Part B - Your Representations

Please note: this section will need to be completed for each representation you make on each separate policy.

4. To which part of the Local Plan or Sustainability Appraisal (SA) does this representation relate?

	Local Plan
Paragraph Number:	
Policy Number:	DS11
Policies Map Number:	29. Kingswood

5. Do you consider the Local Plan is :

	Yes	No
5.1 Legally Compliant?	✓	
5.2 Complies with the Duty to Co-operate?	✓	
5.3 Sound?		✓

6. If you answered no to question 5.3, do you consider the Local Plan and/or SA unsound because it is not: (please tick that apply):

Positively Prepared:	
Justified:	●
Effective:	☒
Consistent with National Policy:	

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Person ID: Rep ID:

7. Please give details of why you consider the Local Plan is not legally compliant or is unsound or fails to comply with the duty co-operate. Please be as precise as possible. If you wish to support the legal compliance or soundness of the Local Plan or its compliance with the duty to cooperate, please also use this box to set out your comments.

Please see below

Continue on a separate sheet if necessary

8. Please set out what modification(s) you consider necessary to make the Local Plan legally compliant or sound, having regard to the test you have identified at 7. above where this relates to soundness. (Please note that any non-compliance with the duty to co-operate is incapable of modification at examination). You will need to say why this modification will make the Local Plan legally compliant or sound. It will be helpful if you are able to put forward your suggested revised wording of any policy or text. Please be as precise as possible.

The number of dwellings on the two sites combined should be increased to approximately 40 on the Meadow House and Kingswood Farm sites.

Continue on a separate sheet if necessary

Please note your representation should cover succinctly all the information, evidence and supporting information necessary to support/justify the representation and the suggested modification, as there will not normally be a subsequent opportunity to make further representations based on the original representation at publication stage. **After this stage, further submissions will be only at the request of the Inspector, based on the matters and issues he/she identifies for examination.**

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Person ID:	Rep ID:

9. If your representation is seeking a modification, do you consider it necessary to participate at the oral part of the examination?

No, I do not wish to participate at the oral examination ☐

Yes, I wish to participate at the oral examination ✓

10. If you wish to participate at the oral part of the examination, please outline why you consider this to be necessary:

To discuss the issues surrounding the allocation.

Continue on a separate sheet if necessary

Please note: This written representation carries the same weight and will be subject to the same scrutiny as oral representations. The Inspector will determine the most appropriate procedure to adopt to hear those who have indicated that they wish to participate at the oral part of the examination.

11. Declaration

I understand that all comments submitted will be considered in line with this consultation, and that my comments will be made publicly available and may be identifiable to my name/organisation.

Signe[redacted]

Date : 27/06/2014

Copies of all the objections and supporting representations will be made available for others to see at the Council's offices at Riverside House and online via the Council's e-consultation system. Please note that all comments on the Local Plan are in the public domain and the Council cannot accept confidential objections. The information will be held on a database and used to assist with the preparation of the new Local Plan and with consideration of planning applications in accordance with the Data Protection Act 1998.

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Person ID: Rep ID:

Q7 Policy DS11 proposes *the* allocation of land at Kingswood – Meadow House for 10 dwellings and Kingswood – Kingswood Farm for a further 10 dwellings (sites H20 arid H30). In separate representations we have supported the principle of this allocation and provide a reasoned justification for this. However the combined sites have a developable area outside of flood zone 2 (1:1000) or 3 (1:100) of approximately 1.9 hectares (excluding The Meadow House), and are capable of accommodating more than the 20 dwellings proposed between them. Indeed the Village Housing Options and Settlement Boundaries Consultation indicated the Meadow House site should accommodate 20 dwellings on a developable area of 1.43 hectares, subject to detailed flood risk assessment work, and the Kingswood Farm site 10 dwellings on a 0.54 hectare developable area. Failure to propose the allocation of the land for a higher number of units is not justified and is not consistent with national policy.

National planning guidance requires the best use to be made of land, to minimise the overall take up of green fields and thus to reduce the impact on the wider landscape. Failure to make best use of the land results in conflict with the NPPF. In this case the overall suitability of the site to accommodate development is not in question. However as a result of concerns over potential flood risk by the Council, the number of dwellings has been reduced to a level which does not make best use of the land.

It is a matter of fact that the site has not flooded. However in response to issues raised about flooding a meeting was convened to agree with the District Council what information they required to overcome their concerns. As a result Robert West Consulting was instructed to undertake detailed hydrological flood modelling work. The outcome was a report which was submitted to the District Council and is attached herewith. The report is backed up by a detailed topographical survey of the land undertaken by Midland Survey, and confirms both the extent of the flood zone and the estimated depth of any flood water in a flood event,

A further meeting was then arranged, attended by persons from Robert West and the Council's flood team. At this meeting the Council agreed that those parts of the site which were not prone to flooding could be developed provided a dry emergency access was available, for vehicles and pedestrians. During the meeting officers at the Council were shown an indicative layout which showed both parcels of land being developed using the existing access for Meadow House and Nursery Cottages. The hydrological study establishes that part of the access road could be subject to shallow flood water (to a depth of approximately 150mm) during a flood event. For emergency purposes (which is very unlikely to ever be needed) an access mute outside of the flood zone 3 is shown taken through the Kingswood Farm land

The District Council accepted that this was a satisfactory solution (as the attached minutes confirm). Following the meeting the indicative layout was further emended to show how surface water run-off will be dealt with, whilst accommodating 39 dwellings between the two sites (retaining Meadow House) (attached).

This level of development, given the constraints (which including avoiding the land within flood zones 2 and 3, and the impact on the Kingswood Farm, which is a listed building), makes best use of the land available whilst still creating an attractive development which can meet the needs of the local a m and the wider District. Thus increasing the number of units on the Kingswood – Meadow House site to approximately 27 would make this part of the Plan sound, overcoming problems of consistency with National Policy and justification. Similarly the housing numbers for Kingswood – Kingswood Farm should be increased to approximately 12.

During the detailed design development stage A C Lloyd will investigate options to further reduce any flood risk issues. These my include:

1. The possibility of enlarging the culvert under the Warwick Road to improve flows under the main road and thereby remove the shallow surface flooding of the adjacent highway / pedestrian access route. This may mean the emergency access could be avoided and may also provide benefit to the wider area,
2. Re-grading and deepening the existing channel back from the canal / rail culvert to approximately I in 500 gradient, within the Meadow House site.
3. Utilising land to the west of the Meadow House site for compensatory flood storage, which may increase the number of units which could be accommodated on the Kingswood – Meadow House site.

Attached are the following:

- Flood Report prepared by Robert West Consulting
- Minutes from lhe meeting held to discuss the outcome of the modelling work
- Swale size calculations
- Revised indicative layout showing 39 dwellings

Robert West

Rail
Buildings
Infrastructure
Transport & Environment

Project Title
Kingswood Nursery, Lapworth

Report Name -

Document Reference:
5300/001/R01

Prepared For
A C Lloyd Homes Ltd.

Date
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First Issue	First Issue	25-3-14	RB	MB

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1 INTRODUCTION

Robert West Consulting have been instructed by A C Lloyd Homes Ltd. to undertake a Flood Mapping Study in relation to a possible residential development on land adjacent to Kingswood Nursery, Lapworth, Warwickshire. Grid Reference: SP18800 70750. Due to Environment Agency Flood maps not being available for this location and to provide a level of confidence to existing local residents and possible future residents, hydrodynamic modelling is to be used to prepare flood maps. The site location is shown in Figure 1 below:

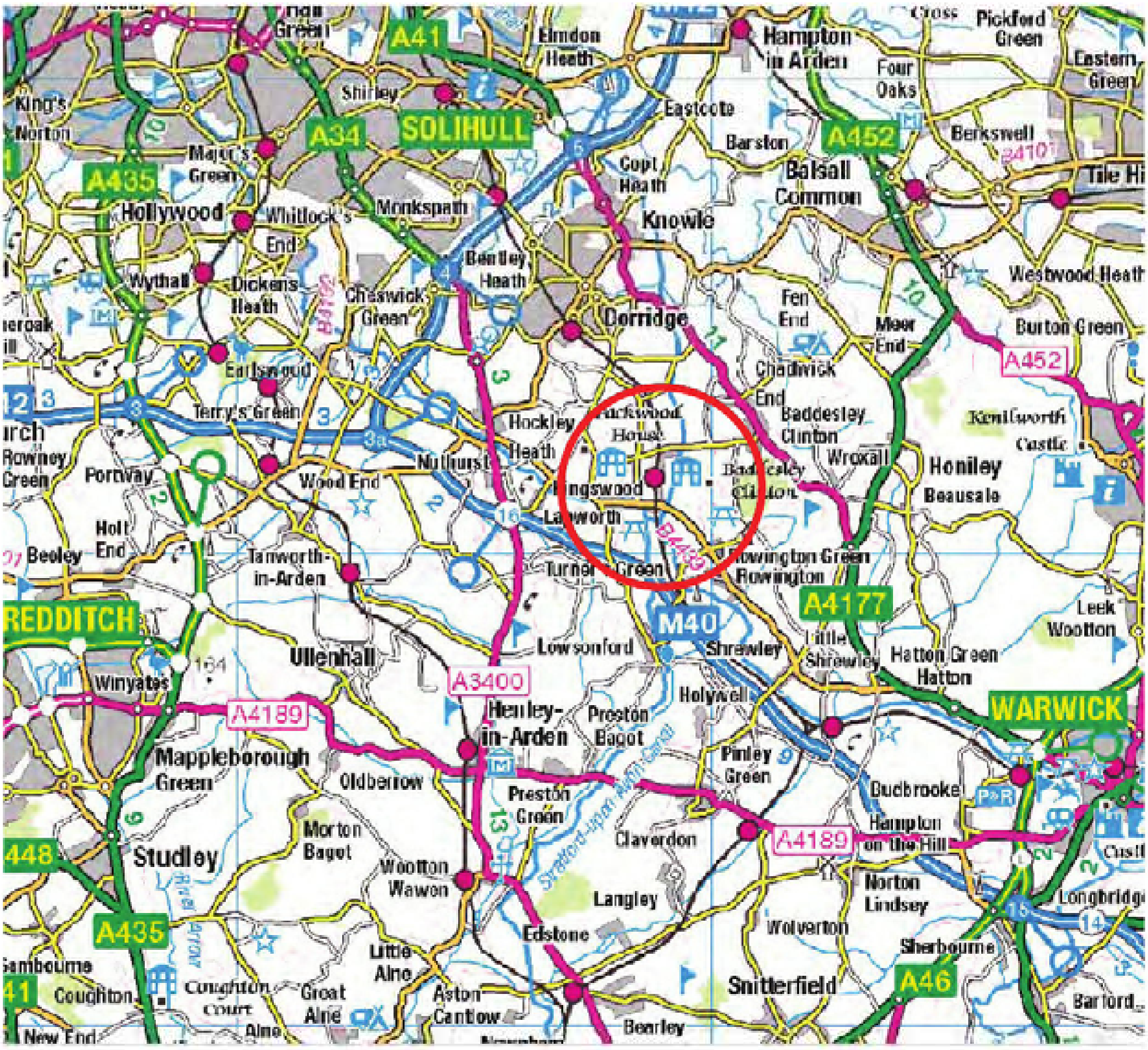

Figure 1 Location Plan, Kingswood, Lapworth

2 SITE AND DEVELOPMENT DESCRIPTION

The existing site is partially developed and includes Kingswood Nursery. The land relating to this proposed development is located south of the B4439 Old Warwick Road. Kingswood Brook runs along the western boundary of the site while a Railway Line runs along part of the southern boundary and the Grand Union Canal forms the eastern boundary to the site. A number of residential properties are located in the area with agricultural land surrounding these residential areas. Figure 2 below shows the existing site layout.

