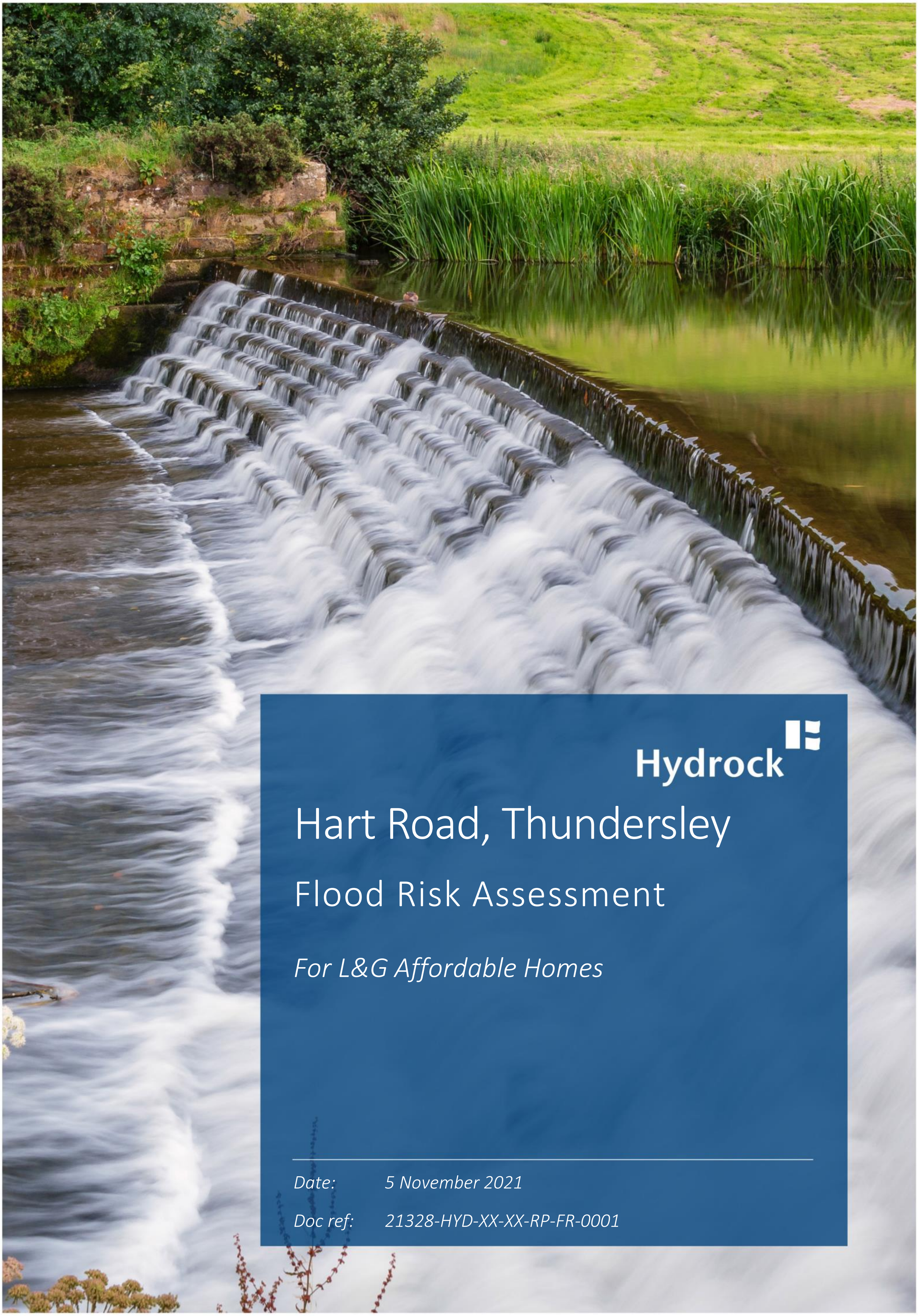

Hydrock

Hart Road, Thundersley

Flood Risk Assessment

For L&G Affordable Homes

Date: *5 November 2021*

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Issued by	Hydrock Consultants Limited Over Court Barns Over Lane Almondsbury Bristol BS32 4DF United Kingdom	T +44 (0)1454 619533 F +44 (0)1454 614125 E bristol@hydrock.com www.hydrock.com
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Issue Number	P01	Name
Prepared by		Luke Whalley BSc (Hons) GradCIWEM
Checked by		Simon Mirams BSc MCIWEM C.WEM CSci
Approved by		Simon Mirams BSc MCIWEM C.WEM CSci

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1. INTRODUCTION

This report has been prepared by Hydrock Consultants Limited (Hydrock) on behalf of our client L&G Affordable Homes in support of a planning application for a proposed development on land off Hart Road, Thundersley, Essex.

Local Planning Authorities are advised by the Government's National Planning Policy Framework (NPPF) to consult the Environment Agency (EA) on development proposals in areas at risk of flooding and / or for sites greater than 1 hectare in area. The EA requires a Flood Risk Assessment to be submitted in support of the planning application for the proposed development.

The report has been prepared to consider the requirements of NPPF through:

- Assessing whether the proposed development is likely to be affected by flooding;
- Assessing whether the proposed development is appropriate in the suggested location, and,
- Detailing measures necessary to mitigate any flood risk identified, to ensure that the proposed development and occupants would be safe, and that flood risk would not be increased elsewhere.

The report considers the requirements for undertaking a Flood Risk Assessment as stipulated in NPPF Technical Guidance. Only those requirements that are appropriate to a development of this nature have been considered in the compilation of this report.

This report has been prepared in accordance with current EA Policy.

2. SITE INFORMATION

2.1 Location

The site is located off Hart Road, Thundersley in southeast Essex, London. The site is bound to the north by residential properties and Hart Road, to the east and south by undeveloped mixed grassland and wooded areas and to the west and by Cedar Hall School. A small unnamed watercourse (for the purpose of this report shall be called the Thundersley Brook) runs along the southern boundary of the site, flowing generally east. The site is within a largely residential use area but is currently undeveloped.

The approximate site address and Ordnance Survey Reference Grid is in Table 1 with the site location shown in Figure 1.

Table 1. Site Referencing Information

Site Referencing Information	
Site Address	Hart Road, Thundersley, SS7 3UQ
Grid Reference	TQ 79694 88646 579694,188646

Figure 1. Site Location

2.2 Topography

A site-specific topographical survey has been provided and is included in Appendix A. The survey shows the site to have a general southerly fall from a high of 72.68m AOD along the boundary with Hart Road near the site entrance to a low of 67.65m AOD in the south east corner of the site near the Thundersley Brook.

2.3 Current Site Use

The site is mostly undeveloped field laid to grass with some concrete hardstanding and minor existing buildings in the north west portion of the site.

2.4 Proposed Development

The proposals are for a residential development of the site.

3. SOURCES OF FLOOD RISK

3.1 Fluvial Flooding

The closest watercourse to the site is the Thundersley Brook, which runs generally east and forms the southern boundary of the site. Mapping does not indicate there to be any 'main' watercourses within the vicinity of the site.

Current EA Flood Zone Mapping (Figure 2) shows the entire site to be within Flood Zone 1 (Low Risk) with the closest area of Flood Zone (Flood Zone 2) indicated to be approximately 1.2km to the north east associated with a small unnamed watercourse however this is not proposed to impact the site and as such is not discussed further.

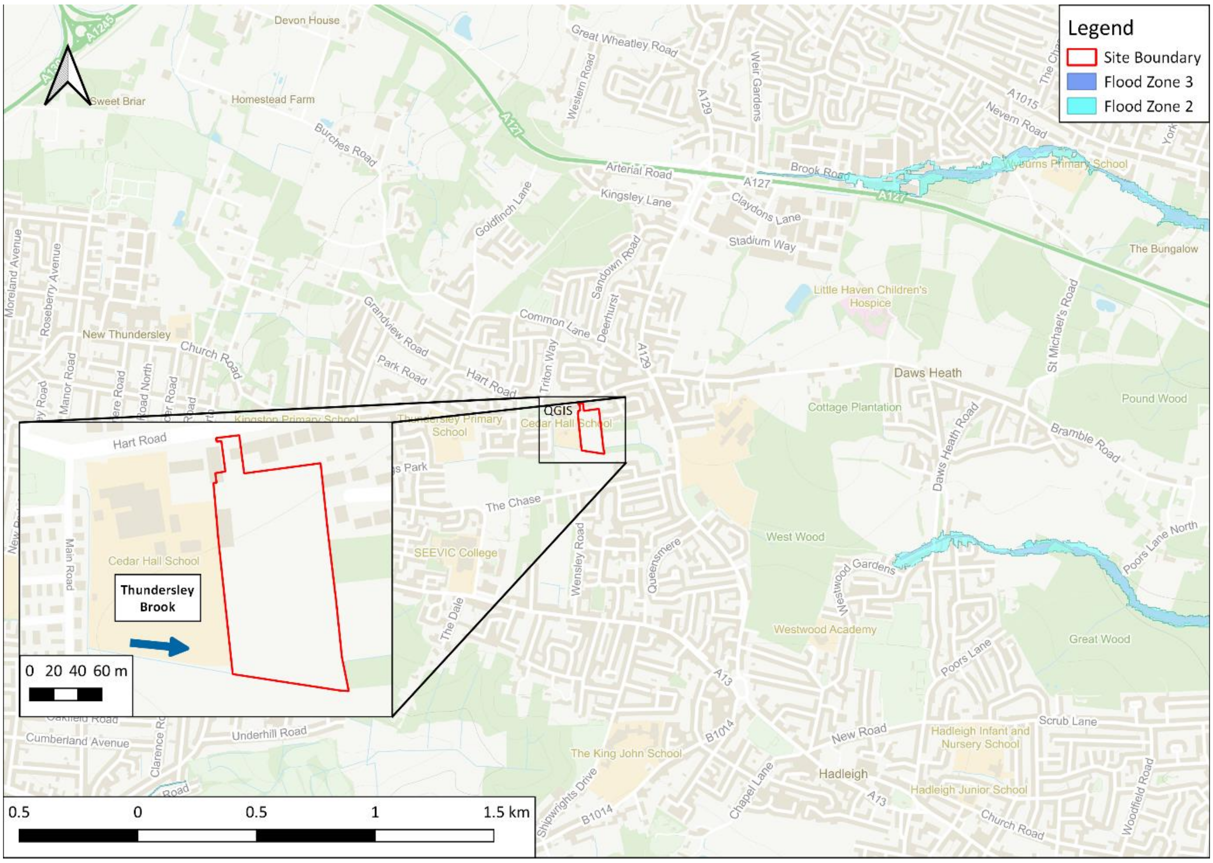


Figure 2. EA Flood Zone Mapping

For reference, the Environment Agency Flood Zones are defined as follows:

- Flood Zone 1 (Low Risk) comprises land assessed as having a ≤0.1% AEP of fluvial flooding in any given year, equivalent to the ≥1,000yr return period flood event.
- Flood Zone 2 (Medium Risk) comprises land assessed as having a 0.1-1% AEP of fluvial flooding in any given year, equivalent to the 1,000-100yr return period flood event.
- Flood Zone 3 (High Risk) comprises land assessed as having a ≥1% AEP of fluvial flooding in any given year, equivalent to the ≤100yr return period flood event.
  - » Flood Zone 3a (High Risk) comprises land assessed as having a 1-5% AEP of fluvial flooding in any given year, equivalent to the 100-20yr return period flood event.

» Flood Zone 3b (Functional Floodplain) comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency.

EA Historic Flood Mapping[1] and the South Essex Council Level 1 Strategic Flood Risk Assessment (SFRA) (AECOM, 2018) show no record of historic flooding at the specified site.

Whilst the site is shown as being entirely within Flood Zone 1 it should be noted that the EA typically provide flood zonation outlines only for watercourses with a catchment of 3km^2 or greater. This is considered as excluding the Thundersley Brook as the catchment to the downstream point of the site (as taken from the CEH web mapping[2]) is 0.88km^2.

It has been confirmed by the EA that no detailed modelling is available for the watercourse. In the absence of modelling, it is considered that the EA's Flooding from Surface Water Mapping (see Figure 3 below) is often a good indication of the worst case (i.e., Flood Zone 2) outlines for flood risk associated with Thundersley Brook as the flows in the watercourse will be largely the result of local surface water flows. On review of this data, mapping indicates a large portion in the south of the site to be at risk from such an event.

Therefore, given the lack of detailed modelling for the watercourse and the large extents indicated by the surface water flood risk maps on site it has been discussed and agreed with the EA that a detailed hydrological and hydraulic modelling study of the Thundersley Brook watercourse will need to be undertaken by Hydrock to confirm the current fluvial flood risk to the site. For full details of the modelling study including outputs and confirmation of site-specific risk see Sections 4 & 5 of this report.

3.2 Tidal Flooding

It should be noted that the EA Flood Zone Mapping and the South Essex SFRA do not distinguish between fluvial and tidal flood risk. Given the sites inland location, elevated topography (>65m AOD) and distance from any tidally influenced waterbodies the risk of tidal flooding at the site is concluded to be 'low'.

3.3 Surface Water Flooding

Surface water flooding occurs as the result of an inability of intense rainfall to infiltrate the ground. This often happens when the maximum soil infiltration rate or storage capacity is reached. Flows generated by such events either enter existing land drainage features or follow the general topography which can concentrate flows and lead to localised ponding/flooding.

The EA Surface Water Flood Risk Mapping (Figure 3) indicates the majority of the site to be classified as 'very low' however much of the southern portion of the site is classified as land at an increased risk with areas of low, medium and high risk predicted along much of the southern part of the site.

[1] EA Historic Flood Mapping - https://environment.data.gov.uk/DefraDataDownload/?mapService=EA/HistoricFloodMap&Mode=spatial
[2] Flood Estimation Handbook Web Service - https://fehweb.ceh.ac.uk/GB/map

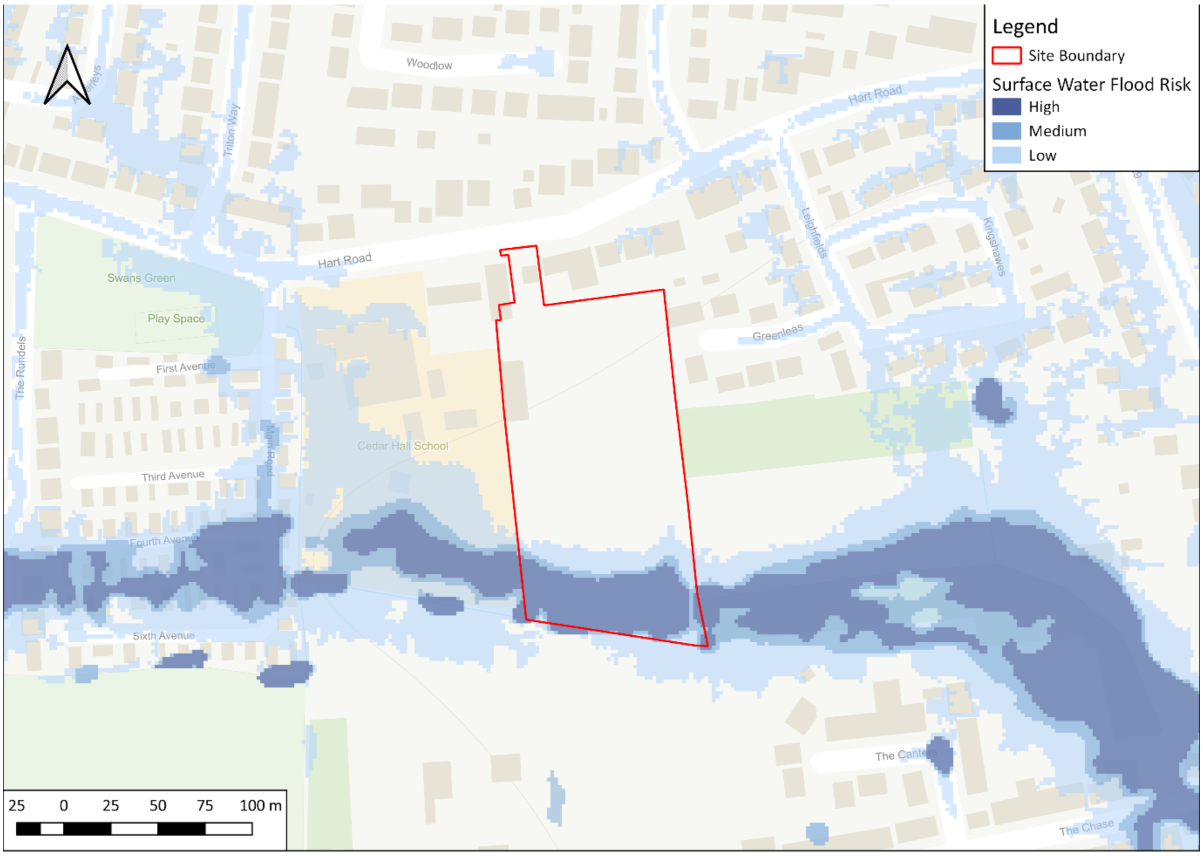


Figure 3. EA Surface Water Flood Risk Maps

Mapping indicates the flooding on site to be part of a large flow path following the general topography of the area flowing in a general easterly direction, backing up behind existing roads to the south east of the site. EA Online Long-Term Flood Risk Mapping indicates the majority of the flooding on site to have depths between 300 to 900mm.

