Mr Peter Lister

Proposed Residential Development
444/446 Bradford Road
Batley
Dewsbury

Flood Risk Assessment

Prepared by EWE Associates Ltd
Final RevA July 2017

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CLIENT DETAILS

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CONTRACT

This report describes work commissioned by Mr Peter Lister following written instruction by their representative during March 2017. Mr Peter Lister representative for the contract was Mr Alison Dumville of Robert Halstead Chartered Surveyor. Lea Favill of EWE Associates Ltd carried out the work.

Date: 15th July 2017

Prepared by: ……. …… Lea Favill
Director

REVISION HISTORY

Draft Report Rev0 issued 6th April 2010 - 1No copy issued to Robert Halstead
Final Report Rev0 issued 10th May 2010 - 3No copy issued to Robert Halstead
Final Report RevA issued 15th July 2017 - 3No copy issued to Robert Halstead Chartered Surveyors

EXECUTIVE SUMMARY

The proposed site covers an area of approximately 0.39 Hectares. The development area within the site presently consists of roofed and paved areas which forms the existing commercial/industrial buildings and yard areas. The site lies at a level of between 54.10mOD within the south east corner of the site up to 55.95mOD within the centre of the site. The lowest ground level proposed for buildings is 55.50mOD. The site is located to the north of the centre of Batley adjacent to Bradford Road. Bridge Street is located to the west of the site and varies between 54.64mOD at its junction with Bradford Road up to 58.50mOD level with the rear of the site. Caladonia Road is located to the east of the site and varies between 54.17mOD at its junction with Bradford Road up to 61.50mOD level with the rear of the site. The existing site is considered to be approximately 80% impermeable as the majority of site is either roofed or paved. The existing roofed areas are supported by roof gutters and downpipes and the paved areas are drained by gullies and slot drains. It is assumed that the site is drained to a Yorkshire Water sewer located within Bradford Road.

The proposal involves the re-development of the existing site to provide a residential development. The development will include 40 residential units located within three blocks. It is proposed that 16 apartments include two bedrooms and 20 apartments only have one bedroom. The remaining four apartments will include a single double bedroom. The development will also include car parking and access roads. It is estimated that the proposed development will reduce the impermeable area to approximately 62% of the total site area following development.

Batley Beck inline with the site is within a 2.1m x 2.5m wide concrete box culvert. The Environment Agency provided estimated 1 in 100 year plus climate change flood level of 53.634mOD at the downstream end of the culvert.

At the upstream end of the culvert which is 270m upstream of the site the 1 in 100 year plus climate change flood level at the culvert entrance has been estimated at 56.142mOD. The flood wall height directly upstream of the culvert entrance is 57.741mOD. Therefore, flows will be maintained within the channel and the site will not be flooded.

It is therefore recommended that the internal ground floor levels of the buildings are elevated at least 600mm above the level of the adjacent Bradford Road. At the junction of Bradford Road and Bridge Street to the west of the site the road level is 54.64mOD. As such it is recommended that the internal ground floor level of the building are at a minimum level of 55.24mOD.

It is considered that the development site is located outside of the flood area and dry access and egress will be available within the site. The access into the site is off Caledonia Road to the east and the road level in line with the entrance is approximately 57mOD which again will be dry.

The proposed escape route from the site will be north along Caladonia Road which continues to rise as you travel north.

The existing connection to the surface water drainage system should be utilised. There is no evidence of localised flooding due to incapacity. The size of the development is unlikely to have any significant impact on the localised drainage system.

It is unlikely that the use of infiltration drainage will be possible. Therefore, it is recommended that Yorkshire Water is approached at the earliest opportunity to discuss and agree the discharge limit for surface water drainage. The runoff from the site should be limited to agreed peak flow. Any flows more than this should be attenuated onsite in the form of storage.

It is concluded that there is a low risk of fluvial flooding to the proposed development from Batley Beck. The implementation of mitigation measures as described within Section 5 of this report will ensure that any risk of flooding at the proposed development may be reduced to an acceptable level.

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1. INTRODUCTION

Terms of Reference

This report was commissioned by Mr Peter Lister to support a planning application for the development of the existing commercial buildings off Bradford Road to provide a residential development. The site can presently be accessed from the south off the A652 Bradford Road. The location of the site is shown on Table 2-1.

The development site lies partly within Zone 2 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 1,000 year (0.1% AEP) or greater for river flooding. However, the majority of the site (95%) is located within Zone 1, being the zone with risk of 1 in 1,000 year (0.1% AEP) or less for river flooding. The overall size of the development is less than 1 hectare.

It is usual for the Agency to raise an objection to development applications within the floodplain or Zone 2 or 3 of the flood map until the question of flood risk has been properly evaluated. The Agency will also object to developments where the total site area is in excess of 1 hectare until suitable consideration has been given to surface water runoff.

Approach to the Assessment

As there are two sources of flood risk – Batley Beck and surface water runoff – it is necessary to determine flood water levels at the site for the desired return periods emanating from these sources. Consideration has also been given to the site flooding from either overland flow or ponding of localised rainfall within the site.

Kirklees Council has recently completed a level 1 Strategic Flood Risk Assessment for the district. References have been taken from the assessment; however, there is very little site-specific information within the report relevant to the Batley area close to the site.

Batley Beck is a tributary of the River Calder and is located to the south of the site. In line with the site the beck is within culvert. The beck is Main River and as such the responsibility for flood defence and land drainage lies with the Environment Agency.

The Environment Agency have been approached for modelled flood data for the beck. The Environment Agency could provide flood levels upstream and downstream of the. Structures within the watercourse which restrict discharge will be considered using hand calculations only.

