



Hydraulic Modelling Technical Note

DATE:	21 March 2025	CONFIDENTIALITY:	Restricted
SUBJECT:	Brightley Brook Hydraulic Model Technical Note		
PROJECT:	70103659-WSP-FRM-ZZ-RP-CW-0001	AUTHOR:	Soledad Berbel Roman and Chrystiann Lavarini
CHECKED:	Louise Markose and Stephanie Davidson	APPROVED:	David Waters

BACKGROUND

WSP has been appointed by Russell Homes (hereinafter referred to as 'the client') to undertake a review of fluvial flood risk within the study area to ensure risks do not increase downstream due to the works associated with the South Heywood Commercial development at Pilsworth Road. This Technical Note outlines the hydraulic modelling work undertaken to meet the requirements for planning permission.

Initial planning advice from the Environment Agency (EA) about this scheme was received in 2020 (details attached within Appendix A). In these consultations, high-level flood risk and water quality aspects were discussed without the requirement to undertake hydraulic modelling.

To assess site-specific flood risk, WSP requested from the EA (21.12.2022) Product 4, 6 and 7 for the Brightley Brook and its tributary. The EA response confirmed the absence of detailed modelling within the study area (23.12.2022). It was noted that, according to their records, the site was located within Flood Zone 1 and only a JFlow model was available, which is not suitable for Flood Risk Assessments. Following this response, WSP engaged with the EA in MS Teams meetings held in January 2023 as described in the section below. These meetings confirmed the necessity for the development of a hydraulic model. Figure 1 illustrates the indicative location of Plot 3 and Plot 4 along with the location of Brightly Brook and its tributary.

The proposed Plot 3 development includes construction of industrial buildings and also encompasses a diversion of Brightly Brook. The proposed diversion design includes installation of in-channel features and the inclusion of a new culvert underneath a proposed new access road. The Plot 4 development consists of bank improvement works (e.g., berms) and the inclusion of a footbridge along the tributary of the Brightley Brook. The Technical Note presented below outlines the agreed modelling methodology and results from the modelled scenarios.

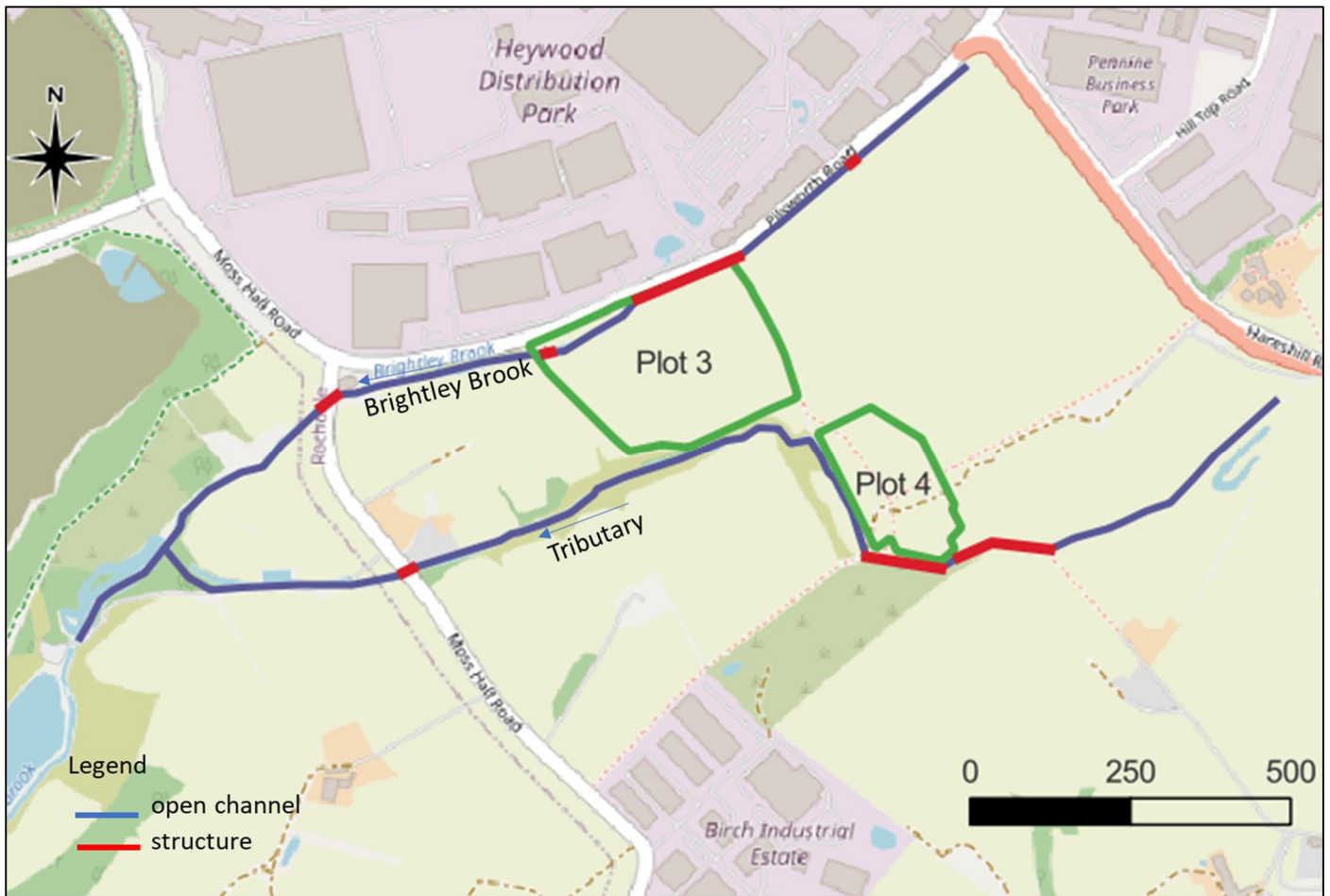


Figure 1 – Location of Plot 3 and Plot 4

CONSULTATION

Consultation with the Environment Agency has been carried out to determine the flood modelling methodology as well as wider water quality and environmental requests to be considered within this development as previously mentioned

In the meeting held on 9.01.2023 between WSP, EA and the client it was agreed that the creation of a high-level hydraulic model was required to assess the existing and post-development flood risks. The resulting hydraulic model includes the latest 2022 climate change allowances to assess the impact of the proposals at Plot 3. Normal depth calculations were used to estimate water levels in the Brightley Brook tributary running along the southern boundary of the Plot 3 development. The proposed hydraulic modelling approach was presented to and accepted by the EA in the meeting held on 27.01.2023.

Meeting minutes from meetings carried out on 9.1.2023 and 27.01.2023 are included in Appendix A.

The following sections outline the agreed modelling methodology and results from the modelling scenarios (baseline and post-development for the 1% AEP plus 35% climate change) that have been run to support the flood risk strategy.

MODELLING METHODOLOGY

Input data

The existing 1D (FMP) model of the Brightley Brook built by WSP in 2016/17 as part of the M62 Junction 19 Link Road Flood Assessment has been updated by linking it with the 2D (TUFLOW) model as a part of this study. The topographical survey for the existing model was completed in 2018.

Drawings from the client regarding proposed features have been utilised to build the proposed model. The information and drawings used to aid the hydraulic modelling are listed in Table 1.

Table 1 – Information Used

	Information/Drawing reference	Source
1	Existing Brightly Brook model built by WSP in 2016/17 to support a reserved matter planning application associated with M62 Junction 19 Link Road	Survey data for this model was commissioned in 2016
2	LIDAR data	2020 data (1m resolution) downloaded from EA website
3	70089657 -WSP-SHP3-WAT-DR-D-0100	WSP drawings. Used to represent diversion channel and the culvert for the Brightley Brook
4	70089657 -WSP-SHP3-WAT-DR-D-0101	
5	70089657 -WSP-SHP3-WAT-DR-D-0102	
6	70089657 -WSP-SHP3-WAT-DR-D-0103	
7	70089657 -WSP-SHP3-WAT-DR-D-0103	
8	70089657 -WSP-SHP3-WAT-DR-D-0103	Ground model created by WSP for Plot 3 design. Used to represent proposed surface of Plot 3 and adjacent area included in the 1D-2D linked model
9	Proposed surface.asc	

Brightley Brook

Flood Modeller (1D) and TUFLOW (2D) software have been used to build the hydraulic model of the Brightley Brook for this study. The entire model extent has been represented as a 1D-2D linked model. The model extent is shown in Figure 2. The downstream boundary of the model is located approximately 60m downstream of the location of the proposed culvert outlet. WSP acknowledged that it would have been more

appropriate to extend the model further downstream to the existing reservoir. However, the stretch of the watercourse between Plot 3 and the reservoir is in 3rd party land and WSP/client could not get access for the topographical survey. Therefore, the existing model has not been extended due to the unavailability of the topographical data and given that only a coarse model was required for this study.

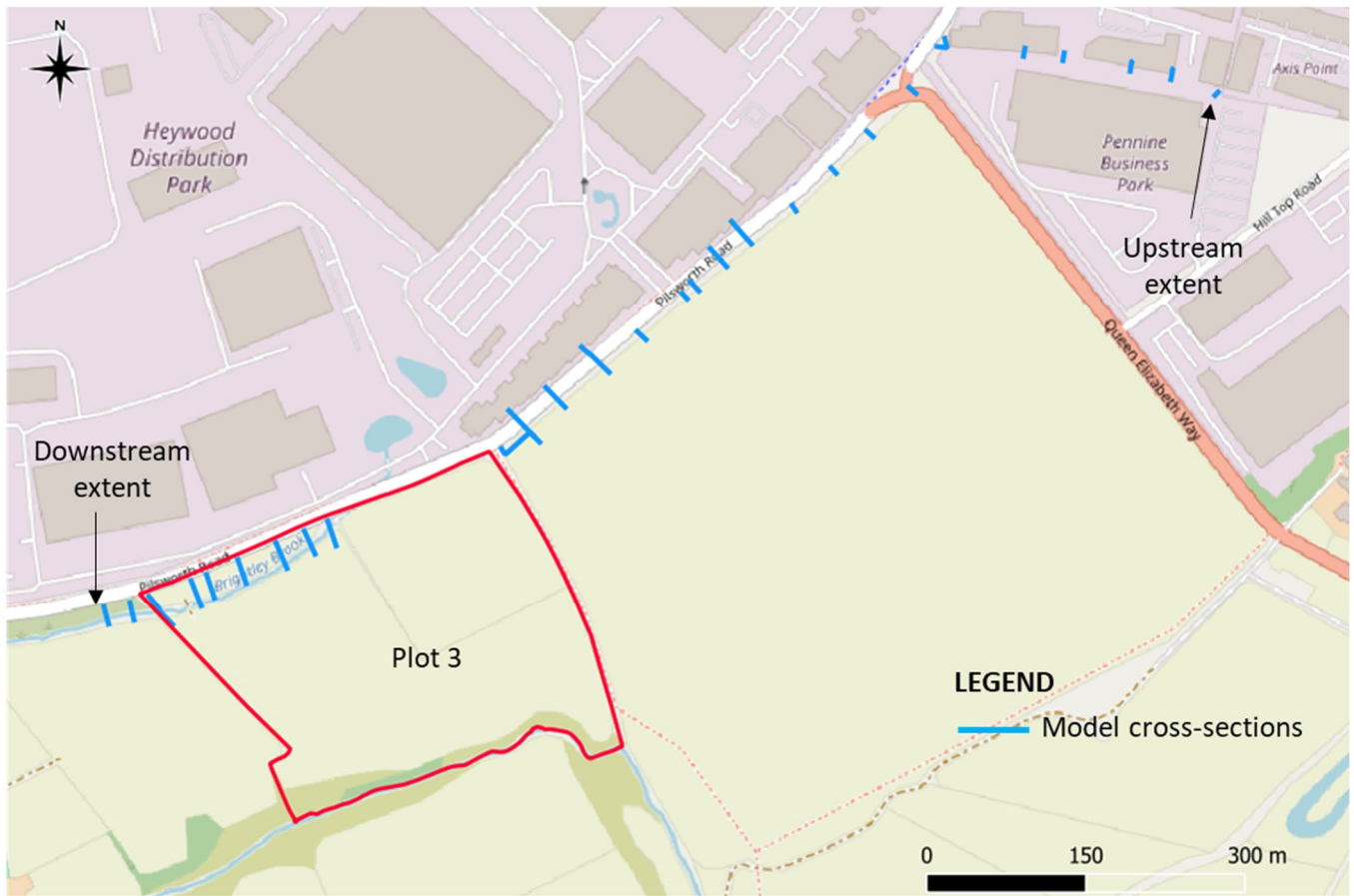


Figure 2 – Brightley Brook Model Extent

Appropriate Manning's roughness value has been used for the channel and floodplain based on the OS map review, site photographs and technical manual recommendations. The roughness value used in the existing model has also been reviewed. A roughness value in the range 0.03 - 0.04 has been used for the channel, whilst a value in the range 0.045 - 0.07 has been used for the floodplain.

The latest 2020 LiDAR data (1m resolution) has been downloaded from the EA website to represent a ground model in the 2D domain. The downstream boundary has been set up as a Normal Depth boundary at the location shown in Figure 2. As agreed in the meeting held on 27.01.2023, the hydraulic model has been run for one return period (1% AEP) with a climate change allowance of 35% which represents the 60-year epoch and central range allowance for Irwell Management Catchment¹.

The proposed in-channel features are composed of translocated riverbed material from the existing channel. These features represent approximately 3% of the overall channel cross section and will not have a significant impact on the capacity of the channel as this is within the expected tolerance for the mobilisation of sediment within the river channel. Therefore, they were not incorporated into the hydraulic modelling ground model, as their influence on long-term hydraulic conditions would be negligible.

¹ [Irwell Management Catchment peak river flows allowances](#)

Tributary of Brightley Brook

Normal depths calculations for open channels have been used to estimate water levels in the Brightley Brook tributary as agreed with the Environment Agency in the meeting held on 27.01.2023. A sensitivity analysis using a range of Manning's roughness coefficients has been undertaken to understand the impact of this parameter on the estimated water levels.

The proposed berms along the Brightley Brook tributary are designed by cutting into the existing riverbank, resulting in an effective increase in channel capacity. This intervention is anticipated to reduce the frequency and extent of flooding both on-site and downstream by providing additional conveyance and temporary water storage during high-flow events.

While this modification introduces a beneficial effect on flood management, it has not been incorporated into the hydraulic modelling ground model. By excluding the berms, the model provides a worst-case scenario for water levels and flood extents, which supports more robust decision-making for flood risk management. Additionally, this approach helps maintain a higher margin of safety in assessing potential downstream impacts.