It should be noted that the EA mapping does not account for any drainage that may be serving the site and given the data uses LiDAR, does not include the surveyed Thundersley Brook to the south of the site and therefore underestimates the storage capabilities of the channel and the influence it has on drainage the site. Therefore, to confirm the surface water risk to the site, Hydrock has undertaken a small rainfall modelling exercise to confirm the level of surface water risk to the site.

For more details of the rainfall modelling including outputs and confirmation of site-specific risk see Section 6 of this report.

3.4 Groundwater Flooding

British Geological Survey (BGS) Mapping indicates the site to be entirely underlain by superficial deposits of Head consisting of clay, silt, sand and gravel overlying the Bagshot Formation bedrock geology consisting of sand.

The South Essex Surface Water Management Plan (URS, 2012) indicates the Bagshot Formation is assigned by BGS as having a high permeability and therefore has the potential to be conducive to groundwater flows. Whilst the superficial deposits of Head are also considered to have a very high to high susceptibility to groundwater flooding, the variable composition and their thickness and lateral extent is thought to be limited and as such the SWMP indicates the deposits are not as susceptible to groundwater flooding as indicated by the BGS data.

Given the presence of the Thundersley Brook in the south of the site, it is thought likely that groundwater within the superficial deposits and bedrock will be in hydraulic connectivity with normal channel water levels. As such, the risk of fluvial flooding is considered to be the 'worst-case' scenario and this risk has been confirmed by the hydraulic modelling study.

The SWMP indicates no groundwater flooding incidents have been reported within the South Essex area and the Areas Susceptible to Groundwater Flooding Map within the SFRA indicates the site to be within a low risk (<25%) area and therefore the risk of groundwater flooding is considered to be 'low'.

Given that the determination of groundwater flood risk in this instance is driven by geological factors which will be unaffected by the potential effects of climate change, the risk of groundwater flooding posed to the site is considered unlikely to increase as a result of climate change.

3.5 Infrastructure Failure Flooding

The nature of the residential developments to the north, east and west of the site suggests it is likely there is a public drainage system serving the surrounding area. Any surcharging of sewer networks up-catchment will likely follow surface water flow routes and be directed through the site following local topography, draining south into the Thundersley Brook. The generally consistent gradient through the site suggests that any such flows would be ‘sheet flow’ and shallow in nature.

The SFRA indicates the site to be in a postcode with 2-3 historic incidents of sewer flooding according to the DG5 register however these do not detail site specific properties. Therefore, given that the risk of sewer flooding is likely only in the event of failure or blockage, this is considered to be a ‘residual’ risk, and as such the risk of potential flooding from sewers is concluded to be ‘low’.

The EA Reservoir Failure Extent mapping (EA, 2020)[3] does not show the site to lie within the extent of potential reservoir flooding and, given there is no known risk of flooding from canals or any other artificial sources at the site, it can be concluded that the risk of flooding from infrastructure failure is 'low'.

[3] EA Long Term Flood Risk Maps - https://flood-warning-information.service.gov.uk/long-term-flood-risk/map

4. HYDROLOGICAL MODELLING

4.1 Introduction

The current EA Flood Zones classifies the site as entirely Flood Zone 1 (Low Risk) however EA typically provide flood zonation outlines only for watercourses with a catchment of 3km^2 or greater. It has been confirmed that no detailed flood risk modelling of the watercourse is available and as such there is a need to confirm site-specific risk.

Therefore, it has been discussed and agreed with the EA that Hydrock Consultants Limited (Hydrock) will undertake a hydrological and hydraulic modelling study of the Thundersley Brook Watercourse on behalf of L&G Affordable Homes.

The current watercourse is shown in Figure 4. Thundersley Brook Watercourse

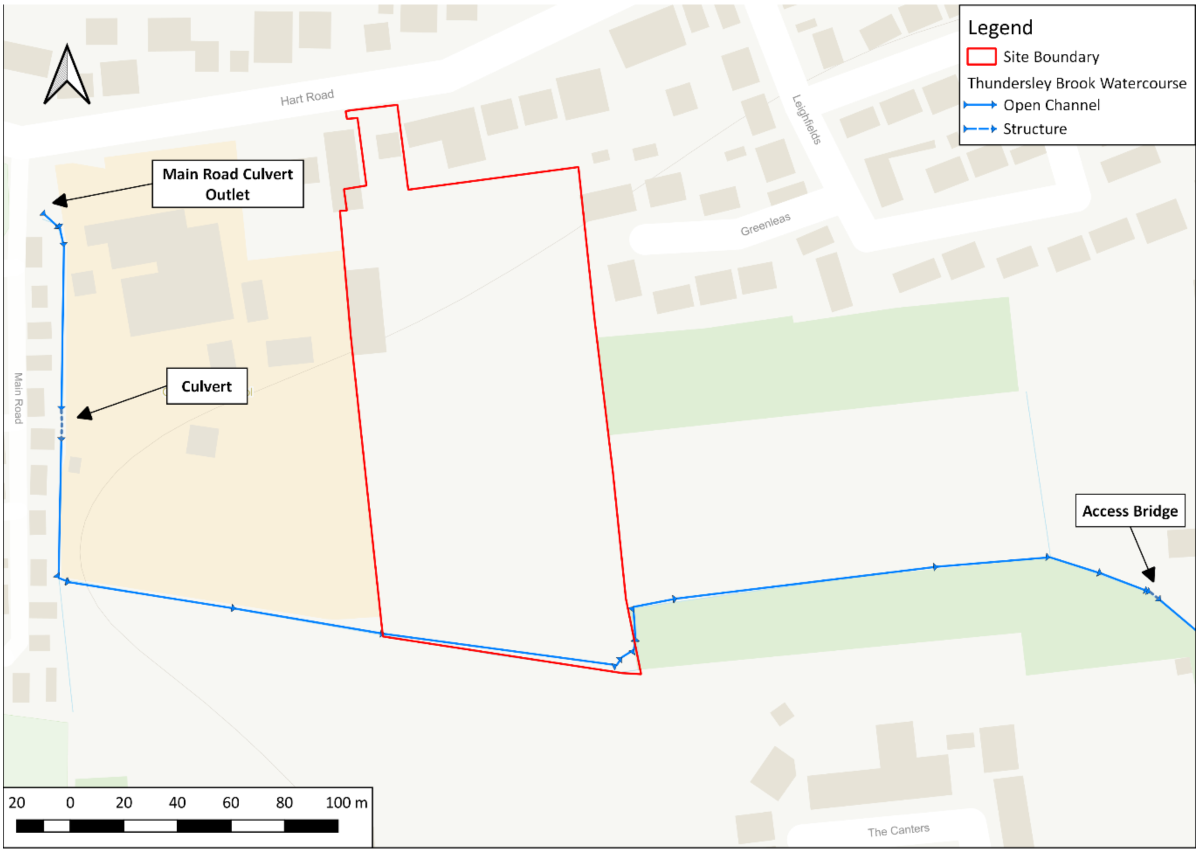


Figure 4. Thundersley Brook Watercourse

4.2 Hydrological Assessment

For the site of interest, the main source of fluvial risk is considered to be the Thundersley Brook which runs along the site's southern boundary in a general easterly direction. It should be noted that the watercourse comes from a culvert travelling under Main Road approximately 250m upstream of the site and this would ultimately restrict the flow entering the site.

4.3 Flood Estimation Handbook

The Flood Estimation Handbook (FEH) Catchment Descriptors and map for the Thundersley Brook watercourse from the FEH Web Service are included in Table 2 and Figure 5.

Table 2. Thundersley Brook FEH Catchment Descriptors

Descriptor	Tributary	Description
	580050	Outlet Easting
	188350	Outlet Northing
	TQ 80050 88350	Outlet Grid Reference
AREA	0.88	Catchment area (km2)
ALTBAR	75	Mean elevation (m)
ASPBAR	124	Mean aspect
ASPVAR	0.57	Variance of aspect
BFIHOST	0.385	Base flow index
DPLBAR	0.76	Mean drainage path length (km)
DPSBAR	21.1	Mean drainage path slope
FARL	1	Index of lakes
FPEXT	0.0653	Prop. of catchment in1% FP
FPDBAR	0.267	Mean flood depth (catchment)
FPLOC	0.395	Avg. dist. of FP to outlet
LDP	1.44	Longest drainage path (km)
PROPWET	0.26	Proportion of time soil is wet
RMED-1H	12.5	Median 1 hour rainfall (mm)
RMED-1D	31.4	Median 1 day rainfall (mm)
RMED-2D	37.3	Median 2 day rainfall (mm)
SAAR	566	Average annual rainfall (mm)
SAAR4170	585	Ditto for 1941-1970 (mm)
SPRHOST	41.7	Percentage runoff
URBCONC1990	0.853	Urban concentration 1990
URBEXT1990	0.2955	Urban extent 1990
URBLOC1990	1.036	Urban location 1990
URBCONC2000	0.885	Urban concentration 2000
URBEXT2000	0.4474	Urban extent 2000
URBLOC2000	1.008	Urban location 2000

Figure 5. FEH Web Service Catchment for Thundersley Brook

Whilst the above data was obtained using an industry standard approach, a check on key descriptors (AREA, SPRHOST, URBEXT) was undertaken to ensure that the values adopted were appropriate for use. This included the following checks:

- The AREA of the catchment was checked using OS contour mapping and available LiDAR data. This exercise identified little difference between the FEH catchment and that identified using topographical information. In addition, no obvious cross-catchment flows from watercourses, land drainage ditches, or sewer networks were identified, and as such, the Catchment Descriptors AREA value remains appropriate and was used in these calculations.
- The Catchment Descriptors provide a SPRHOST of 41.7 which implies the underlying conditions are not considered to be permeable. Given the potential impact of this value on calculated flows this was checked using available soil mapping information. This information confirmed that the majority of the catchment is underlain by slowly permeable seasonally wet acid loamy and clayey soils or slightly acid loamy and clayey soils with impeded drainage. This suggests that the underlying ground conditions are relatively impermeable, and as such, the SPRHOST value is considered acceptable.
- In order to verify the URBEXT value, a review of mapping was undertaken to identify any significant areas where recent development has occurred. Based on available mapping no areas of recent development were identified, and as such, the Catchment Descriptors URBEXT value is considered appropriate.

4.3.1 ReFH2 Method

Given the small, ungauged and rural nature of the catchment, the Revitalised Flood Hydrograph (ReFH) v2 was initially used for the assessment of design events for the Thundersley Brook catchment (see Table 3 for peak flows). For the Thundersley Brook catchment a 4.5hr duration and timestep of 0.5hrs was found to be the critical storm and in the absence of any other information (i.e., gauged data, historical records etc.) this is considered appropriate.

Table 3. ReFH2 Calculated Peak Flows for Thundersley Brook

Return Period (AEP)	Thundersley Brook Peak Flows (m^3/s)
1,000yr (0.1%)	3.64
100yr (1%)	1.82
20yr (5%)	1.18

4.3.2 FEH Statistical Method

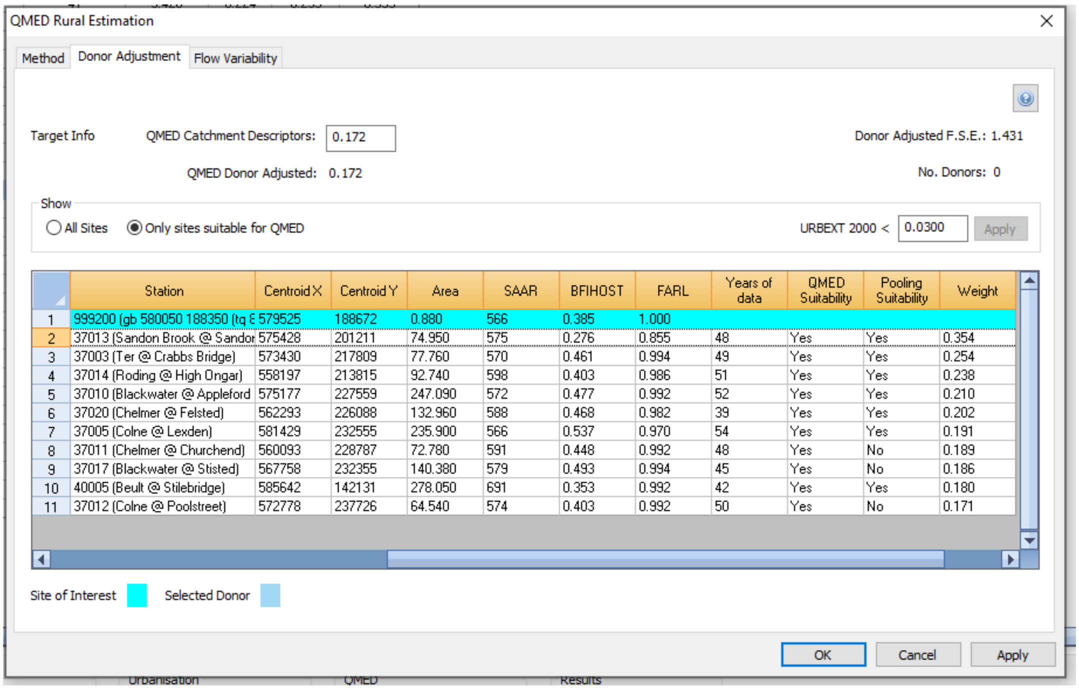
A WINFAP-FEH v4 hydrological assessment of flows (using the latest dataset version) was undertaken based on a pool group for the Thundersley Brook catchment. An initial pooling group with an approximate cumulative total of 1500yrs data was reduced down to one with 1090yrs (see Figure 6) by removing sites with a significantly higher SAAR, a significantly higher (>80%) and lower (<25%) BFIHOST and a significantly lower FARL value (<0.95%). Three stations were removed due to high SAAR value, five stations were removed due to BFIHOST values outside of the typical range and one station was removed due to a low FARL value.

AM Data | Catchment Descriptors

	Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
1	27051 (Crimple @ Burn Bridge)	3.261	42	4.539	0.221	0.149	0.156
2	45816 (Haddeo @ Upton)	3.263	21	3.522	0.313	0.404	0.976
3	28033 (Dove @ Hollinsclough)	3.549	35	4.666	0.259	0.417	1.150
4	25019 (Leven @ Easby)	4.069	36	5.538	0.345	0.383	1.097
5	47022 (Tory Brook @ Newnham	4.229	21	7.331	0.255	0.072	0.627
6	206006 (Annalong @ Recorder)	4.408	48	15.330	0.189	0.052	1.387
7	27010 (Hodge Beck @ Bransda	4.456	41	9.420	0.224	0.293	0.355
8	203046 (Rathmore Burn @ Rath	4.679	32	10.821	0.133	0.100	1.032
9	20002 (West Peffer Burn @ Luff	4.803	41	3.299	0.292	0.015	2.012
10	51002 (Horner Water @ West Lu	4.816	33	10.600	0.395	0.312	2.777
11	36010 (Bumpstead Brook @ Bro	4.820	47	7.500	0.375	0.186	2.133
12	49003 (de Lank @ de Lank)	4.908	48	13.985	0.230	0.220	0.167
13	48009 (st Neot @ Craigshill Woc	4.952	17	7.614	0.251	0.346	0.537
14	48004 (Warleggan @ Trengoffe)	5.035	45	9.983	0.265	0.263	0.162
15	25012 (Harwood Beck @ Harwc	5.073	45	33.265	0.189	0.247	0.938
16	72014 (Conder @ Galgate)	5.089	47	17.703	0.196	0.049	0.443
17	73015 (Keer @ High Keer Weir)	5.124	24	12.187	0.164	0.008	0.775
18	46005 (East Dart @ Bellever)	5.169	50	38.510	0.161	0.078	0.568
19	41020 (Bevern Stream @ Clappe	5.236	45	13.660	0.210	0.189	0.282
20	72007 (Brock @ Upstream of a6	5.277	36	29.438	0.193	0.236	0.733
21	28058 (Henmore Brook @ Ashb	5.368	12	9.006	0.155	-0.064	1.816
22	28041 (Hamps @ Waterhouses)	5.382	29	26.664	0.221	0.314	1.455
23	24006 (Rookhope Burn @ Eastg	5.400	20	24.620	0.152	0.117	0.622
24	47021 (Kensey @ Launceston N	5.402	12	13.685	0.285	0.097	1.827
25	76811 (Dacre Beck @ Dacre Br	5.404	14	35.000	0.194	0.263	2.129
26	51003 (Washford @ Beggearn H	5.431	47	6.105	0.189	0.066	0.591
27	47009 (Tiddy @ Tideford)	5.484	45	6.466	0.213	0.236	0.337
28	49004 (Gannel @ Gwills)	5.508	45	15.022	0.256	0.112	0.904
29	39033 (Winterbourne Stream @	5.540	52	0.403	0.352	0.390	1.632
30	24007 (Browney @ Lanchester)	5.554	15	10.981	0.222	0.212	1.048
31	48001 (Fowey @ Trekeivesteps)	5.617	45	17.316	0.226	0.279	0.330
32							
33	Total		1090				
34	Weighted means		1090		0.238	0.197	

Figure 6. Final WINFAP-FEH Pooling Group

Stations for the catchment were identified within WINFAP-FEH v4. The Donor Stations highlighted as suitable for QMED are provided in Figure 7.



