed redevelopment by reducing surface water runoff to watercourses, either permanently or after peak flow periods in the system;
- Providing an opportunity for infiltration of surface water into soil, where feasible, to replenish groundwater, and help maintain baseflows in rivers;
- Promoting a healthier waterway flow regime to receiving watercourses and reducing the impact of bank erosion and habitat damage caused by the increase in flow rate of additional surface water runoff;
- Reducing the quantity of pollutants reaching waterways and infiltrating the ground; and
- Habitat creation and enhancement of the amenity of an area. This applies predominantly to open drainage options, especially where wet ponds or wetlands are implemented.

6.2. Assessment of Impact

6.2.1. General Design Concept

For new developments, there is a general expectation that a drainage system should be adequate, particularly with regard to drainage created by developments subject to Building Regulations. Adequate performance will usually be achieved if the drainage system:

- Conveys the flow via a suitable network or treatment systems to a suitable outfall (a soakaway, a watercourse, surface water, or combined sewer);
- Minimises the risk of blockage or leakage with good access for clearing blockages and any necessary maintenance;
- Has sufficient capacity to carry or retain the expected flow at any point in the system and so does not increase the vulnerability of the development to flooding; and
- Provides drainage from roofs or paved areas to an adequately and suitably designed drainage system;

In considering the most appropriate SuDS for the proposed development, reference has been made to the CIRIA "*Sustainable Drainage System Manual*" (the "*SuDS Manual*")[xxiv], and the "*Water.People.Places*." which is local SuDS guidance prepared by LLFAs in the south east of England[xxv].

6.2.2. SuDS Hierarchy

When designing the SuDS Strategy, reference has been made to the priorities for discharge (*i.e.*, the "*SuDS Hierarchy*") presented in the SuDS Manual and Building Regulations.

The local superficial geology within the site is classified a "Head" deposit, which comprises a sedimentary layer that can be variable in permeability (refer to Section 4.3 above). The site is not within a SPZ and there is a low risk of groundwater flooding. To demonstrate whether the site is suitable for soakaways or other infiltrating SuDS, BRE365 compliant site-specific ground infiltration investigation may be required, and if so, it is anticipated such testing will be secured by an appropriate Planning Condition. However, the unsuitability of using infiltrating SuDS within these strata was confirmed by the neighbouring 2-dwelling development, directly to the west, *circa* 2011. Consequently, a precautionary approach has been adopted in this report, where the use of non-infiltrating methods for surface water disposal have been assumed.

The final bespoke SuDS solution has been arrived at through a process of elimination in the following way:

1. "*Discharge to the ground*" – The unsuitability of the underlying Head deposits for infiltration was confirmed by the neighbouring 2-dwelling development, *circa* 2011. If required, site-specific BRE365-compliant infiltration testing would be secured by an appropriate Planning Condition.

2. “*Discharge to surface waters*” – This option will not be explored, as the nearest watercourse is the Ferring Rife located 915 m away.

3. “*Discharge to a surface water sewer, highway drain or another drainage system*” – A Southern Water 1200 mm⌀ corrugated polyethylene surface water sewer runs through the southern half of the site (refer to **Appendix G**) – consequently, this is the recommended option on which the SuDS strategy is based.

4. “*Discharge to a combined sewer*” – The sewer records show that the local area is not drained by combined sewers.

6.2.3. Preliminary Runoff Calculations

The following section provides an empirical demonstration of the reduction in surface water runoff volumes and rates, anticipated from the installation of appropriate SuDS devices.

It is proposed for the site to discharge into the Southern Water 1200 mm⌀ corrugated polyethylene surface water sewer at two outfall locations, one serving the eastern Thatch Cottage site and the other serving the western 2 x new dwellings site. As such, runoff calculations for the two drainage catchments have been presented separately.

6.2.3.1. Methodology

Firstly, the greenfield peak runoff rates for a range of return periods have been estimated using the IH124 methodology, included within HR Wallingford’s Greenfield Runoff Rate Estimation Tool. For sites <50 ha, the method uses a *pro-rata* methodology based on IH Report 124 with growth curves from the Flood Studies Report and CIRIA Book 14. The method requires input of the standard average annual rainfall (SAAR) for the site in question (50.4 mm). The SuDS Manual and Wallingford Procedure Technical Report were used to determine values for soil index (SOIL) and ‘urban catchment wetness index’ (UCWI) for the Application Site, 113.

In addition, Flood Estimation Handbook (FEH) and IH Report 124 methods have been employed to facilitate the determination of the surface water runoff from the developed site for a range of return periods, using the HR Wallingford “*Surface water storage volume design tool*” and the FEH Web service, which generates the design rainfall depth for a range of specified return periods and storm durations, used in the tool.

6.2.3.2. Greenfield runoff rates

Greenfield runoff rates were calculated using the methodology described above. The results of this procedure are presented in Table 6.1, which demonstrates an estimated greenfield runoff rate for the 100-year critical storm event of **6.4 l/s/ha.** With catchment areas of 0.0570 ha for the eastern Thatch Cottage catchment and 0.0372 ha for the western new builds catchment, this equates to **0.4 l/s** for the former and **0.2 l/s** for the latter. The HR Wallingford “*Greenfield runoff rate estimation tool*” outputs for the whole site and two separate catchments are presented in **Appendix D.**

Table 6.1 Greenfield runoff rates for whole site

Return period (years)	Peak Greenfield runoff rate (l/s)	Peak Greenfield runoff rate (l/s/ha)
$Qbar_{rural}$	0.2	2.1
1	0.2	2.1
30	0.4	4.3
100	0.6	6.4

6.2.3.3. Post-development runoff rates and volumes

Runoff rates and volumes for the proposed development have been calculated using the HR Wallingford "*Surface water storage volume design tool*".

Within the design of drainage networks for new developments, the incorporation of an appropriate allowance for future climate change impacts on peak rainfall intensities is recommended to ensure that all future developments give rise to a net reduction in runoff rates and volumes throughout their operational lifetime.

Updated UK Government climate change allowances are available for the Adur and Ouse Management Catchment peak rainfall allowance online (refer to https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall).

Both central and upper-end allowances for peak rainfall intensity are provided. Associated guidance advises that "*for flood risk assessments and strategic flood risk assessments, assessments should be provided for both the central and upper-end allowances to understand the range of impact*". Assuming a 100 year lifetime for the proposed development, the guidance suggests that the total potential change anticipated for 2061 to 2125 is 45% for the upper-end allowance in the 1 in 100 year event.

Although the greenfield mean annual maximum flow rate (Qbar) (which equates to a return period of *circa* 1 in 2.3 years) has been targeted as the discharge rate from the scheme, as this is very low (0.2 l/s for the whole site) there is the chance of pipe blockage if the discharge was regulated to this level. Consequently, the tool permits discharge at a self-cleansing rate of **0.9 l/s** during the 1 in 100-year event. Tables 6.2 and 6.3 below present the proposed discharge rates and attenuation volumes for each drainage catchment, whilst full outputs for the tool are presented in **Appendix E.**

Table 6.2 Proposed development runoff rates and volumes for Thatch Cottage drainage catchment

Return Period (Years)	Critical storm duration (mins)	Required Attenuation Storage (m^3)	Peak Flow Q	
			(l/s)	(l/s/ha)
1	240	5.0	0.5	8.8
30	180	14.0	0.8	14.0
100	180	18.0	0.9	15.8

Table 6.3 Proposed development runoff rates and volumes for Thatch Cottage drainage catchment

Return Period (Years)	Critical storm duration (mins)	Required Attenuation Storage (m^3)	Peak Flow Q	
			(l/s)	(l/s/ha)
1	240	3.3	0.5	13.5
30	180	10.0	0.8	21.5
100	120	13.0	0.9	24.2

The tool estimates that **18 m^3** of surface water attenuation will need to be provided for the eastern Thatch Cottage drainage catchment, and **13 m^3** for the western new builds drainage catchment prior to discharge to the adjacent sewer at a maximum of **0.9 l/s** during the 1 in 100-year event

6.2.4. SuDS Design Concept

It is intended that the proposed development will aim to meet the DEFRA 2025 National Standards for Sustainable Drainage Systems. The requirements mandate to the management of everyday rainfall (interception) and the management of extreme rainfall and flooding.

The provision of SuDS within the site will be key to mitigating and future-proofing the site from surface water flooding. Section 6.2.4.1 outlines the proposed SuDS to be utilised within the development. The following SuDS systems are intended to be used in the scheme:

6.2.4.1. Porous / Permeable Paving

Porous or Permeable paving is a type of hard surfacing that allows rainwater to infiltrate through the surface and into underlying layers, which can be temporarily stored before infiltrating into the ground or into attenuation layers (Figure 6-1 below).[xxvi] The materials (i.e. the tiles) are impermeable to water. For porous paving, surface water can infiltrate through the entire surface material, and can be made from various materials, such as gravel, resin-bound gravel, concrete, asphalt, and even reinforced grass. Permeable paving differs from porous paving in that the paving material itself does not allow water to infiltrate through. Water instead can be infiltrated through the space in between the paving's patterned, shaped voids. Some of the advantages of permeable paving include reducing peak flows by intercepting surface water runoff, the voids can also act as a pollution control, having a dual use of space, and can replace gullies and manholes, and they are typically low in maintenance. However, some limitations to this system may need to be considered, such as the risk of clogging if there is a buildup of sediment, and typically, vehicles traversing on permeable paving will need to have a speed limit (up to 30 mph)[xxvii].

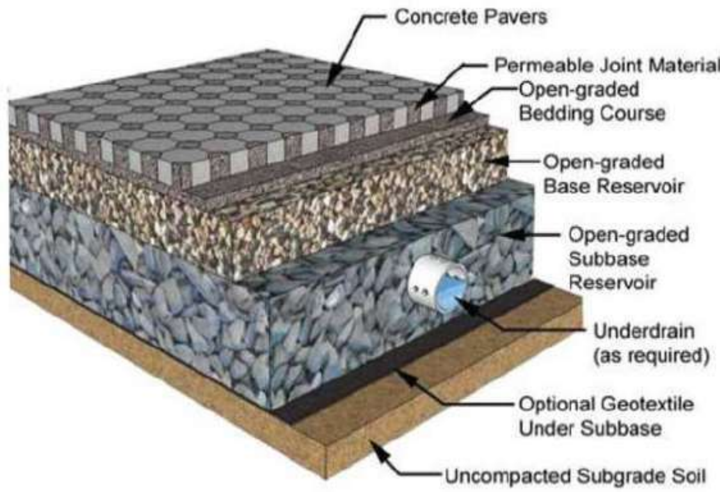


Figure 6-1 Cross-section of the permeable paving system (top layer) along with subsurface layers and drainage that can be installed

6.2.4.2. Sub-surface Storage

Geocellular subsurface units are modular “orange-crate” type SuDS, which can be used to manage and control surface water (refer to Figure 6-2) by being utilised as temporary storage to attenuate flows during a storm event. There is a range of different types and manufacturers on the market, including Polypipe, which manufactures the Permavoid geocellular system and has a range of products that are suitable for heavily trafficked areas such as parking spaces and driveway areas, and can be designed to allow infiltration to groundwater, or alternatively used as non-infiltrating storage by “tanking” the system with an impermeable membrane. A Standard Detail drawing of Permavoid Geocellular Units is provided in **Appendix F** for reference.

Figure 6-2 Example of sub-surface geocellular crates (Polypipe)

6.2.5. Drainage Strategy

As the car parking area (which can also be used as a significant area for attenuation storage), is located upstream from the new builds, it has been decided to discharge at two separate outfall locations for the scheme; one serving the Thatch Cottage and car park and the other serving the two new dwellings and associated hardstanding (refer to Figure 6-3 below).

It is anticipated that the car park will be constructed from a porous surface (*e.g.* porous paving or resin bound gravel), with sub-surface storage provided within the void spaces of an underlying granular sub-base. Assuming a 30 % void ratio within the 375 mm deep granular sub-base, 160 m^2 area with nominal 300 mm cover would provide the required 18 m^3 storage for the Thatch Cottage drainage catchment, discharging into the adjacent 1200 mm⌀ corrugated polyethylene surface water sewer, at existing MH 8053, at a maximum of 0.9 l/s (by means of a control structure such as a critical orifice).

Alternatively, in excess of the required 18 m^3 storage could be provided by 67.7 m^2 of 300 mm depth Permavoid or similar geocellular units (with reference to **Appendix F**, 67.7 m^2 could comprise 10 x 27 Permavoid 150 mm units, stacked 2 high, providing 18.3 m^3 storage).

The required 13 m^3 storage for the 2 x new dwellings drainage catchment would be provided by 25.5 m^2 of 600 mm depth Permavoid or similar geocellular units (with reference to **Appendix F**, 25.5 m^2 could comprise 6 x 17 Permavoid 150 mm units, stacked 4 high, providing 13.8 m^3 storage).

Discharge of runoff from this storage area into the adjacent 1200 mm⌀ corrugated polyethylene surface water sewer, would require construction of a new manhole, with a maximum discharge of 0.9 l/s regulated by means of a control structure such as a critical orifice.

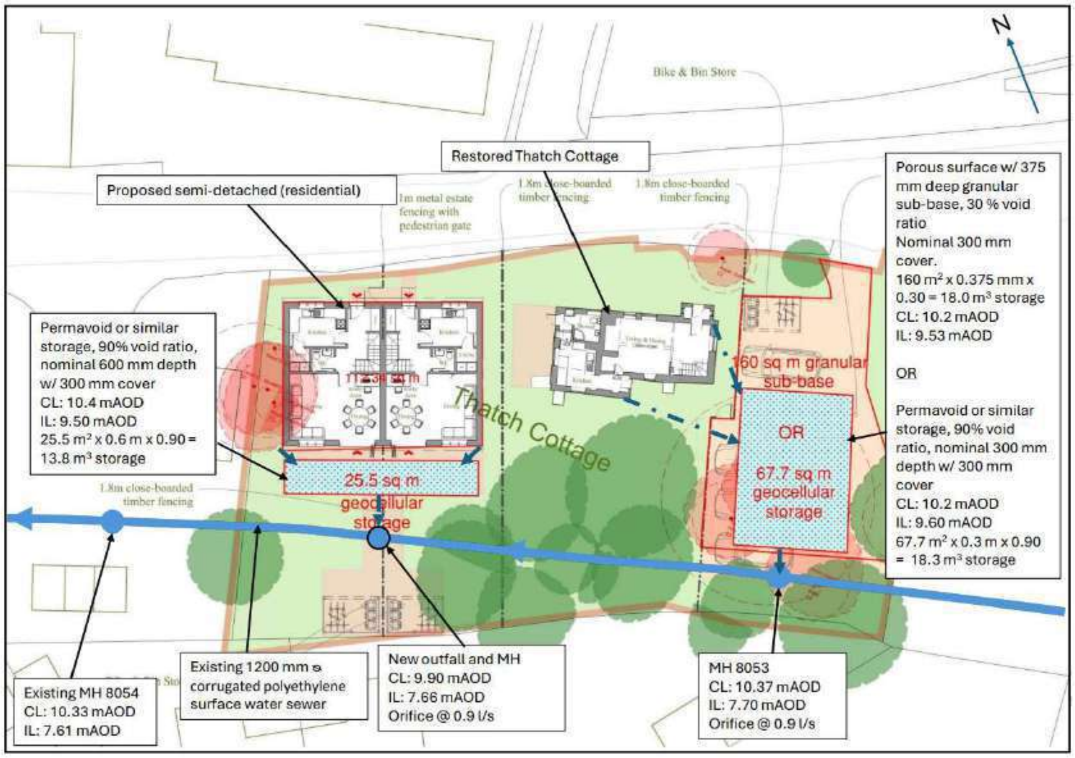


Figure 6-3 Proposed SuDS Strategy for the scheme

6.2.6. Maintenance of SuDS

Maintenance will be required to ensure that the SuDS features within the site remain functional throughout the lifetime of the proposed development. It is anticipated that the maintenance will be secured by planning conditions for the duration of the proposed development. This will be subsequently coordinated and paid for by the applicant and comprise:

- Periodic checking of inspection chambers and pipework for blockages or physical damage, and remediation as required;
- Periodic jetting or rodding of pipework as required to clear blockages;
- Periodic desilting of the flow control (e.g. orifice plate) chambers. The chambers should be emptied/checked at least as follows (but with an annual inspection and additional cleansing if required): On completion of drainage works, Year 1, Year 3, then every 5 years;
- Also ensure that safe access and egress is maintained throughout the lifetime.

6.2.7. Flood Resilience Measures

6.2.7.1. Design Measures

Paragraph 004 of Planning Practice Guidance (PPG) states that:

"*Within sites, using site layout to locate the most vulnerable aspects of development in areas of lowest flood risk, unless there are overriding reasons to prefer a different location. In addition, measures to avoid flood risk vertically can then be taken, by locating the most vulnerable uses on upper storeys, and by raising finished floor and/or ground levels, where appropriate and that such techniques are suitably designed*".

In line with the recommendations of PPG, Thatch Cottage is, and the new dwellings are, to be located on the highest areas of the site along its northern half (although ground levels rise above this along the southern boundary they do not provide any room for development).

Given the listed nature of Thatch Cottage, and the limitations of making significant structural alterations or using modern materials or additions, it is not deemed possible to either raise the ground floor level or achieve a flood exclusion strategy for the building, for the 1 in 30-year +40% CC, 1 in 100-year, 1 in 100-year +45% CC and 1 in 1000-year scenarios. Nevertheless, the first floor will be well above any predicted flood levels. Consequently, sleeping accommodation will be confined to the first floor and this will also provide a safe refuge above flood events, if evacuation is not possible or occupants are advised to stay where they are by the emergency services.

The renovation of the cottage, therefore, will need to be conducted sympathetically, with a flood entry strategy in mind, using fittings and systems designed to minimise flood damage and clean up time when it occurs. These could include, but are not limited the following measures (in line with the UK Government's "*Improving the Flood Performance of New Buildings: Flood Resilient Construction*" guidance[xxviii]):

- Use of building materials, within the constraints of the listing, that are effective for resisting water ingress;
- All effort should be made to ensure a good fit and seal to door and window frames;
- Ground floor glazing, within the constraints of the listing, should aim to conform to the relevant standards to adequately resist the pressures generated by flood waters and debris carrying flows;
- If possible, within the constraints of the listing, place fittings (*e.g*. electrical appliances, gas oven) as high as practicable above the floor (*e.g*. on plinths) to minimise the risk of being affected by flood water;
- For any new pipework, there should be an aim to use closed cell insulation for pipes which are below the predicted flood level;
- Drainage services: if practical include non-return valves in the drainage system to prevent back-flow of diluted sewage in situations where there is an identified risk of the foul sewer surcharging;

- Maintenance of these valves is important to ensure their continued effectiveness;
- If possible, place water, electricity and gas meters above predicted flood level;
- Electrical services: electrical sockets should be installed above flood level for ground floors to minimise damage to electrical services and allow speedy re-occupation;
- Electric ring mains should be installed at first floor level with drops to ground floor sockets and switches;
- Heating systems: boiler units and ancillary devices should be installed above predicted flood level and preferably on the first floors;
- Underfloor heating: should be avoided on the ground floor and controls such as thermostats should be placed above flood level;
- Communications wiring: wiring for telephone, TV, Internet and other services should be protected by suitable insulation in the distribution ducts to prevent damage;
- Any proposed design solution for flood insulation on all potentially vulnerable wiring should be discussed with the relevant service providers; and
- Floor surfaces and fittings should be water resistant where possible and easily washable – the use of carpets on the ground floor should be minimised.

With regard to the 2 x new dwellings, the modelling demonstrates that a flood exclusion strategy can be maintained for all modelled scenarios. Maximum flood levels on the new build facades is predicted to reach a depth of 0.87 m during the 1 in 1000-year event, which equate to a reduced level of 11.49 mAOD. Current ground levels in the vicinity of the new builds range from 10.57 to 10.65 mAOD, averaging 10.61 mAOD. Consequently by setting the ground floor Finished Floor Level (FFL) to 10.89 mAOD (*i.e*. 0.28 m above mean ground level), no more than 0.6 m of flooding will be experienced above the floor level, even during the 1 in 1000-year event.

As with Thatch Cottage, the first floors of the new dwellings will be well above any predicted flood levels. All sleeping accommodation will be confined to the first floors, which will also provide a safe refuge above flood events, if evacuation is not possible or occupants are advised to stay where they are by the emergency services.

The following measures will ensure a water exclusion strategy can be maintained for the 2 x new residential dwellings:

- Setting the ground floor FFL at 10.89 mAOD;
- Inclusion of the flood resilience measures listed for Thatch Cottage above;
- In addition, use building materials that are effective for resisting water ingress, including engineering bricks, cement-based materials, including water retaining concrete and dense stone;
- Sealed PVC external framed doors and windows should be used;

- Use of demountable barriers on all external door frames should be considered; and
- No air bricks should be included within the floor slab construction.

6.2.7.2. Flood Warnings

The EA is responsible for issuing flood warnings to the public based on meteorological reports and forecasts, including the use of radar to track storms and rainfall intensity, and data from the national tide gauge network.

The EA operates a 24-hour telephone service on 0345 988 1188 (Floodline), which includes direct operator advice & frequently updated flood warning information. However, this information primarily relates to flooding from rivers, the sea and groundwater. However, real-time monitoring of the level of the Ferring Rife at Ferring Outfall is presented at **https://check-for-flooding.service.gov.uk/river-and-sea-levels/worthing-west-sussex**. The monitoring station lies *circa* 3.5 km to the south west of the site and receives flow from the catchment in which it is located. The online service provides information on the watercourse height, whether the levels are rising or falling and the potential for flooding in the catchment. As such, this information, in combination with local weather forecasting for Worthing (*e.g.* from the Met Office site at https://weather.metoffice.gov.uk) provides a useful indicator of the risk of pluvial related flooding in the area.

It is also recommended to keep updated on local flooding conditions and council alerts at the Adur & Worthing Councils "Flooding and heavy rain" at **https://www.adur-worthing.gov.uk/preparing-for-emergencies/flooding-and-heavy-rain/** which provides useful information on local flooding and directs users to council service updates on "A&W on Facebook" and "A&W on X".

It is intended that a site-specific Flood Warning and Evacuation Plan (FWEP) will be developed for the occupants of the site, in liaison with Adur and Worthing Councils Emergency Preparedness Team and secured by a suitable Planning Condition.

6.2.7.3. Safe Access & Egress

The NPPF states that safe access and escape routes for emergency services to and from the development during a flood event should be identified, where required.

Given that the site lies wholly within the 1 in 30-year flood extent, it is not considered that guaranteed dry ingress and egress routes could be provided during storm conditions.

With reference to Figure 6-4, if safe to do so, or instructed to evacuate by the emergency services, occupants of Thatch Cottage and the two new dwellings would exit onto Pond Lane and head westwards, taking the first turning on the right. This takes people up a tarmac surface road to a car park, sports pavilion and the Durrington Recreation Ground beyond, above the surface water flooding, within *circa* 55 m of the new dwellings access and *circa* 85 m of the Thatch Cottage access onto Pond Lane.

If evacuation is not deemed possible and/or if the residents have been instructed to stay within the premises by the emergency services, then "invacuation" to the first floor via the stairs of the dwellings will be advised, with all first floors providing safe refuge well above the predicted surface water flood levels

Figure 6-4 Evacuation route from the site

Multi-agency plans activated at the time of the event may include the provision of public transport to aid rapid evacuation. Attention must be given to advice provided by the emergency services at the time of the incident.

6.2.8. Pollution Minimisation during Construction

Minimisation of pollution events during the construction phase will be ensured by the adequate maintenance of vehicles, the responsible handling and storage of potentially polluting materials and liquids, and suitable training of staff.

In order to reduce the impact of accidental spillages (*e.g*. from plant fuel) during construction, appropriate planning will identify such risks and the precautionary measures to be taken such as:

- Spillage response kits;
- Seals to drains;
- Bunding of high-risk areas; and,
- Training of staff in emergency procedures.

Furthermore, the Control of Pollution (Oil Storage) (England) Regulations 2001 (together with the EA's former Pollution Prevention Guidelines 2 [PPG2]) will be complied with. The Regulations cover the storage of oil of any kind, including petrol, mineral oil, heating oil, lubricating oil, vegetable oil, heavy oils such as bitumen, and oils used as solvents, such as paraffin or kerosene. The Regulations stipulate the strength, integrity, and delivery systems of oil containers and prescribe secondary containment systems such as drip trays or bunds, which will ensure that the likelihood of oil spillages is minimised.

7. Sequential Test & Exception Test

7.1. Policy

The need to carry out a Sequential Test for flood risk is prescribed in the NPPF. It advises that a Sequential Test must be applied at all stages of the planning process to ensure that any new development is steered to areas with the lowest probability of flooding.

With regard to the application of the Sequential Test, the restoration of the fire-damaged Thatch Cottage will only be possible if funded by the construction of the two additional dwellings on land within the same ownership as the cottage. Consequently, when applying the NPPF flood risk Sequential Test, no other "*reasonably alternative*" sites can be considered, as no other site could feasibly accommodate the Thatch Cottage listed building, or the new dwellings required to fund its renovation on land in the same ownership as the cottage itself. As such, the Sequential Test is passed and only the Exception needs further consideration.

Furthermore, para. 027 of PPG states that:

"*In applying paragraph 175 a proportionate approach should be taken. Where a site-specific flood risk assessment demonstrates clearly that the proposed layout, design, and mitigation measures would ensure that occupiers and users would remain safe from current and future surface water flood risk for the lifetime of the development (therefore addressing the risks identified e.g. by Environment Agency flood risk mapping), without increasing flood risk elsewhere, then the sequential test need not be applied*."

This FRA demonstrates that:

a) Flood risk from the site only comprises current and future surface water flood risk;

b) With the adoption of the proposed layout, design, and mitigation measures presented in this document, occupiers of the site will remain safe from the current and future surface water flood risk;

c) The proposals do not result in an increase in flood risk elsewhere.

As such, there is no requirement for the scheme to pass either the Sequential Test or the Exception Test. Nevertheless, given the nature of the surface water flooding, as a precautionary measure, the Exception Test has also been applied to the scheme.

7.2. Exception Test

The NPPF (paragraphs 178 and 179), states that for the Exception Test to be passed it should be demonstrated that:

a) the development would provide wider sustainability benefits to the community that outweigh the flood risk; and

b) the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Both elements of the Exception Test should be satisfied for development to be allocated or permitted.

7.2.1. Test A: Wider Sustainability Benefits to the Community

With regard to the community benefit, Thatch Cottage was severely damaged by fire on 1st February 2023 suffering complete loss of the roof and first floor building fabric and further damage by water throughout. The owner's insurance company has declined a claim to repair, citing their reasons as a lack of reasonable care and that the clauses relating to chimney condition had been breached. The owner has no financial means of funding their legal requirement to repair the cottage, nor their desire to rebuild and move back into their home.

The building has remained in a state of ruin since the fire and the site has become completely overgrown, vandalised and used for fly tipping. The building fabric has suffered progressive serious deterioration during more than 2 years since the incident and this continues without an urgent financing solution. Manorwood, a small team of historic building professionals, has been engaged to assess the minimum development feasible on the site that balances the acknowledged harm of the development on the building and its setting.

The proposal is for the division of the site and the construction of two modest dwellings for private sale. Under Manorwood's advice, the two new houses have been designed to blend with the local building character of historic Durrington Farmhouse opposite, in a similar way to the recent development of nos. 7 & 9 a little further to the west. These will be set back from the existing front boundary wall, respecting the building line of Thatch Cottage.

The scheme, as proposed, would generate funds through the development of the site, to reinstate the house and return it to its optimum viable use. Consequently, there will be tangible public benefit through the provision of providing sufficient funds for the repair/restoration works, so securing the building's future. These aims are part of the broader effort to safeguard the historic environment and ensure that the physical evidence of our past is preserved for future generations.

Furthermore, the poor quality of land in its current state detracts from the visual amenity of the area and makes little contribution economically or to the vitality of the borough. Consequently, the proposals have the potential to visually improve the overall aesthetic qualities of the area.

The Site is in a neighbourhood with good amenities and good public transport links to Worthing Town Centre. As such, the proposed development will help with generating additional income to the local economy and will provide significant sustainability benefits, which represent a positive opportunity for the Borough over the "do nothing" option.

The Scheme will make a valuable contribution to the Council's housing requirements, which is a significant material consideration, that weighs heavily in favour of the proposed development. The NPPF now requires that local planning authorities meet their full need for both market and affordable housing as far as is consistent with other policies in the Framework. With limited opportunities for other unidentified 'windfall' sites to emerge during the plan period, smaller sites such as this can provide an important contribution, particularly in central locations, where access to public transport and services provides an opportunity for sustainable development. The Site, therefore, provides redevelopment and revitalisation, in accordance with the objectives and policies of the Core Strategy.

Consequently, small sites such as the Thatch Cottage site, will play a greater role in meeting housing delivery as stated in the Test Action Plan. As such, the provision of three much needed dwellings in a highly sustainable location would make a valuable contribution to local housing needs.

Test (a) of the Exception Test is therefore passed.

7.2.2. Test B: Flood Risk

With regard to Test (b) of the Exception Test, the flood resilience measures described in Section 6.2.7.1 above will be included in the restoration of Thatch Cottage and the design of the new buildings. This FRA also demonstrates that safe access and egress will be provided to an area of continuous land beyond the surface water flood extents (refer to Section 6.2.7.3).

Test (b) also requires that flood risk is not increased elsewhere. Furthermore NPPF states that:

"*Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere*",

whilst paragraph 003 of Planning Policy Guidance (PPG) states that:

"*Measures to avoid, control, manage and mitigate flood risk should also not increase flood risk elsewhere*."

The DEFRA/EA Guidance Document "*Flood and Coastal Defence R&D Programme, Flood Risks to People*"[i], defines flood risk as:

"*probability multiplied by consequences. For flood risks to people, probability is associated with the return period of flood events. This may be a combined probability when the flood event is due to a combination of high water levels and the failure of a flood defence system. The consequences are serious harm or fatality during or within the week following a flood event*."

Within the above Guidance Document, flood risk to people is defined as:

Flood risk to people = (Flood Hazard + Area Vulnerability + People Vulnerability) x Number of people at risk

Flood Hazard describes the flood conditions in which people are likely to be swept over or drown in a flood, and is a combination of flood depth, velocity and the presence of debris. The results are classified in hazard classes. A Flood Hazard map shows the location of different classes of flood hazard on a map of areas prone to flooding.