Figure 2: Development Site Photograph with Topographic info overlaid

3 SCOPE & OBJECTIVES

3.1 The scope of this report is to assess the risk of flooding to the site at Kingswood Nursery. It has involved a hydrological study to estimate the peak 1 in 100 and 1 In 1000 year flows.

3.2 A topographical survey of the site including Kingswood Brook has been undertaken. Using this topographical information, supplemented by a 'Next Map 2" digital terrain model (DTM) an ISIS-TUFLOW model has been created.

3.3 This model, together with the peak flow estimates from the hydrological study, predicts the flood extents of Flood Zones 2 and 3 on the site and provides peak flood water levels.

4 HYDROLOGY

4.1 Hydrological analyses of Kingswood Brook have been undertaken to estimate peak design flows.

The calculation of flows is based on methods detailed in the Flood Estimation Handbook (FEH) and latest Environment Agency's FEH guidelines (Version 4), June 2012.

Full details of the analyses are shown in Appendix A.

Flows have been estimated for return periods 2, 5, 10, 50, 100, 200 and 1000 years using 4 different methods:

FEH statistical method using pooling growth curves

The revitalised flood hydrograph method (ReFH)

Statistical method using ReFH growth curve

FEH statistical method using single site growth curves

A summary of the flows for all methods is shown in Table 4.1 below:

Statistical Method Pooling Group									
Site	**Return Period (Years)**								
	2	**5**	**10**	**20**	**50**	**75**	**100**	**200**	**1000**
Kings	1.91	2.76	3.37	4.01	4.96	-	5.77	6.69	9.31
Flood Flows from ReFH Method									
Site	**Return Period (Years)**								
	2	**5**	**10**	**20**	**50**	**75**	**100**	**200**	**1000**
Kings	2.05	2.70	3.23	3.72	4.53	-	5.28	6.21	9.36
Flow Estimates using Stats method extended ReFH Growth Curves									
Site	**Return Period (Years)**								
	2	**5**	**10**	**20**	**50**	**75**	**100**	**200**	**1000**
Kings	1.91	2.76	3.37	4.01	4.96	-	5.77	6.79	10.23
FEH Statistical Method using single site growth curve									
Site	**Return Period (Years)**								
	2	**5**	**10**	**20**	**50**	**75**	**100**	**200**	**1000**
Kings	1	1.23	1.41	1.60	1.87	-	2.11	2.36	3.06

Table 4-1: Peak flows (m^3/s) from hydrological analysis

5 SELECTION OF METHOD

Flood flows are based on the methods detailed in the Flood Estimation Handbook and the Environment Agency's FEH Guidelines (Version 4). The Statistical Pooling Group Method is based on using flow data from a nearby donor gauging station to adjust QMED and WINFAP used to construct a pooling group from hydrologically similar stations. The Revitalised Flood Hydrograph Method (ReFH) was also used.

ReFH provides slightly lower flows than the Stats method but the differences are small and these are similar. The ReFH growth curve is flatter but the higher QMED provides the similar flood flow estimates.

The choice of method is entirely subjective as without historical flood data there is no means of confirming which method provides the best flood estimates. The Statistical method is based on local data and a pooled growth curve using the most recent HiFlows data set although some of the component stations are far removed.

The single site growth curve, at the nearest local station with records suitable for pooling, is flatter than the Pooling Group and ReFH methods but this is based on a limited number of years of data and for a far larger catchment area where a flatter growth curve may be expected. The choice is subjective but the FEH standard approach and UK practice is to use the pooling group the recommended flows area based on the FEH Statistical Method extended to the 1000 year return period.

As such, it is the flows derived using the Statistical Pooling Group Method, extended to the 1 in 1000 year flow using the Pooling Group growth curve.

Due to the uncertainties in flood estimation and expected climate change impacts, it is required that flood flows should include an allowance for climate change and the latest guidance requires a 20% increase in river flows by 2110.

As a design hydrograph is required it is recommended that the hydrograph shape from the ReFH method is used but forced to fit the peak flows from the Statistical method, referred to in the FEH as the hybrid method. This has been achieved in the ReFH boundary unit in ISIS.

A summary of the flows used in the hydrodynamic modelling are shown in Table 5.1 below:

Flow estimates using Stats method extended using ReFH Growth Curves								
Site	Return Period (year)							
	2	5	10	20	50	100	200	1000
Kings	1.91	2.76	3.37	4.01	4.96	5.77	6.69	9.31

Tabk M: Peak flows (m^3s) used in hydrodynamic modelling

6 TOPOGRAPHICAL SURVEY

6.1 A full topographical survey of the site, including Kingswood Brook, has been undertaken. The survey included top and bottom of banks and bed levels at Kingswood Brook.

6.2 Also included in the survey were details of the Old Warwick Road twin arch culvert at the upstream end of the site and the canal culvert at the downstream end.

6.3 The culvert survey details induded upstream and downstream soffit and invert levels, springing level and dimensions at openings. Additional topographical data was obtained using NextMap2 DTM.

7 MODELLING

7.1 INTRODUCTION

To fully demonstrate the flood risk to the development area, a modelling study was undertaken to accurately assess the flood plain extent. A system of a 1-dimensional channel model (ISIS) dynamically linked to a 2-dimensional flood plain model (TUFLOW) was adopted. The combination of ISIS-TUFLOW provides an accurate assessment of the extent, depth, level and velocity of flooding. The model was developed using topographical information provided by Midland Survey Ltd and flows from the Flood Hydrology Report undertaken by Dr Paul Garrad shown in Appendix A.

The upstream boundary of the model on Kingswood Brook has been applied approximately 10m upstream of the Old Warwick Road Bridge.

Flows have been introduced to the ISIS Model using ReFH boundary conditions with catchment descriptors extracted from the FEH CD-Rom at SP 18800 70750.

The downstream boundary, a normal depth boundary has been set at a suitable location downstream of the Railway line culvert.

Topographical data for the floodplain has been obtained through a combination of the topographical survey data provided and NextMap2 DTM.

7.2 ISIS MODEL

The ISIS model has been developed from cross sections created from a digital ground model created from the topographic survey. Cross sections were generated at 25m centers and upstream and downstream of structures.

There are two structures represented within the model:

- Warwick Road bridge
- Canal culvert

Warwick Road Bridge has been modelled in ISIS using an Arch Bridge unit, is shown in Photograph 0281 in Appendix B.

7.3 ISIS MODEL PARAMATURES

Manning's roughness values of 0.04 have been used for the river channels while a manning's roughness value of 0.015 has been applied to the culvert arch. A typical value of Manning's n equals 0.04 is shown in the Photograph 0283 contained in Appendix B.

7.4 TUFLOW MODEL

The ISIS model has been linked to a TUFLOW 2-dimensional flood plain model. The 1-d/2-d boundary was formed using HX lines with ZP (level) points to model the elevation of the river banks. The ZP points were taken from topographical survey data. A model schematic is shown in Drawing No MWA_CH234_GIS_003 in Appendix C of this report.
Loss coefficients were applied to the HX lines to represent riparian conditions. A value of 0.2 was included were no fence was present while a value of 0.5 was applied at fence locations. Flood plain roughness was defined as the following, shown in Table 7.1.

Type of terrain	Manning's roughness
Grass	0.04
Footpaths and paved areas	0.025
Manmade	0.03
Other surface	0.04

Table 7-1: Flood plain roughness

Buildings have been represented using the "porous buildings method" (Syme, 2008)[1].

7.5 KEY ASSUMPTIONS MADE

Some key assumptions have been made in this modeling which includes the following:

- Channel roughness has been estimated from photographs. Details of the sensitivity analysis runs carried out is included in the next chapter.
- A low loss coefficient of 0.2 was assumed for the river banks, with a higher value of 0.5 where a fence is present. These assumptions are tested in the sensitivity analysis.

8 SENSITIVITY ANALYSIS

There is no gauging station within the modelled reach, nor is any historical flood event data available, hence a calibration and verification exercise has not b e n possible for this model. However, sensitivity analyses have been undertaken to test the key more parameters.

Roughness runs were carried out to test the sensitivity of the model to roughness. The Manning's n numbers selected in the model ranged between 0.016 and 0.04 in accordance with the roughness estimated from photographs of the channel. Therefore, for the sensitivity runs an increase of 20% was applied to all manning's numbers in a separate model run (n + 20%) and a reduction of 20% in a further model run (n − 20%). This was also applied to all material roughness values in the TUFLOW template.tmf file.

As an additional sensitivity run a reduction in loss coefficient due to fence lines adjacent to the channel was carried out with values changed from 0.2 to 0.0 where no fence is present and from 0.5 to 0.3 where a fence is present.

