AAH planning consultants

FLOOD STUDY REPORT

LAND NORTH OF SHERFIELD ROAD BRAMLEY

FEBRUARY 2016

JOB REFERENCE: 44747

Contents

1.0 Introduction

1.1 AAH Planning Consultants have been commissioned to undertake a flood study report to assess planning application reference number 15/02708/OUT. The applicant is seeking outline planning consent for a residential development of up to 50 dwellings, including affordable housing with associated access, highway works, drainage works (SUDS), public open space, landscaping and any other associated infrastructure with all matters reserved except for means of access. The site is within the administrative area of Basingstoke and Deane Borough Council, Thames Water, and the Environment Agency each of whom are interested parties in the flood risk and drainage aspects of planning.

1.2 The National Planning Policy Framework (NPPF) identifies that flood risk assessments should be conducted for new developments proposed on the floodplains of rivers, sites potentially subject to coastal flooding and for developments of 1 hectare and above. The proposal site lies within an area designated as flood zone 1, 2 and 3 by the Environment Agency (EA).

1.3 The NPPF states that residential land uses (class use C3) such as the proposed development are 'more vulnerable' to flooding. The existing use of the site for development as open ground is 'water compatible'. The flood risk vulnerability of the site would increase with respect for the pre and post development site use.

1.4 On behalf of Bramley Parish Council AAH Planning Consultants has undertaken quantitative assessment of the floodplain using two dimensional flood modelling software to consider both the Bramley Green Stream and the ordinary watercourse which crosses the site. The instruction is to produce a hydraulic model to meet planning consultation deadlines and where beneficial to expand the study once flow information for the ordinary watercourse becomes available. The model study will be submitted to the EA as a 'flood map challenge' to improve the accuracy of their flood map, so safeguarding the position of the Parish Council's existing constituents, and indeed those of the new development should the Local Planning Authority grant planning permission.

2.0 Development Context

2.1 The proposal is for a residential development of up to 50 dwellings including access from Sherfield Road, public open space, landscaping, car parking ancillary works and associated infrastructure. The wider surrounding area can best be described as rural, comprising a mixture of farmland and woodland. To the west is the village of Bramley with the site flanked by residential properties to the south and west.

2.2 The plot is divided by a stream flowing generally northwards to link with the Bramley Green Stream which forms the northern boundary of the site, and flows from west to east, discharging into the River Lodden 1.2km to the east. A second stream flows from south to north, forming the eastern boundary of the site. The site is at Grid Reference SU659592 with the nearest post code RG26 5DS and a location map is shown below;

Site Location Plan

2.3 The topographic survey of the site which accompanies the planning application indicates a fall from south to north towards the Bramley Green Stream.

2.4 Thames Water Foul Pumping Station BRAMP1ZZ lies between the site and Sherfield Road, shown on the location plan above. This pumping station supplements fluvial flow within the stream which crosses the site centrally. Neither pumping station nor fluvial flow along the centrally located watercourse are factored in to flood modelling.