HYDROLOGICAL ANALYSIS

Hydrological analysis has been carried out to derive the model inflows to the Brightley Brook and its tributary. Brightley Brook hydrological catchments are shown in Figure 3 below. Flood Estimation Handbook (FEH) statistical and Revitalised Flood Hydrograph rainfall-runoff method version 2 (ReFH2) methods have been used for the hydrological analysis. Peak flow derived from the two methods have been compared and suitable values have been chosen to include in the model. Hydrographs have been taken from ReFH2 analysis. Details and outcomes from the hydrology assessment are included in Appendix B.

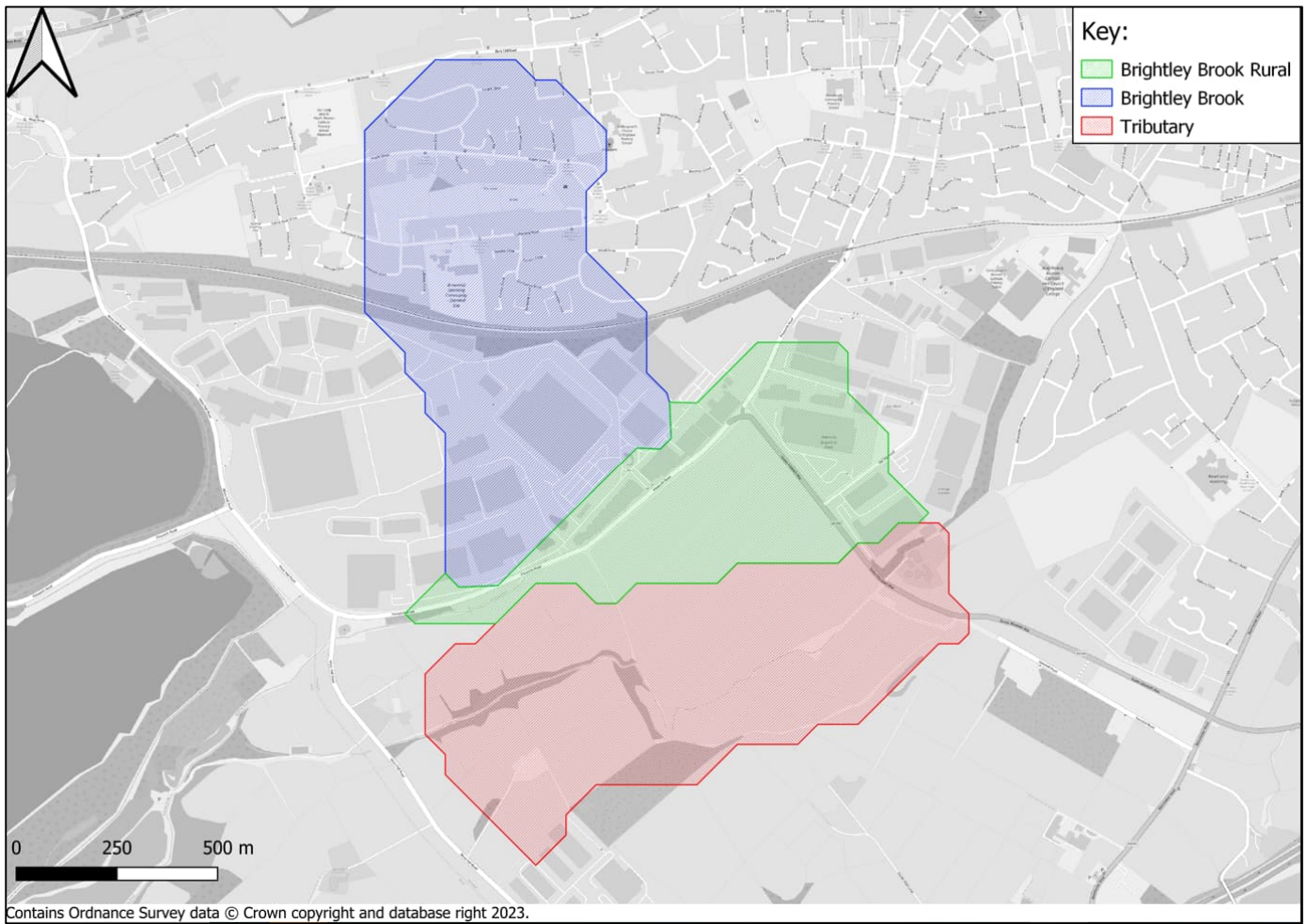


Figure 3 – Brightley Brook hydrological catchments

The peak flows used in the model derived from the FEH statistical method for three sub-catchments are presented in Table 2**Error! Reference source not found..** The detailed hydrological calculation is presented in Appendix B. Figure 4 shows the location of the inflow points in the model.

Table 2 – FEH statistical flow

Site code	Flood peak (m ³ /s) for the following return periods in years									
	2	5	10	20	30	50	75	100	200	1000
Brightley Brook (blue catchment)	0.96	1.22	1.44	1.71	1.90	2.18	2.44	2.66	3.27	5.45
Brightley Brook Rural (green catchment)	0.59	0.69	0.82	0.98	1.09	1.25	1.40	1.51	1.44	2.93
Tributary (red catchment)	0.37	0.51	0.62	0.74	0.83	0.94	1.05	1.13	1.35	2.06

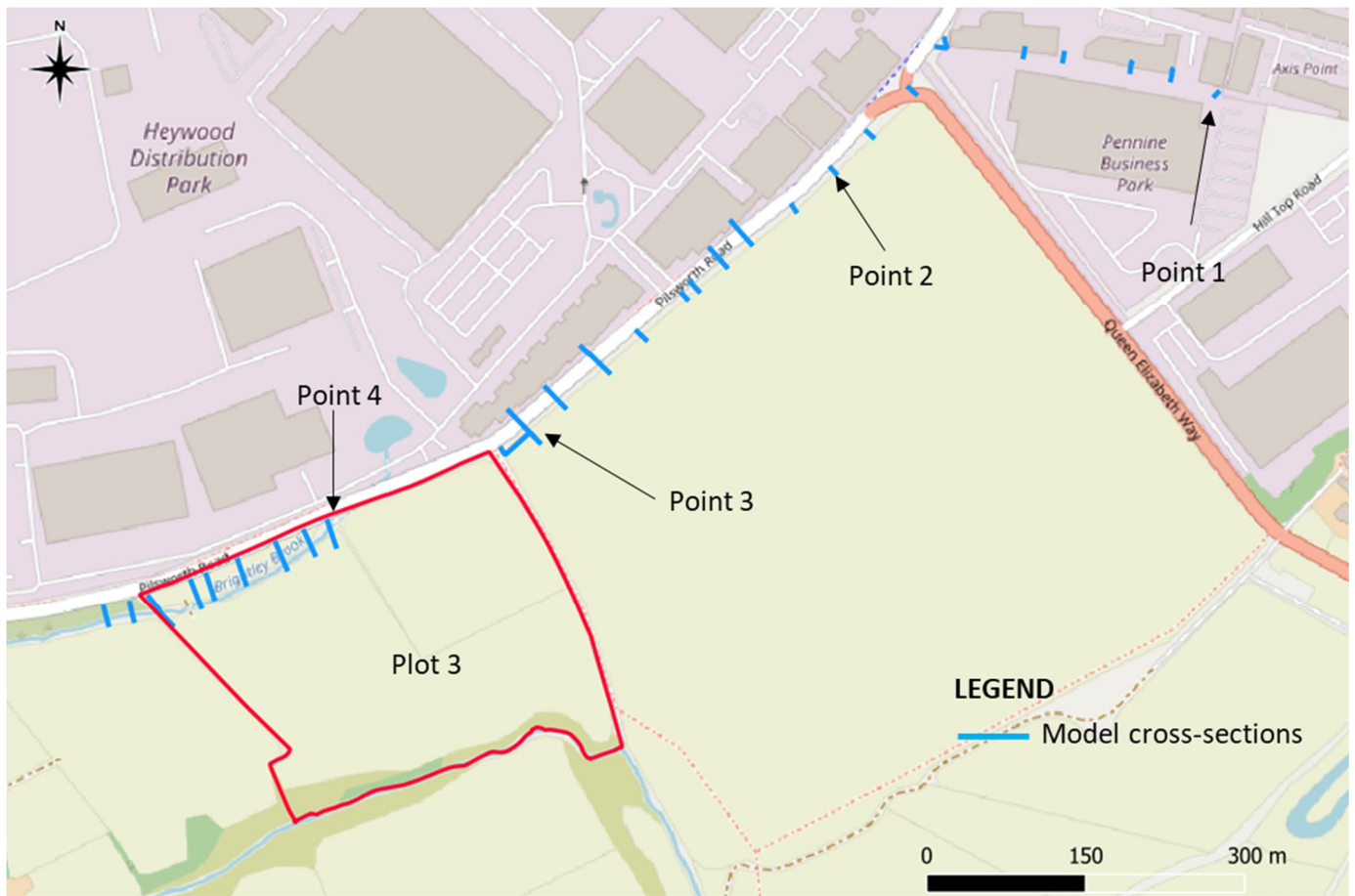


Figure 4 – Model Inflow Schematic

The peak flow derived for the rural area (green area in Figure 3) has been distributed in three locations (Point 1, Point 2 and Point 3) using the FMP lateral unit. 20, 50 and 30% flows were applied in Point 1, Point 2 and Point 3 respectively based on the proportion of the catchment area at each respective point. The peak flow derived for the urban area (blue area in Figure 3) has been applied at Point 4 just downstream of the existing long culvert.

MODELLING ASSUMPTIONS

The following modelling assumptions have been made:

- At this moment it is unknown the influence on water levels at the site due to the presence of a pond and a reservoir situated downstream of Plot 3 as shown in Figure 5. WSP does not have any information on the structural connection of the Brightley Brook to these ponds and reservoirs. For the modelling purpose, it has been assumed that the pond/reservoir will have a negligible impact on the water levels at the site.

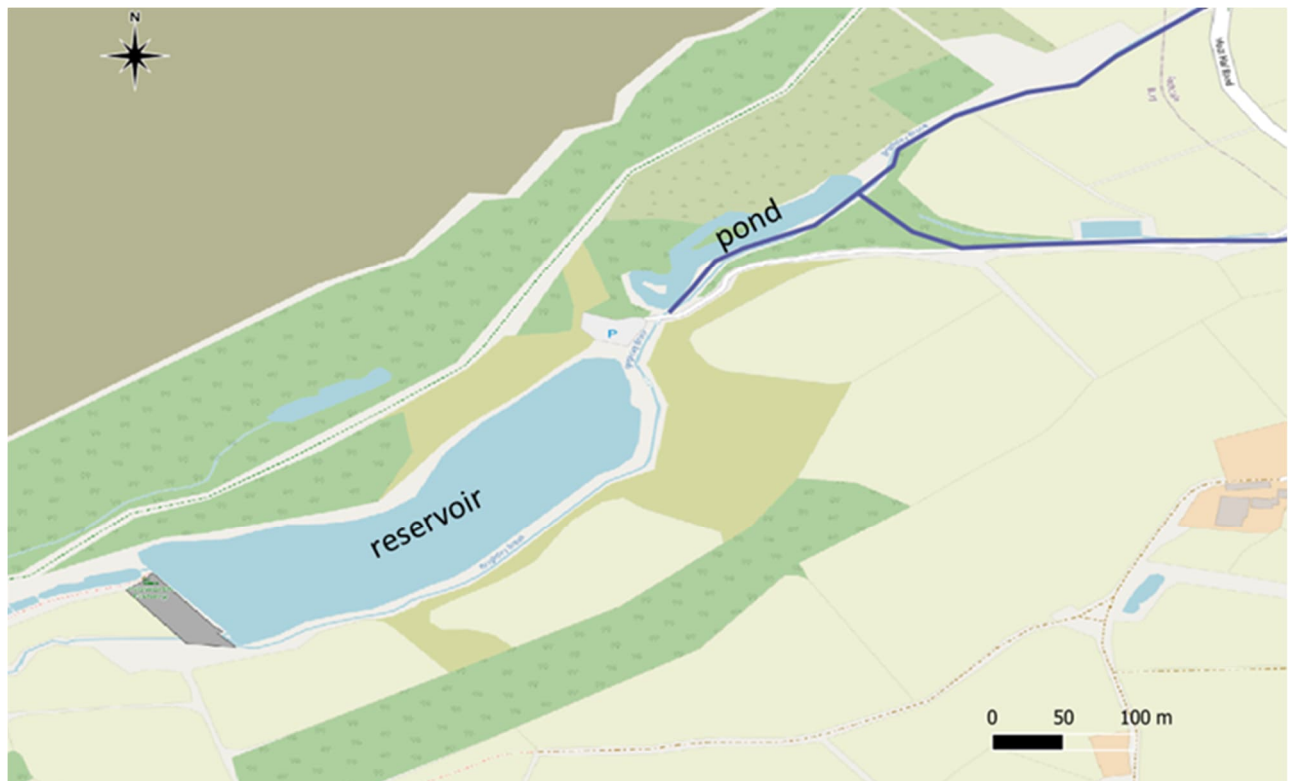


Figure 5 – Location of pond and reservoir downstream of Plot 3

- Hand calculations used to estimate water levels in the Brightley Brook tributary do not consider flow control and attenuation taking place on the long culverts located along the watercourse upstream of the development site (see Figure 6 below). Therefore, outcomes from calculations are expected to be conservative.
- The in-channel features proposed in the Brightley Brook, composed of translocated riverbed material, are designed to be naturally mobile and are expected to be transported during high-flow events (typically exceeding a 2-year return period). As these features are not considered permanent topographical changes, they were excluded from the hydraulic modelling ground model to avoid overestimating their long-term influence on channel hydraulics.
- The proposed berms along the Brightley Brook tributary are cut into the existing riverbank, increasing channel capacity and providing additional flood storage. While this is expected to reduce flood risk both on-site and downstream, the berms have not been incorporated into the hydraulic modelling ground model. This ensures a conservative approach is maintained by not assuming their positive effect on the assessment.



Figure 6 - Long culvert along tributary

MODELLING RESULTS

Brightley Brook

Baseline and post-development model results are presented in this section. The model results represent how the 1% AEP plus 35% climate change flood event will potentially impact the site. Figure 7 shows an overview of baseline flood extents and flood depths. Although riverbank overtopping is observed for the 1% AEP plus 35% and some inundation of the floodplain is observed in areas planned as car parks, these coincide with low spots in the topography.