9 MODEL RESULTS

A summary of the model runs undertaken are shown in Table 9.1 below:

Run ID	Event	Description
01	1 in 100 Year	Statistical Pooling Group method flow
02	1 in 100 year + Climate Change	Statistical Pooling Group method flow with 20% added to account for climate change
03	1 in 1000 year	Statistical Pooling Group method flow extended to the 1 in 1000 year using the Pooling Group growth curve.
04	1 in 100 Year	Sensitivity test of Manning's n + 20%
05	1 in 100 year	Sensitivity test of Manning's n-20%
06	1 in 100 year	Sensitivity test of loss coefficient at 2d_hx boundary.

Table 9-1: Table of model runs for the various event scenarios

The flood outlines for the 1 in 100 year (Flood Zone 3) event and 1 in 1000 (Flood Zone 2) year event, is shown on Drawing No. MWA/CH234/GIS/001 which is included within Appendix D of this report. This shows the site of the existing Kingswood Nursery to be partially within Flood Zone 3 with a slightly greater extent in Flood Zone 2. The eastern area of the site nearest to the canal is noted to be in Flood Zone 1. The maximum 100 year flood level at Section S1 is 100.306m AOD while at S11 this is 99.341m AOD.

For the 1 in 100 year plus climate change event the flood extent is very similar to that of the 100 year event but with a slightly larger extent. Modelled flood levels in relation to this event are shown on drawing MWA/CH234/GIS/002 in Appendix D. The maximum flood level recorded at Section S1 at the entrance to the site is 100.358m AOD at S11 its 99.5m AOD.

The sensitivity to roughness results (n + 20%) are illustrated in table form in Appendix E of this report with relatively small difference in level shown between the 1 In 100 year maximum stage and the n + 20% maximum stage results. The biggest difference In the maximum stage is shown at S10 with an increase of 0.026m in terms of maximum stage for the n + 20% result. The biggest reduction of -0.005m in maximum stage (n + 20%) is shown at S13, CulvertA and S13B.

In relation to the n – 20% results the biggest increase in level of 0.041m is shown at the section "Inflow" and S10 while the biggest reduction of -0.019m is shown at section S3.

A further sensitivity run was carried out which included a change in loss coefficient due to the fence boundary to the channel. The second run included a HX line loss coefficient of 0 and 0.3 compared to 0.2 and 0.5 in the original model runs.

These results showed little difference other than an increase of 0.063m at section S10 and the biggest reduction of 0.01m at section "Inflow" and S1B.

10 POTENTIAL FLOOD MITIGATION OPTIONS

Two flood mitigation options are possible to reduce the flood extent. Consultation with the Environment Agency should be undertaken regarding the suitability of any flood mitigation option and the standard required.

With any flood mitigation option it must be demonstrated that no detriment (i.e. increase in flooding) is caused to adjacent land. Any flwd mitigation option is subject to approval by the Environment Agency and may require flood defence consent.

Option 1: Lower levels in corridor along western bank

Raise levels to take part of the flooded area out of the 1 in 100 year flood plain. The loss of storage could be compensated by lowering levels adjacent to the brook left hand bank, but not lowering the top of bank itself. Figure 3 is a sketch that demonstrates the principle of this option.

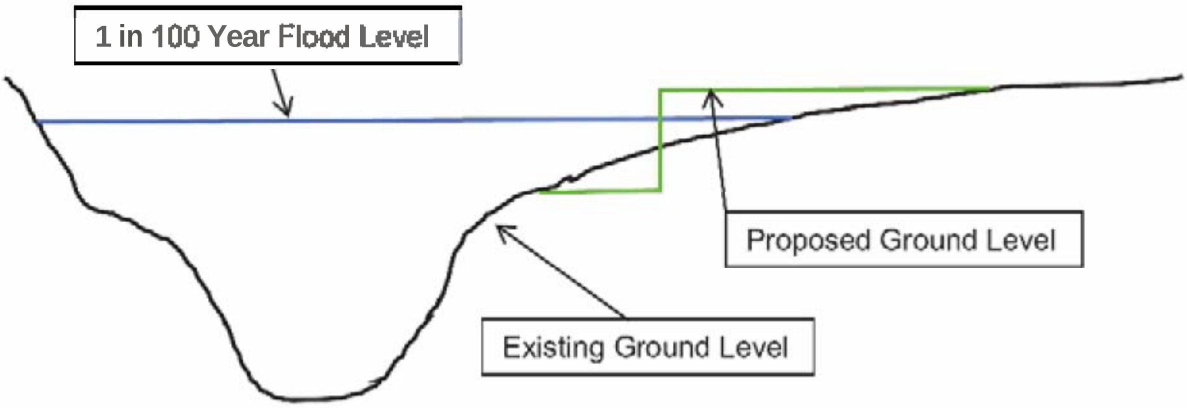

Figure 3 Sketch showing flood mitigation option 1

Option 2: Purchase additional land as flood storage

The client has proposed purchasing extra land, on the opposite side of Kingswood Brook to the proposed development to be wed as flood storage. The location of the proposed storage is shown in Figure 4

Figure 4 Sketch showing flood mitigation option 2

11 CONCLUSIONS

The flow hydrographs for this modeling work have been obtained from the ReFH method but forced to fit the peak flows from the statistical method, referred to in FEH as the hybrid method.

The modelling has shown that part of the site is located within Flood Zone 3 and a slightly greater extent within Flood Zone 2.

Little difference is shown in the sensitivity comparisons carried out in relation to the 1 in 100 year event.

Two flood mitigation options have been proposed. Option 1 involves lowering levels linearly adjacent to the brook western bank to compensate for land raising. Option 2 propose purchase of additional land on the opposite side to the development to be used as flood storage.

Any flood mitigation option is subject to approval by the Environment Agency and may require flood defence consent.

12 REFERENCES

1. W.J. Syme, Flooding in Urban Areas - 2D Modelling Approaches for

Buildings and Fences. Engineers Australia, 9th National Conference on Hydraulics in Water Engineering

Darwin Convention Centre, Australia 23-26 September 2008

Robert West

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Appendix A – Flood Hydrology Report

Flood Hydrology Report

Kingswood Brook at Lapworth

March 2014

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Hydrology Report
Kingswood Brook at Lapworth

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1 INTRODUCTION

1.1 Flood Estimate Locations

As part of a flood risk assessment flood flow estimates are required at one location on the Kingswood Brook at Kingswood Nursery, Old Warwick Road near Lapworth, 094 6LX. (Table 1.1). The watercourse is located 8km to the south east of Solihull in Warwickshire immediately upstream of the canal and railway crossing (Figure 1.1).

Table 1.1 Flood Estimate Location

ID	Grid Ref	Description
Kings	418783 270778	Kingswood Brook at Kingswood Nursery, Old Warwick Road

Flood flows are required for the 20 year, 100 year and 1000 year return periods but to allow for a comparison between different methods flows are provided for the 2, 5, 10, 20, 50, 100, 200 and the 1000 events. The impact of climate change and methods to provide flood hydrographs are also considered.

1.2 Catchment Descriptors

The FEH CD ROM version 3 has been used to provide the catchment delineation for the watercourse at the required location [Figure 1.2). The catchment descriptors (Table 1.2) indicate that this watercourse has a small catchment area (5.97 km^2), with a small proportion of lakes or reservoirs (FARL=0.991), a high percentage runoff (SPRHOST = 40.33%) and is essentially rural (URBEXT90 = 0.024).

Table 1.2 FEH Catchment Descriptors at Flow Estimation Point

Site	Kingswood Brook
Grid ref	SP 18800 70750
ARM	5.97
FARL	0.991
ALTBAR	115
BFIHOST	0.321
DPLBAR	2.09
DPSBAR	28.2
SAAR	702
SPRHOST	40.33
URBEXT 1990	0.024

These catchment descriptors suggest no obvious reasons far not using FEH methods. The catchment area is small but above the 0.5km^2 lower limit of FEH methods. A full definition of the parameters in Table 1.2 is given in the FEH. A comparison of FEH and 05 maps suggests the FEH delineation is quite reasonable and manual changes to the area or other catchment descriptors is not rquired.

1.3 Methodology

The calculation of flood flows is based on the methods detailed in the Flood Estimation Handbook (FEH) and the Environment Agency's FEH Guidelines ('Version 4) June 2012. The recommended approach is to use the Revised FEH statistical method using flow data from a nearby donor gauging station to adjust the median annual flood (QMED) and to then to construct a pooling group from hydrologically similar stations. This is described in Section 2.

The Revitalised Flood Hydrograph Method (ReFH) can also be used to derive peak flaws and the hydrograph shape and this method is considered in Section 3. Extension to the 1000 year return period and a comparison of flood estimates from the two methods, and with single site growth curves at local gauging stations, is considered in Section 4, The conclusions are presented in Section 5.

2 FEH STATISTICAL METHOD

As the site of interest is ungauged as a first approach it is convenient and appropriate to use the FEH Statistical method, This is based on a two stage approach;

- Calculation of the index flood (the median annual flood, QMED) which at an ungauged site is derived from catchment descriptors, but which is then adjusted using the ratio of QMED from catchment descriptors and Row data at a nearby [donor] gauging station.

- The fitting of various extreme value distributions to a pooled group of annual maximum flow data from hydrologically similar sites (pooling group) to estimate the T year flows.

The procedure is described in the following sections.

2.1 FEH Index Flood (QMED)

2.1.1 QMED from Catchment Descriptors

The FEH catchment descriptors for the subject site [Table 1.2) are used to derive QMED (Table 2.1). The original FEH equation for QMED[1] is given for comparison but preference is now given to the Revised Statistical Method QMED equation[2].

Table 2.1 QMED from Catchment Descriptors at Subject Site

Site	Original FEH QMED (m^3/s)	Revised Method QMED (m^3/s)	Revised Method QMED URBAN (m^3/s)
Kings	2.14	1.86	1.89

The revised method provides slightly lower flows than the original FEH equation. The EAs FEH guidelines recommend the use of urban adjusted Revised Method QMED for consistency but the rural and urban QMED values are similar as the catchment is essentially rural,

2.1.2 QMED at Donor Sites

The flaw estimation process then requires the adjustment of the empirically derived QMED using recorded flow data at one or mare nearby Environment Agency flow measurement stations. The Agency do not operate any gauging stations in the upstream or immediate downstream catchment but the extent of data at the nearest Agency gauging stations as available on the HiFlows database (version 3.1.1, July 2011) is summarised in Table 2.2. These potential donor sites are within 15km of the subject site (Figure 2.1).

