

HYDRAULIC MODELLING NOTE

Prepared on behalf of James Cullen



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1.0 INTRODUCTION

Ardent Consulting Engineers (hereafter referred to as Ardent) has undertake a hydraulic modelling exercise for a Site at Folders Lane, Burgess Hill in July 2021.

The Environment Agency's surface water flood mapping indicate that part of the site is located within high risk of flooding from surface water (1 in 30 year probability of flooding). The maps on the EA website are at a national level and give a large range of depths to cover the various risk probabilities. Therefore, in order to quantifying the surface water flood depths on site an overland surface water model would have to be built to assess site specific flood depths and flow routes. This would quantify surface water flood risk and depths for the various flood events.

The purpose of this work is to describe the modelling undertaken and assess flood risk to the site of interest.

2.0 MODEL METHODOLOGY

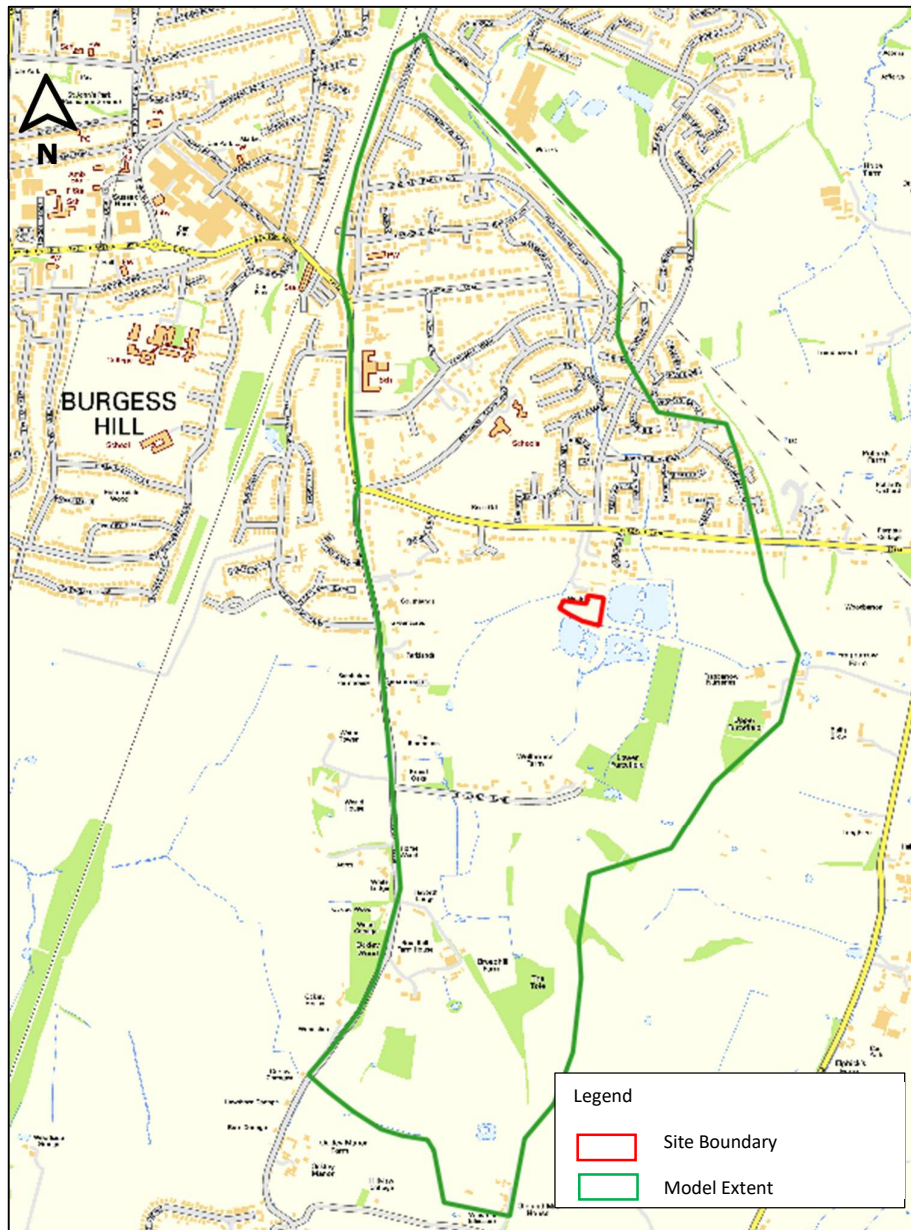
2.1 *Model Software*

The hydraulic model has been run using TUFLOW GPU build 2020-10-AA-iSP-w64. The model has been run on the 64 bit version of this build to take advantage of the faster simulation times.