3.0 Flood Risk

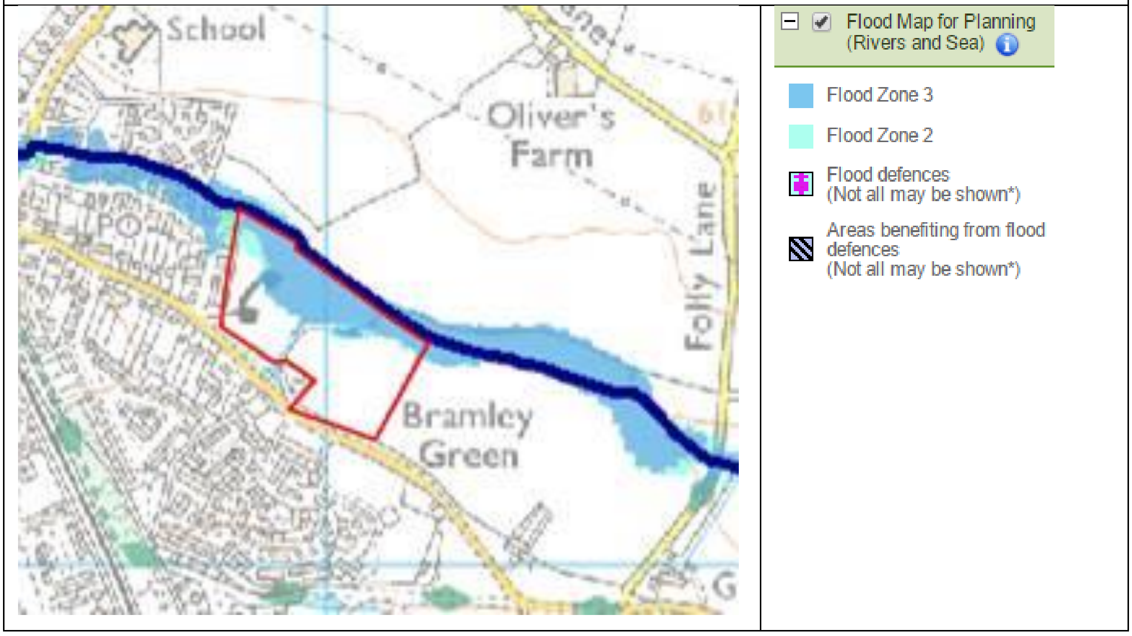
3.1 The National Planning Policy Framework (NPPF) sets out Governmental Policy on a range of matters, including Development and Flood Risk. The policies were largely carried over from the former PPS25: Development & Flood Risk, albeit with certain simplifications. The allocation of development sites and local planning authorities' development control decisions must be considered against a risk based search sequence. In terms of fluvial flooding, the guidance categorises flood zones in three principal levels of risk, as follows:

Flood Zone	Annual Probability of Flooding
Zone 1: Low probability	< 0.1 %
Zone 2: Medium probability	0.1 – 1.0 %
Zone 3a / 3b: High probability	> 1.0 %

3.2 It is therefore important that the flood study identifies accurately the 1 in 100 Year (1%) and the 1 in 1,000 year (0.1%) flood envelopes. The Environment Agency's (EA) National Generalised Modelling (NGM) Flood Zones Plan indicates predicted flood envelopes of Main Rivers such as the Bramley Green Stream across the UK. In many circumstances, the NGM is based on basic catchment characteristic data and modelling techniques. Where appropriate, more accurate models are produced using more robust analysis techniques, such as a computational flood model of the watercourse.

3.3 The Flood Zone mapping identifies flooding on both sides of the Bramley Green Stream during the 1 in 100 (1% AEP) and 1 in 1,000 year (0.1% AEP) events. These outlines are based on the broad scale NGM assessment and therefore it has been necessary to develop a detailed hydrological model to define accurately the extent and level of Flood Zones 2 and 3 associated with the watercourse. No quantitative fluvial flood levels are available within the NGM flood map to establish baseline conditions on and adjacent to the development. The EA Flood Zone plan is reproduced overleaf:

Environment Agency Flood Map



4.0 Hydrology

4.1 Reference to the Flood Estimation Handbook (FEH) dataset v3 shows the site to lie within the catchment of the Bramley Green Stream. With an URBEXT2000 value of 0.0115 the catchment can be described as "moderately urbanised". The FEH catchment is shown below and Catchment Descriptors reproduced later in the report.

Flood Estimation Handbook Catchment Map

4.2 The hydrological inflows to the hydraulic model were derived using the ReFH model. This model is considered the most appropriate method to produce the flood hydrographs. The hydrological assessment has included:

- Development of a hydrological model based on the ReFH rainfall-runoff model, using the FEH catchment descriptors and gauging station as donor to estimate the ReFH model parameters
- Calibration of the hydrological model using historic events

4.3 The FEH provides two distinct methods for estimating flood flows for a given catchment:

- Statistical method
- Revitalised Rainfall run-off method (ReFH)

4.4 The statistical method uses gauged data recorded from a series of hydrologically similar catchments across the UK to develop a statistical sound estimation of the likely flood flow. While this method produces statistically more accurate results when gauging is available for the site in question, the use of data transfer techniques can also be used to improve the overall accuracy of the flow estimate when no gauging is available. Because the method is based on a much larger dataset of flood events and is more directly calibrated to reproduce flood frequency, it is often preferred to the rainfall run-off method. However, where there is no gauging, the catchment is small or the catchment involves disparate sub-catchments such as in this scenario, the ReFH may be preferable and is used for this reason.

