

Thurrock Council

Level 1 Strategic Flood Risk Assessment

Appendix F: West Horndon Integrated Catchment
Modelling Report
Report Version 2

Thurrock Council

AECOM Project number: 60689110

September 2023

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1. Executive Summary

1.1 Background

Thurrock Council have commissioned AECOM to update their Strategic Flood Risk Assessment to provide an up-to-date assessment of flood risk from all sources. In accordance with the National Planning Policy Framework (NPPF) a Strategic Flood Risk Assessment (SFRA) should consider the cumulative impact of development on flood risk and identify opportunities to reduce the causes and impacts of flooding. This Technical Note refers to surface water flood risk in the West Horndon catchment area. Other sources of flooding are described in the SFRA Main Report.

Planning policy relating to the approach to sustainable drainage systems (SuDS) is evolving quickly, with the initial findings of the latest government review¹ recommending that SuDS be mandatory for all new developments in England to reduce the risk of surface water flooding, pollution and help alleviate pressures on our traditional drainage and sewerage systems. Thurrock Council specifically have a need to understand the potential impact of future development in the West Horndon area and in the River Mardyke catchment more generally, to determine the potential cumulative impact of development on surface water flood risk in this area. Thurrock Council also consider it prudent to assess the cumulative impact of development around the Tilbury Flood Storage Reservoir to demonstrate the need to preserve this asset.

Thurrock Council and AECOM have agreed a scope of services to undertake indicative modelling to better understand the potential cumulative impact of development on fluvial and surface water flood risk in these areas. The outcomes of the modelling will form part of the SFRA and may, where required, provide the necessary evidence to support the development of appropriate policies.

This report documents the hydraulic modelling of surface water (overland flow) undertaken for West Horndon. It is anticipated that this will form an appendix to the updated SFRA, part of the technical evidence base which will be used by Thurrock Council in the development of their Local Plan.

1.2 Summary of findings

In addition to the indicative assessment of potential cumulative impacts of development across the whole River Mardyke catchment documented in Appendix E, there is also a need to understand in more detail the potential impacts of development in the West Horndon and Bulphan area. This is in the upper (north-east) part of the Mardyke catchment and the 'Call for sites' shows several potential sites in that part of the catchment.

The Environment Agency 2019 River Mardyke modelling project included an update of a previous Infoworks ICM model for West Horndon which represents this area in more detail than the wider FM-TUFLOW model of the whole catchment. The Infoworks ICM model includes a representation of the surface water sewer network in the urban area and allows for a more detailed assessment of impacts of development in this part of the catchment. However, without incorporating details of the potential developments this is still an indicative assessment.

The 'direct rainfall' form of the West Horndon ICM model (rainfall applied directly to the 2D mesh across the whole model extent) was used for this study because it provides greater flexibility for representing the impacts of cumulative development in the catchment e.g. through changes in landuse affecting Manning's n roughness coefficients and runoff generation. To capture the impacts of potential development sites in this area, the existing model was extended south to cover Bulphan and the new development in the area. The extension area was modelled following the same principles as had been applied in the existing Environment Agency model.

Two sensitivity scenarios have been modelled to understand the flood risk impact of cumulative development and provide Thurrock Council with technical evidence showing the flood risk impact of potential changes in the landuse pattern across these catchments. As this is a strategic assessment (not site scale detail), assumptions have been made in consultation with Thurrock Council about the potential change in landuse pattern on the

¹ Defra, 10th January 2023, Policy paper: Sustainable drainage systems review
<https://www.gov.uk/government/publications/sustainable-drainage-systems-review>

assessment sites and the effect this has on the permeability / impermeability of the sites. This has been represented in the sensitivity scenarios by changing the roughness and infiltration zones in the model.

- Scenario 1: assumes on each of the assessment sites that 50% of potential development would be permeable surfaces and 50% impermeable surfaces.
- Scenario 2: assumes on each of the assessment sites that 10% of potential development would be permeable surfaces and 90% impermeable surfaces.

The scenario testing undertaken for West Horndon and Bulphan shows that if the potential development sites identified by Thurrock Council result in an increase in impermeable surfaces, without sufficient runoff control, there will be a cumulative impact and an increase in flood risk in this area

The areas where there is a predicted increase in flood risk because of cumulative development are generally in the south and west part of the model extent. The increase in flood depth is generally quite small compared to the predicted baseline flood depths. Some of the increase is seen around Bulphan village and also downstream (south) of the industrial area in West Horndon. The increase is greater in Scenario 2 when a higher proportion of the potential development sites area is assumed to be covered by impermeable surfaces.

Thurrock Council need to understand the potential cumulative impact of development around West Horndon and Bulphan on flood risk in the area. The modelling undertaken here demonstrates that cumulatively, development on these sites which results in an increase in impermeable surfaces could increase flood risk.

It is therefore recommended that Thurrock Council consider policies in the Local Plan, supported by this SFRA evidence base, that would reduce runoff from new development sites to avoid an increase in flood risk compared to baseline conditions. If this is sufficiently managed on each development site, the potential cumulative impacts shown in this assessment could be avoided.

2. Context

- 2.1.1 In order to inform their SFRA Thurrock Council are seeking to understand in more detail the potential impacts of development in the West Horndon and Bulphan area. This is in the upper (north-east) part of the Mardyke catchment and the 'Call for sites' shows several potential sites in that part of the catchment.
- 2.1.2 There have been previous Environment Agency modelling studies of the River Mardyke catchment for flood mapping, most recently the PDU4 Mardyke Project. The modelling report was completed in May 2019² and incorporated three models:
- 2D modelling of Barnards Sewer tributary (less urbanised) for flood zone map updates
 - Updated Infoworks ICM model of West Horndon village to derive flood extents; and
 - 1D-2D modelling (Flood Modelling – TUFLOW) of the main River Mardyke
- 2.1.3 The Infoworks ICM model for West Horndon represents the area of interest in more detail than the wider FMP-TUFLOW model of the whole River Mardyke catchment. The Infoworks ICM model includes a representation of the surface water sewer network in the urban area and would allow for a more detailed assessment of impacts of development in this part of the catchment, though this remains an indicative assessment as the model does not incorporate details of the potential developments.
- 2.1.4 This report describes how the existing West Horndon ICM model has been extended and used for the indicative assessment and sensitivity testing as part of this SFRA.

² Environment Agency (Mott MacDonald) PDU4 Mardyke Model Report. Hydraulic Modelling Report *River Mardyke Hydraulic Modelling Report 393325BF_03_B_noID*. Pdf May 2019

3. Modelling Approach

3.1 Existing Model

- 3.1.1 The West Horndon Optioneering and Detailed Design model developed by Jacobs in 2017 was used in the Environment Agency 2019 River Mardyke modelling project and then provided by the Environment Agency for use by Thurrock Council. The model has been extended and updated as part of this study to meet the SFRA objectives.
- 3.1.2 The West Horndon ICM model was provided in two different forms, with different boundary setups representing inflows into the model. One form of the model has ReFH2 inflow hydrographs derived through hydrological analysis and applied at key points where runoff was expected to enter the study area. The other form of the model has direct rainfall applied directly to the 2D mesh across the whole model extent. This direct rainfall form of the InfoWorks ICM model was used for this project as it provides greater flexibility for representing the impacts of cumulative development in the catchment e.g., through changes in landuse affecting Manning's n roughness and runoff generation.
- 3.1.3 To capture the impacts of potential development sites in this area, the existing InfoWorks ICM model was extended south to cover Bulphan and the potential new development in this area. The extension area was modelled following the same principles as had been applied in the existing Environment Agency model.

3.2 Baseline Model Update

- 3.2.1 Table 3-1 shows the updates made to the existing Environment Agency InfoWorks ICM West Horndon model for this project, including the extension of the model around Bulphan to capture potential development sites.

Table 3-1 West Horndon – Key updates to InfoWorks ICM model

Updates made	Assumptions / limitations
Model extended to include Bulphan and all potential development areas around West Horndon, as shown in Figure 3-1	The 2D Zone that covered a limited area in the previous study has been extended to cover the entire catchment and Bulphan.
OSMM (Ordnance Survey MasterMap) data was used to define land use types across the 2D mesh for applying roughness values and fixed runoff coefficients via roughness zones (RZ) and infiltration zones (IZ), respectively.	The roughness values and fixed runoff coefficients for different landuse types are based on previous experience and are applied to Roughness Zones and Infiltration Zones (IZ), respectively.
Table 3-2 shows that the Manning's roughness values and runoff coefficients are based on the standard guidance³. The roughness and infiltration zones were altered from those initially derived from the OSMM at a single location where new development has occurred, in consultation with Thurrock Council. Figure 3-3 shows the location where the roughness and infiltration zones were modified. Polygons representing the new buildings, roads and general surface (manmade) were used to reflect the existing features of new developments. The same roughness values and runoff coefficients in Table 3-2 were used to represent the new buildings, roads and general surface (manmade).	
A maximum triangle area and minimum element area of 100m ² and 25m ² , has been applied in the existing study, compared to a minimum element area of 3m ² from the previous study. Also, the maximum height variation has been reduced to 0.25m from 1m to refine the mesh representation of the drains and other linear features in the DTM data. Rainfall has been applied across the whole model extent, as in previous study.	Any smaller elements less than 0.1m ² have been removed by adjusting the geometry in RZ, MZ, MLZ.
Mesh zone polygons (MZ), porous polygons (PP) and mesh level zones (MLZ) applied in the previous study have been deleted. In the current study, the mesh has been forced to align with buildings, roads, railways, and drains (OSMM feature codes 10021, 10172, 10167 and 10089, respectively). In addition to this, features along the railway have been enforced to the mesh. Figure 3-2 shows the mesh zones in the newly extended model, which have been digitised to cover West Horndon and Bulphan with 5m ² and 2m ² as maximum and minimum element areas, respectively.	Mesh resolution could be improved further by modelling it in a finer resolution. Drains, roads, buildings, and railways are aligned to the mesh in the present study and the mesh representation is considered suitable for this SFRA. No initial conditions in 2D are assumed in the ponds/reservoirs in the upstream catchment.
1m resolution LiDAR DTM (Digital Terrain Model) data flown in 2020 was used	
Initially, a total rainfall hyetograph was applied to the model, not accounting for rainfall losses. The runoff coefficients are applied in the infiltration zones (IZ) to account for the losses.	
Normal depth boundaries are applied wherever water leaves the system.	This assumption is considered a suitable approach for a rain-on-mesh model for this purpose.
1D network – This section describes updates in 1D model schematisation for the baseline scenario. The 1D component consists of stormwater network, and culverts; no other system type has been represented in the model. The representation of the stormwater network has not been changed from the Jacobs 2017 study except the following: US (upstream) and DS (downstream) headloss type of the culverts have been changed to 'FIXED' with US and DS coefficients as 0.5 and 1, respectively;	There are structures missing underneath the embankment on the surface flow paths, and the urban area is not completely covered by the drainage network.

³ http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

Updates made

- Culvert inverts at a few locations have been changed to match the ground level and a mesh level zone has been created at both the ends to avoid instabilities for water entering and leaving the culverts; and
- 1D-2D linkage basis has been changed to 'Depth' wherever applicable to avoid oscillations.