The proposed development will reduce the paved and roofed area within the site. However, the existing method of draining the site will be appraised.

A walk over of the site was conducted by Mr Lea Favill, a senior river engineer on 3rd May 2010; during the visit, a photograph survey of the site and adjacent watercourses was undertaken. A topographic survey of the site, calibrated to Ordnance Datum, has been provided by the client's representative. These surveyed levels have been utilised within this report. During the site visit channel, cross sections within Batley Beck where completed by EWE Associates Ltd.

The requirements for flood risk assessments are generally as set out in Planning Policy Guidance (PPG). The detail and complexity of the study required should be appropriate to the scale and potential impact of the development. For the purposes of this study, the following have been considered: -

- Available information on historical flooding in the area.
- Site level information.
- Details of structures, which may influence hydraulics of the watercourse and consideration of the effect of blockage of structures.

- Estimates of design levels, equivalent to a 200-year (coastal/tidal) and a 100-year (fluvial) return period flood event.
- Allowances for increased flows resulting from the effects of climate change.
- Allowances for sea level rise resulting from the effects of climate change.

Assess the existing runoff characteristics and the potential impact the proposed development will have on the runoff.

Further guidance is also provided in the CIRIA Research Project 624 “Development and Flood Risk: Guidance for the Construction Industry”.

Application of Sequential & Exceptions Test

The majority of the development site lies within Zone 1 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 1,000 year (0.1% AEP) or less for river flooding. However, there is approximately 5% within Zone 2. It should be noted that the buildings within the site have been located within flood zone 1. With the higher risk areas used for landscaping. The proposed development is residential and as such is more vulnerable.

Table 1: Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability classification		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	×	**Exception Test required**	✓
	Zone 3b	Exception Test required	✓	×	×	×

✓ Development is appropriate

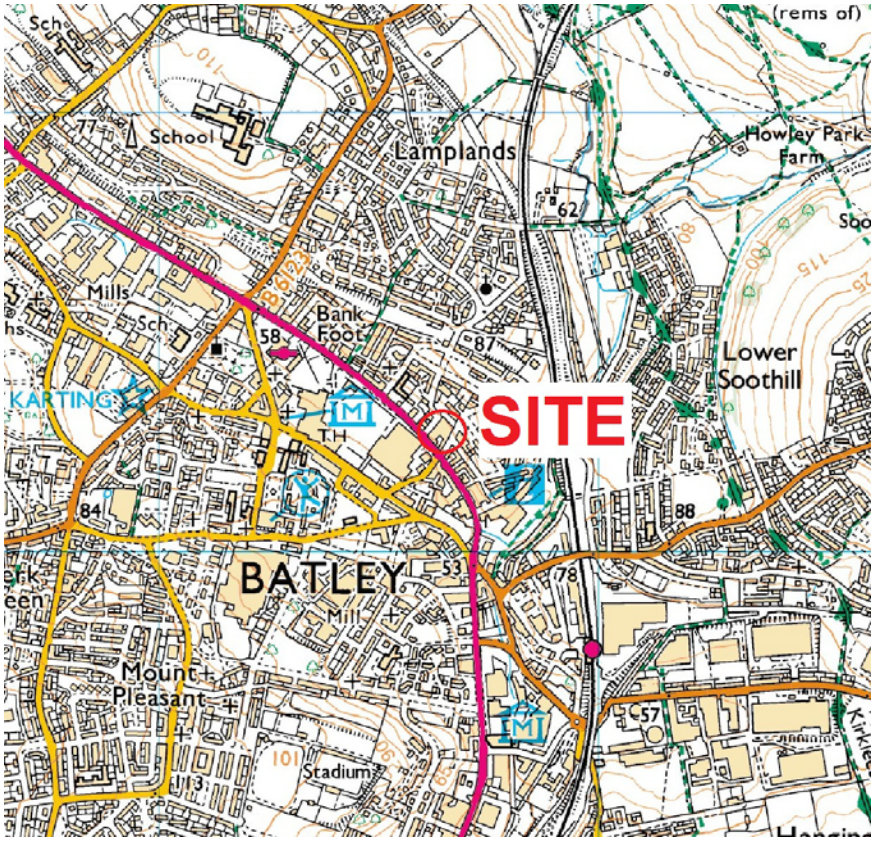
× Development should not be permitted

It is therefore considered that the exceptions test is not required for the site. It is also considered that there are no alternative sites at a lower flood risk within the district which could accommodate the proposed development. As such the site is sequentially preferable.

2. DETAILS OF THE SITE

Site Location

Table 2-1: Location Plan



Ordnance Survey Licence no.: WL1005160

Site Details

Table 2-2: Site Details

Site Name	444/446 Bradford Road, Batley
Existing Land Use	Commercial
Proposed Development	Residential
Grid Reference	SE 24647 24271
County	West Yorkshire
Local Planning Authority	Kirklees Council
Internal Drainage Board	Not Applicable
Post Code	WF17 5NF

Site Description

The proposed site covers an area of approximately 0.39 Hectares. The development area within the site presently consists of roofed and paved areas which forms the existing commercial/industrial buildings and yard areas. The site lies at a level of between 54.10mOD within the south east corner of the site up to 55.95mOD within the centre of the site. The lowest ground level proposed for buildings is 55.50mOD. The site is located to the north of the centre of Batley adjacent to Bradford Road. Bridge Street is located to the west of the site and varies between 54.64mOD at its junction with Bradford Road up to 58.50mOD level with the rear of the site. Caladonia Road is located to the east of the site and varies between 54.17mOD at its junction with Bradford Road up to 61.50mOD level with the rear of the site. Existing ground levels within the site are illustrated on the proposal plan at Appendix A of this report.