[1] Flood Estimation Handbook Volume 3, Centre for \Ecology and Hydrology, 1999.
[2] Improving the FEH statistical procedures for flood frequency estimation. CEH Science Report SC050050, July 2008

Table 2.2 EA Gauging Stations near the Kingswood Brook Catchment

CEH Ref No	Watercourse	Location	QMED ?	Pooling ?	Start Date	End Date	No Years
54004	Sowe	Stoneleigh	Yes	Yes	26-Map51	13-Dec-08	59
54019	Avon	Stareton	Yes	No	30-Mar63	15-Dec-08	46
54112	Avon	Warwick	No	No	02-Sep-56	28-Jan-78	23
54907	Arrow	Broom Old	No	No			0

HiFlows provides the following comments on these gauges:

- 54004, Sowe at Stoneleigh. From 1951 m 1979 the control was formed by two flumes with an overflow weir at 1.45m. The rating was derived from the flume formula and checked with current meter gaugings. A new compound Crump pm Ale weir (3 channels] with *crest* tapping *was* installed from *1979* based on the standard weir equation. There are few gaugings above 0.6m and no high flow gaugings. Flow records are suitable far QMED as the rating is supported by gaugings up to QMED. Also considered suitable far pooling as *all* flows *are* contained *by* the structure.

- 54019, Avon at Stareton. A 7.3m wide crump profile weir but the highest floods overtop the right bank The highest gauging at 1.75m supports the In bank part of the rating but the flood section of the rating is estimated. Flow records art suitable for QMED which is below bankfull where the rating Is considered to be accurate but not *suitable* for pooling as the out of bank section rating is estimated and there are no gaugings to support i t

- 54112. Avon at Warwick, No data located on Hiflows but the gauge is considered not suitable far QMED or pooling.

- 54907, Arrow at Broom Old, Station data combined with another station and was closed in 1978 with limited available records. Not suitable for QMED or pooling,

The time scale of this study does not allow for a detailed analysis of *the* high flow *ratings* or flow series at these five sites. However the flow data is considered suitable for QMED at two of these four local stations and the available A M .series is therefore used in the flood estimation process described below*

2.1.3 *Donor Adjusted QMED*

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

- AREA – a factor of 4 or 5
- FARL – a difference of 0.05.
- BFIHOST – a difference of 0.18
- SAAR – a factor of 1.25
- SPRHOST – difference of 15

A comparison of the catchment descriptors at the potential donor gauging stations with the subject site (Table 2.3) suggests both donor stations are unsuitable due to having far larger catchment areas all of which are outside the acceptable range. Station 54004 also has dissimilar geology, as reflected in the BFIHOST. However the QMED donor ratio Is calculated at these two stations as a check

Table 2.3 Catchment Descriptors at Subject Sites and Donor Gauging Stations

Site	AREA	FARL	BFIHOST	SAAR	SPRHOST	URBEXT 1990
Kings	5.97	0.991	0.321	702	4033	0.0240
54004	262.79	0,977	0,510	667	35.79	0,1345
54019	346.08	0.950	0.424	654	42.53	0.0350

QMED is calculated from flow data and catchment descriptors at these two gauging stations to confirm the QMED ratio. For stations with more than 13 years of flow data FEH recommends that QMED is calculated from annual maximum (AMAX) data (Table 2.4).

Table 2.4 QMED Ratio at Donor Gauging Stations

Station	QMED-CD (m^3/s)	QMED-AMAX (m^3/s)	Ratio
54004	28.494	29.337	1.030
54019	34.540	32.572	0.943

The ratio (Table 2.4) show that QMED from catchment descriptors under estimates that from flow data at 54004 by around 3% and over estimates at 54019 by 6% and either could be used an the QMED-CD estimates. These ratios are reasonably consistent, or rather not extreme, and could be applied to the catchment descriptors estimate of QMED at the ungauged site of interest. However the Revised Statistical method requires a further adjustment based on geographical proximity as detailed below.

2.1.4 Revised Donor Adjusted QMED

The QMED ratio at the donor gauging stations is then adjusted according to the distance between the catchment centroids using an exponent 'a'. This is taken from the distance between the centroid of the subject catchment and the revised ratio varies from 1% at 54004 to 1.3% at 54019, both of which are close to 1.0. The nearest donor gauging station Is adapted and that at S4004 gives an adjustment ratio for the site of interest of 1.01 [Table 2.5).

Table 2.5 Adjusted QMED Ratio at Donor Gauging Stations

Site	Centroid Easting	Centroid Northing	Centroid Distance (km)	Exponent 'a'	Unadjusted Ratio	Adjusted Ratio
Kings	419160	271805				
54004	434145	279835	17.00	0.3274	1.030	1.010
54019	453915	278534	35.40	0.2265	0.943	0.987

This adjustment ratio suggests that QMBD from CDs should be increased by 1% and this ratio is adopted to give the adjusted QMED at the site of interest (Table 2.6).

Table 2.6 Adjusted QMED at Subject Sites

Site	QMED-CD (m^3/s)	Ratio	Adopted QMED (m^3/s)
Kings	1.89	1.010	1.91

2.2 Flood Frequency Curve

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

The initial pooling group contains 16 stations with 530 station years of record. One station was removed for having less than the required 8 years of data (32029, Flores at Flores Experimental). The pooling group is heterogeneous and a review considered desirable [H2 = 3.287). Two stations were removed from the group for having growth curves with a positive curvature and which a n dissimilar to other stations in the group, 36009 (Brett at Cockfield) and 203046 (Rathmore at Rathmore Bridge). These stations are often removed from a pooling group. With the addition of one new station the revised pooled group then contains 14 stations and 508 station years of record and is then possibly heterogeneous and a further review is optional (H2 = 1.978). However there was no valid reason for the removal of any other of the stations.

The component stations [Figure 2.2) indicate that this pooling group includes several stations with relatively steep and several with relatively flat growth curves hence some discordancy may be expected. This often occurs and reflects the lack of small gauged catchments in the HiFlows data set. A summary of the selected pooling group stations (Table 2.7) shows these are located in various parts of the UK, from East Lothian in Scotland, the North East, Northern Ireland, Essex and Sussex and with none from the River Avon catchment.

Table 2.7 Pooling Group Component Stations

Site	Yrs	L-CV	L-Skw	L-Kurt	Discord	Dist
27051 (Crimple @ Burn Bridge Near Pannal)	37	0.220	0.133	0.109	0.729	0.550
36010 (Bumpstead Brook @ Broad Green)	42	0.428	0.223	0.104	2.691	1.031
27010 (Hodge Beck @ Bransdale)	42	0.225	0.297	0.238	0.606	1.091
24007 (Browney @ Lanchester)	15	0.222	0.212	0.054	1.970	1.115
41020 (Bevern Stream @ Clappers Bridge)	40	0.229	0.220	0.237	0.477	1.144
22003 (Usway Burn @ Shillmoor)	13	0.282	0.311	0.111	1.151	1.281
20002 (West Peffer Burn @ Luffness)	41	0.292	0.015	0.142	1.250	1.316
203049 (Clady @ Clady Bridge)	27	0.197	0.123	0.191	0.841	1.442
37016 (Pant @ Copford Hall)	44	0.293	0.043	0.109	0.798	1.444
36004 (Chad Brook @ Long Melford)	42	0.315	0.190	0.217	0.787	1.452
37013 (Sandon Brook @ Sandon Bridge)	44	0.298	0.107	0.093	0.446	1.466
203042 (Crumlin @ Cidercourt Bridge)	30	0.203	0.342	0.291	1.515	1.482
36012 (Stour @ Kedington)	42	0.282	0.185	0.189	0.147	1.496
24004 (Bedburn Beck @ Bedburn)	49	0.270	0.321	0.178	0.592	1.500

The use of WINFAP3 was also considered but it is often found that this provides pooling groups that are even more discordant than WINFAP2. This arises because WINFAP3 uses the FEH parameters FARL and FPEXT to generate a pooling group, measures of flood storage and attenuation, whereas WINFAP2 is based on the soils or geology as reflected in BFIHOST. WINFAP3 will often provide a more discordant pooling group as the growth curves of the component stations is more likely to be a function of the geology whereas WINFAP3 m y select clay as well as chalk catchments. The EAs FEH Guidelines confirm it is quite reasonable to expect BFIHOST to influence the growth curve, despite the findings of Science Report SC050050. WINFAP2, which uses geology to locate similar stations, is therefore preferred but as detailed in Section 4 this is immaterial to the final selection of flood flows.

The pooled group frequency curve (Table 2.8) is then based on the adjusted QMED (Table 2.6) and with URBEXT1990 adjusted to 2013 according to methods detailed in the FBH, and based on the GL distribution as recommended by FEH.

Table 2.8 Pooled Group Flood Frequency Curves (m^3/s)

Site	Return Period (Years)					
	2	5	10	20	50	100
Kings	1.91	2.76	3.37	4.01	4.96	5.77

3 REVITALISED RAINFALL-RUNOFF METHOD

3.1 ReFH Parameters

An alternative approach to flood estimation is given by the rainfall runoff (RR) method. The original FSR/FEH rainfall runoff method underwent significant modification in 2006 taking advantage of new data and m m advanced hydrological modelling techniques since the original method was developed. The improved or revitalised Rainfall-Runoff model (ReFH) retains the overall structure of the earlier FSR/FEH approach but with various improvements. ReFH is now preferred to the original RR method. ReFH is therefore also used to derive peak flows for the specified design events based on the time to peak (Tp) and' critical storm duration (Table 3.1) for the catchment, which is adjusted so it is an odd multiple of the selected time step

Table 3.1 Time to Peak and Critical Storm Duration

Site	Tp	Cmax	BL	BR	Storm duration	Time Step	Adopted Duration
Kings	3.51	275.2	31.9	0.695	5.98	0.25	5.75

3.2 Peak Flows

Flows for the required design events at the site of interest (Table 3.2) are based on the ReFH parameters from CDs rather than any adjusted parameters as no local data are available and the time scale of this study does not allow for such a detailed analyses.

Tabb 3.2 ReFH Flood Frequency Curves (m^3/s)

Site	Return Period (Years)					
	2	5	10	20	50	100
Kings	2.05	2.70	3.23	3.72	4.53	5.28

4 DISCUSSION

4.1 Extension to the 1000 year Event

This study also requires flood flows up to the 1000 year return period. The Statistical method was originally recommended only up to the 200 year return period and ReFH is not calibrated beyond 150 years. Technically, the two methods used above are not suitable for extrapolating to very extreme events such as the 200 or 1000 year event. Flood estimates for these 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 Stats method has been preferred.