	Station	Centroid X	Centroid Y	Area	SAAR	BFIHOST	FARL	Years of data	QMED Suitability	Pooling Suitability	Weight
1	999200 (gb 580050 188350 (tq 8	579525	188672	0.880	566	0.385	1.000				
2	37013 (Sandon Brook @ Sandon	575428	201211	74.950	575	0.276	0.855	48	Yes	Yes	0.354
3	37003 (Ter @ Crabbs Bridge)	573430	217809	77.760	570	0.461	0.994	49	Yes	Yes	0.254
4	37014 (Roding @ High Ongar)	558197	213815	92.740	598	0.403	0.986	51	Yes	Yes	0.238
5	37010 (Blackwater @ Appleford	575177	227559	247.090	572	0.477	0.992	52	Yes	Yes	0.210
6	37020 (Chelmer @ Felsted)	562293	226088	132.960	588	0.468	0.982	39	Yes	Yes	0.202
7	37005 (Colne @ Lexden)	581429	232555	235.900	566	0.537	0.970	54	Yes	Yes	0.191
8	37011 (Chelmer @ Churchend)	560093	228787	72.780	591	0.448	0.992	48	Yes	No	0.189
9	37017 (Blackwater @ Stisted)	567758	232355	140.380	579	0.493	0.994	45	Yes	No	0.186
10	40005 (Beult @ Stilebridge)	585642	142131	278.050	691	0.353	0.992	42	Yes	Yes	0.180
11	37012 (Colne @ Poolstreet)	572778	237726	64.540	574	0.403	0.992	50	Yes	No	0.171

Figure 7. WINFAP-FEH QMED Estimate

The QMED value calculated when using the Catchment Descriptor Method (0.172m^3/s) was equal to that when using the Donor Station method (0.172m^3/s). Whilst the Donor Station method gave an equal QMED for the catchment, on review, the significant catchment size difference between the Thundersley Brook and Donor Stations meant that this method would have been unsuitable for the calculation of QMED.

The QMED value was then extrapolated using the Generalised Logistic growth curve based on the goodness of fit to derive design flows for more 'extreme' return period flood events. In line with standard practice, the Urban Adjustment Factor (UAF) was applied to the final QMED (0.172m^3/s without and 0.256m^3/s with the UAF applied). The calculated peak flows from the WINFAP-FEH method have been provided in Table 4.

Table 4. WINFAP-FEH Calculated Peak Flows

Return Period (AEP)	Thundersley Brook Peak Flows (m^3/s)
1,000yr (0.1%)	1.184
100yr (1%)	0.669
20yr (5%)	0.256

4.4 Summary

Whilst the flows from the ReFH2 are significantly larger than the WINFAP-FEH Statistical method flows and would therefore be considered conservative, given the flows within the channel are ultimately controlled by the 375mm pipe at the upper end of the channel it is considered that the WINFAP-FEH method provides a more accurate representation of flows.

It is also considered that in accordance with the Environment Agency Flood Estimation Guidelines Technical Guidance Ref:197_08 which states:

"...that applicability of ReFH to urban catchments (URBEXT1990>0.125) is 'unclear' without further research. On Many urban catchments, the results of ReFH appear suspect because the winter season event tends to give higher flows than the summer event, contrary to expectations."

And;

"On impermeable and wet catchments (BFIHOST<0.4 and PROPWET>0.45), it can even give a flow volume that is greater than the volume of the input rainfall."

Given that the Thundersley Brook catchment is considered to be heavily urbanised (URBEXT1990 value of 0.853) and would be considered impermeable (BFIHOST value of 0.385) this further suggests that WINFAP flows would be more suitable in this instance.

In line with standard practise, flows were calculated for the 1 in 20 year (Flood Zone 3b), 1 in 100 year (Flood Zone 3), and 1 in 1000 year (Flood Zone 2) flood event.

The impact of climate change on flows was calculated in line with current guidance by multiplying the 1 in 100 year calculated flow by 1.25 and 1.38 to take account of the predicted 25% and 38% increase in flows for the 2080's Central and Higher Central EA climate change allowances.

The final flows calculated and used within the modelling study, are detailed in Table 5.

Table 5. Summary of Design Flows

Return Period (AEP)	Thundersley Brook Peak Flows (m3/s)
1,000yr (0.1%)	1.184
100yr (1%) + Higher Central	0.923
100yr (1%) + Central	0.836
100yr (1%)	0.669
20yr (5%)	0.458

5. HYDRAULIC MODELLING

5.1 Model Summary

Given the size of the Thundersley Brook catchment (0.88km^2) no Flood Zones have been produced for the site by the EA and it has been confirmed that no detailed modelling is available for the watercourse. As such, there is a need to confirm site-specific flood risk through detailed modelling. Owing to the current mapping and likelihood of overland flow routes, a linked 1D/2D model was undertaken.

The model was run using the most up-to-date version of TUFLOW. The version of software that was used is:

- TUFLOW - 2020-10-AB

The model was constructed using a combination of detailed river channel and structure survey (included within Appendix A) with floodplains represented using 1m LiDAR data. The modelling focused on the following reach length:

- An approximate 600m length of the Thundersley Brook watercourse extending from a culvert outlet 250m upstream of the site to an outlet downstream of a farm access bridge.

The construction of the model saw a number of iterations. The files for the final baseline scenario are:

- TCF – varies for different flood event but all follow THUN_001_*event*_BASELINE naming structure for baseline scenarios.
- ECF – THUN_001_BASELINE.ecf
- TRD – THUN_001_BASELINE.trd
- TBC – THUN_001_BASELINE.tbc
- TGC – THUN_001_BASELINE.tgc
- TUFLOW Results and Checks all saved separately for different flood events. Similar reference to TCF.
- BC_DBASE – All event hydrographs referenced in separate .csv files.
- Shapefiles – all references within the TRD, ECF, TBC and TGC files.

5.2 Events & Scenarios

Baseline models have been run for each of the five events listed in Table 5, and further sensitivity tests were then undertaken in line with standard practice:

- A sensitivity test on the baseline scenario model to assess the impact of a 20% increase and 20% decrease in the 1D and 2D roughness parameters.
- A sensitivity test on the baseline scenario model to assess the impact of a 20% increase and a 20% decrease in the downstream boundary gradient.

5.3 Channel, Structures and Topographical Survey

Multiple sources of data were used to construct the model:

- A channel survey was used for the culvert invert levels, structure dimensions and for cross section profiles along the Thundersley Brook channel.
- Environment Agency LiDAR 1m DTM data was used as a baseline DTM both inside and outside of the site boundary. Whilst a site-specific topographical survey was provided, following a ground

truthing exercise comparing the survey to EA LiDAR data, a negligible (<5cm) difference was found between survey levels and LiDAR data and as such the LiDAR data has been used for the baseline model build given the confirmation of levels.

5.4 Baseline Model Build

5.4.1 1D Model Build

A full TUFLOW model schematic is shown in Figure 8.

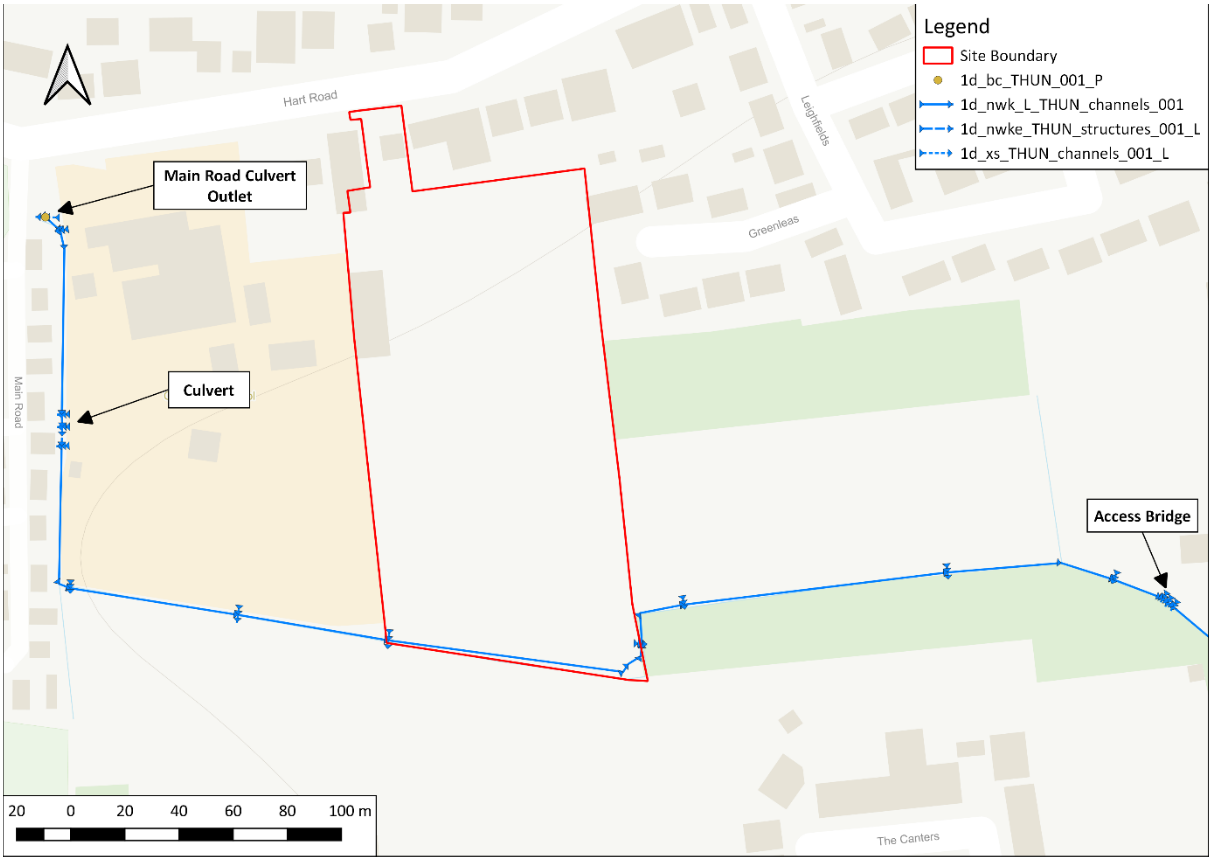


Figure 8. Thundersley Brook TUFLOW 1D Model Schematic

A summary of the cross sections included in the model is as follows:

- Upstream Cross Section – THUN0557CD
- Downstream Cross Section – THUNM0020
- Total number of Channel Cross Sections – 16 surveyed cross sections (includes 2 mid-section cross sections).

The cross sections were based on site-specific topographical data (included with Appendix A).

The 1D network has been built using the 1d_nwk, 1d_nwke and 1d_xs shapefiles linking to individual cross section csv's which define the channel geometry and Manning's n roughness values. Open channels have been defined using the 'S' attribute within the 1d_nwk shapefiles. Two structures have been identified and modelled along the Thundersley Brook: one irregular shaped culvert and one access bridge.

Manning's n roughness values were assigned using the approach adopted by Chow[4]. Values used in the model were based on photographs of the channel, banks and culvert and information obtained during the site walkover survey and are therefore considered appropriate.

Figure 9 shows the long section from the final 1D model setup and provides a summary of the chainage and bed profiles.

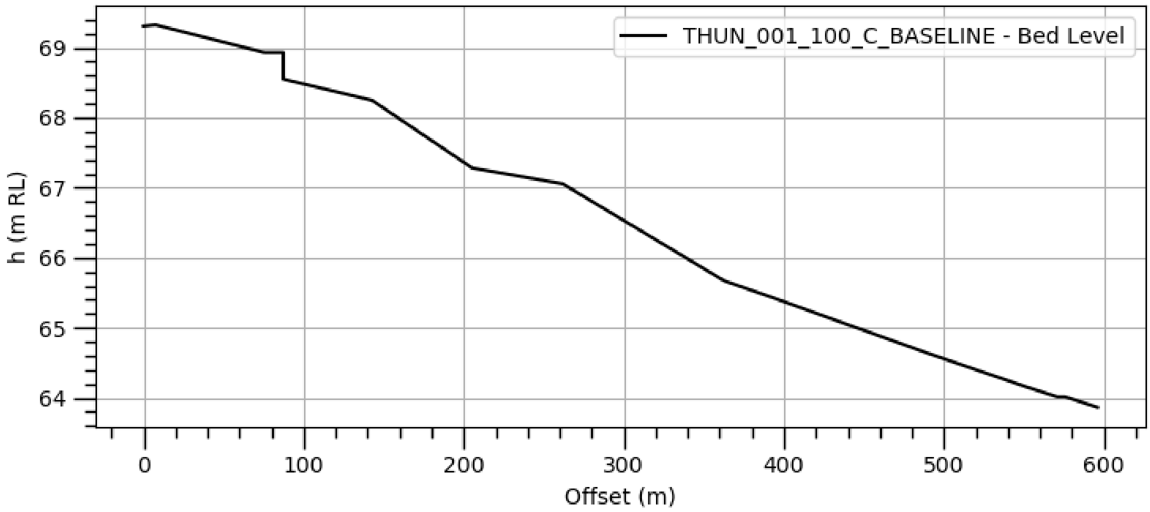


Figure 9. 1D Network Long Section

5.4.1.1 1D Boundary Conditions

For the upstream boundary a QT 1d_bc node was applied linking to the bc database with each event referenced in the .tcf which subsequently linked to the relevant hydrograph .csv file. The hydrographs were scaled to the peak flows in Table 5 with models run for six hours. The 1D timesteps (0.25s) were run at half the 2D timestep (0.5s).

For the 1D downstream boundary a 2d_bc hxi boundary has been snapped to the downstream end of the 1d_nwk with connector lines to convey flow from the 1D network into the 2D floodplain and exit the model.

5.4.1.2 1D Structures

In total, two structures were identified and included within the modelled reaches. Both structures were modelled using a 1d_nwke line with the optional weir attributes included. The first structure is an irregular shaped culvert, defined in the 1d_nwke as 'IW' type, with the culvert geometry defined by a mid-channel cross section within the 1d_xs layer linking to a csv (HW type) with elevations (mAOD) and widths (m). For the automatic weir capabilities of the 1d_nwke shapefile, attributes have been defined from surveyed information of the structure. The survey indicated a 'hand rail' defined as 'closed board fencing' and so a 95% blockage of the rail has been applied.

The second structure is an access bridge with the 1d_nwke type set as 'BBW' to apply the automatic weir functionality. Bridge dimensions have been applied with a mid-channel cross section within the

[4] Manning's n for Channels (Chow, 1959) - http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

1d_xs layer linking to a csv (XZ type) with reach (m) and elevations (mAOD). Weir attributes have been defined from the channel survey.

As part of the channel survey, each structure was photographed. These photographs in conjunction with the level information, were reviewed as a 'sense check' of the levels and values used within the model.

5.4.2 2D Model Build

A model schematic for the 2D TUFLOW element is shown in Figure 10.