The existing site is considered to be approximately 80% impermeable as the majority of site is either roofed or paved. The existing roofed areas are supported by roof gutters and downpipes and the paved areas are drained by gullies and slot drains. It is assumed that the site is drained to a Yorkshire Water sewer located within Bradford Road.

The proposal involves the re-development of the existing site to provide a residential development. The development will include 40 residential units located within three blocks. It is proposed that 16 apartments include two bedrooms and 20 apartments only have one bedroom. The remaining four apartments will include a single double bedroom. The development will also include car parking and access roads.

It is estimated that the proposed development will reduce the impermeable area to approximately 62% of the total site area following development.

Site Photographs

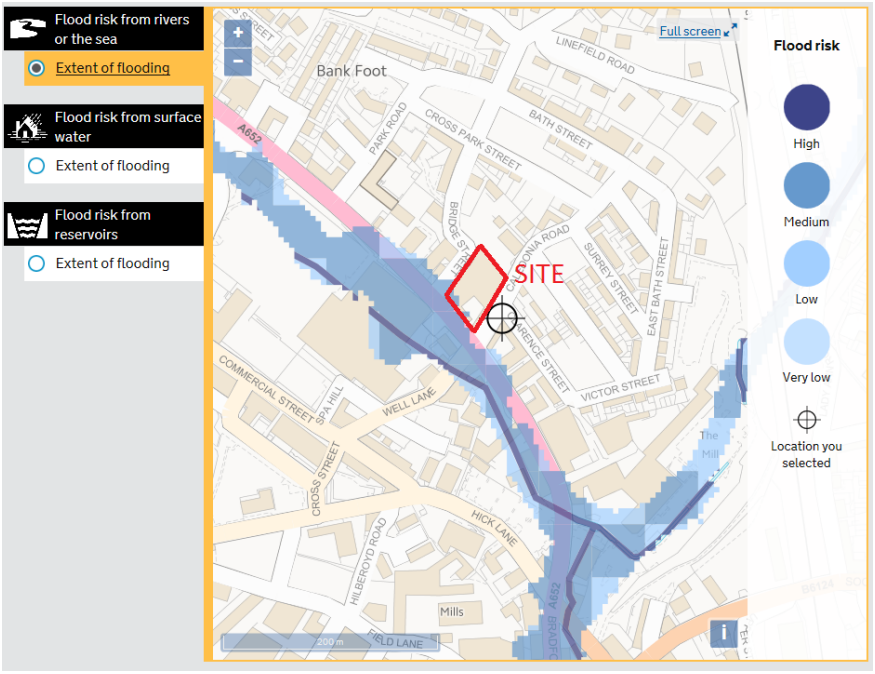
Figure 2.1: Aerial Photograph of the Existing Site.

Figure 2.2: Existing Site viewed from south of Bradford Road.

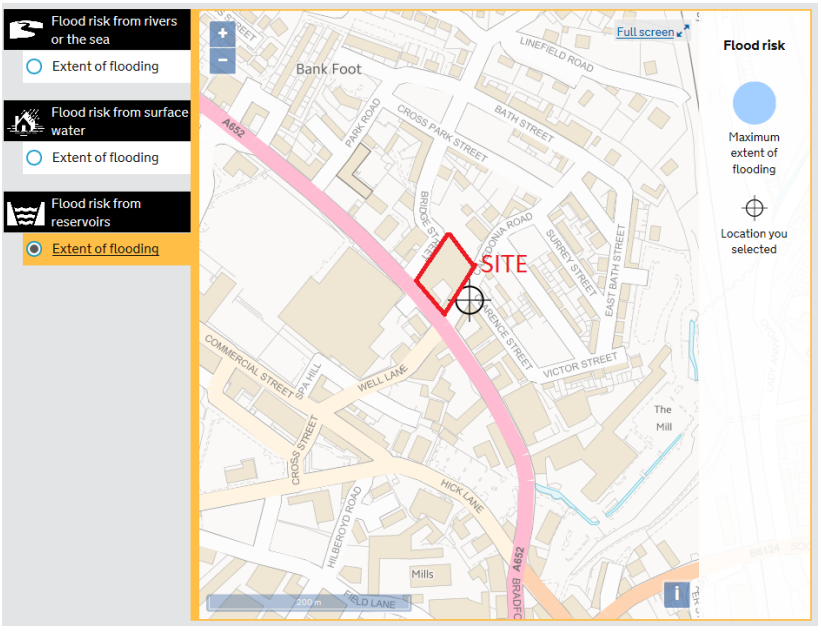
Figure 2.3: Existing Site corner of Caladonia Road and Bradford Road.