The Environment Agency's latest Flood Estimation Guidelines[3] provide two suggestions for calculating extreme floods up to the 1000 year event Firstly using the Statistical method but as the 1000 year pooling group Is likely to be inhomogeneous with many component stations a simple extension of the 200 year and more recently the 100 year has been proposed A second approach is to derive the ReFH growth factors for the 100 to 1000 year event which is then applied to the Stats method 100 year peak flow. These methods arc described below.

4.1.1 FEH Stats Method

The Stats method flood frequency curve Is extended to the 1000 year return period using the same pooled growth curve as detailed In Section 2 above (Table 4.1).

Table 4.1 Statistical Method Pooling Group Extended to 1000 year

Site	Return Period (Years)							
	2	5	10	20	50	100	200	1000
Kings	1.91	2.76	3.37	4.01	4.96	5.77	6.69	9.31

4.1.2 ReFH Growth Curves

Flood estimates for longer return periods may be derived using the ReFH method as it is thought that the rainfall growth curves for longer return periods can be defined with much more confidence than flood growth curves. In some cases the statistical method may be preferred for the shorter and ReFH for longer return periods. To avoid a discontinuity In the results the recommended approach is to use ReFH to obtain the ratio of the 200 year and 1000-year flow to the 100-year flow, the growth factors (Table 4.2). These can then be multiplied by the preferred estimate of the 100-year flow from the statistical method,

[3] Environment Agency's Flood Estimation Guidelines, Version 4 (2012)

Table 4.2 ReFH Growth Factors

Site	ReFH Flow (m3/s)			Growth Factor		
	100	200	1000	100	200	1000
Kings	5.28	6.21	9.36	1.000	1.176	1.772

The flood estimates are then based on the Stats method pooled growth curve to the 100 year event and the ReFH growth factors from the 100 to the 1000 year event (Table 4.3).

Table 4.3 Flow Estimates using Stats method extended using ReFH Growth Curves

Site	Return Period (years)							
	2	5	10	20	50	100	200	1000
Kings	1.91	2.76	3.37	4.01	4.96	5.77	6.79	10.23

However there are concerns that some aspects of the ReFH have not been tested at return periods longer than the calibration limit of 150 years, such as the calibration coefficient and the seasonal correction Factors used for design rainfalls. Recent research has also suggested that ReFH may overestimate extreme rainfall and revising the FEH rainfall data and hence updating ReFH is part of a current research programme. This method should therefore be treated with caution.

4.2 *Comparison of Flood Estimates*

A comparison of the flood estimates (Table 4.4) indicates that ReFH provides slightly lower flows than the Stats method at lower return periods up to the 200 year event (Figure 4.1) but these are quilt similar at the higher 1000 year return period. The differences are small and the methods provide quite similar result.

Table 4.4 Comparison of Flood Estimates (m3/s)

Method	Return Period (years)							
	2	5	10	20	50	100	200	1000
Stats	1.91	2.76	3.37	4.01	4.96	5.77	6.69	9.31
ReFH	2.05	2.70	3.23	3.72	4.53	5.28	6.21	9.36
ReFH+Stats	1.91	2.76	3.37	4.01	4.96	5.77	6.79	10.23

A comparison of the flood growth curves (Figure 4.2) shows ReFH has a flatter growth curve that the Stats method but as the ReFH QMED Is higher the flood estimates from the two methods are quite similar

Table 4.5 Comparison of Flood Growth Curves

Method	Return Period (years)							
	2	5	10	20	50	100	200	1000
Stats	1.00	1.45	1.76	2.10	2.60	3.02	3.50	4.87
ReFH	1.00	1.32	1.58	1.81	2.21	2.58	3.03	4.56
ReFH+Stats	1.00	1.45	1.76	2.10	2.60	3.02	3.55	5.36

The EAs FEH Guidelines indicate the ReFH approach should always be checked against the Pooling Group estimates which implies the latter is more appropriate. The choice is entirely subjective as, unless there is any historical flood data, there is no means of confirming which method provides the best flood estimates.

There is reasonable confidence in the Stats method estimates of QMED, which is based on a donor adjustment using local data and a pooled growth curve using the most recent HiFlows data set, although some of the component stations are far removed from Lapworth. The adopted flows are therefore based on the FEH Stats method flood frequency curve extended to the 1000 year return period using the GL distribution as detailed in Section 2 as these provide slightly conservative flood estimates.

4.3 *Single Site Growth Curves*

Due to she wide variation in the growth curves in the pooling group (Figure 2.2) it is usually considered prudent w check the flood flaw estimates against local flaw data and single site flood growth curves. As detailed above there are four local stations [Figure 2.1) two of which have flow records suitable for estimating QMED but only one (54004) is suitable for pooling. The single site growth curves can often be used to support a pooling group but a comparison revels that this [Table 4.6) is far flatter than the Stats method at the ungauged site [Figure 4.3). This could suggest that the pooled group overestimates flood flows possibly due to the inclusion of stations around the UK where the flood response may be quite different. The single site growth curve relate to a far larger catchment area and is based on a limited number of years of data and a flood frequency curve should not be extended beyond this length of record.

Table 4.6 **Pooled Group and Single Site Growth Curves**

Site	No Years	Return Period (years)							
		2	5	10	20	50	100	200	1000
Kings	PG	1.00	1.45	1.77	2.10	2.60	3.02	3.50	4.87
54004	58	1.00	1.23	1.41	1.60	1.87	2.11	2.36	3.06

The preference for the use of local data rather than WINFAP was highlighted at a recent BHS meeting (November 2013) where the EA-South West in Devon stated a preference for the use of local growth curves rather than a national FEH pooling group. The choice is subjective, and whilst there is some merit in using the local data approach In this case the FEH standard and UK practice pooling group flood estimates (Table 4.6) are adopted despite the large variation on the pooling group stations (Figure 2.2).

4.4 *Climate Change*

Due to the uncertainties in flood estimation and expected climate change impacts, it is required that hydrological analysis of flood flows and definition of defence standards should include an allowance for increased flows that are anticipated due to climate change, The latest guidance[4], which is included in NPPF, suggests (Table 4.7) a 20% increase in river flows by 2110. The adopted 100 year peak flow should therefore be adjusted over a 100 year design life by increasing peak flows by 20%.

Table 4.7 Anticipated Change in River Flow due to Climate Change

Parameter	1990-2025	2025-2055	2055-2085	2085-2115
Peak river flow	+10%	+20%	+20%	+20%

4.5 *Hydrographs*

If a design hydrograph is required it is recommended that the hydrograph shape from the ReFH method is used but forced to fit B e peak *flows* from the Stats method, referred to in FEH as the hybrid method.

The FEH Guidelines suggest two hybrid methods for ungauged sites:

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

[b] 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 it can prove difficult to match the statistical results over a range of return periods, because the ReFH method uses a different growth curve.

Option (a) is the quickest method and often the best and can be achieved in the ReFH boundary unit in ISIS.

[4] Flood and Coastal Defence Appraisal Guidance, Supplementary Note to Operating Authorities – Climate Change Impacts (October 2006)

5 CONCLUSIONS

- Flood flow estimates are provided at one location on the Kingswood Brook near Lapworth and for a range of return periods up to the 1000 year event.
- The PEH CD ROM indicates this is a small catchment with small or limited lakes or reservoirs, a moderately high percentage runoff and is essentially rural. There are no obvious reasons for not using FEH methods and a comparison of FEH and OS maps suggests the FEH delineation is reasonable and no manual changes to the area or catchment descriptors is required.
- Flood flows are based on the methods detailed in the Flood Estimation Handbook (FEH) and the Environment Agency's PEH Guidelines (Version 4). The Revised Statistical Method is based on using flow data from a nearby donor gauging station to adjust QMED and WINFAP used to construct a pooling group from hydrologically similar stations. The Revitalised Flood Hydrograph Method (ReFH) was also used.
- ReFH provides slightly lower flows than the Stats method but the difference are small and these are similar, The ReFH growth curve is flatter but the higher QMED provides the similar flood flow estimates.
- The choice of method is entirely subjective as without historical flood data there is no means of confirming which method provides the best flood estimates. The Stats method is based on local data and a pooled growth curve using the mast recent HiFlows data set although same of the component stations are far removed.
- The single site growth curve, at the nearest local station with records suitable for pooling, is flatter than the Pooling Group and ReFH methods but this is based on a limited number of years of data and for a far larger catchment area where a flatter growth curve may be expected. The choice is subjective but the FEH standard approach and UK practice is to use the pooling group the recommended flows are based on the FEH Stats method extended to the 1000 year return period.
- Due to the uncertainties in flood estimation and expected climate change impacts, it is required that flood flows should include an allowance for climate change and the latest guidance requires a 20% increase in river flaws by 2110.
- If a design hydrograph is required it is recommended that the hydrograph shape from the ReFH method is used but forced to fit the peak flows from the Stats method, referred to in FEH as the hybrid method. This can be achieved in the ReFH boundary unit in ISIS.