2.2 *Model Extent*

The proposed model extent was identified using LiDAR data to ensure that the entire flowpath towards the Site is captured. High ground levels were used as a downstream model boundary to avoid glasswalling. **Figure 1** below shows the model extent.

The northern part of the study area is largely urban whereas the southern part – where the Site of interest is located) is rural. The total area of the catchment to be modelled is approximately 2.2 ha.

**Figure 1: Model Extent**

2.3 *Model Topography*

The model grid size has been set to 3m. The TUFLOW Quadtree feature was used within close proximity to the site to lower the grid size to 1m. The model grid size ensures that

that the roads, buildings and drainage features are appropriately represented in the TUFLOW model.

One meter resolution LiDAR data was used to define the topography of the study area. The ground profile in the current model was checked to ensure that the topography of the area is well represented and that structures are defined. The definition of any basements was checked that they are in the correct locations and covering the right area.

The topographical survey undertaken by Maltby Surveys Ltd in February 2021 was also included in the model. This was done to make sure that the ground surface within the Site is represented accurately.

The watercourse running along the site's southern, eastern and western boundary, for which a survey was available, were modelled in 1D for a more accurate representation.

The 1d modelled watercourses and the extent of the topographical survey are shown in the **Figure 2** below.

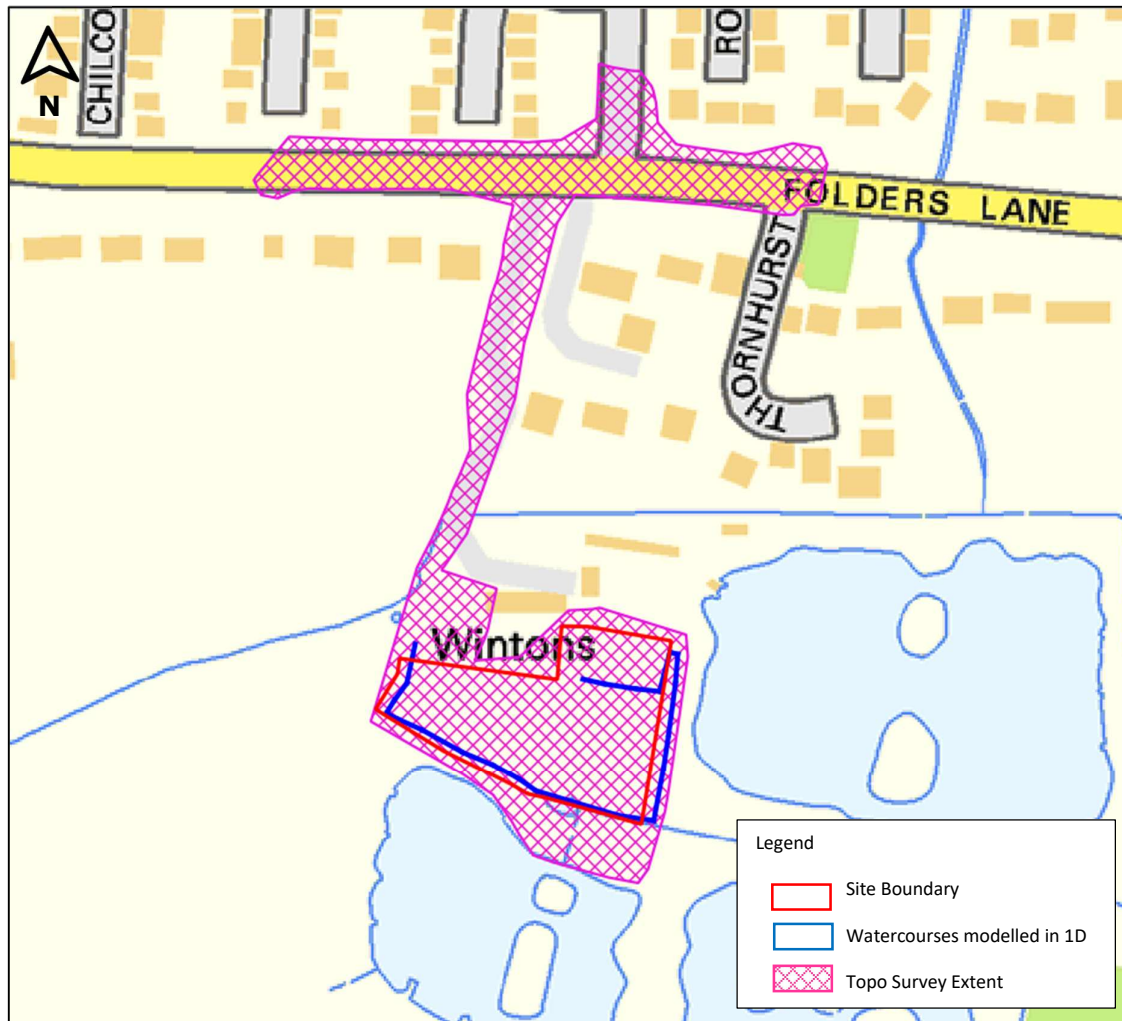


Figure 2: Topographical Survey Coverage

2.4 Model Boundaries

2.4.1 Inflows

The Flood Estimation Handbook web page was used to identify the catchment descriptors for the area of interest. The total rainfall for the catchment was determined using the ReFH2 Method. Hyetographs were produced for summer and winter profiles for five storm durations in order to identify the Critical Storm Duration (refer to **Section 2.4.3** below for more details). Following the critical duration assessment, four hyetographs were

produced for the following return periods: 1 in 30, 1 in 100, 1 in 100 plus climate change, and 1 in 1000 year.

The rainfall was applied across the full model extent and represents total rainfall for the catchment.

2.4.2 Outflows

At a number of locations along the model boundary, where small watercourses are culverted under the railway line, HQ (flow versus stage) boundaries have been applied to ensure that there is no glass walling. The relationship has been defined by interrogating the ground surface slope (LiDAR) and applying a gradient to the relevant TUFLOW layer.

2.4.3 Critical Storm Duration