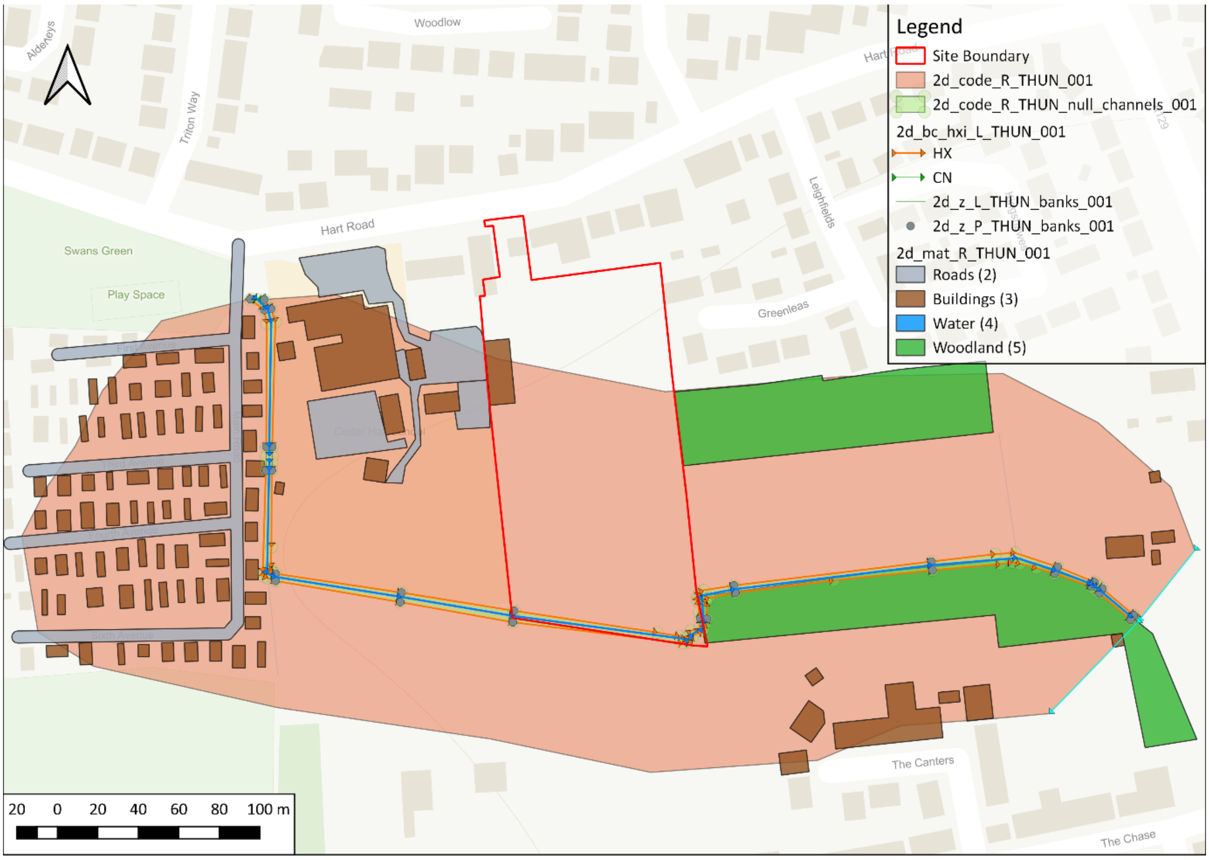


Figure 10. Thundersley Brook TUFLOW 2D Model Schematic

The 2D model domain covered a total area of approximately 0.13km^2, measuring approximately 220m wide, being centred on the site of interest. Whilst the 2d_code does not cover the entire site, given the extents were not predicted to cover the entire site, it was deemed that a large domain was not needed in this instance.

The 2D model was predominantly based on LiDAR data at a 1m resolution obtained from the EA Data library. This LiDAR data is the most recent information available. The LiDAR data was checked against the Topographical Survey of the site itself and there was found to be on average a negligible (<5cm) discrepancy between the two data sets and as such the LiDAR data was considered acceptable for use within the model. The LiDAR data was also used to identify areas of higher ground (ultimately watersheds) which were then used to help determine the required 2D domain extent. The domain chosen followed the line of high ground to both the north and south of the Thundersley Brook channel.

The Environment Agency online flood map for planning service shows there are no flood defences within the areas of the 2D domain to include within the model.

The model was a linked 1D/2D model with coupling via the use of HX and CN lines. A check of each cross-section width was undertaken to ensure that the 1D domain width (i.e., area coded out) matched the surveyed width of the channel. All cross-section widths within the 2D model were within 10% of the surveyed channel width.

5.4.2.1 2D Boundary Conditions

A Stage-Discharge boundary was applied along the downstream edge of the TUFLOW domain to prevent any over-estimation of flood levels within the site due to 'backing up' at the downstream model limit, and this was represented as a HQ boundary within the 2d_hxe file. An average gradient for the downstream boundary had been calculated based on measurements taken from the LiDAR data.

Table 6. Downstream Boundary Gradient

	Gradient (dy/dx)
Left Floodplain	0.04
Right Floodplain	0.03

5.4.2.2 2D Roughness

The baseline 2D roughness values were represented within a 2d_mat file with all buildings, highways, and areas of woodland being represented. The location of all of the features included within the materials file was taken initially from OS Open Map Local data. All highways were modelled as a single centre line with a buffer applied to represent their width. The buffer distance is applied to both sides of the centre line and as there were no dual carriageways or motorways within the 2D domain, a standard value of 3m was applied and these were then sense checked against aerial imagery and OS MasterMap underlaying the shapefile. Any areas deemed to have a significant change in roughness value that were not included within the OS Open Map Local Data (i.e., car parking areas for the school) were added in manually using aerial imagery as a reference

Within the materials file each land use was represented through a reference number (2 for highways, 3 for dwellings, etc) with these being linked to a separate spreadsheet file (materials.csv) which referenced the Manning's values adopting the Chow methodology.

5.4.2.3 2D structures

No structures were identified as being required within the 2D domain.

5.4.2.4 Model Run Parameters

The 2D timesteps were run at half the model grid resolution (1m). The model has been run using TUFLOW classic solver on the CPU.

5.5 Baseline Model Results

The maximum stage in each scenario from the 1D cross sections nearest the site is included in Table 5 and the output drawings included in Appendix B.

Results show that in all events, except the 0.1% AEP (1,000 year) event, the channel is predicted to contain the flows at the point of site. In the 1,000 year event, a small amount of out of bank flows are predicted extending approximately 2m into site from the top of bank with maximum predicted flood levels and depths of 67.88m AOD and <50mm respectively. Approximately 60m downstream of the site, flows are predicted to come out of bank around the access bridge and back up slightly but these are not indicated to predict the site in anyway. In the 0.1% (1,000 year) event, an overland flow route is predicted through the school to the west, upstream of the irregular culvert, but this is not shown to enter the site.

Table 7. Baseline Scenario Maximum Stages (mAOD) at Cross Sections nearest the Site.

	1 in 20yr Max Stage (mAOD)	1 in 100yr Max Stage (mAOD)	1 in 100yr + Central CC Max Stage (mAOD)	1 in 100yr + Higher Central CC Max Stage (mAOD)	1 in 1000yr Max Stage (mAOD)
THUN0370	67.74	67.82	67.87	67.89	67.95
THUN0314	67.30	67.38	67.44	67.46	67.54
THUN0213	66.16	66.26	66.33	66.37	66.46
THUN0185	65.90	66.01	66.08	66.12	66.21

5.5.1 *Baseline Model Mass Error*

The cumulative 1D mass error for the baseline scenario (Figure 11), 1% AEP (1 in 100 year) plus 25% Central (2080s) Climate Change allowance, shows that after an initial spike (reaching a peak of 4.26%) within the first seconds of the model running, the mass balance decreases and settles around 0% and well within the ±1% tolerance and is therefore demonstrated to be stable in the 1D.

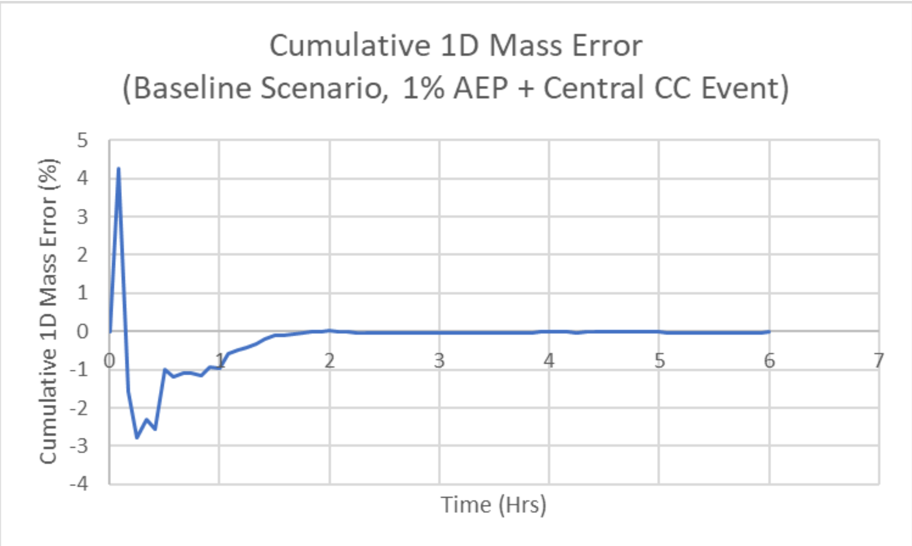


Figure 11. Cumulative 1D Mass Error (Baseline Scenario, 1% AEP + Central CC Event)

The cumulative 2D mass error for the baseline scenario, 1% AEP (1 in 100 year) plus 25% Central (2080s) Climate Change allowance, is shown in Figure 12. This shows that after an initial spike (reaching a maximum of 1.59%) just after the first hour of the model simulation, the mass balance decreases and settles around -0.68%. The model is therefore demonstrated to be stable and with acceptable mass errors between the peak inflows and peak of 2D wet cells.

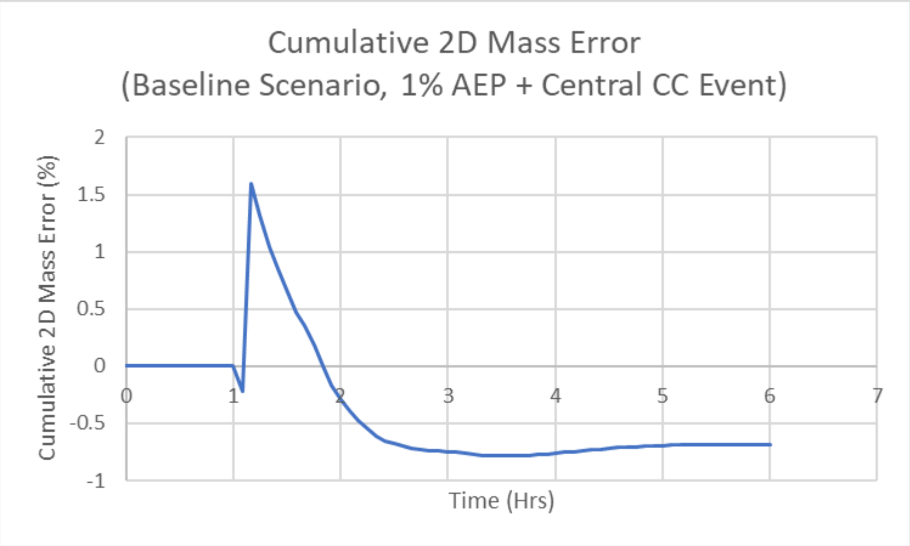


Figure 12. Cumulative 2D Mass Error (Baseline Scenario, 1% AEP + Central CC Event)

5.5.2 Sensitivity Testing

Four sensitivity tests were undertaken for the baseline model, using the 1 in 100 year (1% AEP) + 25% Central Climate Change allowance design event, to confirm the suitability of the results. These are considered below.

5.5.2.1 Baseline Scenario - Sensitivity Test 1 - Roughness +20%

A 20% increase to both the 1D and 2D model parameters was applied to assess the impact on maximum extents and depths across the whole model. Whilst the results show an overland flow route to the east of the site and an increase in flood extents downstream, there is little impact shown on the site with flows remaining contained within the channel.

5.5.2.2 Baseline Scenario - Sensitivity Test 2 - Roughness -20%

A 20% decrease to both the 1D and 2D model parameters was applied to assess the impact on maximum extents and depths across the whole model. Whilst the results show a decrease in out of bank extents downstream of the site, results show little impact at the site with flows remaining contained within the channel.

As such the model is not considered sensitive to changes in Mannings n roughness values.

5.5.2.3 Baseline Scenario - Sensitivity Test 3 - Downstream Boundary Gradient +20%

A 20% increase to the downstream boundary gradient in the 2D floodplain was applied to consider sensitivity to this parameter. The results show a negligible impact at the site or within the model with flows remaining in bank.

5.5.2.4 Baseline Scenario - Sensitivity Test 4 - Downstream Boundary Gradient -20%

A 20% decrease to the downstream boundary gradient in the 2D floodplain was applied to consider sensitivity to this parameter. The results show a negligible impact at the site or within the model with flows remaining in bank.

On this basis the model is not considered sensitive to a change in downstream boundary gradients.

5.6 Summary

Detailed hydraulic modelling of the site and Thundersley Brook has shown that the site is not predicted to be impacted in the event of fluvial flooding from the watercourse in any scenario. The existing channel has shown that it is capable of containing all events modelled with no out of bank flows predicted to impact the site, except the 0.1% AEP (1 in 1,000 year) event but this is predicted to result in an extremely limited amount of on site. Downstream of the site some out of bank flows are predicted but are not shown to impact the site. The outputs therefore confirm the majority of the site to be within Flood Zone 1, with a small amount of Flood Zone 2 in the south west portion of site, and at low risk from fluvial flooding (subject to EA confirmation and acceptance of the modelling).

Sensitivity tests have shown that flood levels on the site are not influenced when the roughness coefficients or downstream boundary gradients are increased or decreased by 20%.

6. SURFACE WATER RUNOFF MODELLING

6.1 Introduction

An initial review of current EA Surface Water Flood Risk Mapping indicates land in the south of the site to be up to 'high' risk of surface water flooding with predicted depths of mostly 300 to 900mm.

It should be noted that EA mapping does not take into account any existing drainage features that may be serving the area and if anything is an overestimation to current levels of risk on site. Based on the topography of the site, the majority of the runoff would flow into the Thundersley Brook and drain away from the site to the east. Given the level of risk, Hydrock has undertaken a simple rainfall runoff model to confirm the level of risk to the site.

6.2 Rainfall Modelling

A '2D Direct Run-Off Model' has been constructed for the site and contributing catchment in order to understand the existing surface water flow routes affecting the site but also includes the surveyed 1D network as discussed in the hydraulic modelling in Section 5.

Rainfall depths are derived from the FEH DDF (Depth Duration Frequency) model with catchment parameters taken from the FEH Web Service from an outlet point at grid reference 420900, 187700.

The following storm events were modelled: 1 in 5, 1 in 20, 1 in 30, 1 in 100, 1 in 100 year + 40% allowances for climate change events. Each were run for a duration of 6 hours which is the required storm length for calculating runoff volume as specified in guidance documents[5]. For a catchment of this size, this is considered an appropriate duration, with the minimum recommended duration being a 3-hour event.

The events considered critical for the surface water drainage design are the 1 in 30 year and 1 in 100 years plus 40% climate change. The 1 in 30 year is the typical design standard under Sewers for Adoption Seventh Edition where no flooding of the system should occur. The 1 in 100 years plus 40% climate change event is the extreme storm which new developments should be designed to withstand, whereby flooding of the network may occur but it must be safely contained away from buildings or key access / egress routes. The 1 in 5 year event has also been run to represent the expected conditions in a more commonly occurring storm event.

6.2.1 Run-off Calculation

Factors which can affect runoff calculations are as follows:

- Permeability of soils, with runoff less accurately predicted in highly permeable soils. The soils in the wider catchment for the Thundersley Brook were assessed to be considered impermeable (SPRHOST of 42%).
- Small drainage catchments can result in small rainfall depths. Runoff calculated by models with an initial storage component (such as the PDM model used in ReFH) may therefore be very sensitive to storage parameters and initial conditions. Total runoff estimates may therefore be uncertain.
- Urbanisation resulting in different surface characteristics and runoff coefficients to the natural catchment.

[5] Defra / Environment Agency (2013) Rainfall runoff management for developments, pg. 7.

Given the complex nature of the issues outlined above, the following method has been used to address the limitations identified above and provide a robust runoff parameterisation for modelling:

- Runoff calculated from 'rural' areas calculated by taking the SPRHOST value from the FEH Catchment Descriptors as a representative percentage run-off value for the site of interest.
- Runoff calculated from 'urban' areas using a hybrid approach which takes the weighted average of the rural runoff (as described above) and a 90% run-off from impermeable areas. The weighting factor is the Percentage Impermeable (PIMP) value as used in the Wallingford procedure. The majority of the study area however was considered to be 'rural' with no significant urban developments within the study area.
- It has been assumed for the purpose of the direct rainfall modelling that no water enters the sewer system. This is considered to be a conservative approach as this system will help to alleviate ponding in low-lying areas. This approach is not considered to impact the predicted flow routes as all flows will be routed via the topography and ultimately into the watercourse.

The results of applying these methods are summarised in Table 8.