3. INITIAL ASSESSMENT

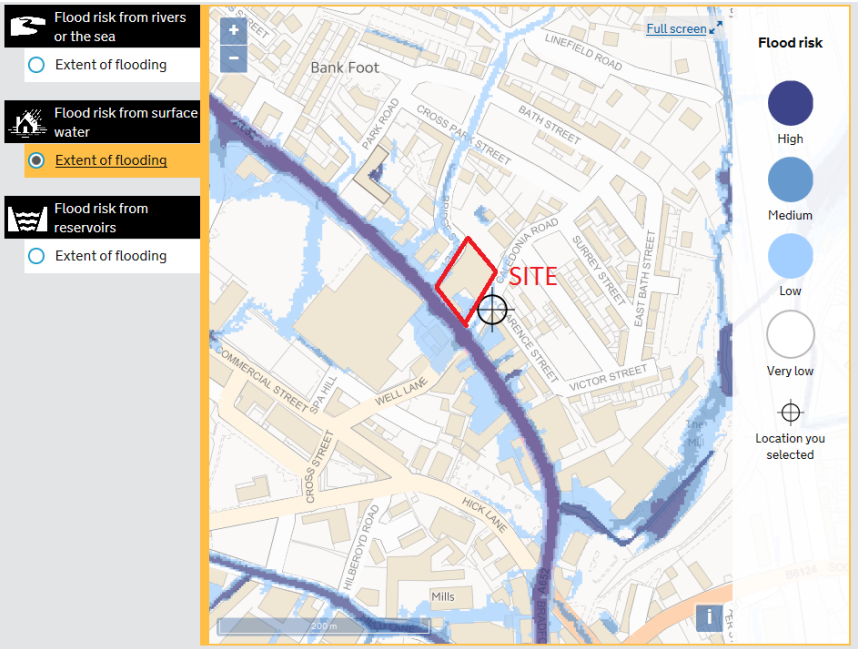
Environment Agency Flood Map



Environment Agency Reservoir Flood Map



Environment Agency Surface Water Flood Map



Reservoir Flood Risk

The Environment Agency reservoir risk map shows that the site is not located in an area which could be affected by a reservoir failure.

Surface Water Flood Risk

The Environment Surface Water flood risk map shows that most of the site is within a is very low risk area (white). There is a small area of low risk within the south east corner of the site. High risk flood depths are estimated at less than 300mm.

Past Flooding History

A search on the British Hydrological Society Chronology of British Hydrological Events website[1] found no records of past flooding close to the site.

Undertaking an internet based search for flooding found no further reference to flooding close to the site.

SFRA Flooding History

The SFRA contained no references to the site being flooded.

1 http://www.dundee.ac.uk/geography/cbhe/

Environment Agency Flooding History

The Environment Agency provided no historical flood information close to the site.

Possible Flooding Mechanisms

As there are two sources of flood risk – Batley Beck and surface water runoff – it is necessary to determine flood water levels at the site for the desired return periods emanating from these sources.

The first is from the Batley Beck which is approximately 50m to the south of the site. The beck is within culvert in line with the site and as such relies upon the natural bank top level for its defence upstream and downstream of the culvert. As such only overtopping will require consideration.

The proposed development is the redevelopment of an existing site. As such the impermeable area will not be increased due to the proposed development. However, the site is Brownfield with an existing positive drainage system within the site discharging to public sewer located within Bradford Road. As such this assessment will considered the discharge routes from the site and the options available for the proposed development in line with NPPF.

There is higher ground adjacent to the north boundary of the site which could promote overland flow of water across the site. However, these areas are generally dense paved and roofed areas which are supported by surface water drainage systems which will intercept surface flows and direct them to the public sewer. If the capacity is exceeded it is considered that excess flows will flow onto Caladonia Road and Bridge Street and flow past the site. It is highly unlikely that any flows will be directed across the site and therefore this flood mechanism has not been considered further.

Information on groundwater flooding is limited within the Kirklees Council district. The SFRA provided no further information. In addition, reference to the Groundwater Vulnerability Map and Source Protection Zones produced by the Environment Agency indicate that district is predominantly underlain by secondary A aquifer and are therefore unlikely to be source of significant flood risk.

Yorkshire Water are the statutory water undertaker and is responsible for the public sewer systems within Batley area. Yorkshire Water maintains a register of historical sewer flooding events (DG5 Register) within the area. There are no report incidents close to the site.

4. FLOOD RISK ASSESSMENT

Requirements of the Environment Agency

The Environment Agency, as part of its development control procedures, generally require finished floor levels to be set above the 1% AEP plus climate change flood water level at the site. The development is residential in nature, as such it is considered that access and egress from the development site will be essential during times of extreme floods.

Batley Beck

The beck collects flows from the residential areas of Batley and conveys them within a rectangular channel through the town eventually discharging into the River Calder to the south of Batley town centre.

The beck is within culvert inline with the site and is located approximately 50m to the south of the site. The site is located approximately 200m upstream of the confluence of Batley Beck and Howley Beck which is located at the downstream end of the Batley Beck culvert which passes to the south of the site. The photograph shown below in Figure 4.1 shows the downstream end of the culvert.

Figure 4.1: Downstream end of Batley Beck culvert.

1 in 100 year flood event within the Batley Beck

The Environment Agency has provided modelled flood levels for the Batley Beck approximately 200m downstream of the site where the watercourse exits the culvert. The data provided is shown at Appendix B of this report. It is considered that node reference BAT1_2997 which is directly downstream of the culvert exit is the closest modelled flood level available. The 1 in 100 year flood level has been estimated at 53.482mOD at this node. The lowest ground level within the site proposed for the buildings is at a level of 55.50mOD and as

such is approximately 2m above the estimated 1 in 100 year flood level at the downstream end of the culvert.

Increase in estimated flood level due to Climate Change

NPPF states that '*…Flood risk assessment should be carried out to the appropriate degree at all levels of the planning process, to assess the risks of all forms of flooding to and from development taking climate change into account. The future users of the development must not be placed in danger from flood hazards and should remain safe throughout the lifetime of the plan or proposed development and land use*.'

As the proposed development includes residential land use, consideration has therefore been given to take into account the potential effects of climate change over the next 100 years in accordance with NPPF. The 1 in 100 year plus climate change flood level has been estimated at 53.634mOD at this node. The lowest ground level within the site proposed for the buildings is at a level of 55.50mOD and as such is approximately 1.7m above the estimated 1 in 100 year plus climate change flood level at the downstream end of the culvert.

Overtopping Culvert entrance upstream of Site

The entrance to the culvert which passes the site is approximately 270m upstream of the site. The entrance is to the west of the Tesco car park and to the north of the Netto superstore car park.