4.5 The Flood Estimation Handbook (FEH) Dataset v3 was used to develop the catchment characteristics for the watercourse, and the catchment descriptors needed to inform the flow hydrology assessment. The FEH contains digital catchment descriptors for over four million UK catchments which drain an area of 0.5km2 or greater.

4.6 The catchment descriptors have been assessed to ensure the applicability of the data, using manual checks of elements such as the catchment area, slope and the like. Having completed checks for robustness, the descriptors have been accepted without amendment.

4.7 It has been widely noted that the original FEH rainfall-runoff method had a tendency to over- estimate flood flows, leading to significantly differing flows to those estimated by the FEH statistical method. To address this issue, a joint DEFRA/Environment Agency research project, Revitalisation of Flood Hydrographs (RE-FH) (Kjeldsen et al., 2005), was initiated.

This project has now been released together with an Excel Spreadsheet Application of the updated model. The research not only addressed the tendency to overestimate flood flows but also introduced technological advances. ReFH and associated software therefore provides an updated method of flood flow estimation in the UK and has been adopted by the Environment Agency for hydrological studies.

4.8 The ReFH model has incorporated several changes the most important of which will be outlined below:

- The ReFH model is a combination of the same three models included in the FEH/FSR model, a routing model, a losses model and a baseflow model. It is of note that all three of these models have been reviewed and incorporate more sophisticated analytical techniques than their predecessors.
- The shape of the unit hydrograph has been amended from simple triangle to a 'kinked' triangle. The revised unit hydrograph effectively transfers additional discharge to the tail of the hydrograph which is in keeping with the majority of observed hydrographs. Whilst this form of hydrograph is mathematically more complex, it introduces more flexibility and enables superior model performance.
- The database upon which the rarity of rainfall events is based is a collection of peak rainfall events which are most likely to occur in summer. Clearly summer antecedent conditions differ from winter with a greater proportion of incident rainfall being 'lost' in summer conditions. Thus, applying estimates of rainfall from a database predominantly populated by summer events to winter antecedent conditions will lead to an over estimate of rainfall. To correct this over estimate, the ReFH model has introduced a seasonal correction factor, effectively reducing the estimate of peak winter rainfall.

4.9 The routing model converts a rainfall input to a flow output using a deterministic model of a catchment's response based on the unit hydrograph concept that a unit of net rainfall produces a unit of flow. The FEH/FSR model used a triangular hydrograph with its dimensions defined by a single parameter, Time to Peak (T_p). However the shape of the ReFH unit hydrograph has been revised within the introduction of a 'kinked' hydrograph as explained above. The kinked hydrograph is defined by the time scaling parameter T_p and two dimensionless numbers U_p and U_k. The U_p parameter controls the angle of the apex with a value of 1 corresponding to an isosceles triangle. The U_k parameter defines angle of the 'kink' and thus controls the volume transferred to the tail.

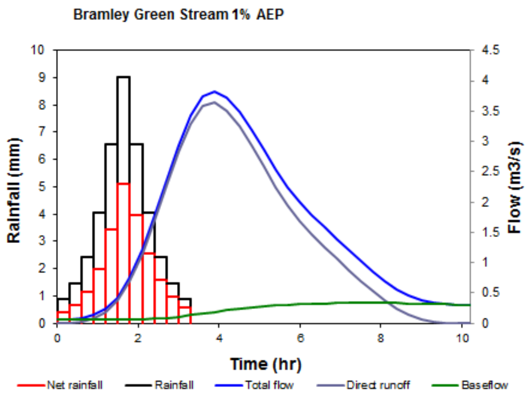
4.10 In the absence of gauged catchment data, ReFH Rainfall Run-off Analysis has been completed based on the accepted Catchment Descriptors. The subject catchment storm duration is calculated using the following equation from Supplementary Report No. 1:

$$D = Tp\ (1 + \frac{SAAR}{1000})$$

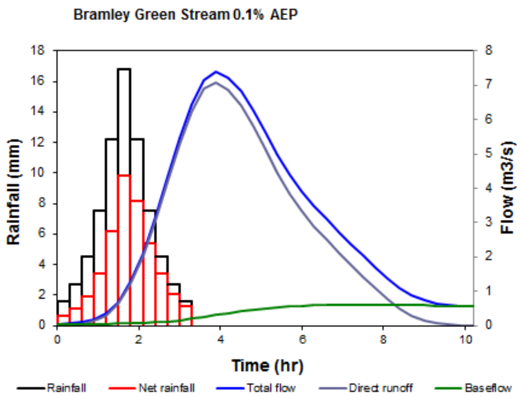
4.11 Using the ReFH rainfall runoff methodology, flow hydrographs have been generated for the 1 in 100 year (1% AEP) and 1 in 1,000 year (0.1% AEP) return events at the downstream boundary of the watercourses. The Catchment Descriptors (summarised below) generated a Time to Peak Tp = 6.7 hours and a storm duration D = 13 hours for the study area.

Area (km2)	2.15	C	-0.02788
PROPWET	0.32	D1	0.30582
BFIHOST	0.216	D2	0.26566
DPLBAR	1.21	D3	0.34615
DPSBAR	16.6	E	0.3023
SAAR	694	F	2.54725
URBEXT2000	0.115		

4.12 The ReFH assessment gives an estimated 1 in 100 year (1% AEP) peak flow of 3.83 m^3/s and an estimated 1 in 1,000 year (0.1% AEP) peak flow of 7.38 m^3/s. Additional of 20% to the 1 in 100 year (1% AEP) peak flow simulates the effects of increased river flow over the lifetime of the development attributable to climate change.



Q_{100} = 3.8 m^3/s, Q_{100} + 20% cc = 4.6 m^3/s



Q_{1000} = 7.4 m^3/s

4.13 The 1% AEP flows are reproduced in tabular form below, together with an allowance of 20% for climate change and the 0.1% AEP flows.

Series	Q100	Q100 + CC	Q1000
Time hrs	m^3/s	m^3/s	m^3/s
0	0.05	0.07	0.05
0.3	0.06	0.07	0.06
0.6	0.08	0.10	0.10
0.9	0.13	0.16	0.18
1.2	0.24	0.28	0.35
1.5	0.43	0.51	0.68
1.8	0.75	0.90	1.26
2.1	1.22	1.46	2.12
2.4	1.78	2.13	3.18
2.7	2.36	2.84	4.32
3	2.93	3.52	5.45
3.3	3.42	4.11	6.45
3.6	3.74	4.49	7.15
3.9	3.83	4.59	7.38
4.2	3.72	4.46	7.23
4.5	3.49	4.19	6.83
4.8	3.19	3.83	6.26
5.1	2.86	3.44	5.62
5.4	2.53	3.04	4.97
5.7	2.25	2.70	4.40
6	2.00	2.40	3.91
6.3	1.78	2.14	3.48
6.6	1.58	1.90	3.09
6.9	1.39	1.67	2.73
7.2	1.21	1.45	2.37
7.5	1.03	1.24	2.03
7.8	0.86	1.03	1.69
8.1	0.70	0.84	1.38
8.4	0.56	0.67	1.10
8.7	0.46	0.55	0.88
9	0.39	0.47	0.74
9.3	0.35	0.41	0.65
9.6	0.32	0.38	0.60
9.9	0.31	0.37	0.57
10.2	0.30	0.36	0.55

5.0 Hydraulic Modelling

5.1 Hydraulic modelling was carried out using Flood Modeller, an industry standard 2D modelling package. In addition to the cross section and ground level survey data that was gathered for the modelling analysis, an inspection was made on Thursday 14th January 2016 of the channel and structures on site.

5.2 The model is based on sections of the river channel and flood plain and on a number of assumptions including boundary conditions and channel and floodplain roughness which are described in the following sections. A 1m grid LiDAR dataset has been obtained to supplement the river floodplain data.

Site viewed from southeast corner, with Thames Water Compound on the left and the stream flowing from left to right.

Mid-site stream viewed from the south, with Bramley Green Stream in the background.

