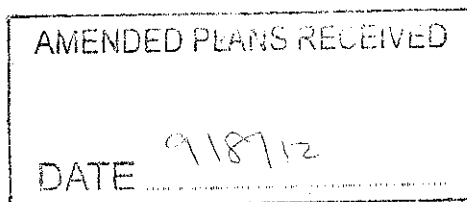


FLOOD RISK ASSESSMENT

**LAND NORTH OF BARROW BROOK BUSINESS VILLAGE, BARROW, CLITHEROE,
LANCASHIRE**



**OUTLINE PLANNING APPLICATION WITH ALL MATTERS RESERVED FOR UP TO
13,000SQM OF MIXED USE CLASS B1, B2 AND B8 EMPLOYMENT FLOORSPEACE WITH
ACCESS AND ASSOCIATED LANDSCAPING**

320120739P

Our Ref: ENV/0604/12FRA

JULY 2012

FLOOD RISK ASSESSMENT

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APPENDIX A:	TOPOGRAPHIC SURVEY
APPENDIX B:	PROPOSED DEVELOPMENT PLAN
APPENDIX C:	SURFACE WATER DRAINAGE CALCULATIONS

1.0 Introduction

- 1.1 AAH Planning Consultants have been commissioned to perform a Flood Risk Assessment (FRA) in support of the outline planning application for the erection of an unknown number of B1, B2 and B8 employment units on Land at Land North Of Barrow Brook Business Village, Barrow, Clitheroe, Lancashire.
- 1.2 The National Planning Policy Framework (NPPF) identifies that Flood Risk Assessments should be conducted for new developments proposed on the floodplains of rivers, sites potentially subject to coastal flooding, and for developments of one hectare in size and above. Sites in critical drainage areas may also be subject to Flood Risk Assessment irrespective of fluvial/tidal flood zoning.
- 1.3 The aforementioned site is in an area broadly classified by The Environment Agency (EA) as Flood Zone 1, with a plan area over 1ha, under the jurisdiction of Ribble Valley Borough Council Local Planning Authority. Each of the above was consulted prior to assessment. Surface water drainage of the surrounding area is controlled by United Utilities. Following liaison with Colin Worswick, the Environment Agency Development Control Engineer for the area, it has been agreed that the scope of assessment at the outline planning stage would be constrained to calculation of a limiting discharge rate from the site based on the existing green runoff rate and calculation of critical storage/attenuation volumes.
- 1.4 The open/agricultural use of the site is cited in table 2 of the National Planning Policy Framework Technical guide (NPPFTG) as 'water compatible' since there is no notable development on the open site. The proposal would be a mixture of B1, B2, and B8 Employment uses and so a 'less vulnerable' development to flooding land use category, this constitutes an increase in the flood risk vulnerability of the site.
- 1.5 A topographic survey of the site has been undertaken by Survey Solutions, with Ordnance Survey national grid coordinates used to establish the survey control point, using GPS and related to OSTN02(GB) and OSGM02(GB). The site survey shows a significant fall from east to west, with the low point of the site of 80.87m AOD on its western boundary, whilst the extents of the site subject to development reach approximately 84.57m AOD on its eastern boundary.

2.0 The Site as Existing

- 2.1 The site is located approximately halfway between the settlements of Clitheroe (to the north) and Whalley (which lies south), in the small settlement of Barrow, Lancashire, 0.17km east of Whalley Road which will provide vehicular and pedestrian access to the site via a private access road.
- 2.2 The site subject to planning consideration is 3.05ha in plan area and is predominantly undeveloped land which it is understood is currently used for agricultural purposes. The site boundaries are predominantly lined with trees, and a small land drainage ditch is located on the southern boundary of the site, whilst a second land drainage ditch runs from east to west across the north eastern corner of the site. There is a slight lateral fall of each half of the site towards each of the ditches which are used for land drainage purposes.
- 2.3 Table 2 of the NPPFTG states that the open pasture use of the site is 'water compatible' development with flooding, which in essence means that it would remain unharmed if flooded and is an appropriate use in all flood zones.
- 2.4 As discussed the topographic survey of the site has been undertaken by Survey Solutions, and shows a significant fall from east to west, with the low point of the site adjacent to Whalley Road 80.87m AOD, whilst the extents of the site subject to B1 development reach approximately 84.57m AOD on its eastern boundary. As noted above there is a slight lateral fall (generally less than 1m) towards each of the land drainage ditches on the site.

3.0 Development Proposal

- 3.1 The proposed development would see the erection of an unknown number of B1, B2, and B8 employment units on the site comprising both office and light industrial uses, however due to the indicative nature of the outline planning application the layout is not fixed. The proposed use, uses would be 'less vulnerable' development to flooding in accordance with table 2 of the NPPFTG.
- 3.2 The proposal would also incorporate areas of hardstanding associated with access and parking, and an access road which would be constructed to an adoptable standard. The remainder of the site would comprise soft landscaped areas.
- 3.3 The proposed units and hardstanding on the site would have a footprint of approximately 1.3ha with this combined impermeable footprint approximately 40-45% of the 3.05ha site.
- 3.4 Surface water from the buildings on the site would connect to the land drain which forms the southern site boundary, with a rate equivalent to the calculated Greenfield runoff rate used as the limiting discharge rate and the base for attenuation storage calculations.
- 3.5 Colin Worswick the Environment Agency Development Control Engineer for the area encompassing this site had indicated in pre-application discussions that at the outline planning stage he would condition the limiting discharge rate from the site based on the green runoff rate calculated in accordance with the Institute of Hydrology Report 124, 'flood estimation for small catchments' methodology. The calculated permissible runoff rates from the site for the 1, 30, and 100 year storm events and critical storage volumes both with and without an allowance for climate change (30% in rainfall intensities) are included in section 4 below;

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4.0 Surface Water Drainage

- 4.1 The proposed development should not increase, and where possible reduce the risk of flooding to downstream properties from all perspectives, and upon this basis the sustainable management of surface water is a key consideration for the proposal. In accordance with the sustainable hierarchy contained in the NPPF Technical Guidance, preference should be for infiltration systems, discharge to an open watercourse, a surface water sewer or combined sewer in that order of preference.

Site Control; Infiltration Systems

- 4.2 The published geology of the site shown on the British Geological Survey Geoindex infers drift deposits comprising Devensian (Diamicton) whilst the bedrock geology of the site is a Hodder Mudstone formation. Both the above drift and bedrock of the site are characteristically impermeable and as such it is unlikely that infiltration systems for full disposal of surface water to the ground would be viable.

Discharge rainwater to a watercourse

- 4.3 It is proposed that the development would discharge surface water arising from the impermeable areas on the site to the land drainage ditch located on the southern border of the proposed development site.
- 4.4 The FRA assumes a precautionary limiting discharge rate from the site equivalent to the IOH124 Greenfield runoff rate for the 1.3ha impermeable footprint which is considered a prudent approach in terms of required storage and limiting discharge. A summary of the IOH124 Greenfield runoff rates are shown below;

Institute of Hydrology Report 124 Greenfield Runoff Rate						
1 year	2 year	5 year	30 year	100 year	200 year	Units
0.009	0.010	0.012	0.017	0.021	0.024	cumecs
8.67	10.20	12.34	17.13	21.42	24.48	l/s
6.67	7.85	9.49	13.18	16.47	18.83	l/s/Ha

Evaluation of Storage Solutions

- 4.5 The peak flow storage programme within the Masterdrain Drainage Software was used to calculate the critical storage volume and durations for the 1, 30 and 100 year storm events, with and without 30% allowance for climate change assuming the proposed 1.3ha impermeable footprint with the Greenfield runoff rate used as the limiting discharge rate. The calculated storage volumes are shown below;

Storm Event	Limiting Discharge (l/s)	Critical Storage Volume (m ³)	Critical Storage Volume +CC (m ³)
1	8.67	118.8	154.5
30	17.13	269.1	349.8
100	21.42	361.9	470.5

- 4.6 The 470.5m³ of storm water storage could be provided on site to attenuate flows arising above the limiting discharge rate during the 1% AEP storm with an allowance for climate change in below ground tanks underlying hard or pervious external surfaces such as the Storm Bloc attenuation units by Hydro International.
- 4.7 There are now a large number of pre-manufactured tanks available that could store storm water for later discharge to the adjacent land drain. These units would provide the most compact volume of storage with up to a 96% void spacing, although it is noted that these systems are often more expensive than other alternatives.
- 4.8 It is anticipated that the limiting discharge rate from the site could be achieved through use of a suitable vortex flow control device such as the Hydrobrake by Hydro International

The Full Drainage Design

- 4.9 At the outline planning application stage, the surface water drainage advice contained in this report is conceptual and may therefore be subject to change depending upon the final drainage design for the site and indeed the final site layout. It is anticipated that details of the proposed surface water conveyance and storage system to be used on the site should be conditioned at the outline planning stage of the development.