Area Vulnerability describes the characteristics of an area of the floodplain that affect the chance of being exposed to the flood hazard. People are more vulnerable in areas of low rise, single-storey buildings, campsites and open floodplain areas than in areas of two-storey or high-rise buildings that can provide “safe refuge” above the maximum flood level.

People Vulnerability describes the characteristics of the people affected by flooding and their ability to respond to ensure their own safety and that of their dependants during a flood.

With reference to the outputs of detailed TUFLOW modelling, described above and presented in **Appendix B,** they demonstrate small increases in flood levels beyond the site boundary as a result of the construction of the new dwellings:

- During the 1 in 30 -year event a rise beyond the site boundary of no more than 10 mm is predicted on a small stretch of Pond Lane directly opposite Thatch Cottage;
- During the 1 in 100-year event, backwater effects are observed resulting in increases of no more than 10 mm eastwards to beyond the site boundary and northwards to the drive of Durrington Farmhouse, again resulting in an increase in flood dept of no more than 10 mm;
- During the 1 in 30-year + 40% event, these backwater effects extend eastwards to Durrington Lane and southeastwards to the junction of Greenland Road with Durrington Lane. However, any flood depth increase is no more than 10 mm;
- During the 1 in 100-year + 45% CC event, backwater effects increase, with areas of up to 15 mm flooding increase in flooding evident northwards towards Spring House and southwards towards 11 and 12 Birkdale Close. A small area of up to 10 mm increase in flooding is observed west of the new builds, in the vicinity of the garage to 7 and 9 Pond Lane.
- During the 1 in 100-year event, backwater effects are predicted to result in a rise in flood depths eastwards within the 15 to 25 mm range and westwards within the 10 to 15 mm range.

Nevertheless, Flood Hazard map outputs from the modelling, as per the DEFRA/EA Guidance Document “*Flood and Coastal Defence R&D Programme, Flood Risks to People*”[l], and presented in **Appendix C**, do not show any significant increases in Flood Hazard beyond the site boundary and no increases in the Flood Hazard classification for any other dwelling or property (refer to Figure 7-1 below for comparison between pre- and post-development Flood Map Hazard outputs for the 1 in 100-year +45% CC event).

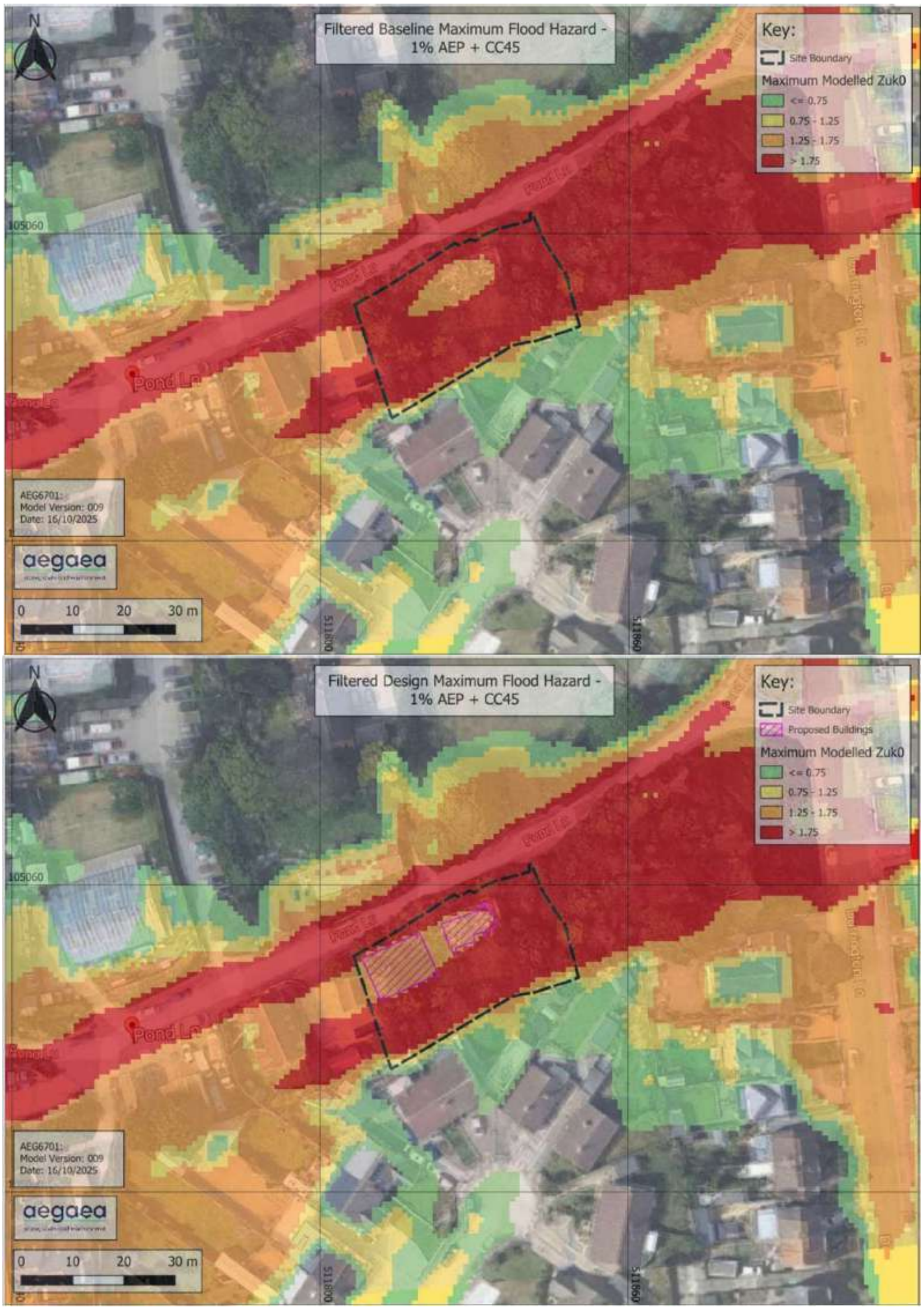


Figure 7-1 Comparison of pre- and post-development TUFLOW detailed Flood Hazard mapping outputs illustrating no significant changes in Hazard classification

As there will be no changes in area vulnerability, people vulnerability or the number of people at risk beyond the site boundary, then there will be no increase in flood risk at any other dwelling or property either.

As such, the modelling confirms that there will not be any increase in flood risk elsewhere, and therefore, Test (b) of the Exception Test is also passed.

7.3. Conclusion

With reference to PPG, there is no requirement for the scheme to pass either the Sequential Test or the Exception Test. Nevertheless, the Sequential Test is satisfied because:

- Restoration of Thatch Cottage is only viable if funded by the two new dwellings on the same site.
- No alternative sites can accommodate this requirement.

The Exception Test is passed because:

- Community benefits: the scheme restores a historic building, improves visual amenity, and contributes to housing supply.
- Safety: This FRA demonstrates occupiers remain safe for the development’s lifetime, with refuge on upper floors and safe egress routes to higher ground within 85 m.
- No increased flood risk elsewhere: TUFLOW modelling shows negligible off-site impacts (max depth increase 10–25 mm), with no significant change in hazard classification or risk beyond the site boundary.

8. Summary & Conclusion

Hilson Moran has been commissioned by Drew Bailey (the 'Client') to undertake a FRA and Drainage Strategy for the proposed development at Thatch Cottage, Pond Lane, Worthing, BN13 2RH. This document constitutes a formal NPPF compliant FRA, Drainage Strategy, Sequential Test and Exception Test, appropriate to the scale and nature of the development and risk involved.

The proposed development is approximately 0.1 ha in size, and is located within a residential area in Durrington, a suburb to the north west of Worthing Town Centre. The site comprises a fire-damaged Listed building and surrounding, overgrown soft landscaping. Because of the existing building within the site, this development is classified as brownfield. Directly adjacent to the north of the site is Pond Lane, with residential buildings and Pond Lane Recreation Ground beyond. To the east of the site is overgrown greenfield land, and to the south and west are residential properties.

The development proposals are for the restoration of the existing fire-damaged Listed building, the erection of 2 no. semi-detached dwellings to the west side of the existing property, and provision of cycle storage and car parking via existing access on land to the east of the existing property.

This FRA and SuDS Strategy demonstrates that:

- The site is at low fluvial risk but high surface water risk, mitigated through design and resilience measures.
- The proposed development is safe for its lifetime, without increasing flood risk elsewhere.
- The drainage strategy complies with DEFRA 2025 SuDS standards, within the constraints of the nature of the site and the listed building status of Thatch Cottage, to provide betterment compared to the existing situation.
- The development delivers significant heritage and housing benefits, justifying approval under NPPF.

Overall, the principle of development is acceptable on flood risk grounds, subject to the implementation of recommended mitigation and drainage measures.

Appendix A Hydraulic Model Report



Hydraulic Model Report

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AEG6071_BN13_Worthing_03

Site Address:
Thatch Cottage
Pond Lane
Worthing
BN13 2RH

UK Experts in Flood Modelling, Flood Risk Assessments, and Surface Water Drainage Strategies

Document Issue Record

Project: Pluvial Hydraulic Modelling Study

Prepared for: Hilson Moran

Reference: AEG6071_BN13_Worthing_Model_Report

Site Location: Thatch Cottage, Pond Lane, Worthing, BN13 2RH

Version	Date	Author	Check	Auth.	Comments
001	28/04/2025	Rebecca Thirkell	CP	CCH	First issue

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Table of Contents

1. Introduction

Scope of Study

1.1. Aegaea have been commissioned by Hilson Moran to undertake a pluvial hydraulic modelling exercise at Thatch Cottage, Pond Lane, Worthing, BN13 2RH. The aim of this study is to ascertain the on-site surface water flood risk under existing conditions.

1.2. This report provides an overview of the hydrology and hydraulic modelling methodology applied, as well as a summary of the modelling results, including sensitivity testing of key model parameters.

Site Overview

1.3. The study area is located at Thatch Cottage, Pond Lane, Worthing, BN13 2RH (hereafter referred to as the 'Site') and covers approximately 730 m^2.

1.4. The Site is located within the urban area of Worthing with Durrington Lane to the east and Pond Lane to the north. The site is currently comprised of scrubland with urban residential land to the south and west. A site location plan is presented in Figure 1.

1.5. No formal watercourses are known to exist within the Site or upslope catchment. The nearest formal watercourse is the Ferring Rife, situated approximately 0.75 km southwest of the Site.

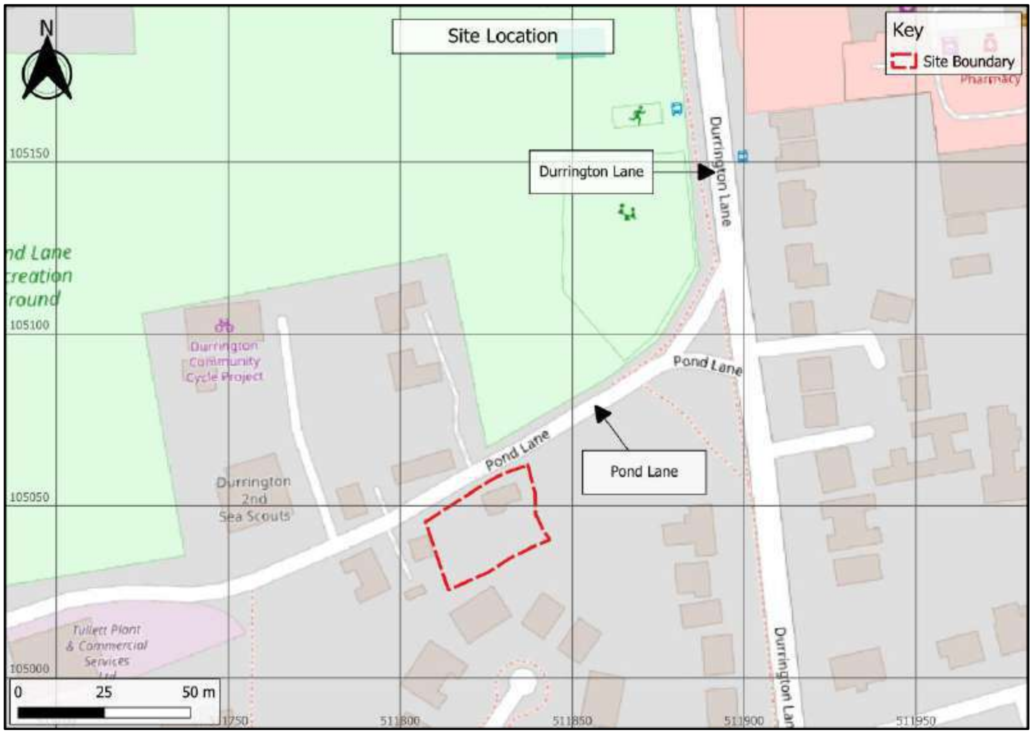

Figure 1: Site Location Plan (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence 100024198).

Aims and Objectives

1.6. The aim of this exercise is to establish a good hydraulic representation of the pluvial flooding mechanisms and magnitude of storm events within the study area for the existing (baseline) conditions.

1.7. To achieve this aim, the following objectives have been identified:

- Construct a baseline two-dimensional (2D) TUFLOW model representing the existing conditions within the Site and upstream catchment.
- Undertake a hydrological assessment, including catchment delineation and generation of a Depth Duration Frequency (DDF) rainfall dataset for the catchment.
- Simulate rainfall events to establish a set of baseline conditions, including climate change allowances.
- Simulate sensitivity scenarios to test key model parameters and any pertaining modelling assumptions.

2. Available Data

Terrain Data

2.1. The Environment Agency's (EA) Light Detection and Ranging (LiDAR) elevation dataset is available for the model extent (Figure 2). This is in the format of a Digital Terrain Model (DTM) at 1m-horizontal resolution. The dataset is provided as part of Environment Agency's National LiDAR Programme LiDAR and was captured in 2022.

2.2. Elevations within the model slope from north to south ranging from 120m AOD at the northern extent of the catchment and 10m AOD in the southern extent of the catchment.

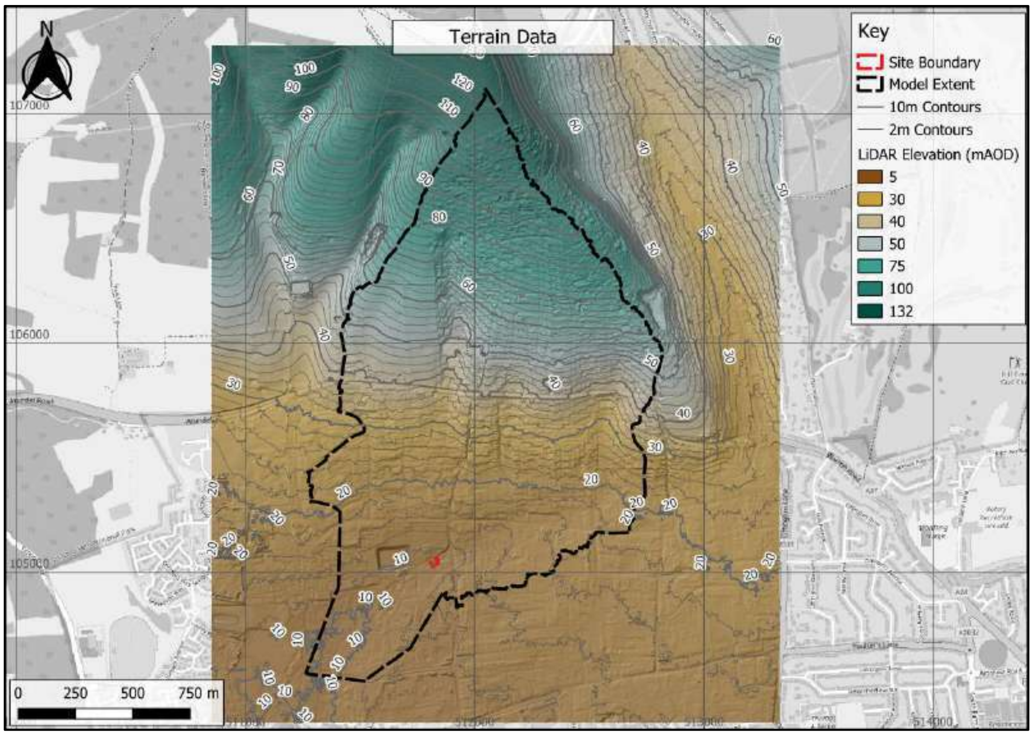

Figure 2: EA 1m resolution LiDAR (Data Source: Environment Agency National LiDAR Programme, Environment Agency © Crown Copyright and database rights 2022. All rights reserved.)

2.3. Elevations within the Site and immediate surrounding area are shown on Figure 3. Elevations fall from north to south until the junction between Durrington Lane and Pond Lane. At this point in the catchment land then falls from east to west through the Site before then falling to the south west.

2.4. On-site elevations range between 10.6m AOD on the northern boundary of the Site to 9.8m AOD in a depression located in the south west of the Site (Figure 3).

2.5. A large depression is located to the west of the site at Pond Lane Recreation Ground. A review of sewer maps for this area suggests there is an outlet from this depression into a surface water sewer 1350mm in diameter.

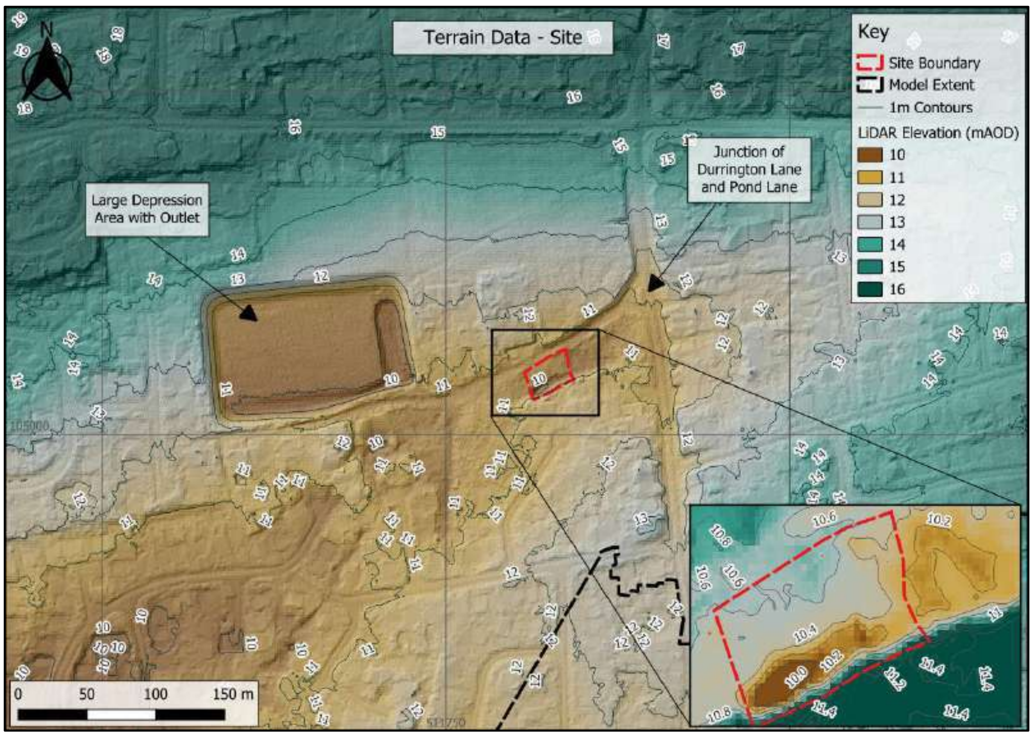

Figure 3: EA 1m resolution LiDAR for Site area (Data Source: Environment Agency National LiDAR Programme, Environment Agency © Crown Copyright and database rights 2022. All rights reserved.)

Roughness Data

2.6. The model roughness values have been determined by assessing OS open data and aerial imagery to infer the land use class. Chow (1959) was utilised as a method by which to assign values.

2.7. A list of Manning's roughness coefficients adopted for this hydraulic modelling study are presented in Table 1. The roughness values have been spatially varied in the hydraulic model using OS open data and checked against aerial imagery.

Table 1: Manning's roughness coefficients

Land use description	Manning's roughness (*n*)
Natural surface (General Greenfield Land)	0.040
Manmade Surface (Concrete/Paved)	0.030
Roads (Main Asphalt)	0.020
Dense Vegetation (Trees and Woodlands)	0.090
Buildings	0.300

Risk of Flooding from Surface Water

2.8. The following section outlines the Environment Agency's Risk of Flooding from Surface Water (RoFSW) 2025 dataset and its relevance to the Site. RoFSW provides an overview of pluvial risk and can be used to compare expected flood extents.

2.9. The Site is located within all RoFSW risk categories, as defined by the Environment Agency's RoFSW map (see Figure 4):

- **High Risk**: Areas with a greater than 3.3% chance of flooding each year (1 in 30-year event).
- **Medium Risk**: Areas with between a 1% and 3.3% chance of flooding each year (1 in 100 to 1 in 30-year event).
- **Low Risk**: Areas with between a 0.1% and 1% chance of flooding each year (1 in 1,000 to 1 in 100-year event).

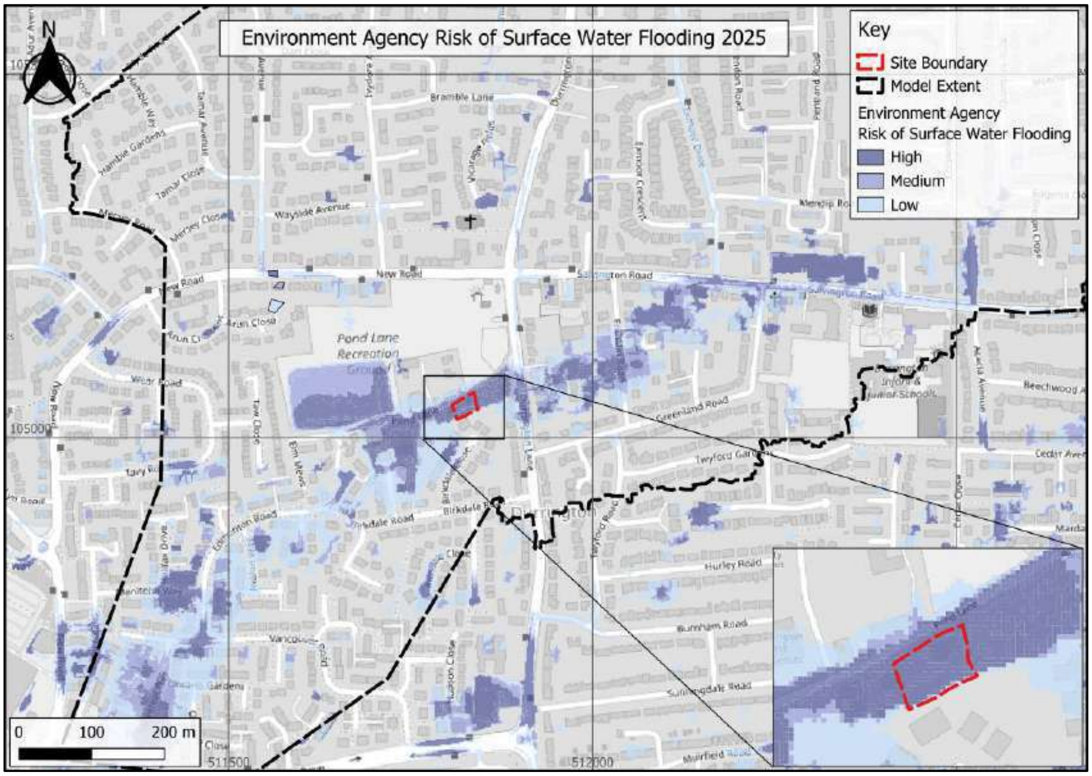

Figure 4: Risk of Flooding from Surface Water (Data source: Environment Agency © Crown Copyright and database rights 2022. All rights reserved. Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

2.10. The Site is shown to be almost fully within High Risk for surface water flooding (Figure 4). The main flow pathway within the catchment is shown to flow from east to east across Durrington Lane through the site and along Pond Lane before flowing southwest. This correlates well with the topography of the catchment defined above.

2.11. While the RoFSW dataset is useful for assessing risk at a national scale, site-specific TUFLOW pluvial modelling, with its high-resolution terrain and detailed data, offers more accurate and reliable results. Therefore site-specific pluvial hydraulic modelling has been undertaken to confirm pluvial flood risk to the Site.

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3. Hydrological Assessment

Catchment Delineation

3.1. A hydrological assessment has been undertaken, following the latest Environment Agency Flood Estimation Guidance, to establish rainfall depths at key return periods and storm durations.

3.2. The FEH catchment extent was defined at location 511300, 104550 with an area of 2.19 km². The catchment area and catchment descriptors were obtained from the FEH Web Service Website[1]. The key catchment descriptors are shown in Table 2.

Table 2: FEH Catchment Descriptors

Area (km²)	ALTBAR (mAOD)	FARL	DPLBAR	BFIHOST19	SAAR 6190	URBEXT $_{2000}$
2.19	36	1	1.49	0.855	781	0.4326

3.3. To verify the FEH catchment extent a catchment delineation was undertaken within SCALGO[2] using Environment Agency LiDAR. This check was undertaken as the hydrological catchments available through the Flood Estimation Handbook (FEH Web Service) are known to have limitations in their underlying elevation dataset.

3.4. The LiDAR catchment identified a catchment area of 2.65 km². A comparison between the FEH catchment area and the LiDAR catchment delineation revealed an upstream area to the east missing from the FEH catchment. The two catchment extents are presented on Figure 5.

3.5. To ensure a precautionary estimation of rainfall in the model, and full representation of the upstream catchment, the LiDAR catchment area was selected for use within the study.

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[1] **FEHWeb Database – UK Centre of Ecology and Hydrology https://fehweb.ceh.ac.uk/GB/map**

[2] **SCALGO - https://scalgo.com/**

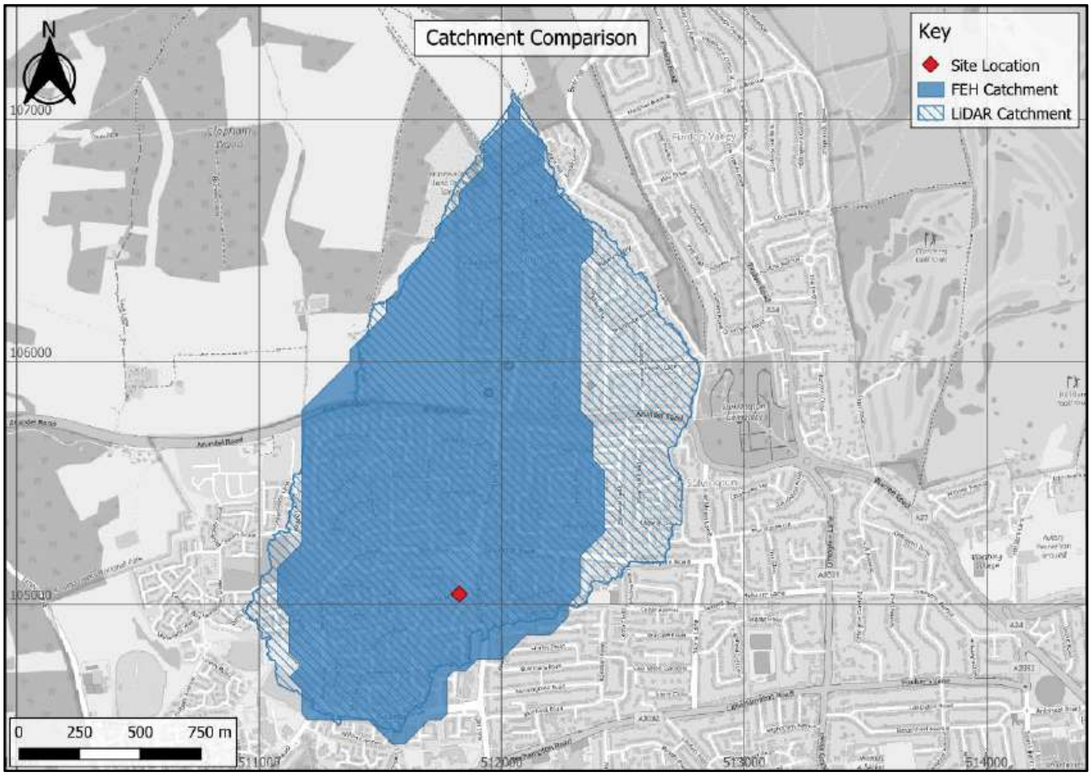

Figure 5: Hydrological Catchment Comparison (Data Source: Environment Agency National LiDAR Programme, Environment Agency © Crown Copyright and database rights 2022. All rights reserved. Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

3.6. Following the change to the catchment area, key catchment descriptors were reviewed against the revised extent. FARL, DPLBAR, BFIHOST19 and SAAR were considered appropriate. No storage areas are shown within the new catchment extent and no change to types of soils or geology were observed. The final catchment characteristics used within the hydrology study are shown in Table 3. The purpose of the hydrology study is to calculate design rainfall hyetographs therefore no adjustment was made to URBEXT as all losses are accounted for within the hydraulic model itself.

Table 3: Final Catchment Descriptors

Area (km^2)	ALTBAR (mAOD)	FARL	DPLBAR	BFIHOST19	SAAR 6190	$URBEXT_{2000}$
2.65	36	1	1.49	0.855	781	0.4326

Climate Change (CC)

3.7. To enable future flood risk to be modelled climate change was applied directly to rainfall within ReFH2.3.

3.8. The Site is located within the 'Arun and Western Streams Management Catchment' for peak rainfall climate change allowances.

3.9. In line with the Environment Agency guidance "Flood risk assessments: climate change allowances" (updated in May 2022), Flood Risk Assessments for developments with a lifetime beyond 2100 should assess the upper end allowance for the 2070s epoch. The allowance should be assessed for both the 1 in 30 year and 1 in 100 year annual exceedance probability events.

3.10. The upper-end allowance for the 2070s epoch was assessed in this study, as the proposals are understood to involve residential uses, which the Environment Agency considers having a lifespan of greater than 100 years.

3.11. Within the 'Arun and Western Streams Management Catchment', the following climate change allowances are set:

- 1 in 30 year 2070s epoch – the upper end allowance is 40%.
- 1 in 100 year 2070s epoch – the upper end allowance is 45%.

Design Rainfall Estimation

3.12. ReFH2.3 was used to estimate the total depth storm profiles, which is an industry standard software to estimate rainfall patterns. Design rainfall estimation was based on catchment descriptors presented in Table 3.

