

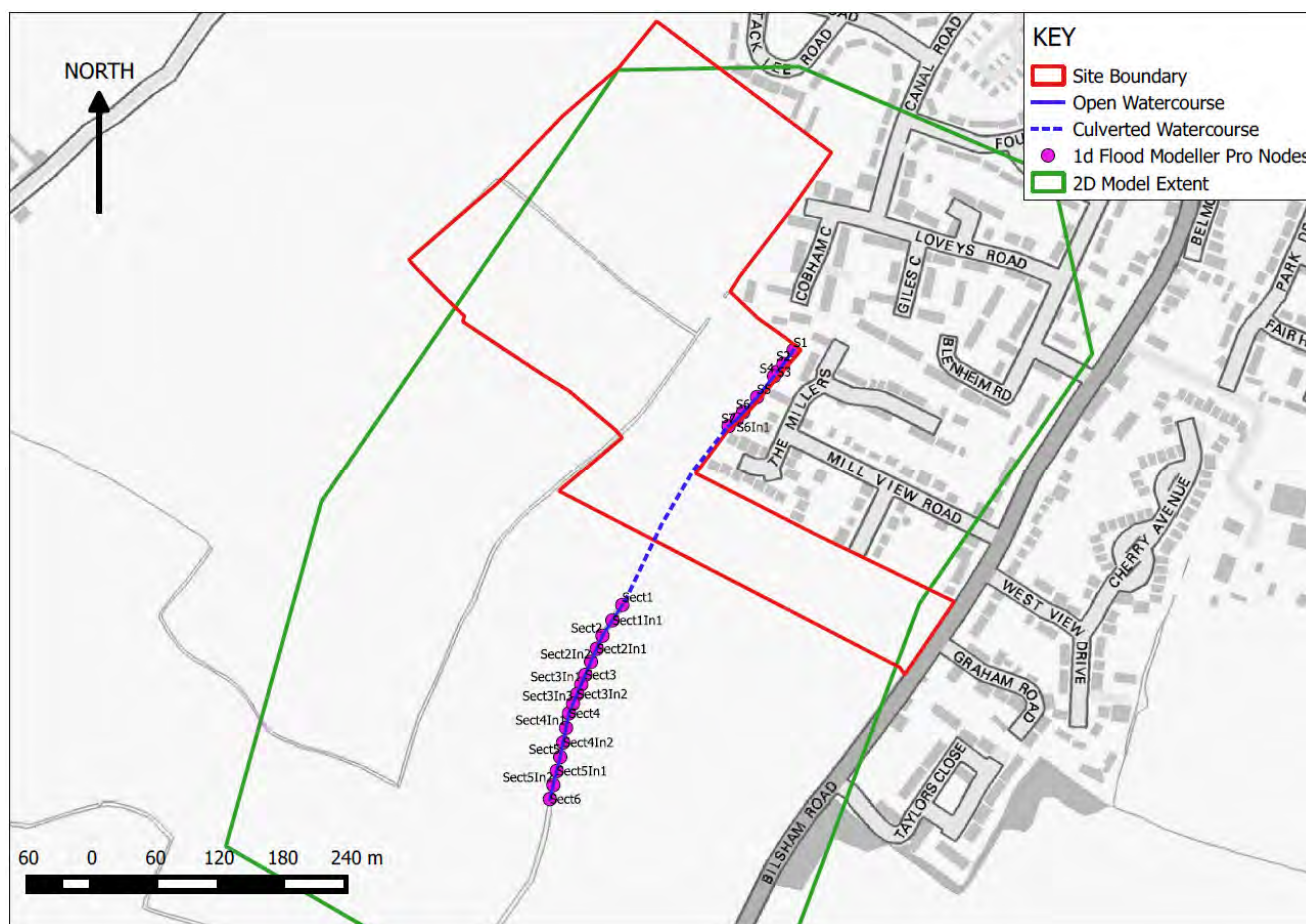


Figure 3:1 Hydraulic model schematic

4 MODEL PROVING

4.1 Calibration and other models

4.1.1 Table 4.1 below summarises the calibration and verification of the hydraulic models.

TABLE 4-1 Calibration and Sensitivity

Was data available for calibration and verification?	No.
Is there an existing model that can be compared against?	There is currently no existing model for the area.
Has sensitivity testing been undertaken in lieu of calibration?	Yes.
Has sensitivity testing been undertaken to support the calibration?	Yes.

4.2 Sensitivity Analysis

TABLE 4-2 Calibration and Sensitivity

What sensitivity tests have been undertaken?	+/-20% roughness, +/-20% spill coefficients across key structures and 50% blockage of the culvert running through the site.
Are there any significant differences between the baseline and sensitivity tests?	Roughness – fairly minor differences. Approximately 0.44m maximum increase in peak water level at the site for +20% roughness for a localised area but generally in the region of 60mm. Spill coefficients – no differences.
Is the model sensitive to key parameters tested?	Roughness – On average generally sensitive to changes in roughness. Spill coefficients – generally insensitive to changes in spill coefficients.

4.3 Blockage analysis

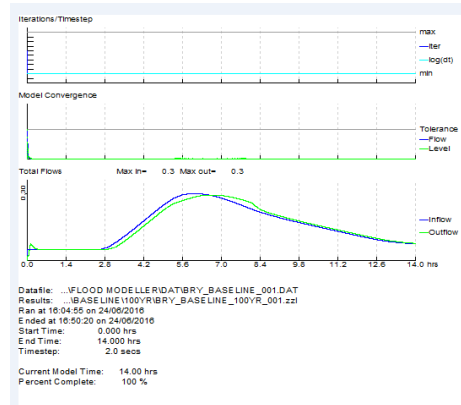
TABLE 4-3 Calibration and Sensitivity

Was blockage analysis undertaken?	Yes
What scenarios were tested?	A 50% blockage of the 600mm diameter culvert running through the site.
What were the key outcomes?	The hydraulic modelling results show that there is a maximum increase of 0.4m in flood levels at the site as a result of the blockage. Care will have to be taken to ensure that the culvert is kept clear of debris.

4.4 Run Performance

4.4.1 A summary of the run performance is summarised in Table 4-4 below;

TABLE 4-4 Run Performance

Is the model stable?	Yes, very little fluctuation in model results throughout both solvers.  The screenshot displays several key performance indicators: 'Iterations/Time-step' showing a stable, low number of iterations; 'Model Convergence' showing a rapid and stable convergence; 'Total Flow' showing a peak flow of 0.3 m³/s; and 'Flow' and 'Level' plots showing a smooth, stable hydrograph. The data file is identified as 'FLOOD MODELLER\DI\BRY_BASELINE_001.DAT' and the results file as 'BASELINE\100YR\BRY_BASELINE_100YR_001.zpl'. The run was completed at 16:04:55 on 24/06/2016, with a start time of 0.000 hrs and an end time of 14.000 hrs. The current model time is 14.00 hrs and the percent complete is 100%.
Is the mass balance error sensible?	Yes, the final cumulative mass balance for the 1 in 100 year event is 0.0%. This is within the +/- 1% recommended within the TUFLOW manual as appropriate values.
Are there any negative water depths?	No
What warnings and checks does the model give? Are any systematic of problems?	All warnings and checks associated with non-critical checks by TUFLOW.
Any other comments?	No
Is the model 'healthy'?	Yes

5 MODEL RESULTS

5.1 Baseline Design Runs

5.1.1 The hydraulic model was used to predict flood levels for the following events:

- 20% AEP (1 in 5 year);
- 5% AEP (1 in 20 year);
- 1% AEP (1 in 100 year);
- 1% AEP plus climate change (1 in 100 year plus 45% and 105% for climate change); and
- 0.1% (1 in 1000 year).

5.1.2 The modelling results show that the 600mm diameter culvert running through the site is the critical hydraulic structure. For all events up to the 1 in 100 year, flood flows are conveyed through the culvert without spilling into the site. However, during the 1 in 100 year plus climate change and the 1 in 1000 year events, flood flows exceed the capacity of the culverts and flow overland following the route of the culvert before re-joining the Bilsham Ditch south of the site. Refer to Figures 5.1 – 5.5 below.