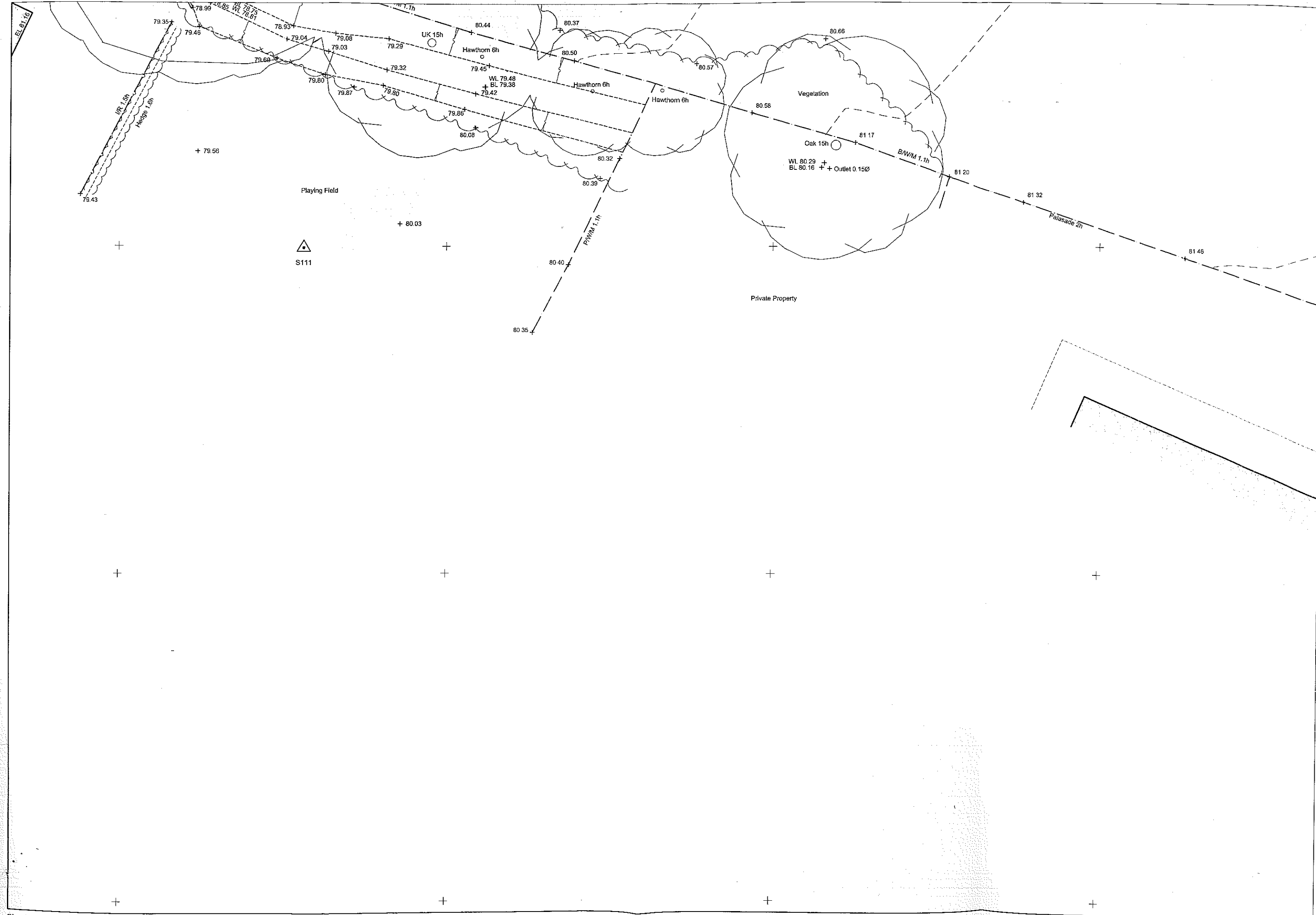
5.0 Conclusion

- 5.1 The proposed development site solely comprises Flood Zone 1, the low flood risk area. Since the footprint of the site is over 1 hectare, the proposal is subject to Flood Risk Assessment in accordance with the National Planning Policy Framework
- 5.2 The flood risk vulnerability of the site increases from 'water compatible' to 'less vulnerable' development to flooding. The location of less vulnerable development in Flood Zone 1 is a principle encouraged by the National Planning Policy Framework.
- 5.3 At the outline planning application stage, indicative surface water calculations infer that the site could utilise the calculated Greenfield runoff rate as the limiting discharge rate for the development, and at this early stage it is anticipated that the critical storage volume associated with the 100 year + Climate Change storm event would be provided via attenuations systems owing to the impermeability of the local geology.

APPENDIX A

TOPOGRAPHIC SURVEY

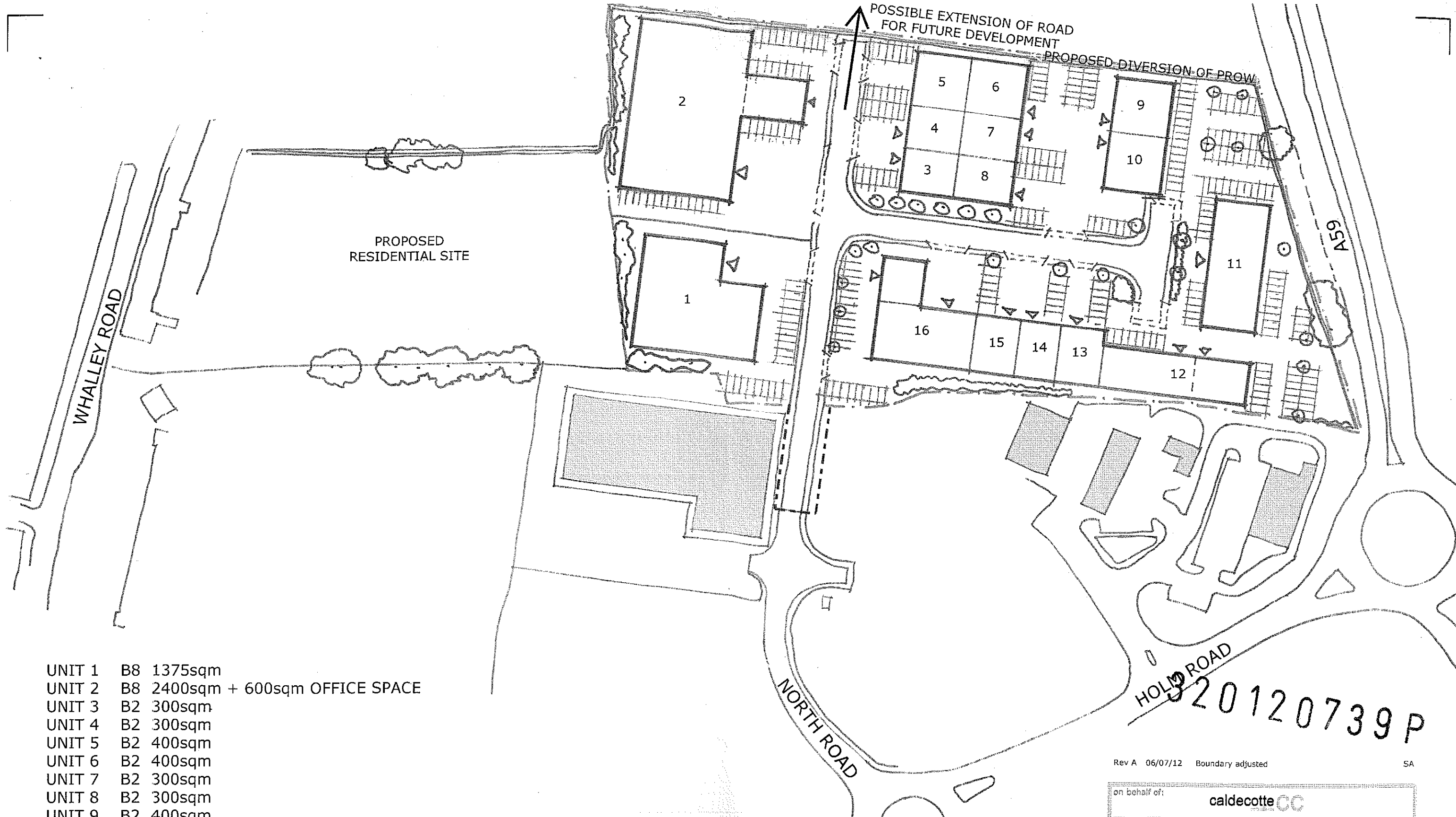
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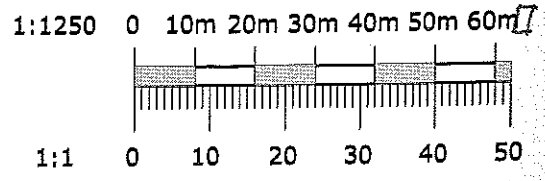
APPENDIX B

PROPOSED DEVELOPMENT PLAN

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UNIT 1	B8	1375sqm
UNIT 2	B8	2400sqm + 600sqm OFFICE SPACE
UNIT 3	B2	300sqm
UNIT 4	B2	300sqm
UNIT 5	B2	400sqm
UNIT 6	B2	400sqm
UNIT 7	B2	300sqm
UNIT 8	B2	300sqm
UNIT 9	B2	400sqm
UNIT 10	B2	400sqm
UNIT 11	B1	2700sqm
UNIT 12	B2	750sqm + 300sqm OFFICE SPACE
UNIT 13	B2	300sqm
UNIT 14	B2	300sqm
UNIT 15	B2	300sqm
UNIT 16	B2	700sqm + 450sqm OFFICE SPACE
TOTAL		12975sqm



Issued for: **PLANNING**

project: **LAND OFF WHALLEY ROAD, BARROW**

drawing: **EMPLOYMENT SITE INDICATIVE SITE LAYOUT**

project number: **5251**

drawing number: **09**

north:

revision: **A**

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Rev A 06/07/12 Boundary adjusted SA

on behalf of: **caldecotte CC**

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APPENDIX C

SURFACE WATER DRAINAGE CALCULATIONS

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SW 7.1



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Job No.		
Sheet no. 1		
Date 01/02/10		
By	Checked	Approved

Project Barrow Brook Business Park
Title IoH 124 Runoff calcs for WHALLEY

Hydrological Data:-

FSR Hydrology:-

Location	= WHALLEY	Grid reference	= SD7335
M5-60 (mm)	= 18.8	r	= 0.30
Soil runoff	= 0.47	SAAR (mm/yr)	= 1060
WRAP	= 4	Area	= England & Wales
Hydrological area	= 10	Hydrological zone	= 4

Soil classification for WRAP type 4

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Design data:-

Area = 0.013 Km² - 1.3 Ha - 13000 m²

Calculation method:-

Runoff is calculated from:-

$$Q_{\text{BAR(rural)}} = 0.00108 \text{ AREA}^{0.89} \cdot \text{SAAR}^{1.17} \cdot \text{SOIL}^{2.17}$$

where

AREA = Site area in Km²
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
 $Q_{\text{BAR(rural)}}$ = Runoff (cumecs)

$Q_{\text{BAR(rural)}}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.026

Mean Annual Peak Flow $Q_{\text{BAR(rural)}} = 10.20 \text{ l/s}$

Values for $Q_{\text{BAR(rural)}}$

1 year	2 year	5 year	30 year	100 year	200 year	Units
0.009	0.010	0.012	0.017	0.021	0.024	cumecs
8.67	10.20	12.34	17.13	21.42	24.48	l/s
6.67	7.85	9.49	13.18	16.47	18.83	l/s/Ha
0.850	1.000	1.210	1.680	2.100	2.400	GC(T)

The above is based on the Institute of Hydrology Report 124 to which you are referred for further details (see Sect 7).
Note that the 200 year growth curve was taken from W5-074/A.