3.13. For this study, the design rainfall was applied to the model, with losses modelled via Green-Ampt or via continuous sewer losses where applicable modelled in TUFLOW.

3.14. The Revitalised Flood Hydrograph (ReFH) method generates total design rainfall depth profiles for a given frequency event i.e. depth duration frequency. The seasonal correction factor and areal reduction factor are both applied to the rainfall DDF to adjust the respective depths.

3.15. Rainfall hyetographs have been generated for the 1 in 30 year, 1 in 30 year plus climate change uplift, 1 in 100 year, 1 in 100 year plus climate change uplift and 1 in 1000 year annual exceedance probability events.

3.16. The summer profile for design events with 1, 3, 6 and 9 hour storm durations were used to generate the rainfall DDF datasets in accordance with the Environment Agency's user guidance 'Improving Surface Water Flooding Mapping'[3].

3.17. The critical storm duration was assessed based on the modelled flood extents and depths across the Site for the 1hr, 3hr, 6hr and 9hr duration storms for the 1 in 100 year + climate change storm. The storm with the largest extent and highest depths was found to be the 1hr. The conclusions hereafter discussed are for the 1hr storm duration, unless stated otherwise. The comparison between flood extents for the 1hr, 3hr, 6hr and 9hr storm events is shown in Figure 6.

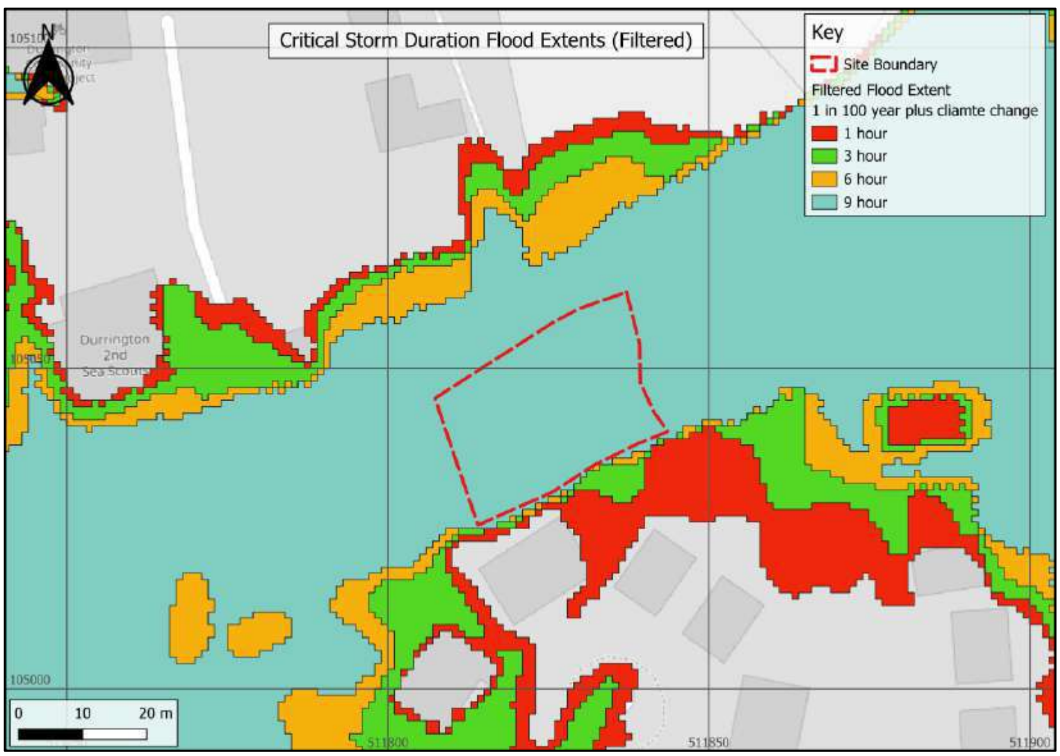

Figure 6: Modelled flood extents for the 1hr, 3hr, 6hr and 9hr duration for the 1 in 100 year + climate change storm event (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

[3] **https://assets.publishing.service.gov.uk/media/6036611ee90e0740b50cac5a/Improving_surface_water_flood_mapping_-_estimating_local_drainage_rates_-_user_guidance.pdf**

3.18. The estimated design rainfall depths for each return period at each storm duration are presented in Table 4 below while peak rainfall intensity for each storm is presented in Table 5.

Table 4: Total design rainfall depth (5-min), summer profile.

Storm Event	Total Design Rainfall (mm) 5-min timestep			
	1-hour	3-hour	6-hour	9-hour
1 in 30 year	34.78	47.36	55.80	60.41
1 in 30 year +40%	48.69	66.31	78.12	84.58
1 in 100 year	44.37	58.88	69.18	75.10
1 in 100 year +45%	64.33	85.38	100.31	108.90
1 in 1000 year	65.79	86.26	103.82	114.22

Table 5: Peak design rainfall intensity (5-min), summer profile.

Storm Event	Peak Rainfall Intensity (mm) 5-min timestep			
	1-hour	3-hour	6-hour	9-hour
1 in 30 year	9.57	6.01	3.83	2.78
1 in 30 year +40%	13.40	8.42	5.37	3.90
1 in 100 year	12.21	7.48	4.75	3.46
1 in 100 year +45%	17.71	10.84	6.89	5.02
1 in 1000 year	17.94	10.95	7.13	5.26

4. Hydraulic Model Build

Baseline Model Build

4.1. A 2D modelling approach was adopted using TUFLOW Heavily Parallelised Compute (HPC) (version 2025.0.2-iSP-w64). The model follows the national-scale approach outlined in the 'What is the Risk of Flooding from Surface Water map?' RoFSW guidance, prepared by the Environment Agency[4] with site specific data applied.

4.2. The 2D TUFLOW baseline hydraulic model schematic is presented in Figure 7 below.

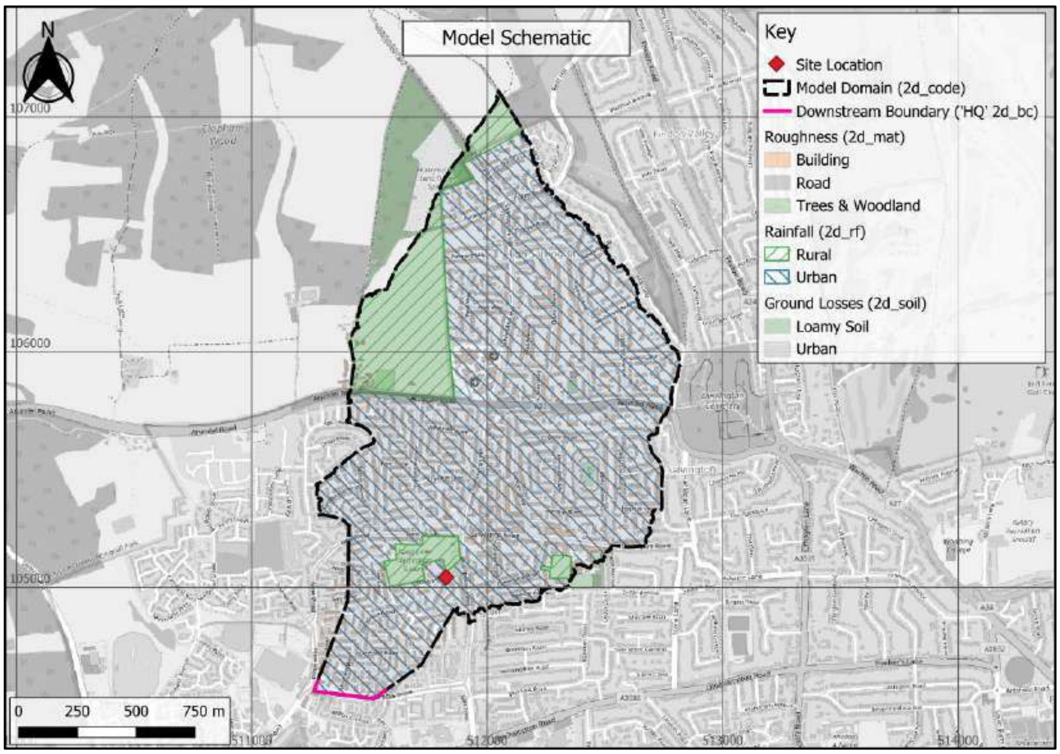

Figure 7: 2D Model Schematic (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

[4] **https://assets.publishing.service.gov.uk/media/5db6ded540f0b6379a7acbb8/What-is-the-Risk-of-Flooding-from-Surface-Water-Map.pdf**

4.3. A 2m resolution grid was adopted for the TUFLOW 2D domain which is considered suitable for an urban catchment.

4.4. Sub-Grid Sampling was adopted to capture for micro topographic features down to a sampling distance of 1m (horizontal resolution of ground model), ensuring small-scale variations in elevation were accounted for in the hydraulic computations. This approach allows for improved representation of flow paths and optimises model accuracy.

4.5. A single hydraulic structure was identified within the model domain. This is a pipe inlet located to the north west of the Site in Pond Lane Recreation Ground. Sewer maps do not provide dimensions for the inlet to the surface water sewer therefore these have been based on aerial imagery. The inlet has been modelled as a Virtual Pit Inlet (VPI) with the opening assumed to be 50% blocked from a trash screen. VPI curves for the structure were calculated based on the discharge per m^2 of grate area curves provided in the TUFLOW guidance for a 50% blocked structure.

4.6. Buildings in the wider catchment were modelled with a 300 mm threshold, following the 'stubby buildings' approach to align with the methodology used in the RoFSW dataset.

4.7. Road locations were reviewed within the ground model and lowered by the standard 0.125m to account for the presence of high kerbs along the road. The model was tested without roads being lowered. The results of this test found no impact on flood risk to the Site itself but changes in overland flow pathways elsewhere within the catchment. When these locations were reviewed solid kerbs were identified from Streetview, therefore these flow pathways were not considered real and lowered roads were taken forwards with the model.

4.8. No further changes were made to the geometry or TUFLOW control files.

4.9. Roughness values were applied to the model to reflect variations in land use and terrain across the model. These values were applied using a 2d_mat layer, where different land types were assigned roughness values via the .tmf file. The digitisation of the 2d_mat layer polygons was informed by OS MasterMap and aerial photography. Chow (1959) was utilised as a method for assigning roughness values, as discussed in Sections 2.6 and 2.7.

4.10. Losses to ground were represented directly within the model. The majority of the catchment is urban; therefore a global loss was initially applied using the Initial Loss / Continuing Loss (ILCL) approach was used to represent drainage system losses within the urban extent of the catchment. A standard 12mm/hr loss was applied to reflect the interception by surface water drains in accordance with Environment Agency's user guidance. The 'Improving Surface Water Flooding Mapping'[5] a 70% runoff coefficient was also applied to represent losses prior to interception in urban catchments.

4.11. Parkland/ open spaces within the catchment were then digitised with soil losses applied using the Green-Ampt (GA) method in TUFLOW through the application of a 2d_soil layer and .tsoilf file linked to the TUFLOW control file.

4.12. The losses due to infiltration in parkland and open areas of the catchment were defined based on soil classifications from the LandIS Soilscapes only database [6]. While a number of different soil classifications (class 5, 6 and 7) are shown to be located within the catchment boundary all are classified as freely draining with a loamy texture. Therefore, the GA classification of 8 was applied to all parkland or open spaces.

Boundary Conditions

4.13. The gross design rainfall was applied directly to the 2D domain (2d_code) using 2d_rf polygons to distribute the rainfall across the catchment. While the rainfall patterns were considered uniform across the catchment, the rainfall polygons were differentiated between urban and rural to account for the different types of losses i.e. 70% volumetric coefficient in urban areas.

4.14. An automated 'Head-Flow' (HQ) boundary was applied at the downstream extent of the model catchment. LiDAR was used to calculate the ground slope in the vicinity of this outflow boundary with a gradient of 0.0013 applied. This boundary was located perpendicular to flow within the catchment allowing water to leave the model, preventing artificial backing up.

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[5] https://assets.publishing.service.gov.uk/media/6036611ee90e0740b50cac5a/Improving_surface_water_flood_mapping_-_estimating_local_drainage_rates_-_user_guidance.pdf

[6] https://www.landis.org.uk/soilscapes/

Design Events

4.15. The model was simulated against the following key design flood events:

- 1 in 30-year return period
- 1 in 30-year return period plus 40% climate change uplift
- 1 in 100-year return period
- 1 in 100-year return period plus 45% climate change uplift
- 1 in 1000-year return period

5. Model Results

5.1. After comparison of all simulated storm durations, the 1h storm duration was found to have the most significant impact on the Site. Therefore, this section shows results for the 1h storm duration event.

5.2. To ensure consistency with the methodology used in the RoFSW dataset (Section 6.2 of the EA document: What is the Risk of Flooding from Surface Water map?), model results were filtered based on hazard classification and extent thresholds.

5.3. Unfiltered depth and velocity maps for the model study area are presented in Appendix A.

Flood Extents

5.4. The maximum modelled flood extents within the model are shown in Figure 8 below. The figure shows the model outputs for all events simulated. The hydraulic model outputs indicate that the Site is affected by surface water flooding for storm events as frequent as the 1 in 30 year event.

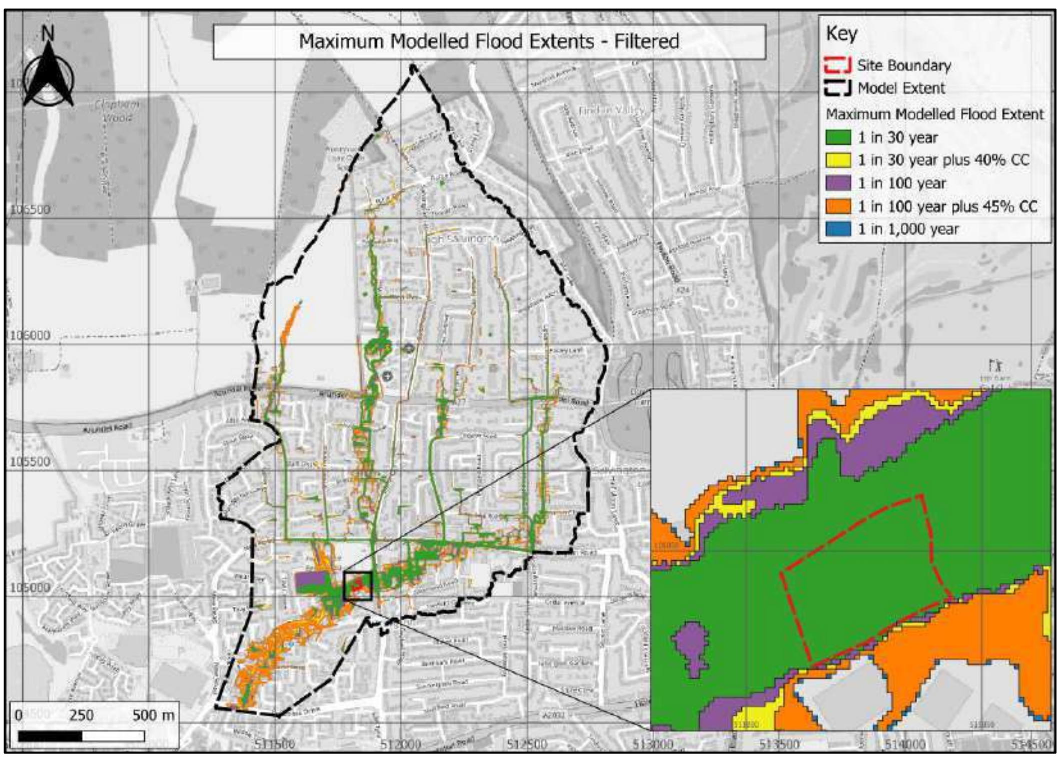
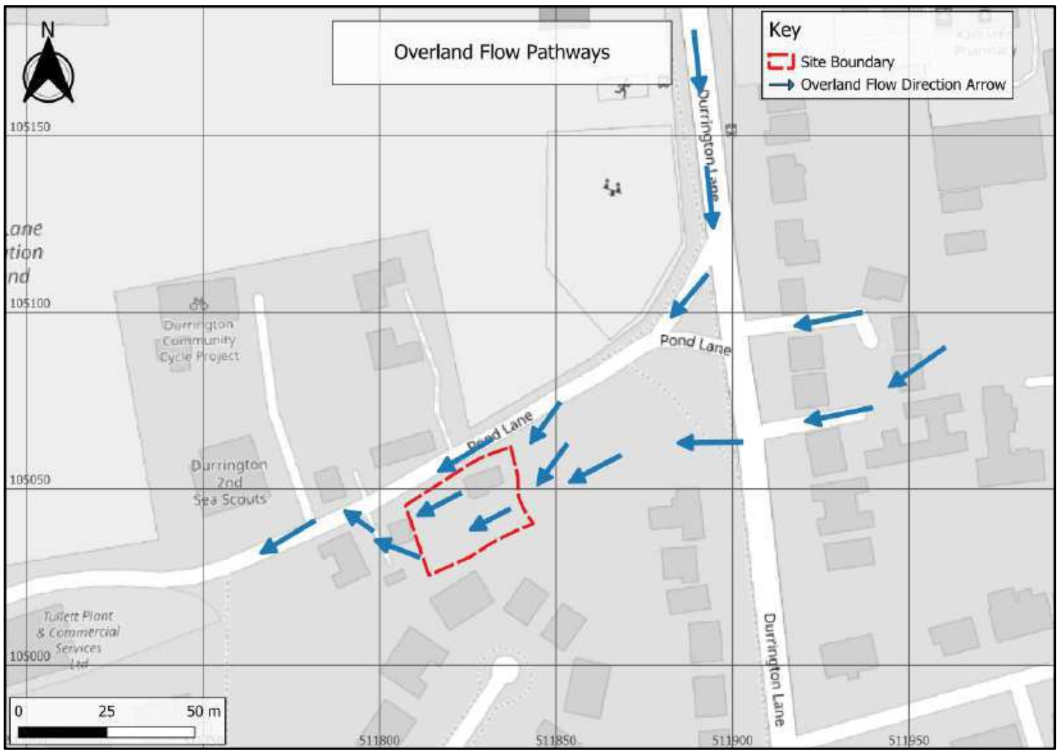


Figure 8: Maximum modelled flood extents - filtered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

5.5. Surface water within the modelled catchment was found to flow in a north to south direction following the general topographical slope identified in paragraph 2.2. Surface water flow pathways within close proximity to the Site were found to flow south down Durrington Lane to the northeast of the site before joining flow from the east and travelling towards the Site and flowing south west. The surface flow pathway within close proximity to the Site is depicted on Figure 9.

Figure 9: Overland flow pathways within close proximity to the Site (Base map: OpenStreetMap ©



https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

Maximum Modelled Depths

5.6. Filtered maximum modelled flood depth maps for all simulated storm events between the 1 in 30 year and the 1 in 1,000 year are shown in Figure 10 to Figure 14. The deepest flooding observed onsite is located within the depression in the southwest corner of the Site. This location is marked on Figure 10 to Figure 14 as a yellow point within the Site boundary.

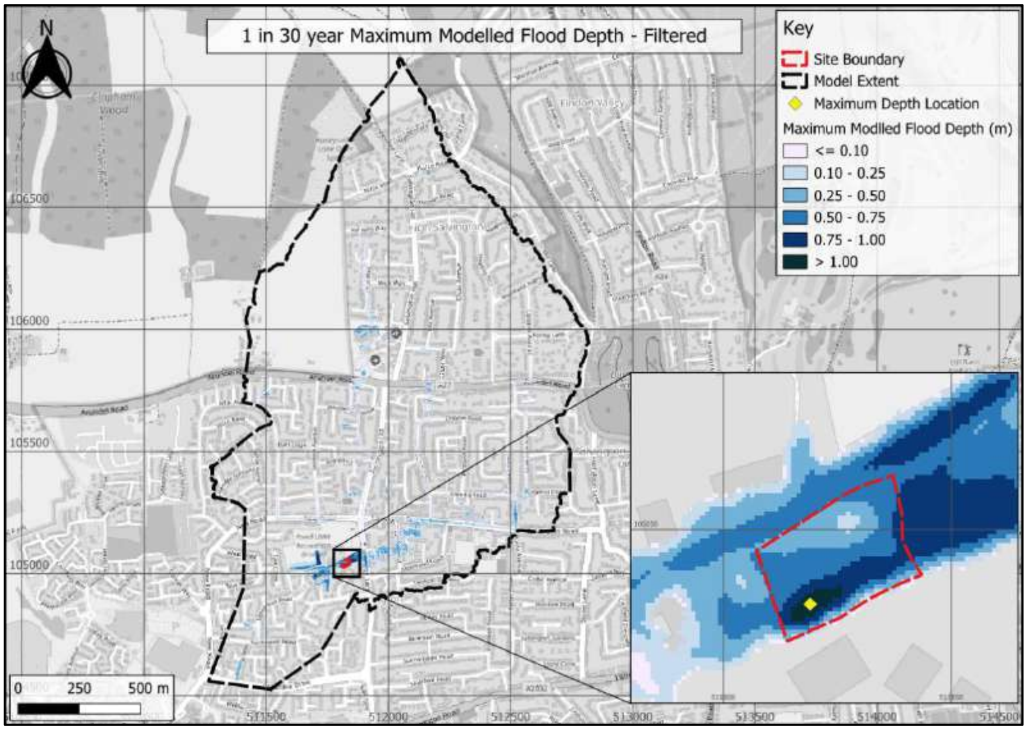


Figure 10: Maximum modelled filtered depths for the 1 in 30 year event (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

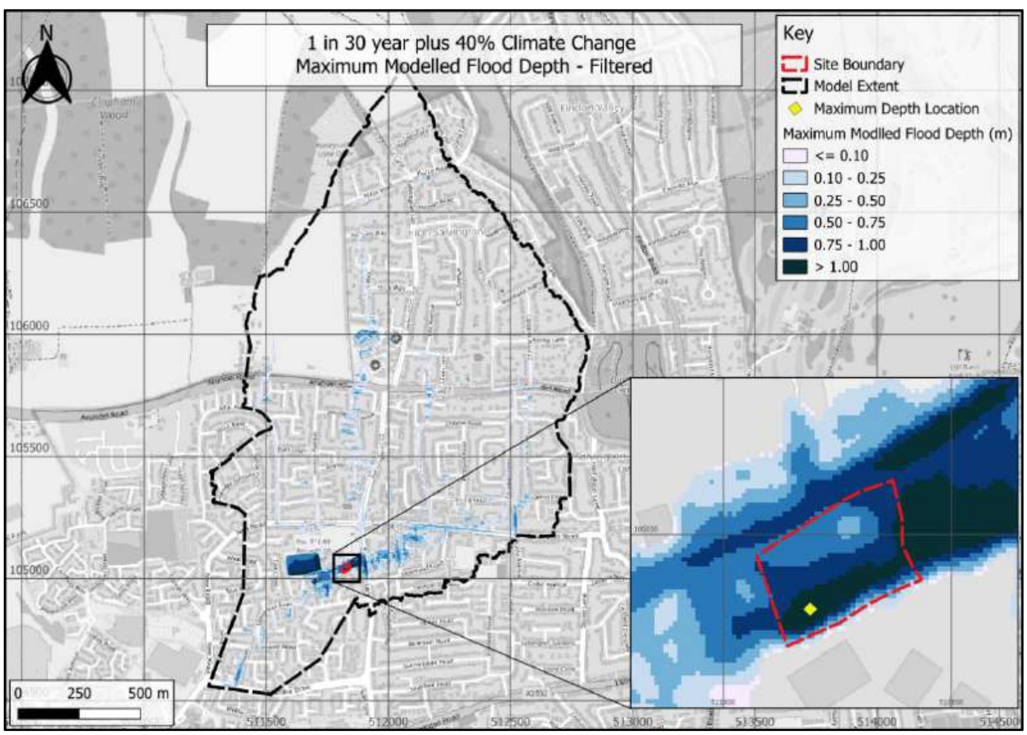


Figure 11: Maximum modelled filtered depths for the 1 in 30 year plus 40% climate change event (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

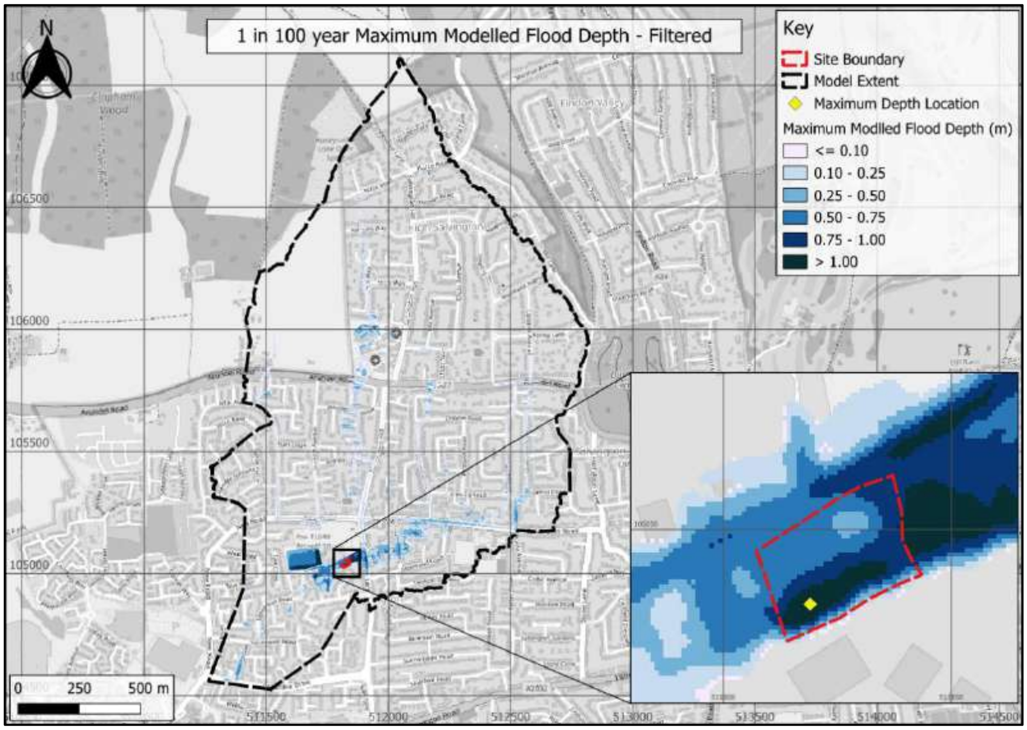


Figure 12: Maximum modelled filtered depths for the 1 in 100 year event (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

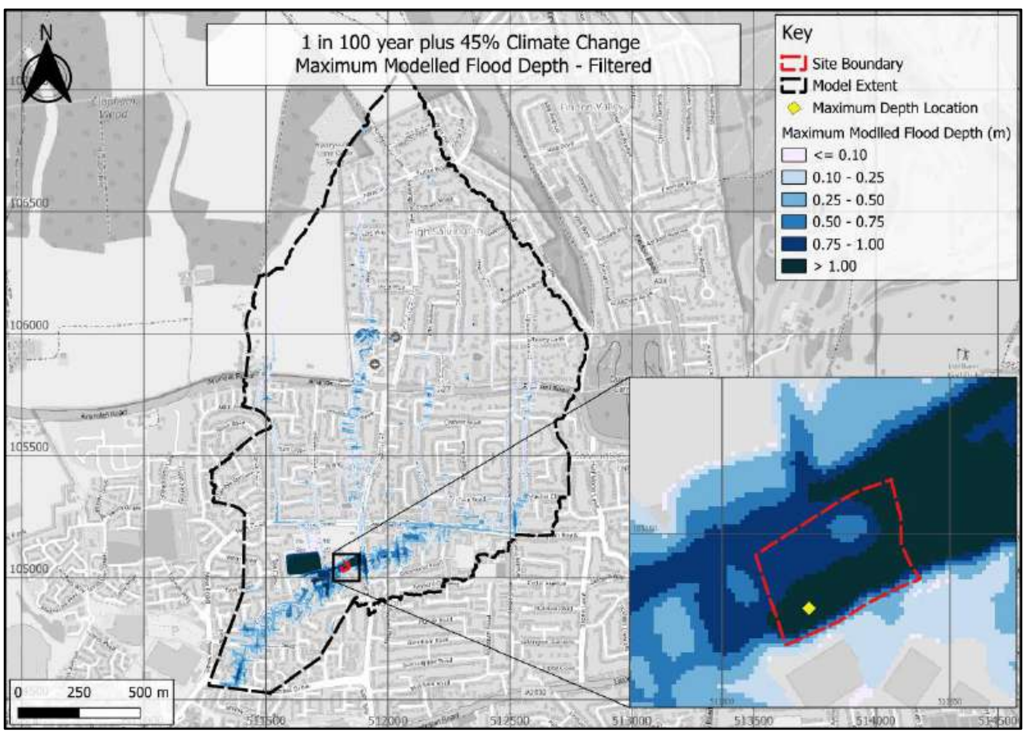


Figure 13: Maximum modelled filtered depths for the 1 in 100 year plus 45% climate change event (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

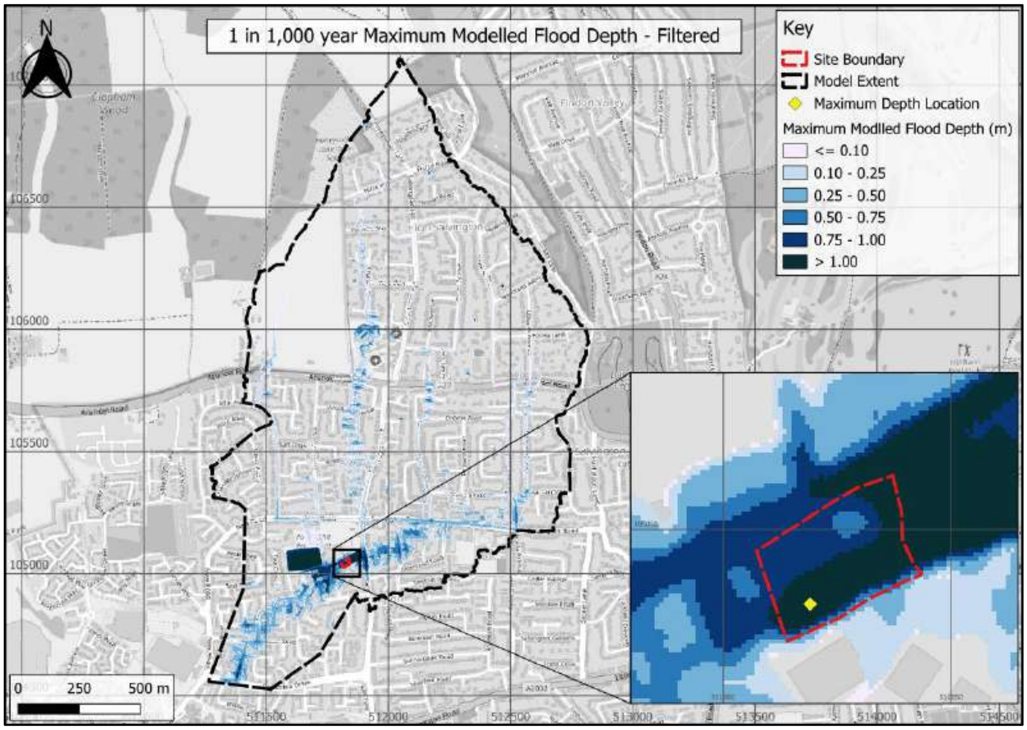


Figure 14: Maximum modelled filtered depths for the 1 in 1,000 year event (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

5.7. Maximum and minimum flood depths across the Site for each return period are summarised in Table 6 below.

Table 6: Maximum and minimum modelled flood depth within the Site boundary

Storm Event	Maximum Modelled Depth (m)	Minimum Modelled Depth (m)
1 in 30 year	1.19	0.20
1 in 30 year plus 40% climate change	1.41	0.42
1 in 100 year	1.35	0.36
1 in 100 year plus 45% climate change	1.60	0.60
1 in 1,000 year	1.61	0.61

RoFSW Results Comparison

5.8. A comparison between the modelled extents and the Environment Agency's Risk of Surface Water Mapping (RoFSW) data (NaFRA2 release) for the 1 in 100 year and 1 in 1,000 year events are shown in Figure 15 and Figure 16. The modelled extents for both events were found to be slight larger than the Environment Agency's medium (equivalent to 1 in 100 year) and low (1 in 1,000 year) risk.