Figure 5:1 Baseline 1 in 5 year peak flood depths



Figure 5:2 Baseline 1 in 20 year peak flood depths

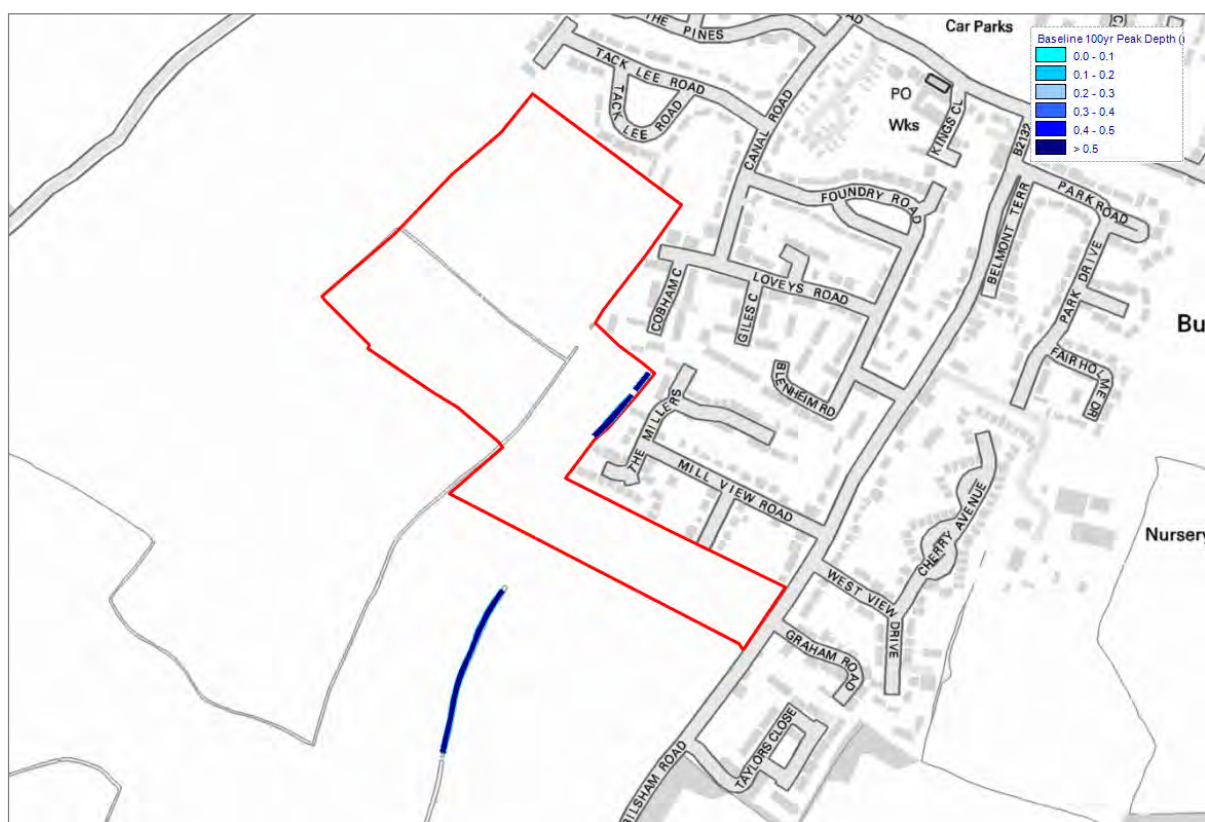


Figure 5:3 Baseline 1 in 100 year peak flood depths

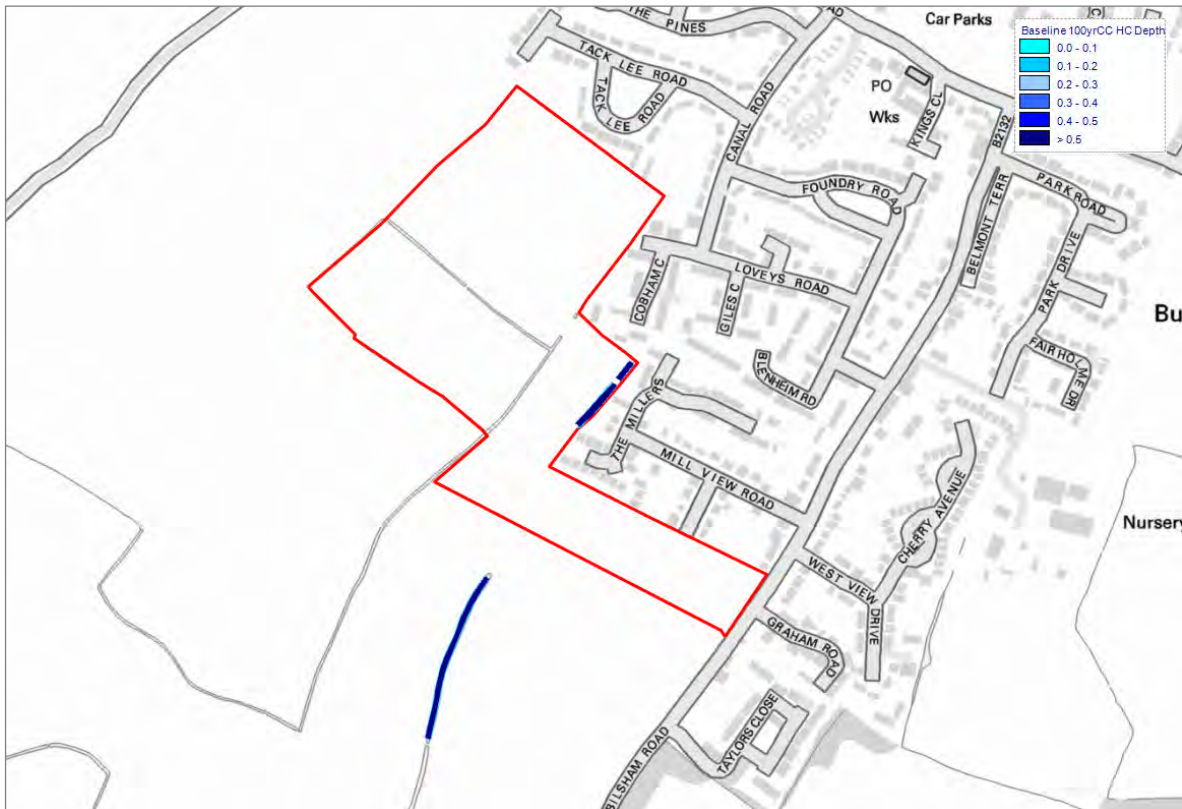


Figure 5:4 Baseline 1 in 100yrCC (45%) Higher Central peak flood depths



Figure 5:5 Baseline 1 in 100yrCC (205%) Upper End peak flood depths



Figure 5:6 Baseline 1 in 1000 year peak flood depths

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- 6.1.1 Odyssey Markides was commissioned by Gleeson Strategic Land to assess flood risk associated with the Bilsham Ditch for a proposed residential development in Yapton, West Sussex.
- 6.1.2 The Environment Agency (EA) flood map shows parts of site as being located within Flood Zone 3 (High Risk) and the EA do not hold suitable flood levels for the Bilsham Ditch to inform a Flood Risk Assessment for the site. It was therefore necessary to carry out hydraulic modelling of the Bilsham Ditch within the site's vicinity to determine flood levels and the resulting flood extents. Once agreed this data can then be used to inform the sequential approach within the site and therefore confirming the land available for development.
- 6.1.3 The fluvial model was constructed using the TUFLOW hydraulic modelling package which was dynamically linked to the 1D computational Flood Modeller Pro River Modelling software package. The 2D domain was designed to cover the area at risk of flooding with a 2m grid.
- 6.1.4 The sensitivity analysis has shown that the flood levels are moderately sensitive to any variation in structure coefficients and roughness; however the sensitivity results show the model is sensitive to flow variations though the variations in flow inputs results in small changes to the flood extents.
- 6.1.5 The following limitations to the hydraulic are notes;
- No hydrometric data exists for the ditches within the study area. This meant that the model could not be calibrated against observational data to further improve confidence in the results; and
 - The catchment is highly permeable and most of the FEH flow estimation methods are outside the ranges for permeable catchments.
- 6.1.6 It is recommended that the flood extents and model results replace the existing Environment Agency fluvial floodplain extents currently shown on site and the model results will inform the following;
- Flood Zone classification at the site;
 - Testing of flood mitigation options to ensure that the proposals do not exacerbate flooding in all areas upstream and downstream of the site;
 - Finished floor levels for the proposed development parcels;
 - Flood hazard mapping to inform safe access and egress from the site; and
 - Soffit levels for proposed crossings or bridges on the existing watercourses.

APPENDICES

APPENDIX A

Hydrology

1.1 FEH Statistical Analysis

QMED from Catchment Descriptors

1.1.1 The FEH catchment descriptors are initially used to derive an estimate of QMED (Error! Not a valid bookmark self-reference.) using WINFAP-FEH software package version 3.0 that is based on the methods documented by Kjeldsen (2009).

Table 1 QMED from Catchment Descriptors at Subject Site

Site	QMED from catchment descriptors (m ³ /s)	QMED adjusted for urban influence (m ³ /s)
Bilsham Ditch	0.106	0.131

QMED at Donor Sites

1.1.2 The flow estimation process requires the adjustment of the empirically derived QMED flows using recorded flow data at one or more nearby Environment Agency flow measurement stations. The nearest gauging stations, as available on the NRFA website (WINFAP-FEH data version 3.3.4, released August 2014), with catchments that drain areas within 50km of the site are reviewed. Three stations have been selected in this assessment and their details are summarised in **Table 2**.

Table 2 EA Gauging Stations near the Unnamed Tributary of Avon at Ringwood Catchment

NRFA Ref No.	Watercourse	Location	Grid Ref	Flow record start	Flow record end	Number of years
41023	Lavant	Graylingwell	SU870064	01/10/1970	30/09/2012	42
41011	Rother	Rother	SU852229	27/10/1966	30/09/2012	45
41022	Lod	Halfway Bridge	SU931222	01/10/1973	30/09/2012	39

1.1.3 NRFA provides the following comments on these three gauges:

■ 41023 - Lavant at Graylingwell.

- A flat-V weir gauging an ephemeral stream in a permeable catchment. Baseflow-dominated regime affected by significant groundwater abstraction. The weir has a crest width of 5.0 m, cross-slope of 1:10, maximum head of 1m and a capacity of 6 m³/s. The River Lavant has a long history of flooding, the last major events occurring in 1960, 1994 – 95 and 2000.
- Flow would be bypassed during extreme events (e.g. January 1994 and November 2000 when peaks were approximately 8 m³/s - based on current-meter gaugings). November 2000 event was gauged at 7.925 m³/s; bypassing of the gauge occurred at this time with further groundwater issuing from banks into the stream downstream of the gauge. Severe weed growth especially during summer can cause structure to drown out if not cleared. Structure suffers from velocity problems (underestimation of flow) at higher flows but this has been gauged. Gauge board had levelling problems in the past, this was amended following the rating review that was undertaken in May 2003. Major channel works were carried out for Flood Alleviation scheme after 1994 flood; review in 2003 suggested rating should change in 1994 to accommodate channel clearance work. Two ratings applied across period of record, the most recent is valid from August 1994. Hydraulic modelling was used to derive upper limbs of the current rating.
- Flow record contains extended periods with zero flow as the stream is spring fed, which can give very low AMAX flows and no POT data are presented. During summer 1963, low and medium

flows were gauged by current meter on portable rods at weekly intervals until the Lavant dried up; gauging was continued on the downstream side of the Marsh Lane Bridge. Complete flow record from the 1970's. January 1994 peak flow estimated at 7.8 m³/s by gaugings.