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Job No.		
Sheet no. 1		
Date 09/07/12		
By JP	Checked	Approved

Project	
Title	Peak flow storage calcs for WHALLEY

Data:-

FSR Hydrology:-

Location	= WHALLEY	Grid reference	= SD7335
M5-60 (mm)	= 18.8	r	= 0.30
Soil index	= 0.45	SAAR (mm/yr)	= 1060
Return period	= 1	WRAP	= 4
UCWI	= 107.9		

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 82.0, calculated from:-

Runoff factor = $(0.829 \times \text{PIMP}) + (25 \times \text{SOIL}) + (0.078 \times \text{UCWI}) - 20.7$

where

$\text{PIMP} = \frac{\text{Impervious Area} \times 100}{(\text{Impervious Area} + \text{Pervious Area})}$

UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 13000 m ²	Pervious area	= 0 m ²
Total area (TA)	= 13000 m ²	Equiv area	= 10660 m ² (TA x RF)
Discharge to drain	= 8.67 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s		

Calculated data:-

Time to max	= 120.0 mins	Storage volume	= 118.8 m ³
Rainfall at max	= 8.50 mm/hr	Discharge rate per Ha	= 6.67 l/s/Ha

Adjustments to result for climate change:-

Volume + 10% for normal discharge (W5-074)	-	Storage volume = 130.7 m ³
Volume + 20% for discharge into river flows (DEFRA)-	-	Storage volume = 142.6 m ³
Volume + 30% for EA residential requirements	-	Storage volume = 154.5 m ³
Volume + 50% for other residential requirements	-	Storage volume = 178.2 m ³

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len	Ovoid	Len	Box culvert	Len
100	15130.4	1125	119.5	400 x 600	660.1	500 x 500	475.2
150	6724.6	1200	105.1	600 x 900	287.4	500 x 750	316.8
225	2988.7	1275	93.1	800 x 1200	161.6	500 x 1000	237.6
300	1681.2	1350	83.0			750 x 1000	158.4
375	1075.9	1425	74.5			750 x 1200	132.0
450	747.2	1500	67.2			750 x 1500	105.6
525	548.9	1575	61.0			1000 x 1000	118.8
600	420.3	1650	55.6			1000 x 1200	99.0
675	332.1	1725	50.8			1000 x 1500	79.2
750	269.0	1800	46.7			1000 x 1800	66.0
825	222.3	1875	43.0			1000 x 2000	59.4
900	186.8	1950	39.8			1500 x 1500	52.8
975	159.2	2025	36.9			1500 x 1800	44.0
1050	137.2	2100	34.3			1500 x 2000	39.6

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		Sheet no. 2		
		Date 09/07/12		
Project		By JP	Checked	Approved
Title Peak flow storage calcs for WHALLEY				

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	39.0	69.704	5.202	64.502
20	27.0	94.645	10.404	84.241
30	21.0	110.996	15.606	95.390
40	17.0	123.491	20.808	102.683
50	15.0	133.793	26.010	107.783
60	13.0	142.668	31.212	111.456
70	12.0	150.534	36.414	114.120
80	11.0	157.647	41.616	116.031
90	10.0	164.172	46.818	117.354
100	10.0	170.226	52.020	118.206
110	9.0	175.893	57.222	118.671
120	9.0	181.235	62.424	118.811
130	8.0	186.301	67.626	118.675
140	8.0	191.128	72.828	118.300
150	7.0	195.747	78.030	117.717
160	7.0	200.183	83.232	116.951
170	7.0	204.455	88.434	116.021
180	7.0	208.583	93.636	114.947
190	6.0	212.578	98.838	113.740
200	6.0	216.456	104.040	112.416
210	6.0	220.225	109.242	110.983
220	6.0	223.895	114.444	109.451
230	6.0	227.474	119.646	107.828
240	5.0	230.902	124.848	106.054
250	5.0	234.197	130.050	104.147
260	5.0	237.404	135.252	102.152
270	5.0	240.531	140.454	100.077
280	5.0	243.581	145.656	97.925
290	5.0	246.559	150.858	95.701
300	5.0	249.470	156.060	93.410
310	5.0	252.317	161.262	91.055
320	4.0	255.104	166.464	88.640
330	4.0	257.834	171.666	86.168
340	4.0	260.510	176.868	83.642
350	4.0	263.135	182.070	81.065
360	4.0	265.710	187.272	78.438
370	4.0	268.239	192.474	75.765
380	4.0	270.723	197.676	73.047
390	4.0	273.164	202.878	70.286
400	4.0	275.565	208.080	67.485
410	4.0	277.926	213.282	64.644
420	4.0	280.250	218.484	61.766
430	4.0	282.538	223.686	58.852
440	4.0	284.791	228.888	55.903
450	4.0	287.012	234.090	52.922
460	4.0	289.200	239.292	49.908
470	3.0	291.357	244.494	46.863
480	3.0	293.484	249.696	43.788
490	3.0	295.583	254.898	40.685
500	3.0	297.654	260.100	37.554
510	3.0	299.698	265.302	34.396
520	3.0	301.716	270.504	31.212
530	3.0	303.709	275.706	28.003
540	3.0	305.678	280.908	24.770
550	3.0	307.623	286.110	21.513
560	3.0	309.546	291.312	18.234
570	3.0	311.446	296.514	14.932
580	3.0	313.324	301.716	11.608
590	3.0	315.182	306.918	8.264
600	3.0	317.020	312.120	4.900

Storage volume (m³) = 118.8 m³



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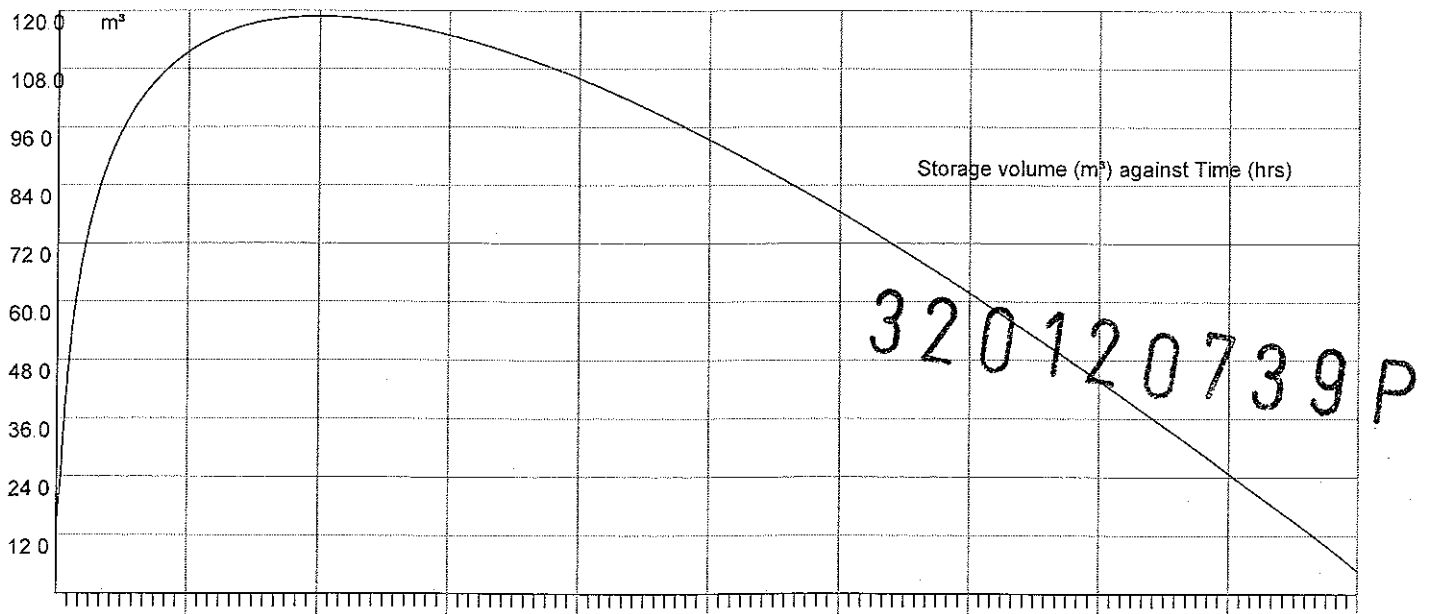
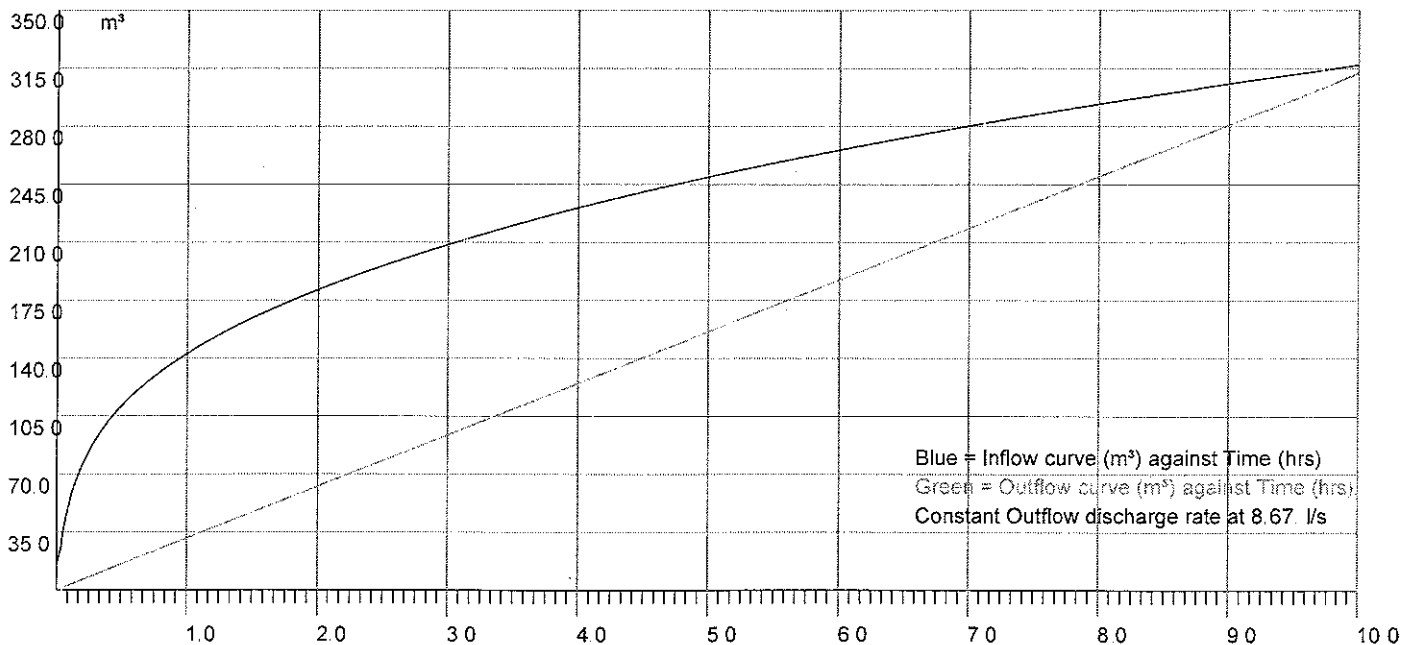
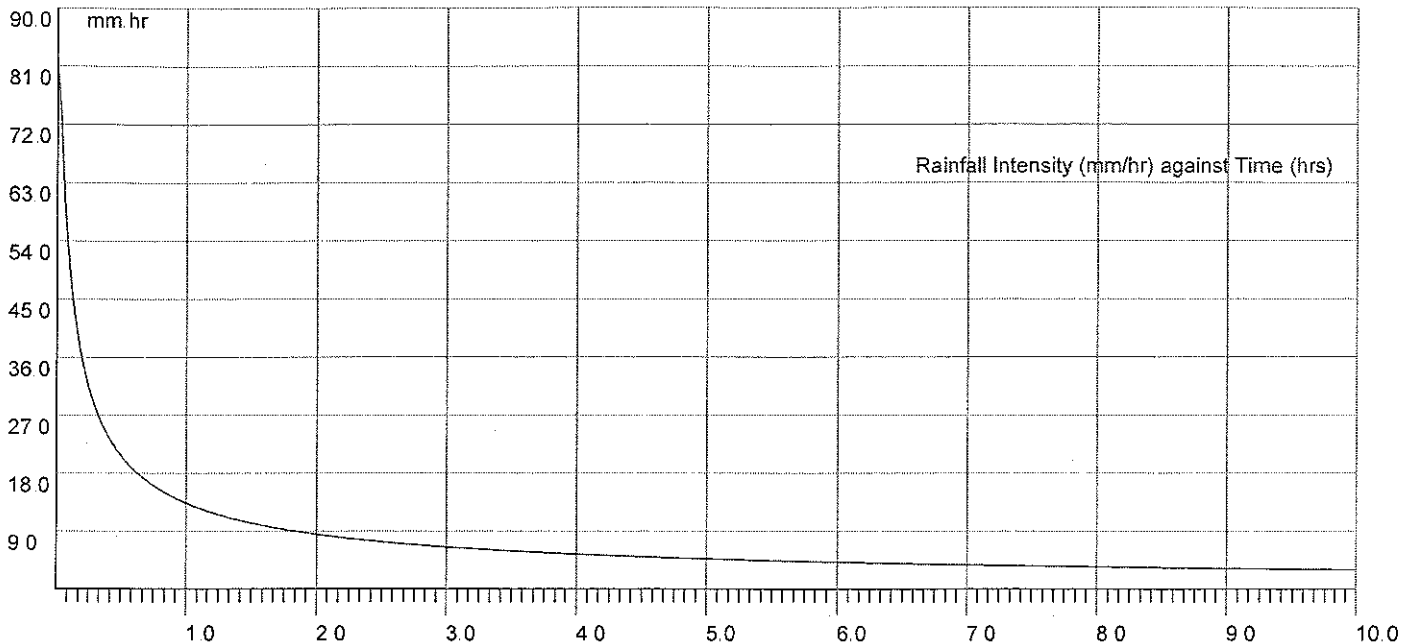
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By JP	Checked	Approved