The critical duration has been determined using the baseline hydraulic model (1 in 100yr event). A range of storm durations were defined using Flood Modeller Pro. Three storm durations were run through the model: 1.25, 3.25, 5.5 and 8.5 hours. The maximum flood depth and extent of surface water flooding for the three durations were compared against each other to determine the critical storm duration. This comparison showed that the critical duration was the 1.25 hour duration for a summer profile.

2.5 *Drainage Network*

The drainage network will not be explicitly modelled as part of this assessment. The capacity of the network was instead represented by a loss applied to the model. The value of the loss applied in the model was 6.5 mm/hr for impermeable land uses.

3.0 Overland Flow

3.1 Structures

Structures that influence the flooding mechanisms within the model extent have been included in the model. The Underpass at Folders Lane was included in the model using a 2d_zsh layer to allow flows under the road.

3.2 Roads

All roads (identified using OS MasterMap) were dropped by 125mm (in line with the EA Flood Risk from Surface Water¹) such that flow is preferentially routed down the roads. This method assumes that the road level is not picked up in the LiDAR.

3.3 Manning's Roughness

The spatial assignment of roughness values has been defined using OS MasterMap. The values that were assigned to the different areas are defined below.

¹ Environment Agency (2012). *Guidance on surface water flood mapping for Lead Local Flooding Authorities*, Report version 2.0. Bristol: Environment Agency.

Table 1: Manning's Roughness values

Feature Code	Descriptive Group	Comment	Manning's Roughness
10021	Building		0.015 for depths less than 0.030 0.500 for depths greater than 0.030
10053	General Surface	Residential yards	0.04
10054	General Surface	Steps	0.025
10056	General Surface	Grass, parkland	0.03
10057	General Surface	Manmade	0.02
10062	Building	Glasshouse	0.015 for depths less than 0.030 0.500 for depths greater than 0.030
10076	Land; Heritage And Antiquities		0.5
10089	Water	Inland	0.035
10111	Natural Environment (Coniferous/Non-coniferous Trees)	Heavy woodland and forest	0.1
10119	Roads Tracks And Paths	Steps, manmade	0.02
10123	Roads Tracks And Paths	Tarmac or dirt tracks, manmade	0.025
10167	Rail	Manmade	0.05
10172	Roads Tracks And Paths	Tarmac	0.02
10183	Roads Tracks And Paths (Roadside)	Pavement	0.02
10185	Structure	Roadside structure	0.03
10187	Structure	Generally on top of buildings	0.5
10203	Water	Foreshore	0.04
10210	Water	Tidal water	0.035
10217	Land (unclassified)	Industrial Yards, Car parks	0.035

3.4 ***Infiltration***

Infiltration of rainfall into the ground has been applied in the model using the Green-Ampt method so that infiltration losses are applied to permeable surfaces based on the underlying soil textural class. TUFLOW uses the hydraulic properties (hydraulic

conductivity, suction and porosity) corresponding to each textural class, as well as the initial moisture content, to vary the rate of infiltration over time.