- Flow originated from a winterbourne stream with baseflow-dominated regime but spring outflows can increase dramatically following exceptional rainfall. Runoff is substantially reduced by groundwater abstraction. Flood alleviation scheme for Chichester had been completed sufficiently by 1992 – 93 for water to be taken from the Lavant downstream of the weir, through culverts to Church Farm Pit, through Forebridge Rife and discharged to Pagham Harbour through Pagham Rife. The oldest known continuous groundwater level record exists at Chilgrove House, within the catchment. This record, dating back to 1836, gives early warning of flood flows for Chichester. The area to the east and south of Chichester has undergone large scale gravel extraction over the past 50 years, leaving many worked out pits either filled in and developed, or water filled. This has possibly enhanced groundwater levels as the bulk flow is now confined to narrow corridors between former workings.
- Flow records are suitable for QMED determination and pooling analysis.

■ **41011 - Rother at Iping Mill.**

- A Compound Crump profile weir, bypassing occurs at the mill channel. Flow regime has a large groundwater component. The weirs have crest widths of 3.05m and 2 × 5.03m, central bay 0.3m lower. New ultrasonic gauge present downstream at Fittleworth to measure high flows. Prior to 1968 an existing penstock weir was in place, consisting of 5 irregularly shaped masonry piers & abutments, constructed in the late 18th century. The 6 wooden ratchet operated doors had fallen into disuse.
- The weir was originally designed to measure flows up to 51 m³/s, however the actual capacity when built was only 45 m³/s. Upstream approach is not central, probably affecting uniformity of flows in weir section. Non-modular only during high flows (conveyance affected by growth of trees obstructing a downstream bridge; downstream siltation may also be a factor). Sept 2000 visit notes suggest flood flows during December 1999 had deposited up to 0.6m of sand on the right bank downstream of the structure, adding to effects of the bridge downstream causing drowning. Bankfull stage 1.9m above weir crest. One rating applied across period of record. Derived from hydraulic modelling, it fits well to the maximum gauging of 0.6m.
- The gauging data that was recorded in 1968 is the largest high flow event on record, when the channel was overtopped a maximum level 0.7m above structure full was obtained; flow was estimated at 100-150 m³/s. Significantly greater than late 2000 maxima when all flows were contained with no overtopping or bypassing.
- Many springs provide a large baseflow component but the Rother is very responsive to rainfall. Runoff influenced by groundwater abstraction and recharge. Petersfield forms a significant urban area. Abstractions for spray irrigation and sewage treatment works discharges affect the flow regime, particularly low flows – but with limited impact overall. The Rother is influent above Iping Mill.
- Flow records are suitable for QMED determination, however the records are not suitable for pooling analysis due to few high flow gaugings and rating cannot be validated beyond QMED.

■ **41022 - Lod at Halfway Bridge.**

- A crump profile weir. Primarily an impervious catchment. Minor flow regulation associated with upstream mill. Flashy response caused by steep clay topography in the upper catchment. The weir has a crest of 7.05m broad.
- Crest tapping present, however it is not currently used as the area is very sandy and could be blocked easily, when in operation it would add a reduction factor of 0.8 assessed for high flows. Structure limit (from 1974 records) 1.95m / 41.49 m³/s. However, one or two floods have an appreciable crest tapping level, giving reduction factors of 0.8. All but highest flows modular. Footbridge just upstream of weir crest can control flow - effectively limits the free water surface at 1.95m. Some bypassing in exceptional floods. Good current meter record. Rating confirmed to 10 m³/s by gaugings but footbridge can control flows above ~40 m³/s. One peak flow rating applied across period of record. Developed using slope-area method for the lowest stage and

ISIS modelling for the remaining flow range; confirmed to 14 m³/s with spot flow gaugings. Some bypassing in exceptional floods.

- Flow data in between November 2000 and Jan 2001 was estimated.
- Flow is very responsive to rainfall due to the steep clay topography in the upper catchment. The more permeable components feed springs that provide the baseflow for the tributary headwaters. Flows are natural with a small net export of water due to groundwater abstraction. Minor flow regulation associated with upstream mill.
- Flow records are suitable for QMED determination and pooling analysis.

1.1.4 From the comments provided by NRFA, the flow data is considered suitable for QMED at all three stations and therefore a detailed analysis of the high flow ratings at these three gauges is not considered necessary as part of this study. Therefore, the available AMAX series at these sites is used in the flood estimation process described below.

Donor Adjusted QMED

1.1.5 FEH requires that the catchment descriptor derived QMED at an ungauged site is adjusted using the ratio between QMED from the catchment descriptors and QMED from flow data at a local donor gauging station. As detailed above there are three suitable potential donor gauging stations with flow records considered suitable for estimating QMED. However in selecting a suitable gauging station FEH provides hydrological similarity criteria as follows;

- AREA - a factor of no more than 4 or 5
- FARL - a difference of no more than 0.05.
- BFIHOST - a difference of no more than 0.18
- SAAR - a factor of no more than 1.25
- SPRHOST - difference of no more than 15
- URBEXT2000 – falls into a similar urbanisation category

1.1.6 A comparison of the catchment descriptors at the three potential donor gauging stations with the subject site with a combined catchment (**Table 3**) suggests the catchment areas of all three donors are well above the recommended limit and hence none of these gauges would make a suitable donor. The BFIHOST and SPRHOST are also significantly different at stations 41023 which suggest these stations lie on different geological strata and hence these sites are discounted. It is also noted that while the subject site is categorised as 'heavily urbanised' due to its URBEXT2000 being in between 0.15 to 0.30, the URBEXT2000 of most of the adjacent stations within 50 km radius of the site are less than 0.06 (categorised as 'Slightly urbanised') and may therefore not be suitable for the donor site purpose.

Table 3 Catchment Descriptors at Subject Sites and Donor Gauging Stations

Site	AREA	FARL	BFIHOST	SAAR	SPRHOST	URBEXT2000
Bilsham Ditch @ Yapton	0.51	1.000	0.646	747	34.74	0.1634
41023	86.29	1.000	0.935	922	7.25	0.0076
41011	156.90	0.973	0.675	921	26.84	0.0288
41022	52.44	0.951	0.480	857	38.72	0.0087

1.1.7 Although the remaining gauge is unsuitable as a donor in terms of catchment AREA and URBEXT2000; as a check QMED is calculated from flow data and catchment descriptors at this gauge (41022) to confirm whether the QMED ratio is low or high in this area.

1.1.8 For stations with more than 13 years of flow data FEH recommends that QMED is calculated from annual maximum (AMAX) data (Table 4).

Table 4 QMED Ratio at Donor Gauging Stations

Station	QMED-Catchment Descriptors (m ³ /s)	QMED-Catchment Descriptors adjusted for urban influence (m ³ /s)	QMED-AMAX (m ³ /s)	Ratio
41022	11.225	11.342	16.260	1.434

1.1.9 This ratio between QMED from AMAX data and catchment descriptors suggests the QMED from catchment descriptors overestimates that from flow data with a ratio of 1.434. However, the Revised Statistical method requires a further adjustment based on geographical proximity as detailed below.

Revised Donor Adjusted QMED

1.1.10 In addition to adjusting QMED based on the ratio of QMED estimates from catchment descriptors and flow data, the Revised Statistical method requires that the QMED ratio at a donor gauging station is also adjusted according to the distance between the catchment centroids using an exponent 'a'. Exponent 'a' is derived as the straight line distance between the centroid of the subject catchment and the donor gauging station, which in this case is 41022. This exponent in the ratio of QMED at this station gives a revised adjustment ratio at the site of interest of 1.103 (Table 5).

Table 5 Adjusted QMED Ratio at Donor Gauging Stations

Site	Centroid Easting	Centroid Northing	Centroid Distance (km)	Exponent 'a'	Unadjusted Ratio	Adjusted Ratio
Bilsham Ditch @ Yapton	497696	103290				
41022	491432	126898	24.425	0.282	1.415	1.103

Flood Frequency Curve

1.1.11 The calculation of a flood frequency curve and the peak flows at the flood estimation points requires the construction of a pooling group and the fitting of an extreme value distribution to the pooled group data.

1.1.12

1.1.13

1.1.14

1.1.15 Table 6 below gives details of the pooling group including any stations added or removed and reasons for this.

Table 6 Pooling Group Details

Station removed (with reasons)			
Diversed GL Growth Curve	Station in Ireland	High PROPWET	High SAAR
45817 (Rhb Trib to Haddeo @ Upton (trib))	203046 (Rathmore Burn @ Rathmore Bridge)	91802 (Allt Leachdach @ Intake)	49003 (de Lank @ de Lank)
44009 (Wey @ Broadwey)	206006 (Annalong @ Recorder 1895)		48004 (Warleggan @ Trengoffe)
28033 (Dove @ Hollinsclough)	203049 (Clady @ Clady Bridge)		27032 (Hebden Beck @ Hebden)
34005 (Tud @ Costessey Park)	203042 (Crumlin @ Cidercourt Bridge)		
Final Pooling Group			
27073 (Brompton Beck @ Snainton Ings)			
36009 (Brett @ Cockfield)			
27051 (Crimple @ Burn Bridge)			
33029 (Stringside @ Whitebridge)			
72014 (Conder @ Galgate)			
44006 (Sydling Water @ Sydling st Nicholas)			
33054 (Babingley @ Castle Rising)			
26003 (Foston Beck @ Foston Mill)			
33063 (Little Ouse @ Knettishall)			
37003 (Ter @ Crabbs Bridge)			
43017 (West Avon @ Upavon)			
53017 (Boyd @ Bitton)			
48803 (Carnon @ Bissoe)			
34012 (Burn @ Burnham Overy)			
30004 (Lymn @ Partney Mill)			

1.1.16 The revised pooling group contains 15 stations with 547 station years of record. Guidance from the WINFAP Software indicates the pooling group is 'possibly heterogeneous and a review of the pooling group is optional' ($H_2 = 1.9531$). There was no valid reason for the removal of any other of the component stations and the pooling group was considered acceptable. A 500 year record length is reasonable to calculate the 1 in 100 year peak flow and the 1 in 1000 year peak flow was extrapolated

using ReFH as described in the following paragraphs. The pooling ground for the 1 in 1000 year event is likely to be inhomogeneous.