Project
Title Peak flow storage calcs for WHALLEY





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				Sheet no. 4
Project				Date 09/07/12
Title Peak flow storage calcs for WHALLEY		By JP	Checked*	Approved

Explanatory notes for Peak Flow Storage

- 1) This system uses the rainfall intensity/ duration curve calculated using either the Wallingford or FEH method as selected.
- 2) The outflow is regarded as constant for the duration of the storm; i.e. no allowance is made for the changing head behind the flow restrictor.*
- 3) The balance is calculated from the inflow minus the outflow.
- 4) The storage volume is the maximum value of the balance curve.
- 5) This method was described by Davis (1963) - see Butler & Davies, 2nd edition, p294
- 6) References to 'storm duration' relate only to the hydrograph method (qv).
- 7) There are always 600 steps in the calculation process, thus a 'run' time of 10 hours will be sampled every minute,

Explanatory notes for Hydrograph Storage

- 1) The user has the choice of Summer or Winter curves
- 2) The mean intensity varies with the duration of the storm curve
- 3) There are always 120 steps in the calculation process, irrespective of storm duration.
- 4) The outflow is regarded as constant for the duration of the storm; i.e. no allowance is made for the changing head behind the flow restrictor.*
- 5) The balance is calculated from the inflow minus the outflow.
- 6) The storage volume is the sum of the balance values for each step.
- 7) Varying durations should be tried to find the maximum storage value - this can be narrowed down very closely.

*Modelling using the flow characteristics of the restrictor is available using Vortex Control modelling function. Please be aware that this function needs the full design data file to function

Why do the two methods give different results?

The rainfall characteristics for each method are very different

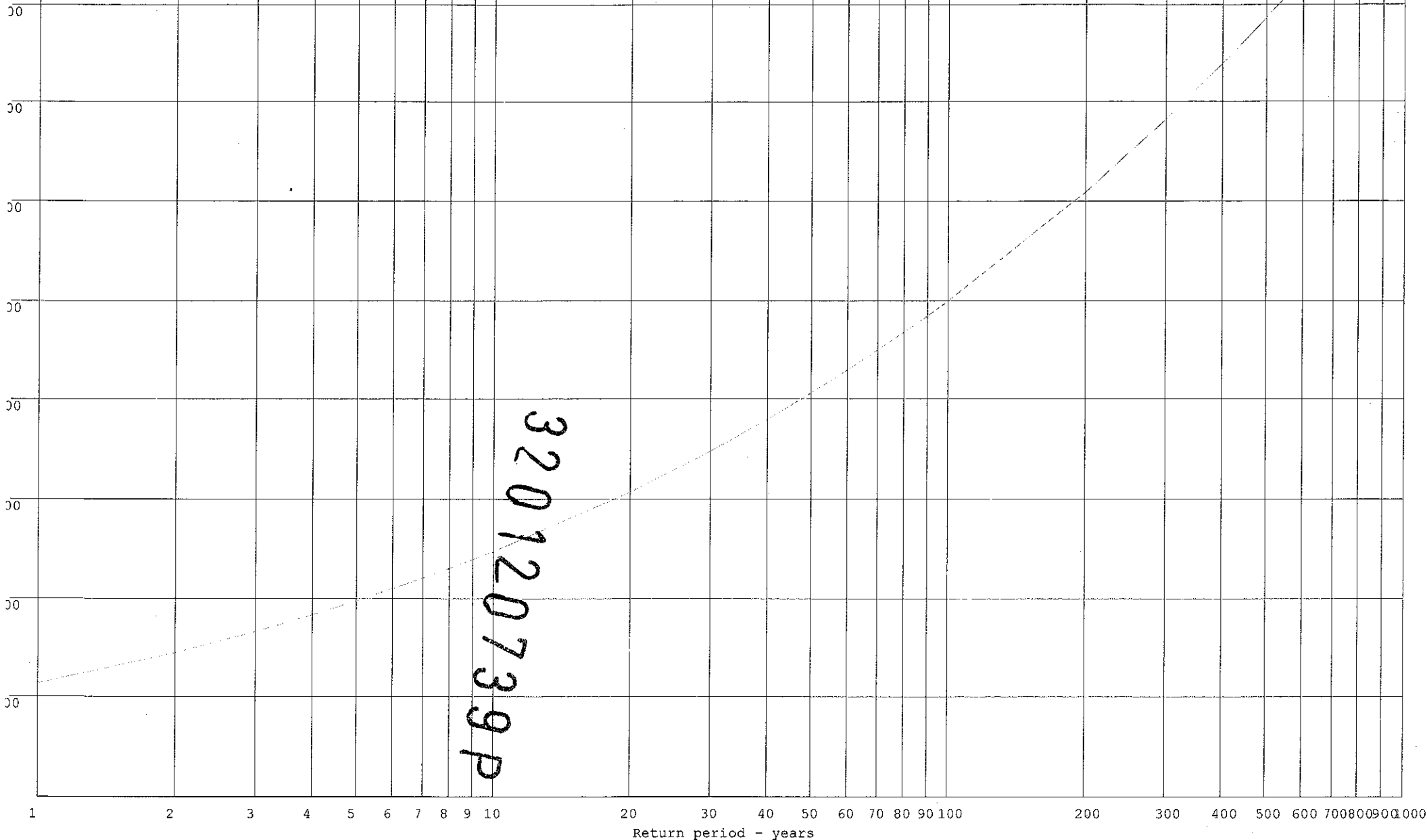
The Peak flow (using the Intensity/Duration/Frequency curve) does not model the actual rainfall. This curve is joined points which represent the mean intensity of a storm at a given duration i.e. a value of 19.5 mm/hr for a 60 minute storm indicates that over the sixty minute period, the mean intensity was 19.5 mm/hr. The calculation method samples the IDF curve for a given location and frequency (Return Period) and calculates the storage for that rate and duration less the outflow volume. The maximum value is displayed as the 'worst case' storage.

The hydrograph method uses a standard curve for either Winter or Summer storms. Traditionally these are symmetrical about the central peak. UK rainfall does not fit into this convenient curve, so the calculations are dealing with a stylised set of data. The mean intensity for the storm is calculated from the IDF curve and applied to the curve data, calculating the storage for that step less the outflow volume. The final storage volume is the sum of the storage for all the steps.