Figures

Figure 1.1 Flow Estimate Location

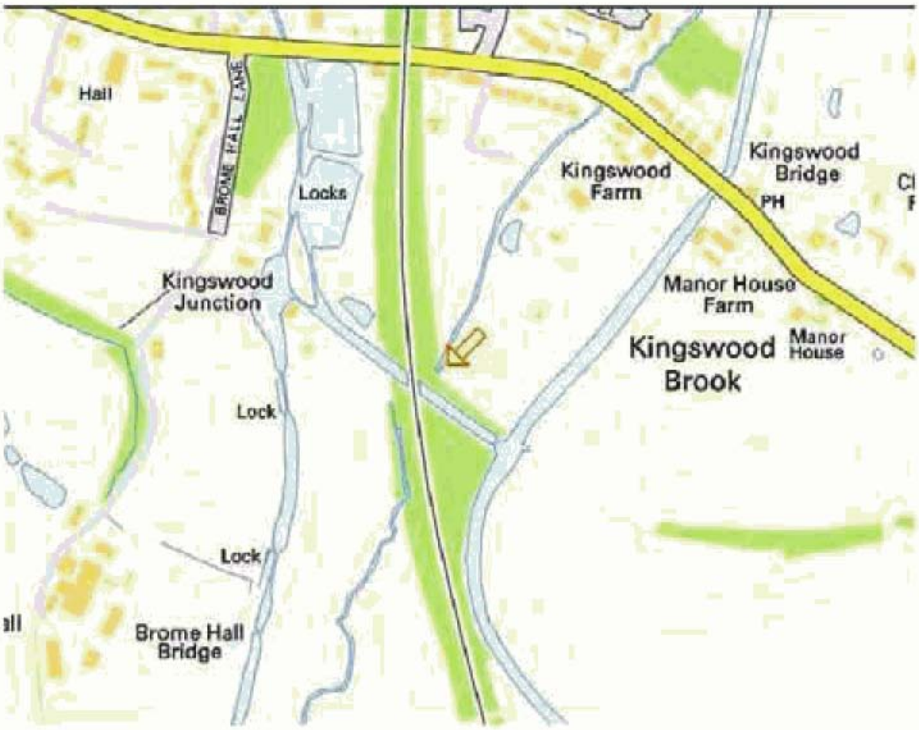


Figure 1.2 FEH Catchment Delineation

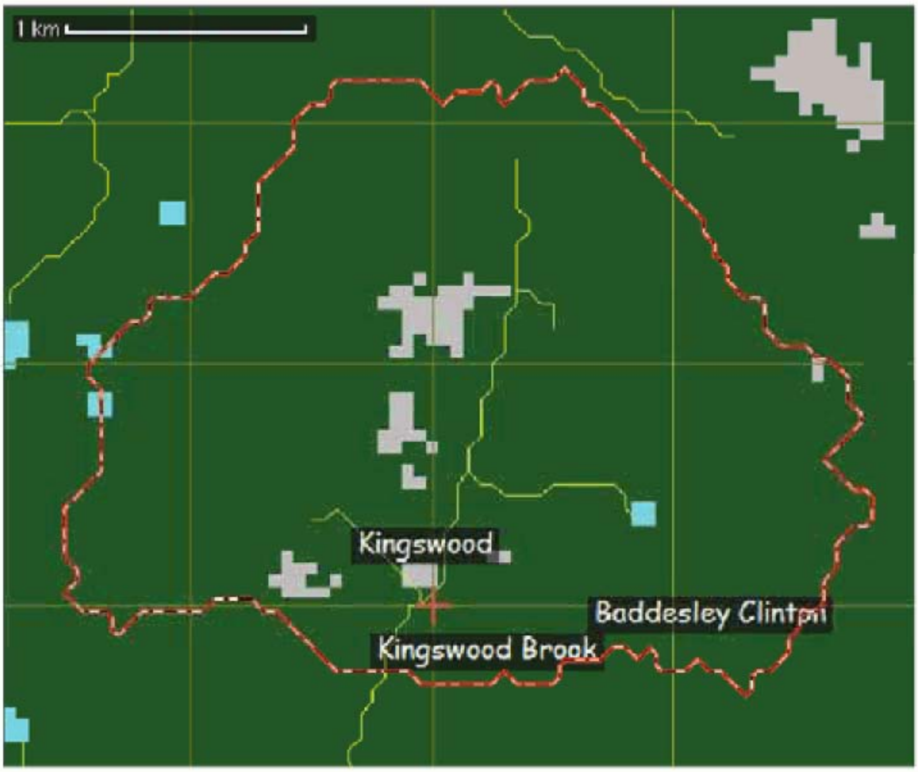


Figure 2.1 Subject Site and Potential Donor Sites

Figure 2.2 WINFAP Component Stations

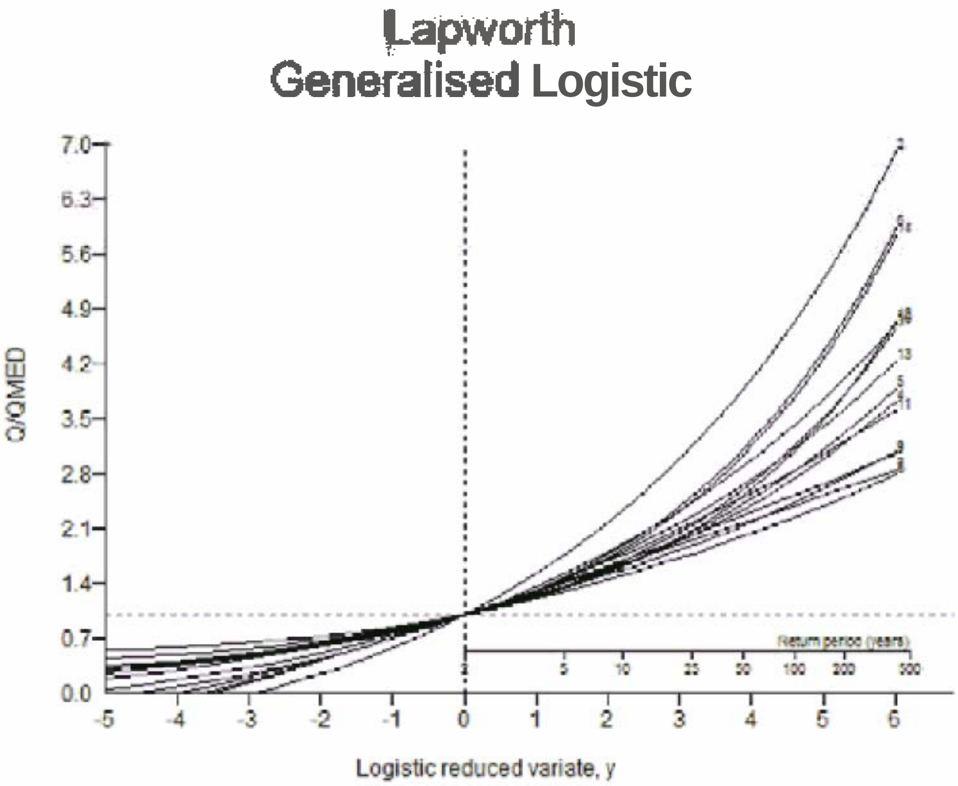


Figure 4.1 Comparison of Flood Frequency Curves

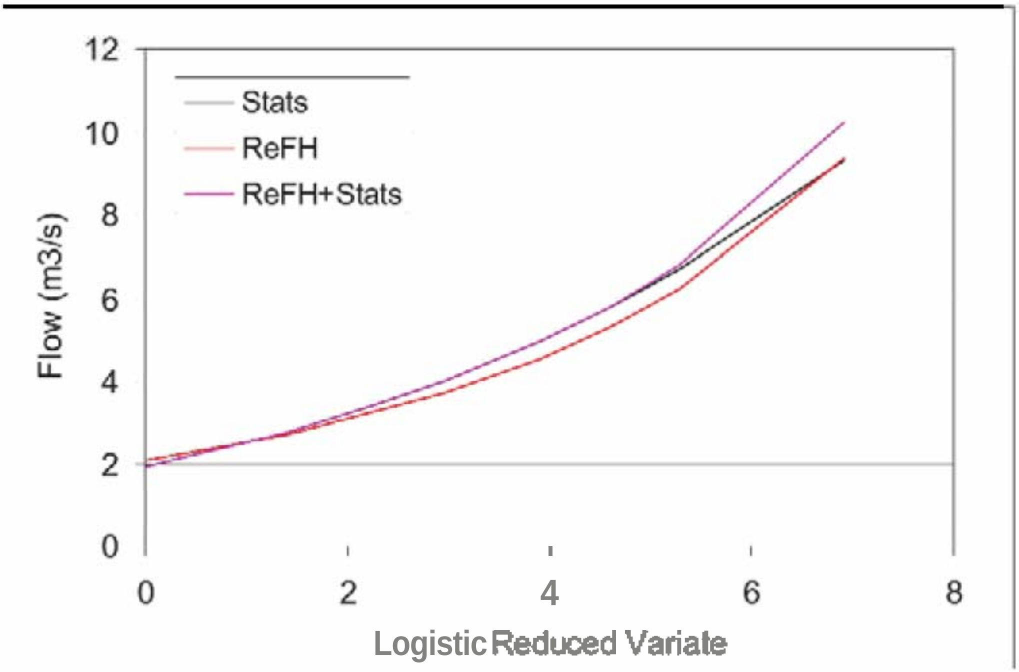


Figure 4.2 Comparison of Flood Growth Curves

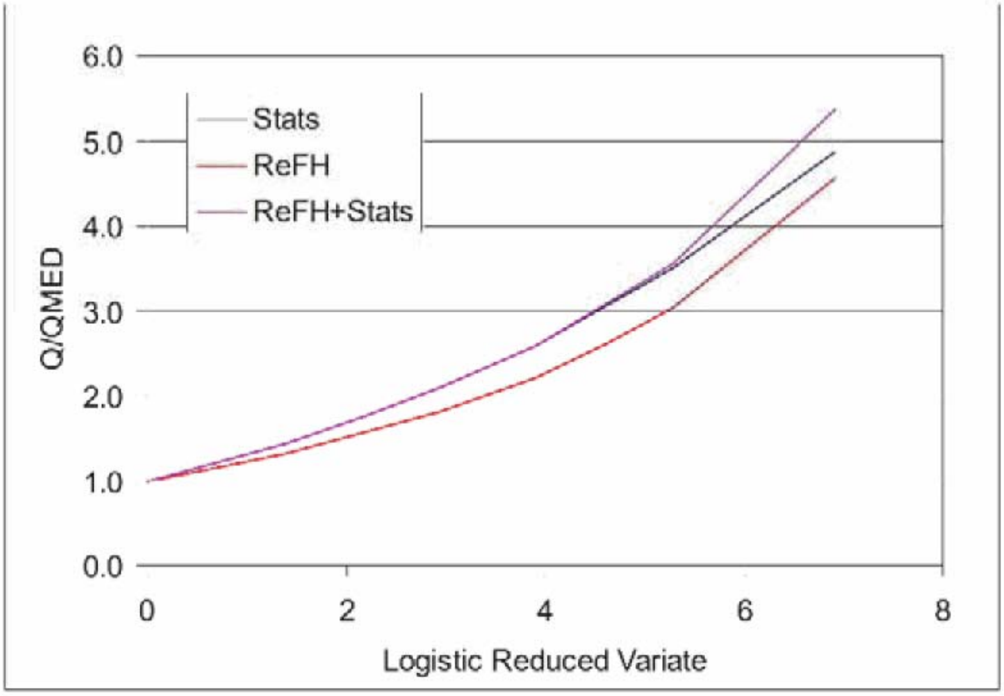
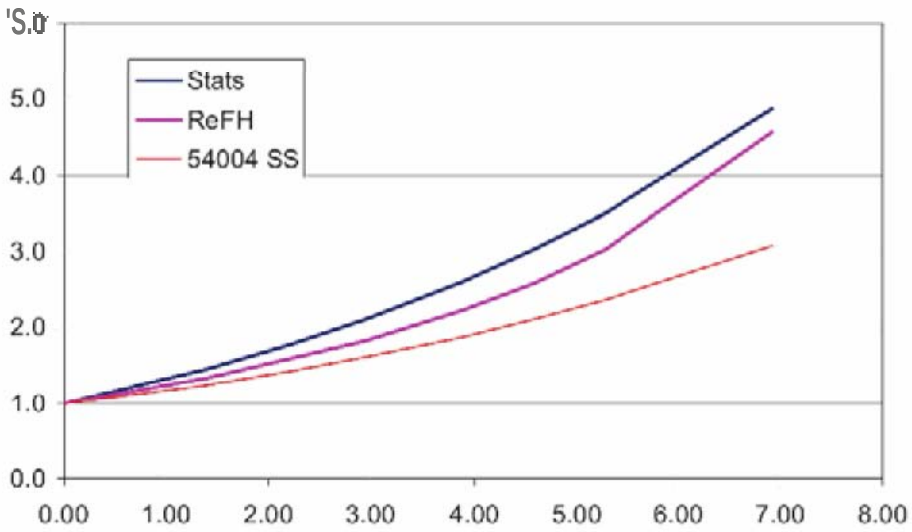