Hydrology:

The hydraulic model used in the present project requires direct rainfall hyetographs of various storm durations to be applied to the mesh elements within the surface model in the software. The FEH 2013 rainfall DDF model was used to estimate total rainfall depths for the 3.33%, 1% and 0.1% AEP events and for the 7-hours, 11-hours, 15-hours, and 19-hours storm durations. The ReFH2.3 software was then used to create a design event hyetograph storm profile, for the winter season (this catchment did not reach the urbanisation threshold above which a summer storm profile is recommended).

To generate the storm event profiles for this project, a set of catchment descriptors was purchased from the FEH web service at the 3 outfall locations before joining Mardyke. Figure 3-4 shows the combined catchment area for these three locations which aligns to the new model extent. Table 3-3 shows the outfall coordinates where the catchment descriptors were extracted.

The total area of the 3 catchments is 37.89km² with a Standard Average Annual Rainfall (SAAR) of 564mm. The catchment descriptors of these three catchments were averaged and then used in ReFH2.3 to derive the hyetographs. The rainfall was distributed uniformly when applied in the hydraulic model. Areal and seasonal reduction factors were different for different storm durations.

The total rainfall depths for all the AEP events and storm durations are summarised in Table 3-4. The typical hyetographs for the winter season 15-hour storm duration for all the three AEP events are shown in Figure 3-5.

A critical storm analysis was performed for 1% AEP event for winter profile of 7-hours, 11-hours, 15-hours, and 19-hours storm durations. Based on the modelled flood extents for all the durations and hydrological analysis, 15-hours storm duration was chosen as the critical duration. In the previous study, winter profile of 15.5-hours was used.

Highway drainage infrastructure is not represented in the ICM model.

Assumptions / limitations

No initial conditions in 2D are assumed in the ponds/reservoirs in the upstream catchment.

The critical storm duration can be checked again in future study by adding structures wherever necessary. In the present study, summer season was not compared against the 15-hours winter season. Also, models can be simulated for a range of other durations too and by further reducing the time interval.

This is a conservative approach that shows surface flooding on the highways but is considered an appropriate approach considering this is an SFRA

Figure 3-1 West Horndon – Updated Model Schematic

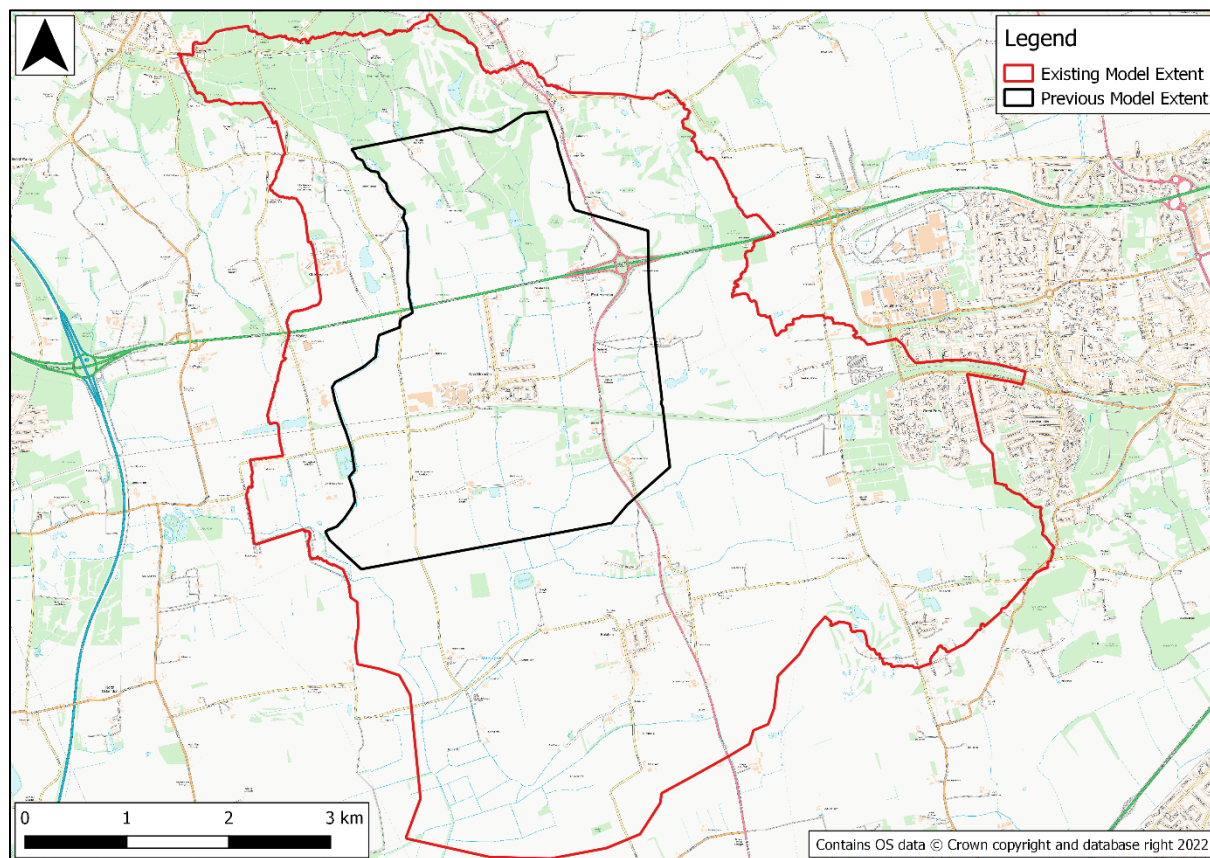


Figure 3-2 West Horndon – Mesh Zones

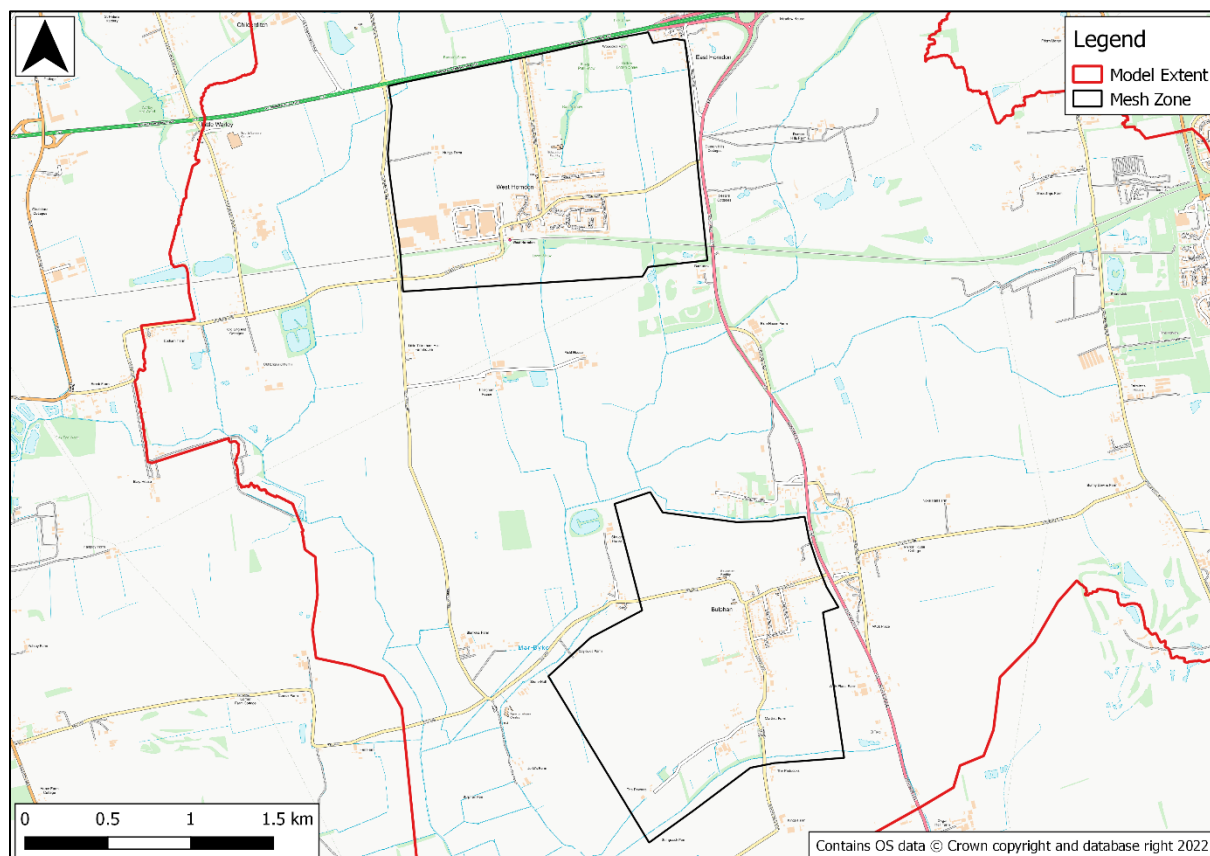


Figure 3-3 West Horndon – Refined Roughness and Infiltration Zones

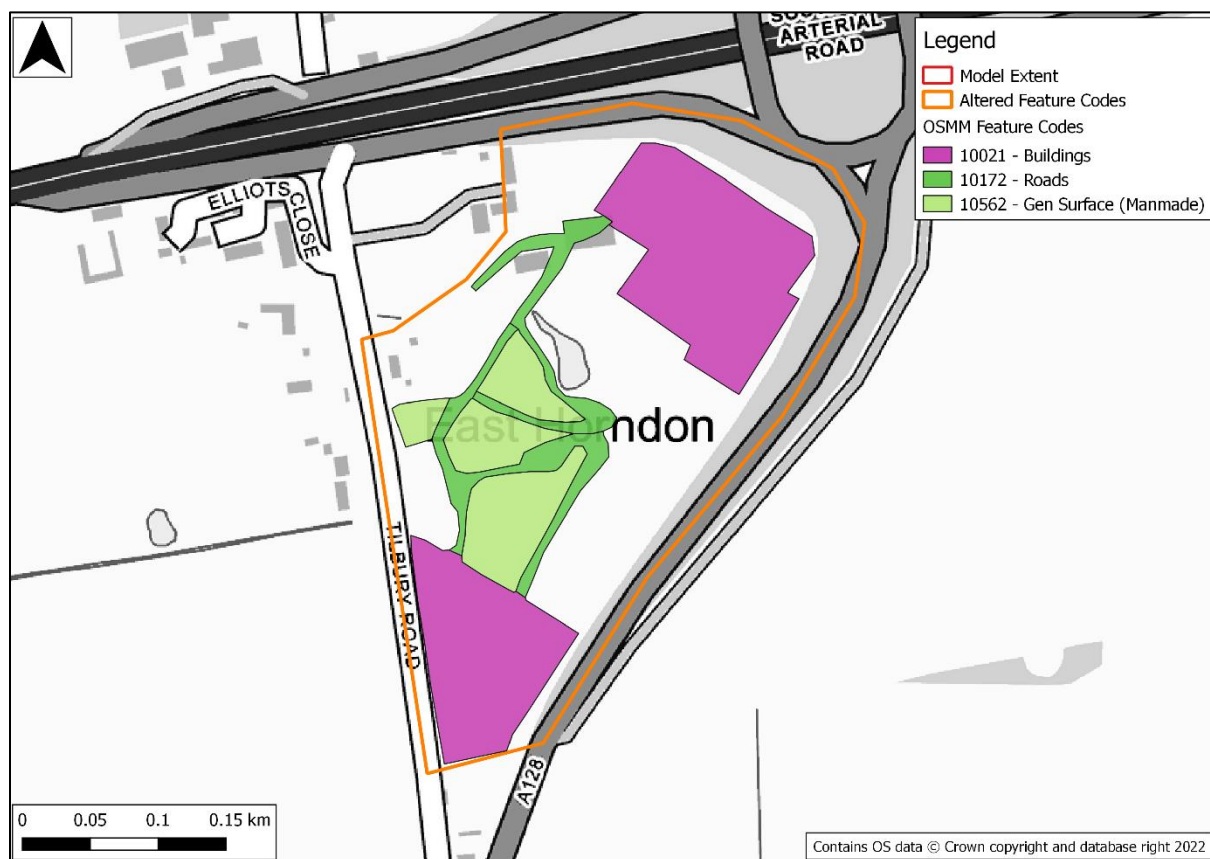


Table 3-2 West Horndon – Manning's 'n' and Runoff Coefficients, assigned by OSMM landuse type