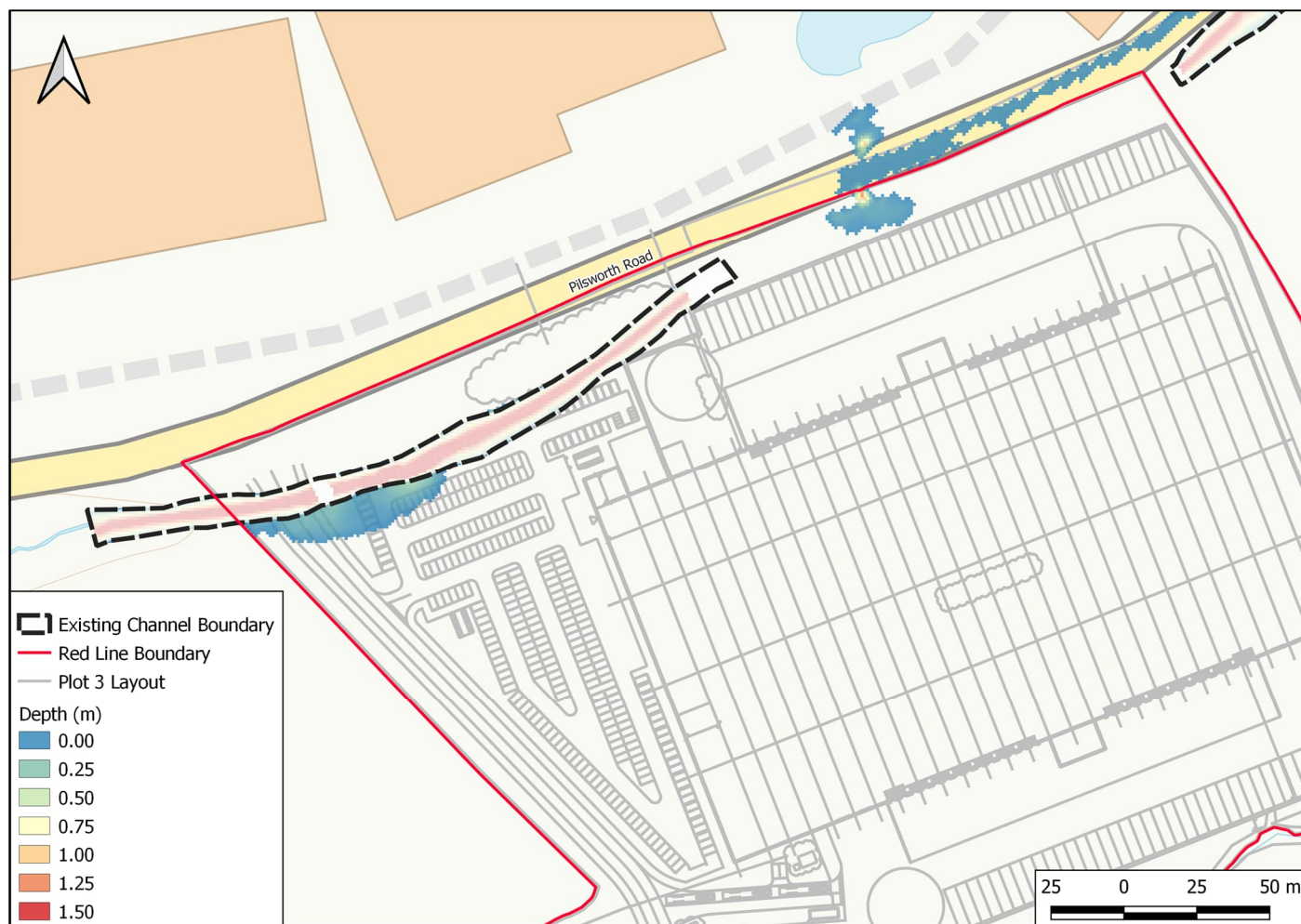


Figure 7 – Baseline flood depths

The proposed watercourse diversion (see

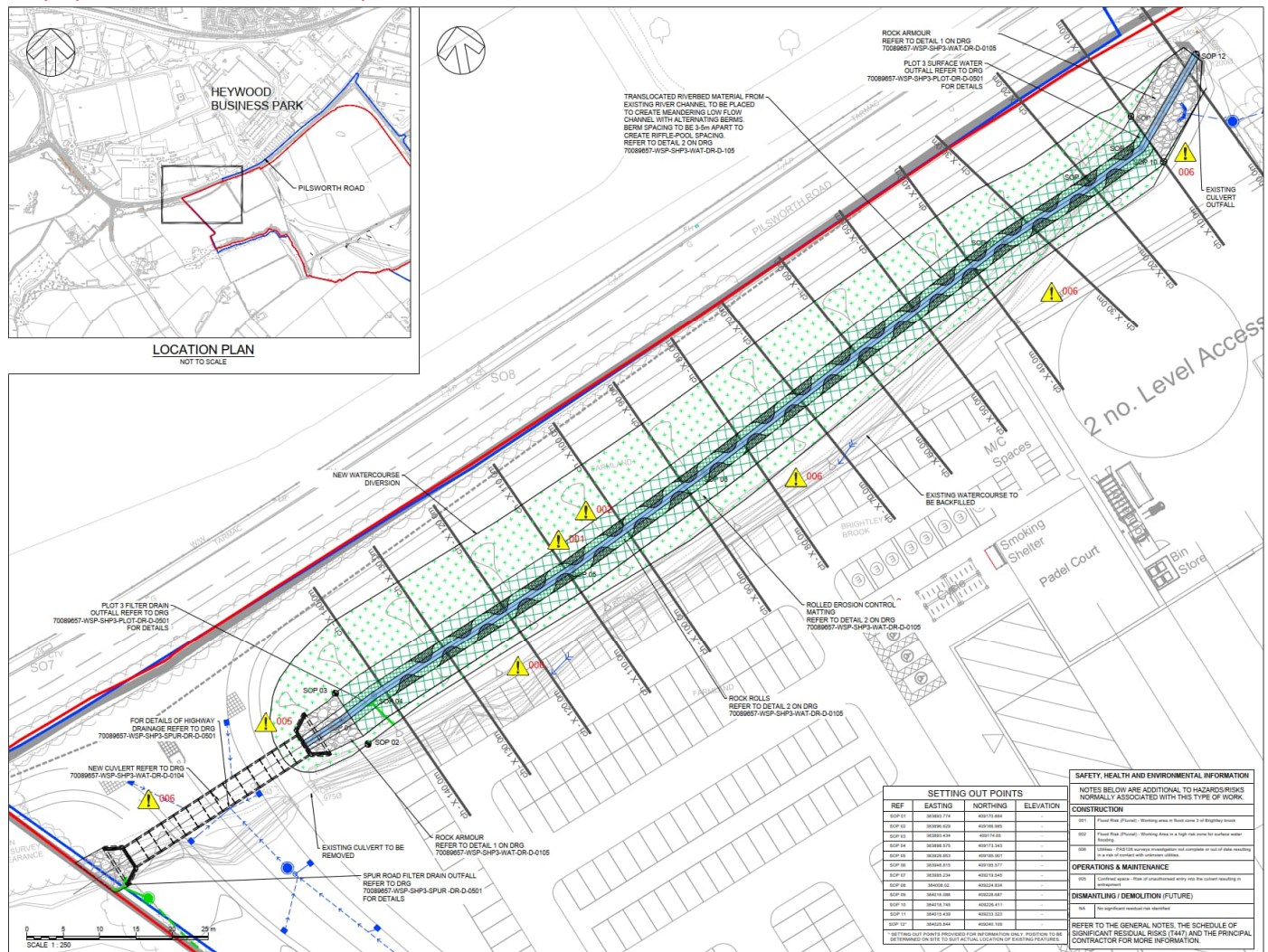


Figure 8 below and drawing 70089657-WSP-SHP3-WAT-DR-D-0100 for further details) comprises a channel with 1:3 natural bank slopes and a vertical profile with slope of approximately 1% that mimics the existing watercourse. A box culvert of 3mx3m and a length of 29m have also been included within the post-development hydraulic model. The baffle inside the culvert has not been explicitly included in the model. However, WSP has included comparatively high Manning's roughness value for culvert geometry (0.04), taking account of the potential future sediment deposit as well as the effect of the baffle.

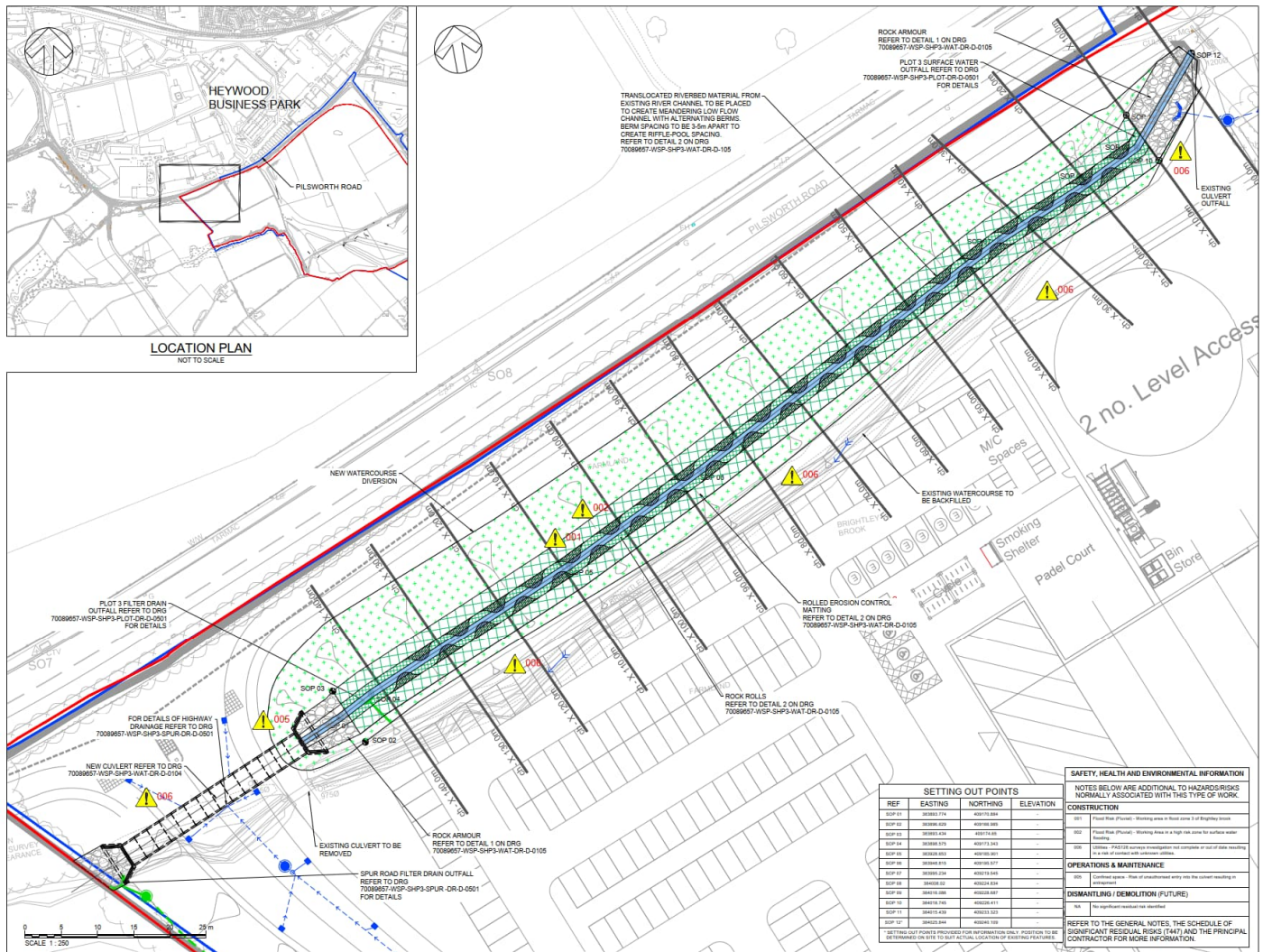


Figure 8 – General Arrangement watercourse diversion

Figure 9 shows flood extents and flood depths when the watercourse has been diverted, and the new culvert has been installed under the access road. These results show that the diverted watercourse can manage the 1% AEP plus 35% climate change flood event and flooding is unlikely to happen for flood events up to the 1% AEP plus 35% climate change allowance.

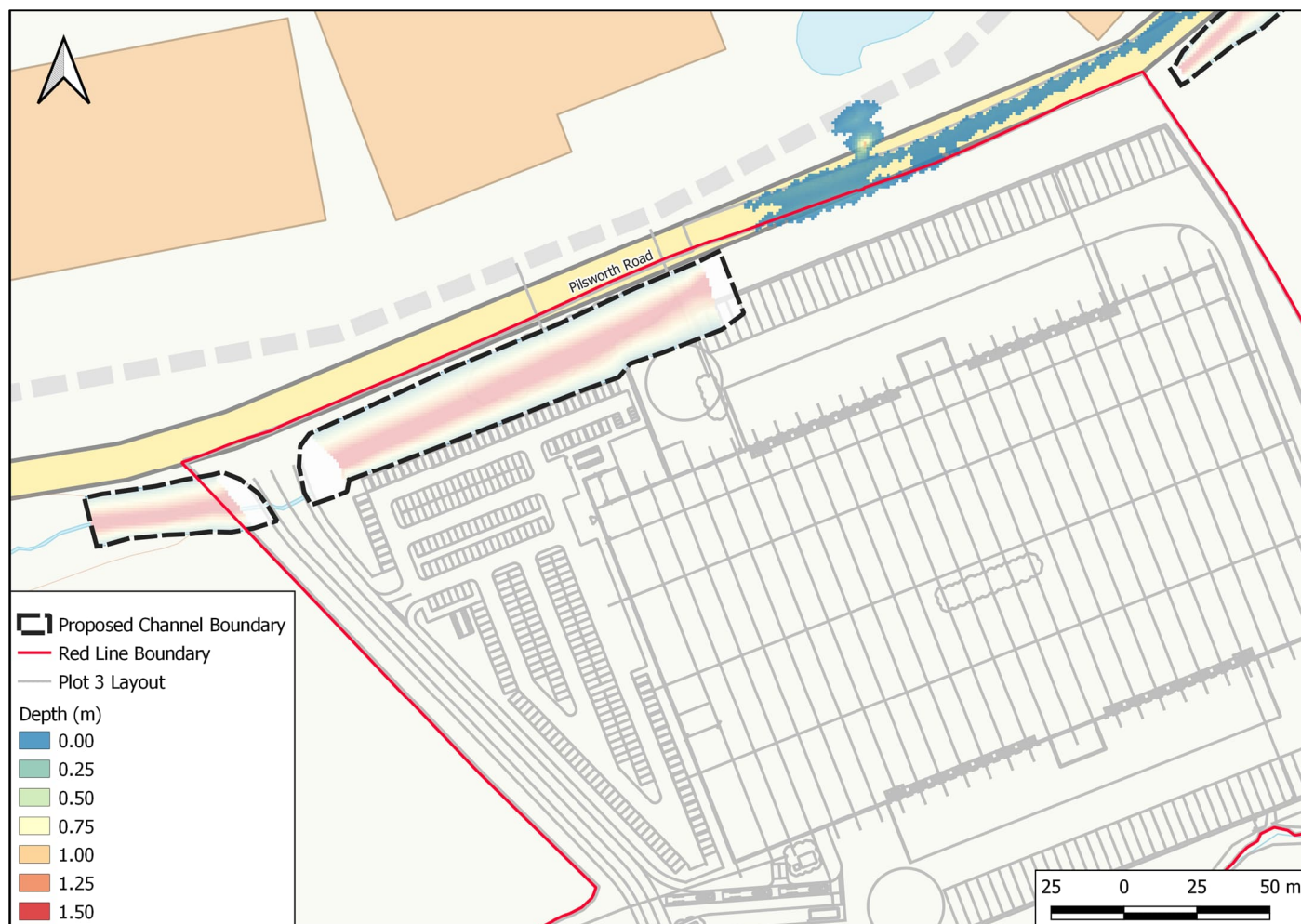


Figure 9 – Proposed flood depths

Error! Reference source not found. indicates the differences in water levels and water depths expected onsite at four locations within the site indicated in Figure 10 and Figure 11 for the run flood scenarios.