5.9. It is important to note that the TUFLOW modelled extents incorporate a higher-resolution Digital Terrain Model and a higher horizontal-resolution grid. Consequently, the site-specific modelling results are considered more reliable and take precedence over the national-scale approach.

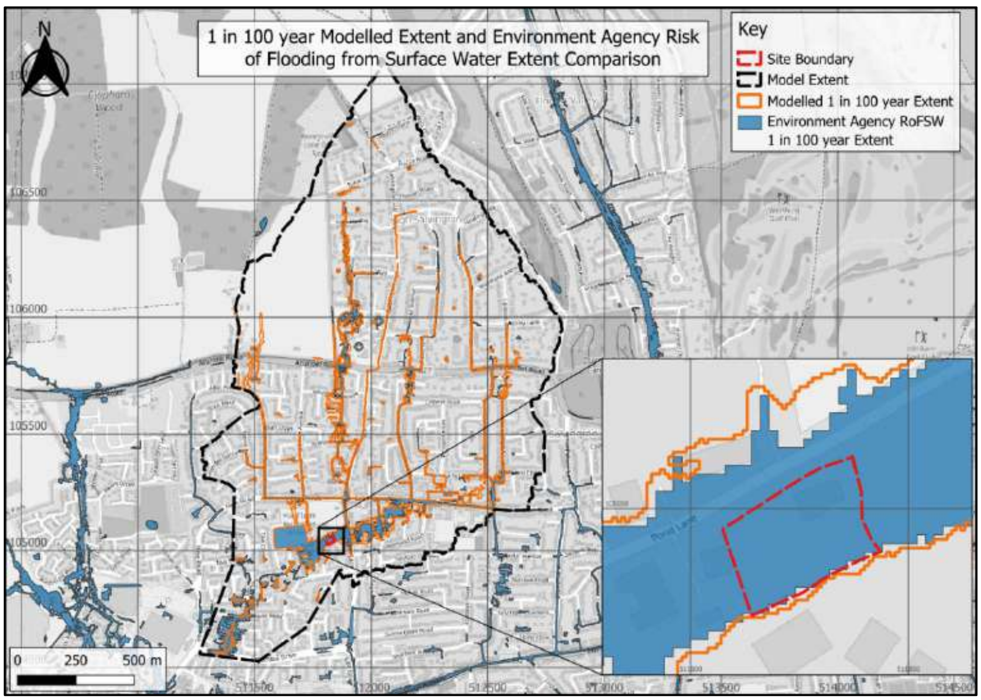


Figure 15: Comparison between the 1 in 100 year maximum modelled flood extents and EA's RoFSW (2025) mapping (RoFSW Data: EA ©. Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

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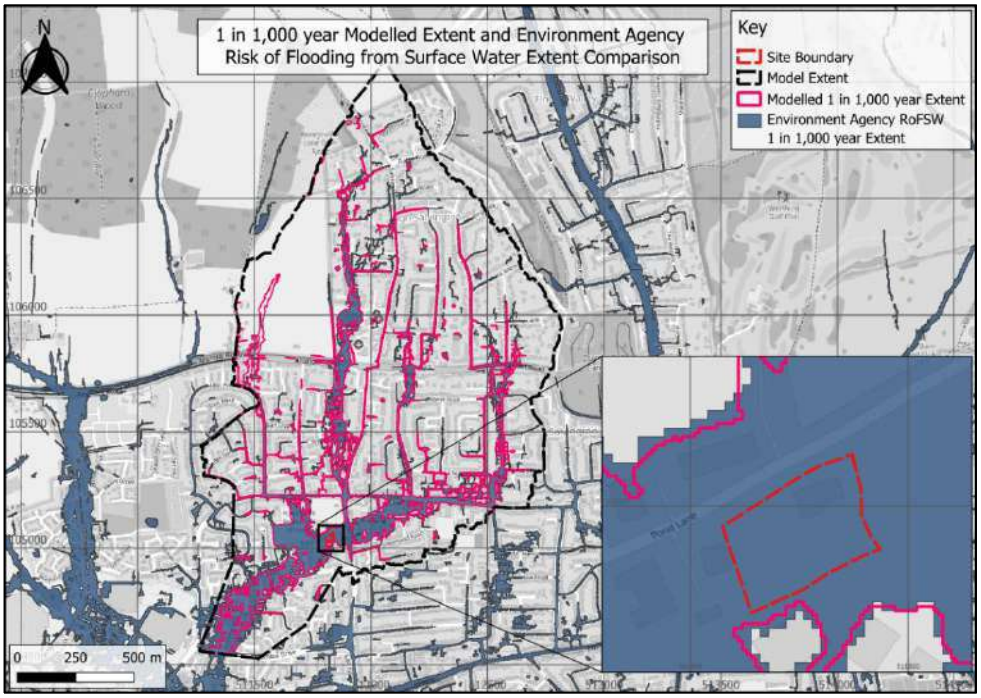

Figure 16: Comparison between the 1 in 1,000year maximum modelled flood extents and EA's RoFSW (2025) mapping (RoFSW Data: EA ©. Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

6. Model Sensitivity

6.1. This section summarises the sensitivity tests conducted using the 1 in 100 year storm event. The sensitivity tests were undertaken to identify variations in key parameters' impact on results and robustness of the hydraulic model.

6.2. The sensitivity runs included:

- 20% increase of the roughness values
- 20% decrease of the roughness values
- 20% increase in rainfall
- 20% decrease in rainfall

6.3. The results of the senstivity assessment are presented using the unfiltered depth results from the 1 in 100 year event for the full catchment and the Site itself.

Rainfall

6.4. Rainfall applied to the model was decreased and increase by 20% to review the impact of uncertainty in the hydrological estimation. The resulting change in flood depths compared to the base model are presented in Figure 17 and Figure 18.

6.5. The model was found to be sensitive to changes in rainfall applied within the model. An increase in rainfall resulted in an increase in predicted flood depths and extents while a decrease in rainfall resulted in a decrease in predicted flood depths and extents.

6.6. As a new hydrological study was undertaken as part of this modelling exercise to estimate rainfall the base model results are considered most appropriate. This is further emphasised by the comparison to current Environment Agency RoFSW mapping which show slightly smaller extents.

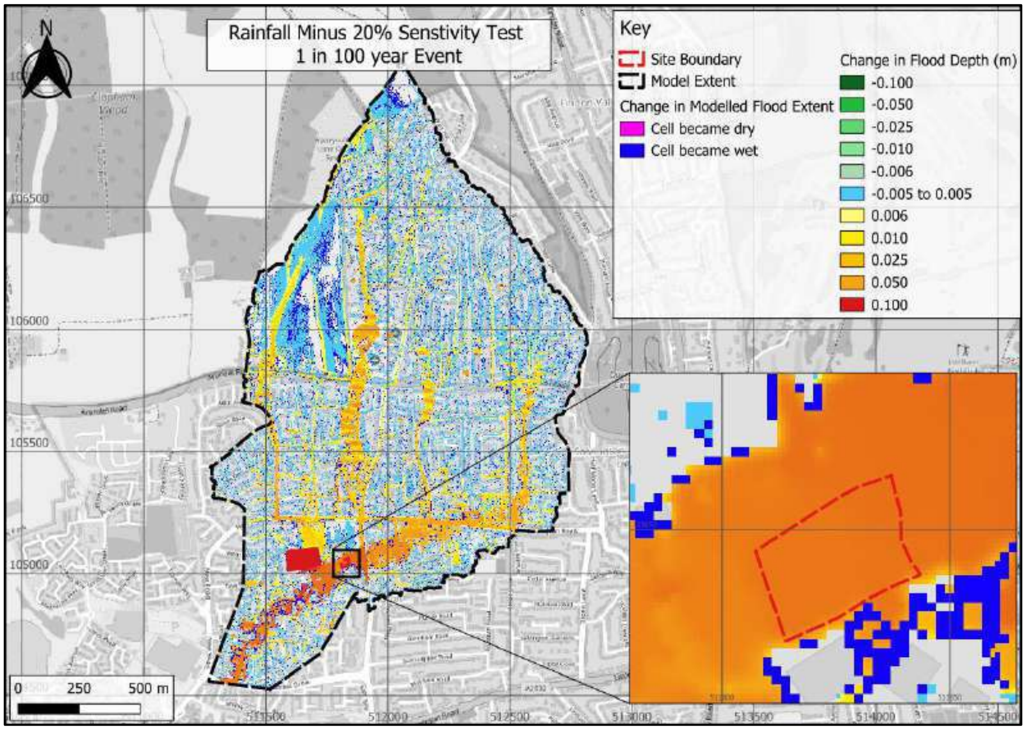

Figure 17: Increase in rainfall by 20% against base model for the 1 in 100 year event. Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

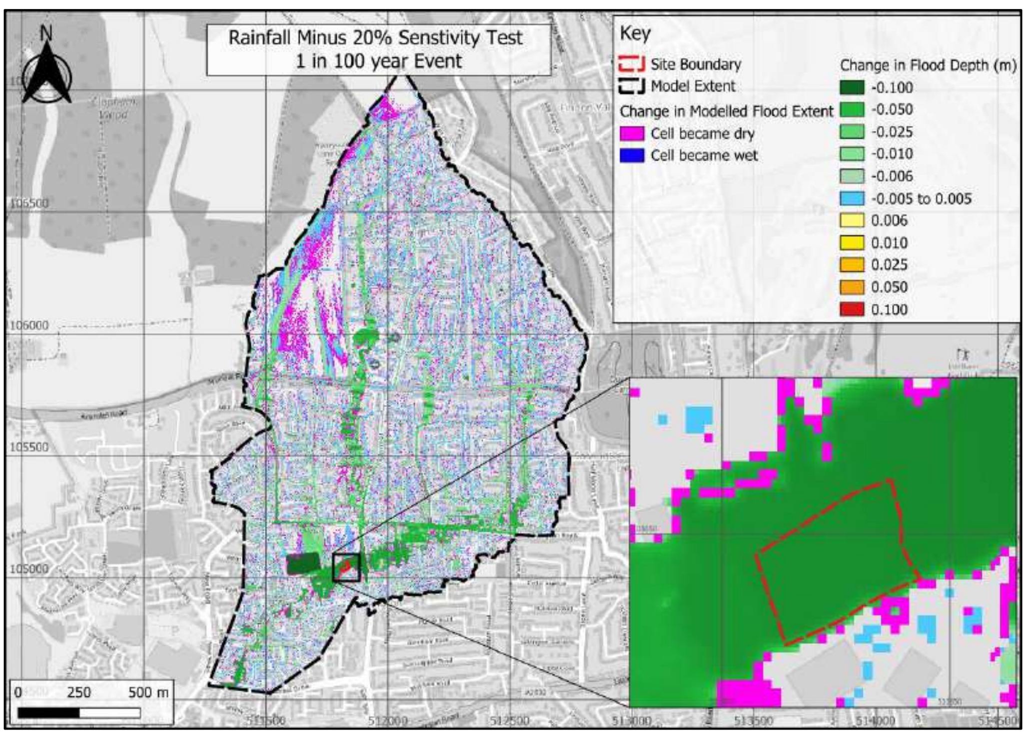

Figure 18: Decrease in rainfall by 20% against base model for the 1 in 100 year event. (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

Roughness

6.7. Roughness within the model was increased and decreased by 20%. The resulting change in flood depths compared to the base model are presented on Figure 19 and Figure 20.

6.8. The model was found to be sensitive to changes in roughness. An increase in roughness resulted in a decrease in flood depths at the site. This was caused by flow being slowed higher in the catchment resulting in depths reducing at the site as the timing of different flow pathways were delayed and no longer coinciding through the site (Figure 19).

6.9. A decrease in roughness saw the reverse impact with more water flowing through the catchment and reaching the site increasing the predicted flood depth and extent (Figure 20).

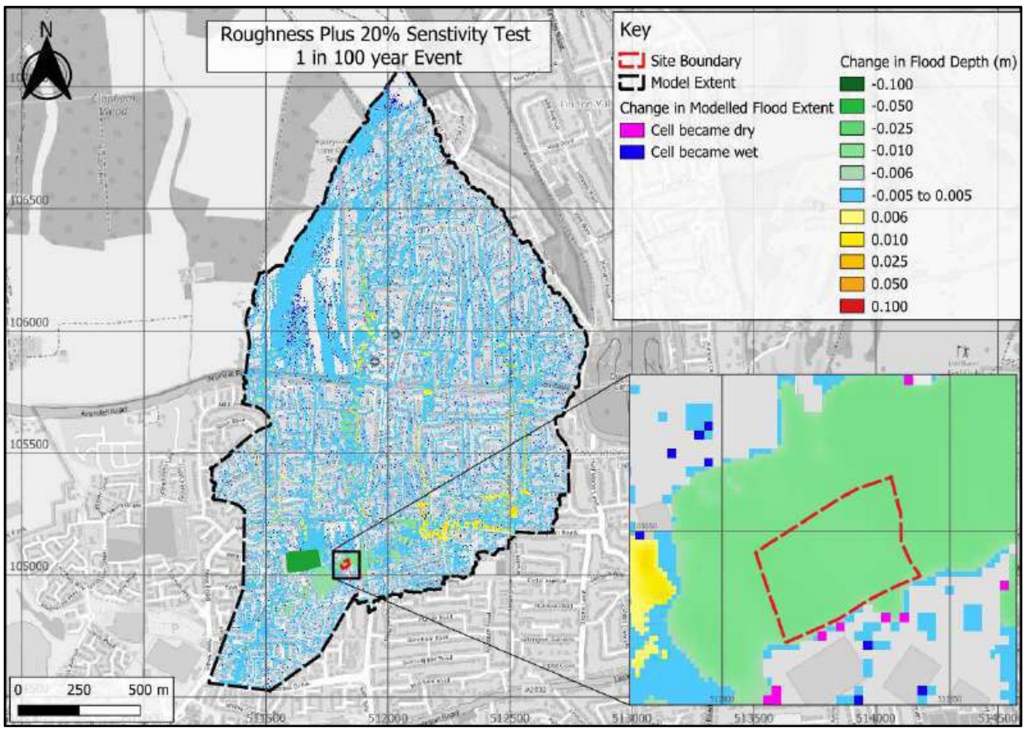

Figure 19: Increase in roughness by 20% against base model for the 1 in 100 year event. (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

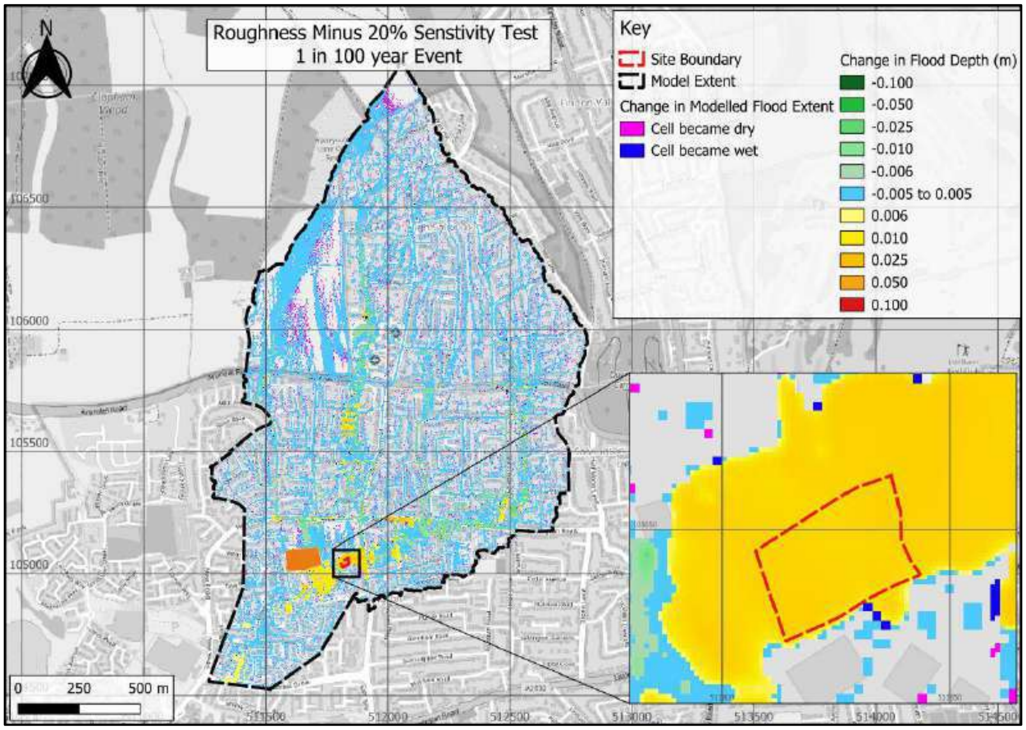

Figure 20: Decrease in roughness by 20% against base model for the 1 in 100 year event (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

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7. Model Stability & Limitations

Simulation Parameters

7.1. TUFLOW version 2025.0.2-iSP-w64 Heavily Parallelised Compute (HPC) was used in all simulations.

7.2. All parameters were retained as default and a variable timestep (based on stability conditions) was adopted, albeit the maximum timestep was capped at 4s to prevent numerical instability.

Model Stability

7.3. No negative depths were reported in the 2D domain for the baseline and design simulations.

7.4. No repeated timesteps were reported in the HPC (2D) domain for the baseline and design simulations.

7.5. The cumulative mass error was reported as 0.00% for all simulated events.

7.6. For a HPC model to be considered stable, three parameters should be maintained: N_u (Courant number relates to velocity relative to the cell size), N_c (Celerity Control number relates to water depth relative to cell size) and N_d (Diffusion control relates diffusion of momentum relating to the sub grid viscosity). Generally, for a stable model these values should be: $N_u<1$, $N_c<1$ and $N_d<0.3$.

7.7. The model-specific stability outputs are shown in Table 7 for the 1 in 100 year plus 45% climate change simulation.

Table 7: HPC solver stability outputs for the 1 in 100 year plus 45% climate change

	Maximum stability criteria value	Max Model outputs	Average Model outputs
Nu (Courant number)	1.00	0.85	0.35
Nc (Celerity Control number)	1.00	1.01	1.00
Nd (Diffusion control number)	0.30	0.25	0.09

7.8. The N_u and N_d outputs indicate good model performance and stability. The Nc number is at the upper limit for stability and warranted further investigation. N_c is particularly sensitive to high water depths compared to grid cell size, such as at the depression in Pond Lane Recreation Ground resulted in higher depths compared to the remainder of the model.

7.9. The N_c number could be reduced by increasing the model grid size however this would sacrifice model accuracy. Therefore, it was decided to retain the high-resolution model cell size and tolerate the high N_c number during more extreme storm events where modelled water depths are highest. It's important to note that, despite the borderline N_c value, the model remains within acceptable tolerance for stability.

Limitations

7.10. This report and the associated hydraulic model were developed using the best available data and methodologies at the time of construction and simulation. However, the following limitations apply:

- The model was informed by the Environment Agency's (EA) publicly available LiDAR at 1m resolution (RMSE of ±150mm).
- There is limited information on the outlet from the Pond Lane Recreation Ground depression, information has been assumed based on utility mapping and aerial imagery. Overflow from this area is downstream of the Site therefore it is not considered to have an impact on model results.
- Rainfall estimates were modelled using ReFH2 and adjusted for climate change per Environment Agency guidance. These methods may not fully account for local variations.
- The model follows the EA's Risk of Flooding from Surface Water (RoFSW) national-scale approach. Micro-topographical features in urban areas are not fully represented, but this is not expected to materially affect results.

7.11. Unique TUFLOW checks and warnings generated during the 1 in 100 year plus 45% climate change event are shown in Table 8. These were reviewed and deemed not to affect the results or conclusions of this assessment.

Table 8: TUFLOW checks and warnings for the 1.0%AEP +CC45% scenario

Check/ Warning	TUFLOW ID	Description	Number of occurrences	Comments
Warning	2583	Material ID 10021 has a manning's n value (0.300) greater than Wu n limit (0.100) - n value will be limited in Wu formulation.	1	The use of stubby buildings in the model resulted in a single Manning's n value warning, with no impact on outcomes.
Warning	0255	One or more GIS layers not closed during simulation	1	Writing message, this does not impact model calculation or final results.
Check	3548	Setting SGS Sample Distance Target to minimum grid zpt resolution of 1	1	Standard reporting message within model. No impact on results as setting to default
Check	3505	SGS TIN outside model domain	1	Model reviewed and all files included as required. No impact on model results
Check	1424	Pit VPI_PondLane width calculated as no. of pits [1] x 1d_pit width[1.]x pit database width [2.] – Total width = 2	1	Standard VPI reporting message, input of VPI reviewed and considered appropriate so no further action required.

8. Conclusions

8.1. This pluvial hydraulic modelling exercise adheres to the best practices outlined in the Environment Agency's guidance document '*What is the Risk of Flooding from Surface Water Map?*'.

8.2. The results indicate that the model outputs show a slightly greater flood extent for both the 1 in 100 year and 1 in 1,000 year events when compared to the Environment Agency RoFSW mapping.

8.3. The model shows the Site is affected by all simulated storm events with a range of maximum depth of 1.19m in the 1 in 30 year and 1.61m in the 1 in 1,000 year event. Minimum onsite flood depths are predicted to be 0.20m in the 1 in 30 year and 0.61m in the 1 in 1,000 year event.

8.4. Sensitivity analysis of key hydraulic and physical parameters was undertaken - as expected the model is sensitive to changes in rainfall applied while roughness was found to have less of an impact on model results.

Appendix A - Unfiltered Model Results

Unfiltered Model Results

Maximum Depth Grids

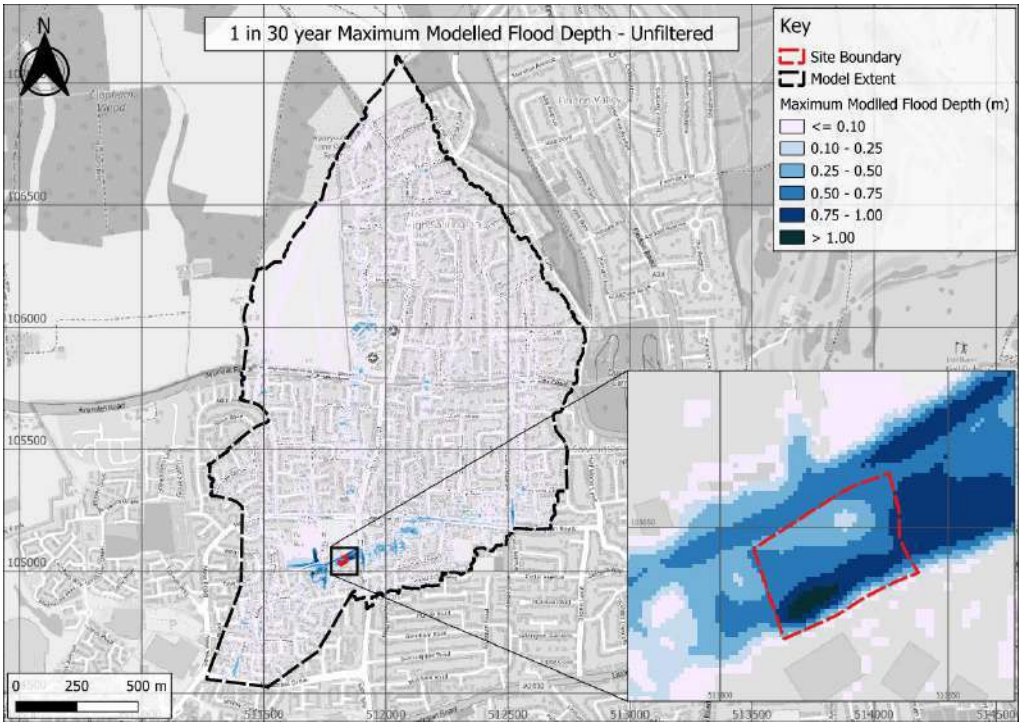

Figure A1 – 1 in 30 year maximum modelled flood depths unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

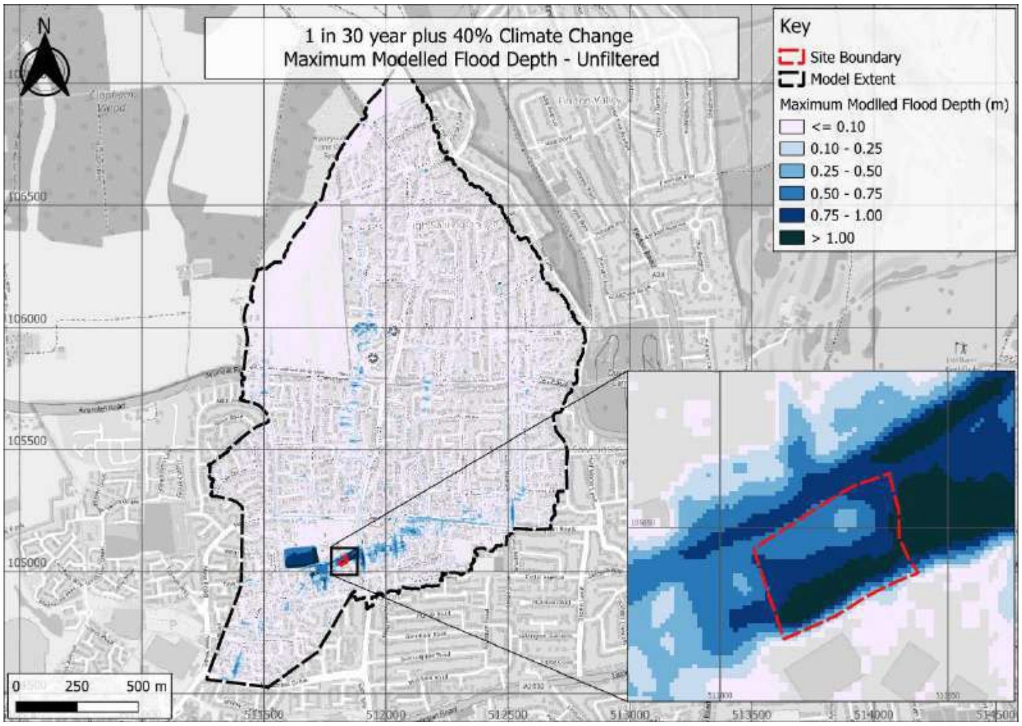

Figure A2 – 1 in 30 year plus 40% climate change maximum modelled flood depths unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

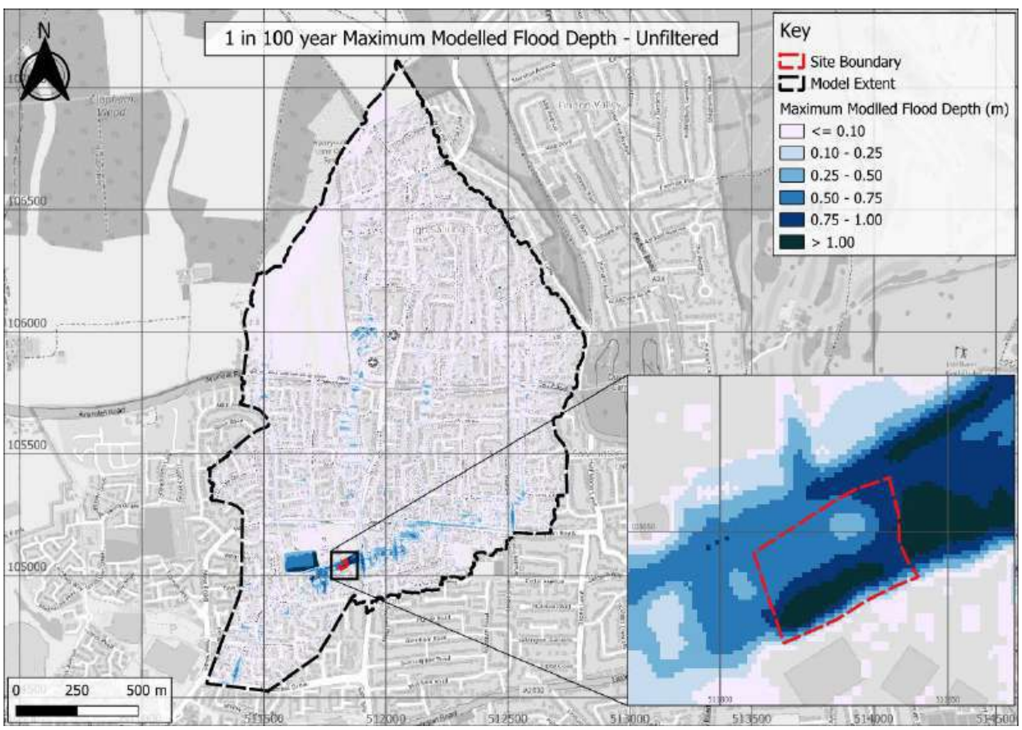

Figure A3 – 1 in 100 year maximum modelled flood depths unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