Feature Code	Landuse Type	Manning's 'n'	Runoff Coefficient	Type of Surface
10021	Building	1	0.9	Impermeable
10053	General Surface (Multi Surface)	0.05	0.5	Impermeable
10054	General Surface (Step)	0.025	0.8	Impermeable
10561	General Surface (Grass, parkland)	0.035	0.2	Permeable
10562	General Surface (Manmade)	0.025	0.85	Impermeable
10062	Glasshouse	1	0.9	Impermeable
10089	Inland Water	0.02	1	Impermeable
10096	Landform (Slope)	0.05	0.4	Impermeable
10099	Landform (Cliff)	0.05	0.4	Impermeable
10111	Natural Environment	0.07	0.2	Permeable
10119	Path (Step)	0.025	0.85	Impermeable
10123	Path	0.025	0.75	Impermeable
10167	Rail	0.035	0.35	Permeable
10172	Road or Track	0.025	0.85	Impermeable
10183	Roadside	0.025	0.85	Impermeable
10185	Structure	0.025	1	Impermeable
10203	Tidal Water (Foreshore)	0.02	1	Impermeable
10210	Tidal Water	0.02	1	Impermeable
10217	Unclassified	0.025	0.85	Impermeable

Figure 3-4 West Horndon – Combined Catchment

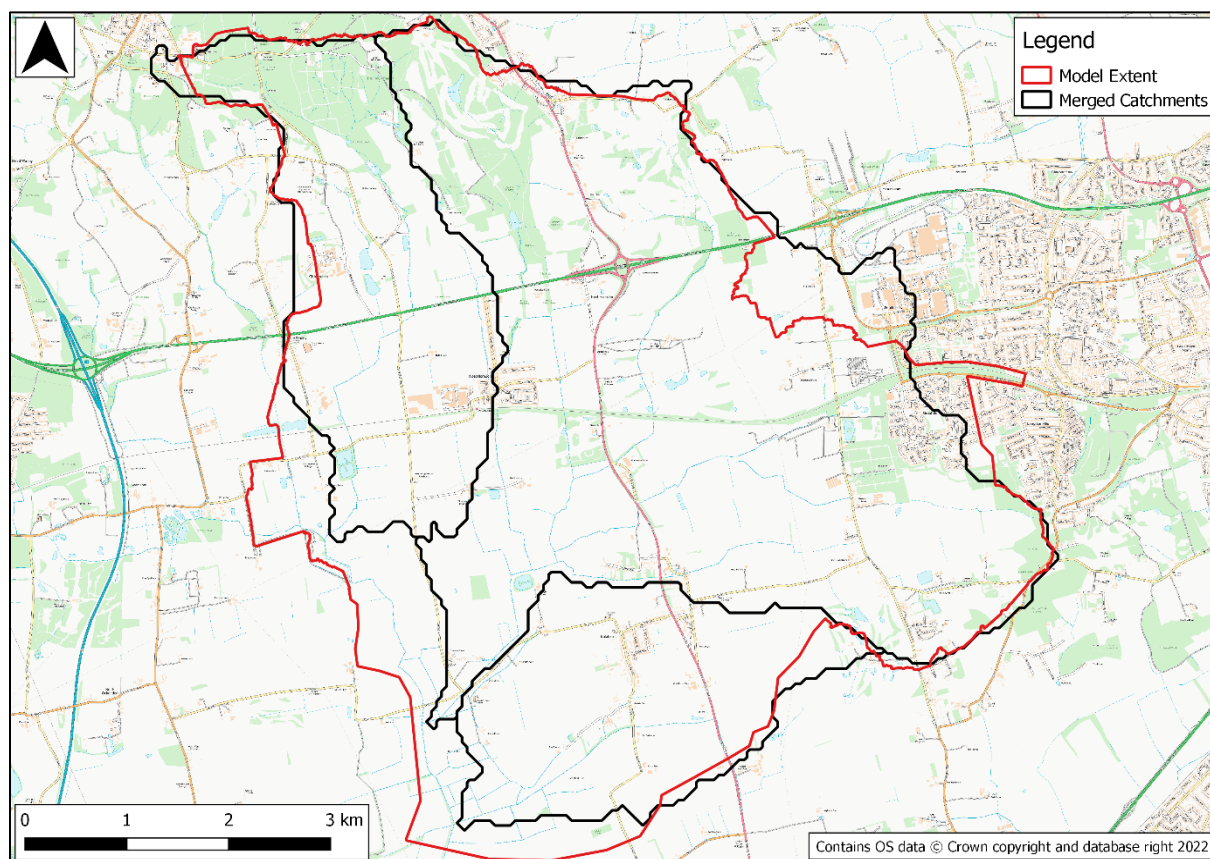


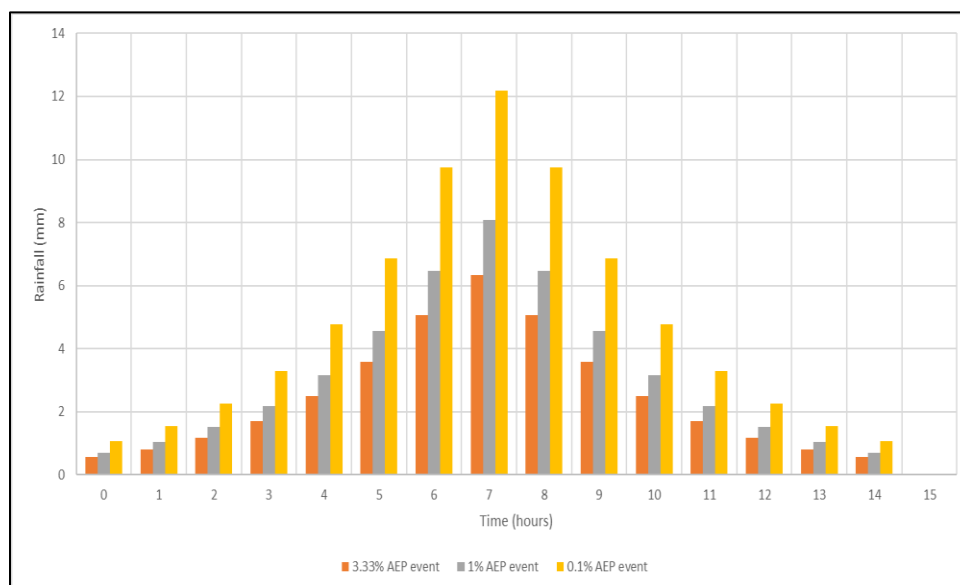
Table 3-3 West Horndon – Outfall coordinates

NGR (National Grid Reference)	Easting	Northing
TQ 60900 86800	560900	186800
TQ 61850 84950	561850	184950
TQ 62150 83950	562150	183950

Table 3-4 West Horndon – Total rainfall depths (FEH2013 DDF model)

Storm duration	Total rainfall depths in mm for AEP events		
	3.3%	1%	0.1%
7hr	30.37	39.75	62.46
11hr	34.27	44.21	67.67
15hr	37.13	47.39	71.35
19hr	39.44	49.94	74.30

Figure 3-5 West Horndon – 15hr storm duration total rainfall depths



3.3 Modelled Events and Scenarios

3.3.1 The models have been simulated for the events and scenarios as shown in Table 3-5.

- Scenario 1: assumes on each of the assessment sites that 50% of the development would be permeable surfaces and 50% impermeable surfaces.
- Scenario 2: assumes on each of the assessment sites that 10% of the development would be permeable surfaces and 90% impermeable surfaces.

3.3.2 This has been represented in the sensitivity scenarios by changing the roughness and infiltration zones in the model.

3.3.3 A critical storm analysis was performed for 1% AEP event for winter profile of 7-hours, 11-hours, 15-hours, and 19-hours storm durations. Based on the modelled flood extents for all the durations and hydrological analysis, 15-hours storm duration was chosen as the critical duration. (In the previous study, winter profile of 15.5-hours was used).

3.3.4 The two scenarios were then simulated for 3.33%, 1% and 0.1% AEP design events for the 15hr storm duration. A winter storm profile was adopted for all these scenarios.

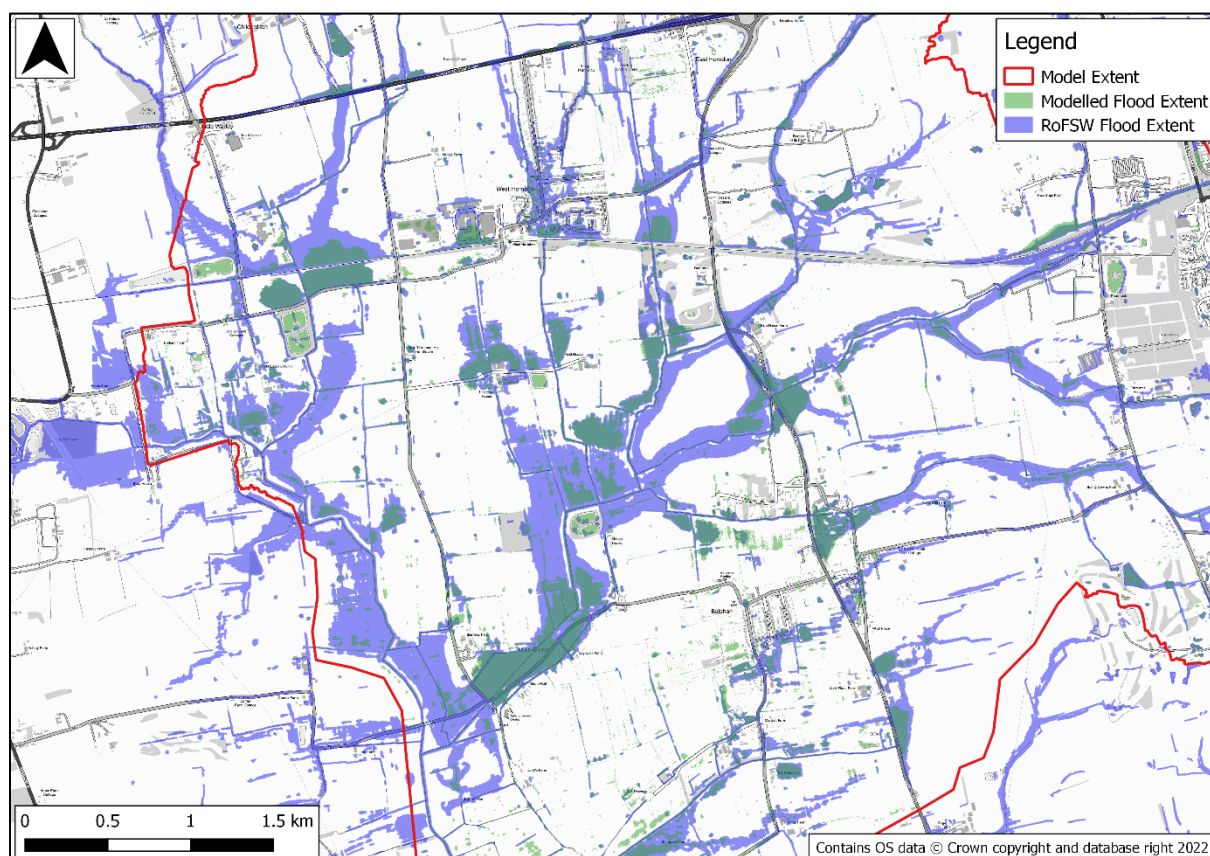
Table 3-5 West Horndon – Modelled Events and Scenarios