It can be seen that these two methods are very different, and the user may have the choice of which result to use. This is not an exact science, though is often treated as such by those that do not understand the principles of the calculations

Serial storage volumes for WHALLEY against time - years on lin/log scale

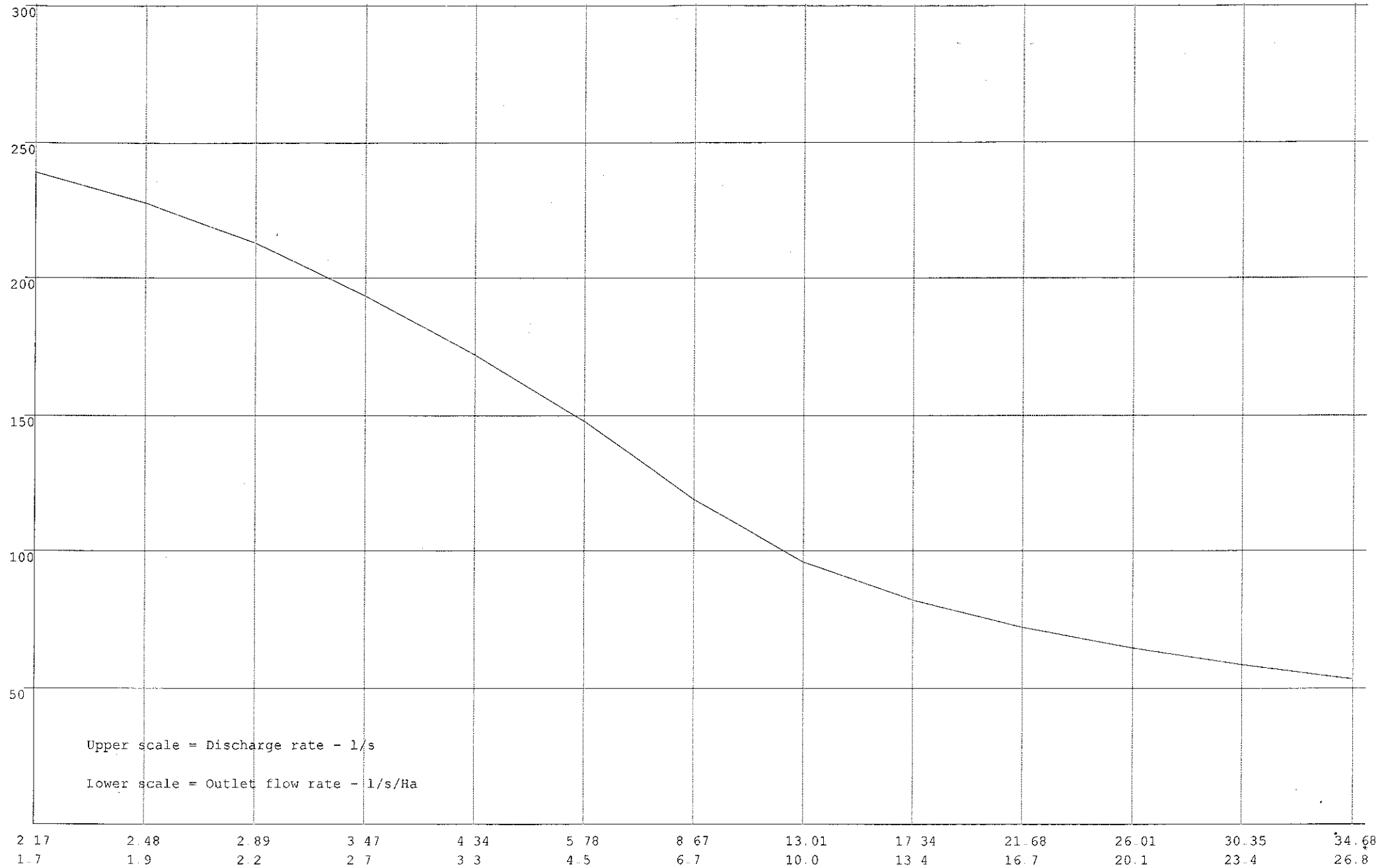
Permeable area drained = 0.00 m2
 Impermeable area drained = 1.30 Ha
 Total discharge rate = 8.7 l/s



Storage volumes for WHALLEY against varying discharge rates

3 storage

Design discharge rate= 8.7





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Sheet no. 1		
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By JP	Checked	Approved

Project	
Title	Peak flow storage calcs for WHALLEY

Data:-

FSR Hydrology:-

Location = WHALLEY
M5-60 (mm) = 18.8
Soil index = 0.45
Return period = 30
UCWI = 107.9

Grid reference = SD7335
r = 0.30
SAAR (mm/yr) = 1060
WRAP = 4

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 82.0, calculated from:-

$$\text{Runoff factor} = (0.829 \times \text{PIMP}) + (25 \times \text{SOIL}) + (0.078 \times \text{UCWI}) - 20.7$$

where

PIMP = Impervious Area * 100 / (Impervious Area + Pervious Area)

UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area = 13000 m²
Total area (TA) = 13000 m²
Discharge to drain = 17.13 l/s
Additional flow = 0.00 l/s

Pervious area = 0 m²
Equiv area = 10660 m² (TA x RF)
Areal reduction factor = 1.000

Calculated data:-

Time to max = 126.0 mins
Rainfall at max = 17.81 mm/hr

Storage volume = 269.1 m³
Discharge rate per Ha = 13.18 l/s/Ha

Adjustments to result for climate change:-

Volume + 10% for normal discharge (W5-074)	-	Storage volume = 296.0 m ³
Volume + 20% for discharge into river flows (DEFRA)	-	Storage volume = 322.9 m ³
Volume + 30% for EA residential requirements	-	Storage volume = 349.8 m ³
Volume + 50% for other residential requirements	-	Storage volume = 403.6 m ³

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len	Ovoid	Len	Box culvert	Len
100	34269.2	1125	270.8	400 x 600	1495.0	500 x 500	1076.4
150	15230.8	1200	238.0	600 x 900	650.9	500 x 750	717.6
225	6769.2	1275	210.8	800 x 1200	366.1	500 x 1000	538.2
300	3807.7	1350	188.0			750 x 1000	358.8
375	2436.9	1425	168.8			750 x 1200	299.0
450	1692.3	1500	152.3			750 x 1500	239.2
525	1243.3	1575	138.1			1000 x 1000	269.1
600	951.9	1650	125.9			1000 x 1200	224.2
675	752.1	1725	115.2			1000 x 1500	179.4
750	609.2	1800	105.8			1000 x 1800	149.5
825	503.5	1875	97.5			1000 x 2000	134.5
900	423.1	1950	90.1			1500 x 1500	119.6
975	360.5	2025	83.6			1500 x 1800	99.7
1050	310.8	2100	77.7			1500 x 2000	89.7

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Data:-

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		Date 09/07/12		
Project		By JP	Checked *	Approved
Title Peak flow storage calcs for WHALLEY				

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	78.0	139.378	10.278	129.100
20	55.0	197.131	20.556	176.575
30	44.0	235.138	30.834	204.304
40	37.0	264.209	41.112	223.097
50	32.0	288.015	51.390	236.625
60	29.0	308.303	61.668	246.635
70	26.0	326.050	71.946	254.104
80	24.0	341.863	82.224	259.639
90	22.0	356.146	92.502	263.644
100	21.0	369.183	102.780	266.403
110	20.0	381.182	113.058	268.124
120	18.0	392.301	123.336	268.965
130	17.0	402.662	133.614	269.048
140	17.0	412.363	143.892	268.471
150	16.0	421.482	154.170	267.312
160	15.0	430.084	164.448	265.636
170	15.0	438.223	174.726	263.497
180	14.0	445.943	185.004	260.939
190	13.0	453.285	195.282	258.003
200	13.0	460.282	205.560	254.722
210	13.0	466.961	215.838	251.123
220	12.0	473.349	226.116	247.233
230	12.0	479.467	236.394	243.073
240	11.0	485.515	246.672	238.843
250	11.0	491.479	256.950	234.529
260	11.0	497.264	267.228	230.036
270	10.0	502.883	277.506	225.377
280	10.0	508.346	287.784	220.562
290	10.0	513.663	298.062	215.601
300	10.0	518.843	308.340	210.503
310	10.0	523.893	318.618	205.275
320	9.0	528.822	328.896	199.926
330	9.0	533.635	339.174	194.461
340	9.0	538.338	349.452	188.886
350	9.0	542.938	359.730	183.208
360	9.0	547.440	370.008	177.432
370	8.0	551.847	380.286	171.561
380	8.0	556.166	390.564	165.602
390	8.0	560.399	400.842	159.557
400	8.0	564.550	411.120	153.430
410	8.0	568.624	421.398	147.226
420	8.0	572.623	431.676	140.947
430	8.0	576.551	441.954	134.597
440	7.0	580.410	452.232	128.178
450	7.0	584.203	462.510	121.693
460	7.0	587.933	472.788	115.145
470	7.0	591.601	483.066	108.535
480	7.0	595.212	493.344	101.868
490	7.0	598.765	503.622	95.143
500	7.0	602.264	513.900	88.364
510	7.0	605.711	524.178	81.533
520	7.0	609.106	534.456	74.650
530	7.0	612.452	544.734	67.719
540	6.0	615.751	555.012	60.739
550	6.0	619.004	565.290	53.714
560	6.0	622.212	575.568	46.644
570	6.0	625.378	585.846	39.532
580	6.0	628.501	596.124	32.377
590	6.0	631.583	606.402	25.182
600	6.0	634.627	616.680	17.947