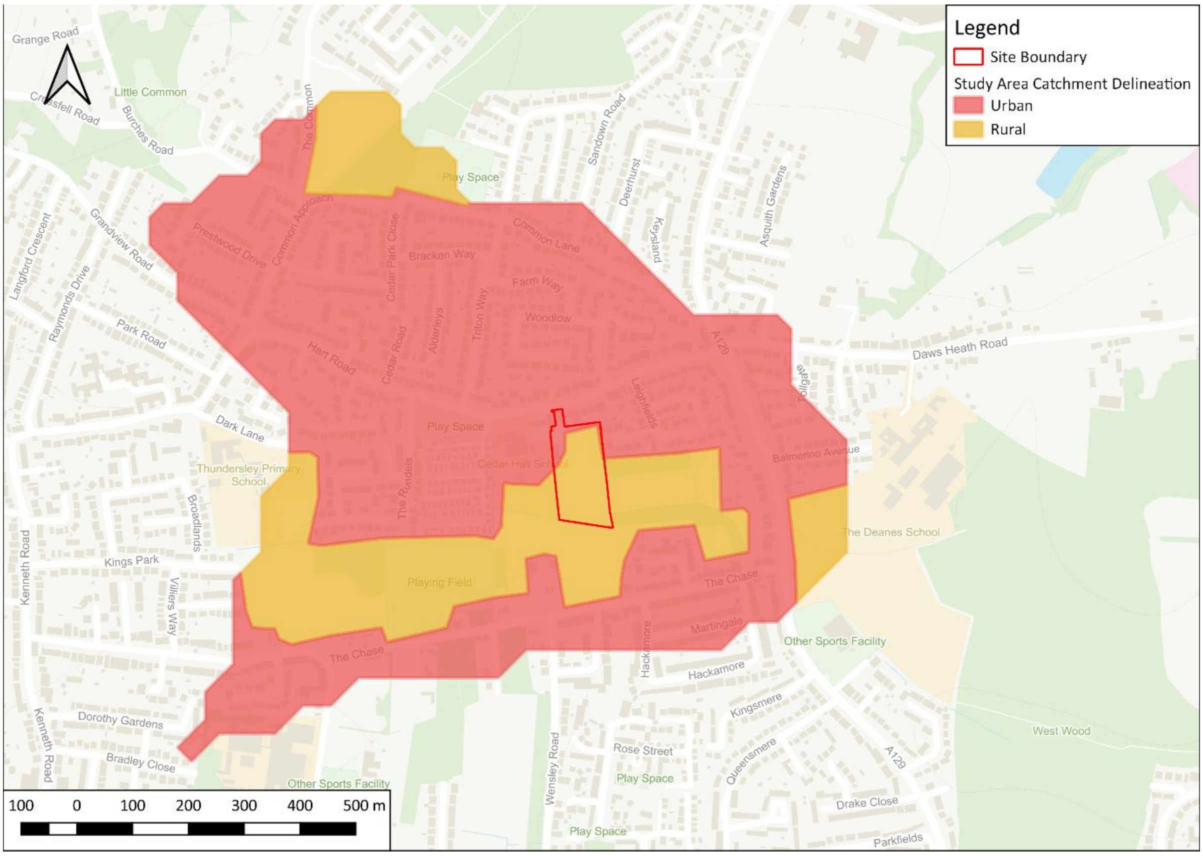


Figure 13. Urban / Rural Catchment Delineation

Table 8. Runoff Parameterisation, Rural and Urban

Method	Percentage Run-off Values
SPRHOST	0.417
PIMP Weighted Rural/Urban	0.524

6.3 Hydraulic Assessment

Based on the identified need to consider overland flow routes, a linked 2D model has been developed using TUFLOW v2020-10-AB. This was run in double precision to follow standard guidance for direct run-off modelling.

The 2D model is based on LiDAR data flown in 2020 which is at a 1m resolution, this was converted within TUFLOW to a 2m grid. The 1D network for the Thundersley Brook has also been included and does not differ from the baseline hydraulic assessment as described in Section 5.

Buildings were also included within the ground model as these are an important factor in determining surface water pathways. The building footprints were determined from OS Open Map Local vector files and were raised above immediately surrounding ground levels by 300mm to represent typical flood levels but also to deflect flows.

The watershed area (i.e., the model domain '2d_code_RAIN_001_R') was determined from the FEH catchment boundary which was checked against LiDAR contours. The extent of the domain was greater than the area of interest for this assessment to ensure that all areas draining to the site and ditch would be accounted for. The file '2d_rf_R_RAIN_001' follows the domain boundary and references the percentage runoff values for the rural areas as shown in Table 8.

For stability purposes, a 2d_bc_hxi point layer with SX attribute was applied at the downstream end of the 1d_nwk layer to allow water to exit the model. The 2D boundary was applied at the outlet of the FEH catchment with an average gradient calculated from EA LiDAR data.

Similarly to the baseline hydraulic model, 2D roughness values were represented within the 'Materials.csv' file reference in the .TRD linking to the model shapefile '2d_mat_RAIN_001_R'.

The model was run at a 2m grid resolution with a 1 second timestep which was considered to provide an appropriate balance between model run times and resolution of results. A 10-hour run time was specified for the 6-hour rainfall events which was sufficient time to observe the runoff affecting the site.

6.3.1 Results

Depth surface water flood maps for the key return periods are included in Appendix B. This includes the following:

- 1 in 5 year, 6 hour Depths - drawing 20832-HYD-RF-XX-DR-FR-0006.
- 1 in 30 year, 6 hour Depths - drawing 20832-HYD-RF-XX-DR-FR-0003.
- 1 in 100 year, 6 hour Depths - drawing 20382-HYD-RF-XX-DR-FR-0004.
- 1 in 100 year plus Climate Change, 6 hour Depths - drawing 20382-HYD-RF-XX-DR-FR-0005.

The results show that in all scenarios, the majority of the site is predicted to be at very low risk with areas of isolated low risk shallow ponding across the southern portion of the site indicative of locally lower lying areas.

The results of the rainfall scenarios show a significant reduction in surface water flooding extents and depths on site when compared to the current EA Surface Water Flood Risk Map. The inclusion of the surveyed Thundersley Brook to the south of the site have aided with the reduction of surface water flooding in the site, with flows now able to drain away from the site.

Whilst flooding in the south of the site is still predicted to occur, the modelling indicates the extents are significantly reduced with more isolated ponding indicative of locally lower lying areas rather than connected flow paths. When comparing depths to the current EA Online Mapping, in all events modelled the majority of flooding out of the channel is indicated to be below 300mm and would therefore be classified as shallow. It should be noted that the flooding on site does not show connectivity to the surrounding areas and is therefore concluded to be generated from in site flows rather than third party lands.

On the basis of the above, the majority of the site is concluded to be at low risk of flooding from surface water flooding however there is an increased risk associated with the Thundersley Brook and in the southern portion of the site. As the modelling predicts the channel is capable of carrying the surface water flows within the site.

7. NATIONAL PLANNING POLICY FRAMEWORK

7.1 Sequential and Exception Test

The NPPF Sequential Test requires that a sequential approach is followed to steer new development to areas with the lowest probability of flooding (i.e., Flood Zone 1, then 2, then 3).

Based on the site-specific modelling study and subject to confirmation from the EA and Local Planning Authority, this assessment has demonstrated the majority of site to be entirely within Flood Zone 1 in the present-day and climate change scenarios with a very small area of Flood Zone 2 in the south west of the site.

Paragraph 033 of the Flood Risk and Coastal Change National Planning Practice Guidance (NPPG) states that "Nor should it normally be necessary to apply the Sequential Test to development proposals in Flood Zone 1".

The NPPG Flood Risk Vulnerability and Flood Zone Compatibility matrix (Table 3 of the NPPG) also indicates that all forms of development are "appropriate" in Flood Zone 1 without application of the Exception Test.

Accordingly, the application of the Sequential and Exception Tests is concluded to not be required in this instance.

7.2 Mitigation Measures

Whilst an Exception Test is not explicitly required under the NPPG, and on the basis a sequential approach is adopted, the following section details any measures recommended to mitigate any 'residual' flood risks and to ensure that the proposed development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, akin to the requirements of section 'b' of the Exception Test as outlined in the NPPF.

7.2.1 Finished Floor Levels

It is recommended that, where possible, the ground floor thresholds are set above the adjacent ground levels by a minimum of 300mm, either by raising the floor level above existing ground levels or sloping ground levels away from the building. This will address any residual risks of surface water flooding (e.g., blockage of the proposed drainage network serving the site or exceedance of the drainage design capacity) by directing runoff away from the building.

It should be noted that, post-development, any rainfall and surface water flood risk within the site will be managed through an engineered surface water drainage strategy which will further reduce/mitigate the risk of surface water flooding within the site.

7.2.2 Access and Egress

Access to the site is currently provided via an existing entrance off Hart Road in the north of the site which is indicated to be at 'low' or negligible risk of flooding from all assessed sources and therefore safe access and egress is concluded to be possible.

7.2.3 Floodplain Storage

On the basis that the site has been demonstrated to be at low risk of fluvial flooding, and therefore outside a functioning floodplain, the proposed development is not considered to increase flood risk within the catchment through a loss of floodplain storage, and accordingly no further mitigation measures are required in this respect.

8. SUMMARY

This Flood Risk Assessment (FRA) report has been prepared by Hydrock on behalf of L&G Affordable Homes in support of a planning application for the proposed development on the land off Hart Road, Thundersley.

A detailed assessment of flood risk has identified that, based on current EA Flood Zone Mapping, the site is indicated to be within Flood Zone 1 (Low Risk) but is suggested to be at 'high' risk of surface water flooding in the southern portion of the site and is at ‘low’ or ‘negligible’ risk of flooding from all other assessed sources.

Detailed hydraulic modelling of the site has confirmed that, subject to confirmation from the EA, the site is within Flood Zone 1, and in all fluvial flood events modelled flows are predicted to remain within the channel, except the 0.1% AEP (1 in 1,000 year event) which is predicted to have a small extent (approx. 2m) within the site.

A surface water runoff exercise has shown that whilst the southern portion of the site is still indicated to be at an increased risk of surface water flooding, extents and depths are predicted to be significantly reduced when compared to current EA mapping with the Thundersley Brook channel shown to help with draining the site. As such the site is concluded to be at low risk of flooding from surface water.

In accordance with the NPPF and NPPG, the application of the Sequential and Exception Tests is concluded to not be required in this instance, subject to confirmation by the EA and Local Planning Authority.

It is recommended that where possible, FFLs are raised a minimum of 300mm above adjacent ground levels to address any residual risk of surface water flooding on the site.

It should be noted that, post-development, any rainfall and surface water flood risk within the site will be managed through an engineered surface water drainage strategy which will further reduce/mitigate the risk of surface water flooding within the site.

It has also been demonstrated that a means of safe access and egress is possible to and from the site via the existing entrance off Hart Road that the proposed development is also not considered to increase flood risk within the catchment through a loss of floodplain storage.

This report therefore demonstrates that, in respect of flood risk, the proposed development of the site:

- Is suitable in the location proposed.
- Will be adequately flood resistant and resilient.
- Will not place additional persons at risk of flooding, and will offer a safe means of access and egress.
- Will not increase flood risk elsewhere as a result of the proposed development through the loss of floodplain storage or impedance of flood flows.
- Will put in place measures to ensure surface water is appropriately managed.

Based on the above, the application is concluded to meet the flood risk requirements of the NPPF.

9. REFERENCES

References			
	Author	Date	Description
A	AECOM	April 2018	South Essex Council Level 1 Strategic Flood Risk Assessment (https://localplan.southend.gov.uk/sites/localplan.southend/files/2019-02/South%20Essex%20Strategic%20Flood%20Risk%20Assessment%20Level%201.pdf)
B	URS / Scott WIlson	April 2012	South Essex Surface Water Management Plan Phase I - Report (https://www.rochford.gov.uk/sites/default/files/planning_surfacemanagement2011.compressed.pdf)

Appendix A - Survey

Haycock+Todd
Land Survey Consultants Architectural Surveyors
The Hollies, 43 Church Street, Royston, Barnsley, S71 4QU. T:01226 709630
E:info@land-surveying.co.uk W:land-surveying.co.uk

SITE SURVEY

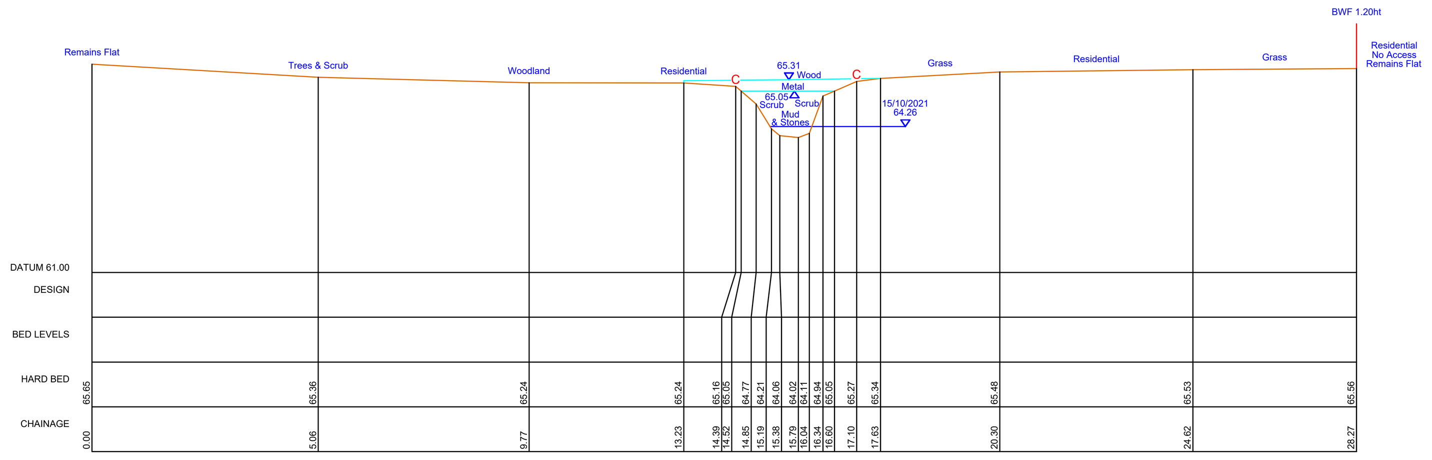
248 Hart Road,
Thundersley,
SS7 3UQ.

SURVEY STATIONS			
Station	Easting	Northing	Level
HT1	579650.856	188704.868	72.709
HT2	579712.440	188723.135	71.441
HT3	579603.738	188697.486	71.947
HT4	579716.832	188616.970	69.344
S2	579652.235	188698.591	72.440
S3	579655.989	188672.418	71.818
S4	579659.112	188645.902	71.213
S5	579658.427	188622.102	70.528

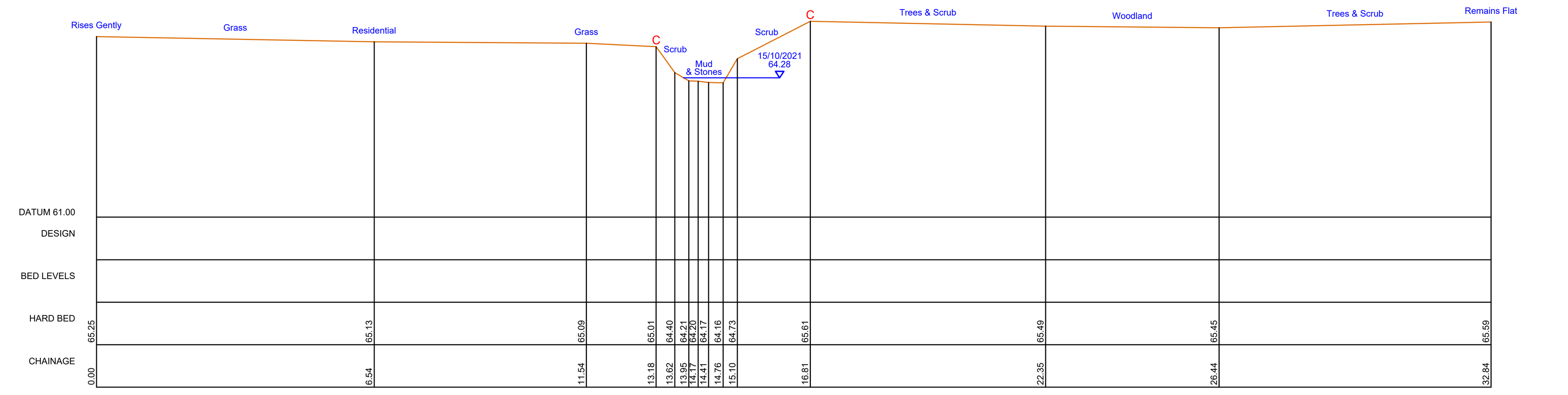
Datum
GRID– Related to Ordnance Survey using One Point Localisation on Station S3. Orientation at OS Grid North.
LEVEL– Related to Ordnance Survey by connection to the OS Active Network by G.P.S