Table 3 - Comparison of maximum water depths and maximum water levels expected at key locations onsite

ID	Baseline 1% AEP Plus 35%CC		Post development 1% AEP Plus 35%CC	
	Maximum Water levels (m AOD)	Maximum Depths (m)	Maximum Water levels (m AOD)	Maximum Depths (cm)
1	No Flooding	No Flooding	No Flooding	No Flooding
2	No Flooding	No Flooding	No Flooding	No Flooding
3	No Flooding	No Flooding	No Flooding	No Flooding
4	111.23	0.055	No Flooding	No Flooding

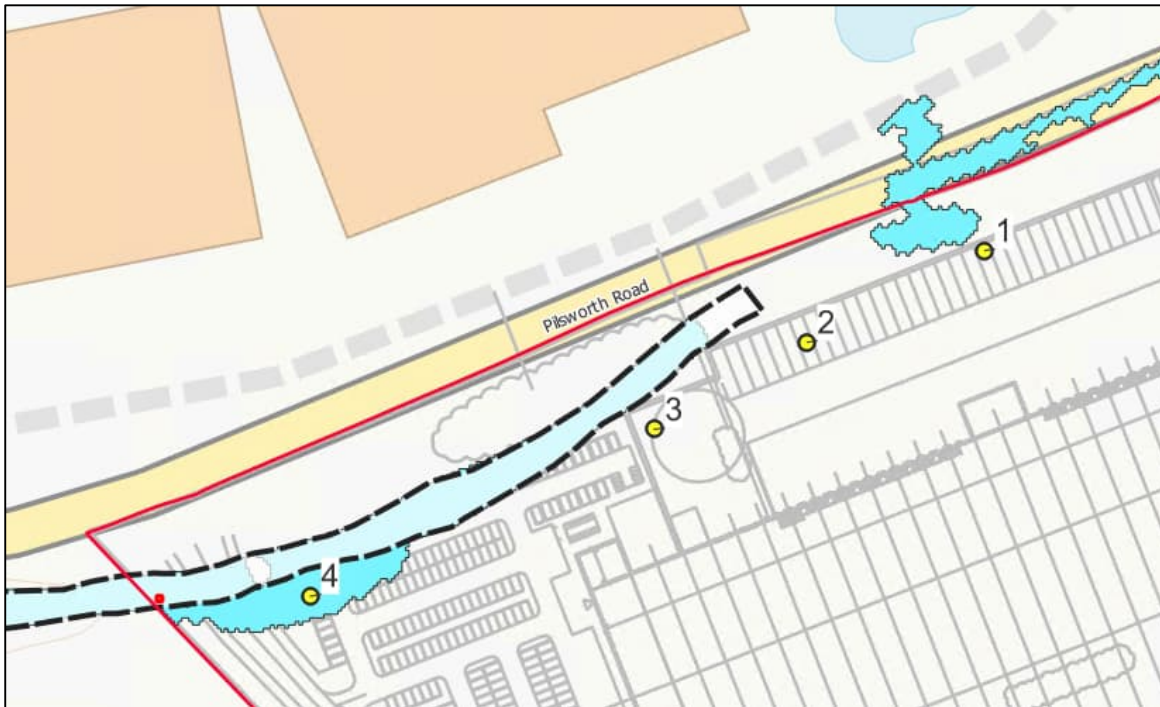


Figure 10 – Baseline maximum water depths (m) and water levels (mAOD) control points

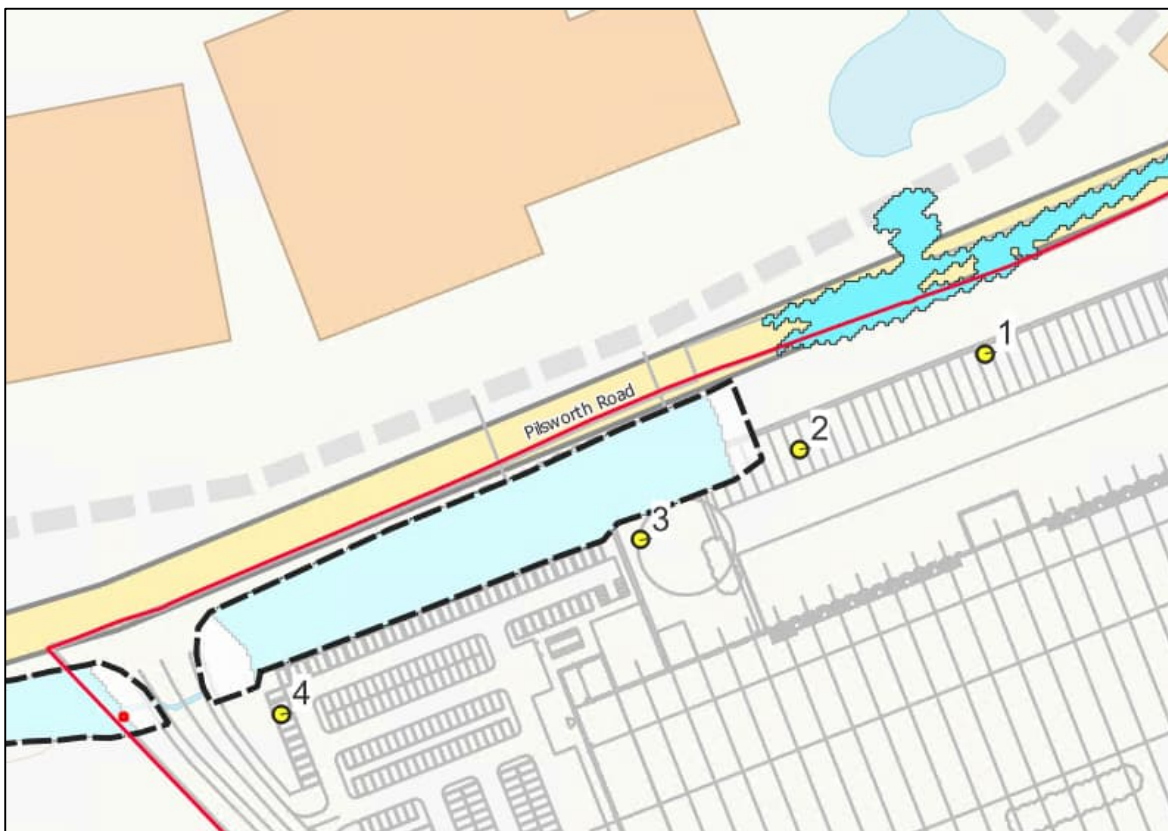


Figure 11 - Post-development maximum water depths (m) and water levels (mAOD) control points

The results show a reduction of flood depth and water levels in location 4 between baseline and post-development. No flooding is observed for the 1% AEP plus 35% climate change at locations 1, 2, and 3. There are no water volumes displaced due to the works required for the development. Therefore, it is unlikely that any sensitive receptor might be impacted.

Downstream of the proposed culvert, the water levels remain within the channel as shown in Figures 6 and 8 for both baseline and proposed scenario. Figure 12 (extracted directly from the FMP model) below shows water level comparison in the channel downstream of the proposed culvert.

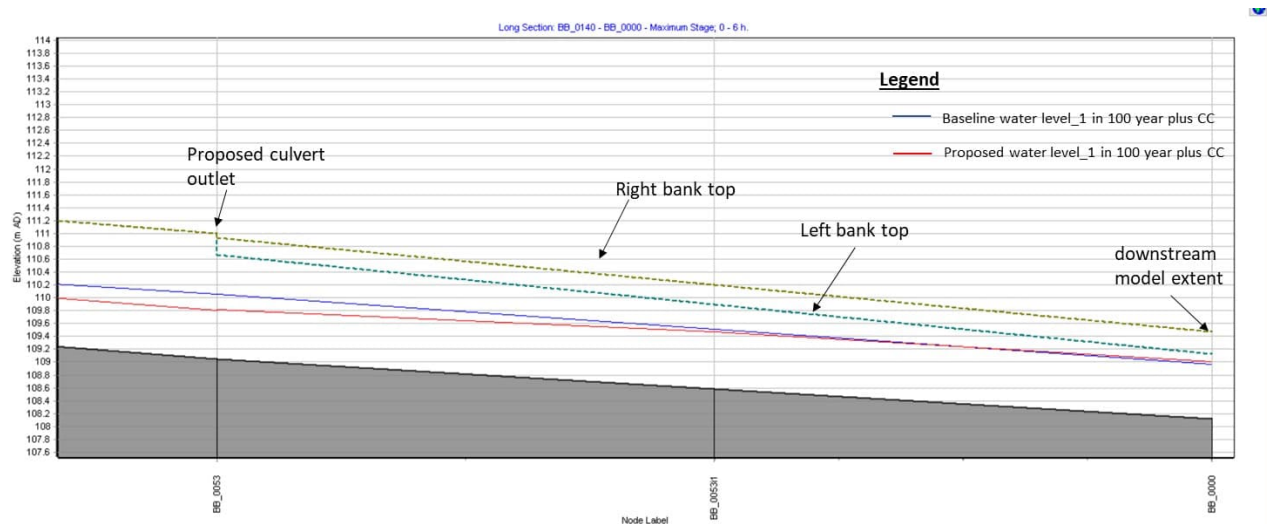


Figure 12 – Peak water level comparison

As shown in Figure 12, the proposed water levels are generally lower than the baseline water levels in the reach downstream of the proposed culvert except at the location of the downstream boundary, where the proposed water level is higher than the baseline water levels by 0.047m. However, the proposed water levels are well contained within the channel and therefore, it does not induce additional flooding.

Tributary of Brightley Brook

Normal depth calculation results for the locations indicated in Figure 13 are shown in Table 4.**Error! Reference source not found.:**

Table 4 - Comparison of approximate maximum water levels expected at key locations for different Manning's roughness

ID	Return Period 1%AEP Plus 35%CC			
	Top Riverbank level	Maximum Water levels (m AOD)		
		N = 0.1	N = 0.08	N = 0.06
1	113.49	112.18	112.17	112.16
2	113.84	113.61	113.56	113.44

The results show that the expected maximum water levels in the tributary for the flood event of 1% AEP plus 35% climate change is always below riverbank levels. It must be highlighted that the expected water levels are conservative values since the hydraulic control structures located upstream and the increase in capacity due to the berm excavation are not considered in the calculations. Therefore, it is concluded that the risk of flooding is negligible at this location.

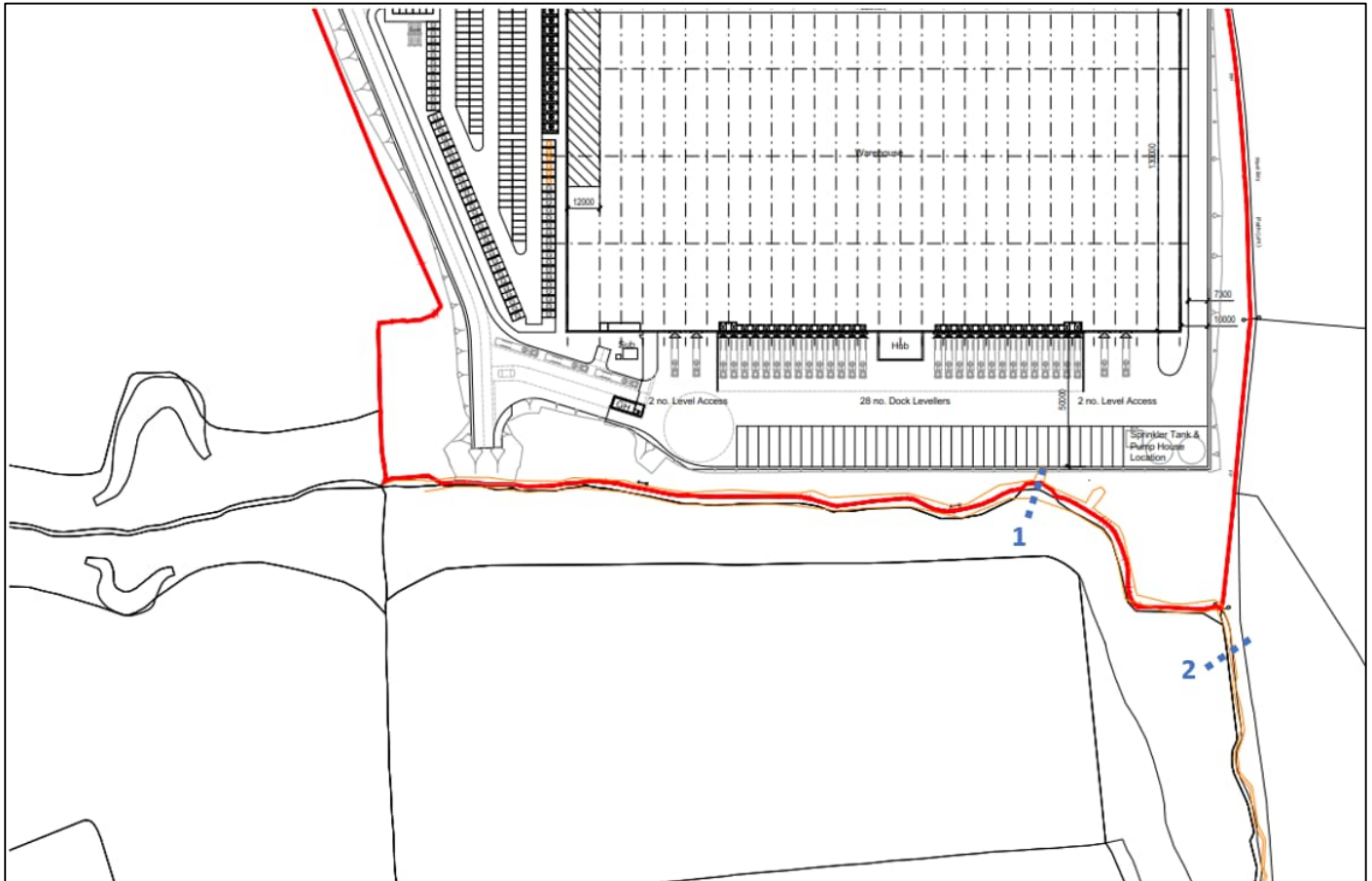


Figure 13 - Approximate location map of cross sections used for hand calculations

CONCLUSION

The purpose of this Technical Note is to review fluvial flood risk from the Brightley Brook and its tributary to inform the flood risk associated with Plot 3 of the South Heywood Commercial Project.