Storage volume (m³) = 269.1 m³



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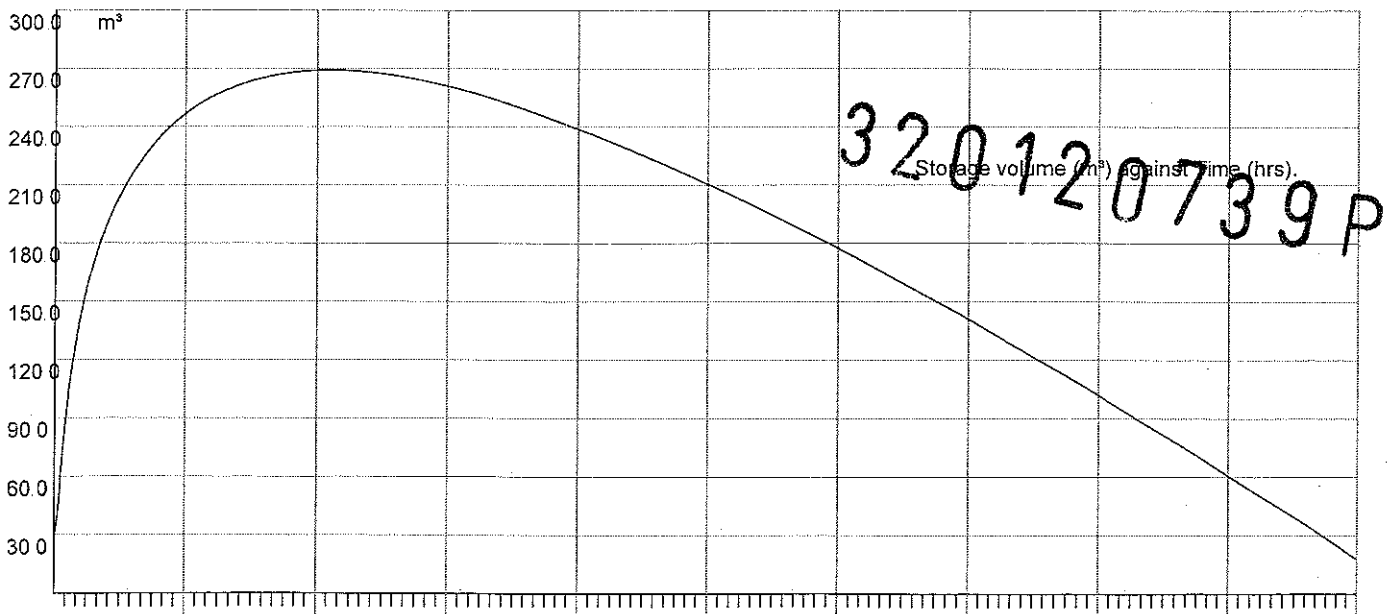
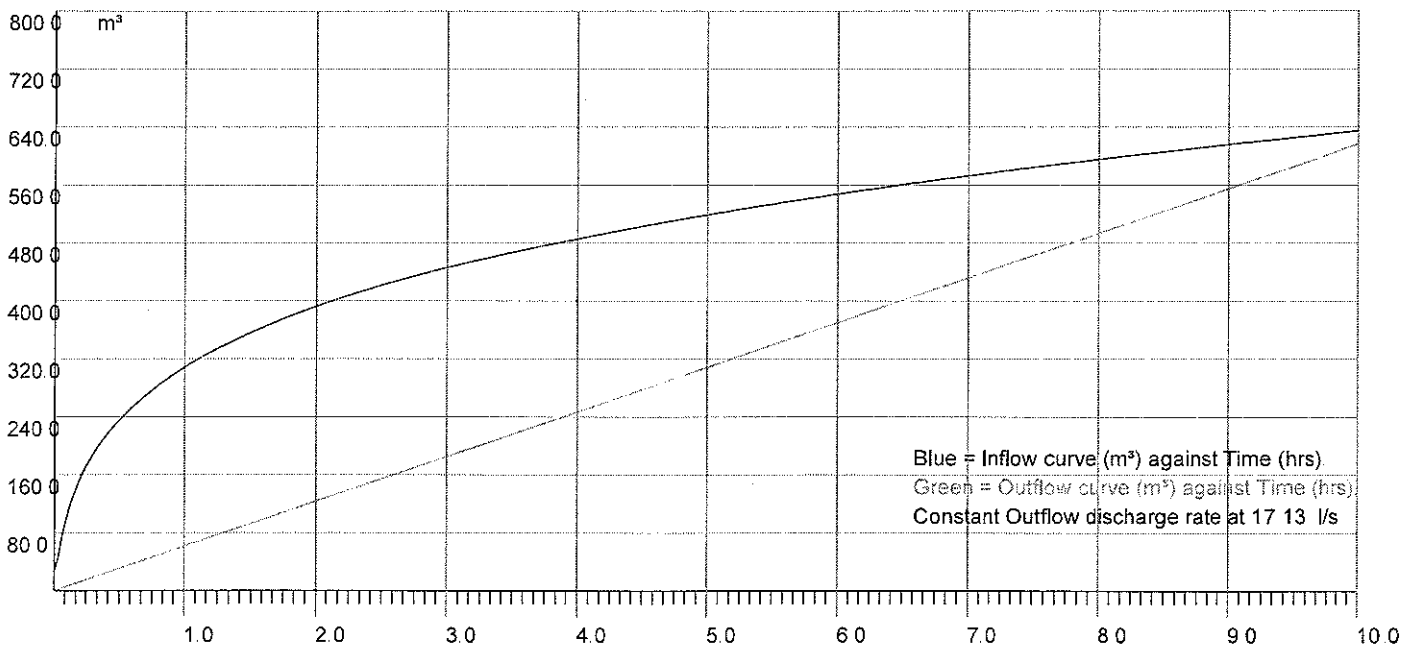
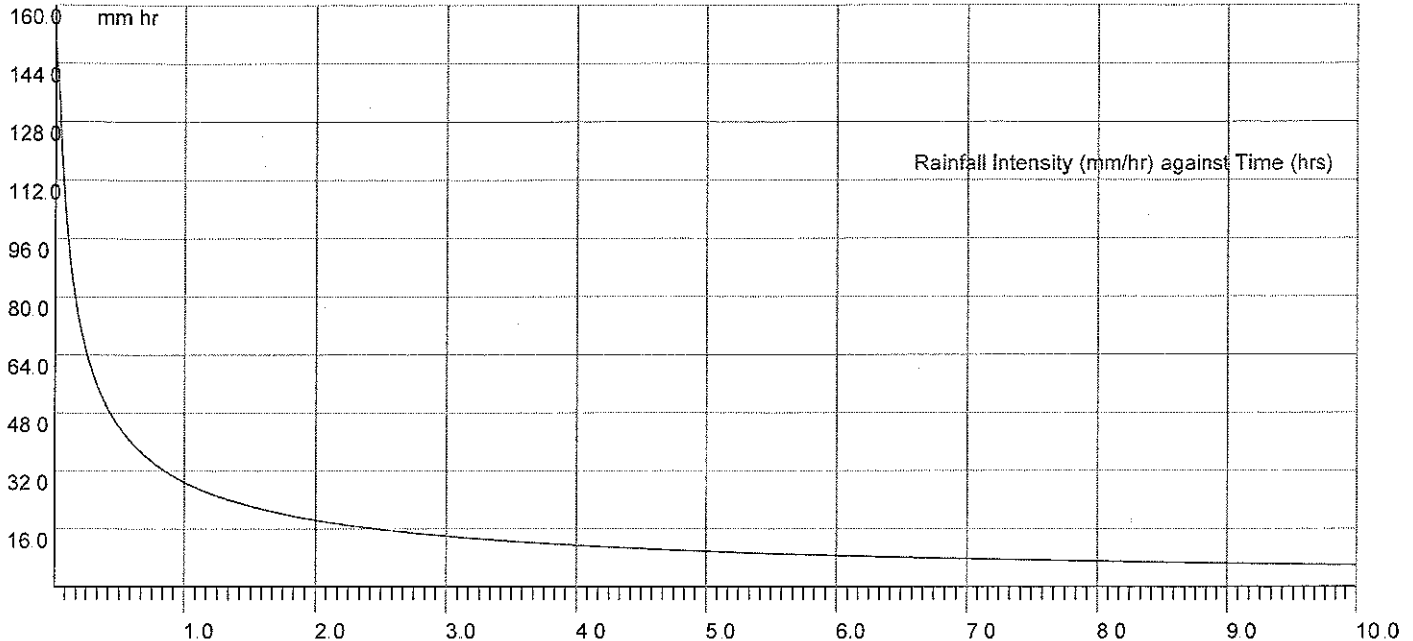
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Job No.		
Sheet no. 3		
Date 09/07/12		
By JP	Checked	Approved

Project

Title Peak flow storage calcs for WHALLEY





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		Sheet no. 4	
		Date 09/07/12	
Project	By JP	Checked *	Approved
Title Peak flow storage calcs for WHALLEY			

Explanatory notes for Peak Flow Storage

- 1) This system uses the rainfall intensity/ duration curve calculated using either the Wallingford or FEH method as selected.
- 2) The outflow is regarded as constant for the duration of the storm; i.e. no allowance is made for the changing head behind the flow restrictor *
- 3) The balance is calculated from the inflow minus the outflow.
- 4) The storage volume is the maximum value of the balance curve.
- 5) This method was described by Davis (1963) - see Butler & Davies, 2nd edition, p294
- 6) References to 'storm duration' relate only to the hydrograph method (qv).
- 7) There are always 600 steps in the calculation process, thus a 'run' time of 10 hours will be sampled every minute,

Explanatory notes for Hydrograph Storage

- 1) The user has the choice of Summer or Winter curves
- 2) The mean intensity varies with the duration of the storm curve
- 3) There are always 120 steps in the calculation process, irrespective of storm duration
- 4) The outflow is regarded as constant for the duration of the storm; i.e. no allowance is made for the changing head behind the flow restrictor.*
- 5) The balance is calculated from the inflow minus the outflow.
- 6) The storage volume is the sum of the balance values for each step.
- 7) Varying durations should be tried to find the maximum storage value - this can be narrowed down very closely.

*Modelling using the flow characteristics of the restrictor is available using Vortex Control modelling function. Please be aware that this function needs the full design data file to function.

Why do the two methods give different results?

The rainfall characteristics for each method are very different.

The Peak flow (using the Intensity/Duration/Frequency curve) does not model the actual rainfall. This curve is joined points which represent the mean intensity of a storm at a given duration i.e. a value of 19.5 mm/hr for a 60 minute storm indicates that over the sixty minute period, the mean intensity was 19.5 mm/hr. The calculation method samples the IDF curve for a given location and frequency (Return Period) and calculates the storage for that rate and duration less the outflow volume. The maximum value is displayed as the 'worst case' storage.

The hydrograph method uses a standard curve for either Winter or Summer storms. Traditionally these are symmetrical about the central peak. UK rainfall does not fit into this convenient curve, so the calculations are dealing with a stylised set of data. The mean intensity for the storm is calculated from the IDF curve and applied to the curve data, calculating the storage for that step less the outflow volume. The final storage volume is the sum of the storage for all the steps.