Sheet 1 of 1
Surveyed by DR/PF/PT
Drawn by PT
Checked by DR/PF

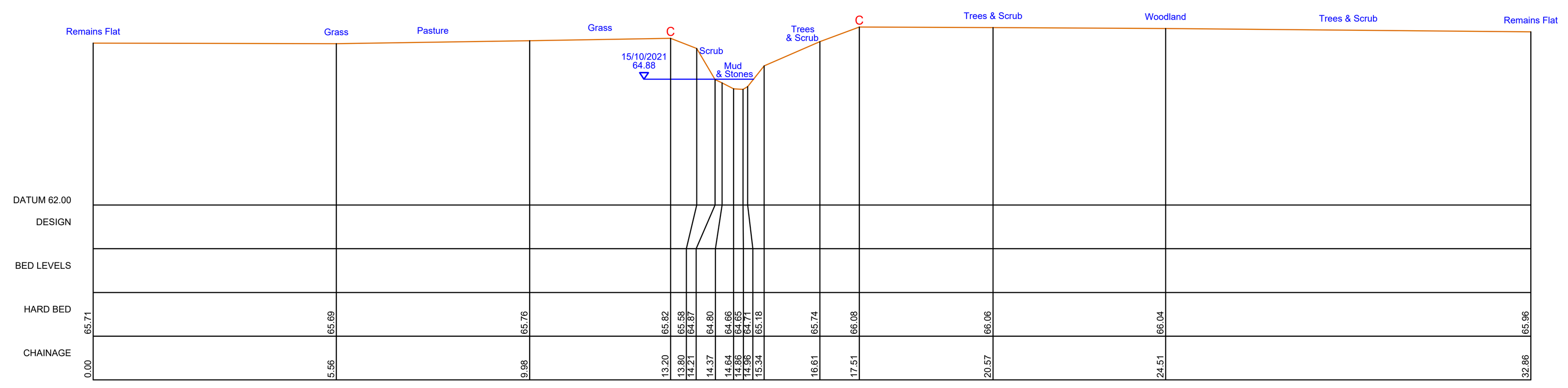
Survey Job No. S9835
Scale 1/200
Date of Survey November 2020
S9835



THUN0005BU
579954.7mE 188537.48mN Brg 213
Access Bridge
Tunnel Length = 4.82m



THUN0024
579933.98mE 188545.02mN Brg 204
Open Channel



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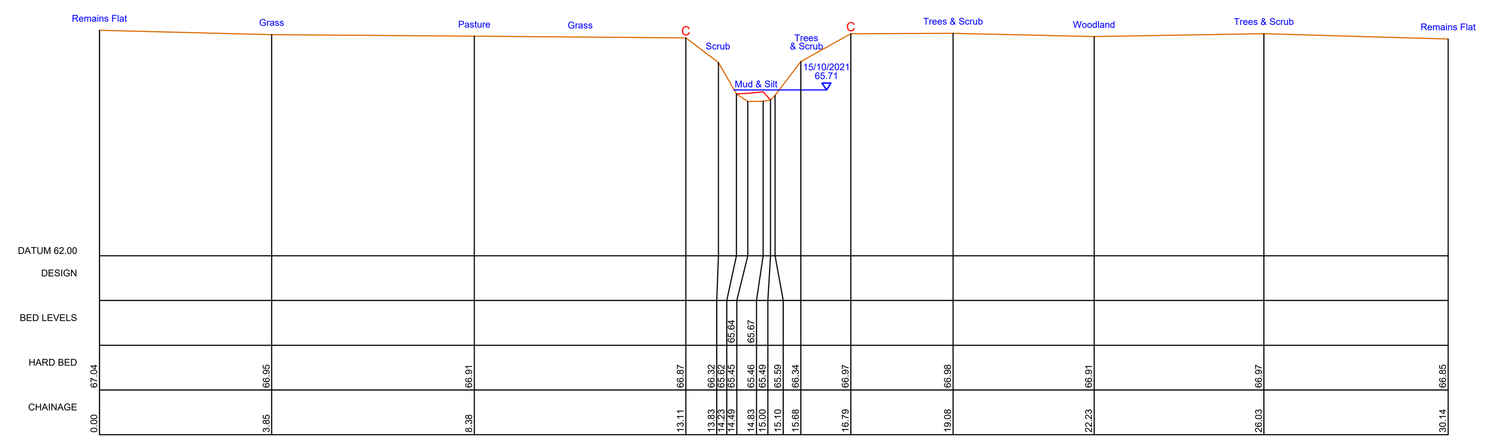
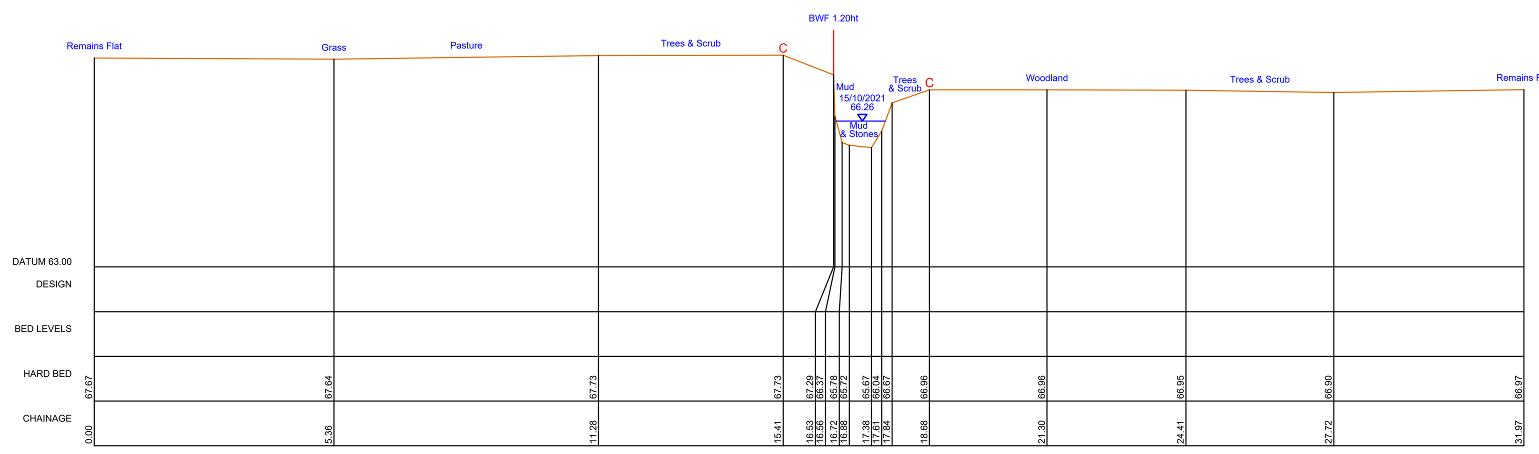
579864.71mE 188548.75mN Brg 173
Open Channel



THUN0185
579766.27mE 188536.73mN Brg 169
Open Channel



THUN0213
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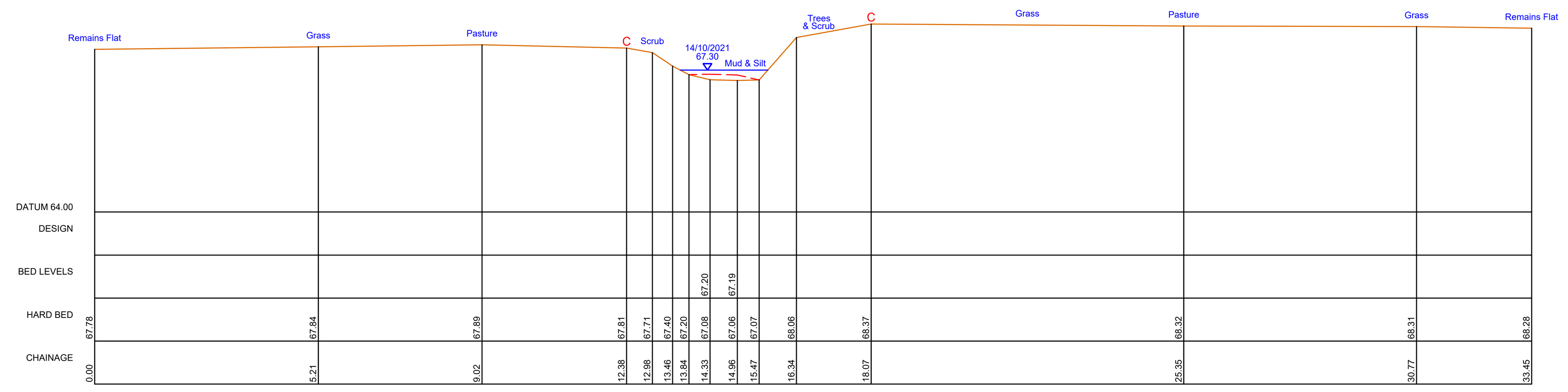
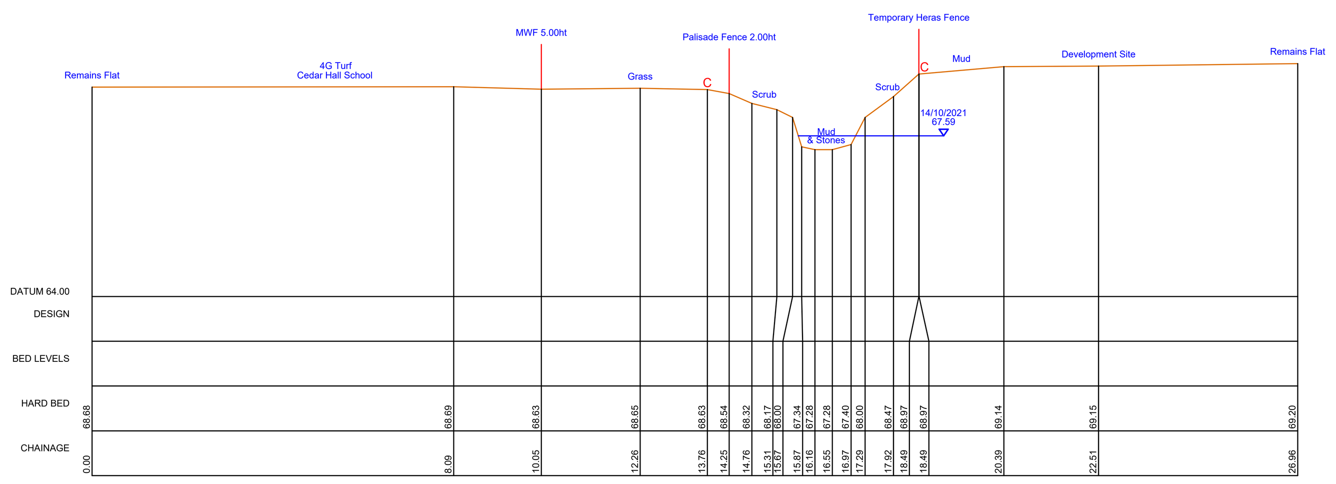
Open Channel



THUN0314
579661.51mE 188523.66mN Brg 186
Open Channel



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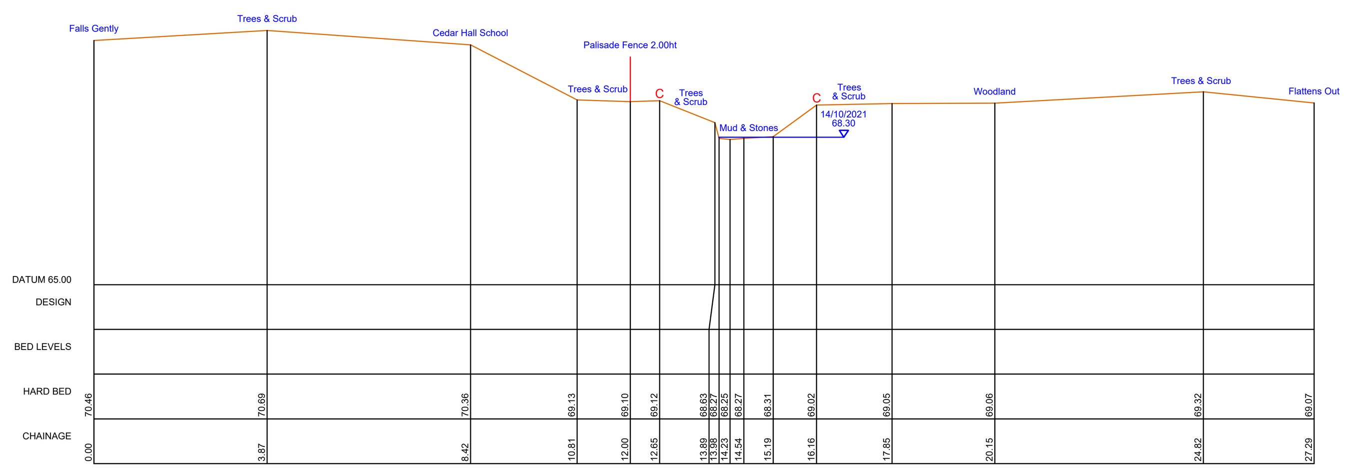
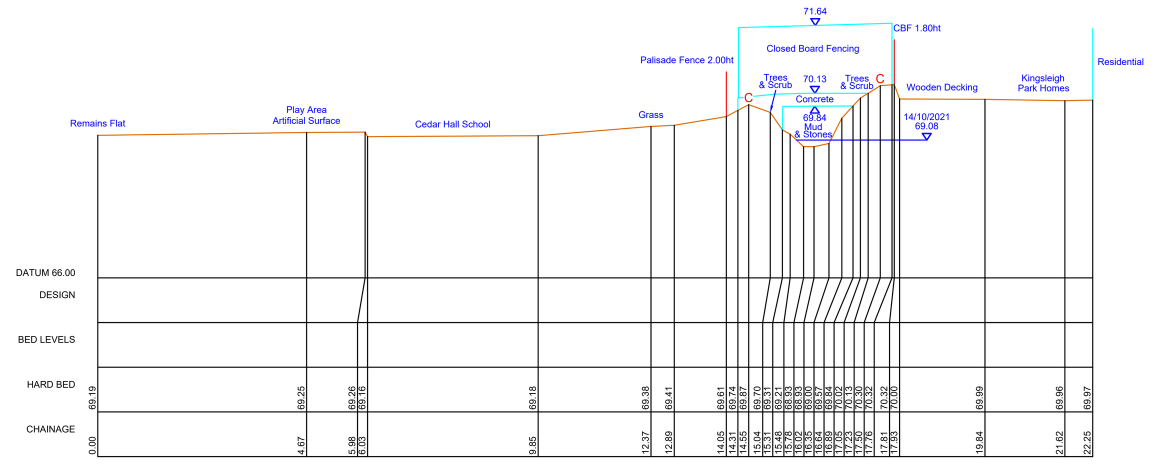
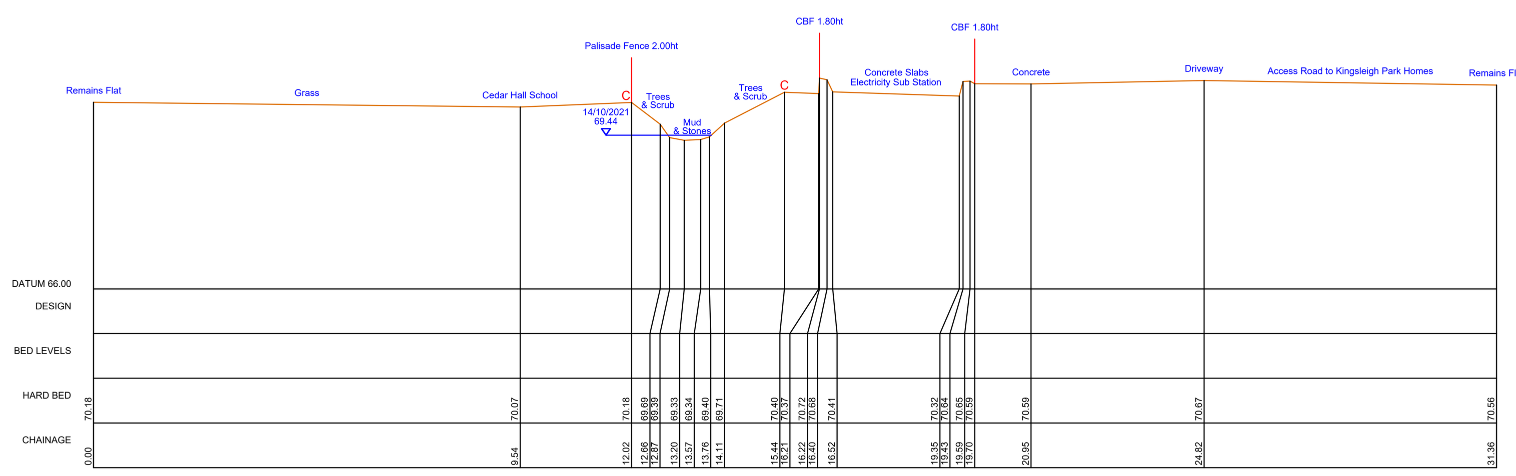
Open Channel