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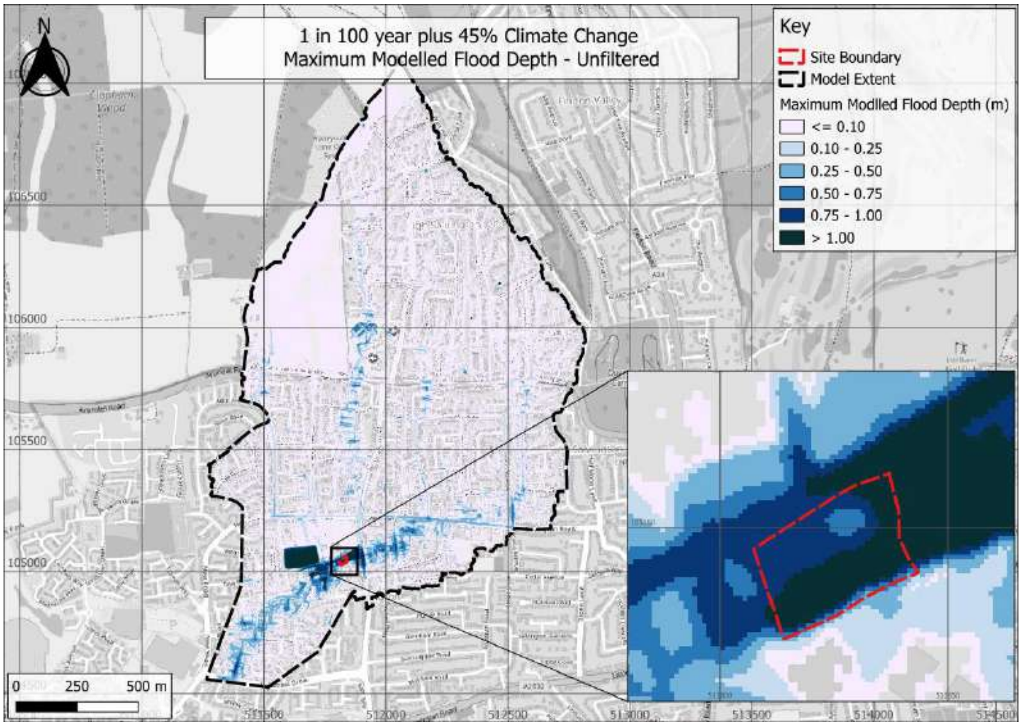

Figure A4 – 1 in 100 year plus 45% climate change maximum modelled flood depths unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

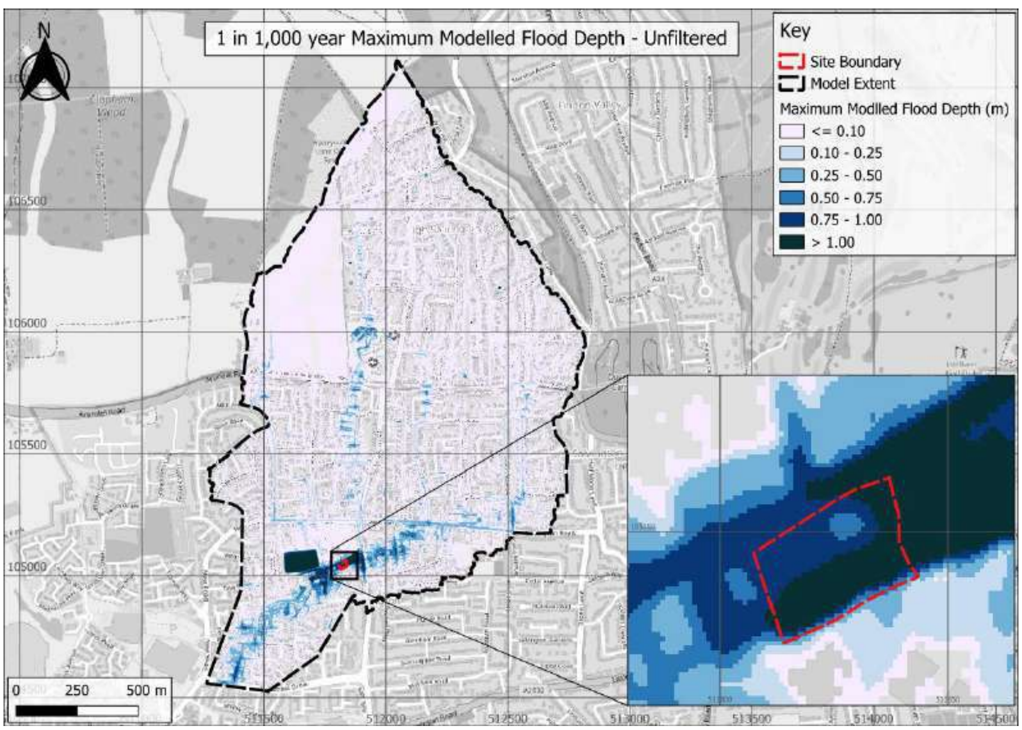

Figure A5 – 1 in 1,000 year maximum modelled flood depths unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

Maximum Velocity Grids

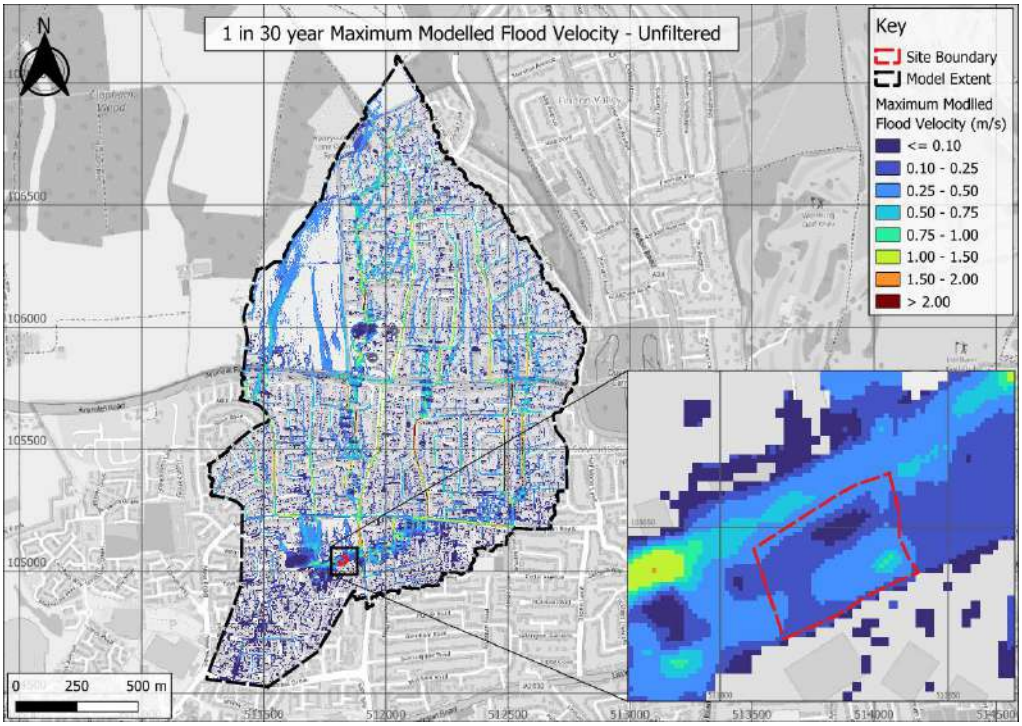

Figure A6 – 1 in 30 year maximum modelled flood velocity unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

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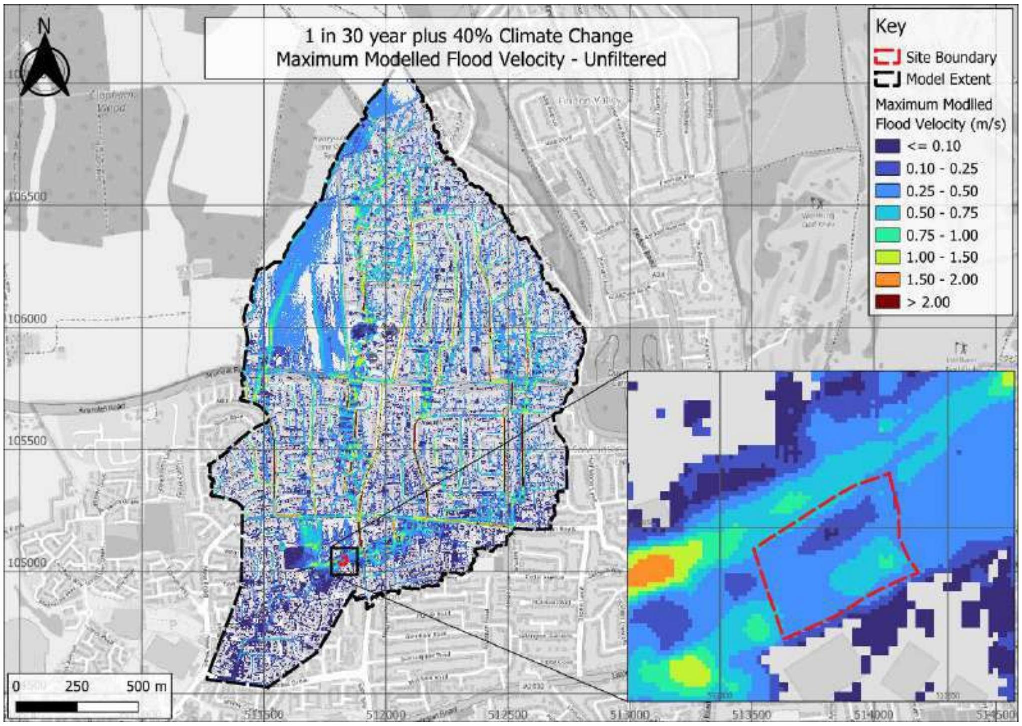


Figure A7 – 1 in 30 year plus 40% climate change maximum modelled flood velocity unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

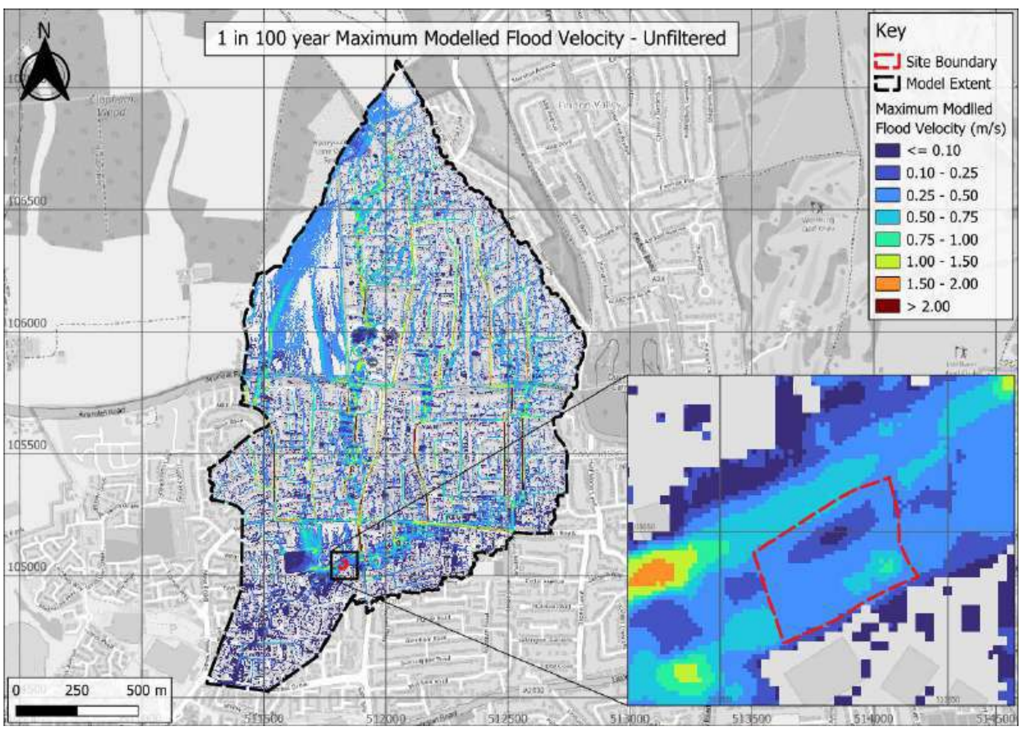


Figure A8 – 1 in 100 year maximum modelled flood velocity unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

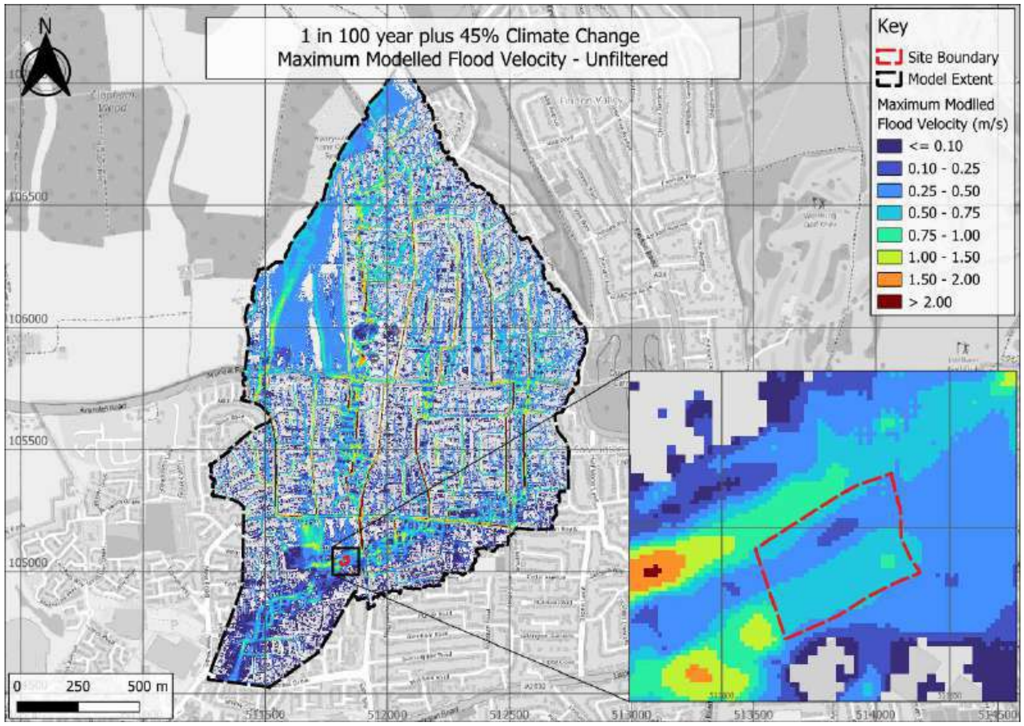


Figure A9 – 1 in 100 year plus 45% climate change maximum modelled flood velocity unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

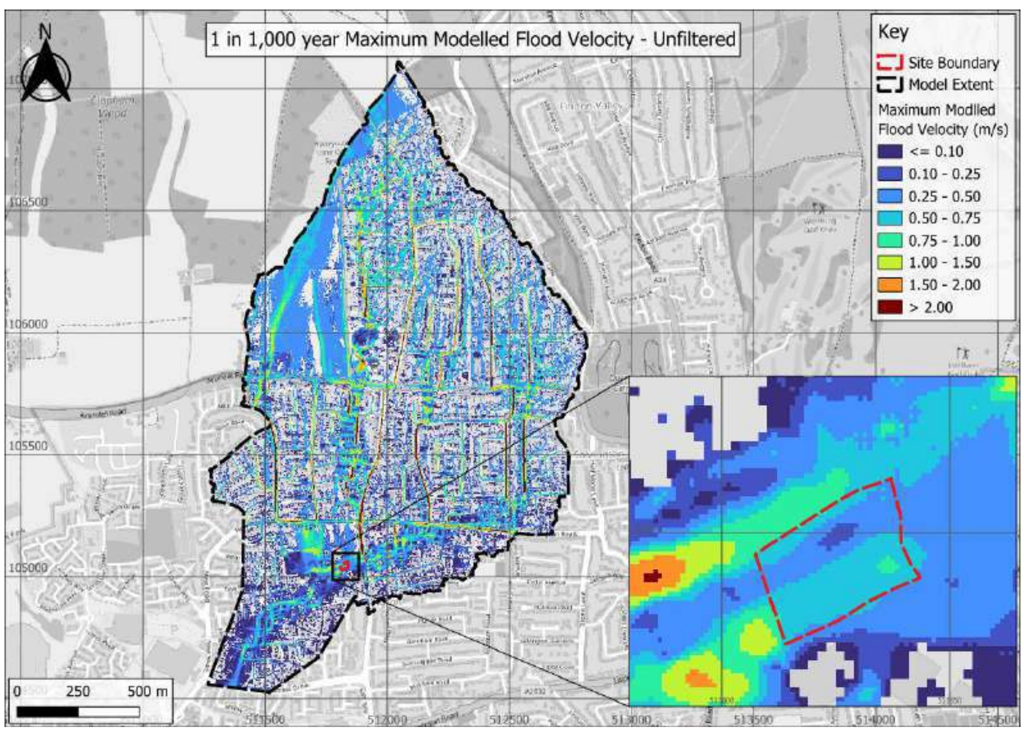
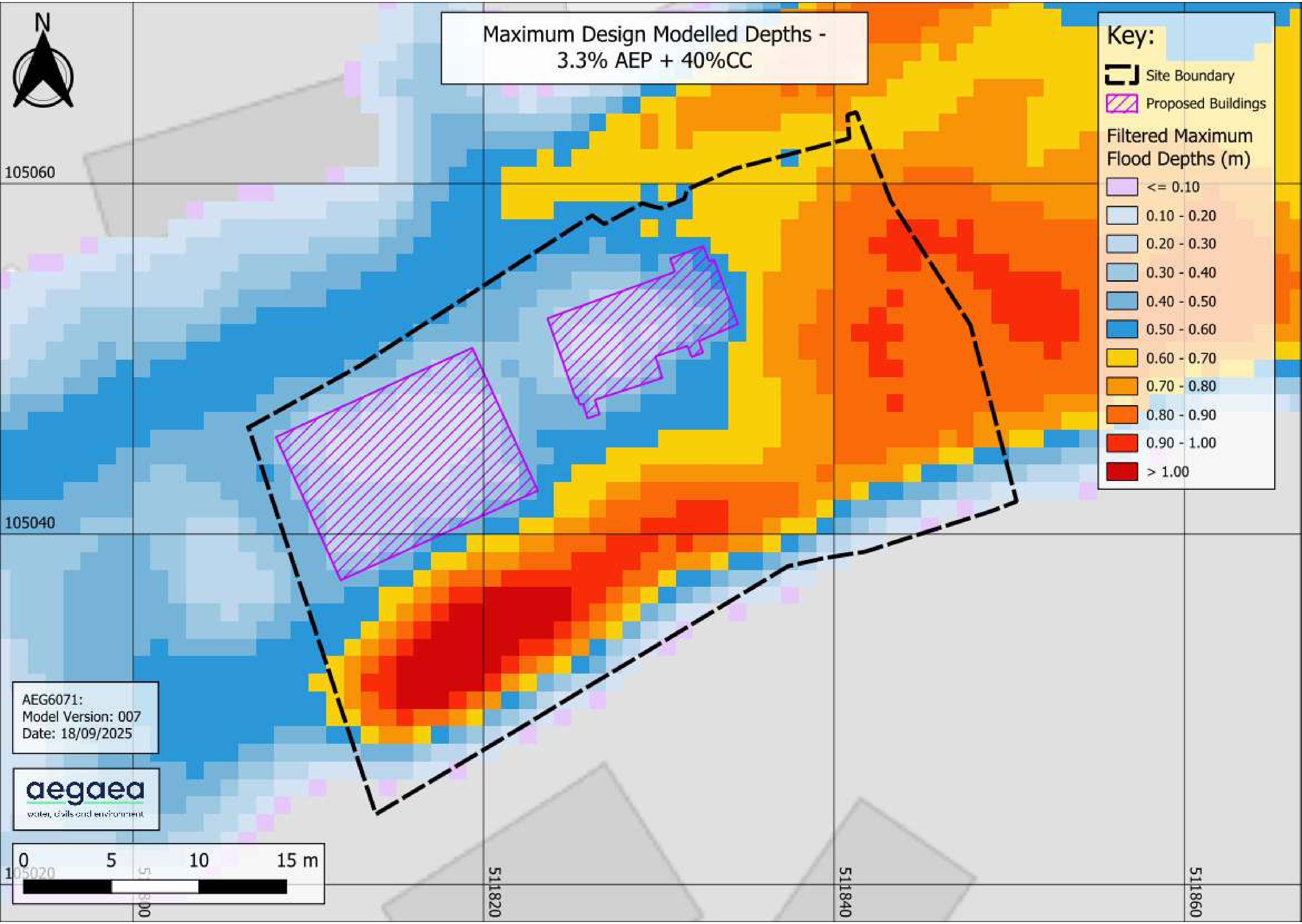
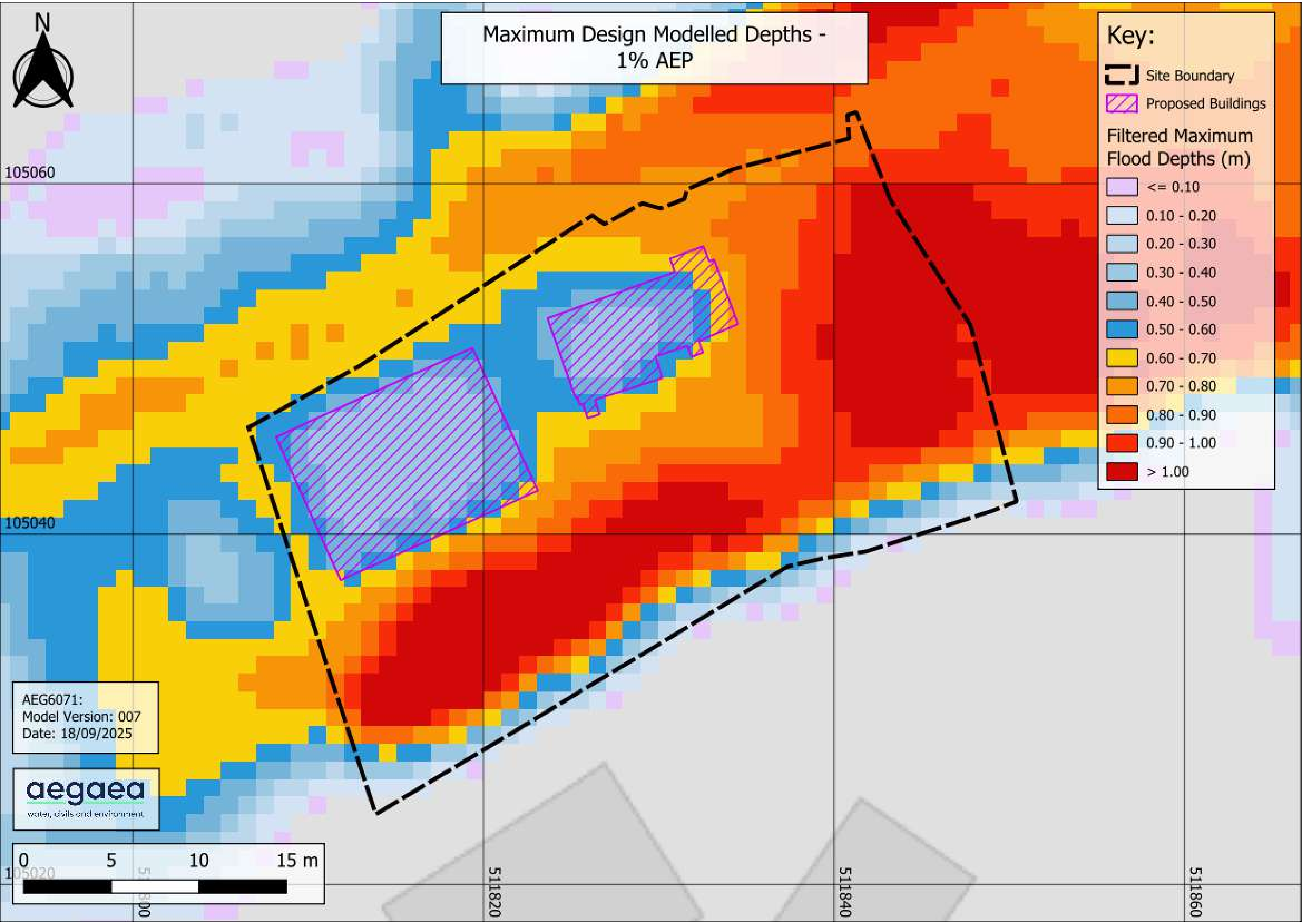


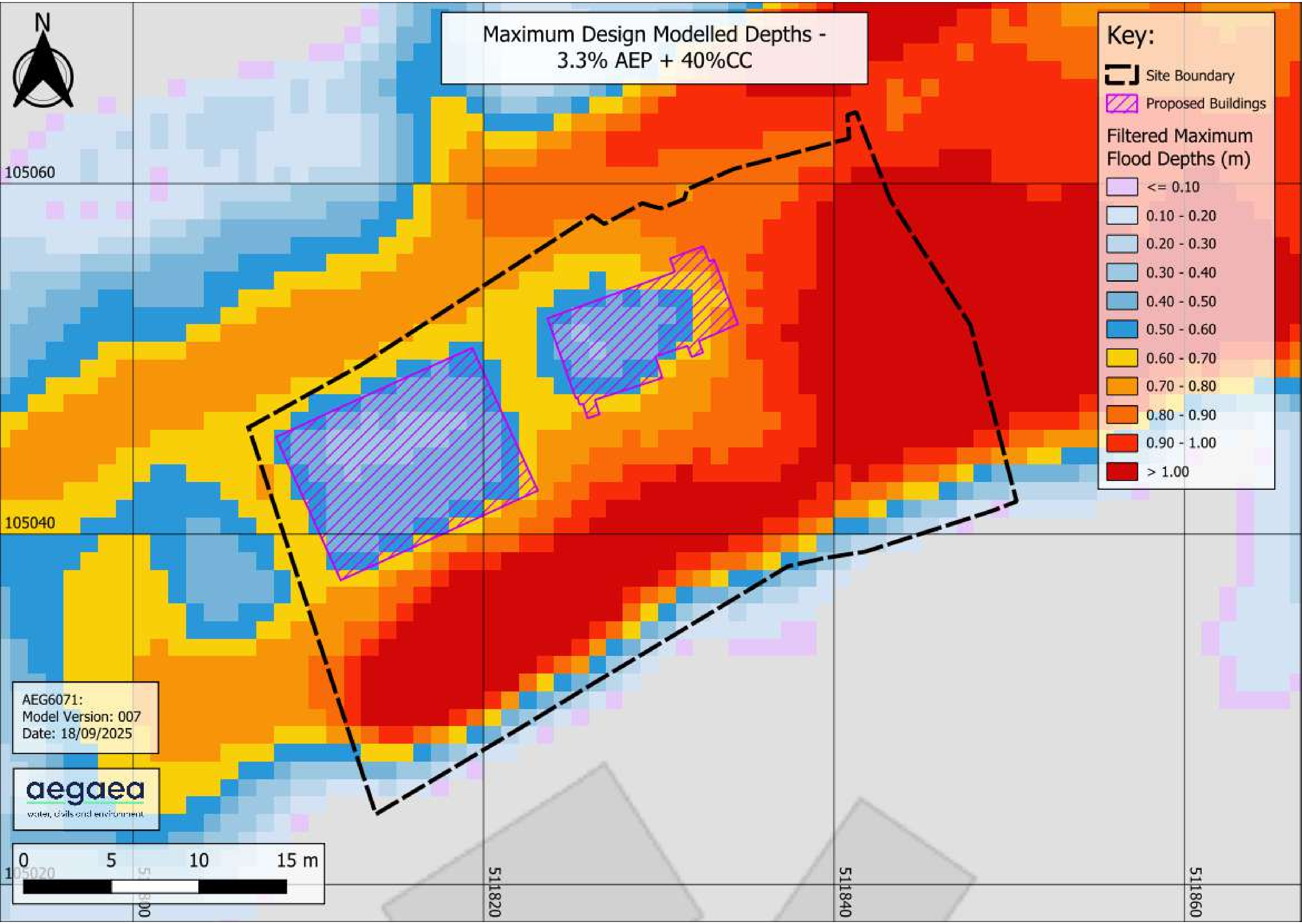
Figure A10 – 1 in 1,000 year maximum modelled flood velocity unfiltered (Base map: OpenStreetMap © https://www.openstreetmap.org and contributors. Ordnance Survey licence number 100024198).