Scenarios/Events	Baseline	Scenario 1	Scenario 2
3.33%, W15hr	√	√	√
1%, W15hr	√	√	√
0.1%, W15hr	√	√	√
1%, W07hr	√		
1%, W11hr	√		
1%, W19hr	√		

3.4 Model Performance and Results

- 3.4.1 For 1D-2D models, InfoWorks ICM software developers⁴ recommend the Volume Balance Error Percentage (VBEP) to be within +/-5%. Numerical performance has been checked for all the AEP events and the Log Results show that the VBEP is within +/-5%. For example, for the 1% AEP event simulated for a 15-hours winter storm duration, a VBEP of 0.01% was achieved for the baseline scenario.
- 3.4.2 Additionally, the node results grid was checked for maxima and it was observed that Volume Balance (%) had a few nodes beyond the threshold of +/-1% for all the AEP events, but this is not a significant concern because the volume (m³) in those nodes are less than 1m³ for all the AEP events.
- 3.4.3 There was limited information available on historical flood events and not sufficient data to calibrate the model to previous flood events. The model was verified against the Environment Agency Risk of Flooding from Surface Water (RoFSW). Figure 3-6 shows the comparison of flood extents between the modelled and RoFSW for the 1% AEP events. The modelled flood extent from this study is generally smaller than the RoFSW flood extent, this is attributed to the difference in the modelling approach. The more detailed modelling approach used in this project has a more refined representation of runoff and infiltration and also includes a representation of the surface water sewer system, where this exists in West Horndon. The effect of this is to show less risk of surface water flooding than in the conservative RoFSW flood extent.

Figure 3-6 West Horndon – Modelled and RoFSW Flood Extents comparison for 1% AEP event



Baseline Model Results

- 3.4.4 Figure 3-7, Figure 3-8 and Figure 3-9 show the maximum flood depths for 3.3%, 1%, and 0.1% AEP events and 15-hours critical storm duration for the entire model extent for the baseline scenario. There are limited areas predicted to be at risk of flooding in the 3.33% AEP design event but the extent and depth of flooding increases in the higher magnitude / less frequent events.

⁴ <https://www.innovyze.com/en-us/blog/troubleshooting-hydraulic-models-in-infoworks-icm>

Figure 3-7 West Horndon – Maximum Flood Depths for 3.3% AEP event (15h storm duration) - Baseline

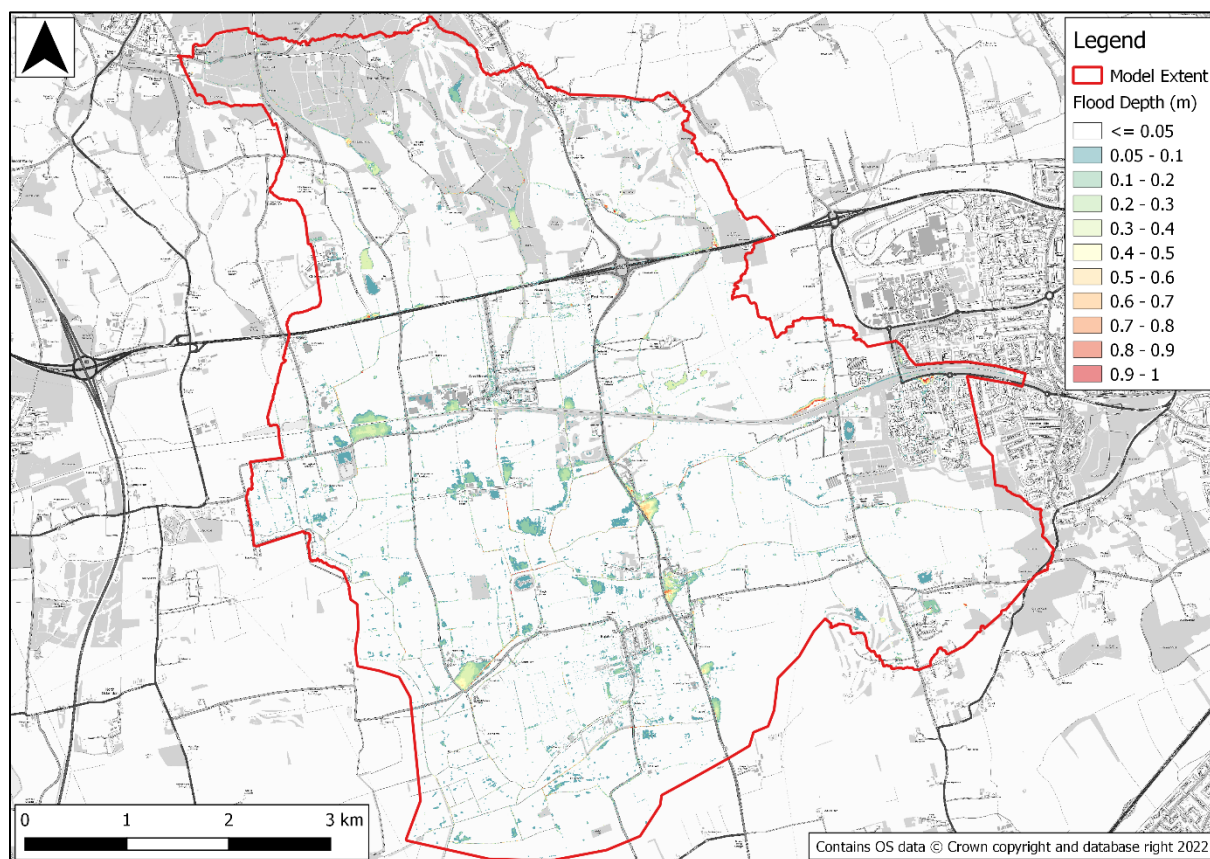


Figure 3-8 West Horndon – Maximum Flood Depths for 1% AEP event (15h storm duration) - Baseline