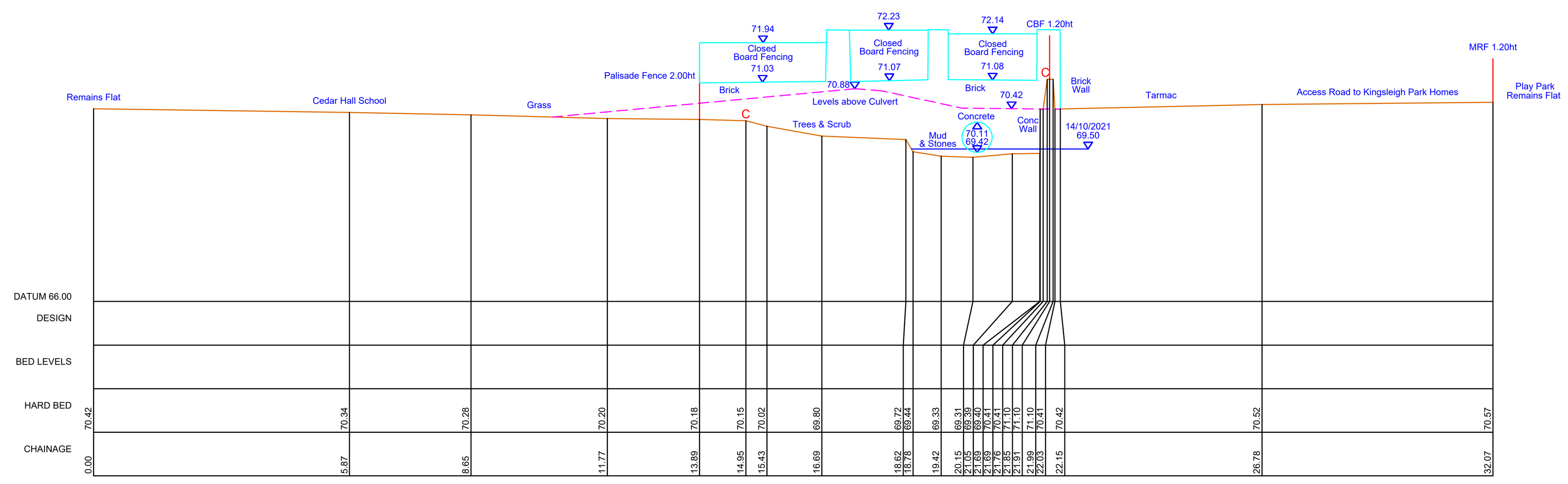
THUN0433
579542.6mE 188542.28mN Brg 181
Open Channel



THUN0500CU
579555.2mE 188592.9mN Brg 268
Culvert Entrance
Tunnel Length = 11.82m



THUN0568
579551.97mE 188662.67mN Brg 259
Open Channel



THUN0577CD
579551.77mE 188664.6mN Brg 272
Culvert Exit
Tunnel Length = Unknown (Unable to locate Culvert Entrance)

KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C — BANK CREST

KEY TO LONGITUDINAL SECTION & LOCATION PLAN ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'C' ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RB	RIGHT BANK
B	BOLLARD	FL	FLOOR LEVEL	RE	RODDING EYE
BB	BELISHA BEACON	FP	FENCE POST	RSJ	ROLLED STEEL JOIST
BDY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTW	RETAINING WALL
BH	BOREHOLE	G	GULLY	RWP	RAINWATER PIPE
BL	BED LEVEL	GB	GAUGEBOARD	SC	STOP COCK
BRK	BRICKWORK	GL	GROUND LEVEL	SDP	STAND PIPE
BS	BUS STOP	GP	GATE POST	SK	SOAKAWAY
BM	BENCH MARK	GM	GAS MARKER	SL	SOFFIT LEVEL
BW	BRICK WALL	HW	HEAD WALL	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
CBF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	SP	SIGN POST
CIF	CORRUGATED IRON FENCE	IRF	IRON RAILING FENCE	STN	STATION
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	SV	SLUICE VALVE
CLF	CHAIN LINK FENCE	JB	JUNCTION BOX	SVP	SOIL VENT PIPE
CONC	CONCRETE	KIG	KERB INLET GULLY	SWF	SHEEP WIRE FENCE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CHESTNUT PALING FENCE	LFB	LIFEBUOY	TCB/TCP	TELEPHONE CALL BOX/POST
CR	CYCLE RACK	LP	LAMP POST	TC	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
CUL	CULVERT	MF	MISCELLANEOUS FENCING	THL	THRESHOLD LEVEL
DK	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DOWNPIPE	MP	MOORING PILE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DS	DOWNSTREAM	MS	MILE STONE	TS	TREE STUMP
DWB	DOG WASTE BIN	NB	NOTICE BOARD	TSR	TUBULAR STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	US	UPSTREAM
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	UTS	UNABLE TO SURVEY
ECF	ELECTRIC CABLE FENCE	OS	ORDNANCE SURVEY	WL	WATER LEVEL/WATER LINE
ECP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	PILE	WMF	WIRE MESH FENCE
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PRF	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

Rev	Date	Description	By	Ckd

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Client:
L&G AFFORDABLE HOMES

Project:
THUNDERSLEY FLOOD MAPPING SURVEY
THUNDERSLEY DRAIN

Project Number: 21328

Drawing Title:
CROSS SECTIONS -
THUN0005BU TO THUN0577CD

Drawn:	Checked:	Scale @ A0:	Drawn Date:	First Issue:
PLS	JWH	1:100	21/10/2021	22/10/2021

Drawing Status: INFORMATION

Drawing No. 21328-RS01 Revision -

Notes:
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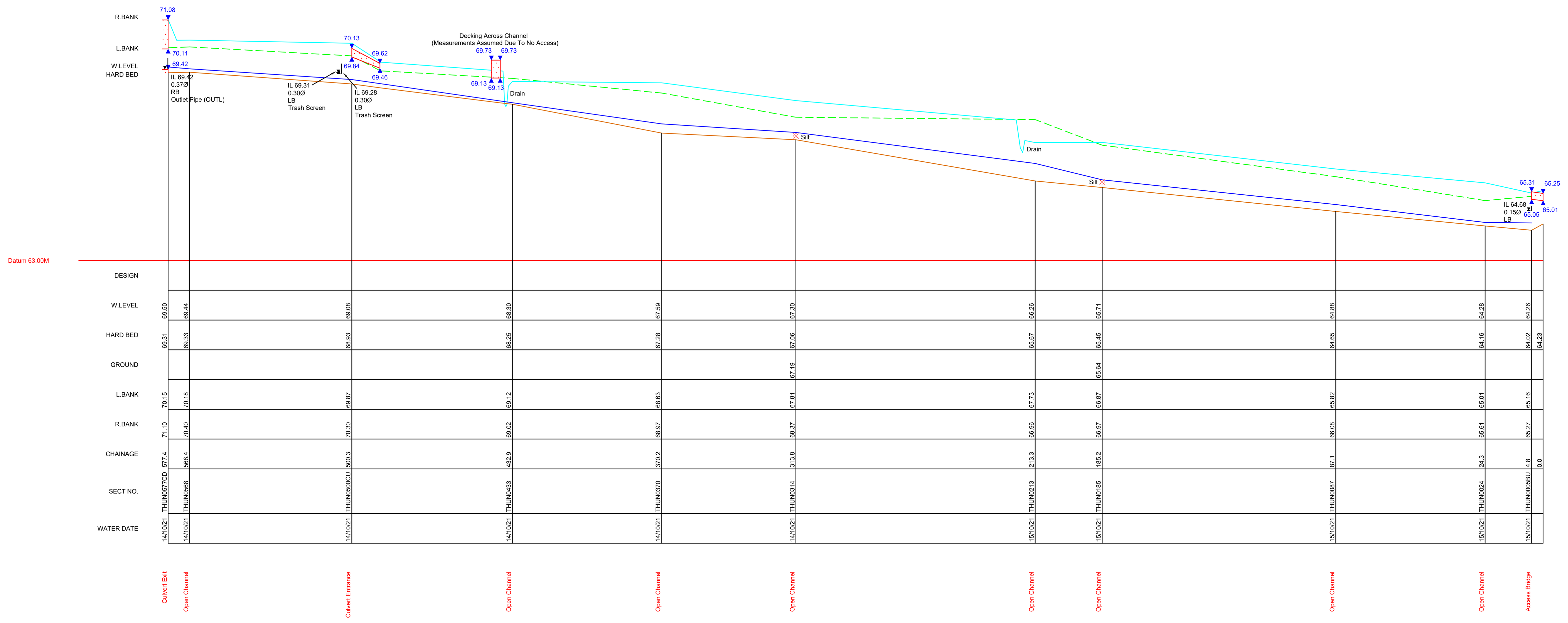
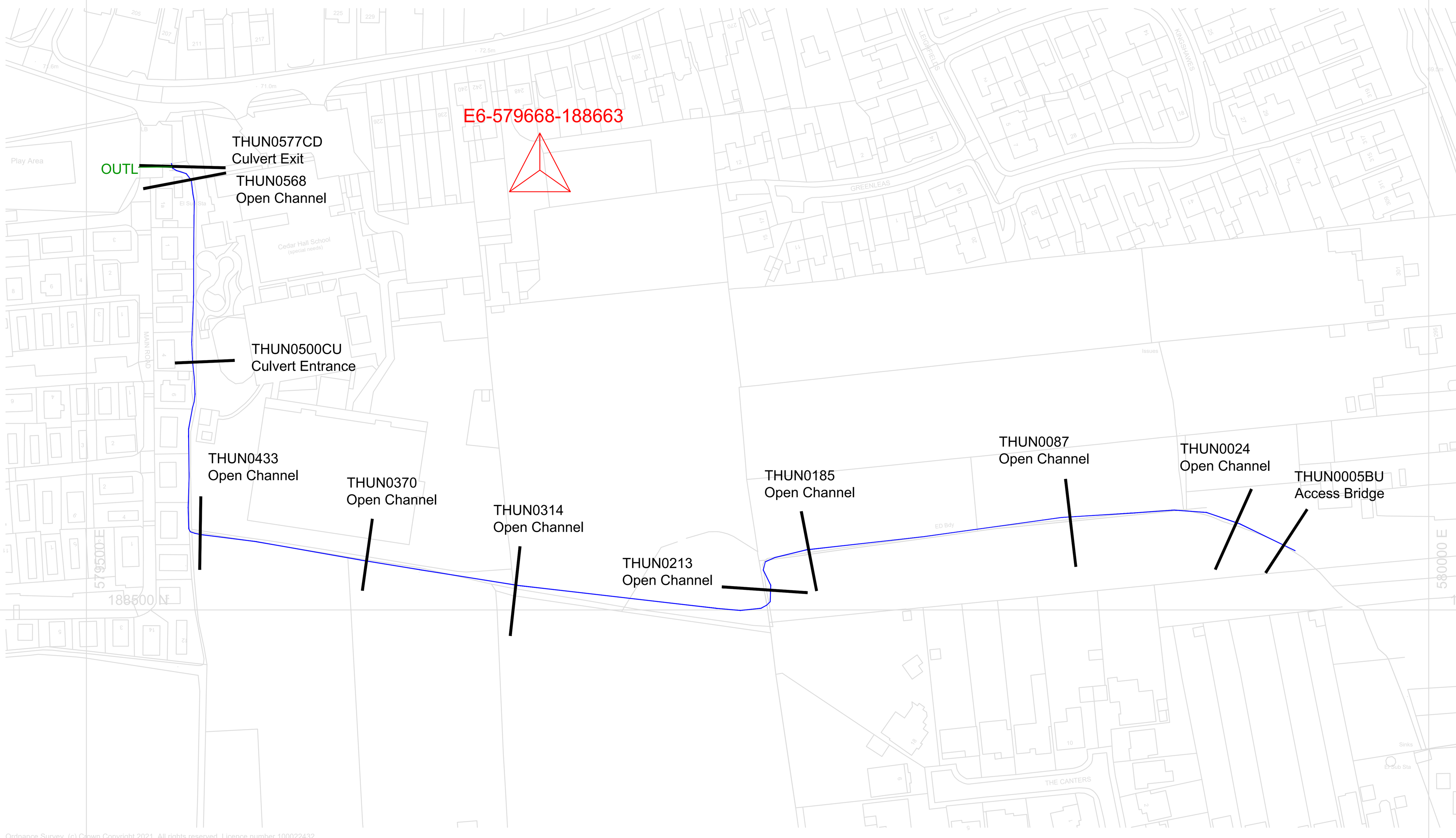
SCALE: 1:1250 H, 1:100 V



SCALE: 1:1250

OS NORTH



KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C — BANK CREST

KEY TO LONGITUDINAL SECTION & LOCATION PLAN ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'C' ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RB	RIGHT BANK
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BDY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTW	RETAINING WALL
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BW	BRICK WALL	HW	HEAD WALL	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
CBF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	SP	SIGN POST
CIF	CORRUGATED IRON FENCE	IRF	IRON RAILING FENCE	STN	STATION
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	SV	SLUICE VALVE
CLF	CHAIN LINK FENCE	JB	JUNCTION BOX	SVP	SOIL VENT PIPE
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CPF	CHESTNUT PALING FENCE	LFB	LIFEBUOY	TCB/TCP	TELEPHONE CALL BOX/POST
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DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
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EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	US	UPSTREAM
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ECF	ELECTRIC CABLE FENCE	OS	ORDNANCE SURVEY	WL	WATER LEVEL/WATER LINE
ECP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	PILE	WMF	WIRE MESH FENCE
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ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PRF	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

Rev	Date	Description	By	Ckd

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Client: L&G AFFORDABLE HOMES

Project: THUNDERSLEY FLOOD MAPPING SURVEY THUNDERSLEY DRAIN

Project Number: 21328

Drawing Title: LONG SECTION & LOCATION PLAN - THUN0005BU TO THUN0577CD

Drawn:	Checked:	Scale @ A0:	Drawn Date:	First Issue:
PLS	JWH	As Shown	21/10/2021	2/10/2021

Drawing Status. INFORMATION

Drawing No. 21328-RS02 Revision -

Notes:
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Appendix B - Hydraulic Modelling Outputs

KEY PLAN

Maximum extents for the baseline scenario flood events.

-5% AEP (1 in 20 year) Event
-1% AEP (1 in 100 year) Event
-0.1% AEP (1 in 1000 year) Event

NOTES

REVISIONS

P01

REV.	REVISION NOTES/COMMENTS			
P01	FIRST ISSUE EXAMPLE			
	DRAWN BY LW	CHECKED BY SDM	APPROVED BY SDM	DATE 29/10/21
REV.	REVISION NOTES/COMMENTS			
	DRAWN BY N/A	CHECKED BY N/A	APPROVED BY N/A	DATE N/A

Hydrock

Over Court Barns,
Over Lane,
Almondsbury,
Bristol,
BS32 4DF
t. +44(0) 1454 619533
e. bristol@hydrock.com

TITLE
Baseline Scenario Maximum Extents

HYDROCK PROJECT NO.
21328-IOCB

SCALE @ A3
1:1,000

CLIENT
Legal & General Affordable Homes

PURPOSE OF ISSUE
SUITABLE FOR INFORMATION

STATUS
S2

PROJECT
Hart Road, Thundersley

DRAWING NO.
21328-HYD-BL-XX-DR-FR-0001

REVISION
P01

KEY PLAN

Maximum extents for the baseline scenario flood events with the latest EA Climate Change Allowances.