Figure 4.3 Comparison of Flood Growth Curves with Single Site Growth Curves



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Rail
Buildings
Infrastructure
Transport & Environment

Appendix B – Photographs

Photo0278

Photo0280

Photo0281

Photo0282

Photo0283

Photo0284

Photo0285

Photo0286

Photo0287

Appendix C – Isis Tuflow Model Schematic

A C LLOYD HOMES LTD

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KINGSWOOD NURSERY FLOOD MAPPING STUDY

ISIS TUFLOW MODEL SCHEMATIC

GJ	22/09/14
JK	22/09/14
NL	22/09/14
NTS	A3 — A

MWA/CH234/GIS/003

Appendix D – Flood Outline Maps

A C LLOYD HOMES LTD

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KINGSWOOD NURSERY FLOOD MAPPING STUDY

1 IN 100 + CLIMATE CHANGE FLOOD OUTLINE

GJ			
DK			
NJ			
NTS		A3	A

MWA/CH234/GIS/002

LEGEND:

- FLOOD ZONE 3 (1 in 100 YEAR)
- FLOOD ZONE 2 (1 in 1000 YEAR)

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KINGSWOOD NURSERY FLOOD MAPPING STUDY

FLOOD ZONES 2 AND 3

Appendix E: Sensitivity to roughness results table.

Sensitivity Results Table

	100 YEAR EVENT		N+20			N-20			LOSS		
Node Ref	Max Flow	Max Stage	Max Flow	Max Stage	Diff	Max Flow	Max Stage	Diff	Max Flow	Max Stage	Diff
Inflow	5.77	101.045	5.77	101.064	0.019	5.77	101.086	0.041	5.77	101.035	-0.01
S1	4.422	100.306	4.385	100.311	0.005	4.472	100.293	-0.013	4.497	100.319	0.013
S1B	4.914	101.05	4.909	101.06	0.01	5.064	101.072	0.022	4.943	101.04	-0.01
S1C	4.914	100.391	4.909	100.393	0.002	5.064	100.395	0.004	4.943	100.415	0.024
S2	4.762	100.178	4.799	100.179	0.001	4.714	100.191	0.013	4.789	100.206	0.028
S3	4.435	100.071	4.487	100.082	0.011	4.473	100.052	-0.019	4.596	100.078	0.007
S4	3.72	99.862	3.775	99.864	0.002	3.573	99.876	0.014	3.723	99.892	0.03
S5	4.96	99.619	5.015	99.629	0.01	4.972	99.611	-0.008	5.138	99.618	-0.001
S6	4.517	99.518	4.616	99.527	0.009	4.416	99.523	0.005	4.475	99.548	0.03
S7	3.667	99.5	3.791	99.511	0.011	3.658	99.492	-0.008	3.742	99.5	0
S8	3.991	99.413	4.032	99.436	0.023	3.958	99.42	0.007	3.989	99.436	0.023
S9	3.131	99.421	3.212	99.423	0.002	3.052	99.403	-0.018	3.265	99.43	0.009
S10	3.435	99.338	3.529	99.364	0.026	3.233	99.379	0.041	3.587	99.401	0.063
S11	2.755	99.341	2.964	99.355	0.014	2.559	99.362	0.021	2.818	99.371	0.03
S12	5.597	98.906	5.646	98.91	0.004	5.561	98.909	0.003	5.659	98.907	0.001
S13	5.797	98.715	5.79	98.71	-0.005	5.937	98.724	0.009	6.034	98.74	0.025
CULVERTA	5.797	98.632	5.79	98.627	-0.005	5.937	98.637	0.005	6.034	98.651	0.019
CULVERTB	5.875	98.282	5.873	98.28	-0.002	5.874	98.282	0	5.869	98.282	0
S13A	5.875	98.204	5.873	98.203	-0.001	5.874	98.205	0.001	5.869	98.205	0.001
S13B	5.831	98.14	5.78	98.135	-0.005	5.811	98.138	-0.002	5.872	98.144	0.004

Minutes of meeting at WDC 28th April 10am

Kingswood, Lapworth

Present:

Paul Taylor and Sophie Wynne: Health & Community Protection, Warwick District Council

Mark Bellringer: Robert West Consultancy

Des Wynne, Alistair Clark, Darren Avern: A C Lloyd Homes Ltd

DW outlined the recent history on the site, the survey work undertaken and the issues that have been highlighted relating to the access Into the site, the highway at the entrance In the 1:100 flood zone, and modelling to identify *the* depth of expected flood In the event of a 1:100 event.

MR confirmed that the depth of water in a 1:100 went would be approx. 130mm to 150mm.

DW asked if this meant that we would require an emergency pedestrian access or a full emergency vehicular access.

PT confirmed that a vehicular access would be required in the event that the main access road into the site would remain in the 1:100 flood zone.

ACL tabled the sketch scheme produced by Robotham Architects fur 35 houses. PT advised that we would need to provide a retention pond (SUDS) outside of the flood zone, this will need to bc suitable sired to attenuate flows from the site to mimic greenfield runoff rates up to a 1 in 100y +30 allowance for climate change event which will reduce the amount of plots on this plan. (or alternately by underground storage). Subject to this, there should be no objection in principle to layout as proposed.

PT advised that ACL should consult with WDC planning staff direct re property number allocations for the site and that he deals with drainage and Rood risk matters.

Discussion took place on the possible options for reducing the extent of the 1:100 zone.

- The culvert under the main road is a 600mm pipe with a 450mm overflow. MR confirmed the reason why the main road was in the 1:100 zone was because these two culverts were Insufficient to cope with the flow and In such an event would pour over the road. The option of widening this culvert with the construction of a box culvert was discussed and would remove a number of existing properties from the flood zone at great benefit to the existing local community. This is the more favoured option for WDC and the local community. This would involve a road closure and some possible service diversion works. While this might improve the flows upstream it might conversely have the effect of increasing the flow downstream with potentially greater impact on our site. It was agreed that modelling works would be used to determine the affects of the upsize of the culvert.

  We also discussed raising the level of the access mad into the site by 150mm approx. This would need to be compensated for by providing some increased storage further into the site/ or localised channel widening at this point, and it was concluded that this might not be an effective solution due to the limited space at this point. It might also cause some issues to access points into the existing properties close to the main road. Modelling works would determine a suitable solution.

- Other alternative measures could include regrading the brook, or diverting part of the brook into another channel or onto the adjacent triangular land (currently outside the scheme proposals]
- Finally discussion took place on the benefit of a trash screen to the culvert. The conclusion of both MR and PT is that this might not be an effective benefit where there is no guaranteed management regime in place.

In conclusion PT confirmed he would haw no objection in principle to the new adoptable estate road being constructed on the line and level of the existing access as long a5 flooding is not exacerbated In this area and provided that a separate emergency and pedestrian access is provided linking onto the Warwick Road outside the line of the 1 in 100 flood which would provide a permanent dry access.

Ha would also glue consideration to engineering solutions that we mlght put forward to free up additional land or that would remove the existing 1 in 100 year flooding to the existing access which would therefore negate the need for an alternative emergency/pedestrian access.

It was agreed that we would now work towards a planning application approximately based on the layout tabled, to include the emergency access out onto the main road adjacent to the canal.