5.3 Cross sections are provided for a distance of 1.1km upstream of Folly Lane.

Section ID	Chainage	Invert level mAOD
1	0	57.43
2	41	56.94
3	141	56.49
4	181	56.35
5	269	56.21
6	303	56.09
7	359	56.05
8	421	56.01
9	444	55.9
10	606	55.27
11	653	55.08
12	716	54.96
13	789	54.83
14	923	54.2
15	958	54.05
16	1045	54.26
17	1111	53.96

5.4 The downstream boundary condition was modelled as critical depth and also as normal depth conditions assuming a downstream slope of 1:800. The upstream boundary assumed the 1 in 100 year catchment flow excluding climate change, derived for a point downstream of the lower site boundary. This flow entered the model at the upstream inflow boundary northwest of the Strawberry Fields public highway.

5.5 The model includes the rectangular box culvert located at Folly Lane, assumed to have a Manning's roughness of 0.013. The channel is very overgrown, and is therefore assumed to have a roughness of 0.07, and the floodplain is assumed to be 0.035.

	
Bramley Green Stream at its junction with the mid-site stream.	Culvert at Folly Lane.

Sensitivity Analysis

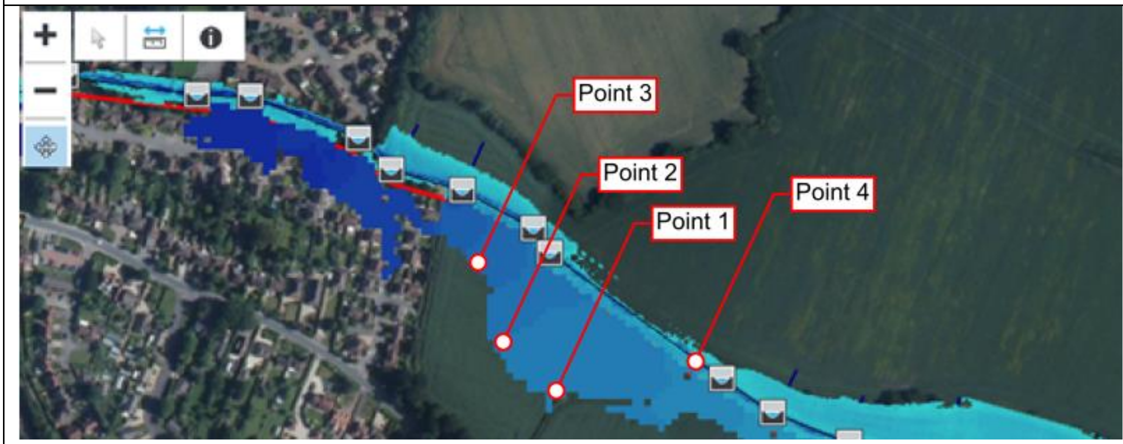
5.6 Sensitivity analysis has been carried out to determine the effect of variations in the model parameters on the model outputs. The parameters tested are the model inflows, channel roughness (Manning's 'n') and downstream boundary conditions. Sensitivity to changes in the downstream boundary conditions has also been tested by changing the gradient used in the normal depth calculation.

5.7 Inflows have been tested by running the model at Q100 ± 20%. Channel and floodplain roughness have been similarly tested at ± 20%, as has the gradient for the downstream boundary condition.

Model Output

5.8 Four sampling points/nodes have been identified, Point 1 at the first bend in the mid-site stream and close to the location for the cellular storage, Point 2 adjacent to the above ground attenuation basin, Point 3 is close to the location of the flood relief depression and Point 4 is at the junction of the mid-site stream and the Bramley Green Stream. The sample point locations and associated flood levels are shown below;

Q100 flood outline, with sampling point locations and flood levels (m AOD).



Point	1	2	3	4
Q100 (design level)	56.40	56.50	56.73	56.23
Q100 + 20%	56.44	56.51	56.83	56.28
Q100 – 20%	56.35	56.44	56.68	56.22
Manning's n + 20%	56.43	56.53	56.85	56.27
Manning's n - 20%	56.38	56.48	56.71	56.24
Gradient + 20%	56.41	56.52	56.76	56.25
Gradient – 20%	56.41	56.50	56.76	56.25

6.0 Development Constraints

Flood Resilient Design

6.1 In accordance with standard Environment Agency requirements, the finished ground floor level of the proposed dwellings should be set at least 0.6m above design flood level which under the present day 1 in 100 year scenario (1% annual exceedance probability) fall from 56.73m AOD (upstream) to 56.50m AOD central and 56.40m AOD on the downstream site extents. These levels will increase over time with increased river flows resultant from climate change to 56.83m AOD (upstream) to 56.51m AOD central and 56.44m AOD on the downstream site extents.