The entirety of the model extent is assumed to be unsaturated at the start of the simulation.

A 2d_soil layer was created to represent the soils present in the study area based on the Soilscales Viewer from Cranfield University's National Soil Resources Institute (NSRI), supported by Defra. Polygons have been digitised to represent the soil type in the study area (shown **Figure 3**). This polygon was then allocated a unique code according to textural class. The soil textural classes and corresponding TUFLOW codes, as defined in the TUFLOW manual, are shown below.

An impermeable layer has been defined in the model, which included roads and buildings. A Soil Type number of '99' has been applied to this layer and a value of NONE has been applied. This mean no water is infiltrated on the road and buildings.

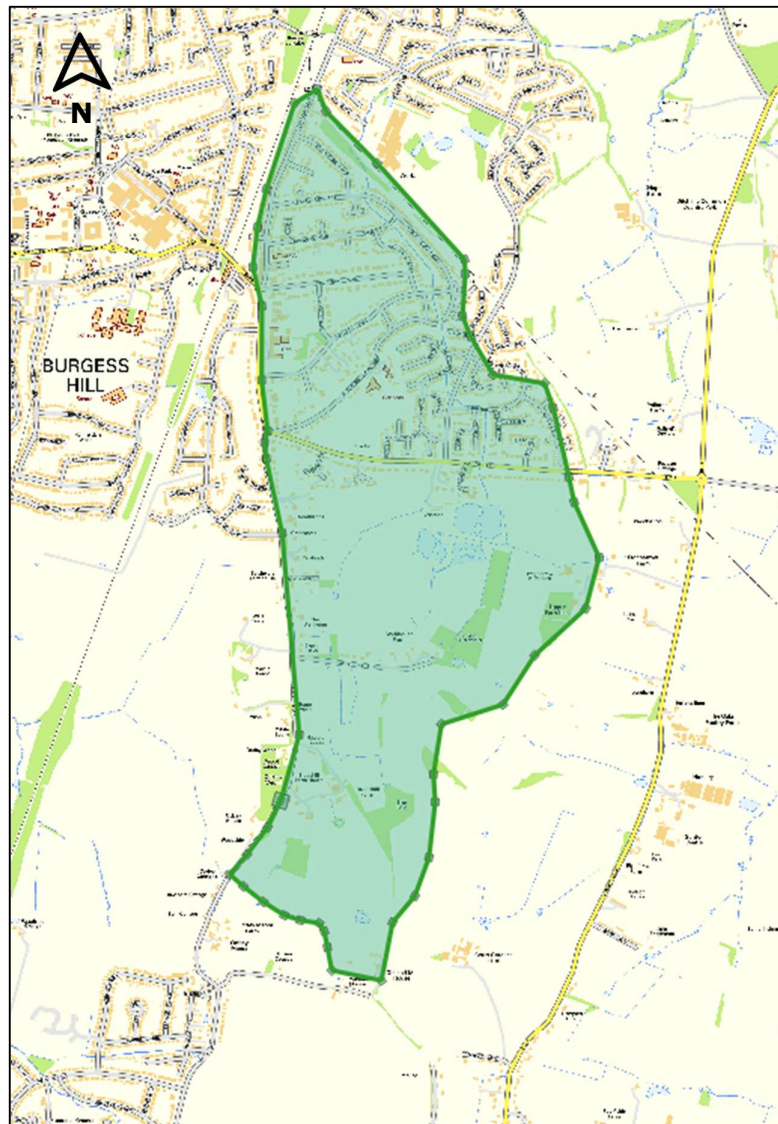


Figure 3: Soil Type Polygon

Table 2: Soil Type Description and Values

Soil Type Number	Description	TUFLOW Definition
1	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils	CLAY LOAM

3.5 **Model Simulation**

The model naming convention adopted is detailed below:

FLN_~s~_~e~_XXX

FLN: Folders Lane.