Site-specific baseline modelling results for Plot 3 show that most of the site is within Flood Zone 1 with a small area in the floodplain adjacent to the northern boundary within Flood Zone 3. Post-development flood modelling results show no flooding within the site boundary and no offsite sensitive receptors at risk of flooding as a result of developing this site.

Normal depths calculations carried out in a couple of sections along the Brightley Brook tributary indicate that flooding is not expected for any of the flood events including the 1% AEP plus 35% climate change allowance.

It is important to note that these calculations adopt a conservative approach, as they exclude the potential benefits of upstream hydraulic control structures and the increased channel capacity from the berm excavation. As such, the assessed flood levels may overestimate actual conditions, further reinforcing the conclusion of negligible flood risk.

Moreover, the proposed watercourse diversion and installation of a 3m x 3m, 29m-long box culvert have been incorporated into the post-development model. Despite the exclusion of the baffle from the model, a higher Manning's roughness coefficient (0.04) was applied to account for potential sediment deposits and the hydraulic influence of the baffle. The results indicate that the diverted watercourse can effectively convey the 1% AEP plus 35% climate change flood event without resulting in flooding.

At downstream locations, the post-development model results show water levels generally lower than baseline levels, except at the downstream boundary where a minor increase of 0.047m is observed. However, these levels remain well contained within the channel, and no additional flood risk is introduced.

In summary:

- **No Onsite Flooding:** Post-development modelling confirms no flooding within the site boundary for the 1% AEP plus 35% climate change scenario.
- **No Offsite Receptors at Risk:** Sensitive receptors downstream of Plot 3 are not adversely impacted by the development.
- **Conservative Approach:** Normal depth calculations applied conservative assumptions, excluding upstream hydraulic controls and increased capacity from berm excavation, further validating the low flood risk.
- **Effective Watercourse Management:** The proposed watercourse diversion and culvert installation effectively manage flow conveyance without inducing additional flood risk.

Therefore, fluvial flood risk is considered minimal, and no further flood mitigation measures are required.



APPENDIX A - ENVIRONMENT AGENCY CONSULTATION

Rochdale Metropolitan Borough Council
Development Control
Number One Riverside
Smith Street
ROCHDALE
Lancashire
OL16 1XU

Our ref: SO/2023/122868/01-L01
Your ref: 22/01569/OUT
Date: 27 February 2023

Dear Sir/Madam

OUTLINE APPLICATION (MEANS OF ACCESS ONLY) FOR THE ERECTION OF A CLASS B8 (STORAGE OR DISTRIBUTION) DEVELOPMENT AND ASSOCIATED WORKS LAND ON PLOT 3 OF THE SOUTH HEYWOOD MASTERPLAN OFF PILSWORTH ROAD SOUTH HEYWOOD, ROCHDALE

Thank you for referring the above application to the Environment Agency, which we received on the 25 January 2023. We would wish to make the following comments.

Environment Agency position

Based on the two waterbodies crossing through the proposed plot 3 greenfield site, we would wish to see the following River Corridor Strategy condition be included as part of decision notice for outline planning application to ensure the Brightley Brook waterbodies and main green infrastructure assets are positively integrated and enhanced as part of new riparian development, as outlined in the D&A (Ashton Smith, Nov 2022) and as stipulated within the wider Northern Gateway strategic allocation site JPA1.1 (Places for Everyone).

**River Corridor Strategy
Condition**

No development shall take place until a detailed River Corridor Strategy for overall Plot 3 development site has been submitted to, and be approved in writing by, the local planning authority in consultation with the Environment Agency. The content of the strategy shall include the following:

1. Full details of earthworks including any required land remodelling or remediation works, and vegetation clearance on and adjacent to both Brightley Brook waterbodies.

Environment Agency
Richard Fairclough House Knutsford Road, Warrington, WA4 1HT.
Customer services line: 03708 506 506
www.gov.uk/environment-agency

Cont/d..

2. details of any required diversion of waterbodies associated within plot 3 development, based on sound geomorphological understanding of both existing and new channel hydrology; and based on design using more environmentally sympathetic bio-engineering solutions.
3. Provide pre and post scheme detailed cross-sections (a minimum 6 cross-sections along both stream corridors, and particularly at pinch points of scheme design), showing the new commercial scheme; including new landform or retaining solutions (if required) along both northern and southern reaches of Brightley Brook.
4. Construction details for the formation of any new embankments, retaining structures and revetments.
5. details of enhancement opportunities integrated into overall scheme proposals i.e., sky lighting of existing culverted sections of waterbody, ecological/geomorphological improvements to existing modified agricultural channels etc.
6. Measures adopted to protect and preferably improve Brightley Brook's water quality, during both scheme construction and operation.
7. Full details of proposed new soft landscaping scheme including planting schedule predominantly based on native species along both ecological corridors.
8. Integrated invasives non-native species (INNS) treatment programme within riparian corridor.
9. details of any new surface water connections to rivers; and
10. Biodiversity enhancement strategy for the Brightley Brook waterbodies and key green infrastructure assets; preferably informed by Biodiversity Metric 3.1 assessment of riparian development site; that ensures net gain in the riverine environment for Plot 3 development site.

The development shall be undertaken in full accordance with the approved strategy and the measures retained thereafter.

Reason

To ensure the protection and positive integration of both Brightley Brook waterbodies, linking wildlife corridors, and main green infrastructure assets; securing opportunities for the enhancement of the nature conservation value of the site in accordance with Rochdale Core Strategy Policies G6, G7 & G8, Places for Everyone policy JPA1.1, and the National Planning Policy Framework.

Design options for any new revetments or embankments should preferably be guided by relevant best environmental practice literature promoting green engineering options (<https://www.hrwallingford.com/projects/green-infrastructure-supporting-green-river-engineering>); and design new site surface water drainage based on best practice CIRIA guidance in regards to the construction or removal of redundant surface water outfalls (CIRIA Culvert, Screen and Outfall manual C786) and adopting multifunctional Sustainable Urban Drainage solutions (C753).

Please send me a copy of the decision notice and forward a copy of this letter to the applicant.

Yours faithfully

Mrs. SYLVIA WHITTINGHAM
Planning Advisor

Direct dial [REDACTED]
Direct e-mail [REDACTED]

Berbel Roman, Soledad

From: [REDACTED]
Sent: 23 December 2022 10:55
To: Berbel Roman, Soledad
Subject: GMMC293056AB Information attached

Dear Soledad,

Re: Product 4, 6 &7: South Heywood Distribution Park

Thank you for your enquiry which was received on 21/12/22.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

Our officer has advised that the site is located approximately 1.7km away from the nearest modelled watercourse and according to our data is in Flood Zone 1. The nearest modelling is the Nationalised 2004 JFlow modelling which is approximately 1km away from the site location. We can provide this information if you would like it, but please note that JFlow data is not suitable for use in conjunction with an Flood Risk Assessment. We are currently undertaking new nationalised JFlow modelling but there is no information as to when this will be delivered. Please let me know if you would like the JFlow data.

Please refer to the [Open Government Licence](#) which explains the permitted use of this information.

Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Kind regards,

Anne Ball
Customer and Engagement Officer
Greater Manchester, Merseyside and Cheshire
Email: [REDACTED]

Office address: Richard Fairclough House, Knutsford Road, Latchford, Warrington, WA14 4UW

From: Berbel Roman, Soledad [REDACTED] >
Sent: 21 December 2022 17:10
To: Enquiries, Unit [REDACTED]
Cc: Markose, Louise [REDACTED] >
Subject: Product 4, 6 &7: South Heywood Distribution Park

Good afternoon,

WSP has been appointed to undertake the flood risk assessment of the Masterplan for the wider South Heywood Distribution park (Post Code OL10 2RF, Grid Ref SD 83675 09025). The project involves the construction of a warehouse incorporating internal office space at circa 319,000sq/ft (Unit 3) as indicated in the figure below. The proposed development is surrounded by the Brightley Brook and a tributary both classified as main rivers.

C.WEM, MCIWEM, CEng MICE, MEng, MSc
Water Risk Management and Engineering, WEI
Future Ready Champion



WSP House
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London
WC2A 1AF

wsp.com

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Berbel Roman, Soledad

From: Bryan, John [REDACTED] >
Sent: 04 January 2023 09:47
To: Berbel Roman, Soledad; Markose, Louise
Cc: GMMC Info Requests
Subject: RE: GMMC293056AB FOLLOW ON

Morning Soledad,

Thanks for your email, I will be able to answer the following for you (see comments in red):

Based on your response below, I wanted to confirm the following:

- The watercourse next to the development is a main river own by the Environment Agency, however it is not a modelled watercourse; **The Environment Agency do not own any watercourses, we have permissive powers to maintain the watercourses, but ownership would fall under riparian ownership - [Owning a watercourse - GOV.UK \(www.gov.uk\)](https://www.gov.uk/government/publications/owning-a-watercourse)**
- The proposed development involve a diversion of the existing watercourse and the implementation of a new culvert. Would modelling be required to support the Flood Risk Activity Permit? **To divert a watercourse that is designated as main river it quite an extensive process. We require a full Water Framework Directive (WFD) assessment, full ecology report, modelled levels providing the proposal will not increase flood risk elsewhere, as part of the permitting process.**

Finally, regarding a culvert, the Agency are extremely unlikely to permit a new culvert. We are opposed to the culverting of any watercourse because of the adverse ecological, flood risk, geomorphological, human safety and aesthetic impacts. Watercourses are important linear features of the landscape and should be maintained as continuous corridors to maximise their benefits to society. Applicants will be expected to demonstrate why culverting is both necessary and the only reasonable and practicable alternative. Alternatives could include open span bridges, revisions to site layout or diversion of the watercourse. Where it has been robustly demonstrated that the culverting is both necessary and the only reasonable practicable alternative, the length of any culvert should be restricted to the minimum necessary to meet the applicant's objective.

I think it would be best for us to have a team's meeting to discuss the requirements for the site.

Anne – You can close the request; I will liaise with Soledad and Louise directly.

John

John Bryan | Flood & Coastal Risk Management Officer
FCRM - Partnerships & Strategic Overview
Greater Manchester, Merseyside and Cheshire Area
The Environment Agency
Richard Fairclough House, Knutsford Road, Warrington, WA4 1HT

External: [REDACTED]

Creating a better place
for people and wildlife



From: Berbel Roman, Soledad [REDACTED]
Sent: 03 January 2023 14:20
To: GMMC Info Requests [REDACTED]
Cc: Markose, Louise [REDACTED]
Subject: RE: GMMC293056AB Information attached

You don't often get email from [REDACTED]

Dear Anne,

Thank you very much for the information provided.

Based on your response below, I wanted to confirm the following:

- The watercourse next to the development is a main river own by the Environment Agency, however it is not a modelled watercourse;
- The proposed development involve a diversion of the existing watercourse and the implementation of a new culvert. Would modelling be required to support the Flood Risk Activity Permit?

Thank you very much.

Best Regards,



Soledad Berbel Roman

Principal Engineer
Location Lead London and Guildford
C.WEM, MCIWEM, CEng MICE, MEng, MSc
Water Risk Management and Engineering, WEI
Future Ready Champion

T [REDACTED]

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From: GMMC Info Requests <[REDACTED]>
Sent: 23 December 2022 10:55
To: Berbel Roman, Soledad <[REDACTED]>
Subject: GMMC293056AB Information attached

Dear Soledad,

Re: Product 4, 6 &7: South Heywood Distribution Park

Thank you for your enquiry which was received on 21/12/22.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

Our officer has advised that the site is located approximately 1.7km away from the nearest modelled watercourse and according to our data is in Flood Zone 1. The nearest modelling is the Nationalised 2004 JFlow modelling which is approximately 1km away from the site location. We can provide this information if you would like it, but please note that JFlow data is not suitable for use in conjunction with an Flood Risk Assessment. We are currently undertaking new nationalised JFlow modelling but there is no information as to when this will be delivered. Please let me know if you would like the JFlow data.

Please refer to the [Open Government Licence](#) which explains the permitted use of this information.

Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Kind regards,

Anne Ball

Customer and Engagement Officer

Greater Manchester, Merseyside and Cheshire

Email: [REDACTED]

Office address: Richard Fairclough House, Knutsford Road, Latchford, Warrington, WA14 4UW

From: Berbel Roman, Soledad [REDACTED]

Sent: 21 December 2022 17:10

To: Enquiries, Unit [REDACTED]

Cc: Markose, Louise [REDACTED]

Subject: Product 4, 6 &7: South Heywood Distribution Park

Good afternoon,

WSP has been appointed to undertake the flood risk assessment of the Masterplan for the wider South Heywood Distribution park (Post Code OL10 2RF, Grid Ref SD 83675 09025). The project involves the construction of a warehouse incorporating internal office space at circa 319,000sq/ft (Unit 3) as indicated in the figure below. The proposed development is surrounded by the Brightley Brook and a tributary both classified as main rivers.



including Main River Map changes



4

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Berbel Roman, Soledad

Subject: FW: 13230: Plot 3, South Heywood - Design Workshop
Location: Microsoft Teams Meeting

Start: Mon 16/01/2023 14:00
End: Mon 16/01/2023 15:00
Show Time As: Tentative

Recurrence: (none)

Meeting Status: Not yet responded

Organizer: Charlotte Fuller

-----Original Appointment-----

From: Charlotte Fuller [REDACTED] >

Sent: 10 January 2023 15:56

To: [REDACTED]

[REDACTED]

[REDACTED]

Cc: [REDACTED]

Subject: 13230: Plot 3, South Heywood - Design Workshop

When: 16 January 2023 14:00-15:00 (UTC+00:00) Dublin, Edinburgh, Lisbon, London.