It can be seen that these two methods are very different, and the user may have the choice of which result to use. This is not an exact science, though is often treated as such by those that do not understand the principles of the calculations

m3 storage

Serial storage volumes for WHALLEY against time - years on lin/log scale

Permeable area drained = 0.00 m2

Impermeable area drained = 1.30 Ha

Total discharge rate = 17.1 l/s

10

10

10

10

10

10

10

1

2

3

4

5

6

7

8

9

10

20

30

40

50

60

70

80

90

100

200

300

400

500

600

700

800

900

1000

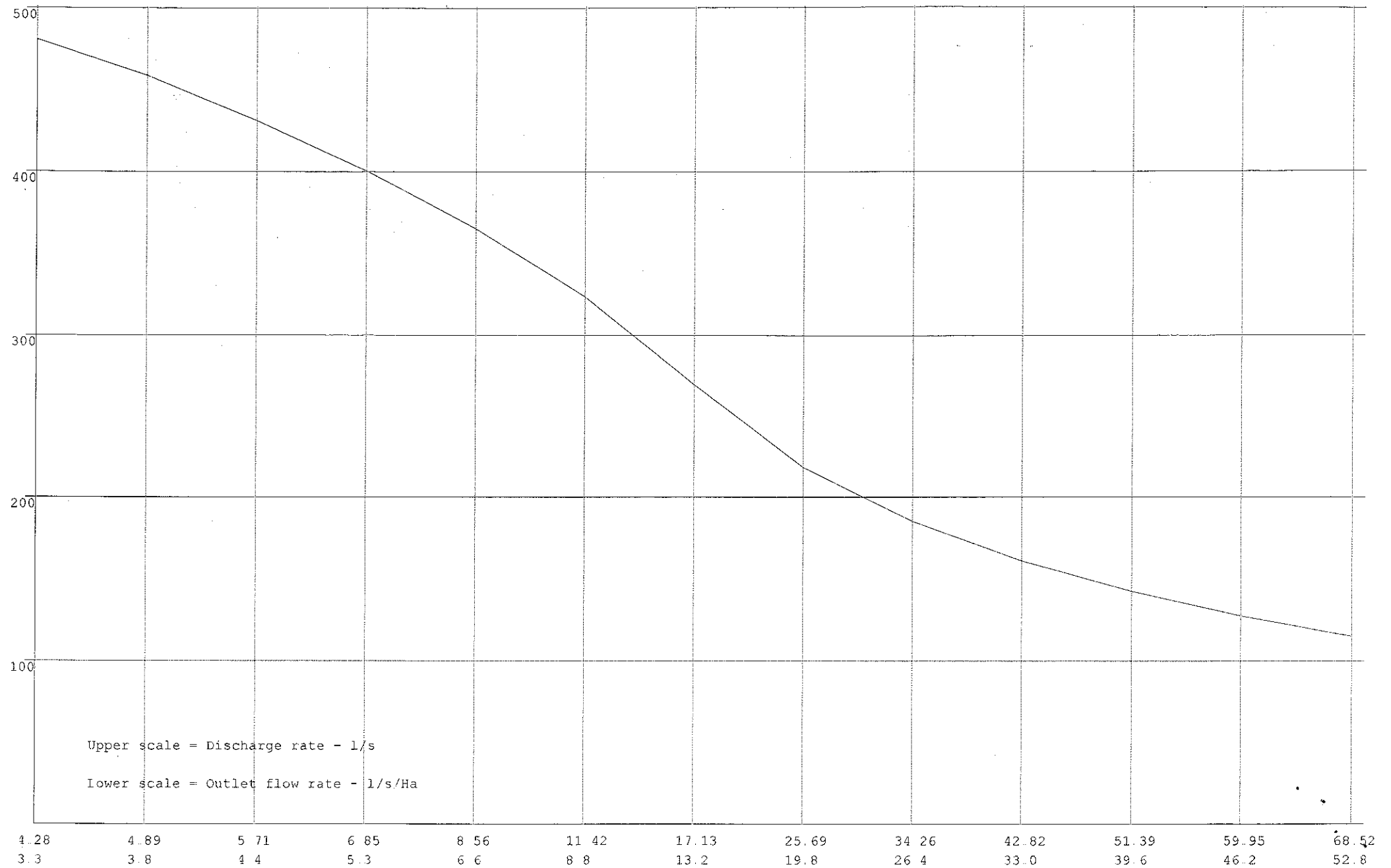
Return period - years

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Storage volumes for WHALLEY against varying discharge rates

3 storage

Design discharge rate= 17.1





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Job No.		
Sheet no. 1		
Date 09/07/12		
By JP	Checked	Approved

Project	
Title	Peak flow storage calcs for WHALLEY

Data:-

FSR Hydrology:-

Location	= WHALLEY	Grid reference	= SD7335
M5-60 (mm)	= 18.8	r	= 0.30
Soil index	= 0.45	SAAR (mm/yr)	= 1060
Return period	= 100	WRAP	= 4
UCWI	= 107.9		

Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.

Runoff factor (RF) = 82.0, calculated from:-

Runoff factor = $(0.829 \times \text{PIMP}) + (25 \times \text{SOIL}) + (0.078 \times \text{UCWI}) - 20.7$

where

PIMP = $\text{Impervious Area} \times 100 / (\text{Impervious Area} + \text{Pervious Area})$

UCWI = Calculated value for Wetness Index

Design data:-

Imperv. area	= 13000 m ²	Pervious area	= 0 m ²
Total area (TA)	= 13000 m ²	Equiv area	= 10660 m ² (TA x RF)
Discharge to drain	= 21.42 l/s	Areal reduction factor	= 1.000
Additional flow	= 0.00 l/s		

Calculated data:-

Time to max	= 130.0 mins	Storage volume	= 361.9 m ³
Rainfall at max	= 22.90 mm/hr	Discharge rate per Ha	= 16.48 l/s/Ha

Adjustments to result for climate change:-

Volume + 10% for normal discharge (W5-074)	-	Storage volume	= 398.1 m ³
Volume + 20% for discharge into river flows (DEFRA)-	-	Storage volume	= 434.3 m ³
Volume + 30% for EA residential requirements	-	Storage volume	= 470.5 m ³
Volume + 50% for other residential requirements	-	Storage volume	= 542.8 m ³

Rainfall intensities calculated using the Wallingford Procedure

Storage lengths for initial calculation (x 1.1, 1.2, 1.3 or 1.5 as above if required) :-

Diam	Len	Diam	Len	Ovoid	Len	Box culvert	Len
100	46086.1	1125	364.1	400 x 600	2010.5	500 x 500	1447.6
150	20482.7	1200	320.0	600 x 900	875.4	500 x 750	965.0
225	9103.4	1275	283.5	800 x 1200	492.3	500 x 1000	723.8
300	5120.7	1350	252.9			750 x 1000	482.5
375	3277.2	1425	227.0			750 x 1200	402.1
450	2275.9	1500	204.8			750 x 1500	321.7
525	1672.1	1575	185.8			1000 x 1000	361.9
600	1280.2	1650	169.3			1000 x 1200	301.6
675	1011.5	1725	154.9			1000 x 1500	241.3
750	819.3	1800	142.2			1000 x 1800	201.1
825	677.1	1875	131.1			1000 x 2000	180.9
900	569.0	1950	121.2			1500 x 1500	160.8
975	484.8	2025	112.4			1500 x 1800	134.0
1050	418.0	2100	104.5			1500 x 2000	120.6

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http://www.mstdrain.co.uk		Project Title Peak flow storage calcs for WHALLEY		By JP Checked * Approved

Data:-

Time (mins)	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)
10	100.0	178.125	12.852	165.273
20	72.0	255.597	25.704	229.893
30	58.0	306.710	38.556	268.154
40	49.0	345.839	51.408	294.431
50	43.0	377.820	64.260	313.560
60	38.0	404.985	77.112	327.873
70	34.0	428.646	89.964	338.682
80	32.0	449.625	102.816	346.809
90	29.0	468.472	115.668	352.804
100	27.0	485.575	128.520	357.055
110	26.0	501.222	141.372	359.850
120	24.0	515.629	154.224	361.405
130	23.0	528.967	167.076	361.891
140	22.0	541.371	179.928	361.443
150	21.0	552.950	192.780	360.170
160	20.0	563.795	205.632	358.163
170	19.0	573.981	218.484	355.497
180	18.0	583.573	231.336	352.237
190	18.0	592.626	244.188	348.438
200	17.0	601.186	257.040	344.146
210	16.0	609.294	269.892	339.402
220	16.0	616.985	282.744	334.241
230	15.0	624.293	295.596	328.697
240	15.0	631.626	308.448	323.178
250	14.0	638.941	321.300	317.641
260	14.0	646.028	334.152	311.876
270	14.0	652.901	347.004	305.897
280	13.0	659.574	359.856	299.718
290	13.0	666.060	372.708	293.352
300	13.0	672.371	385.560	286.811
310	12.0	678.517	398.412	280.105
320	12.0	684.507	411.264	273.243
330	12.0	690.349	424.116	266.233
340	12.0	696.053	436.968	259.085
350	11.0	701.624	449.820	251.804
360	11.0	707.070	462.672	244.398
370	11.0	712.396	475.524	236.872
380	11.0	717.609	488.376	229.233
390	10.0	722.714	501.228	221.486
400	10.0	727.716	514.080	213.636
410	10.0	732.618	526.932	205.686
420	10.0	737.426	539.784	197.642
430	10.0	742.144	552.636	189.508
440	10.0	746.775	565.488	181.287
450	9.0	751.322	578.340	172.982
460	9.0	755.790	591.192	164.598
470	9.0	760.180	604.044	156.136
480	9.0	764.496	616.896	147.600
490	9.0	768.741	629.748	138.993
500	9.0	772.917	642.600	130.317
510	9.0	777.027	655.452	121.575
520	8.0	781.073	668.304	112.769
530	8.0	785.057	681.156	103.901
540	8.0	788.981	694.008	94.973
550	8.0	792.847	706.860	85.987
560	8.0	796.658	719.712	76.946
570	8.0	800.414	732.564	67.850
580	8.0	804.118	745.416	58.702
590	8.0	807.770	758.268	49.502
600	8.0	811.374	771.120	40.254