~s~: Scenario

~e~: Rainfall Event Probability & Critical Storm Duration

XXX: Version number

3.6 **Timestep**

The model was simulated with a 1.5 second time step in the 2D domain (TUFLOW). The chosen time step was deemed suitable for the model grid size and has been shown to produce stable model results.

3.7 **Verification**

The model was validated using the EA Surface Water maps. The model correlates well with the Flood Risk from Surface Water map.

4.0 SUMMARY OF RESULTS

The model has been run for the 1 in 30, 1 in 100, 1 in 100 + 40% CC and 1 in 1000 year events.

Predicted flood depths for the 1 in 30 and 1 in 100 year+40% climate change outline are shown in **Figure 4** and **Figure 5** below. A cut-off depth of 100mm has been used for the representation of the results. As shown below, predicted flood depths for the 30yr event are largely contained within the existing drains.

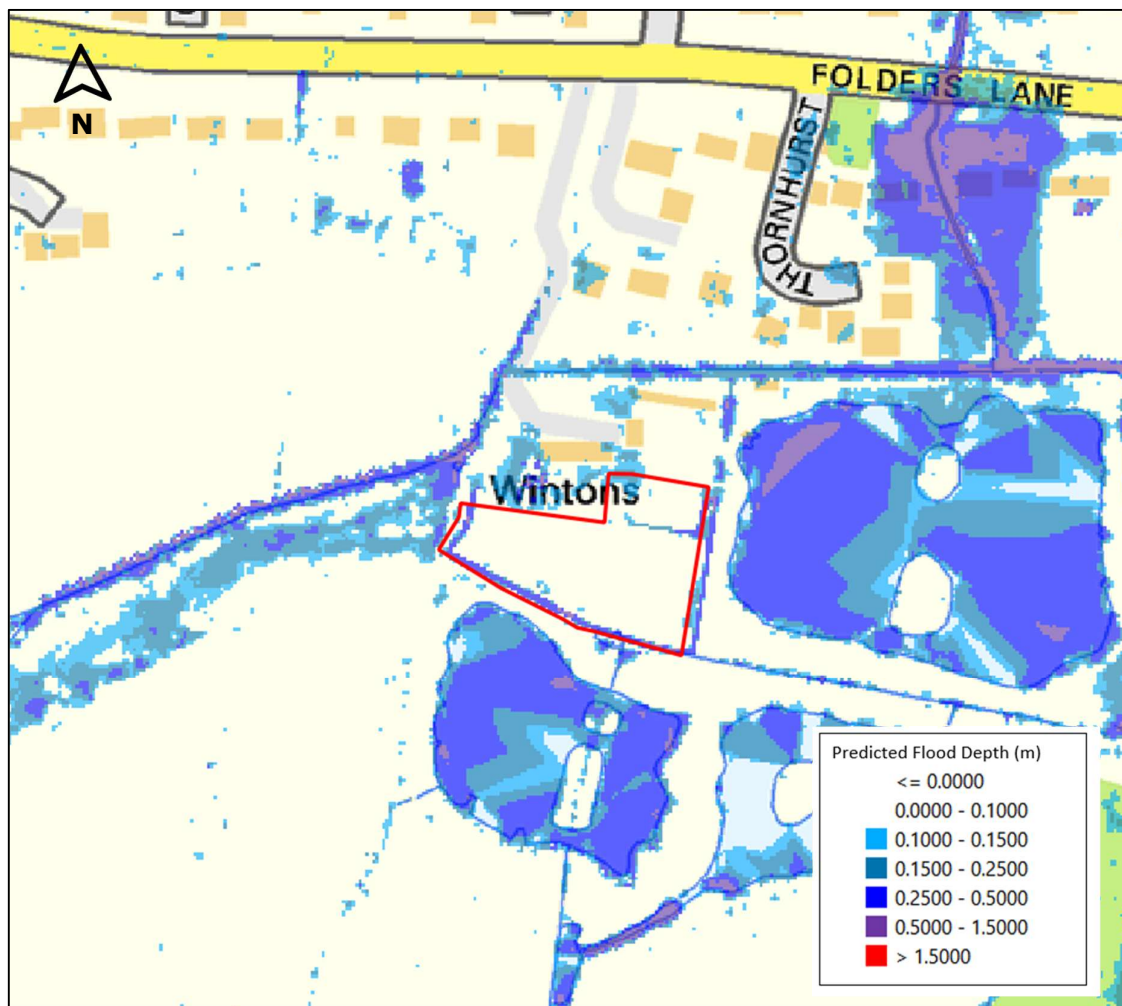


Figure 4: Predicted flood Depths (30yr Event)