1.1.17 Two extreme value distributions are often used on the pooled group data (i) the Generalised Logistic (GL) and (ii) the General Extreme Value (GEV) distribution both fitted to the annual maximum data by the method of L-Moments. FEH indicates that the GL distribution can often provide the best fit to extreme value flood series and in this case WINFAP indicates that the GL provides an acceptable distribution for this site.

1.1.18 The results of the frequency analysis based on the QMED donor adjustment factor of 1.103 and on the basis that the GL distribution is recommended by WINFAP. Refer to **Table 7** for the full range of results.

Table 7 Pooled Group Growth Curve and Flood Frequency Curves (m³/s) for Mole at Leatherhead

Return periods	2	5	10	20	30	50	100	1000
Growth Curve	1.000	1.309	1.497	1.676	1.779	1.910	2.089	2.714
Flood Frequency Curves (m ³ /s)	0.145	0.189	0.217	0.243	0.257	0.276	0.302	0.393

Extension to the 1 in 1000 Year Event

1.1.19 The FEH Statistical method was originally recommended for return periods only up to the 1 in 200 year event and noted as not suitable for extrapolating to very extreme events such as the 1 in 1000 year event. Flood estimates for longer return periods were historically derived using the FSR/FEH rainfall-runoff method as the rainfall growth curves for long return periods could be defined with much more confidence than flood growth curves. However the original FEH rainfall-runoff method was known to overestimate flows and more recently the extension of the Statistical method has been preferred.

1.1.20 The Environment Agency's Flood Estimation Guidelines² provide two suggestions for calculating extreme floods up to the 1000 year event. Firstly using the Statistical method but the 1 in 1000 year pooling group is likely to be inhomogeneous with many component stations hence a simple extension of the 1 in 200 year and more recently the 1 in 100 year event has been proposed. A second approach is to derive the ReFH growth factor for the 1 in 100 year to 1 in 1000 year event which is then applied to the Statistical method 1 in 100 year peak flow.

1.1.21 The Statistical method flood frequency curve is extended to the 1 in 1000 year event using the ReFH growth factor as described above. (**Table 8**).

Table 8 Statistical Method Pooling Group Extended to 1 in 1000 year using ReFH

Return periods	2	5	10	20	30	50	100	1000
Growth Curve	1.000	1.309	1.497	1.676	1.779	1.910	2.089	4.732
Flood Frequency Curves (m ³ /s)	0.145	0.189	0.217	0.243	0.257	0.276	0.302	0.685

Hydrograph Shape

1.1.22 If a design hydrograph is required it is recommended that the hydrograph shape from the ReFH method is used and forced to fit the peak flows from the Statistical method, referred to as the hybrid method. This can be achieved in the ReFH boundary unit in Flood Modeller Pro suite¹.

1.1.23 The FEH Guidelines suggest two hybrid methods for ungauged sites:

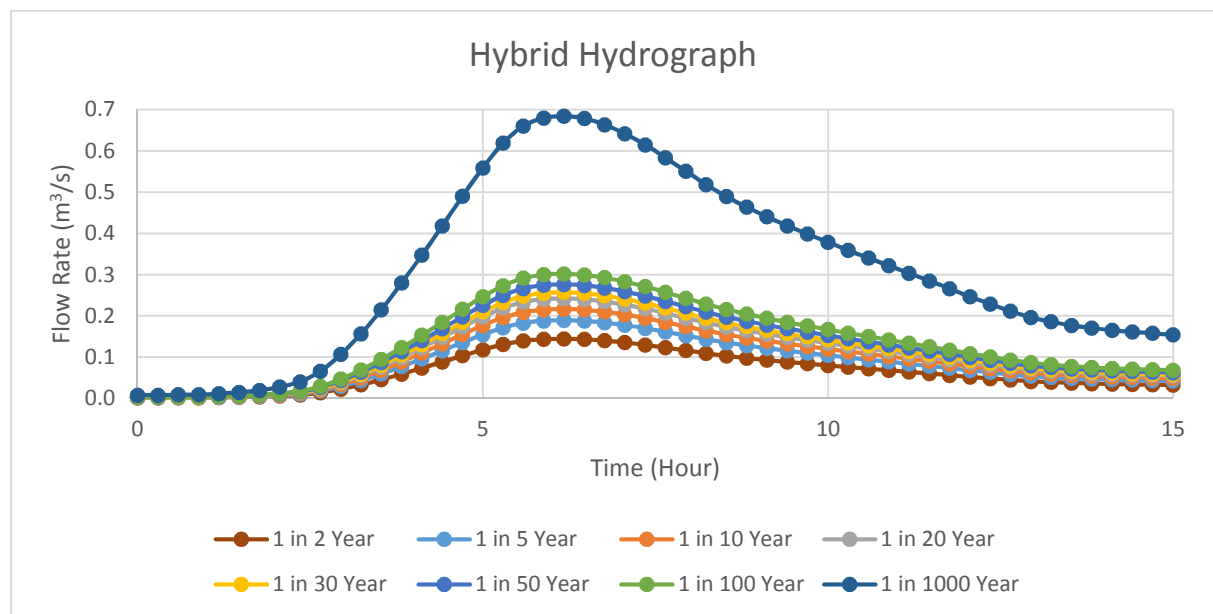
¹ Flood Modeller Pro is a hydraulic modelling software developed by CH2M HILL and includes inflow boundary units for calculating hydrographs. Flood Modeller Pro Version 4.1.5742.30303 was used in this study.

1.1.24 Generating the hydrograph using ReFH method and scaling the ordinates so the peak flow matches the statistical estimate.

1.1.25 Adjusting the parameters of the ReFH model until the simulated peak flows match the preferred values. This might appear more elegant than option (a) but should be used with caution. It may prove difficult to match the statistical results over a range of return periods, because the ReFH method may give a different growth curve.

1.1.26 Option a) is the quickest method and often the best. The flood hydrograph for all return periods from this method is provided in **Figure 1**.

Figure 1: ReFH Flow Hydrograph



WINFAP V3 Created Pooling Group (original total length = 5000 Year including stations that are not suitable for Pooling, below only showing the stations that are suitable for Pooling with discordancy less than 2.0)

Station	Distance	Years of da	QMED AM	L-CV	L-SKEW	Discordancy
27073 (Brompton Beck @ Snainton Ings)	7.684	28	0.739	0.210	0.017	0.438
76011 (Coal Burn @ Coalburn)	8.661	31	1.805	0.188	0.368	1.160
29009 (Ancholme @ Toft Newton)	9.011	34	1.919	0.390	0.367	2.585
33045 (Whittle @ Quidenham)	9.219	40	1.083	0.345	0.178	0.812
45817 (Rhb Trib to Haddeo @ Upton (trib))	9.312	15	1.317	0.304	0.313	0.666
36002 (West Pepper Burn @ Luffness)	9.614	41	3.299	0.292	0.015	0.942
36009 (Brett @ Cockfield)	9.733	38	3.661	0.263	-0.103	1.411
45816 (Haddeo @ Upton)	9.894	14	3.427	0.318	0.449	1.784
54002 (Severn @ Horn Flume)	9.907	31	6.329	0.146	-0.075	2.288
44009 (Wey @ Broadwey)	9.908	31	1.679	0.345	0.259	0.687
27051 (Crimple @ Burn Bridge)	9.939	36	4.610	0.219	0.122	0.261
33029 (Stringside @ Whitebridge)	9.970	43	2.661	0.241	-0.116	1.524
25003 (Trout Beck @ Moss House)	10.013	35	15.088	0.173	0.348	1.335
203046 (Rathmore Burn @ Rathmore Bridge)	10.023	26	10.996	0.126	0.115	1.777
28033 (Dove @ Hollinsclough)	10.044	29	4.608	0.262	0.406	0.831
72014 (Conder @ Galgate)	10.144	41	16.957	0.189	0.054	0.597
44006 (Sydling Water @ Sydling st Nicholas)	10.158	34	0.861	0.231	0.087	0.183
26802 (Gypsy Race @ Kirby Grindalythe)	10.164	9	0.142	0.236	0.134	0.598
49003 (de Lank @ de Lank)	10.168	42	12.994	0.223	0.250	0.393
91802 (Allt Leachdach @ Intake)	10.200	34	6.350	0.153	0.257	1.000
33054 (Babingley @ Castle Rising)	10.214	32	1.129	0.222	0.071	0.216
34005 (Tud @ Costessey Park)	10.235	47	2.971	0.317	0.261	0.540
25019 (Leven @ Eastby)	10.243	30	5.538	0.361	0.411	1.525
206006 (Annalong @ Recorder 1895)	10.261	48	15.330	0.189	0.052	1.664
54022 (Severn @ Plynlimon Flume)	10.267	36	15.054	0.158	0.170	1.641
25011 (Langdon Beck @ Langdon)	10.287	22	15.362	0.254	0.405	1.840
41020 (Bevern Stream @ Clappers Bridge)	10.328	39	13.490	0.225	0.222	0.308
56007 (Senni @ Pont Hen Hafod)	10.342	40	28.694	0.159	0.109	0.610
203049 (Clady @ Clady Bridge)	10.346	26	22.461	0.202	0.139	0.158
33032 (Heacham @ Heacham)	10.355	40	0.461	0.319	0.091	1.079
73006 (Cunsey Beck @ Eel House Bridge)	10.368	35	7.658	0.179	0.110	0.456
76811 (Dacre Beck @ Dacre Bridge)	10.394	9	34.576	0.250	0.345	1.902
36010 (Bumpstead Brook @ Broad Green)	10.427	41	6.759	0.433	0.239	2.638
46005 (East Dart @ Bellever)	10.473	44	37.406	0.148	0.075	1.755
26003 (Foston Beck @ Foston Mill)	10.494	48	1.739	0.251	-0.016	0.636
44008 (Sth Winterbourne @ W'bourne Steepleton)	10.495	29	0.406	0.390	0.340	1.573
72007 (Brock @ U/s a6)	10.499	30	29.438	0.194	0.273	2.654
27010 (Hodge Beck @ Bransdale Weir)	10.500	41	9.420	0.224	0.293	0.300
48004 (Warleggan @ Trengoffe)	10.521	39	9.565	0.244	0.207	0.024
203042 (Crumlin @ Cidercourt Bridge)	10.556	29	36.683	0.207	0.341	0.667
27032 (Heldben Beck @ Heldben)	10.563	42	3.910	0.222	0.267	0.298
36003 (Box @ Polstead)	10.567	45	3.830	0.319	0.121	0.792
48009 (st Neot @ Craigshill Wood)	10.582	12	8.469	0.246	0.172	0.858
73009 (Sprint @ Sprint Mill)	10.612	39	41.879	0.188	0.212	0.323
206004 (Bessbrook @ Carnbane)	10.633	24	9.405	0.134	-0.072	1.607
22603 (Dusway Burn @ Shillimor)	10.643	27	15.307	0.331	0.354	2.089
33063 (Little Ouse @ Knettishall)	10.650	28	3.659	0.257	-0.105	1.621
25012 (Harrowood Burn @ Harwood)	10.653	38	31.368	0.178	0.261	0.948
48007 (Kernal @ Ponsanooth)	10.662	40	3.958	0.182	0.186	0.423
37003 (Ter @ Crabbs Bridge)	10.667	44	4.680	0.251	-0.022	1.264
205005 (Ravernet @ Ravernet)	10.695	36	14.180	0.227	0.359	0.948
43017 (West Avon @ Upavon)	10.704	38	5.594	0.242	0.096	0.101
36004 (Chad Brook @ Long Melford)	10.718	41	4.938	0.320	0.203	0.392
36007 (Belchamp Brook @ Bardfield Bridge)	10.722	44	4.628	0.399	0.146	1.878
48001 (Fowey @ Trekeivesteps)	10.762	39	16.858	0.220	0.300	0.347
28041 (Hamps @ Waterhouses)	10.778	23	26.664	0.252	0.331	1.562
41022 (Lod @ Halfway Bridge)	10.785	35	16.406	0.286	0.209	0.669
53017 (Boyd @ Bitton)	10.797	35	12.730	0.252	0.126	0.220
48803 (Carnon @ Bissoe)	10.819	14	5.307	0.247	0.161	0.095
203019 (Claudy @ Glenone Bridge)	10.848	37	34.033	0.134	0.274	1.449
37013 (Sandon Brook @ Sandon Bridge)	10.868	42	7.202	0.299	0.107	0.481
34012 (Burn @ Burnham Overy)	10.869	42	1.024	0.233	-0.135	1.533
37016 (Pant @ Copford Hall)	10.883	43	8.502	0.296	0.054	0.528
47009 (Tiddy @ Tideford)	10.894	39	5.916	0.175	0.133	0.642
30004 (Lynn @ Partney Mill)	10.901	46	7.311	0.239	0.038	0.445
33011 (Little Ouse @ County Bridge Euston)	10.906	47	3.829	0.319	0.037	0.955
Total		2280				
Weighted means				0.245	0.169	