A C Lloyd		Page 1
Nicholls House Tachbrook Park CV34 6TT		Micro Drainage
Date 28/05/2014 15:56 File lapworth.srcx Micro Drainage	Designed by Checked by Source Control 2014.1.1	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	99.678	0.278	9.0	0.0	9.0	179.0	O K
30 min Summer	49.755	0.355	9.0	0.0	9.0	232.9	Flood Risk
60 min Summer	99.827	0.427	9.0	D.0	9.0	285.2	Flood Risk
120 min Summer	99.886	0.486	9.0	D.0	9.0	329.8	Flood Rink
180 min Summer	89.805	0.505	9.0	1.2	9.5	346.1	Flood Risk
240 min Summer	99.911	0.511	9.0	1.9	10.3	348.5	Flood Risk
360 min Summer	99.908	0.508	9.0	[illegible].2	9.5	346.5	Flaad Risk
480 min Summer	99.904	0.504	9.P	D.4	9.0	343.6	Flood Risk
600 min Summer	99.895	0.495	9.0	Q.P	9.0	336.5	Flood Risk
720 min Summer	99.885	0.485	9.P	D.0	9.0	328.7	Flood Risk
960 min Summer	99.061	0.461	9.0	D.P	9.0	310.9	Flood Risk
1440 min Summer	99.R07	0.407	9.0	0.0	9.n	270.7	Flood Risk
2160 min Summer	99.731	0.332	9.0	D.0	9.0	216.9	Flood Risk
2880 min Summer	99.669	0,269	9.0	0.0	9+0	173.0	O K
4320 min Summer	99.584	0.184	9.0	0.0	9.0	115.8	O K
5760 min Summer	49.545	0.145	B.4	0.0	8.4	90.6	O K
7200 min Summer	99.527	0.127	7.3	D.0	7.3	79.0	O K
B640 min Summer	89.516	0.116	6.4	D.P	6.4	51.4	O K
10080 min Summer	99.507	0.107	5.7	D.0	5.7	65.5	O K
15 min Winter	99.710	0.310	9.0	D.0	9.0	201.3	Flaad Risk
30 min Winter	99.796	0.396	9.P	D.0	9.0	162.3	Flood Risk

Storm Event	Rain	Flooded Volume (m³)	Discharge [illegible] (m³)	Overflow V (m³)	[illegible]
15 min Summer	123.371	0.0	100.4	0.0	26
30 min Summer	81.055	0.0	238.6	0.0	40
60 min Summer	50.758	0.0	304.8	0.0	68
120 min Summer	30.731	0.0	369.6	0.0	126
180 min Summer	22.618	0.0	408.3	1.3	182
240 min Summer	18.094	0.0	435.6	5.1	238
360 min Summer	15.134	0.0	474.5	5.1	302
480 min Summer	10.469	0.0	504.3	1.0	378
600 min Summer	8.975	0.0	528.3	0.0	448
720 min Summer	7.592	0.0	548.5	0.0	514
960 min Summer	6.037	0.0	581.5	0.0	654
1440 min Summer	4.964	0.0	630.1	0.0	916
2160 min Summer	9.150	0.0	686.6	0.0	1300
2880 min Summer	2.497	0.0	725.3	0.0	1652
4320 min Summer	1.747	0.0	781.0	0.0	2336
5760 min Summer	1.922	0.0	827.6	0.1	3000
7200 min Summer	1.185	0.0	861.8	0.0	3588
8640 min Summer	1.020	0.0	890.0	0.0	4416
10080 min Summer	0.899	0.0	913,[illegible]	0,0	5144
15 min Winter	123.371	0.0	202.7	0.0	25
30 min Winter	81.055	0.0	267.7	0.0	40

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
60 min Winter	99.876	0.476	9.0	0.0	9.0	322.0	Flood Risk
120 min Winter	99.930	0.530	9.0	9.0	17.5	363.5	Flood Risk
180 min Winter	89.955	0.535	8.0	11.0	19.6	367.0	Flood Risk
240 min Winter	99.937	0.537	9.0	12.2	20.8	368.9	Flood Risk
360 min Winter	90.935	0.535	9.0	11.3	19.9	367.0	Flood Risk
480 min Winter	99.931	0.531	9.0	9.4	18.0	364.5	Flood Risk
600 min Winter	99.926	0.526	9.0	7.P	5 . 8	360.5	Flood Risk
720 min Winter	99.921	0.521	9.0	5.1	13.6	356.2	Flood Risk
960 min winter	99.906	0.506	9.0	0.7	9.1	344.7	Flood Risk
1440 min Winter	99.830	0.430	9.0	0.P	9.0	287.9	Flood Risk
2160 min Winter	99.714	0.314	9.0	P.0	9.0	204.4	Flood Risk
2880 min Winter	99.625	0.225	9.0	0.P	9.0	142.7	Q K
4320 min Winter	99.542	0.142	8.2	0.P	8.2	88.4	Q K
5760 min winter	99.518	0.118	6.6	0.0	6.6	73.2	O K
7200 rain Winter	99.505	0.105	5.6	0.0	5.6	64.5	O K
8640 min Winter	99.495	0.095	4.8	Q.0	4.8	58.5	O K
10080 min Winter	99.488	0.085	4.3	0.0	4.3	51.1	Q K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	50.758	0.0	341.7	0.0	68
320 min Hinter	30.731	D. D	414.3	16.7	120
180 min Hinter	22.618	D. P	457.7	37.3	154
240 min Winter	18.094	0.0	488.4	47.8	188
360 min Winter	13.134	0.0	531.3	52.0	264
480 min Winter	10.469	0.0	565.3	46.5	342
600 min Winter	8.775	0.0	592.2	35.9	424
720 min Winter	7.592	0.0	614.8	24.5	508
960 min Winter	5.037	0.0	651.6	2.4	694
1440 min Winter	4.364	0.0	706.0	0.0	1000
2160 min Winter	5.150	0.0	769.3	0.0	1372
2880 min Winter	2.497	0.0	812.7	0.0	1708
4320 min Winter	1.797	0.0	875.5	0.0	2296
5760 min Winter	1.422	0.0	927.1	0.0	3000
7200 min Winter	1.185	0.0	965.4	0.0	3744
8640 min Winter	1.020	0.0	997.2	0.0	4416
10080 min Winter	0.849	0.0	1023.5	0.0	5144

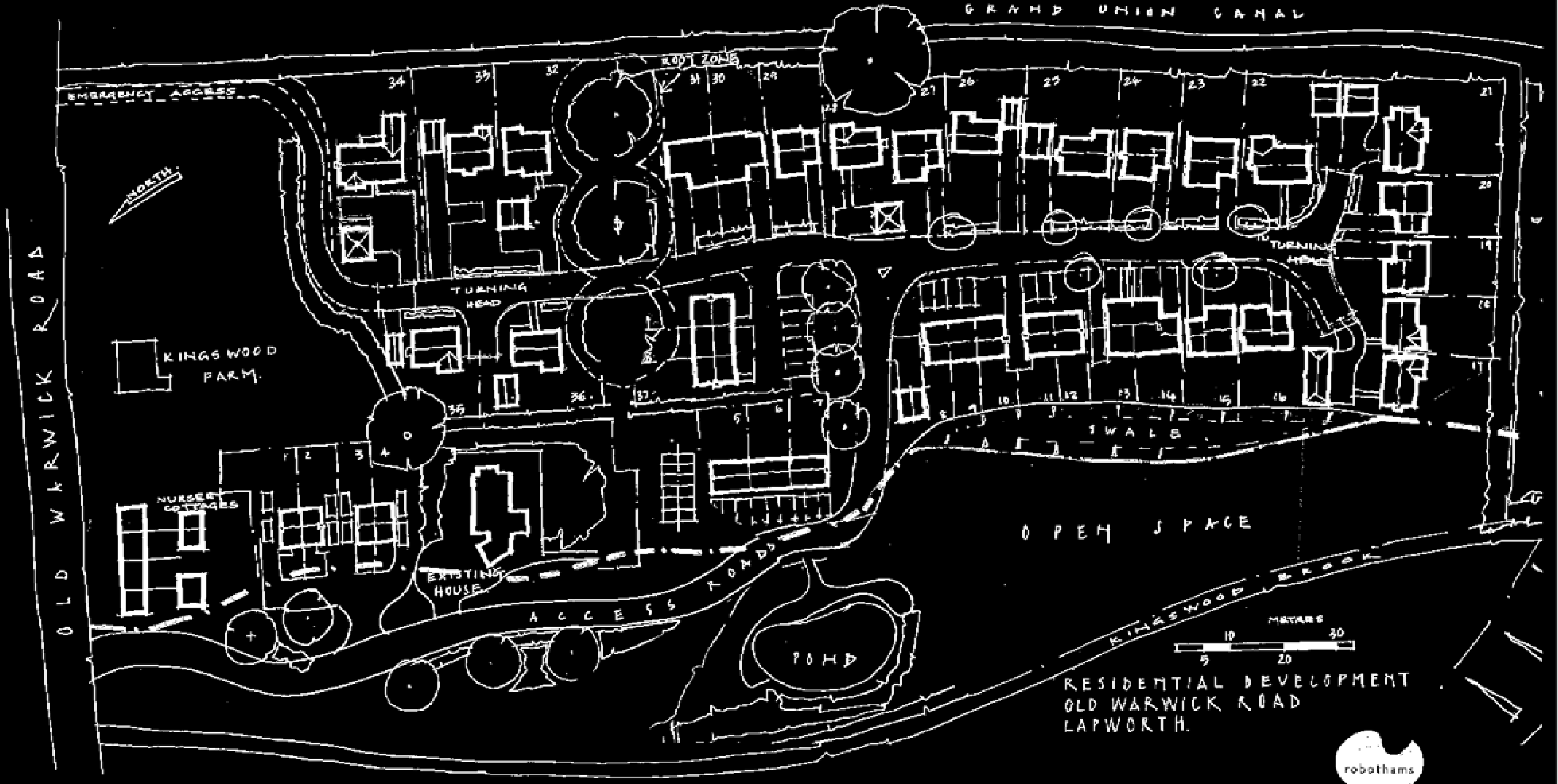
Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.301	Shortest Storm (mins)	15
Ratio R	0.401	Longest Storm (mins)	10080
Summer Storms	Yea	Climate Change %	+30

Time Area Diagram

Total Ares (ha) 0.810

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
P	4	0.270	4	8	0.270	8	12	0.270



RESIDENTIAL DEVELOPMENT
OLD WARWICK ROAD
LAPWORTH.

Model Details

Storage is Online Cover Level (m) 100.000

Tank or Pond Structure

Invert Level (m) 99.400

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	600.Q	0.600	800.0

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0144-9100-0600-9100
Design Head (m)	0.600
Design Flow (l/s)	P.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	144
Invert Level (m)	99.400
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	(m)	Flow (l/s)
Design Point (Calculated)	0.600	4.1
Flush-Flo™	0.228	9.0
Kick-Flo®	0.451	7.9
Mean Flow over Head Range	-	7.4

The hydrological calculations have hen based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage muting calculations will be invalidated

(m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
Π.100	5.2	1.200	12.5	3.000	19.4	7.000	29.1
Π.200	9.0	1.400	13.5	3.500	20.9	7.500	30.1
P.300	8.9	1.600	14.4	4.000	22.3	8.000	31.1
0.400	8.5	1.800	15.2	4.500	23.6	8.500	32.1
Q500	8.3	2.000	16.0	S.000	24.8	9.000	33.1
0.600	9.1	2.200	16.7	5.500	26.0	9.500	34.0
0.800	10.4	2,400	17.4	6.000	27.1		
1.000	11.5	2.600	18.1	6.500	28.0		

Weir Overflow Control

Discharge Coef 0.544 Width (m) 1.000 Invert Level (m) 99.900