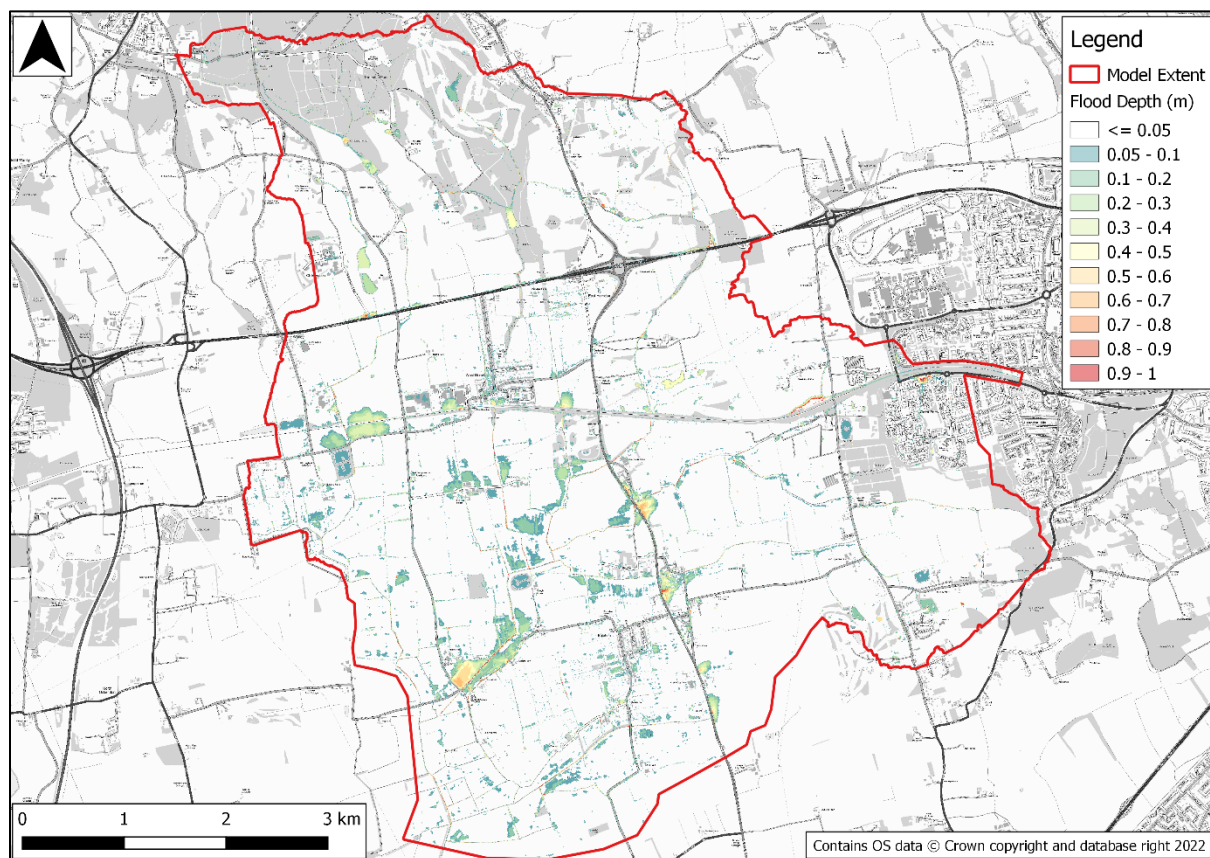
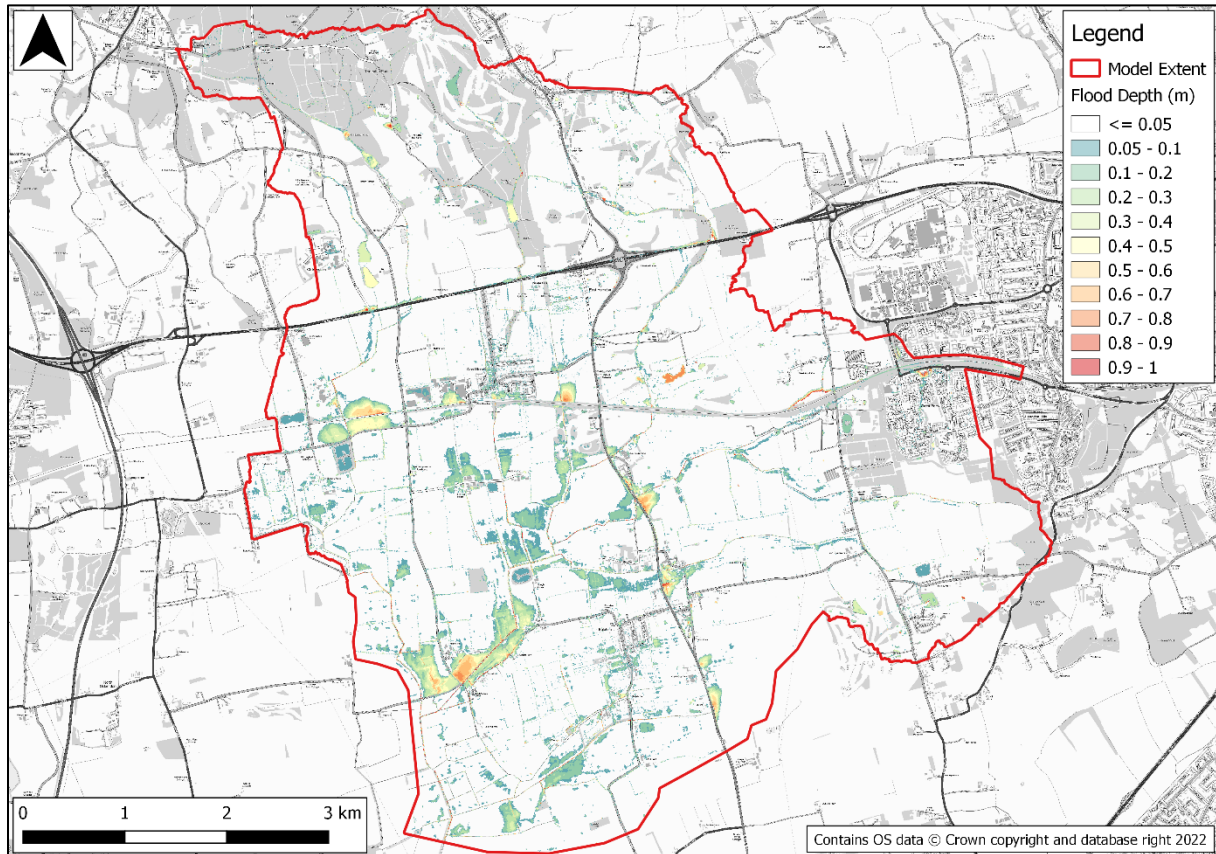
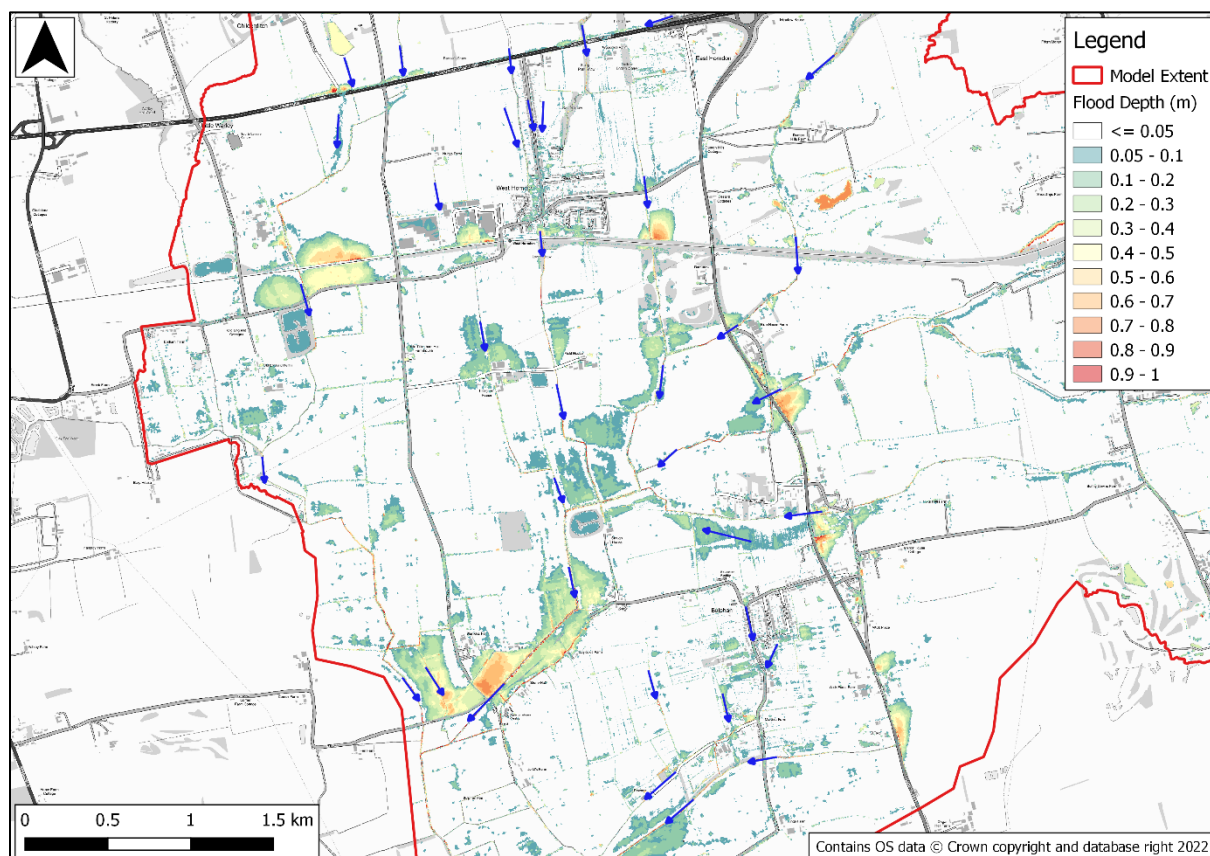


Figure 3-9 West Horndon – Maximum Flood Depths for 0.1% AEP event (15h storm duration) - Baseline



3.4.5 Figure 3-10 shows the river and 2D surface flood mechanisms in a more detailed map of West Horndon and Bulphan for the 0.1% AEP event and 15-hours storm duration. It can be seen from blue arrows that the flow direction is generally north to south and the catchment flows to meet River Mardyke. There are some well-defined flow routes and also noticeable ponding of surface water behind some of the main infrastructure routes and embankments across the catchment.

Figure 3-10 West Horndon – Flooding mechanism in West Horndon and Bulphan for 0.1% AEP event

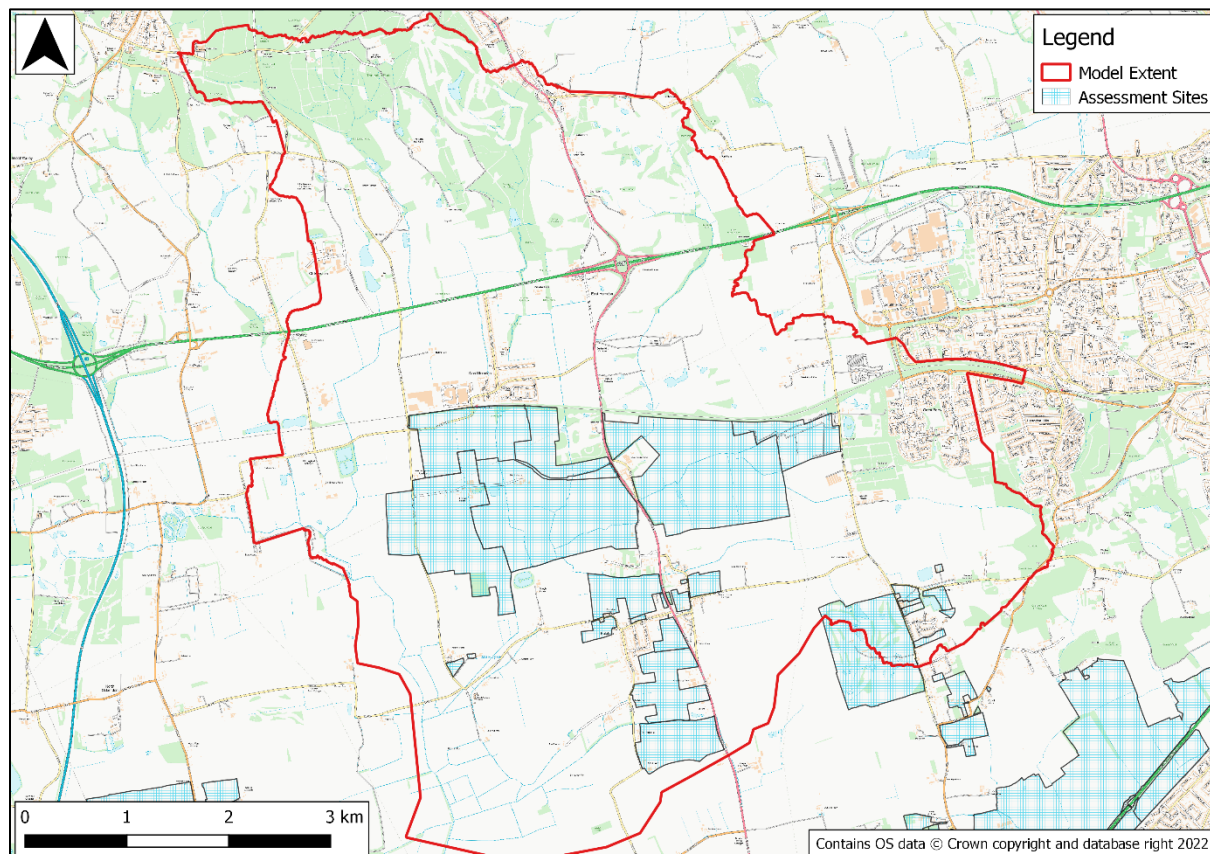


3.5 Scenario Modelling

- 3.5.1 Two sensitivity scenarios have been modelled to understand the potential impact on flood risk of cumulative development in the West Horndon and Bulphan area. This provides Thurrock Council with technical evidence showing the potential flood risk impact of changes in the landuse pattern across these catchments.
- 3.5.2 Figure 3-11 the assessment sites included in this modelling, based on landuse planning information provided by Thurrock Council. As this is a strategic assessment (not site scale detail), assumptions have been made in consultation with Thurrock Council about the likely change in landuse pattern on the assessment sites, and the effect this has on the permeability / impermeability of the sites. This has been represented in the sensitivity scenarios by changing the roughness and infiltration zones in the model. There were no changes made to the ground model (i.e. land raising) to represent potential developments.
- 3.5.3 **Scenario 1:** assumes for each of the assessment sites that 50% of the development would be permeable surfaces and 50% impermeable surfaces. This is represented in the Roughness Zones (RZ) and Infiltration Zones (IZ) in the model. The RZ and IZ values in the roughness and runoff coefficients used for the new development sites are shown in Table 3-2.
- 3.5.4 For example, runoff coefficients for grassland and roads are 0.2 and 0.85, respectively, therefore, for 50% permeable, the value would be $0.2 \times 0.5 = 0.1$ and for 50% impermeable scenario, the value would be $0.85 \times 0.5 = 0.425$, and the sum would be 0.525. This value was then brought forward and applied to the relevant polygons which fell under the assessment site area. The same approach was followed for the RZ polygons and partial polygons which covered the assessment site area.
- 3.5.5 **Scenario 2:** assumes for each of the assessment sites that 10% of the development would be permeable surfaces and 90% impermeable surfaces. As above, this is represented in the Roughness Zones (RZ) and Infiltration Zones (IZ) in the model. The RZ and IZ values in the roughness and runoff coefficients used for the new development sites are shown in Table 3-2.