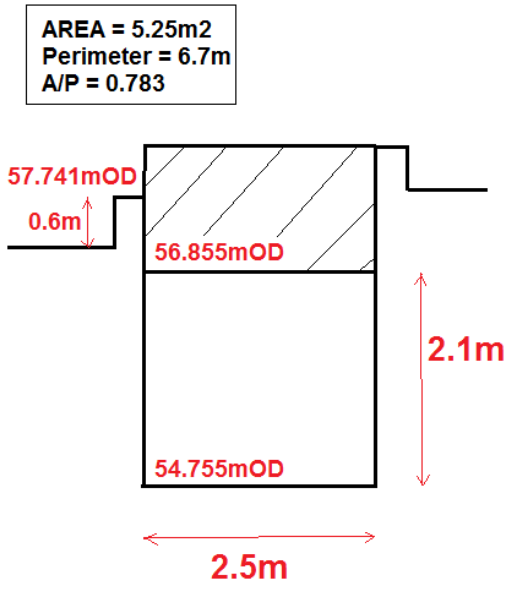
Node reference BAT1_3455 is directly upstream of the culvert entrance. The 1 in 100 year plus climate change flood level has been estimated at 56.142mOD at this node. The 1 in 1,000 year flood level has been estimated at 56.401mOD.

The entrance to the culvert is shown below in Figure 4.2. The culvert is constructed from a reinforced concrete box culvert which is 2.1m high and 2.5m wide. The retaining wall located on the left bank is at a level of 57.741mOD and the bed level is 54.755mOD.

Figure 4.2: Upstream end of Batley Beck culvert.

A cross section through the watercourse taken at the upstream end of the culvert is shown below in Figure 4.3.

Figure 4.3: Cross section though the existing watercourse upstream of culvert entrance.



It is therefore considered that the during the 1 in 100 year plus climate change flood event and the 1 in 1,000 year flood event that flows will be maintained within the channel and below the soffit level of the entrance to the culvert.

A blockage of the culvert entrance could reduce flows through the culvert and result in the left bank flood wall being overtopped. It is likely that any overtopping will be shallow and will not affect the site.

Increase in Surface Water Runoff due to Development

Existing Drainage

The site is currently a brownfield development which consists of roofed and paved areas which are supported by a formalised surface water drainage system which conveys flows below ground to the Yorkshire Water surface water sewer located within the adjacent highway. The total site area has been estimated at 0.39 hectares. It is estimated that the existing roofed and paved area is 0.305 hectares which is approximately 80% of the total site area.

Based on the soil maps and experience of other projects local to the site it is considered that infiltration drainage is not a practical option. Therefore, the proposed point of discharge is to the existing surface water sewer located within the adjacent highway to the south of the site.

For the purpose of this assessment the peak discharge rates from the site below in Table 4-1 have been conservatively adopted. The Modified Rational Method has been used to calculate the Brownfield runoff from the site. The calculation sheet is provided at Appendix C of this report. The peak 1 in 1 year runoff has been calculated at 31.03 l/s. In line with current climate change allowance a reduction of 30% is proposed from the site. Therefore, the peak discharge from the site is to be restricted to 21.7l/s (31.03l/s x 70%). Any discharge from the site into the surface water system will require the consent of the appropriate water authority/riparian owner, as such, they will also need to be approached to agree the discharge restriction from the site.

Table 4-1: Modified Rational Method flows from impermeable site area of 0.2405 ha

Return Period	Flow in litres per second (l/s)
1 in 1 year	31.03
1 in 30 year	104.12
1 in 100 year	148.82

Proposed Drainage Strategy

It is proposed to ultimately discharge any surface water flows generated by the development of the site which cannot drain via infiltration to the Yorkshire Water surface water sewer to the south of the site. A discharge restriction of 21.7l/s has been estimated from the site for this assessment.

The proposed impermeable area for the development site has been calculated to be approximately 0.2405 hectares which is 62% of the total site area, with the remainder of the site proposed as landscaping and open space.

The drainage strategy utilises an appropriately sized hydro brake to restrict the flow rate to a maximum of 21.7l/s. As such, the flow will vary for each of the design storms and it is expected that during the more extreme return periods there will be a considerable betterment as the hydro brake is likely to restrict flows to the 1 in 1 year flow rate.

Based upon the assumption that the local authority will agree to the maximum discharge rate, an assessment of the required balance volume has been made using the estimated post development impermeable area of 0.2405 hectares. Using WinDes Source Control software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (40%) event.

Reference should be made to Appendix D where the drainage strategy drawing is provided and Appendix E where the calculation sheets are provided. The attenuation size has been tabulated below in Table 4-2 for the 1 in 100 year plus climate change return period.

It is estimated that during the 1 in 100 year plus climate change (40%) event that 70.4m³ of storage will be required. Therefore, two crate tanks 75m² by 0.4m deep have been provided which will store the rainfall events up to the and including the 1 in 100 year plus climate change event. The location of the proposed crate tanks are shown on the master plan drawing at Appendix C of this report.

Table 4-2: WinDes 1 in 100 year+CC Storage Volume

Return Period	Required Attenuation	WinDes Calculated Volume (m³)
1 in 100 year + CC	2No tanks 75m² x 0.4m deep	70.4

5. MITIGATION MEASURES

Raising Floor Levels/Land Raising

Batley Beck inline with the site is within a 2.1m x 2.5m wide concrete box culvert. The Environment Agency provided estimated 1 in 100 year plus climate change flood level of 53.634mOD at the downstream end of the culvert.

At the upstream end of the culvert which is 270m upstream of the site the 1 in 100 year plus climate change flood level at the culvert entrance has been estimated at 56.142mOD. The flood wall height directly upstream of the culvert entrance is 57.741mOD. Therefore, flows will be maintained within the channel and the site will not be flooded.