Where: Microsoft Teams Meeting

Afternoon All,

Following feedback received in the environment agency meeting yesterday, we thought it best to schedule time in for a design workshop to discuss the way forward regarding the site access/culvert proposal, river diversion and embankments.

This will follow any further comments as a result of the site walk round on Friday afternoon.

For those not in yesterday's meeting, in summary:

- A culvert will not be accepted under a FRAP application.
This means the design team need to reconsider site access via a bridge. Proximity of construction to the bell mouth off Pilsworth Road will need to be considered here.
- A meandering/natural watercourse diversion is of preference as a linear solution would be deemed a deterioration of the existing watercourse from an ecology perspective.
- It would be preferential to have shallower banks which can be more easily maintained and have a more natural look.
This may require more land take.

The above items will determine finalisation of the masterplan, so your input to refine these details would be greatly appreciated.

Many thanks,

Charlotte Fuller
Architect



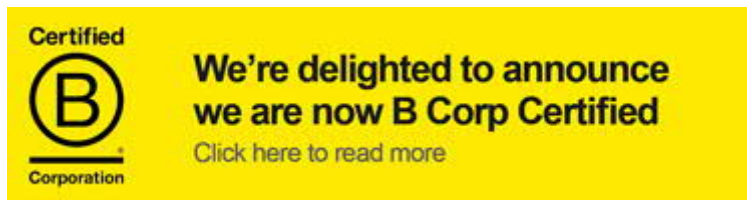
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We work flexibly – so whilst it suits me to email now, I don't expect a response or action outside of your working hours.

Microsoft Teams meeting



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Berbel Roman, Soledad

From: Ryan Holland <[REDACTED]>
Sent: 30 January 2023 10:31
To: [REDACTED]
Cc: [REDACTED]
Subject: SHP3; EA Pre-App Consultation Meeting Nr 2 2023 - Minutes
Attachments: RE: South Heywood Masterplan - Hydraulic Modelling Approach

All,

Further to Friday's teams meeting, please see below minutes and notes from the call for reference.

Thanks

Ryan

SHP3 North/South EA Main River Pre-App Consultation – Meeting Nr 2

Attendees:

- [REDACTED]

Distribution:

All present, plus;

- [REDACTED]

Date and Time:

- Friday 27th January 2023 @ 1pm - 2pm

Agenda:

1. Southern watercourse sections review & parameters discussion
2. Northern watercourse boundary improvements, culvert principle
3. Fluvial modelling requirements and outputs

Notes:

1. Southern watercourse –
 - a. DWa – WSP have prepared sections at key areas of interest. Existing levels are shown in green and proposed are shown in red. To be issued to EA for review following meeting.
 - b. DWa – Watercourse profile can be reasonably well defined. Top of channel taken from the topo survey.
 - c. DWa – Localised section of retaining structure likely required between CH50.000m and CH75.000 due to path of the watercourse into the development area. Extent of retaining wall to be reviewed as design progresses.
 - d. DWa – 70deg reinforced earth slopes proposed which is a standard approach across the wider park – including to alongside the large batter to the south east. Reinforced earth suggested as doesn't require anything too structural, or systems which could affect the watercourse by introducing foundations and additional loads, etc.
 - e. DWa – Minimum separation of 3.8m at the pinch point (CH61.696m) – toe of slope filter drain may reduce this further by approximately 0.5m. Development level hasn't been fixed at this stage until site plan can be confirmed.
 - f. JBr commented - If no flood risk, then there no concern about proximity of earthworks to watercourse.
 - g. GMo – the northern and southern watercourses should be viewed as one proposal – and therefore the design principles of both watercourses are needed. An improvement to the north may offset the requirements at the south.
 - h. RHo – raised artificial bund alongside river corridor to be removed back down to the assumed original level – to improve ecology.
 - i. RHo – To improve landscaping and ecology most suitable option is to introduce 1:3 landscaped earthworks batters at the boundary of the scheme where possible.
 - j. DCh – 1:3 earthworks batters can be planted with native trees, hedgerows, low level shrubs and other habitat rich elements. This would not be possible if 70deg structural retaining walls are introduced to significant lengths along the boundary of the site.
2. Northern watercourse -
 - a. CFu - the site plan has moved to the south, and has resulted in sections shown in the meeting to the south watercourse, but gives more opportunity to improve the design to the North.
 - b. CFu - the north yard has been chamfered to provide more area for meandering to the watercourse directly north of the service yard area.
 - c. GMo - opening up the existing culvert upstream of the headwall has environmental / ecology benefits.
 - d. DWa – background information given regarding the previous consultation and work previously undertaken prior to this consultation stage. Previous White Young Green drawings set principle of meander to the north which has since been improved.
 - e. GMo - Multi-functional SUDs preferred where feasible.
 - f. JBr – Groundwater needs to be consulted. PMN – contact details issued [attached email – Hydraulic Modelling Approach].
 - g. JBr – Wide box culvert preferred for maintenance underneath the access road (either landowner or by EA).
 - h. GMo – Length of culvert to be kept to minimum possible. Embedment required to the box culvert. Minimum 300mm below bed level.
3. Modelling requirements
 - a. JBr - Don't need to model. 26% CC rate based on a 30-year design life for the building included in proposed modelling strategy, however, minimum that is to be included is 35% on a 60-year design life. Needs to stay in the watercourse bank when factoring in CC. Creating more capacity in the area due to the improvement works. Qualitative assessment only suitable because river sited in flood zone 1. Main risks to the site are surface water discharge (under LLFA control). Run off rates to be limited. Fluvial assessment to be a quick calculation. Little detail needed. Cross sections every 100m etc are not required. Watercourse is located at the top of the catchment, no documentation or detailed flood modelling in the area. Only a high-level flood output required showing what is going

into the system. Limiting the surface water run-off. Permit is a formality. Planning permission is the main focus. Permit is the method statement.

- b. DWa – Surface water proposals to be discussed and agreed with LLFA. Anticipate that discharge rates will be limited to Q_{bar} . Possible requirements for to have an outfall into the southern watercourse to ensure the proposed drainage regime matches existing. Pollution prevention to be in place. Limited availability of SUDs due to site plan however there are large attenuation ponds across the wider masterplan. Detailed drainage strategy will be submitted as part of the detailed RM application.

Thanks



Ryan Holland BSc (Hons)
Lead Design Manager

13 Westpoint Enterprise Park, Clarence Avenue, Trafford Park, Manchester, M17 1QS

russell-ldp.co.uk

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APPENDIX B – HYDROLOGICAL ASSESSMENT

CALCULATION CONTROL SHEET

PROJECT: South Heywood Scheme

PART OF PROJECT: South Heywood Model Hydrology

CALCULATION TITLE: South Heywood FEH Methods

FILE LOCATION: <\\uk.wspgroup.com\Central Data\Projects\70103xxx\70103659 - South Heywood - Plot 3 Infrastructure\03 WIP\FD Flooding\Hydrology>

CALCULATION SUMMARY

This report provides a record of the calculations and decisions made during design flood estimation using the techniques of the Flood Estimation Handbook (Institute of Hydrology, 1999).

Purpose of Calculations

To generate peak flows and hydrographs for input into the South Heywood model.

CHECKING AND REVIEW STATUS

Rev	Purpose	Author	Reviewed	Authorised	Date
1	Hydrology Assessment	EK	PG	TJ	06/02/2023

REVISION HISTORY

Revision Ref./ Date Issued	Date	Purpose and description of Amendments	Issued to
1	06/02/2023	Hydrology Assessment	South Heywood

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Abbreviations

AM.....	Annual Maximum
AREA	Catchment area (km ²)
BFI	Base Flow Index
BFIHOST	Base Flow Index derived using the HOST soil classification
CD.....	Catchment Descriptors
CFMP	Catchment Flood Management Plan
CPRE.....	Council for the Protection of Rural England
FARL.....	FEH index of flood attenuation due to reservoirs and lakes
FEH.....	Flood Estimation Handbook
FSR.....	Flood Studies Report
HOST	Hydrology of Soil Types
NRFA	National River Flow Archive
POT.....	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
RaDAR.....	Radio Detection and Ranging
ReFH	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
SPR.....	Standard percentage runoff
SPRHOST	Standard percentage runoff derived using the HOST soil classification
Tp(0)	Time to peak of the instantaneous unit hydrograph
UAF.....	Urban Adjustment Factor
URBAN	Flood Studies Report index of fractional urban extent
URBEXT1990	FEH index of fractional urban extent
URBEXT2000	Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH	Windows Frequency Analysis Package – used for FEH statistical method

Introduction

This calculation record document provides a record of the calculations and decisions made during flood estimation. The information given here should enable the work to be reproduced in the future. This version of the record is for studies where flood estimates are needed at multiple locations.

1 Method Statement

Table 1.1: Overview of study

Item	Comments
Purpose of study Give an overview which includes: • Purpose of study • Approx. no. of flood estimates required • Peak flows or hydrographs?	The purpose of this study is to determine peak flow estimates and hydrographs for the Brightley Brook in South Heywood and the associated tributary.
Description of catchment Brief description of catchment, or reference to section in accompanying report	The catchment of the Brightley Brook - rural and the tributary drains from east to west. The urbanised Brightley Brook catchment drains from north to south. The FEH catchments were taken from an inflow point downstream of the site. FEH defined the tributary catchment correctly, but the Brightley Brook catchment was split into the northern catchment and eastern catchment based on site knowledge and descriptors were updated accordingly. Area, Urbext and DPLBar were updated. Soil mapping indicates that the catchment is underlain by a combination of slowly permeable seasonally wet acid loamy and clayey soils and naturally wet very acid sandy and loamy soil. The Brightley brook catchment to the north is fairly steep but the other two are moderately flat.
Flood estimates required	The model will be run with the following flood estimates: 2yr, 10yr, 20yr, 30yr, 50yr, 75yr, 100yr, 200yr & 1000yr

Table 1.2: Source of flood peak data

Was the HiFlows-UK dataset used? If so, which version? If not, why not? Record any changes made	HiFlows-UK v11 (latest version as of August 2022)
---	---

Table 1.3: Gauging Stations (flow or level data available at sites or nearby donor catchments)

Watercourse	Station Name	Gauging authority number	NWA number (used in FEH)	Grid reference	Catchment Area (km ²)	Rating?	Period of available data
Calder	Mytholmroyd	N/A	27088	SE011260	141.9 km ²	Theoretical	1989-2022
Lostock	Wincham Brook	N/A	68007	SJ697757	148km ²	Theoretical	1960-2018

Table 1.4: Data available at each Gauging Station

Station Name	Start and end of data in HiFlows-UK	Update from EA for this study? Dates?	Suitable for QMED?	Suitable for pooling?	Data Quality Check needed?
Mytholmroyd	1989-2022	N/A	Yes	Yes	No
Wincham Brook	1960-2018	N/A	Yes	No	No

Station Name	Start and end of data in HiFlows-UK	Update from EA for this study? Dates?	Suitable for QMED?	Suitable for pooling?	Data Quality Check needed?
Comments on data quality (inc. rating) and any checks made	27088 Calder @ Mytholmroyd: Heavily reservoiried. Estimated 21.4% of catchment area drains through around 8 impoundments. Net export of water; Hebden Water Reservoirs provide supply to Halifax. Effluent and (minor) minewater discharge can affect flow pattern. Offtake into Rochdale Canal can also reduce flows. 68007 Lostock @ Wincham Brook: Minor abstractions and discharges.				

Table 1.5: Rating Equations

Station Name	Type of rating e.g. theoretical, empirical; degree of extrapolation	Rating review needed?	Reasons e.g. availability of recent flow gaugings, amount of scatter in the rating.
Mytholmroyd	Theoretical	No	Gauged up to water year 2022. The scatter around the rating curve is limited.
Wincham Brook	Theoretical	No	Gauged up to water year 2018. The scatter around the rating curve is limited.

Table 1.6: Other data available

Item	Comments
Flow / levels gaugings	Based on NRFA gauging station dataset we understand there are no flow or level gauging stations in the South Heywood area.
Historic flood data	N/A
Extra data for other sites in pooling groups	All pooling group data taken from HiFlows-UK v11 and NRFA, no additional data collated.
Flow data for events	N/A
Rainfall data for events	N/A
Potential evaporation data / MORECS data	N/A
Results from previous studies / models	N/A
Other data (e.g. Groundwater, tidal)	N/A

Table 1.7: Initial choice of approach

Item	Comments
Outline the conceptual model, addressing questions such as: - Where are the main sites of interest? - What is likely to cause flooding at those locations? (peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides...) - Might those locations flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir? - Is there a need to consider temporary debris dams that could collapse?	The main site of interest is south of Pilsworth Road in South Heywood. The site is unlikely to flood from runoff generated on part of the catchment only. There is no need to consider temporary debris dams that could collapse.
Any unusual catchment features to take into account? e.g. - highly permeable – avoid ReFH if BFIHOST >0.75 (or BFIHOST19 >0.65), consider permeable catchment adjustment for statistical method if SPRHOST <20% - highly urbanised – avoid standard ReFH if URBEXT2000>0.150; consider FEH Statistical or other alternatives; consider method that can account for differing sewer and topographic catchments - pumped watercourse – consider lowland catchment version of rainfall-runoff method - major reservoir influence (FARL<0.90) – consider flood routing, extensive floodplain storage – consider choice of method carefully	At this stage, no catchment descriptors have been deemed as unusual. The SPRHOST values of the Brightley Brook and Tributary catchments are 37.84% and 34.02% respectively, indicating that the site is neither highly permeable nor highly impermeable. The BFIHOST19 values are recorded at 0.386 and 0.542 which are similar between the two catchments. Both catchments have a FARL value of 1, indicating there is no influence from reservoirs or lakes across the catchments. The urbanisation across the area of interested is classified as very heavily urbanised for the Brightley Brook catchment with an URBEXT2000 value of 0.4857. The Tributary catchment is considered essentially rural with an URBEXT2000 value of 0.0.