Adopted Pooling Group:

Station	Distance	Years of da	QMED AM	L-CV	L-SKEW	Discordancy
27073 (Brompton Beck @ Snainton Ings)	7.684	28	0.739	0.21	0.017	0.71
36009 (Brett @ Cockfield)	9.733	38	3.661	0.263	-0.103	1.689
27051 (Crimple @ Burn Bridge)	9.939	36	4.61	0.219	0.122	0.72
33029 (Stringside @ Whitebridge)	9.97	43	2.661	0.241	-0.116	0.845
72014 (Conder @ Galgate)	10.144	41	16.957	0.189	0.054	2.189
44006 (Sydling Water @ Sydling st Nicholas)	10.158	34	0.861	0.231	0.087	0.505
33054 (Babingley @ Castle Rising)	10.214	32	1.129	0.222	0.071	0.536
26003 (Foston Beck @ Foston Mill)	10.494	48	1.739	0.251	-0.016	0.414
33063 (Little Ouse @ Knettishall)	10.65	28	3.659	0.257	-0.105	0.973
37003 (Ter @ Crabbs Bridge)	10.667	44	4.68	0.251	-0.022	1.469
43017 (West Avon @ Upavon)	10.704	38	5.594	0.242	0.096	0.332
53017 (Boyd @ Bitton)	10.797	35	12.73	0.252	0.126	1.514
48803 (Carnon @ Bissoe)	10.819	14	5.307	0.247	0.161	1.485
34012 (Burn @ Burnham Overy)	10.869	42	1.024	0.233	-0.135	1.106
30004 (Lynn @ Partney Mill)	10.901	46	7.311	0.239	0.038	0.514
Total		547				
Weighted means		547		0.236	0.014	
Growth Curve Fittings from WINFAP						
	2	5	10	20	30	50
GL	1.000	1.309	1.497	1.676	1.779	1.910
GEV	1.000	1.344	1.530	1.681	1.759	1.846

Factored FFC:	2	5	10	20	30	50	100	1000
Return periods								
Growth Curve	1.000	1.309	1.497	1.676	1.779	1.910	2.089	2.714
Flood Frequency Curves (m³/s)	0.145	0.189	0.217	0.243	0.257	0.276	0.302	0.393
Replaced 1000 year Flow Rate with Pro-rata ReFH Rate:								
Return periods	2	5	10	20	30	50	100	1000
Growth Curve	1.000	1.309	1.497	1.676	1.779	1.910	2.089	4.732
Flood Frequency Curves (m³/s)	0.145	0.189	0.217	0.243	0.257	0.276	0.302	0.685

Adjusted QAdjusted Ratio

0.131 1.103

Peak Flow Rate from ReFH (Flood Modeller REFHBDY):

1/100 Yr 1/1000 Yr
0.26 0.589

0.684904

Unit Hydrograph and Hybird Hydrograph based on 1 in 1000 yr ReFH Hydrograph:

		Flow (m³/s)										Return periods
Index Flow	Time (Hour)	1 in 2 Year	1 in 5 Year	1 in 10 Year	1 in 20 Year	1 in 30 Year	1 in 50 Year	1 in 100 Yr	1 in 1000 Yr			
0.012	0	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.008			
0.012	0.294	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.008			
0.014	0.588	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.009			
0.014	0.882	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.009			
0.017	1.176	0.002	0.003	0.004	0.004	0.004	0.005	0.005	0.012			
0.022	1.47	0.003	0.004	0.005	0.005	0.006	0.006	0.007	0.015			
0.029	1.764	0.004	0.005	0.006	0.007	0.007	0.008	0.009	0.020			
0.041	2.058	0.006	0.008	0.009	0.010	0.010	0.011	0.012	0.028			
0.059	2.352	0.009	0.011	0.013	0.014	0.015	0.016	0.018	0.041			
0.097	2.646	0.014	0.018	0.021	0.023	0.025	0.027	0.029	0.066			
0.156	2.94	0.023	0.030	0.034	0.038	0.040	0.043	0.047	0.107			
0.229	3.234	0.033	0.043	0.050	0.056	0.059	0.063	0.069	0.157			
0.314	3.528	0.045	0.060	0.068	0.076	0.081	0.087	0.095	0.215			
0.409	3.822	0.059	0.078	0.089	0.099	0.105	0.113	0.124	0.280			
0.508	4.116	0.073	0.096	0.110	0.123	0.131	0.140	0.153	0.348			
0.611	4.41	0.088	0.116	0.132	0.148	0.157	0.169	0.185	0.419			
0.716	4.704	0.104	0.136	0.155	0.174	0.184	0.198	0.217	0.491			
0.817	4.998	0.118	0.155	0.177	0.198	0.210	0.226	0.247	0.559			
0.905	5.292	0.131	0.171	0.196	0.220	0.233	0.250	0.274	0.620			
0.964	5.586	0.140	0.183	0.209	0.234	0.248	0.267	0.292	0.660			
0.993	5.88	0.144	0.188	0.215	0.241	0.256	0.275	0.300	0.680			
1.000	6.174	0.145	0.189	0.217	0.243	0.257	0.276	0.302	0.685			
0.992	6.468	0.143	0.188	0.215	0.241	0.255	0.274	0.300	0.679			
0.969	6.762	0.140	0.184	0.210	0.235	0.250	0.268	0.293	0.664			
0.937	7.056	0.136	0.178	0.203	0.227	0.241	0.259	0.283	0.642			
0.898	7.35	0.130	0.170	0.195	0.218	0.231	0.248	0.272	0.615			
0.852	7.644	0.123	0.161	0.185	0.207	0.219	0.236	0.258	0.584			
0.805	7.938	0.116	0.152	0.174	0.195	0.207	0.222	0.243	0.551			
0.757	8.232	0.110	0.143	0.164	0.184	0.195	0.209	0.229	0.519			
0.715	8.526	0.103	0.135	0.155	0.173	0.184	0.198	0.216	0.490			
0.677	8.82	0.098	0.128	0.147	0.164	0.174	0.187	0.205	0.464			
0.643	9.114	0.093	0.122	0.139	0.156	0.166	0.178	0.195	0.441			
0.611	9.408	0.088	0.116	0.132	0.148	0.157	0.169	0.185	0.419			
0.582	9.702	0.084	0.110	0.126	0.141	0.150	0.161	0.176	0.399			
0.553	9.996	0.080	0.105	0.120	0.134	0.143	0.153	0.165	0.379			
0.526	10.29	0.076	0.099	0.114	0.127	0.135	0.145	0.158	0.361			
0.497	10.584	0.072	0.094	0.108	0.121	0.128	0.138	0.150	0.341			
0.470	10.878	0.068	0.089	0.102	0.114	0.121	0.130	0.142	0.323			
0.443	11.172	0.064	0.084	0.096	0.107	0.114	0.122	0.134	0.303			
0.416	11.466	0.060	0.079	0.090	0.101	0.107	0.115	0.126	0.285			
0.389	11.76	0.056	0.074	0.084	0.094	0.100	0.107	0.118	0.266			
0.360	12.054	0.052	0.068	0.078	0.087	0.093	0.099	0.109	0.247			
0.334	12.348	0.048	0.063	0.072	0.081	0.086	0.092	0.101	0.229			
0.309	12.642	0.045	0.059	0.067	0.075	0.080	0.085	0.093	0.212			
0.287	12.936	0.042	0.054	0.062	0.070	0.074	0.079	0.087	0.197			
0.272	13.23	0.039	0.051	0.059	0.066	0.070	0.075	0.082	0.186			
0.258	13.524	0.037	0.049	0.056	0.063	0.066	0.071	0.078	0.177			
0.250	13.818	0.036	0.047	0.054	0.061	0.064	0.069	0.075	0.171			
0.241	14.112	0.035	0.046	0.052	0.058	0.062	0.067	0.073	0.165			

APPENDIX B

DVD with Hydraulic Models and Channel Survey

Mr Gerald Guma
Odyssey Markides
Tuscany House White Hart Lane
BASINGSTOKE
Hampshire
RG21 4AF

Our ref: HA/2016/118518/02-L01
Your ref: PAC/SLTSDN/00162
Date: 08 September 2016

Dear Mr Guma

MODEL REVIEW : LAND WEST OF BILSHAM ROAD, YAPTON

Thank you for accepting our offer to provide detailed planning advice. We have reviewed the following:

- Hydraulic Modelling of the Main River (Bilsham Ditch)
- Email dated 13 July 2016

We are providing this advice under Agreement No. PAC/SLTSDN/00162. Please note we have taken 10 hours to review and provide our advice on these documents which is as we estimated in our Programme of Works. The total will be £840 which is payable on receipt of our invoice.