Appendix B Detailed TUFLOW Modelling Depth & Velocity Outputs

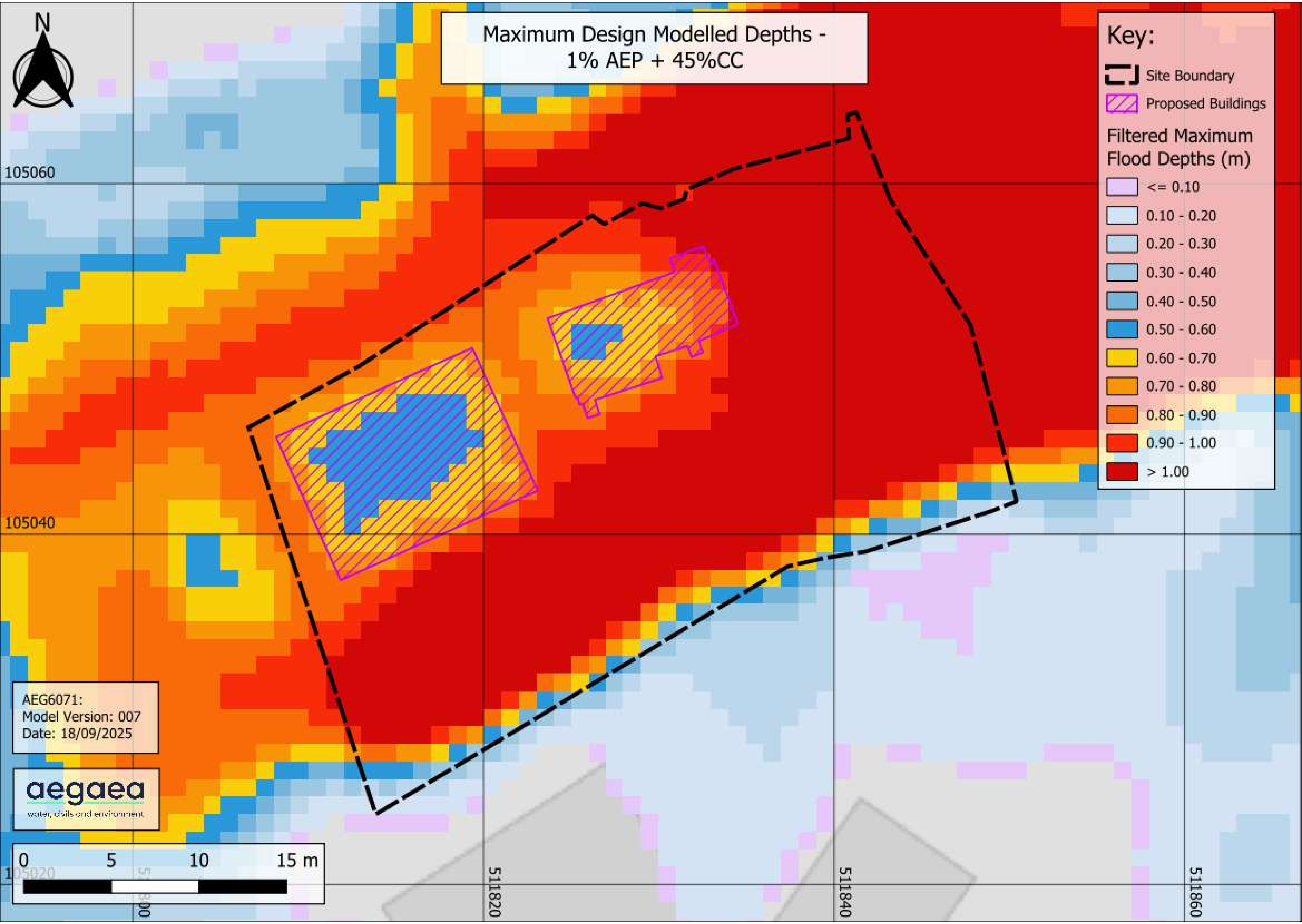


Maximum Design Modelled Depths -
3.3% AEP + 40%CC
N
Key:
Site Boundary
Proposed Buildings
Filtered Maximum
Flood Depths (m)
<= 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
> 1.00
105060
105040
105020
511800
511820
511840
511860
AEG6071:
Model Version: 007
Date: 18/09/2025
aegaea
water, civils and environment
0
5
10
15 m

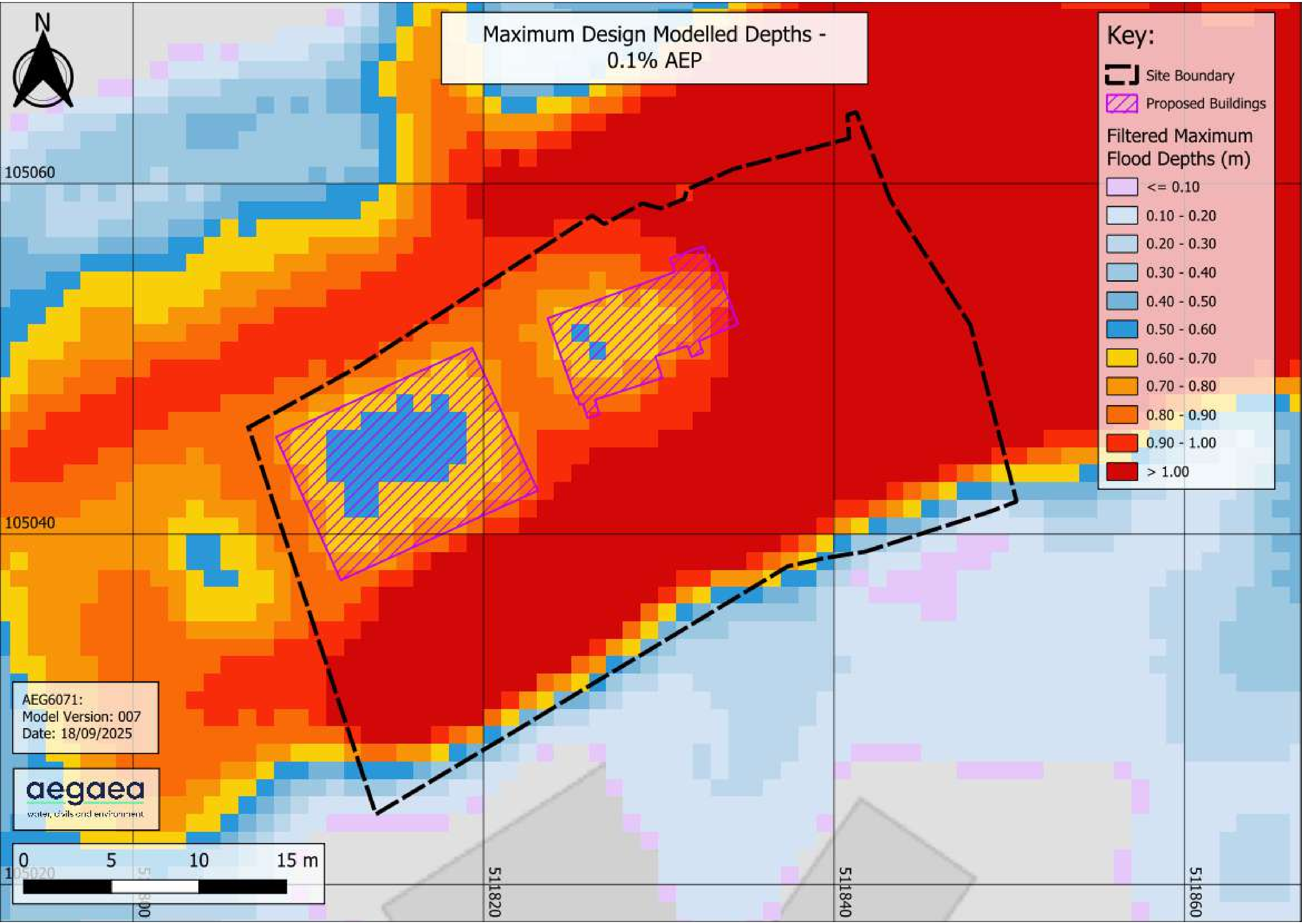

Maximum Design Modelled Depths -
1% AEP
N
Key:
Site Boundary
Proposed Buildings
Filtered Maximum
Flood Depths (m)
<= 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
> 1.00
105060
105040
105020
511800
511820
511840
511860
AEG6071:
Model Version: 007
Date: 18/09/2025
aegaea
0 5 10 15 m

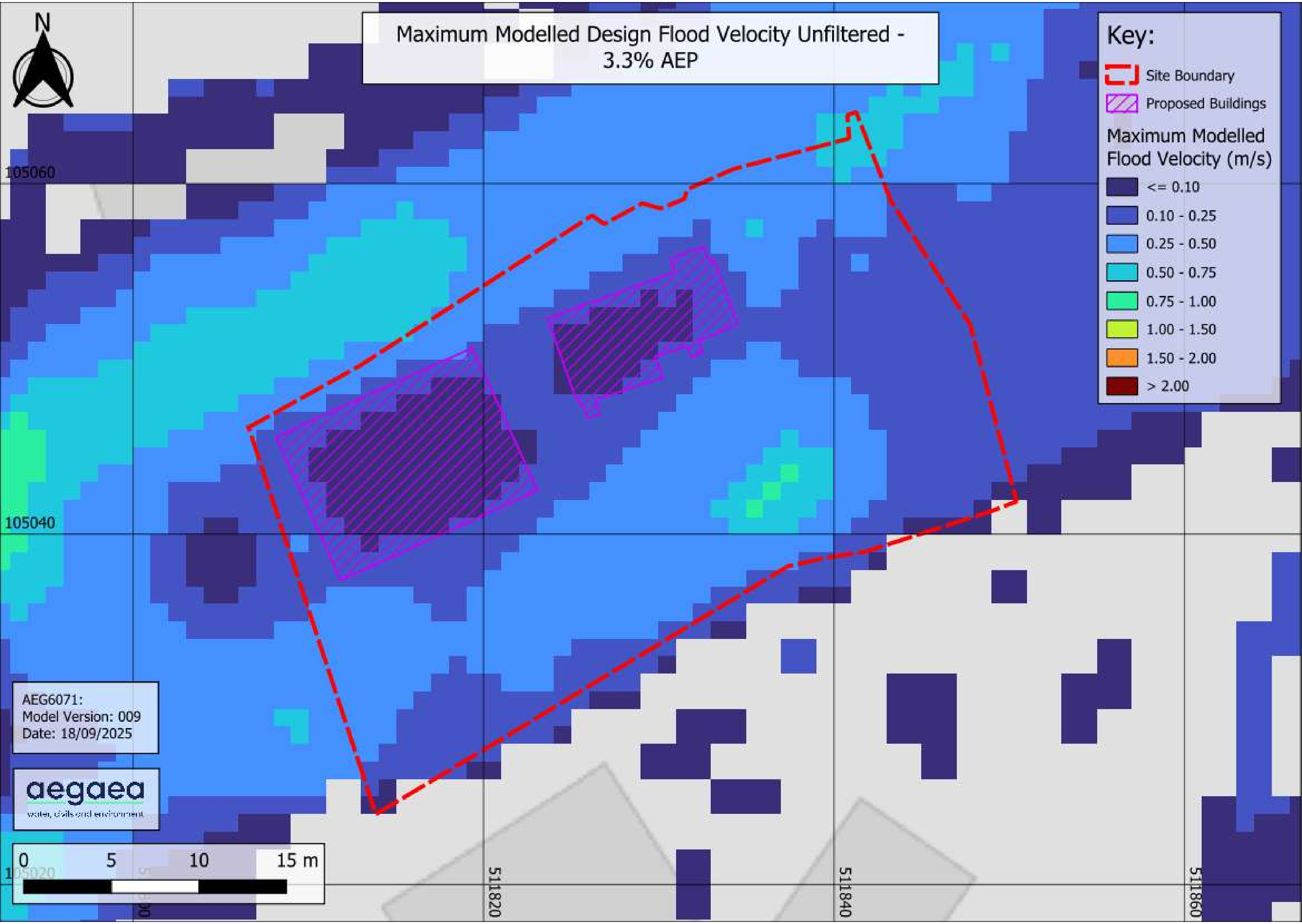


N
Maximum Design Modelled Depths -
3.3% AEP + 40%CC
Key:
Site Boundary
Proposed Buildings
Filtered Maximum
Flood Depths (m)
<= 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
> 1.00
105060
105040
105020
511800
511820
511840
511860
AEG6071:
Model Version: 007
Date: 18/09/2025
aegaea
water, civils and environment
0
5
10
15 m

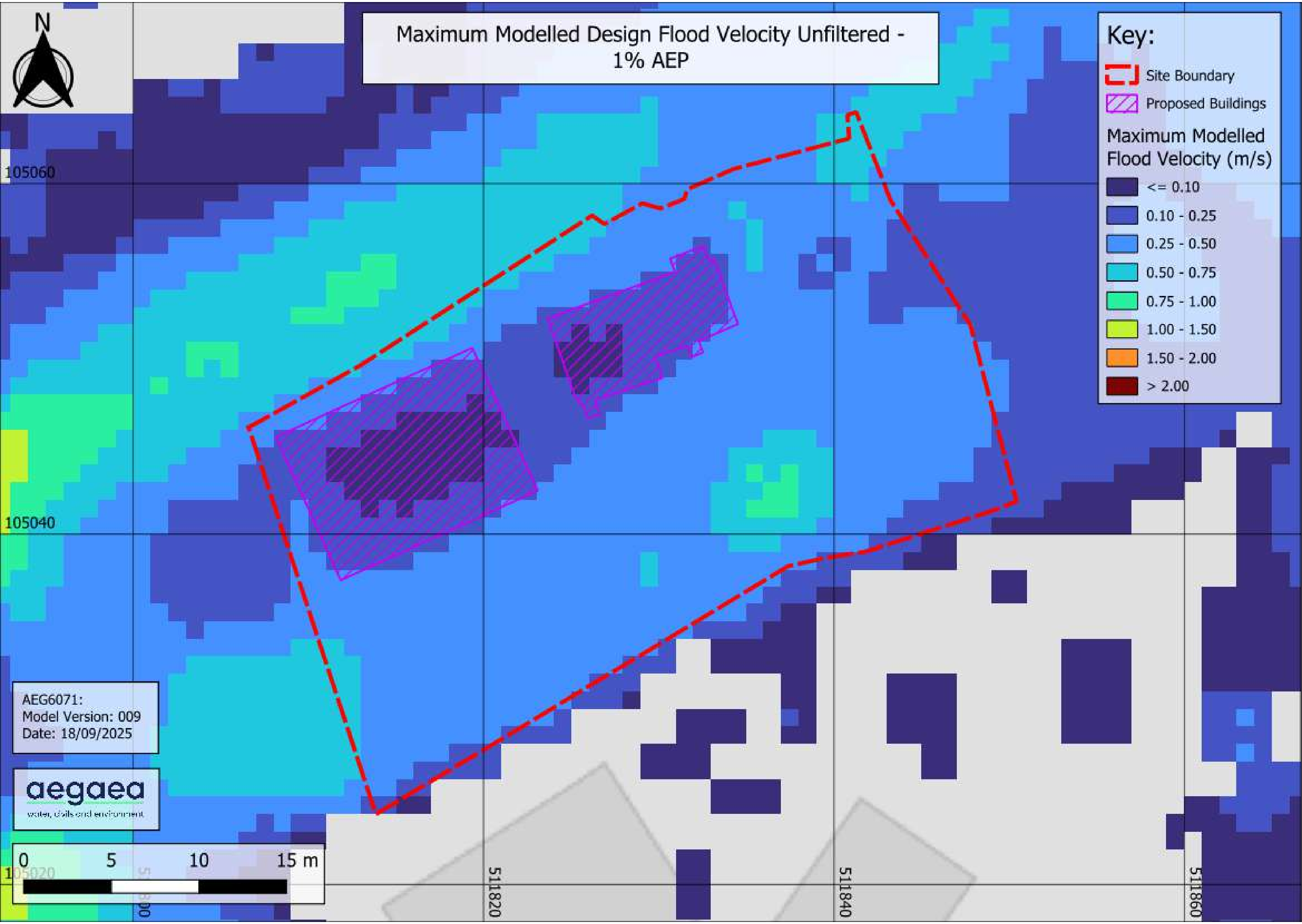


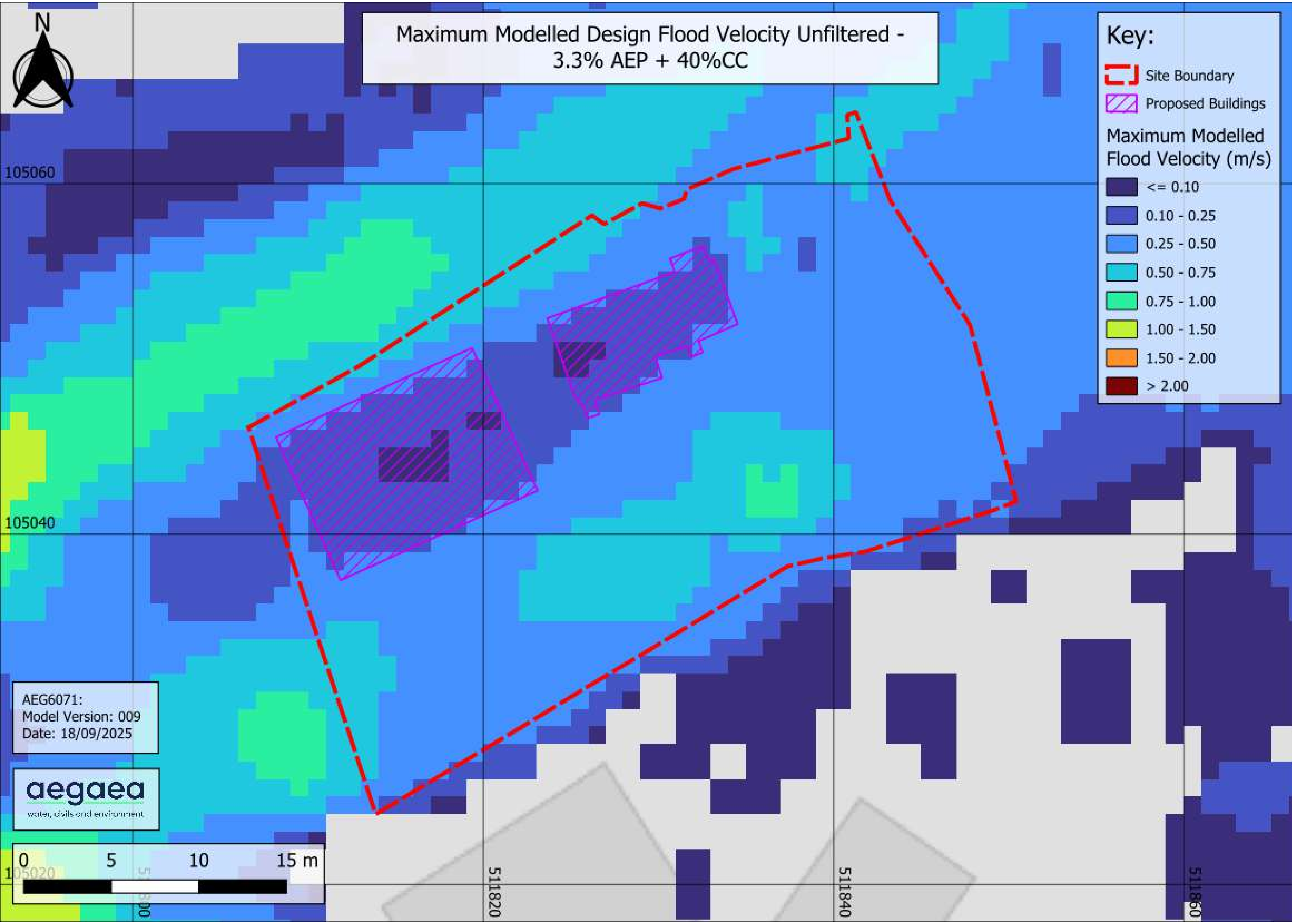
Maximum Design Modelled Depths -
1% AEP + 45%CC
N
Key:
Site Boundary
Proposed Buildings
Filtered Maximum
Flood Depths (m)
<= 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
> 1.00
105060
105040
105020
511820
511840
511860
AEG6071:
Model Version: 007
Date: 18/09/2025
aegaea
0 5 10 15 m

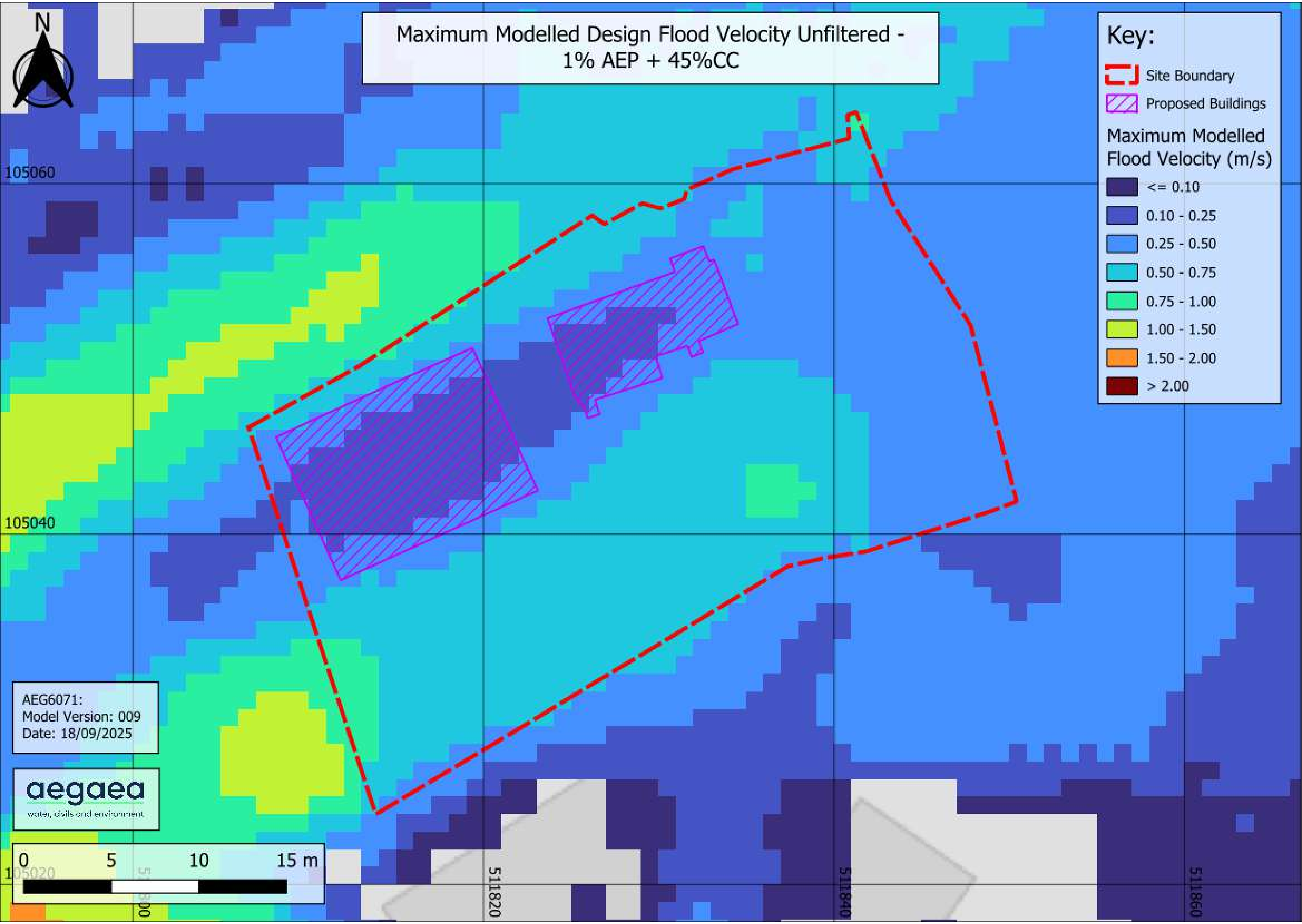

Maximum Design Modelled Depths -
0.1% AEP
N
Key:
Site Boundary
Proposed Buildings
Filtered Maximum
Flood Depths (m)
<= 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
> 1.00
105060
105040
105020
511800
511820
511840
511860
AEG6071:
Model Version: 007
Date: 18/09/2025
aegaea
water, civils and environment
0
5
10
15 m

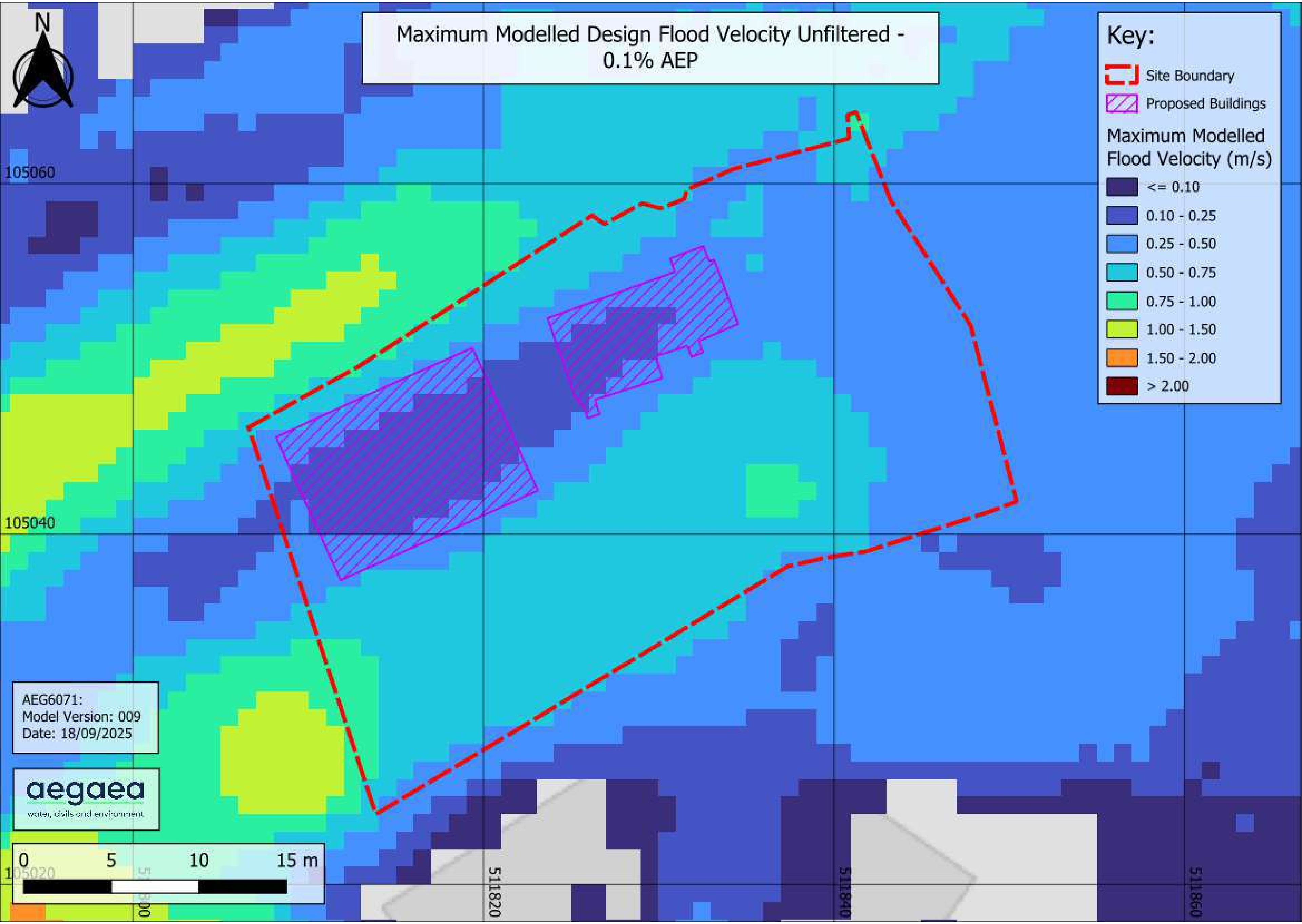


Maximum Modelled Design Flood Velocity Unfiltered - 3.3% AEP
N
Key:
Site Boundary
Proposed Buildings
Maximum Modelled Flood Velocity (m/s)
<= 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
> 2.00
105060
105040
105020
511820
511840
511860
AEG6071:
Model Version: 009
Date: 18/09/2025
aegaea
water, civils and environment
0
5
10
15 m

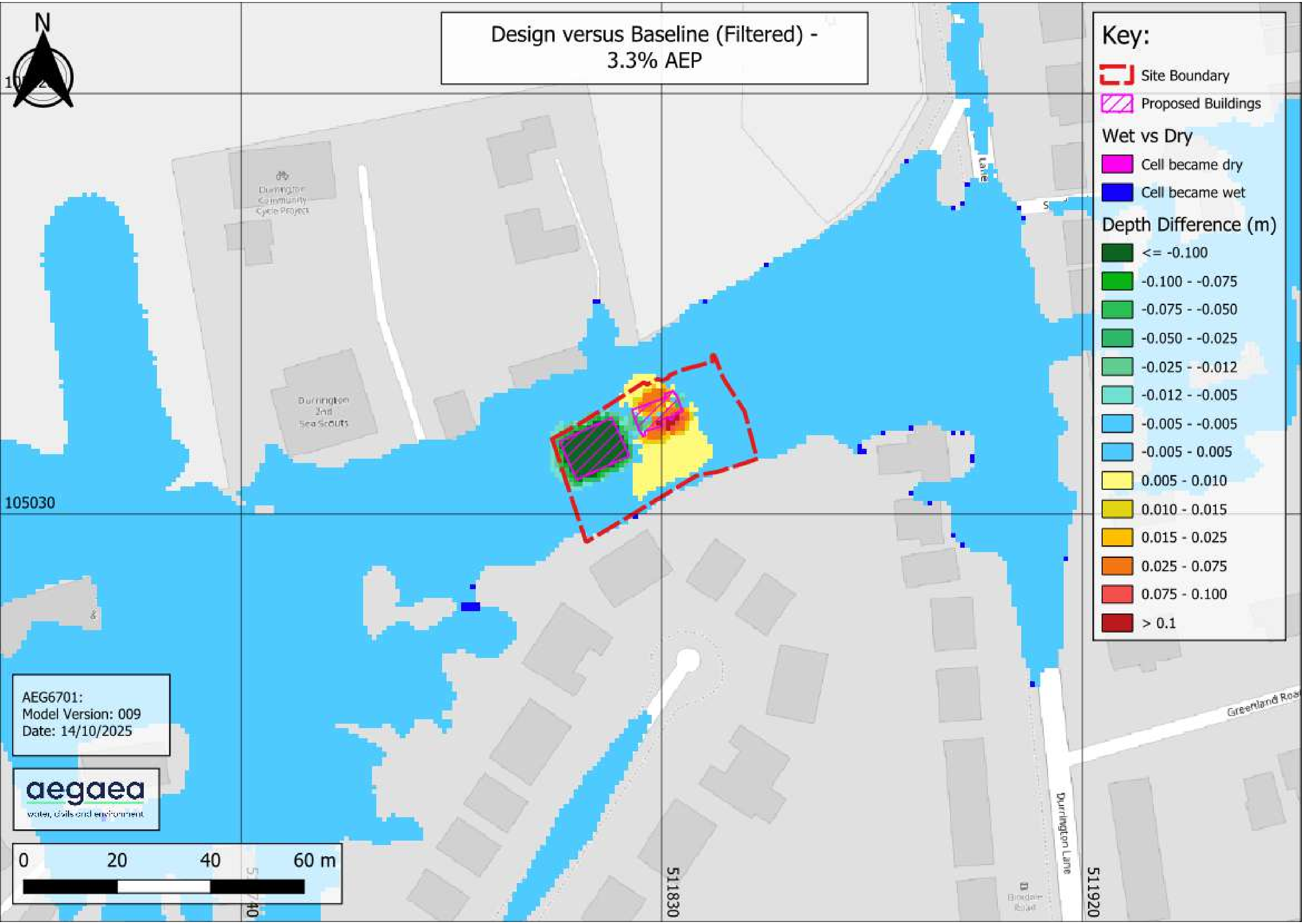

Maximum Modelled Design Flood Velocity Unfiltered - 1% AEP
N
Key:
Site Boundary
Proposed Buildings
Maximum Modelled Flood Velocity (m/s)
<= 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
> 2.00
105060
105040
105020
511820
511840
511860
AEG6071:
Model Version: 009
Date: 18/09/2025
aegaea
water, civils and environment
0
5
10
15 m