Table 1.7: Initial choice of approach

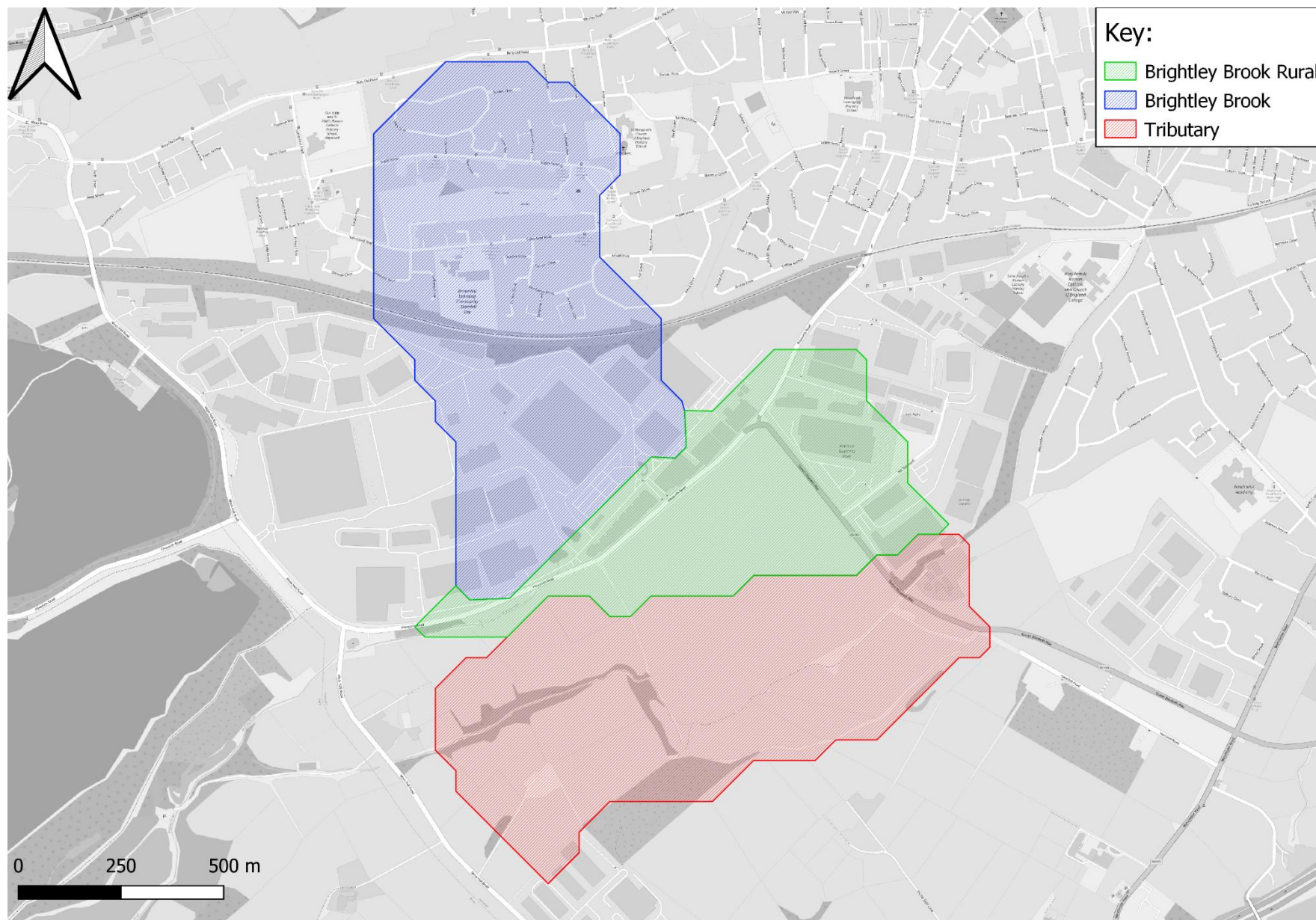
Item	Comments
Is FEH appropriate? (it may not be for very small, heavily urbanised or complex catchments) Outline the choices available and whether appropriate for the sites of interest: • FEH Statistical (single site or pooled?) • FEH rainfall-runoff • Revitalised rainfall runoff • loH124 • Rational Method • Hybrid approach?	Based on the catchment characteristics the FEH Statistical and ReFH2 methods are considered appropriate. The FEH Statistical pooling group method is appropriate for the two sites chosen with catchment areas over 0.5km² and an SPRHOST over 20%. Both methods will be applied to enable a comparison of flows within the catchments. A Hybrid approach of fitting the REFH2 hydrograph to the peak flows from the FEH Statistical pooled analysis for an ungauged catchment is the most appropriate. Single point flow estimates and hydrographs are needed at the downstream confluences of each watercourse.
Initial choice of method(s) and reasons • Will the catchment be split into subcatchments? If so, how?	The Brightley Brook catchment will be split into two catchments. One catchment drains from east to west, hereafter referred to as Brightley Brook Rural. The other catchment drains from north to south, hereafter referred to as Brightley Brook.
Software to be used (with version numbers)	WINFAP v5 and REFH 2.3

2 Locations where flood estimates are required

The table below lists the locations of hydrological points of interest (for all subject sites). The site codes listed below are used in all subsequent tables to save space. A map showing the hydrological boundaries and downstream points of interest is shown in Figure 2.1.

Table 2.1: Summary of hydrological points of interest (all subject sites)

Site code	Watercourse	Site	Grid Reference		Catchment area from FEH WEB (km ²)	Revised area if required (km ²)
BRIG HTLE Y BROO K	Brightley Brook	Northern Brightley Brook Catchment	383750	409150	1.03km ²	0.646km ²
BRIG HTLE Y BROO K RURA L	Brightley Brook Rural	Eastern Brightley Brook Rural Catchment	383750	409150	1.03km ²	0.383km ²
Tributary	Tributary	Tributary	383800	408850	0.595km ²	0.595km ²
Reasons for choosing hydrological points of interest (subject sites)		The Brightley Brook catchment and the Brightley Brook Rural catchment covers all areas draining into the Brightley Brook. The Tributary Catchment covers all areas draining into the Tributary.				
How catchment descriptors were checked		FEH catchment boundaries were downloaded from the FEH web service and considered to be appropriate. The Brightley Brook was split into two subcatchments in order for the flows to be split appropriately between two inflow points in the model. They were checked using global mapper to delineate the catchments using LiDAR but these delineated catchments were fairly different from the FEH catchments and not considered to be accurate. The FEH catchment boundaries were therefore taken forward and the AREA, URBEXT and DPLBAR were updated accordingly. BFIHOST and SPRHOST were not updated due to the urbanisation of the catchments.				



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Figure 2.1: Map of catchment

3 Data used in analysis

Catchment Descriptors from FEH Web Service at the hydrological points of interest have been extracted for use in this study.

For the design runs, the URBEXT 2000 values were updated to 2020 for each sub-catchment. The method used to adjust QMED for urbanisation is that published in Kjeldsen (2010)¹ in which PRUAF (percentage runoff urban adjustment factor) is calculated from BFIHOST.

$$PRUAF = 1 + 0.47 \cdot URBEXT_{2000} (BFIHOST / (1 - BFIHOST))$$

N.B. The FEH Web Service provides URBEXT values for the year 2000 (URBEXT₂₀₀₀). URBEXT₂₀₀₀ is not simply an update of URBEXT₁₉₉₀ but it is based on new data produced using different mapping techniques.

Table 3.1 shows the re-statement of the categories of urbanisation distinguished in the FEH according to their URBEXT 1990 values, together with 'equivalent' URBEXT 2000 values.

Table 3.1: Categories of catchment urbanisation related to FEH

Category	URBEXT1990	URBEXT2000
Essentially rural	0.000 <_ URBEXT ₁₉₉₀ < 0.025	0.000 <_ URBEXT ₂₀₀₀ < 0.030
Slightly urbanised	0.025 _ URBEXT ₁₉₉₀ < 0.050	0.030 _ URBEXT ₂₀₀₀ < 0.060
Moderately urbanised	0.050 _ URBEXT ₁₉₉₀ < 0.125	0.060 _ URBEXT ₂₀₀₀ < 0.150
Heavily urbanised	0.125 _ URBEXT ₁₉₉₀ < 0.250	0.150 _ URBEXT ₂₀₀₀ < 0.300
Very heavily urbanised	0.250 _ URBEXT ₁₉₉₀ < 0.500	0.300 _ URBEXT ₂₀₀₀ < 0.600
Extremely heavily urbanised	0.500 _ URBEXT ₁₉₉₀ _ 1.000	0.600 _ URBEXT ₂₀₀₀ _ 1.000

In addition to updating URBEXT to 2020 values, URBEXT values were checked, and adjustments were made based on visual inspection of Ordnance Survey maps and satellite imagery. The original catchment descriptors and the final catchments descriptors (With adjusted URBEXT) used in the analysis are provided in Tables 3.2 and 3.3.

Table 3.2 shows the original catchment descriptors for each point of interest.

Table 3.2: Catchment descriptors

CD	Brightley Brook	Brightley Brook Rural	Tributary
Grid Ref	383750, 409150	383750, 409150	383800, 408850
AREA	1.03	1.030	0.595
ALTBAR	123	123	121
ASPBAR	216	216	249
ASPVAR	0.49	0.49	0.42
BFIHOST	0.344	0.344	0.433
BFIHOST19	0.386	0.386	0.542
DPLBAR	1.01	1.01	0.84
DPSBAR	28.3	28.3	36.7
FARL	1.000	1.000	1.000
FPEXT	0.11	0.11	0.10
FPDBAR	0.626	0.626	0.887
FPLOC	0.6	0.6	0.4
LDP	1.7	1.7	1.9
PROPWET	0.6	0.6	0.6
RMED-1H	10.9	10.9	10.9
RMED-1D	35.5	35.5	35.2
RMED-2D	48.40	48.40	48.20
SAAR	1057	1057	1051
SAAR4170	1110	1110	1098
SPRHOST	37.840	37.840	34.020
URBCONC ₁₉₉₀	0.519	0.519	-999999.000
URBEXT ₁₉₉₀	0.1553	0.1553	0.0000
URBLOC ₁₉₉₀	1.022	1.022	-999999.000
URBCONC ₂₀₀₀	0.885	0.885	-999999.000
URBEXT ₂₀₀₀	0.4857	0.4857	0.0000

¹ Kjeldsen, T. R. (2010). Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrol. Res. 41. 391-405.

URBLOC ₂₀₀₀	0.918	0.918	-999999.000
C	-0.02600	-0.02600	-0.02600
D1	0.34531	0.34531	0.34111
D2	0.42007	0.42007	0.42402
D3	0.376	0.376	0.368
E	0.301	0.301	0.302
F	2.467	2.467	2.472
C(1km)	-0.0260	-0.0260	-0.0260
D1(1km)	0.3430	0.3430	0.3430
D2(1km)	0.4200	0.4200	0.4200
D3(1km)	0.3630	0.3630	0.3630
E(1km)	0.3020	0.3020	0.3020
F(1km)	2.4720	2.4720	2.4720
Adjusted URBEXT ₂₀₀₀ to URBEXT ₂₀₂₃	0.507	0.507	0.0
Notes on changes made:	URBEXT2000 factor used = 1.04		

Table 3.3 shows the catchment descriptors to be used for each point of interest.

Table 3.3: Catchment descriptors

CD	Brightley Brook	Brightley Brook Rural	Tributary
Grid Ref	383750, 409150	383750, 409150	383800, 408850
AREA	0.646	0.383	0.595
ALTBAR	123	123	121
ASPBAR	216	216	249
ASPVAR	0.49	0.49	0.42
BFIHOST	0.344	0.344	0.433
BFIHOST19	0.386	0.386	0.542
DPLBAR	0.789	0.591	0.752
DPSBAR	28.3	28.3	36.7
FARL	1.000	1.000	1.000
FPEXT	0.11	0.11	0.10
FPDBAR	0.626	0.626	0.887
FPLOC	0.6	0.6	0.4
LDP	1.7	1.7	1.9
PROPWET	0.6	0.6	0.6
RMED-1H	10.9	10.9	10.9
RMED-1D	35.5	35.5	35.2
RMED-2D	48.40	48.40	48.20
SAAR	1057	1057	1051
SAAR4170	1110	1110	1098
SPRHOST	37.840	37.840	34.020
URBCONC ₁₉₉₀	0.519	0.519	-999999.000
URBEXT ₁₉₉₀	0.1553	0.1553	0.0000
URBLOC ₁₉₉₀	1.022	1.022	-999999.000
URBCONC ₂₀₀₀	0.885	0.885	-999999.000
URBEXT ₂₀₂₁	0.514	0.305	0.023
URBLOC ₂₀₀₀	0.918	0.918	-999999.000
C	-0.02600	-0.02600	-0.02600
D1	0.34531	0.34531	0.34111
D2	0.42007	0.42007	0.42402
D3	0.376	0.376	0.368
E	0.301	0.301	0.302
F	2.467	2.467	2.472
C(1km)	-0.0260	-0.0260	-0.0260
D1(1km)	0.3430	0.3430	0.3430
D2(1km)	0.4200	0.4200	0.4200
D3(1km)	0.3630	0.3630	0.3630
E(1km)	0.3020	0.3020	0.3020
F(1km)	2.4720	2.4720	2.4720

4 Statistical Method

The FEH statistical method constructs a flood frequency curve based on the estimation of QMED, which is then used to calculate peak flow estimates for each return period. FEH methods should not normally be applied on heavily urbanised catchments (with an URBEXT value greater than 0.5) or catchments smaller than 0.5km². This method was only used on catchments 1-8 as the REFH2 method was deemed more appropriate for the additional sites.

Table 4.1: Search for donor sites (if applicable)

Comment on potential donor sites: • Number of potential donor sites available • Distances from subject site • Similarity in terms of AREA, BFIHOST, FARL and other catchment descriptors • Quality of flood peak data • Include a map if necessary. Note that donor catchments should usually be rural.	For the Brightley Brook catchment, 2 donor stations were taken forwards for analysis. Any donor station further than 20km away from the site was rejected as stations further than 20km from the site have limited impact on QMED adjustment. Stations with low FARL and BFIHOST values were also rejected. Both taken forward have areas which are largely greater than the Brightley Brook and the closest station has a relatively smaller BFIHOST values but was retained due to its proximity to the site.																				
	The stations taken forward and their catchment descriptors are presented in the table below:																				
	<table><tr><th>Station</th><th>Station Number</th><th>Area</th><th>SAAR</th><th>BFIHOST95</th><th>FARL</th><th>Years of Data</th></tr><tr><td>Calder @ Mytholmroyd</td><td>27088</td><td>146.868</td><td>1360</td><td>0.354</td><td>0.945</td><td>29</td></tr><tr><td>Witham @ Colsterworth</td><td>30017</td><td>148.34</td><td>818</td><td>0.541</td><td>0.942</td><td>54</td></tr></table>	Station	Station Number	Area	SAAR	BFIHOST95	FARL	Years of Data	Calder @ Mytholmroyd	27088	146.868	1360	0.354	0.945	29	Witham @ Colsterworth	30017	148.34	818	0.541	0.942
Station	Station Number	Area	SAAR	BFIHOST95	FARL	Years of Data															
Calder @ Mytholmroyd	27088	146.868	1360	0.354	0.945	29															
Witham @ Colsterworth	30017	148.34	818	0.541	0.942	54															
	For the Brightley Brook Rural, the same donor stations were taken forward as both catchments are within the same location and therefore have very similar catchment descriptors and distances from the site.																				