Surface Water Drainage Infrastructure

6.2 At this stage it is acknowledged that the surface water drainage strategy for the site is conceptual due to the outline nature of the proposals whereby all matters other than access are reserved. A series of attenuation features are provided within the proposals comprising of four basins and a bank of geocellular crates. There are two separate catchments and outfalls in to the watercourse which crosses the site each with a limiting discharge rate of

5.0l/S (roughly equivalent to 5.0l/S/HA) which is a reasonable provision in terms of best practice.

6.3 The bank of geocellular crates appears to be located in an area of flood zone 3, the high fluvial flood risk area, which would render the attenuation storage unusable under design flood conditions, resulting in an unattenuated rate and volume of surface water discharge from the development into Bramley Green Steam, thus exacerbating flooding downstream. A sealed system as suggested by the developer's representatives could not freely discharge by gravity if located below flood level. A pumped outfall would require substantial spatial provisions (15m radius from buildings) for placement of a suitable pumping station, and would need to include access for a HGV Tanker to empty the wet well in the event of failure (sewers for Adoption 7th Addition).

6.4 The levels of the attenuation basins shown in flood zone 1 are not published however it is clear their invert levels will lie well below the corresponding flood level. Were design rainfall conditions to coincide with high water levels in the Bramley Green Steam (a very plausible scenario), exceedance of the attenuation basins would occur, which would increase flooding both on and off of the site.

6.5 For illustrative purposes the northernmost basin offers 96m^3 of storm water storage over circa 168m^2, this implies a 0.6m depth of storage, approximately 56.1m AOD (ground level 56.7m AOD). In reality storage will be provided at least partially below the basin inlet and therefore invert level will be much lower. The 1 in 100 year fluvial flood level at this location is 56.50m AOD, 0.20m below ground level, rendering a gravity outfall from the basin largely inoperable. Provision of larger, shallower basin at this location could increase storage volumes above fluvial flood level, but would need to be in the order of 480m^2 to allow gravity drainage of the entire 96m^3 critical storm water storage provision. The same design constraints would apply to the three other storage basins and geocellular crates (even when relocated to flood zone 1).

6.6 Larger, shallower SuDS located within the areas of flood zone 1 would substantially reduce the available land for development, which in turn will require increased housing densities to realise a 50 unit scheme. Alternatively, increased SuDS provisions would reduce the number of units which may be developed at current densities. A pumped outfall from above ground storage basins would require substantial spatial provisions (15m radius from buildings) for placement of a suitable pumping station, and would need to include access for a HGV Tanker to empty the wet well in the event of failure (sewers for Adoption 7th Addition).

7.0 Conclusions

7.1 This report summarises the baseline hydrology and flood risk on the watercourses associated with the Bramley Green Stream in Bramley, Hampshire.

7.2 The Q100 flood outline yielded by hydraulic modelling (which in annual probability terms is equivalent to fluvial flood zone 3) is similar to the EA flood map flood zone 3 extents, this is to be expected as the input data (LiDAR ground levels and FEH derived flows) are broadly similar. Accuracy of the flood model is improved through incorporation of the developer's own topographic survey whilst flood levels produced provide comprehensive baseline conditions which are used to identify deficiencies within the developer's flood resistant housing measures and surface water drainage design.

7.3 Sensitivity analysis shows that variations of ± 20% to inflow, channel roughness and gradient produce up to 0.13m increase in flood level. A similar increase in manning's roughness also has an impact at the west end of the site, increasing flood levels by 0.12m. Changing the downstream gradient has little impact, as the stream is relatively steep and thus there is no backwater effect.

7.4 Future flood modelling investigations planned will quantify substantial flooding of the site which it has been shown by indicative flood modelling could occur should an ordinary watercourse (or its associated culvert) located centrally within the site become fully or partially blocked. This flood scenario should be considered as an unknown residual risk to the proposed development which in turn casts uncertainties over the necessary requirements for flood resistant building design.