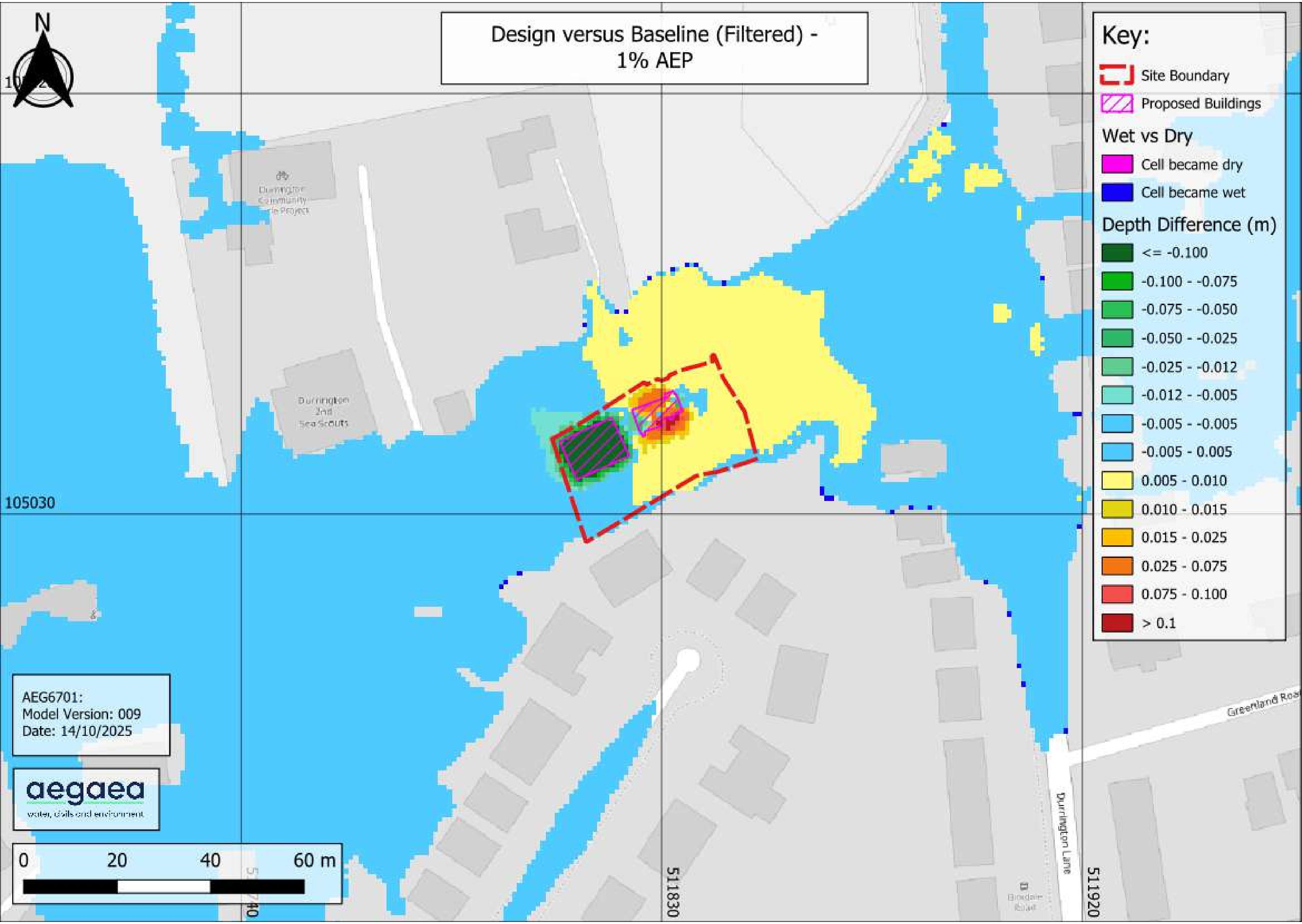

Maximum Modelled Design Flood Velocity Unfiltered -
3.3% AEP + 40%CC
Key:
Site Boundary
Proposed Buildings
Maximum Modelled
Flood Velocity (m/s)
<= 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
> 2.00
N
105060
105040
105020
511820
511840
AEG6071:
Model Version: 009
Date: 18/09/2025
aegaea
water, civils and environment
0
5
10
15 m


Maximum Modelled Design Flood Velocity Unfiltered -
1% AEP + 45%CC
Key:
Site Boundary
Proposed Buildings
Maximum Modelled Flood Velocity (m/s)
<= 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
> 2.00
N
105060
105040
105020
511800
511820
511840
511860
AEG6071:
Model Version: 009
Date: 18/09/2025
aegaea
water, civils and environment
0
5
10
15 m

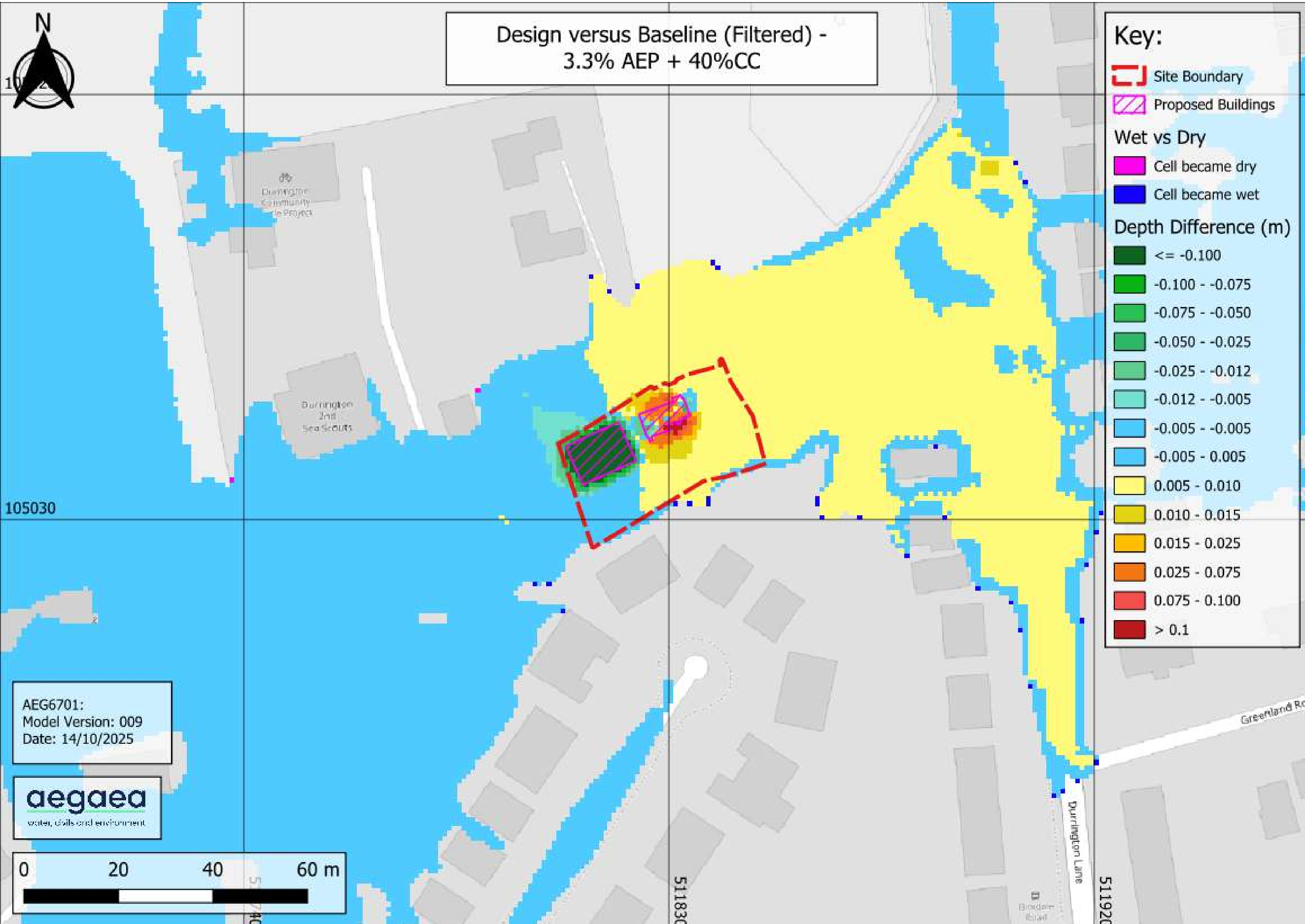


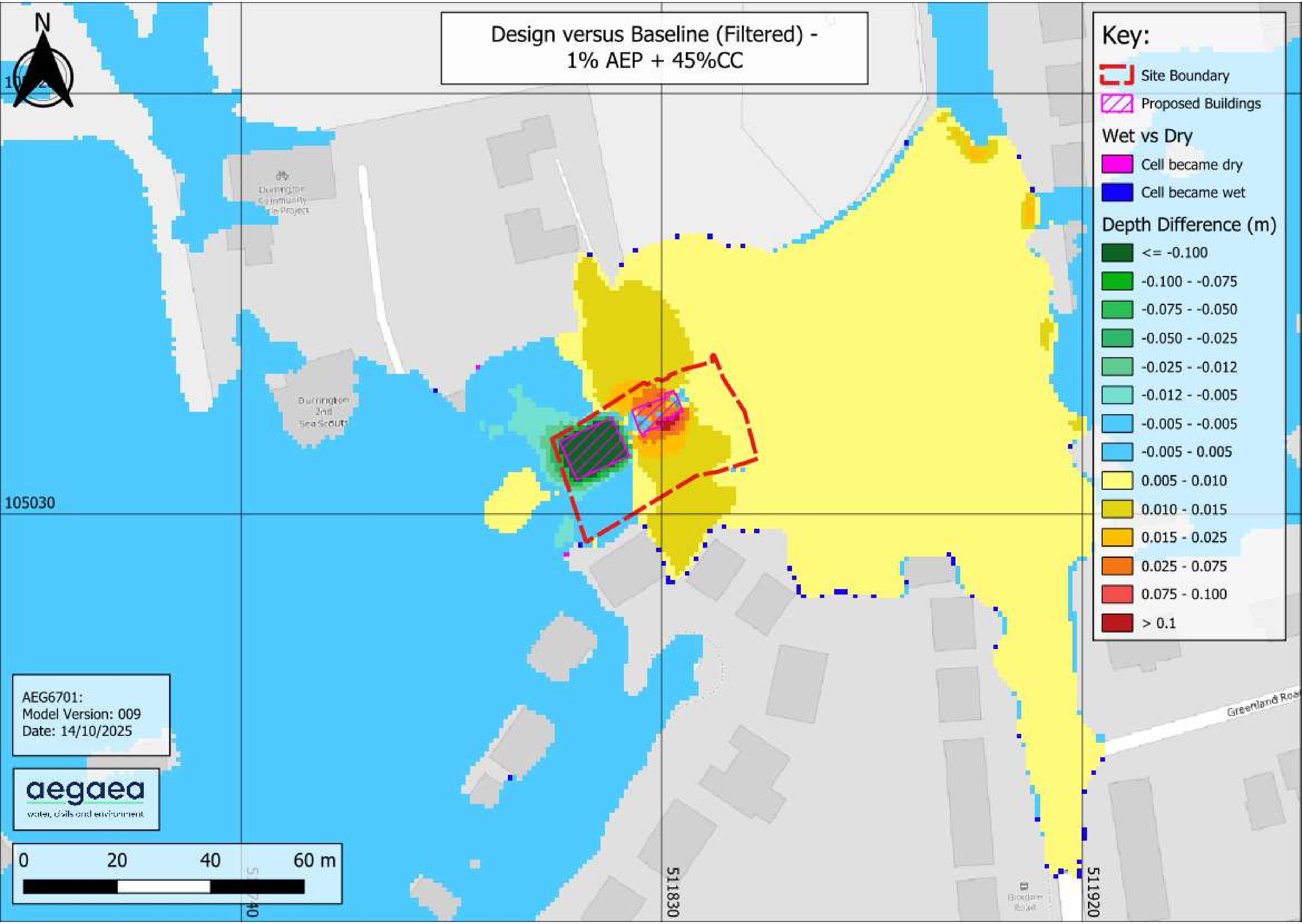
Maximum Modelled Design Flood Velocity Unfiltered - 0.1% AEP
N
Key:
Site Boundary
Proposed Buildings
Maximum Modelled Flood Velocity (m/s)
<= 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
> 2.00
105060
105040
105020
511800
511820
511840
511860
AEG6071:
Model Version: 009
Date: 18/09/2025
aegaea
water, civils and environment
0
5
10
15 m

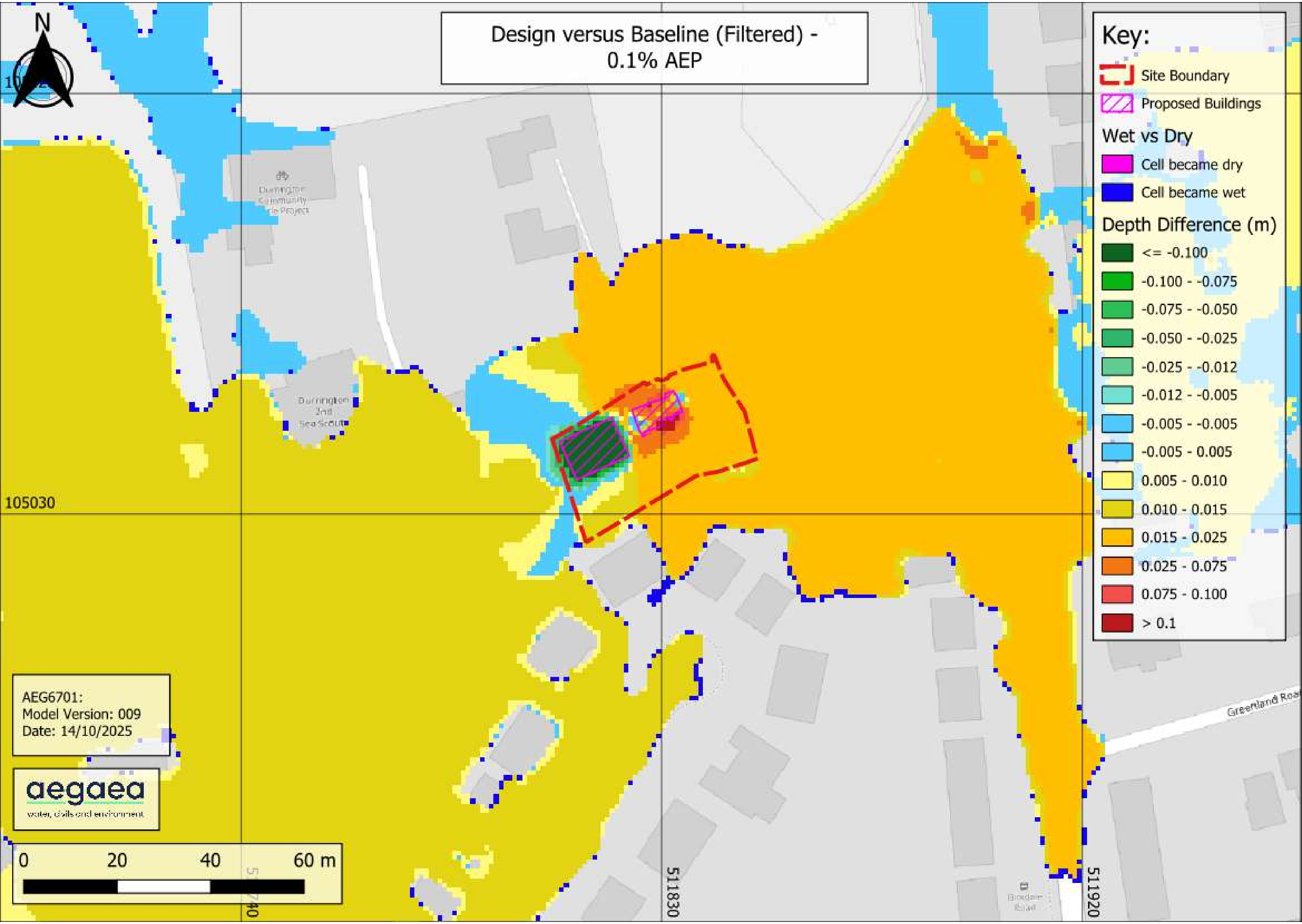

Design versus Baseline (Filtered) -
3.3% AEP
Key:
Site Boundary
Proposed Buildings
Wet vs Dry
Cell became dry
Cell became wet
Depth Difference (m)
<= -0.100
-0.100 - -0.075
-0.075 - -0.050
-0.050 - -0.025
-0.025 - -0.012
-0.012 - -0.005
-0.005 - -0.005
-0.005 - 0.005
0.005 - 0.010
0.010 - 0.015
0.015 - 0.025
0.025 - 0.075
0.075 - 0.100
> 0.1
AEG6701:
Model Version: 009
Date: 14/10/2025
aegaea
water, civils and environment
0
20
40
60 m
105030
511830
511920
Durrington Lane
Greenland Road
Durrington 2nd Sea Scouts
N



Design versus Baseline (Filtered) -
1% AEP
Key:
Site Boundary
Proposed Buildings
Wet vs Dry
Cell became dry
Cell became wet
Depth Difference (m)
<= -0.100
-0.100 - -0.075
-0.075 - -0.050
-0.050 - -0.025
-0.025 - -0.012
-0.012 - -0.005
-0.005 - -0.005
-0.005 - 0.005
0.005 - 0.010
0.010 - 0.015
0.015 - 0.025
0.025 - 0.075
0.075 - 0.100
> 0.1
N
105030
511830
511920
Durrington 2nd Sea Scouts
Durrington Lane
Greenland Road
AEG6701:
Model Version: 009
Date: 14/10/2025
aegaea
water, civils and environment
0
20
40
60 m

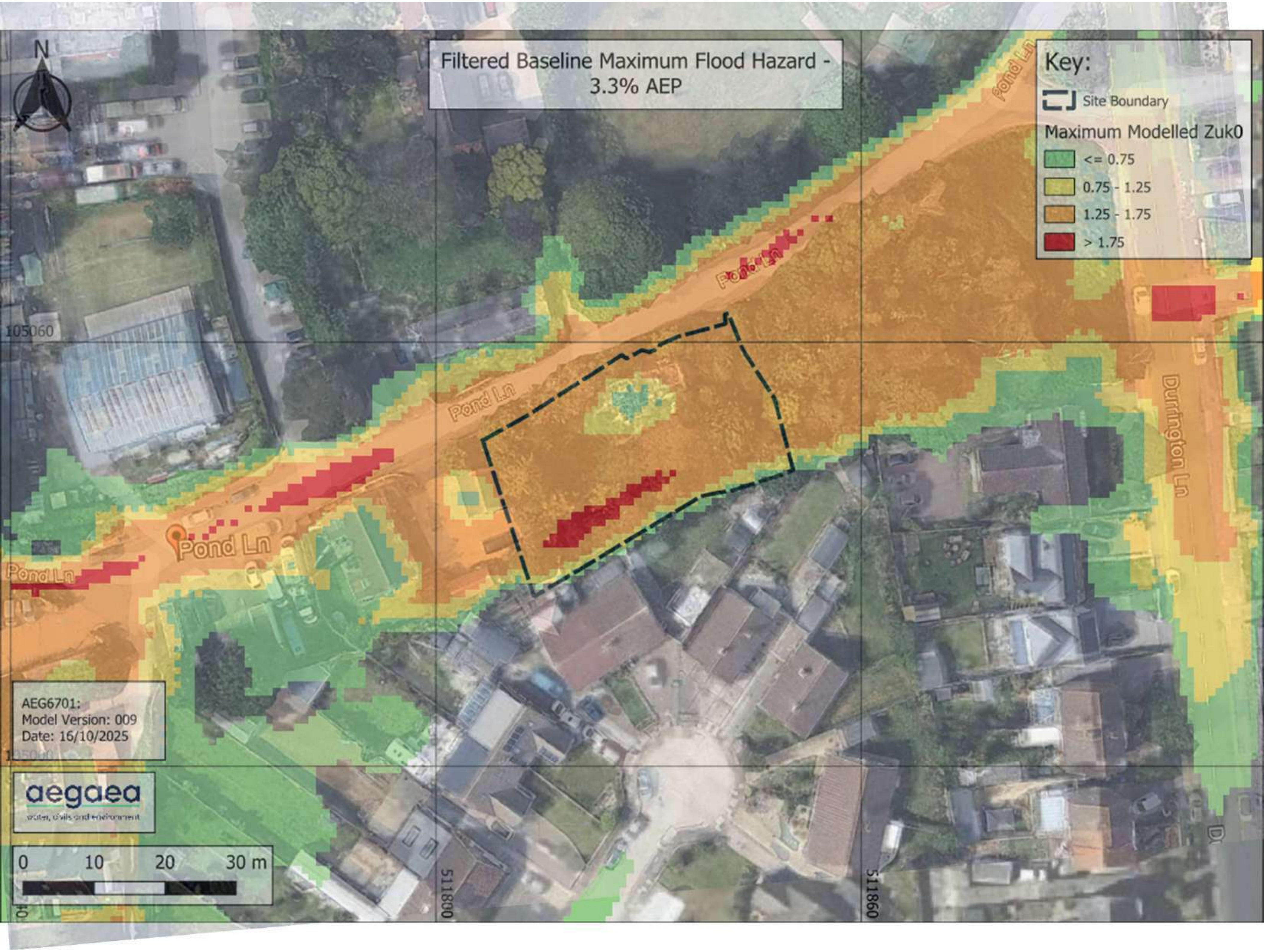

Design versus Baseline (Filtered) -
3.3% AEP + 40%CC
N
Key:
Site Boundary
Proposed Buildings
Wet vs Dry
Cell became dry
Cell became wet
Depth Difference (m)
<= -0.100
-0.100 - -0.075
-0.075 - -0.050
-0.050 - -0.025
-0.025 - -0.012
-0.012 - -0.005
-0.005 - -0.005
-0.005 - 0.005
0.005 - 0.010
0.010 - 0.015
0.015 - 0.025
0.025 - 0.075
0.075 - 0.100
> 0.1
105030
511830
511920
Durrington 2nd Sea Scouts
Greenland Road
Durrington Lane
AEG6701:
Model Version: 009
Date: 14/10/2025
aegaea
water, civils and environment
0
20
40
60 m


Design versus Baseline (Filtered) -
1% AEP + 45%CC
N
Key:
Site Boundary
Proposed Buildings
Wet vs Dry
Cell became dry
Cell became wet
Depth Difference (m)
<= -0.100
-0.100 - -0.075
-0.075 - -0.050
-0.050 - -0.025
-0.025 - -0.012
-0.012 - -0.005
-0.005 - -0.005
-0.005 - 0.005
0.005 - 0.010
0.010 - 0.015
0.015 - 0.025
0.025 - 0.075
0.075 - 0.100
> 0.1
105030
511830
511920
Durrington 2nd Sea Scouts
Greenland Road
AEG6701:
Model Version: 009
Date: 14/10/2025
aegaea
water, civils and environment
0
20
40
60 m

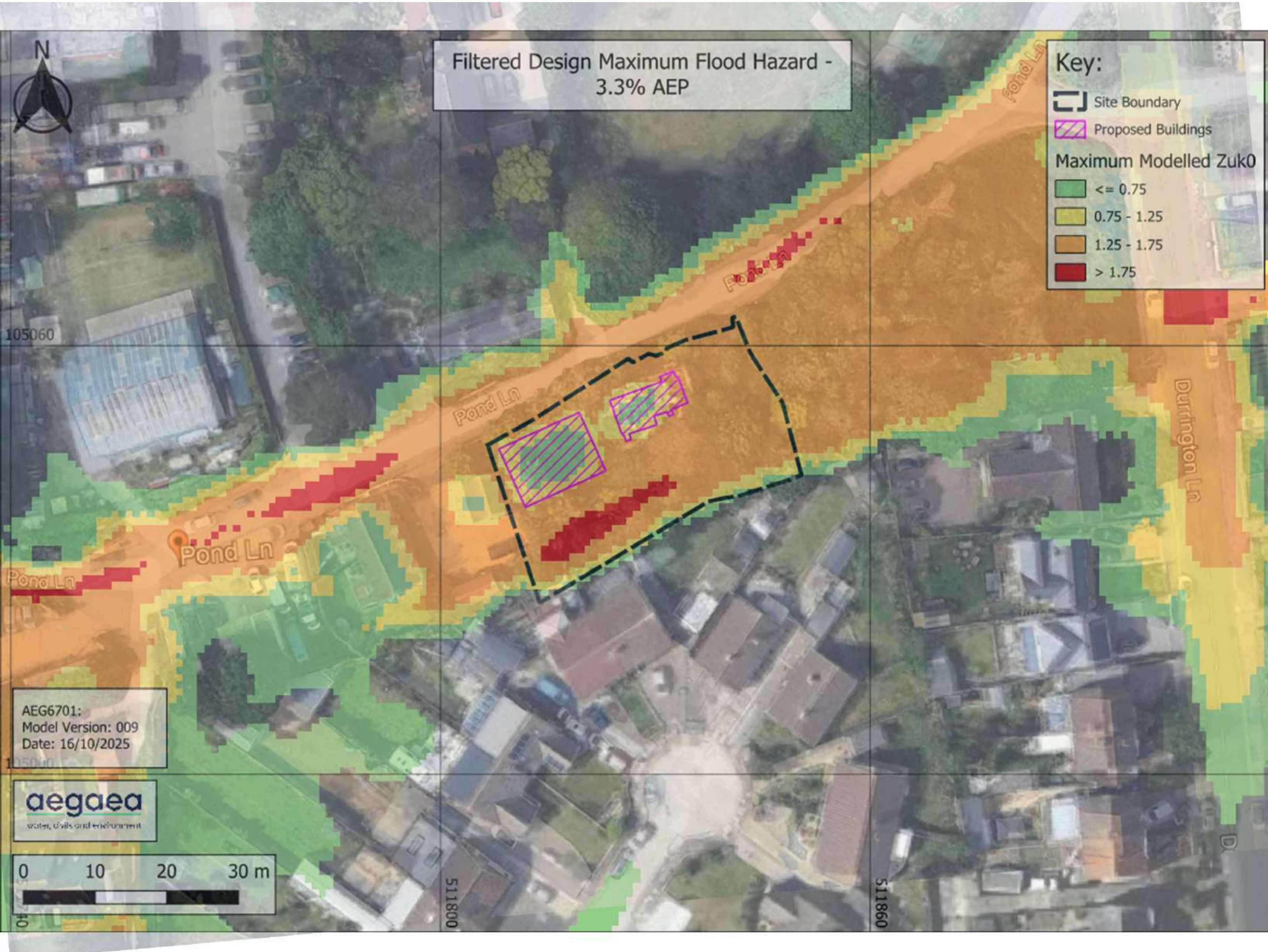


Design versus Baseline (Filtered) -
0.1% AEP
N
Key:
Site Boundary
Proposed Buildings
Wet vs Dry
Cell became dry
Cell became wet
Depth Difference (m)
<= -0.100
-0.100 - -0.075
-0.075 - -0.050
-0.050 - -0.025
-0.025 - -0.012
-0.012 - -0.005
-0.005 - -0.005
-0.005 - 0.005
0.005 - 0.010
0.010 - 0.015
0.015 - 0.025
0.025 - 0.075
0.075 - 0.100
> 0.1
105030
511830
511920
Greenland Road
AEG6701:
Model Version: 009
Date: 14/10/2025
aegaea
water, civils and environment
0
20
40
60 m

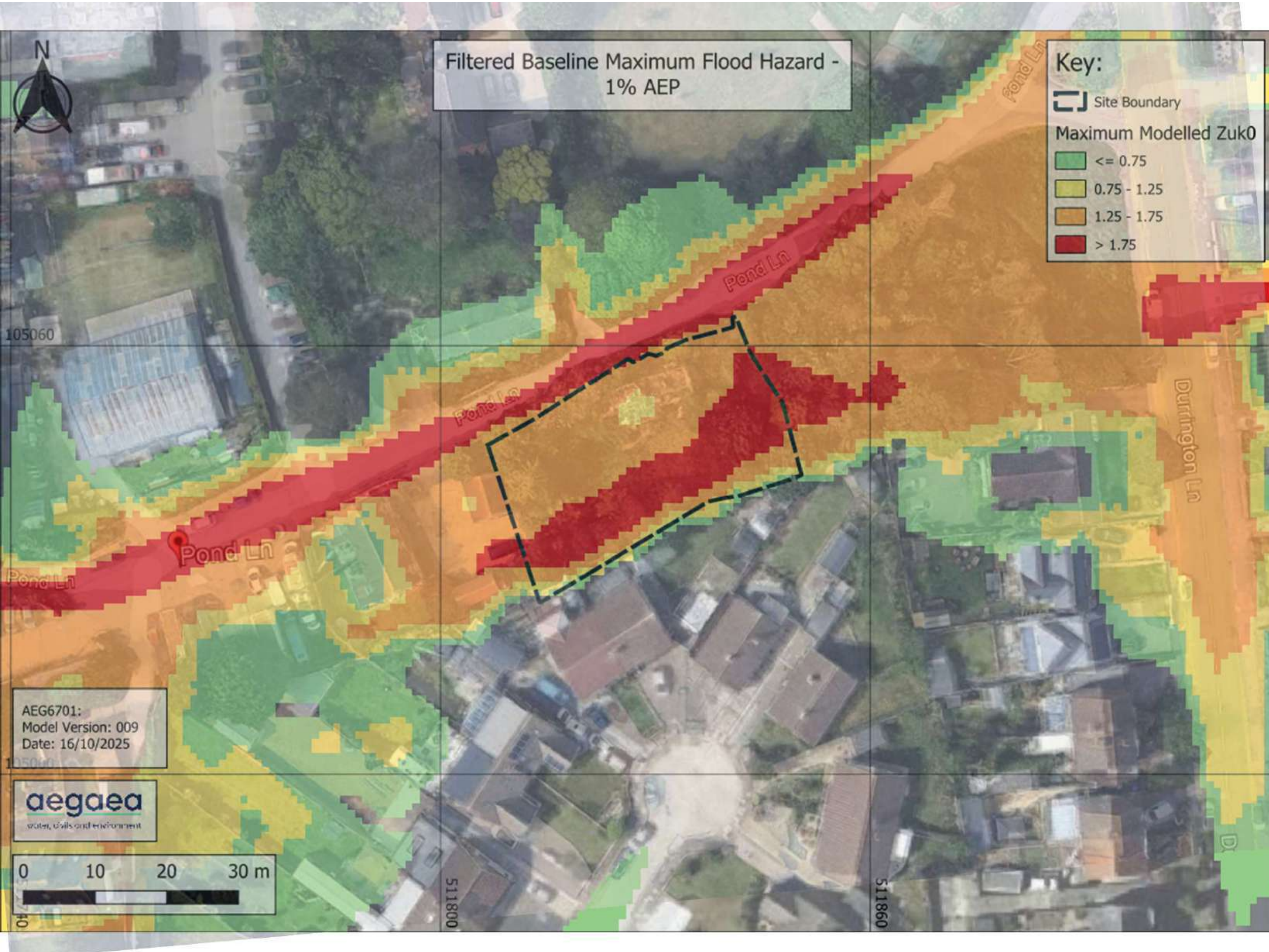
Appendix C Detailed TUFLOW Flood Hazard Mapping Outputs