It is therefore recommended that the internal ground floor levels of the buildings are elevated at least 600mm above the level of the adjacent Bradford Road. At the junction of Bradford Road and Bridge Street to the west of the site the road level is 54.64mOD. As such it is recommended that the internal ground floor level of the building are at a minimum level of 55.24mOD.

Flood Volume Compensation

It is considered that none of the site will be flooded during the 1 in 100 year plus climate change flood event. It is proposed that the front of the site adjacent to Bradford Road is elevated and as such a retaining wall will be constructed. However, based on this assessment it is considered that the retaining wall will not displace any flood water or constrict flood flows local to the site.

Emergency Access & Egress

It is considered that dry access and egress from the development site will be desirable during extreme flood events.

It is considered that the development site is located outside of the flood area and dry access and egress will be available within the site. The access into the site is off Caledonia Road to the east and the road level in line with the entrance is approximately 57mOD which again will be dry.

The proposed escape route from the site will be north along Caladonia Road which continues to rise as you travel north.

Control of Runoff

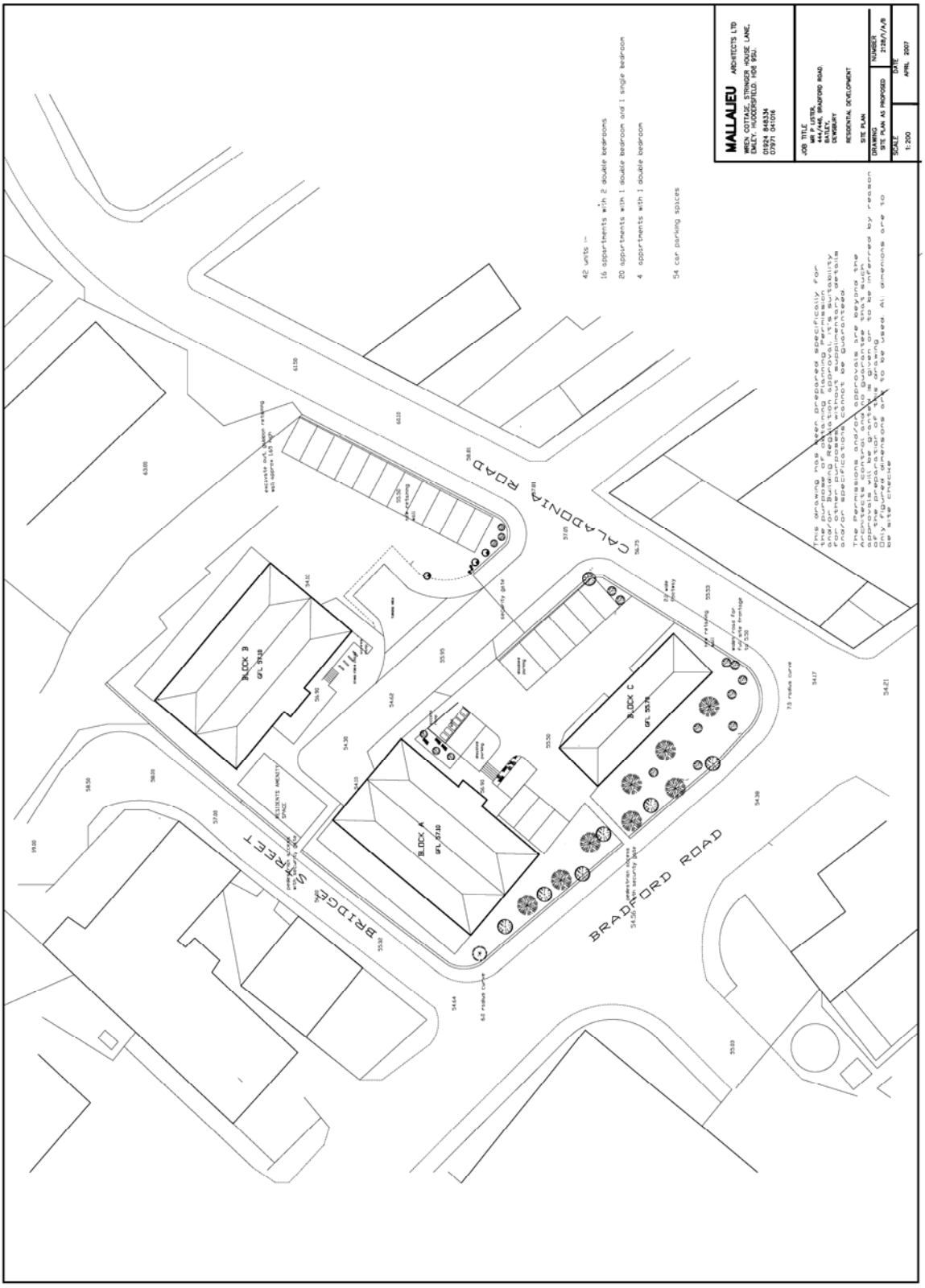
The existing connection to the surface water drainage system should be utilised. There is no evidence of localised flooding due to incapacity. The size of the development is unlikely to have any significant impact on the localised drainage system.

It is unlikely that the use of infiltration drainage will be possible. Therefore, it is recommended that Yorkshire Water is approached at the earliest opportunity to discuss and agree the discharge limit for surface water drainage. The runoff from the site should be limited to agreed peak flow. Any flows more than this should be attenuated onsite in the form of storage.