- 3.5.6 For example, runoff coefficients for grassland and roads are 0.2 and 0.85, respectively, therefore, for 10% permeable, the value would be $0.2 \times 0.1 = 0.02$ and for 90% impermeable scenario, the value would be $0.85 \times 0.9 = 0.765$, and the sum would be 0.785. This value was then brought forward and applied to the relevant polygons which fell under the assessment site area. The same approach was followed for the RZ polygons and partial polygons which covered the assessment site area.

Figure 3-11 West Horndon – Assessment site locations, provided by Thurrock Council



Model Results – Scenario Testing

- 3.5.7 Table 3-6 shows the maximum flood depth for the 1% AEP event (15-hour storm duration, winter storm profile) for the baseline and two sensitivity scenarios. The table also shows the difference in maximum flood depth between the two scenarios and the baseline model results. The model results are shown for a number of inspection points across the model extent as shown in Figure 3-12. There is a small increase in maximum flood depth for 9 of the 10 inspection points in Scenario 1 with a maximum depth increase of 60mm compared to the baseline. This compares to maximum flood depths in the baseline scenarios of approximately 0.2m across much of the model. The impact on maximum depth is generally higher for Scenario 2, where a higher proportion of each development site is assumed to be covered by impermeable surfaces, but is still not considered particularly high in the context of baseline flood depths of approximately 0.2m at most locations. In this scenario, the increase in flood depth is between 10mm and 110mm for the 1% AEP event.

Table 3-6 West Horndon – Peak depth and depth difference for the 1% AEP event for all scenarios

Inspection Points	Peak depth (m)	Peak depth (m)	Peak depth (m)	Depth difference (m)	Depth difference (m)
	Baseline	Scenario 1	Scenario 2	Scenario 1 - Baseline	Scenario 2 - Baseline
1	0.27	0.33	0.38	0.06	0.11
2	0.21	0.27	0.32	0.06	0.11
3	0.29	0.29	0.30	0.00	0.01
4	0.25	0.26	0.26	0.01	0.01
5	0.17	0.19	0.20	0.02	0.03
6	0.20	0.21	0.21	0.01	0.01
7	0.63	0.67	0.69	0.04	0.06
8	0.81	0.84	0.85	0.03	0.04
9	0.17	0.19	0.21	0.02	0.04
10	0.25	0.28	0.30	0.03	0.05

Figure 3-12 West Horndon – Inspection Points for Flood Depth Analysis (maximum depth 1% AEP baseline)

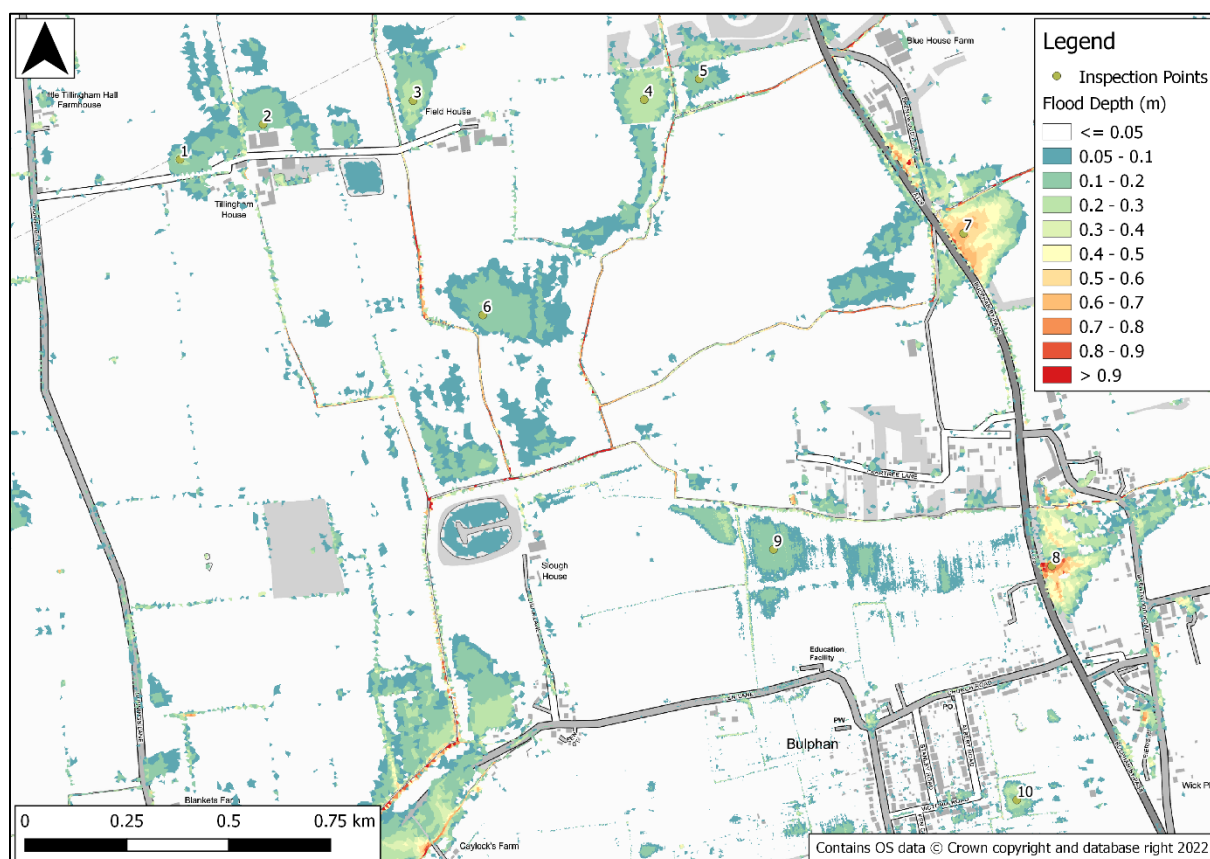


Figure 3-13 to Figure 3-18 show the difference in maximum stage (water level) for the 3.33%, 1%, and 0.1% AEP events for both scenarios as compared to the baseline scenario (15-hour storm duration, winter storm profile) for the entire model extent highlighting particularly where the impacts are greater than +/- 0.02m. The figures show that the areas most vulnerable to increases in flood risk because of cumulative development in these areas are in the lower, south-western part of the catchment. The figures show a predicted increase in flood risk in the south-western part of West Horndon between the railway line and St Mary's Lane, i.e., south of Horndon Industrial Park. The results also show a predicted increase in flood risk around the residential area in Bulphan.

Figure 3-13 West Horndon – Difference in Maximum Stage: Scenario 1 vs. Baseline Scenario, 3.33% AEP

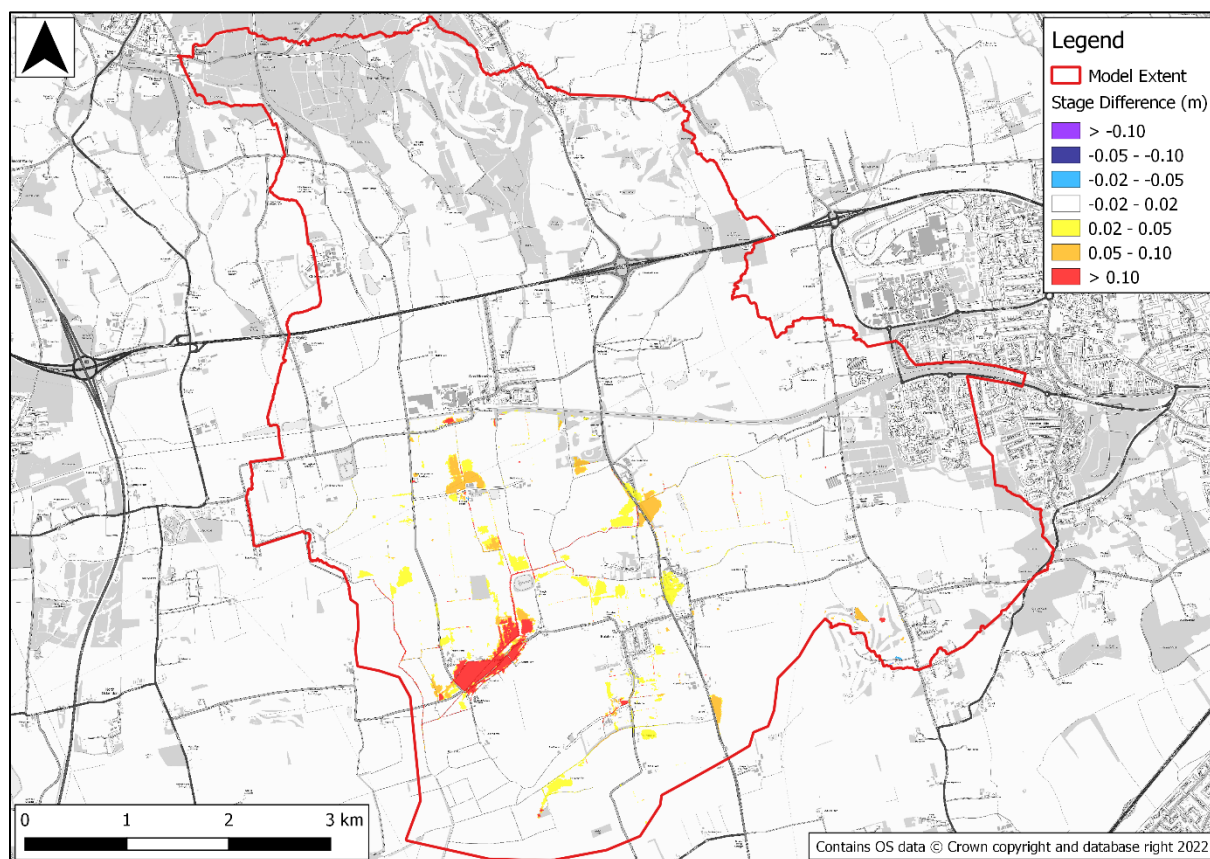


Figure 3-14 West Horndon – Difference in Maximum Stage: Scenario 1 vs. Baseline Scenario, 1% AEP