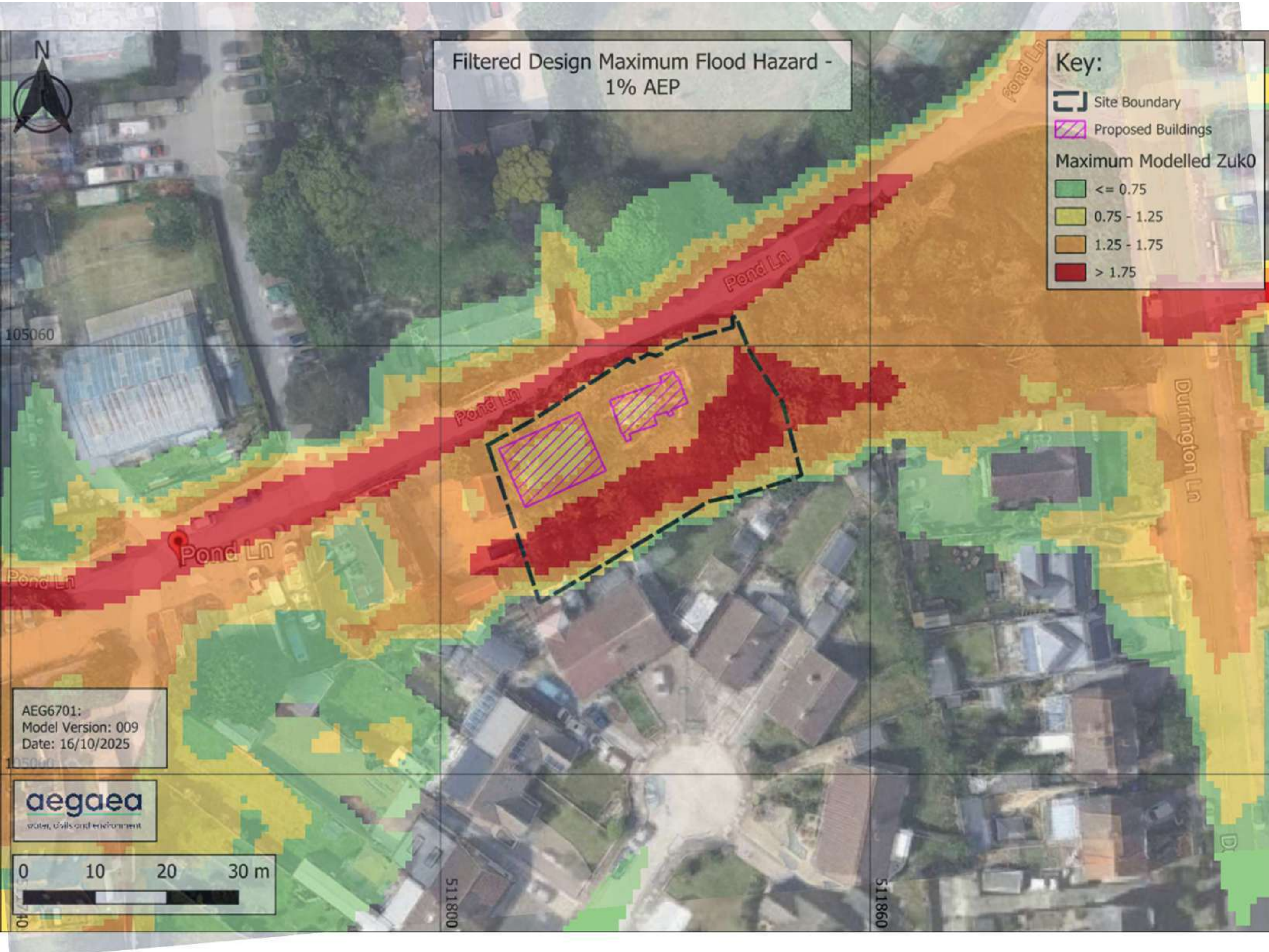
N
Filtered Baseline Maximum Flood Hazard - 3.3% AEP
Key:
Site Boundary
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Durrington Ln
105060
511800
511860
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
water, civils and environment
0 10 20 30 m

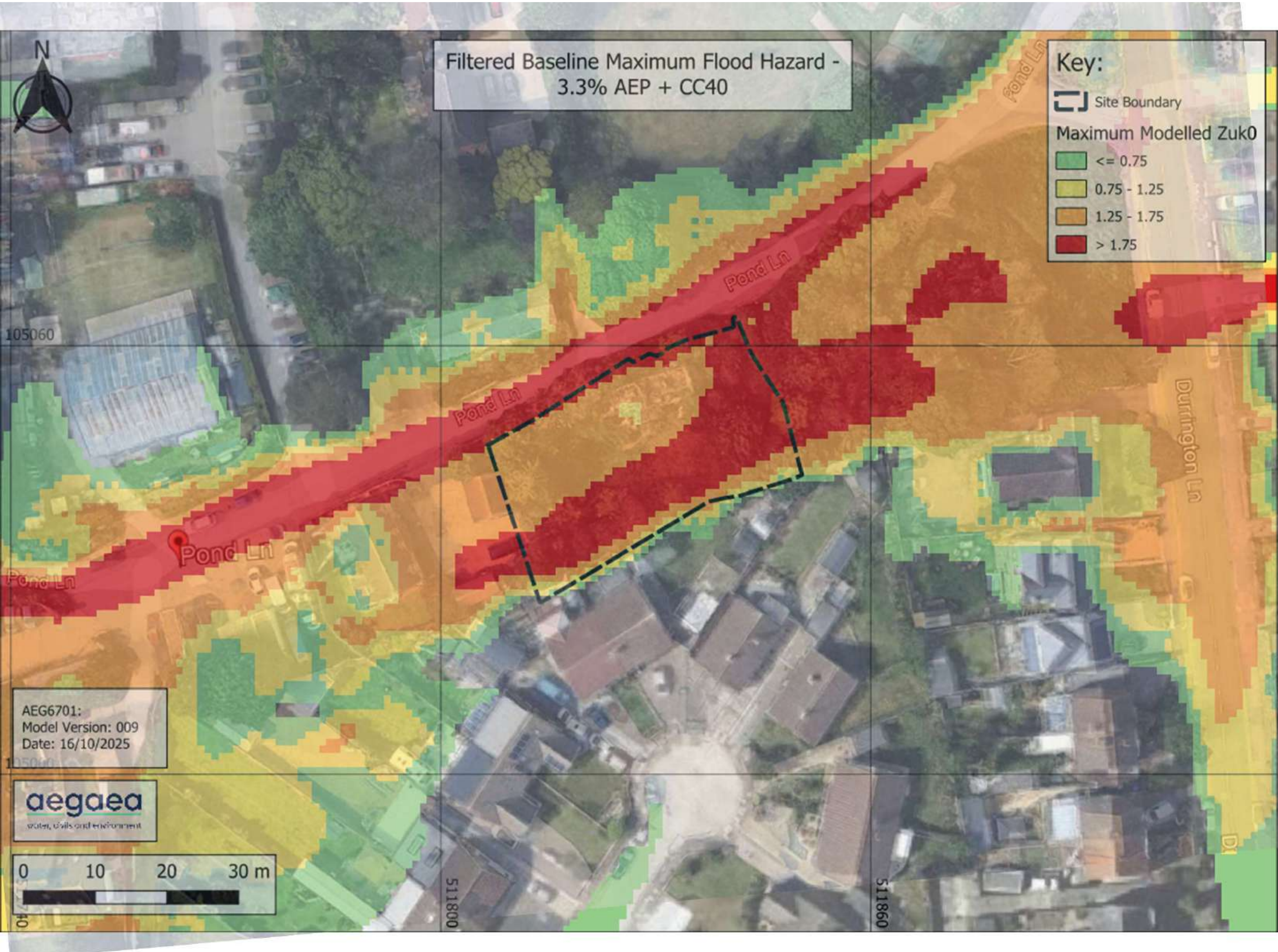


Filtered Design Maximum Flood Hazard - 3.3% AEP
N
Key:
Site Boundary
Proposed Buildings
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Durrington Ln
105060
511800
511860
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
water, civils and environment
0 10 20 30 m

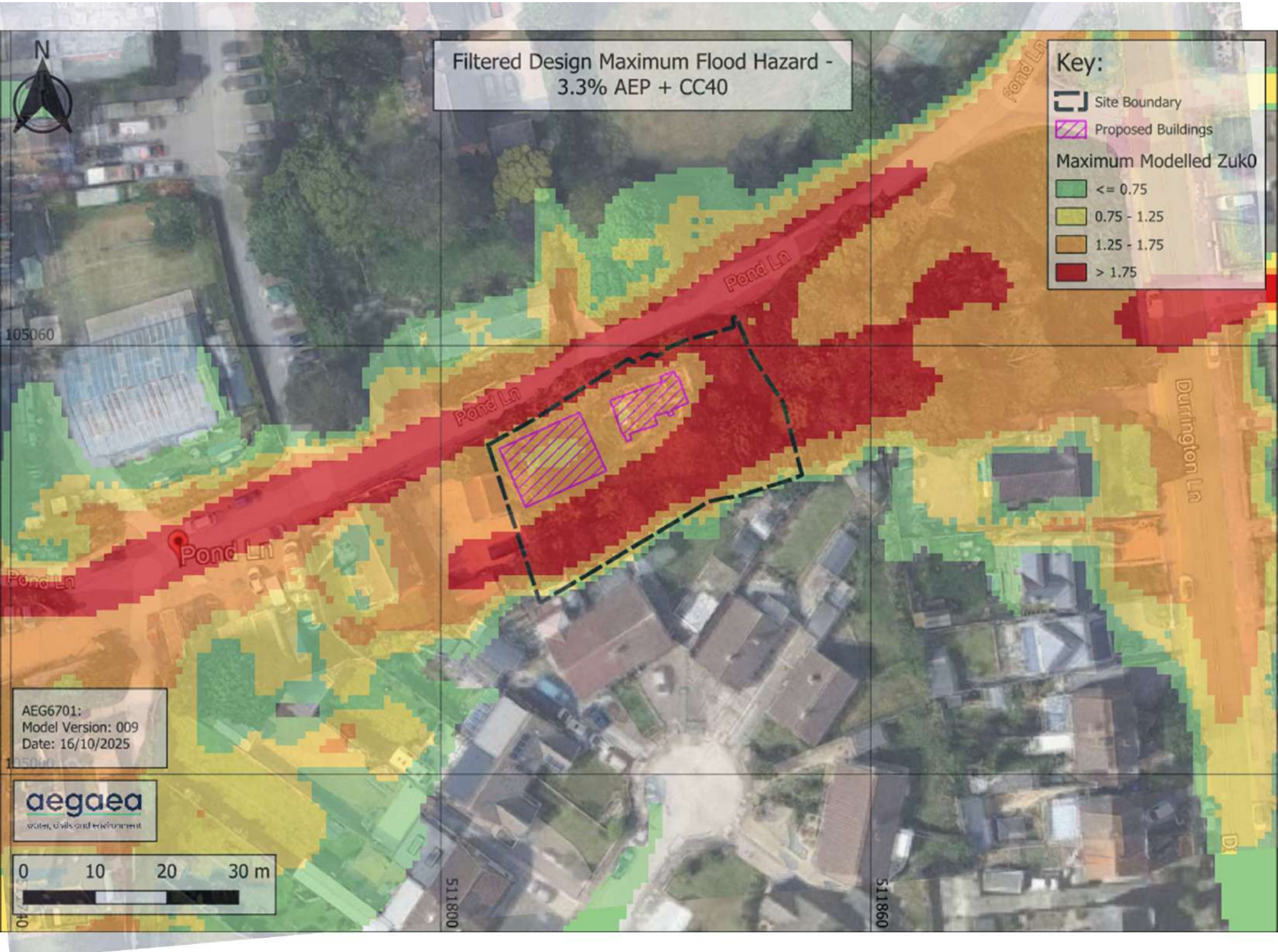


N
Filtered Baseline Maximum Flood Hazard - 1% AEP
Key:
Site Boundary
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Durrington Ln
105060
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
water, civils and environment
0
10
20
30 m
511800
511860

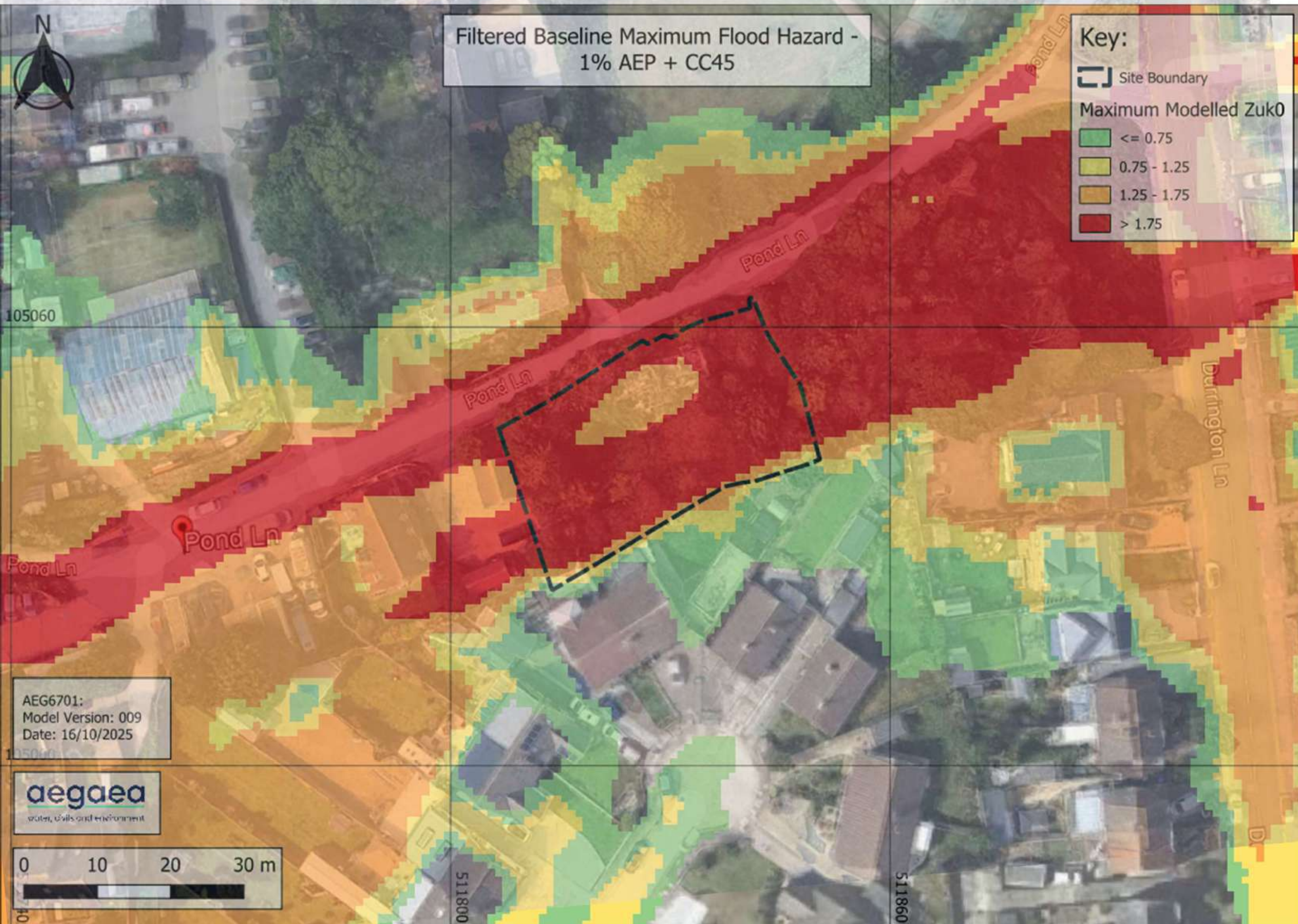

Filtered Design Maximum Flood Hazard - 1% AEP
N
Key:
Site Boundary
Proposed Buildings
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Durrington Ln
105060
511800
511860
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
0
10
20
30 m



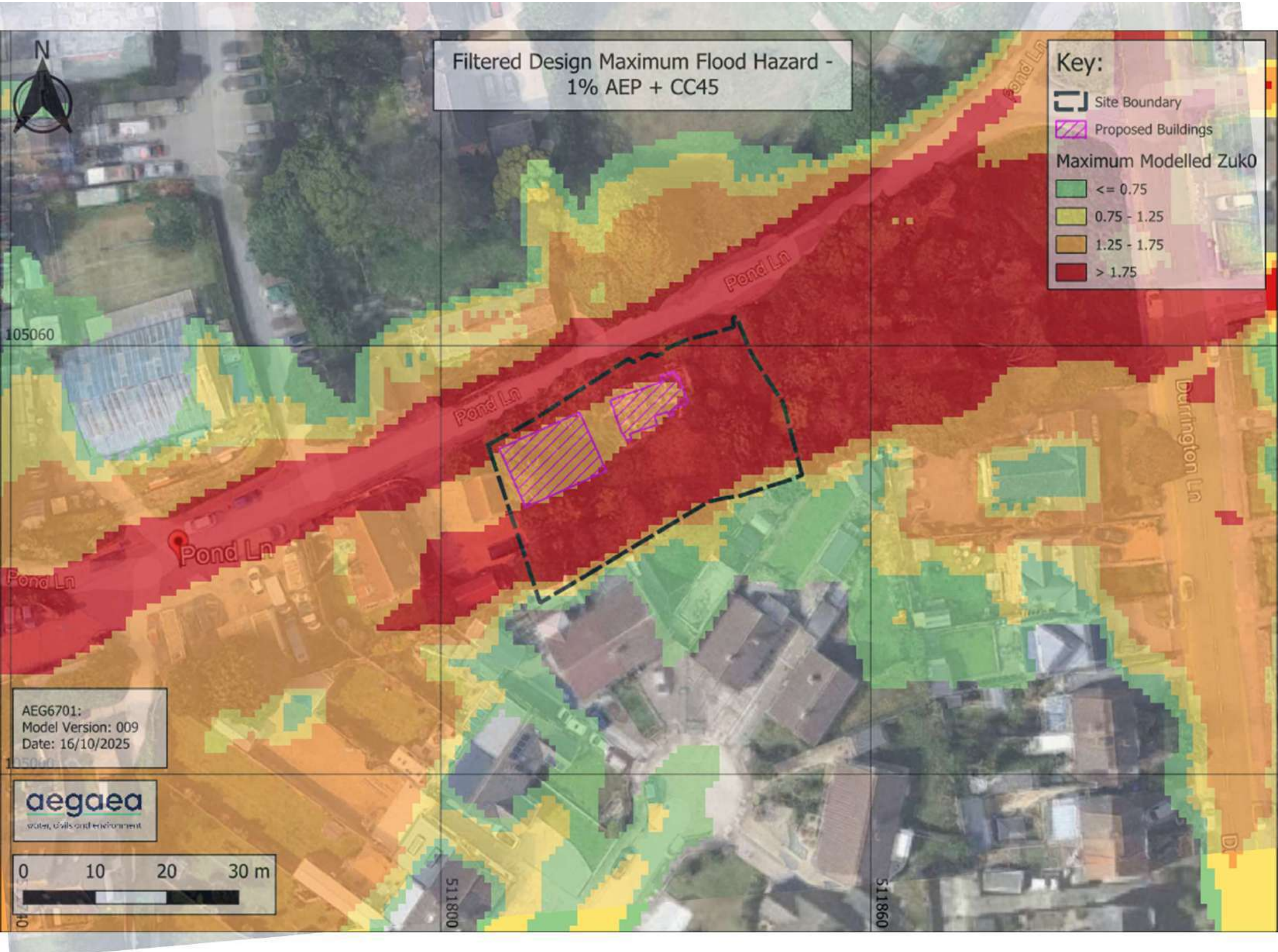
Filtered Baseline Maximum Flood Hazard -
3.3% AEP + CC40
N
Key:
Site Boundary
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Durrington Ln
105060
511800
511860
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
water, civils and environment
0
10
20
30 m



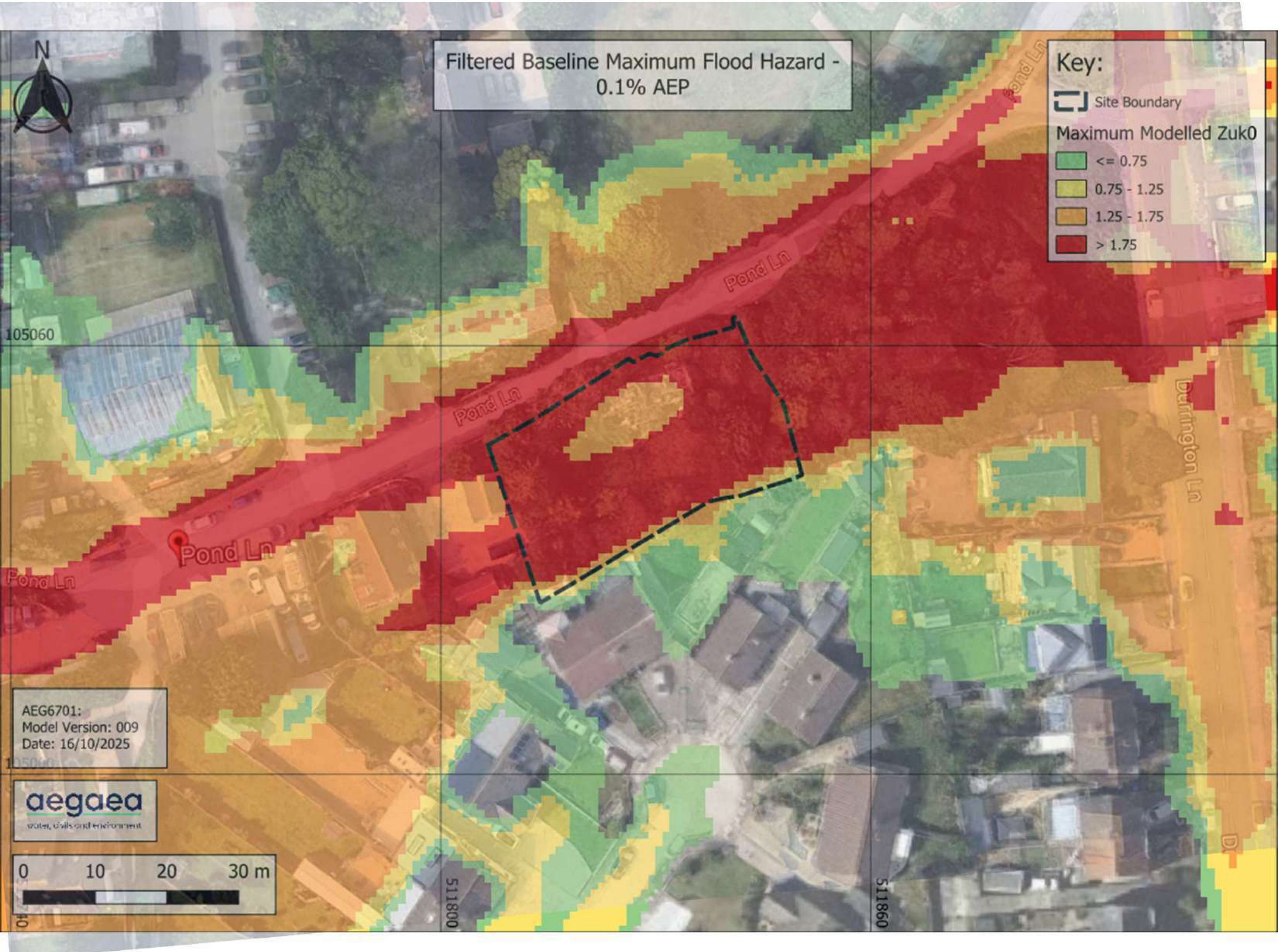
N
Filtered Design Maximum Flood Hazard -
3.3% AEP + CC40
Key:
Site Boundary
Proposed Buildings
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Durrington Ln
105060
511800
511860
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
water, civils and environment
0
10
20
30 m

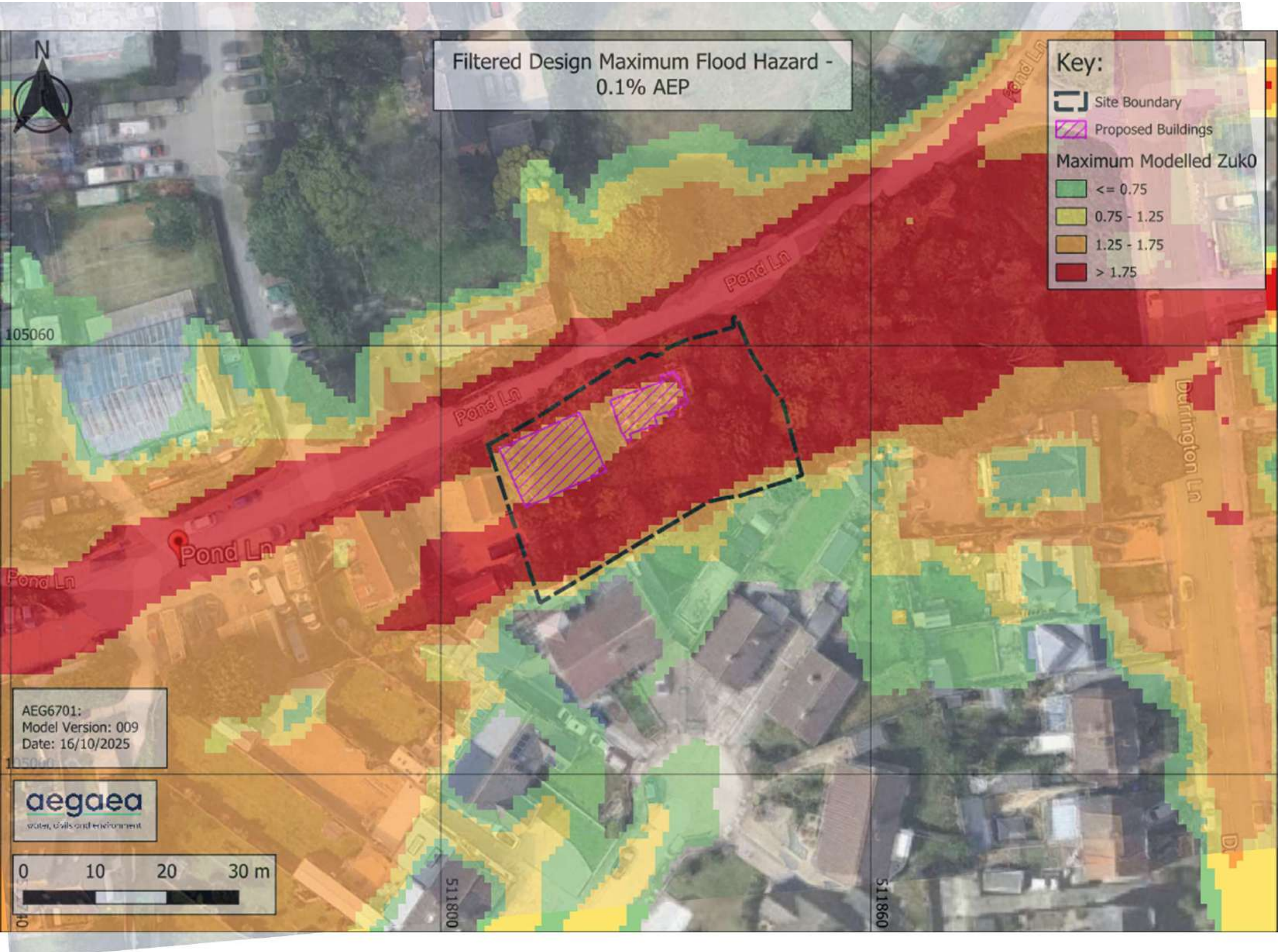


Filtered Baseline Maximum Flood Hazard -
1% AEP + CC45
Key:
Site Boundary
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
N
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Durrington Ln
105060
511800
511860
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
water, civils and environment
0
10
20
30 m



Filtered Design Maximum Flood Hazard - 1% AEP + CC45
Key:
Site Boundary
Proposed Buildings
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
N
Pond Ln
Durrington Ln
105060
511800
511860
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
water, civils and environment
0 10 20 30 m


N
Filtered Baseline Maximum Flood Hazard -
0.1% AEP
Key:
Site Boundary
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Pond Ln
Durrington Ln
105060
511800
511860
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
water, civils and environment
0
10
20
30 m



Filtered Design Maximum Flood Hazard - 0.1% AEP
N
Key:
Site Boundary
Proposed Buildings
Maximum Modelled Zuk0
<= 0.75
0.75 - 1.25
1.25 - 1.75
> 1.75
Pond Ln
Durrington Ln
105060
511800
511860
AEG6701:
Model Version: 009
Date: 16/10/2025
aegaea
water, civils and environment
0
10
20
30 m