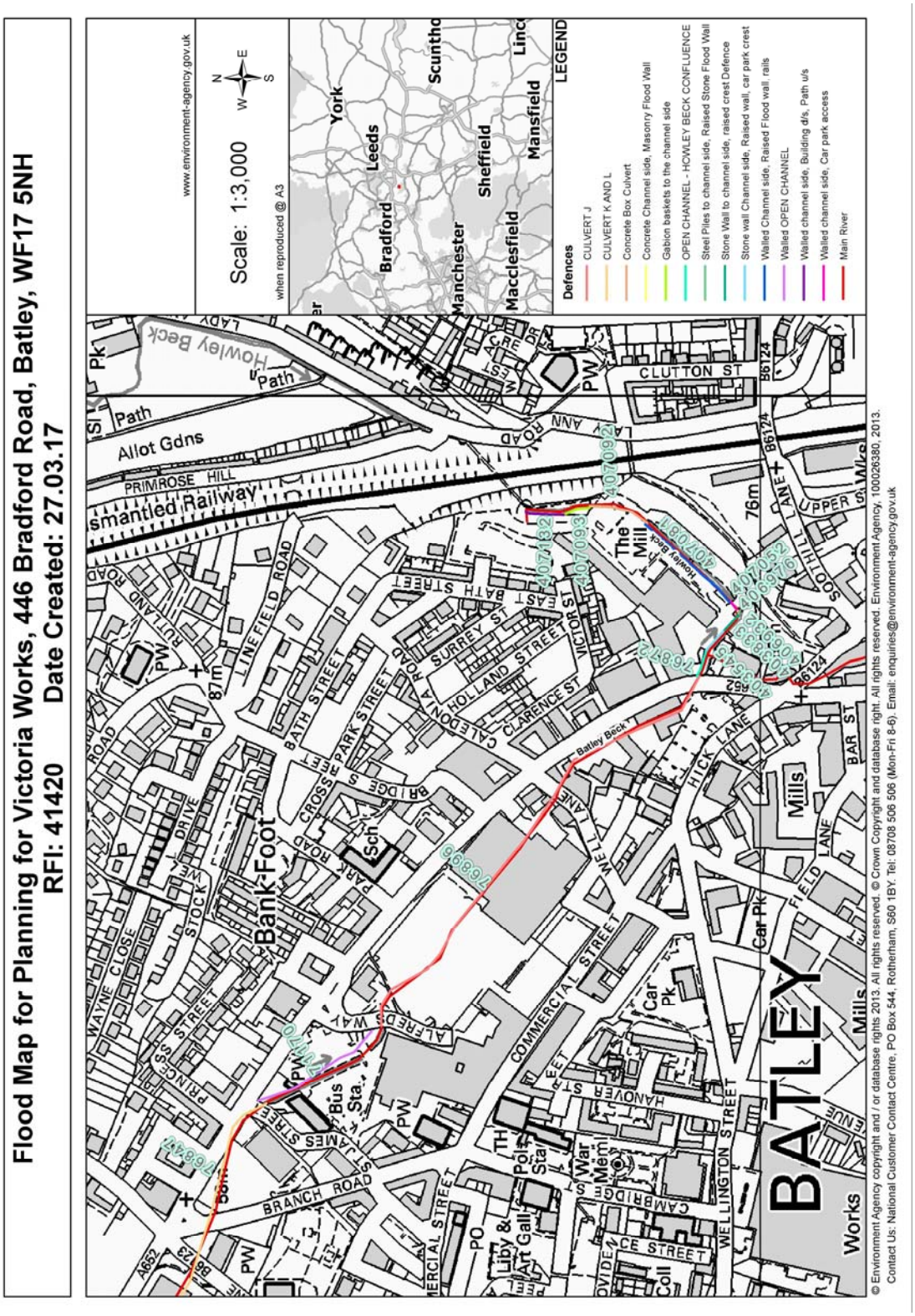
6. CONCLUSION

It is concluded that there is a low risk of fluvial flooding to the proposed development from Batley Beck. The implementation of mitigation measures as described within Section 5 of this report will ensure that any risk of flooding at the proposed development may be reduced to an acceptable level.

Appendix A: - Existing Ground Levels and Proposed Layout Plan


MALLALIEU ARCHITECTS LTD
WREN COTTAGE, STRINGER HOUSE LANE,
EMLEY, HUDDERSFIELD. HD8 9SU.
01924 848334
07971 041014
JOB TITLE
MR P LISTER,
444/446, BRADFORD ROAD,
BATLEY,
DEWSBURY
RESIDENTIAL DEVELOPMENT
SITE PLAN
DRAWING
SITE PLAN AS PROPOSED
NUMBER
2136/A/8
SCALE
1:200
DATE
APRIL 2017
42 units :-
16 appartments with 2 double bedrooms
20 appartments with 1 double bedroom and 1 single bedroom
4 appartments with 1 double bedroom
54 car parking spaces
CALADONIA ROAD
BRADFORD ROAD
BRIDGE STREET
BLOCK A
GFL 37.10
BLOCK B
GFL 39.20
BLOCK C
GFL 35.70