Methods:

AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer; CD – Catchment descriptors alone. When QMED is estimated from POT data, it should also be adjusted for climatic variation.

Table 4.2: Donor sites chosen and QMED adjustment factors

NWA number	Watercourse	Station	Reason	AM or POT	QMED from flow data (A)	QMED from CDs (B)	Adj ratio (A/B)
27088	Calder	Mytholmroyd	Most suitable FARL	AM	82.325	83.546	0.985
30017	Witham	Colsterworth	Most suitable FARL	AM	20.402	20.091	1.015
If a spreadsheet has been used to calculate QMED insert link here:							

The data transfer procedure is the revised one from Science Report SC050050. The QMED adjustment factor A/B for each donor site is given in Table 4.2. This is moderated using the power term, a , which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial estimate from catchment descriptors.

$$a = 0.4598 \cdot \exp(-0.020 \cdot d_{ij}) + (1 - 0.4598) \cdot \exp(-0.4785 \cdot d_{ij})$$

If more than one donor has been used, use multiple rows for the site and give the weights used in the averaging. Record the weighted average adjustment factor in the penultimate column.

Table 4.3: Estimation of QMED at subject sites

Site Code	Method	Initial QMED from CDs (m ³ /s)	Initial QMED from CDs (m ³ /s)						Final estimate of QMED (m ³ /s)
			NRFA no. used	Distance between centroid s d _{ij}	Power term, a	Moderated QMED adjustment factor, (A/B) ^a	If more than one donor		
							Weight	Weighted ave. adjustment	
Brightley Brook	DT	0.615	27088	6.2	0.301	0.995	0.301	0.266	0.614
			30017	16.45	0.231	0.996	0.231		
Brightley Brook Rural	DT	0.394	27088	5.8	0.301	0.995	0.301	0.266	0.394
			30017	18.68	0.231	0.996	0.231		
Tributary	DT	0.364	27088	21.13	0.298	1.004	0.298	0.266	0.363
			30017	34.51	0.234	1.003	0.234		
Are the values of QMED consistent, for example at successive points along the watercourse and at confluence?					N/A				

Pooling groups were derived using the revised procedures from Science Report SC050050 (2008). Several subject sites may use the same pooling group.

Table 4.4: Derivation of pooling groups

Name of Group	Site code for which group initially derived	Subject site treated as gauged? (enhanced single site analysis)	Changes made to default pooling group with reasons. Note also any sites that were investigated but retained in the group.	Weighted average L-moments, L-CV and L-skew (before urban adjustment)
Brightley Brook	Brightley Brook	No	The initial pooling group had 525 years of records from 15 stations with an H₂ value of 3.7075. The following stations were removed from the initial pooling group: 27073 Brompton Beck @ Snainton Ings 26016 Gypsey Race @ Kirby Grindalythe 26017 Ings Beck @ South Newbald 44008 South Winterbourne @ Winterbourne Steepleton All four stations were removed as they were highly permeable stations with low SPRHOST values and high BFIHOST values. This lowered the station record to 408. To increase the years of data the following stations were added: 25003 Trout Beck @ Moor House 27032 Hebden Beck @ Hebden 48009 St Neot @ Craigshill Wood The pooling group station record was then increased to 521 years. No further stations were removed or	L-CV_{initial} = 0.182 L-Skew_{initial} = 0.334 L-CV_{final} = 0.226 L-Skew_{final} = 0.272

			added to the pooling group at this stage. The H ₂ value for this final pooling group was 0.7739. This is considered to be acceptably homogeneous.	
Brightley Brook Rural	Brightley Brook Rural	No	The initial pooling group had 525 years of records from 15 stations with an H₂ value of 2.6170. The following stations were removed from the initial pooling group: • 27073 Brompton Beck @ Snainton Ings • 26017 Ings Beck @ South Newbald • 26016 Gypsy Race @ Kirby Grindalythe • 44008 South Winterbourne @ Winterbourne Steepleton All four stations were removed as they were highly permeable stations with low SPRHOST values and high BFIHOST values. This lowered the station record to 408. To increase the years of data the following stations were added: • 25003 Trout Beck @ Moor House • 27032 Hebden Beck @ Hebden • 91802 Allt Leachdale @ Intake The pooling group station record was then increased to 543 years. No further stations were removed or added to the pooling group at this stage. The H₂ value for this final pooling group was 1.6170. This is considered to be Possibly Heterogeneous.	L-CV_{initial} = 0.245 L-Skew_{initial} = 0.257 L-CV_{final} = 0.235 L-Skew_{final} = 0.272
Tributary	Tributary	No	The initial pooling group had 508 years of records from 14 stations with an H₂ value of 3.7360. The following stations were removed from the initial pooling group: • 27073 Brompton Beck @ Snainton Ings • 26017 Ings Beck @ South Newbald • 26016 Gypsy Race @ Kirby Grindalythe • 44008 South Winterbourne @ Winterbourne Steepleton All four stations were removed as they were highly permeable stations with low SPRHOST values and high BFIHOST values. This lowered the station record to 408. To increase the years of data the following stations were added: • 25003 Trout Beck @ Moor	L-CV_{initial} = 0.215 L-Skew_{initial} = 0.266 L-CV_{final} = 0.227 L-Skew_{final} = 0.272

			House 27032 Hebden Beck @ Hebden 48009 St Neot @ Craigshill Wood The pooling group station record was then increased to 521 years. No further stations were removed or added to the pooling group at this stage. The H₂ value for this final pooling group was 0.8785. This is considered to be acceptably homogeneous.	
If a spreadsheet has been used for pooling group growth curves insert link here:				
<u>Notes:</u> The weighted average L-moments, before urban adjustment, can be found at the bottom of the Pooling-group details window in WINFAP-FEH.				

Table 4.5: Derivation of flood growth curves

Site code	Method:	Distribution(s) chosen and reason, include goodness of fit parameters	Any urban adjustment or permeable adjustment?	Parameters of chosen distribution(s)
Brightley Brook	P	Generalised Logistic (GL) value is -0.2027 (Chosen as it was the distribution that fit best)	N/A	Scale: 0.222 Shape: -0.272 Bound: 0.185
Brightley Brook Rural	P	Generalised Logistic (GL) value is 0.3627 (Chosen as it was the distribution that fit best)	N/A	Scale: 0.232 Shape: -0.264 Bound: 0.120
Tributary	P	Generalised Logistic (GL) value is -0.2027 (Chosen as it was the distribution that fit best)	N/A	Scale: 0.222 Shape: -0.272 Bound: 0.184
<u>Notes:</u> Methods: SS – Single site; P – Pooled; ESS – Enhanced single site; J – Joint analysis A pooling group (or ESS analysis) derived at one gauge can be applied to estimate growth curves at a number of ungauged sites. Each site may have a different urban adjustment, and therefore different growth curve parameters. Urban adjustments are all carried out using the v3 method: Kjeldsen (2010). Growth curves were derived using the revised procedures from Science Report SC050050 (2008).				

Table 4.6: Growth Curves

Site Code	Growth Curve Factor for the following return periods									
	2	5	10	20	30	50	75	100	200	1000
Brightley Brook	1.000	1.264	1.495	1.778	1.976	2.269	2.543	2.763	3.398	5.672
Brightley Brook Rural	1.000	1.319	1.583	1.896	2.108	2.416	2.696	2.918	3.541	5.648
Tributary	1.000	1.368	1.658	1.990	2.210	2.521	2.800	3.016	3.612	5.520

Table 4.7 provides the final peak flow estimates calculated using the statistical method with urban adjustment factors (UAF) of 1.565, 1.317 and 1.029 applied to the QMED_{rural} and urban adjustment applied to the growth curves utilising Kjeldsen, Version 3 (2010).

Table 4.7: Statistical Method Estimate of Peak Flows

Site code	Flood peak (m ³ /s) for the following return periods in years									
	2	5	10	20	30	50	75	100	200	1000
Brightley Brook	0.961	1.215	1.437	1.709	1.899	2.180	2.444	2.655	3.265	5.451
Brightley Brook Rural	0.519	0.685	0.822	0.984	1.094	1.254	1.399	1.514	1.838	2.931
Tributary	0.37	0.51	0.62	0.74	0.83	0.94	1.05	1.13	1.35	2.06

5 Revitalised FSR/FEH rainfall runoff method

The Revitalised Flood Hydrograph (ReFH) method was developed by CEH to provide a more realistic representation of flood hydrology. This method is generally believed to perform reasonably well on most catchments. However, this method is not currently appropriate for either 'heavily urbanised' or 'very heavily urbanised' based on the values of URBEXT2000 extracted from FEH Web Service because its summer design event was only calibrated on seven urban catchments, and further research to improve the ReFH method has been recommended.

Parameters used to derive the ReFH method hydrographs are provided in Tables 5.1 and 5.2. For this study, the critical storm duration of each catchment has been calculated (based on the 1 in 100 event) in order to generate the maximum peak flow estimate produced by each catchment. This may change following optimisation of the hydraulic model inflows.

Table 5.1: Parameters for ReFH

Site Code	Method OPT: Optimisation BR: Baseflow Recession Fitting CD: Catchment Descriptors DT: Data Transfer	T _p (hours)	C _{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow Recharge
Brightley Brook	CD	1.10	272.43	21.41	1.36
Brightley Brook Rural	CD	1.00	272.43	20.10	1.36
Tributary	CD	1.00	408.54	26.03	2.89
Brief description of any flood event analysis carried out (further details should be or in a project report)					

Table 5.2: Design events for ReFH method

Site Code	Urban or Rural	Season of design (summer or winter)	Storm Duration (hours)	Storm area for ARF (if not catchment area)
Brightley Brook	Urban	Summer	02:06	0.646
Brightley Brook Rural	Urban	Summer	02:06	0.383
Tributary	Urban	Summer	02:06	0.595
Are the storm durations likely to be changed in the next stage of the study? (e.g. by optimisation within a hydraulic model?)			No, they are unlikely to change.	

Table 5.3: Peak flow estimates from the Revitalised FEH rainfall-runoff model

Site code	Flood peak (m ³ /s) for the following return periods in years										
	1	2	5	10	20	30	50	75	100	200	1000
Brightley Brook	0.80	1.18	1.47	1.78	1.98	2.26	2.51	2.70	3.23	4.87	0.80
Brightley Brook Rural	0.43	0.63	0.79	0.96	1.07	1.22	1.36	1.46	1.76	2.68	0.43
Tributary	0.28	0.41	0.52	0.63	0.71	0.83	0.93	1.01	1.24	1.98	0.28

Summary of results

Peak discharges were calculated for each sub-catchment for the following events: 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.2% AEP. The following methods were investigated: FEH Statistical, ReFH2 and 2014 FEH RR. Table 7.1 summarises the 100 year peak flows for both methods for all sub-catchments.

Table 7.1: Summary of 100 year return period peak flow estimated for the different methods

Site code	Site name	Peak flow for 100 year return period (m ³ /s)	
		FEH Statistical	ReFH2
Brightley Brook	Brightley Brook	2.655	3.23
Brightley Brook Rural	Brightley Brook Rural	1.514	1.76
Tributary	Tributary	1.13	1.24

Table 7.2 summarises the choice of method for each watercourse, alongside the final peak flow used in the model and the model node that the inflow was applied to.

Table 7.2: Choice of method, final flows used in the model and model node.

Name of Watercourse	Site code	Critical Storm Duration	Peak flow for 100 year return period (m ³ /s)
			FEH Statistical
Brightley Brook	Brightley Brook	02:06	2.655
Brightley Brook Rural	Brightley Brook Rural	02:06	1.514
Tributary	Tributary	02:06	1.13

Table 7.3: Choice of method

Item	Comments
Final choice of method and reasons Include: - Reference to type of study - Nature of catchment - Type of data available	The final choice of method is to use the FEH Statistical peak. This has been chosen as it is the most appropriate method for small catchments and the Brightley Brook is 0.646km ² , Brightley Brook Rural is 0.383km ² and the Tributary is 0.595km ² . This is because there is greater confidence in using the FEH Statistical method due to stronger reliance on local data as a donor station and the larger AMAX data set.

Table 7.4: Assumptions, limitations and uncertainty

Item	Comments
List the main assumptions made (specific to this study)	None.

Item	Comments
Discuss any particular limitations , e.g. applying methods outside the range of catchment types or return periods for which they were developed	Key limitation is lack of at site gauged flows and reliance on an ungauged approach.
Give what information you can on uncertainty in the results – e.g. confidence limits for the QMED estimates using FEH 3 12.5 or the factorial standard error from Science Report SC050050 (2008).	Uncertainty in the URBEXT values has been minimised where possible by comparing against Ordnance Survey and satellite mapping to ensure up to date values for urban area have been used. For the catchment used in this study, the standard methods have been applied and appropriate guidance followed. Donors for QMED were available for this catchment, reducing the uncertainty in QMED values. The QMED confidence intervals for the 95% confidence level are 0.38(Lower) and 2.41 (Upper) for the Brightley Brook, 0.21(Lower) and 1.30 (Upper) for the Brightley Brook Rural and 0.15(Lower) and 0.94 (Upper) for the Tributary.
Comment on the suitability of the results for future studies , e.g. at nearby locations or for different purposes.	The calculations were carried out for the specific development at Pilsworth Road, Heywood and should not be used for any other purposes.
Give any other comments on the study , for example suggestions for additional work.	None.

Table 7.5: Checks

Item	Comments
Are the results consistent , for example at confluences?	N/A
What do the results imply regarding the return periods of floods during the period of record?	N/A
What is the 100-year growth factor? Is this realistic? (The guidance suggests a typical range of 2.1 to 4.0)	The growth factor for Brightley Brook site code is 2.763, for Brightley Brook Rural site code it is 2.918 and for the Tributary site code it is 3.016 which are within the typical range.
If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow?	The ratios are 2.053, 1.936 and 1.830.

Item	Comments
What range of specific runoffs (l/s/ha) do the results equate to? Are there any inconsistencies?	The specific runoffs (for the 1% AEP event) are 41.10, 39.54 and, 18.94l/s/ha.
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	N/A
Are the results compatible with the longer-term flood history? Are there any amendments to parameters after verification / Calibration?	No amendments necessary.
Describe any other checks on the results	No other checks have been made.