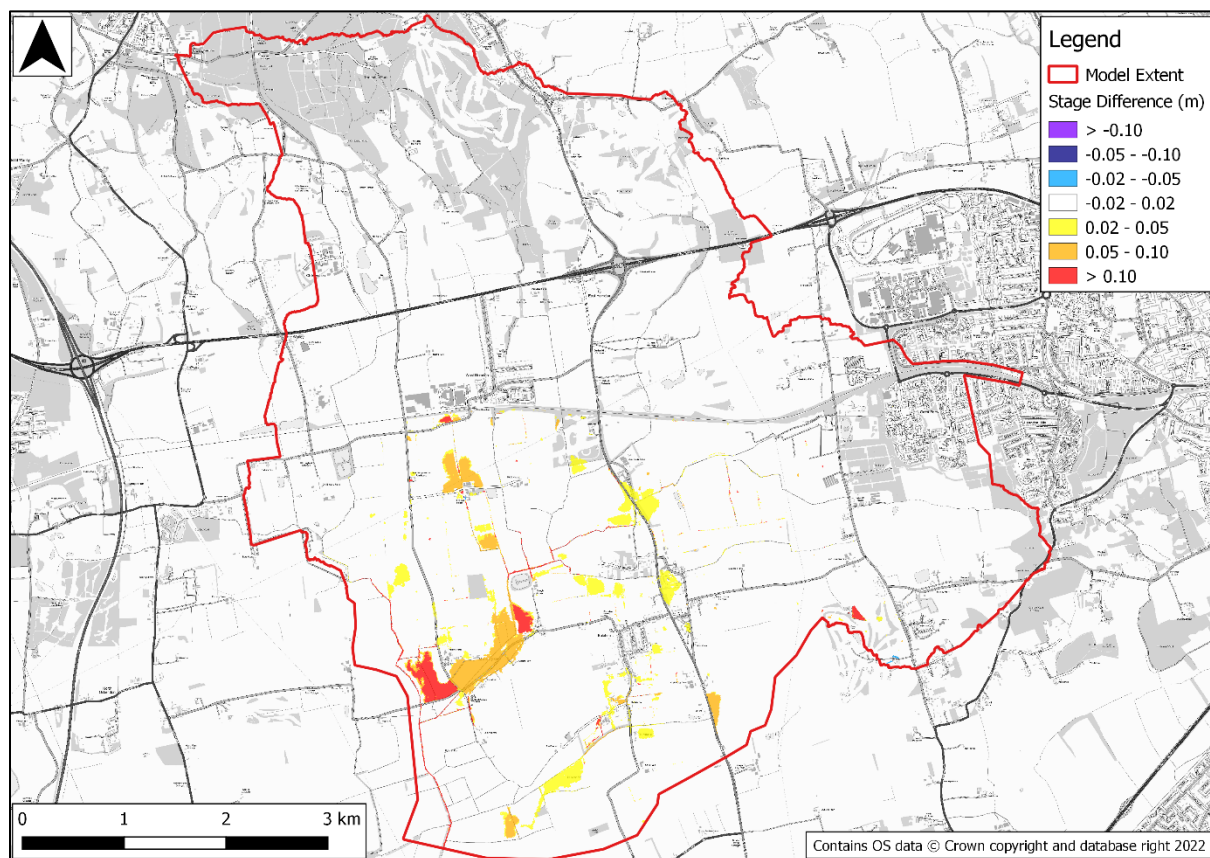


Figure 3-15 West Horndon – Difference in Maximum Stage: Scenario 1 vs. Baseline Scenario, 0.1% AEP

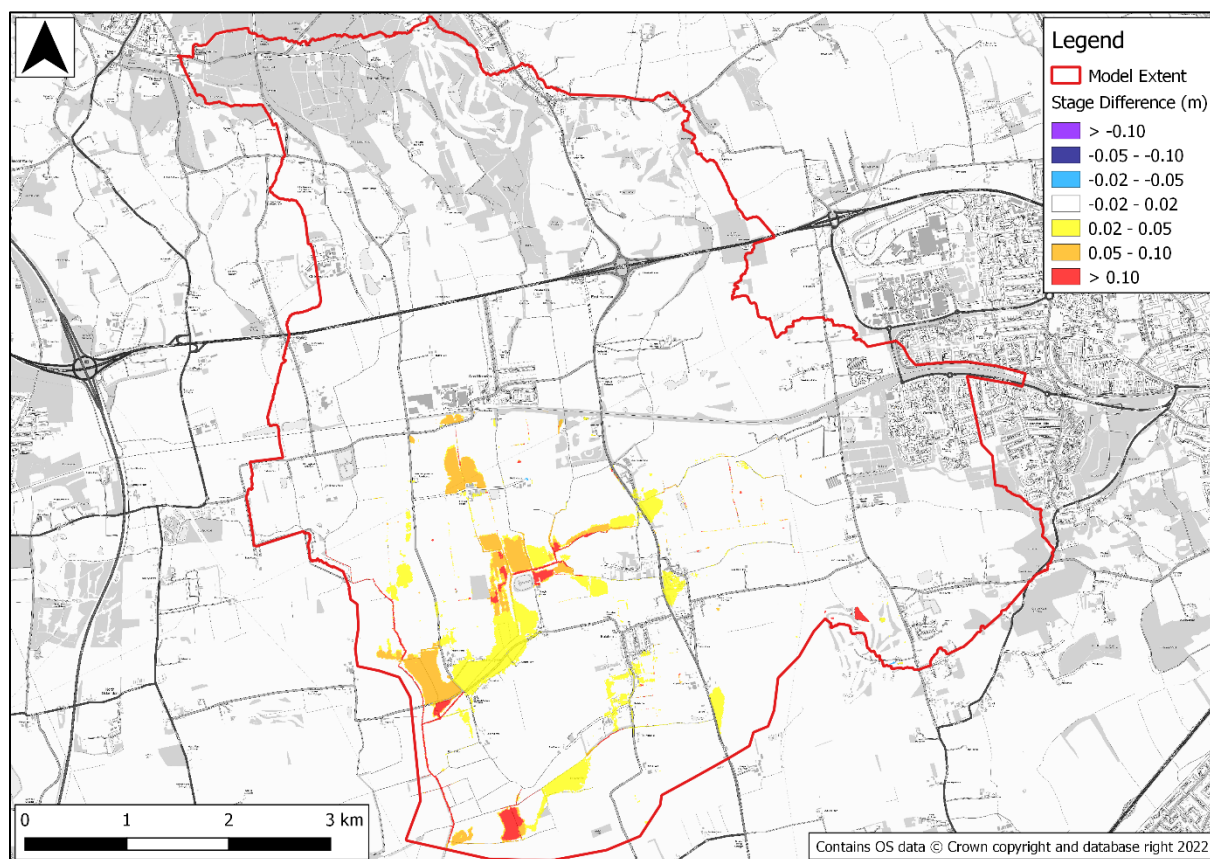


Figure 3-16 West Horndon – Difference in Maximum Stage: Scenario 2 vs. Baseline Scenario, 3.33% AEP

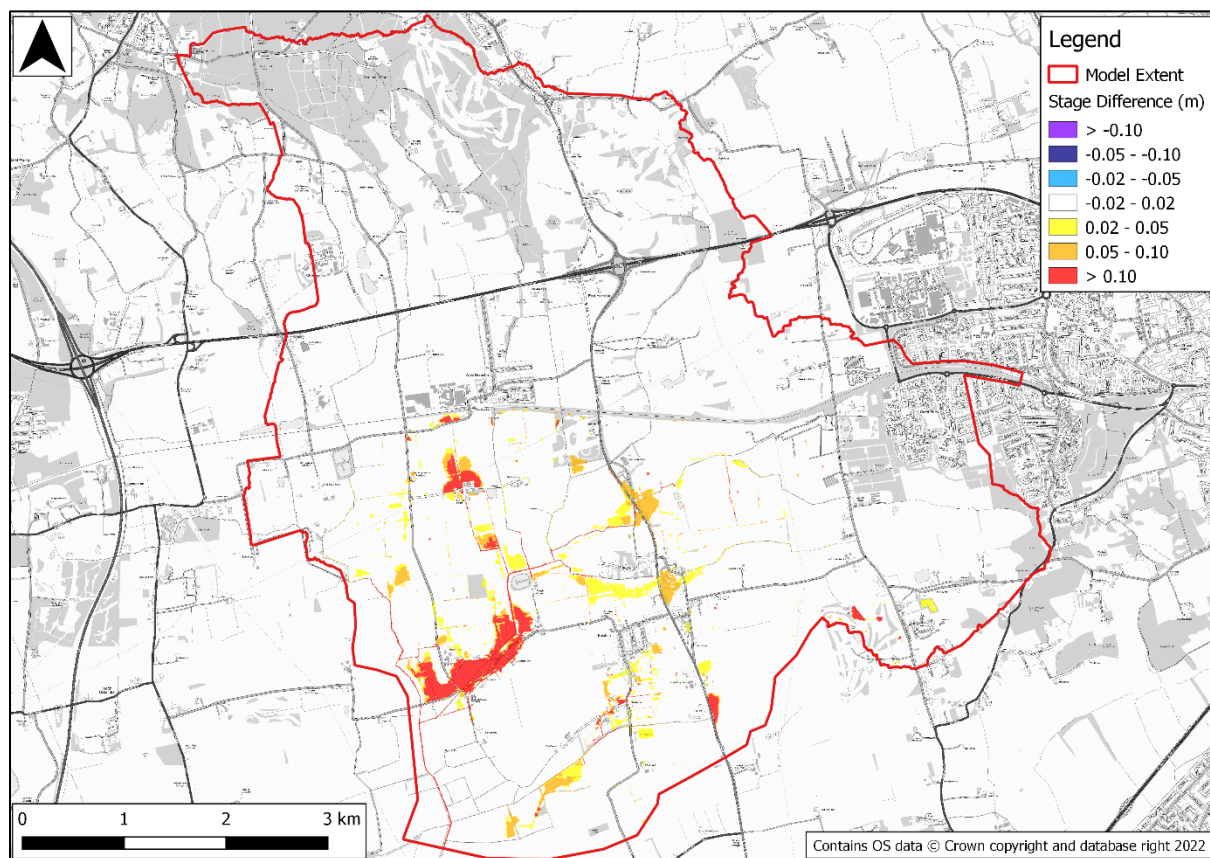


Figure 3-17 West Horndon – Difference in Maximum Stage: Scenario 2 vs. Baseline Scenario, 1% AEP