Summary

We have reviewed the hydraulic model submitted and the original email dated 13 July 2016. We are satisfied the model is fit for purpose and would be suitable for use in your Flood Risk Assessment.

Environment Agency Advice

We have reviewed the submitted information in relation to the proposed development and have the following detailed comments to make on the hydraulic modelling:

Hydrodynamic Model Checklist

Dataset name	BRY
Dataset reach length including Grid References	
Purpose of model	Site specific – site development
Was an interim handover report or other notes provided with the model	A model Report was provided with the model
Are there sufficient notes within the model	No notes were included in the model.
Are there sufficient comments on the model nodes	No comments were included in the model.
Have survey drawing numbers been included, to allow easy reference for the review and future users	No. A legend or comments containing the drawing reference would make easier the future checks and use of the model.
Files provided For example, 2011s5080 Upper Alt_Draft.dat (x) range of return period .ied files V9.17_Q100.iic – initial conditions file .ief for (x) return periods Results for Q100 and Q1000. Note a .gxy is essential unless it is a linked TuFLOW model. NFFS requires .dat, .ief and .zxs as minimum.	All files provided, including .gxy for all return periods.
Boundary Conditions	
Upstream boundary locations and types Do upstream and downstream inflows correspond to those reported in the FEH proforma/hydrology report?	Boundary locations and type are appropriate. The flows for the several return periods are matching those reported in the hydrology description.
What range of design events have been modelled? Have minimum inflows been used? If so are they appropriate for all design events? What is the storm duration? Is this appropriate (check report for critical storm duration). Also note any scaling factors or delays.	A wide range of events was simulated (from 1 in 5 year to 1 in 1000 year). Climate change scenario were run for the 1 in 100 year event. A number of sensitivity tests were also undertaken. A 5 hours storm duration was chosen. Considering the dimension of the catchment this is acceptable. Though, the choice was not justified in the report.
Downstream boundary locations and types	Normal depth boundary representing the rating curve of the downstream end of the model is used. The Downstream boundary is located fairly far from the area of interest. This is appropriate.
Downstream boundary conditions – are these appropriate for the study? Do tidal and fluvial peaks coincide? Any evidence of “ghost tides” i.e. unexpected tidal peaks.	Appropriate. No tide is involved.
Is the downstream boundary condition applicable over the entire range of flows? I.e. is it affected by other sources or does it drown out at higher flows?	The downstream boundary condition is applicable over the entire range of events as it is based on the rating curve of the section.
Convergence and Model Stability	
Is the dataset convergent for all events considered during the development? If there is	A single time step of struggle affects the 100CC_HC, 100CC_UE and 1000 runs at the flow peak time. This does not significantly affect the model result.

any poor convergence has this been investigated/improved?	
Detail all non-default run-parameters, their values plus and supplied justification. In particular check if Automated Preissman slot has been used, and check the dflood value and maxitr.	All default parameters were used.
Structures	
Are there any movable structures in the dataset and have they been correctly modelled? Check any rules for pumps, sluices, gates.	No movable structures were modelled.
Are there any bridges in the dataset and have they been correctly modelled? Check which units have been used, have spills over the structure been accounted for (may need to consider TuFLOW if linked model)? If a USBPR unit, has the “model surcharged bridge as orifice flow” option been selected? Compare a selection to surveyed data.	1 bridge appears in the model. This has been modelled as orifice to help the model stability. This action is acceptable considering the very small dimension of the bridge. A spill unit was applied to account for volume of water overtopping the structure when the bridge is surcharged.
Are there any other structures in dataset and have they been correctly modelled? E.g. culverts, weirs. To model a culvert in ISIS, the sequence of units used would normally be: 1. a Culvert Inlet or Orifice 2. two or more Conduit type or River Section nodes forming a reach 3. a Culvert Outlet. Compare a selection to surveyed data. Check loss coefficients are sensible / justified. Check any QH units/boundaries for drowning out (may be used in forecasting models to match ratings or to extract levels). Check unit representing weirs are appropriate.	The main Culvert was correctly modelled, with Inlet and Outlet units. The Culvert loss coefficient is set to 1. This is a coefficient used in model to loss head energy loss due to the expansion of the water coming out of the culvert and it is typically 0.5. Though this issue is recognised it does not have a significant impact on the results.
Are any flood mitigation measures included within the dataset, such as flood basin or washlands operation? Have they been correctly modelled? Check a selection of reservoir units and associated spill units, or extended cross-sections as appropriate.	No mitigation measures were included in this model.
Are there any unusual headlosses for Q100 flow at any nodes, especially structures? (check long section)	No unusual head losses. The water level profiles appear sensible.
Other Comments	
Has the model been fully geo-referenced?	Yes, the model is fully georeferenced.

Have the correct roughness factors been used? Check a few sections and structures on each watercourse.	Roughness values in the channel are set to 0.04. this is considered appropriate considering the channel properties.
Check conveyance – are panel markers appropriate? (Note that panel markers are used to instruct ISIS of a change in conveyance. Hence it may not be appropriate to always have a panel marker where there is a change in roughness.) Plot conveyance at sections in critical locations, or where there seem to be model instabilities.	Conveyance looks sensible (spot check shows sensible conveyance).
Is the model built using soft (silt) or hard (clean) bed, channels. Example, for Flood Map purposes, it is necessary to use the hard bed elevations.	Not specified in the report.
Detail any calibration runs undertaken. (If enough data is available, a minimum of 3 calibration plus one verification event). Are the differences between modelled and observed levels and flows within an acceptable tolerance for the study? Is the modelled hydrograph shape, rising and receding limbs represented throughout each event? Detail any known issues with the observed data.	No calibration runs were performed, a large number of sensitivity tests was run instead.
Check a sample of x-section distances and structure lengths (e.g. culverts) compared to survey.	Cross section spacing is regular and within 10-20m. This is appropriate.
Other	

Tuflow Model Checklist

TUFLOW model files provided:	Comments	Consultant response
 BRY_Baseline_001.feb Control files (.tcf)	All provided	
Geometry files (.tgc)	All provided	
Boundary files (.tbc)	All provided	
ESTRY control files (.ecf)	N/A	
Other data input files provided:		
Boundary conditions (.csv)	N/A	
Roughness (.tmf)	provided	
GIS files (.mid/.mif)	provided	

Model development notes		
Has a model handover guide been provided with the TUFLOW model?	A model development report was provided.	
Has a modelling development log been provided?	A model log file was provided.	
Tuflow - ISIS link		
Is this an ISIS-TUFLOW linked model?	Yes.	
Linked model only: are node points from 1D model correct?	Yes.	
Linked model only: do HX lines start/stop at structures? Are all lines labelled correctly?	HX lines have been properly applied into the model.	
Do the top of bank values in ISIS match the top of bank values in TuFLOW (on the zlns)?	z-lines and z-points were used to define the bank elevations and these were verified to be matching the ISIS sections banks.	
Model Domain and DTM		
Check location and dimension of 2D grid. is the domain large enough/does it tie-in to high ground?	Location and dimension of 2D grid is appropriate.	
What is grid cell size? Is this suitable for the study?	2m grid cell size is used. This is considered appropriate to represent the floodplain and the flow paths.	
Are boundaries/active TUFLOW areas located correctly?	Model boundaries are located correctly and there is no risk of glasswalling.	
Are there any z-points with a null value or -99,999?	No.	
How have buildings been represented? Is this appropriate for the study or consistent with similar EA studies?	Buildings have been by their footprint and characterised by a Manning's n = 1.0. This approach is assumed appropriate for this study considering the very low presence of buildings in the flooded area.	
Is it necessary to fill in the channel? If so how has this been done? Have flows been adjusted to reflect this?	Not necessary.	