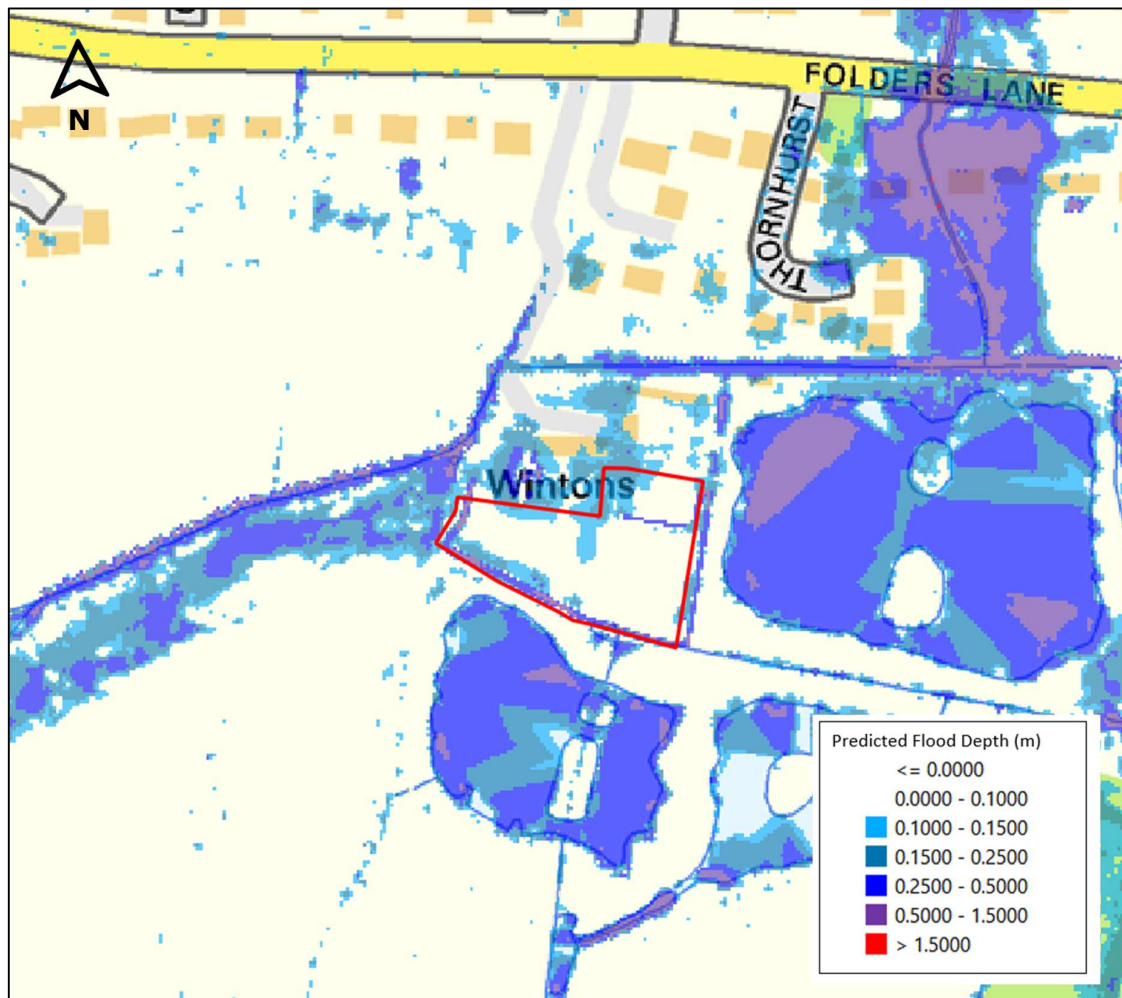


Figure 5: Predicted flood Depths (100yr + 40% CC Event)

The hydraulic model showed that surface water flood depths on site, for the baseline scenario are mainly less than 150mm (100yr + 40% CC Scenario). Some deeper ponding (up to 250mm) occurs along the site's southern boundary and in the north eastern part of the site.

4.1 **Post-development Scenario**

A post development scenario was also run to assess the impact of the proposed development on and off site. The building footprints were raised above the flood level in order to protect the proposed development. The post development model showed that predicted flood depths for the 100yr + 40% CC event are confined within the back gardens of Units 1-6 as shown in **Figure 6** below.