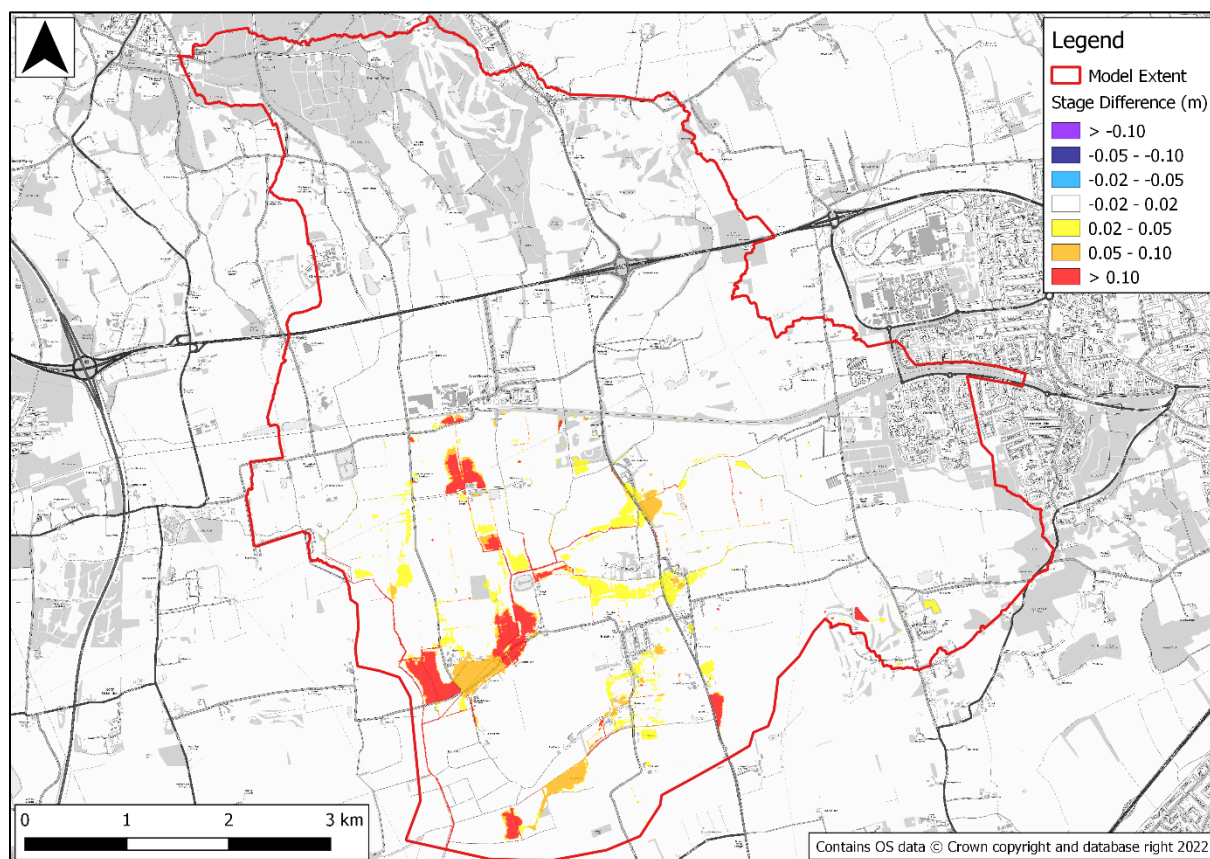
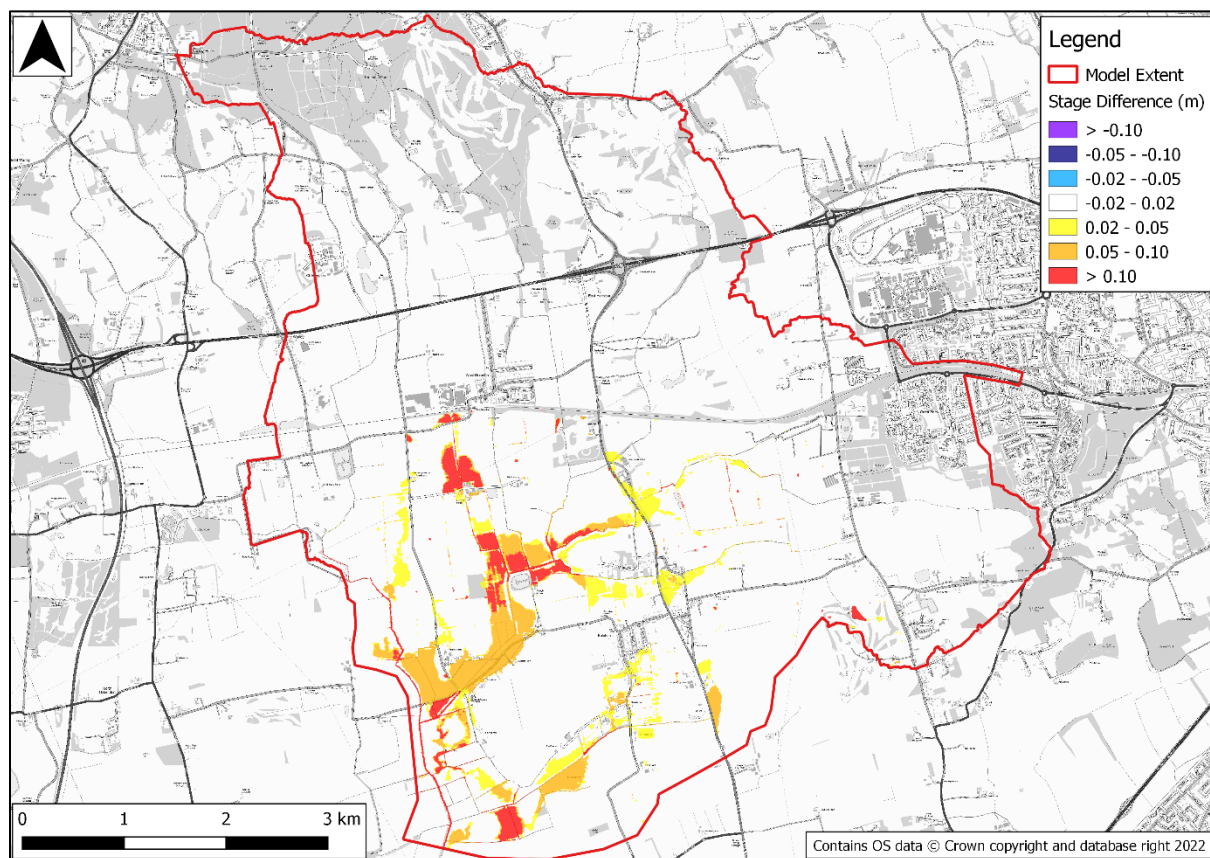


Figure 3-18 West Horndon – Difference in Maximum Stage: Scenario 2 vs. Baseline Scenario, 0.1% AEP



3.6 Discussion

- 3.6.1 An updated hydraulic model of the West Horndon and Bulphan catchment areas has been developed by AECOM for Thurrock Council as part of their technical evidence basis for the SFRA. This model has been developed by extending and refining a previous Infoworks ICM model of West Horndon (part of the Environment Agency 2019 study).
- 3.6.2 The baseline flood modelling and mapping shown here is for the 3.33%, 1% and 0.1% AEP design events. Storm duration testing was undertaken, and a 15-hour storm duration (winter profile) was identified as critical in the West Horndon and Bulphan area and adopted for the mapping and scenario testing. There are clear flow paths for surface water across the model area with areas of ponding behind infrastructure and embankments.
- 3.6.3 The scenario testing undertaken for West Horndon and Bulphan shows that if the potential development sites identified by Thurrock Council result in an increase in impermeable surfaces, and without sufficient runoff control, there is potential for a cumulative impact and potentially an increase in flood depth in this area. The two sensitivity tests undertaken in the model represent two different scenarios, one where 50% of the allocated development site area is assumed to be covered by impermeable surfaces and one where 90% of the allocated development site area is assumed to be covered by impermeable surfaces. The impacts of the increased runoff have been presented for a 3.33%, 1% and 0.1% AEP event, all for a 15-hour storm duration (winter profile).
- 3.6.4 The areas where there is a predicted increase in flood depths due to cumulative development are generally in the south and west part of the model extent. The increase in flood depth is generally quite small compared to the predicted baseline flood depths. Some of the increase is seen around Bulphan village and also downstream (south) of the industrial area in West Horndon. The increase is greater in Scenario 2 when a higher proportion of the development sites area is assumed to be covered by impermeable surfaces.
- 3.6.5 Thurrock Council needed to understand the potential cumulative impact of development around West Horndon and Bulphan on flood risk in the area. The modelling undertaken here demonstrates that cumulatively, development on the identified sites which results in an increase in impermeable surfaces may increase flood depth to a small degree. The areas that seem most susceptible to an increase in flood depth as a consequence of more runoff from development are the rural area between West Horndon and Bulphan and South Ockendon where multiple flow routes converge.
- 3.6.6 It is therefore recommended that Thurrock Council consider policies in the Local Plan, supported by this SFRA evidence base, that would reduce runoff from new development sites to avoid an increase in flood risk compared to baseline conditions and where possible provides a reduction in the risk of flooding. If this is sufficiently managed on each development site, the potential cumulative impacts shown in this assessment could be avoided.

3.7 Modelling Limitations

- 3.7.1 The modelling undertaken and presented in this report is suitable for a strategic assessment of the potential cumulative impacts of development around West Horndon and Bulphan. As the modelling was undertaken a number of limitations in the methodology and approach were noted, with recommendations as to how the model could be refined in future. These are summarised below but are not considered essential for the purposes of this SFRA. They would be recommended if the model was used for a more local / site specific assessment of flooding or testing of impacts.
- No calibration of the model was undertaken due to a lack of historical event data, but the model outputs were validated against the Environment Agency RoFSW map and the results are consistent with the Bulphan critical drainage area and records of flooding (recorded by Thurrock highways department) shown in SFRA Appendix A Figure 8. The predicted flood extent from this new modelling is smaller than that shown in the RoFSW mapping due to the differences in modelling approach. It is not possible to quantify the degree of confidence in this modelling. Calibration of the model would require more hydrometric and quantitative data of observed flood events that resulted in surface water flooding in this area.

- The sensitivity testing of the model was limited to the development / permeability scenarios described above. No sensitivity testing of other modelling assumptions (e.g., Manning's n roughness values or roughness coefficients) was undertaken and no sensitivity testing of model inflows or rainfall input was undertaken, apart from the duration testing. Additional sensitivity testing would give more information about the level of confidence in the model but was not essential for the relative impact assessment needed in this SFRA.
- The scenario testing was based on simple assumptions about the proportion of permeable and impermeable surfaces on the allocated development sites. No information about the development layout on those sites was used, rather an average runoff coefficient and Manning's n value was calculated based on the assumed proportion of impermeable surfaces. More detailed information about the development could be represented in the model including the layout of ditches, structures (culverts), roads and buildings, but this was not necessary for this initial strategic assessment.
- The development / permeability scenarios tests do not account for other types of impact development might have on flood risk, beyond reducing the permeability area and increasing the runoff. For example, the model does not represent the effects that large buildings might have by obstructing flow paths or the new flow paths that could be created by the layout of new roads. These effects would need assessing in site specific modelling for FRAs to support planning applications.
- The model geometry is currently based mostly on LiDAR DTM and OSMM data. There are structures in the model e.g., underneath the roads, railways and embankments where additional survey data would help refine the representation in the model which would give a better understanding of flow mechanisms across the area.
- There is a network of watercourses / ditches across this modelled area which are currently represented in a simple way within the 2D mesh. This representation could be refined using a 1D modelling approach to represent these watercourses (channel survey data would be needed) but at present this is not considered necessary for the SFRA evidence base. The main flow routes across the area are clearly seen in the 2D model results.
- Additional modelling scenarios could be undertaken with alternative assumptions of the permeable / impermeable proportions on the development sites, e.g., varying the proportions between different sites where land uses are known. The model could also be used to identify if there are benefits that could be realised by reducing runoff within development around West Horndon and Bulphan, e.g., through control of surface water runoff.
- This modelling has been undertaken to provide an evidence base suitable for the SFRA. This modelling should not be used in the assessment of specific planning applications and associated FRAs. It is expected that planning applications in these areas would include FRAs supported by modelling that represented the development in a more refined way based on the proposed layouts and levels of each site.