Are there any gullies that represent watercourses/drains? Do these look ok?	A network of drains runs through the model domain. A 5m resolution grid may not pick up as small lines. The drainage network feedline would be more accurate using 1m grid lines. Though, considering the flood extent this is not essential to have a detailed model.	
Have defences/bank crests been represented correctly?	Yes.	
Compare 1d cross-section widths to the widths of the inactive areas within the 2d domain.	Widths are comparable in the 1D and 2D.	
Roughness		
Are roughness polygons appropriate? Has Mastermap been used?	Roughness polygons are based on standard values, photographs and engineering judgement. The material polygons were checked and assumed appropriate.	
Are roughness values appropriate?	Manning's n values are appropriate.	
Is depth varying roughness applied? E.g. for shallow or pluvial flows	No.	
Model boundaries		
Are the locations of the inflows and downstream boundaries correct?	Yes (see 1D model review)	
Check the type of boundary used and if it is appropriate. E.g. QT more suitable at edge of domain, SA more suitable within the domain.	N/A	
How are incremental flows modelled – single point or distributed along a reach?	A unique inflow is applied in the 1D model.	
Initial conditions		
Are they appropriate? E.g. start time of run, Initial Water Level.	N/A	
Structures		
Have any structures excluded from the model been justified?	No structures were excluded.	
How have structures been represented, 1D or 2D? Culvert, bridge etc?	The long culvert crossing the entire site was properly schematised in the 1D 2D interaction. An orifice unit was used to	

	model the bridge located upstream of the model (See 1D)	
Are entrance/exit losses appropriate?	See 1D	
Model stability		
Does the .tif contain any warnings, checks or errors? Check messages.mif E.g. negative depths	Tif and message layers do not show major warnings or errors.	
What is timestep? Is this half grid cell size?	The timestep is 1 sec that is consistent with 2m grid cell size. Though it is not consistent with the 12 time steps.	
Are there any poor mass balance errors? >1 to 3%	The peak mass balance error is within the tolerance range (+/-1%)	
Are there unnatural fluctuations in flow/volume values? Plot change of volume in the model (dV) Check MB.csv and MB2D.csv files.	No, the model results seem sensible.	
Review check files	OK	
Other		
Comments from viewing animation and outlines.	N/A	
Have any sensitivity tests been undertaken?	Sensitivity tests were undertaken on the manning's n values across the domain (both 1D and 2D), spill coefficients and on the culvert blockage. All the sensitivity runs were carried out for the 1 in 100 year event.	

We have reviewed the submitted information in relation to the proposed development and have the following detailed comments on the information in your original email dated 13 July 2016:

We agree that the recommended climate change allowance for a proposed access road crossing the Flood Zone 2 should use the Higher Central allowance of 45%.

We suggest that soffit levels of the proposed crossing be 600mm freeboard above the 1 in 100 year plus climate change.

A permit from the Environment Agency is required for any proposed works or structures, in, under, over or within 8 metres of the top of the bank of a 'main river'. Please be aware that the Environment Agency has up to two months to determine applications for a permit; therefore, you are advised to contact the Environment Agency as soon as possible to discuss making an application. Please contact the Environment Agency at: 03708 506506 for further information.

I hope the above advice is helpful. If there is any further work you anticipate needing our detailed advice on in relation to this project please let me know so it can be incorporated into this charging agreement.

Yours sincerely

Mrs Sophie Brown
Sustainable Places Planning Advisor

Direct dial 02030 257250

Direct e-mail planningSSD@environment-agency.gov.uk

Disclaimer

Our opinion is based on the information available to us at the time of the enquiry. When the formal planning application is submitted, our position may change if there have been changes to environmental risk or evidence, and/or planning policy.

SSD 7679: Flood Map for Planning (Rivers and Sea). Created 21 December 2015



Scale 1: 10,000



Flood Map for Planning (Rivers & Sea)

- Flood Map - Defences
- Area Benefitting from Flood Defences
- Flood Map - Flood Storage Area
- Flood Zone 3
- Flood Zone 2
- Sealed Main Rivers

Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

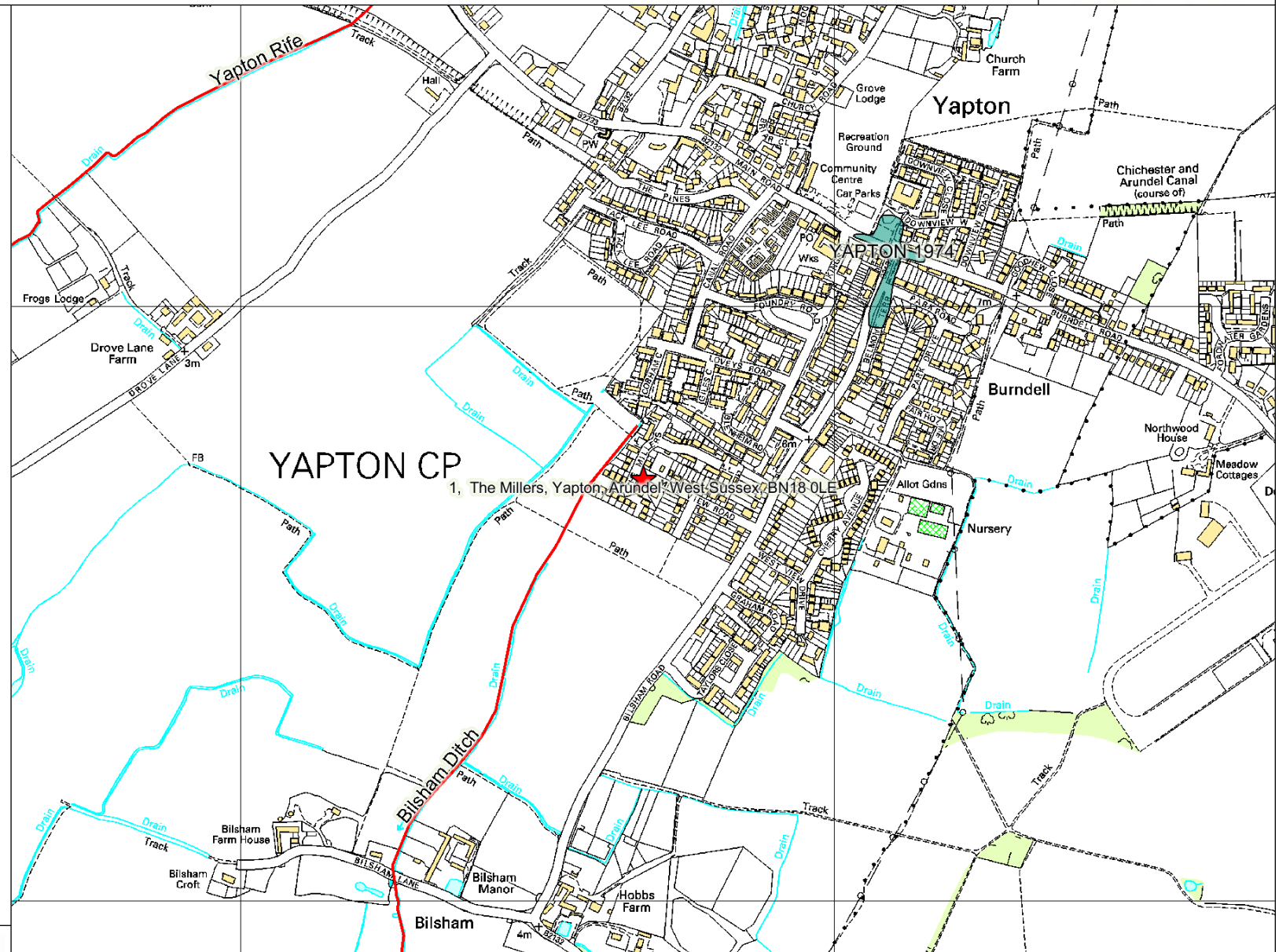
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Historic Flood Map. Created 22 December 2015. Ref: SSD 7679



Legend

- Sealed Main Rivers
- Flood Event Outlines

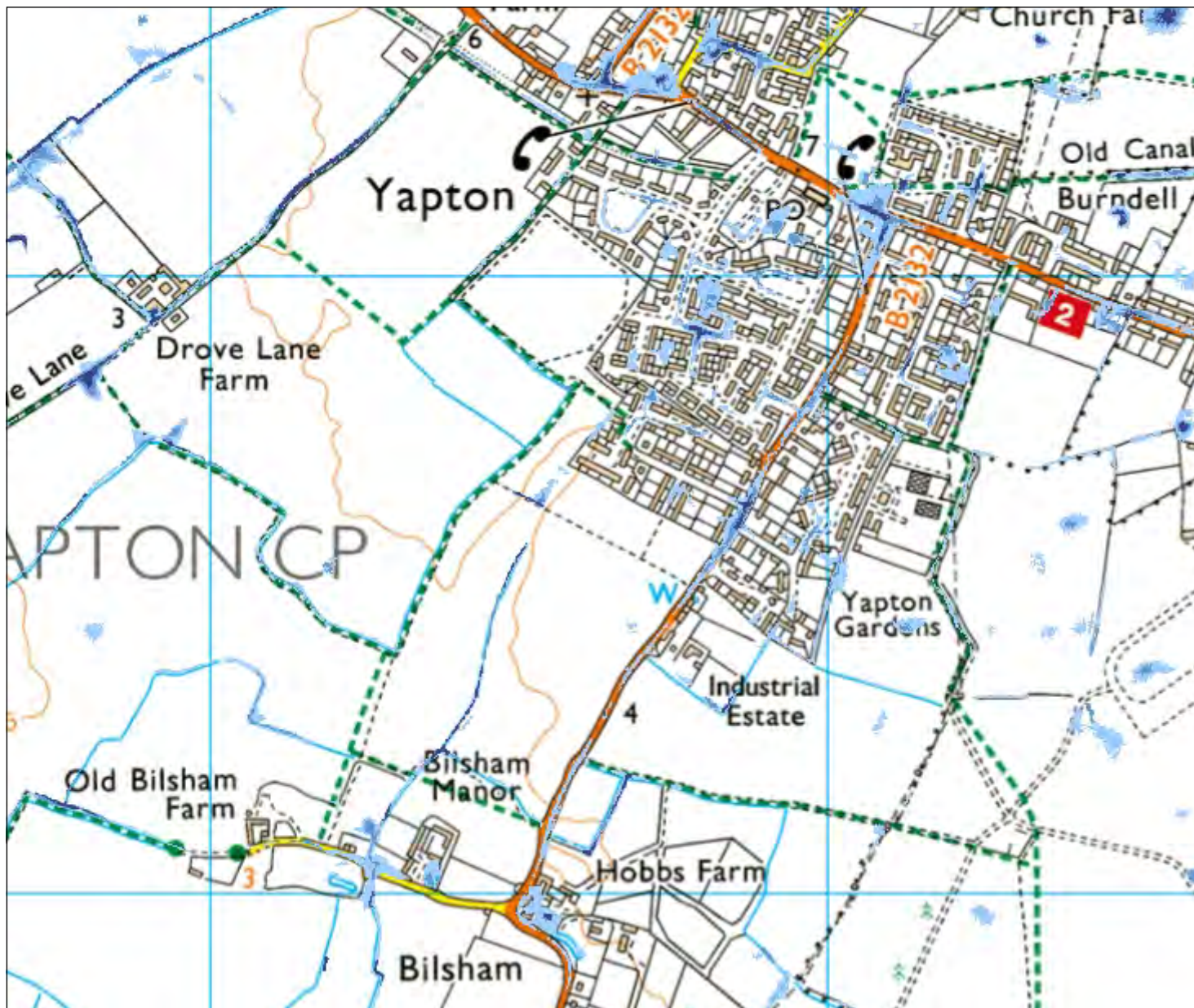


0 95 190 285 m.