-1% AEP (1 in 100 year) Event
-1% AEP (1 in 100 year) plus Central Climate Change Allowance Event
-1% AEP (1 in 100 year) plus Higher Central Climate Change Allowance Event

NOTES

REVISIONS

P01

REV.	REVISION NOTES/COMMENTS			
P01	FIRST ISSUE EXAMPLE			
	DRAWN BY LW	CHECKED BY SDM	APPROVED BY SDM	DATE 29/10/21
REV.	REVISION NOTES/COMMENTS			
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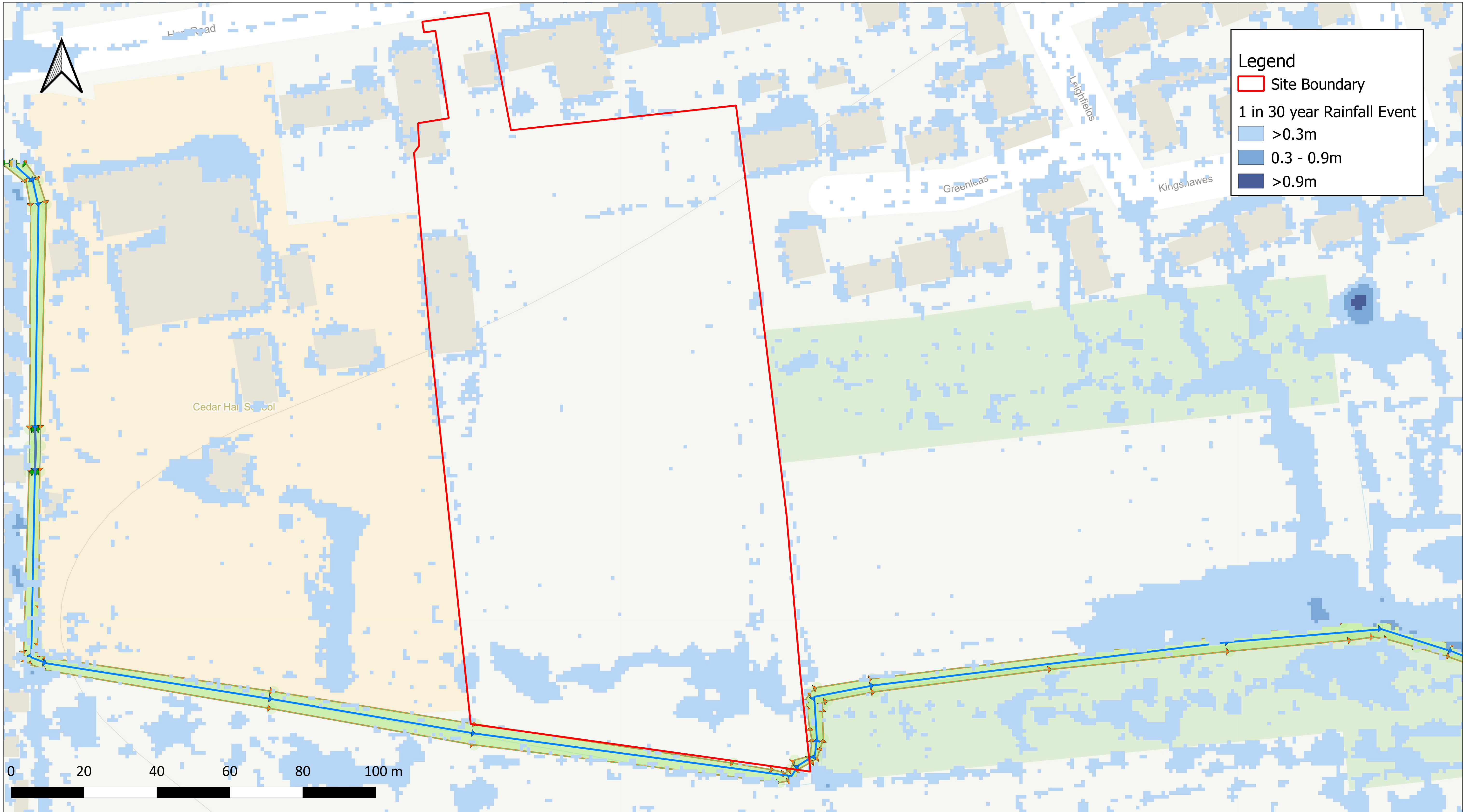
Bristol,
BS32 4DF
t. +44(0) 1454 619533
e. bristol@hydrock.com

TITLE	Baseline Scenario plus Climate Change Maximum Extents
HYDROCK PROJECT NO.	21328-IOCB
SCALE @ A3	1:1,000
CLIENT	Legal & General Affordable Homes
PURPOSE OF ISSUE	SUITABLE FOR INFORMATION
STATUS	S2
PROJECT	Hart Road, Thundersley
DRAWING NO.	21328-HYD-BL-XX-DR-FR-0002
REVISION	P01



KEY PLAN

Maximum depths for the 1 in 30 year rainfall event.

NOTES

REVISIONS

P01

REV.				
P01	FIRST ISSUE EXAMPLE			
	DRAWN BY LW	CHECKED BY SDM	APPROVED BY SDM	DATE 29/10/21
REV.	REVISION NOTES/COMMENTS			
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Bristol,
BS32 4DF
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e. bristol@hydrock.com

TITLE
1 in 30 year Rainfall Event Maximum Depths

HYDROCK PROJECT NO. 21328-IOCB

SCALE @ A3 1:1,000

CLIENT
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PURPOSE OF ISSUE
SUITABLE FOR INFORMATION

STATUS
S2

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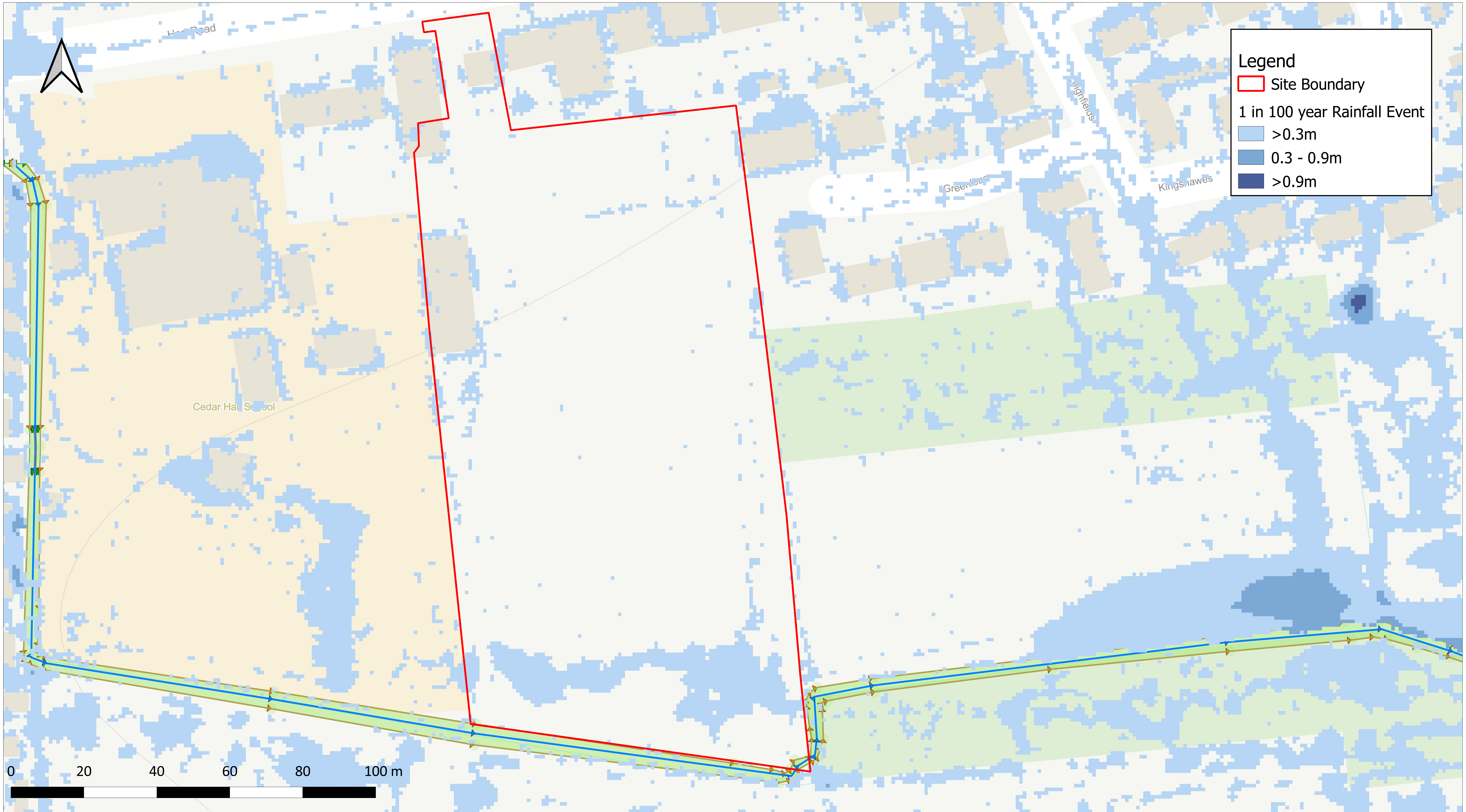
Hart Road, Thundersley

DRAWING NO.
21328-HYD-RF-XX-DR-FR-0003

REVISION
P01



KEY PLAN

Maximum surface water depths for the 1 in 100 year rainfall event.

NOTES

REVISIONS

P01

REV.				
P01	FIRST ISSUE EXAMPLE			
	DRAWN BY LW	CHECKED BY SDM	APPROVED BY SDM	DATE 29/10/21
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BS32 4DF
t. +44(0) 1454 619533
e. bristol@hydrock.com

TITLE
1 in 100 year Rainfall Event Maximum Surface Water Depths

HYDROCK PROJECT NO.
21328-IOCB

SCALE @ A3
1:1,000

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STATUS
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Hart Road, Thundersley

DRAWING NO.
21328-HYD-RF-XX-DR-FR-0004

REVISION
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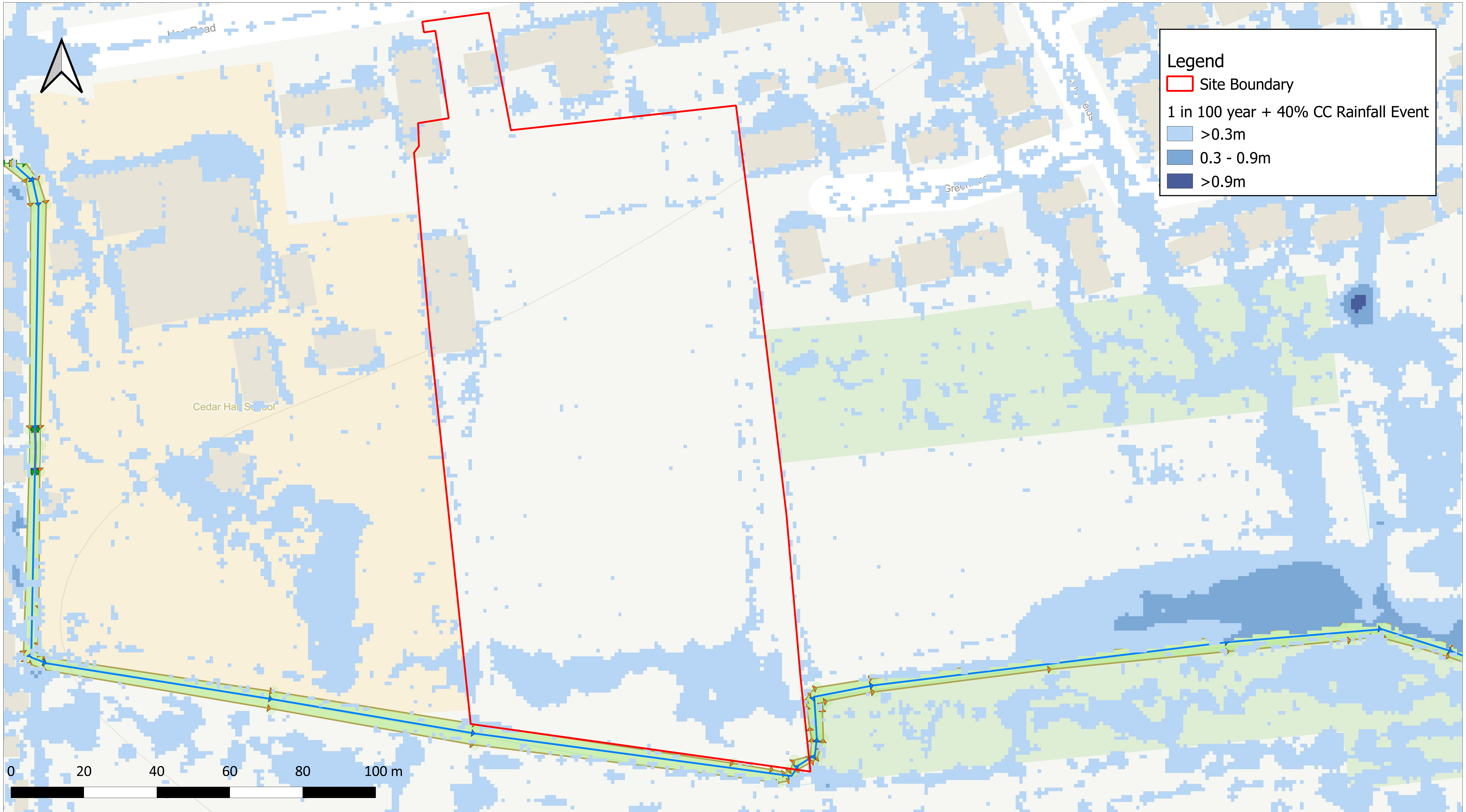

KEY PLAN

Maximum surface water depths for the 1 in 100 year plus 40% Climate Change allowance rainfall event.

NOTES

REVISIONS

P01

REV.	REVISION NOTES/COMMENTS			
P01	FIRST ISSUE EXAMPLE			
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Bristol,
BS32 4DF
t. +44(0) 1454 619533
e. bristol@hydrock.com

TITLE
1 in 100 year Rainfall Event Maximum Surface Water Depths

HYDROCK PROJECT NO. 21328-IOCB

SCALE @ A3 1:1,000

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PROJECT
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REVISION
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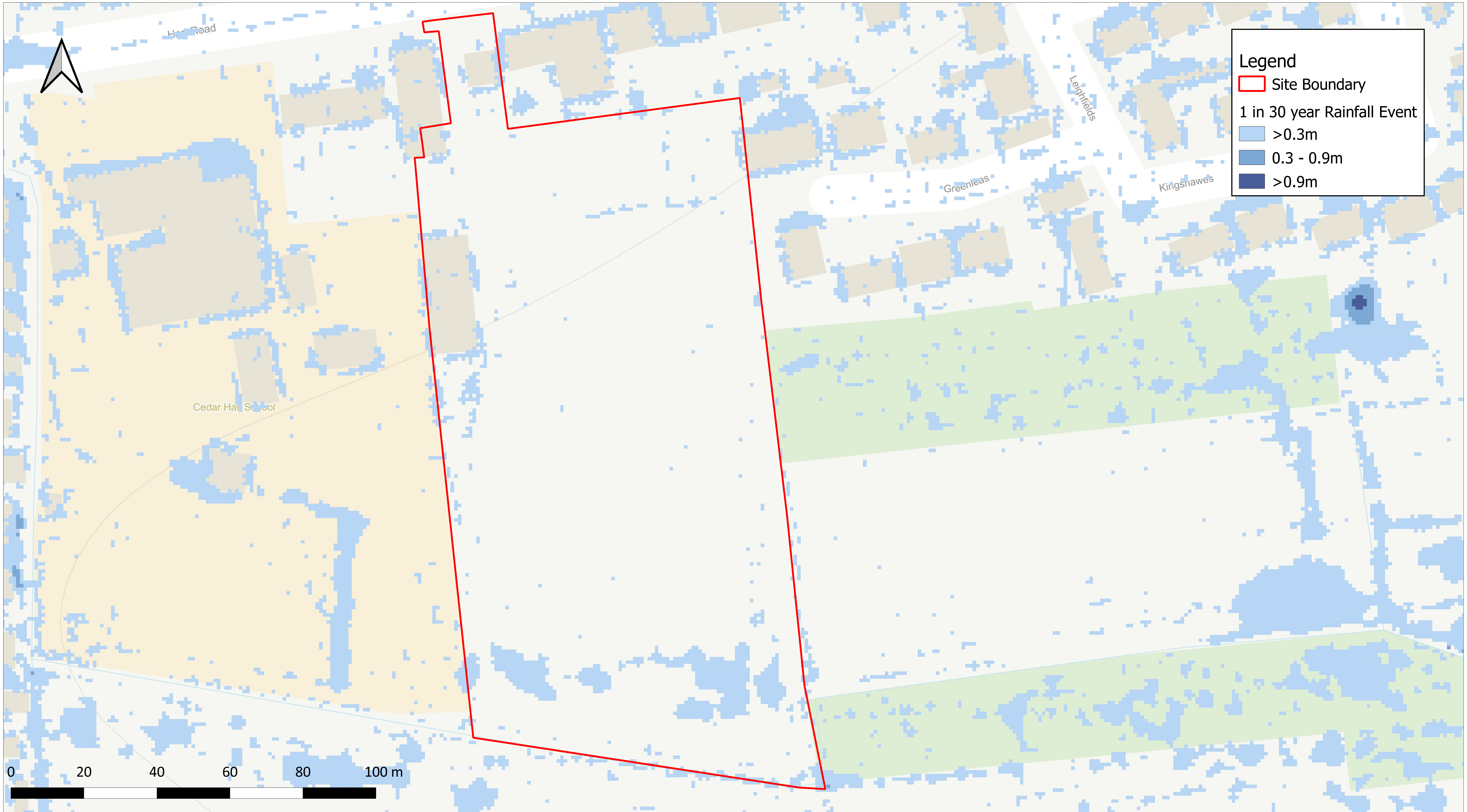

KEY PLAN

Maximum depths for the 1 in 5 year rainfall event.

NOTES

REVISIONS

P01

REV.	REVISION NOTES/COMMENTS			
P01	FIRST ISSUE EXAMPLE			
	DRAWN BY LW	CHECKED BY SDM	APPROVED BY SDM	DATE 03/11/21
REV.	REVISION NOTES/COMMENTS			
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BS32 4DF
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TITLE
1 in 5 year Rainfall Event Maximum Depths

HYDROCK PROJECT NO.
21328-IOCB

SCALE @ A3
1:1,000

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PROJECT
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REVISION
P01