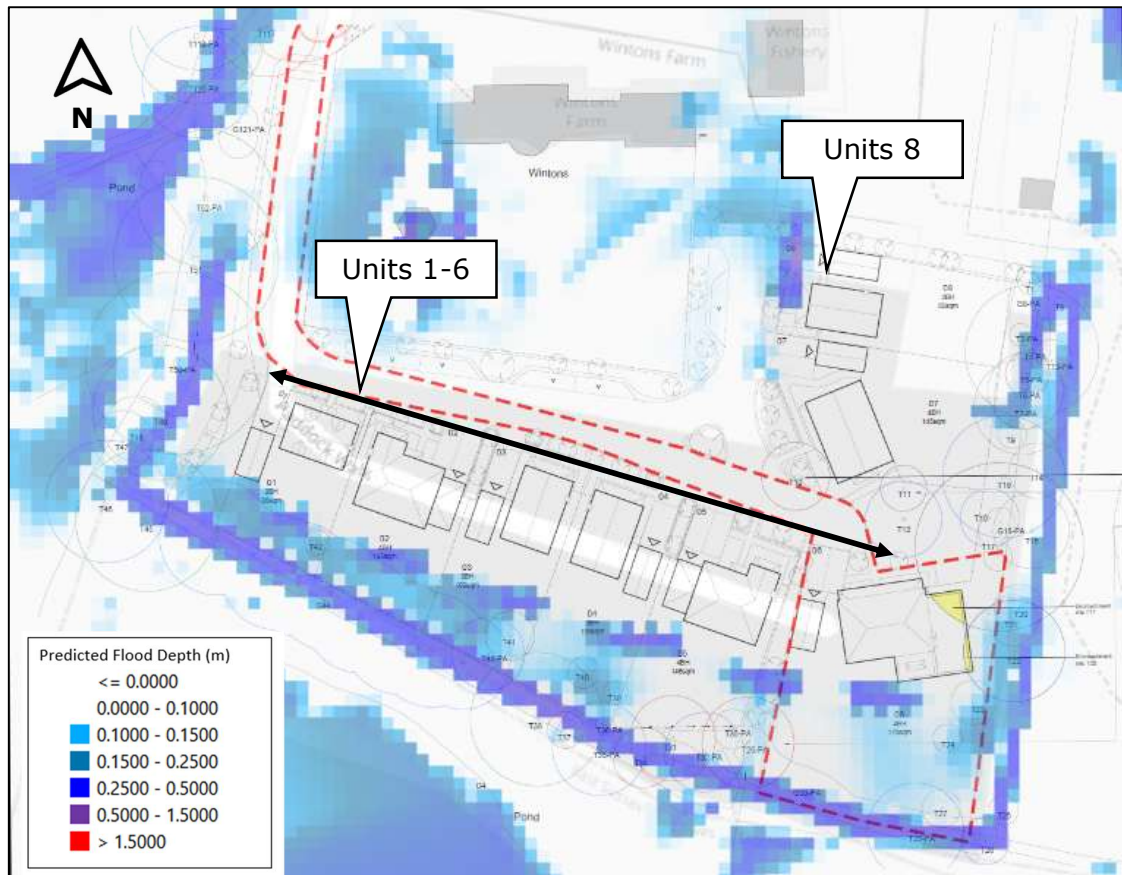


Figure 6: Predicted flood Depths (100yr + 40% CC Event – Post-development Scenario)

Predicted flood depth had increased in those areas by approx. 100mm but the increase remains with the site. Predicted flood depths of up to 170mm can be found along the access road of unit 8. There is a small increase in flood risk, up to 60 mm, in a small area outside the south eastern corner of the site. This is located near the pond and there are no properties in the area. The increase is de-minimis, is confined within a small area only and it doesn't impact on existing or future properties (refer to **Figure 7** below for the difference map between the pre and post development scenario). A decrease in flood risk is shown to the north, in and out of the site boundary.