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Risk of flooding from Surface Water



Scale 1: 10,000



Likelihood of flooding from Surface Water

- High (1 in 30yr)
- Medium (1 in 100yr)
- Low (1 in 1000yr)
- Very Low

Likelihood of flooding from Surface Water

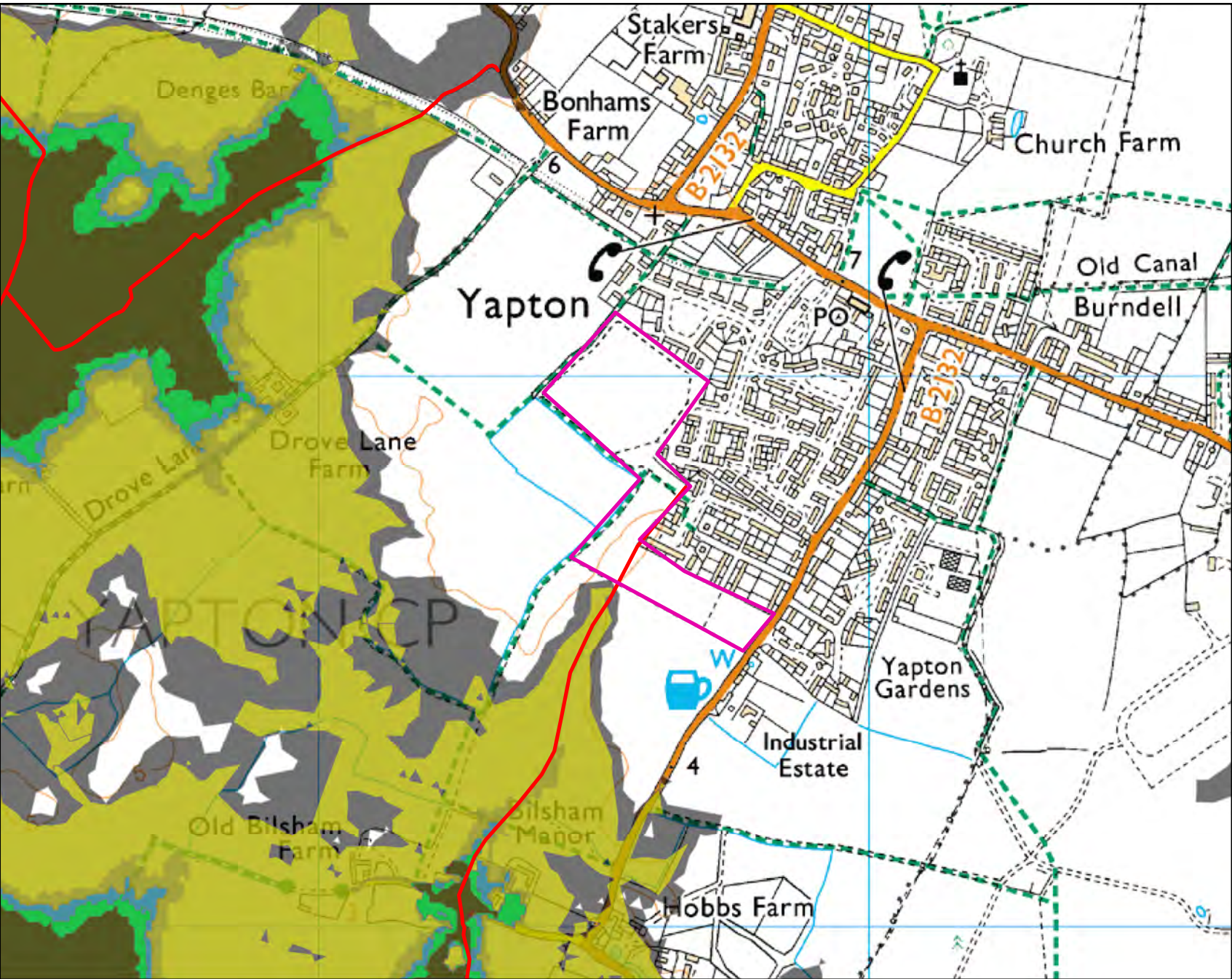
- High: Greater than or equal to 1 in 30 (3.3%) chance in any given year
- Medium: Less than 1 in 30 (3.3%) but greater than or equal to 1 in 100 (1%) chance in any given year
- Low: Less than 1 in 100 (1%) but greater than or equal to 1 in 1,000 (0.1%) chance in any given year
- Very Low: Less than 1 in 1,000 (0.1%) chance in any given year

This information is shown on the Risk of Flooding from Surface Water map on our website.

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Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). E-mail: enquires@environment-agency.gov.uk

1. Modelled Undefended Tidal Flood Extent Map centred on 14-111 Bilsham Road, Yapton, Arundel, BN18 0LE. Created 21/12/2015 (Ref: SSD 7679)



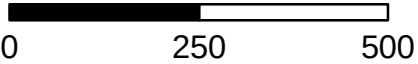


Legend

- Main River
- Boundary
- 5% AEP (Undefended)
- 1% AEP (Undefended)
- 0.5% AEP (Undefended)
- 0.5% AEP 2115 (Undefended)
- 0.1% AEP (Undefended)
- 0.1% AEP 2115 (Undefended)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:10,000

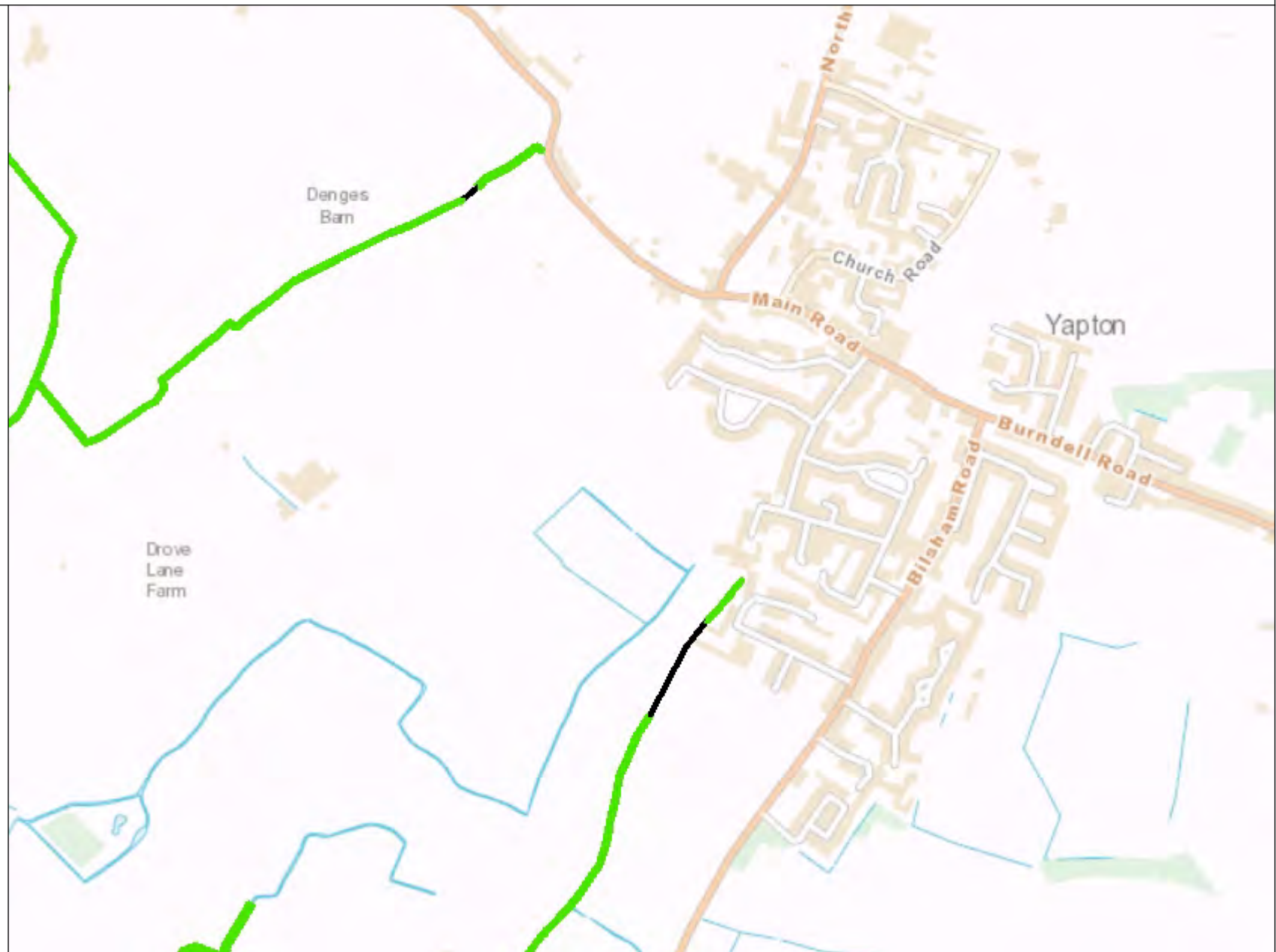


0 250 500
Meters

Legend

Defences

-  Embankment
-  Wall
-  Flood Gate
-  Demountable Defence
-  Bridge Abutment
-  High Ground
-  Beach
-  Barrier Beach
-  Promenade
-  Quay
-  Cliff
-  Dunes
-  Culvert



0 100 200 300
Metres