Storage volume (m³) = 361.9 m³



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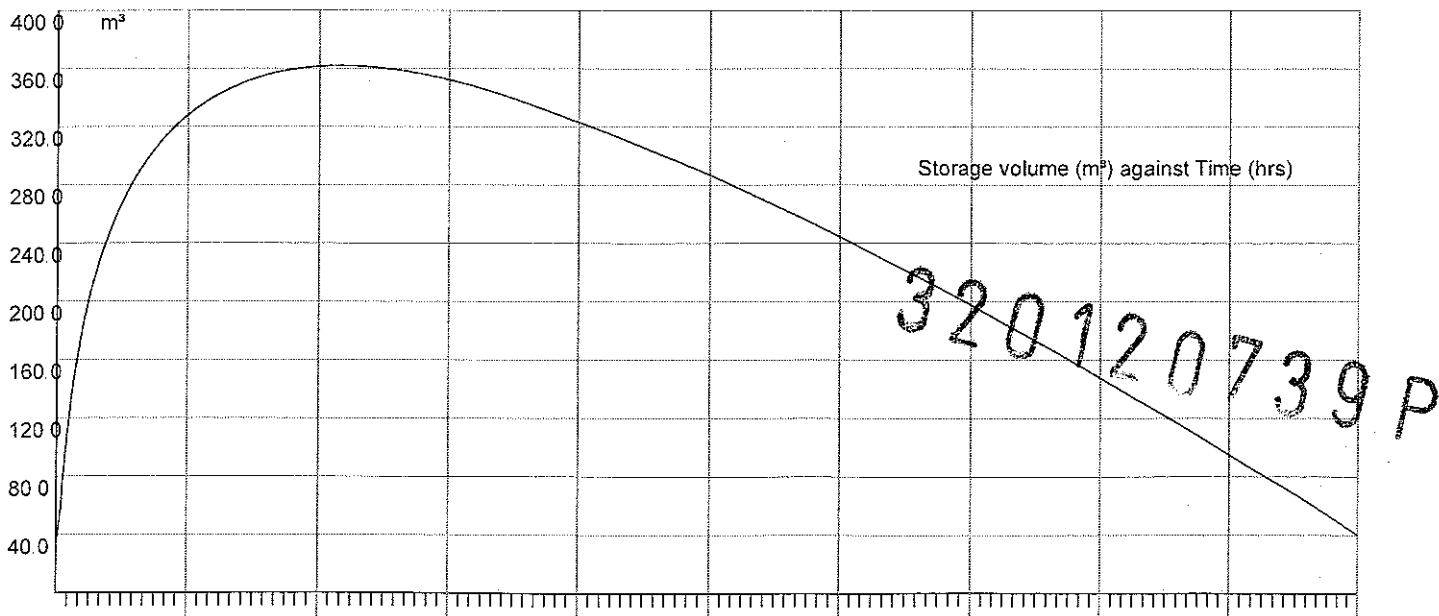
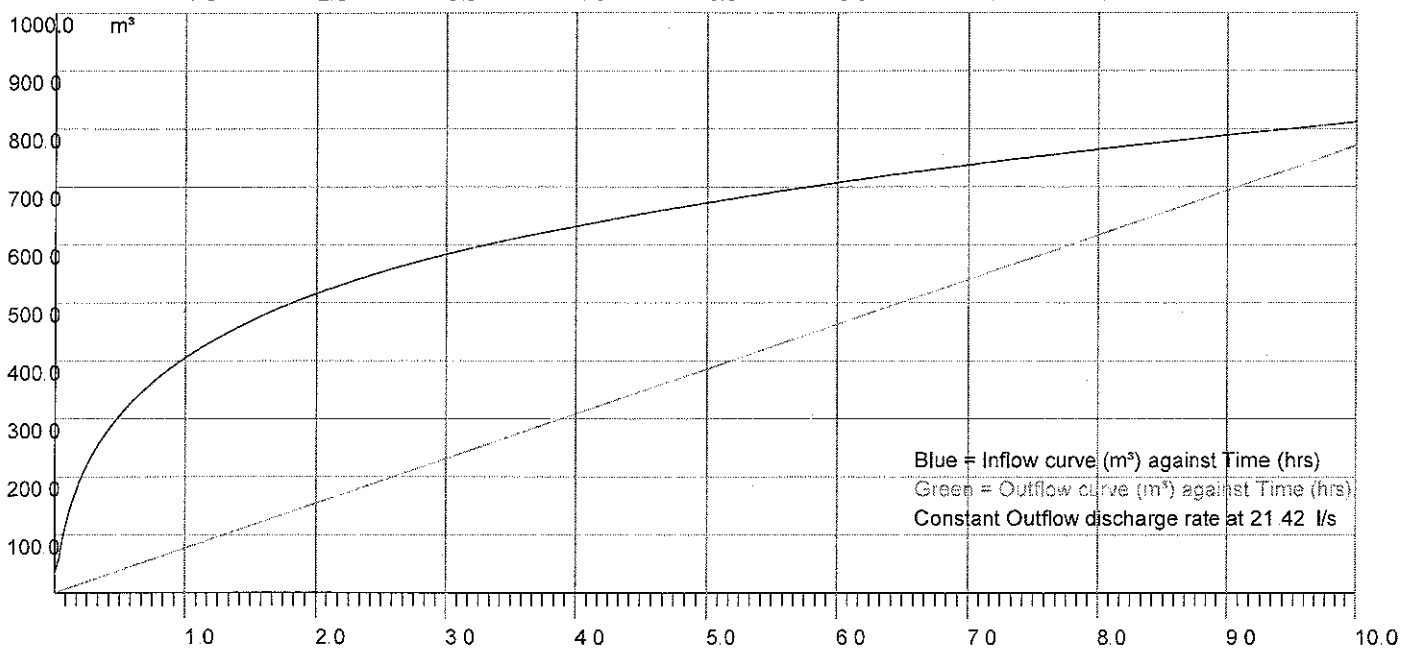
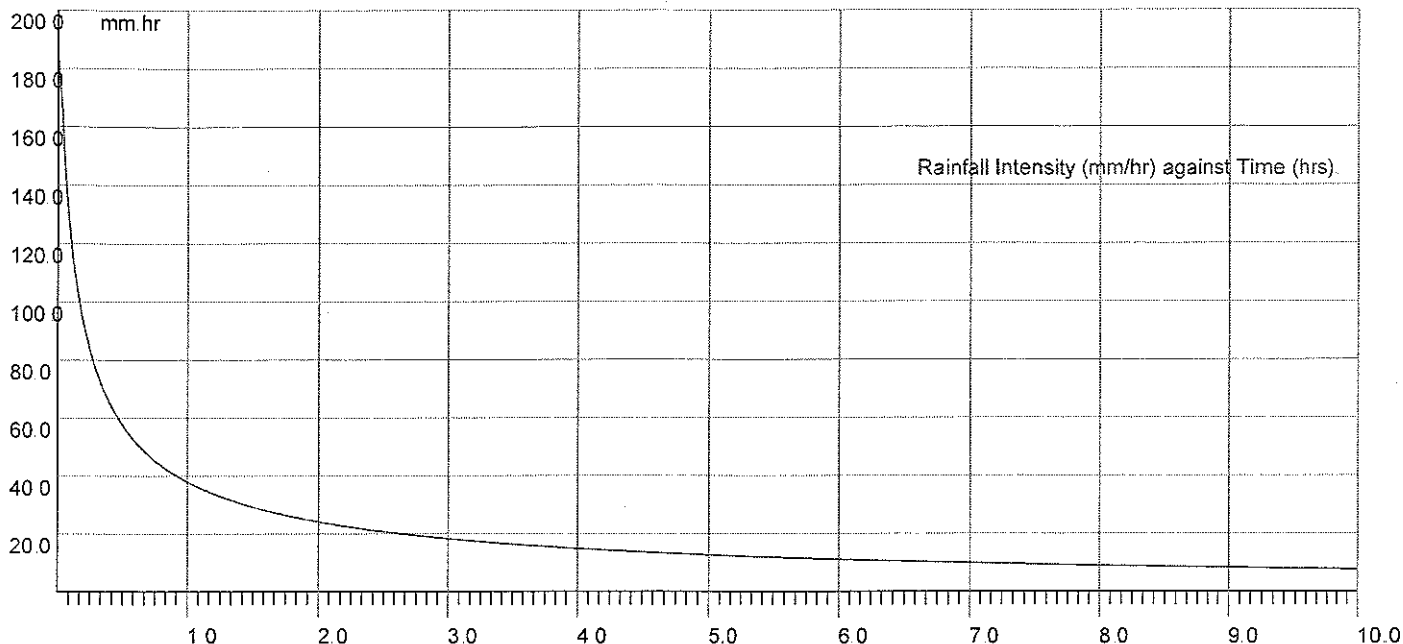
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Job No.		
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By JP	Checked	Approved

Project

Title Peak flow storage calcs for WHALLEY





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		Sheet no. 4	
		Date 09/07/12	
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Title Peak flow storage calcs for WHALLEY			

Explanatory notes for Peak Flow Storage

- 1) This system uses the rainfall intensity/ duration curve calculated using either the Wallingford or FEH method as selected.
- 2) The outflow is regarded as constant for the duration of the storm; i.e. no allowance is made for the changing head behind the flow restrictor.*
- 3) The balance is calculated from the inflow minus the outflow.
- 4) The storage volume is the maximum value of the balance curve.
- 5) This method was described by Davis (1963) - see Butler & Davies, 2nd edition, p294
- 6) References to 'storm duration' relate only to the hydrograph method (qv)
- 7) There are always 600 steps in the calculation process, thus a 'run' time of 10 hours will be sampled every minute.

Explanatory notes for Hydrograph Storage

- 1) The user has the choice of Summer or Winter curves
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The rainfall characteristics for each method are very different.

The Peak flow (using the Intensity/Duration/Frequency curve) does not model the actual rainfall. This curve is joined points which represent the mean intensity of a storm at a given duration i.e. a value of 19.5 mm/hr for a 60 minute storm indicates that over the sixty minute period, the mean intensity was 19.5 mm/hr. The calculation method samples the IDF curve for a given location and frequency (Return Period) and calculates the storage for that rate and duration less the outflow volume. The maximum value is displayed as the 'worst case' storage.

The hydrograph method uses a standard curve for either Winter or Summer storms. Traditionally these are symmetrical about the central peak UK rainfall does not fit into this convenient curve, so the calculations are dealing with a stylised set of data. The mean intensity for the storm is calculated from the IDF curve and applied to the curve data, calculating the storage for that step less the outflow volume. The final storage volume is the sum of the storage for all the steps.

It can be seen that these two methods are very different, and the user may have the choice of which result to use. This is not an exact science, though is often treated as such by those that do not understand the principles of the calculations.

m3 storage

Serial storage volumes for WHALLEY against time - years on lin/log scale

Permeable area drained = 0.00 m2

Impermeable area drained = 1.30 Ha

Total discharge rate = 21.4 l/s

100

100

100

100

100

100

100

1

2

3

4

5

6

7

8

9

10

20

30

40

50

60

70

80

90

100

200

300

400

500

600

700

800

900

1000

Return period - years

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Storage volumes for WHALLEY against varying discharge rates

3 storage

Design discharge rate= 21.4