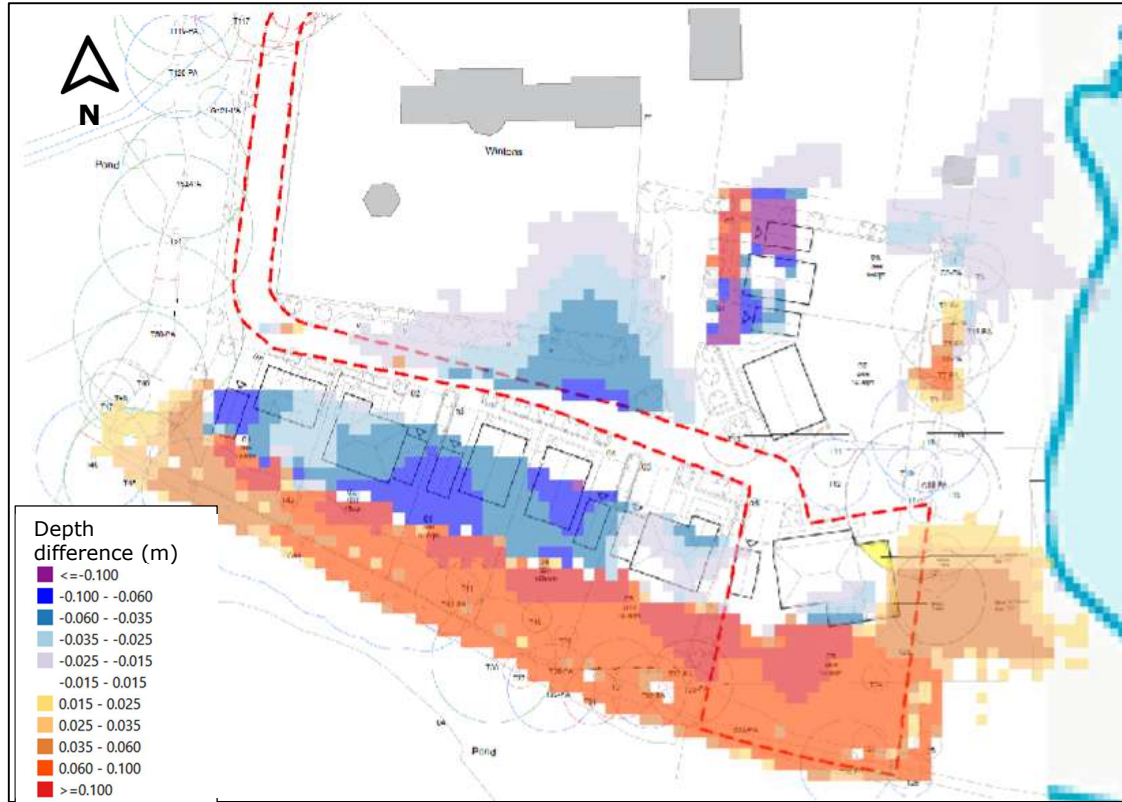


Figure 7: Difference map between the pre and post development scenario (100yr + 40% CC Event)

Predicted flood hazard is very low and safe access and egress is available. Please refer to **Figure 8** below for the hazard map.



Figure 8: Predicted Flood Hazard (100yr + 40% CC Event)

5.0 CONCLUSIONS AND RECOMMENDATIONS

Ardent Consulting Engineers has undertaken a hydraulic modelling exercise for a Site at Folders Lane, Burgess Hill in July 2021. The Site of interest is at high risk of surface water flooding according to the EA surface water flood map. The purpose of this work is to identify whether there is a need to provide further flood risk mitigation.

In order to quantifying the surface water flood depths on site an overland surface water model would has been built to assess site specific flood depths and flow routes. The hydraulic model has been run using TUFLOW GPU build 2020-10-AA-iSP-w64. The model has been run for the 1 in 30, 1 in 100, 1 in 100 + 40% CC and 1 in 1000 year events.

The modelled outputs indicated that predicted flood depths for the 30yr event are largely contained within the existing drains. The hydraulic model showed that surface water flood depths on site, for the baseline scenario are mainly less than 150mm (100yr + 40% CC Scenario). Some deeper ponding (up to 250mm) occurs along the site's southern boundary and in the north eastern part of the site.

A post development scenario was also run to assess the impact of the proposed development on and off site. The building footprints were raised above the flood level in order to protect the proposed development. The post development model showed that predicted flood depths for the 100yr + 40% CC event are confined within the back gardens of Units 1-6. Predicted flood depth had increased in those areas by approx. 100mm but the increase remains with the site. Predicted flood depths of up to 170mm can be found along the access road of unit 8. However, predicted flood hazard is low and safe access and egress in available for all units on Site.

There is a small increase in flood risk, up to 60 mm, in a small area outside the south eastern corner of the site. This is located near the pond and there are no properties in the area. The increase is de-minimis, is confined within a small area only and it doesn't impact on existing or future properties.