Appendix B: - Environment Agency Flood Data



UNCLASSIFIED

Asset Defence Information - RFI 41420

Maximum modelled levels and flows for the defended scenarios

Node Point	2		5		10		20		30		50	
	Level	Flow	Level	Flow	Level	Flow	Level	Flow	Level	Flow	Level	Flow
HOW1_0000	51.863	1.861	52.176	2.491	52.414	2.974	52.694	3.913	52.87	4.558	53.044	5.254
BAT1_3593	56.6	5.411	56.822	7.227	57.001	8.703	57.219	10.549	57.341	11.65	57.657	13.783
BAT1_3583	56.622	5.411	56.857	7.227	57.034	8.703	57.251	10.549	57.373	11.651	57.687	13.774
BAT1_3561i	56.522	5.412	56.75	7.228	56.922	8.705	57.135	10.551	57.255	11.652	57.568	13.841
BAT1_3539	56.403	5.413	56.621	7.23	56.786	8.706	56.996	10.553	57.113	11.654	57.521	13.372
BAT1_3494	55.958	5.795	56.199	7.775	56.38	9.365	56.601	11.41	56.725	12.61	57.335	14.238
BAT1_3494D	55.958	5.795	56.199	7.775	56.38	9.365	56.601	11.41	56.725	12.61	57.335	14.238
BAT1_3471iD	55.639	5.795	55.809	7.775	55.938	9.364	56.103	11.41	56.205	12.609	56.328	14.167
BAT1_3455	55.235	5.795	55.398	7.775	55.529	9.364	55.7	11.409	55.817	12.608	55.957	14.098
BAT1_2997	51.908	5.785	52.23	7.721	52.476	9.316	52.764	11.367	52.944	12.58	53.121	14.182
BAT1_2978iD	51.864	5.784	52.176	7.717	52.415	9.311	52.694	11.361	52.87	12.572	53.045	14.059
BAT1_2974	51.863	5.784	52.176	7.716	52.414	9.31	52.694	11.36	52.87	12.571	53.044	14.033

Maximum modelled levels and flows for the defended scenarios

Node Point	75		100		101		200		1000	
	Level	Flow	Level	Flow	Level	Flow	Level	Flow	Level	Flow
HOW1_0000	53.285	5.443	53.411	5.524	53.566	5.718	53.56	5.712	54.428	5.912
BAT1_3593	57.667	14.24	57.694	15.331	57.702	16.756	57.702	16.714	57.721	18.008
BAT1_3583	57.698	14.24	57.727	15.331	57.749	16.756	57.749	16.715	57.775	18.008
BAT1_3561i	57.585	14.241	57.598	15.332	57.596	16.756	57.595	16.715	57.596	18.008
BAT1_3539	57.561	13.477	57.618	13.866	57.664	14.71	57.662	14.692	57.762	15.412
BAT1_3494	57.371	14.318	57.439	14.701	57.513	15.102	57.51	15.088	57.624	15.436
BAT1_3494D	57.371	14.318	57.439	14.701	57.513	15.102	57.51	15.088	57.624	15.436
BAT1_3471iD	56.367	14.317	56.409	14.7	56.468	15.102	56.466	15.088	56.728	15.434
BAT1_3455	56.011	14.316	56.063	14.7	56.142	15.119	56.139	15.106	56.401	15.437
BAT1_2997	53.359	14.291	53.482	14.688	53.634	15.185	53.629	15.17	54.534	15.385
BAT1_2978iD	53.285	14.29	53.411	14.687	53.566	15.185	53.561	15.17	54.449	17.405
BAT1_2974	53.285	14.29	53.411	14.687	53.566	15.185	53.56	15.17	54.428	17.662

Maximum modelled levels and flows for the undefended scenarios

Node Point	2		5		10		20		30		50	
	Level	Flow	Level	Flow	Level	Flow	Level	Flow	Level	Flow	Level	Flow
HOW1_0000	51.864	1.861	52.175	2.49	52.414	2.975	52.686	3.79	52.837	4.21	52.995	4.989
BAT1_3593	56.601	5.421	56.821	7.219	56.998	8.699	57.214	10.542	57.337	11.651	57.542	12.795

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BAT1_3583	56.623	5.421	56.857	7.219	57.033	8.699	57.25	10.543	57.374	11.652	57.545	12.818
BAT1_3561i	56.522	5.422	56.75	7.22	56.921	8.701	57.135	10.544	57.257	11.653	57.532	12.796
BAT1_3539	56.404	5.423	56.621	7.222	56.785	8.702	56.995	10.546	57.114	11.656	57.39	13.261
BAT1_3494	55.959	5.804	56.198	7.769	56.379	9.356	56.6	11.401	56.725	12.612	57.19	13.19
BAT1_3494D	55.959	5.804	56.198	7.769	56.379	9.356	56.6	11.401	56.725	12.612	57.19	13.19
BAT1_3471iD	55.639	5.803	55.809	7.769	55.937	9.356	56.102	11.4	56.205	12.611	56.288	14.063
BAT1_3455	55.236	5.803	55.398	7.768	55.529	9.355	55.699	11.399	55.817	12.611	55.879	13.652
BAT1_2997	51.909	5.793	52.23	7.713	52.477	9.308	52.759	11.358	52.914	12.596	53.104	13.787
BAT1_2978iD	51.865	5.792	52.176	7.709	52.415	9.303	52.687	11.352	52.838	12.593	53.001	13.722
BAT1_2974	51.864	5.792	52.175	7.708	52.414	9.302	52.686	11.351	52.837	12.592	52.995	13.71

Maximum modelled levels and flows for the undefended scenarios						
Node Point	75		100		101	
	Level	Flow	Level	Flow	Level	Flow
HOW1_0000	53.448	5.348	53.717	5.543	54.006	6.057
BAT1_3593	57.546	14.055	57.683	17.21	57.689	17.137
BAT1_3583	57.59	14.057	57.749	17.195	57.747	17.139
BAT1_3561i	57.538	14.057	57.544	17.434	57.545	17.296
BAT1_3539	57.43	13.132	57.479	15.929	57.5	15.788
BAT1_3494	57.26	13.574	57.42	14.738	57.43	14.761
BAT1_3494D	57.26	13.574	57.42	14.738	57.43	14.761
BAT1_3471iD	56.324	14.083	56.412	14.63	56.533	14.666
BAT1_3455	55.993	13.675	56.087	14.543	56.193	14.605
BAT1_2997	53.59	13.705	53.865	14.302	54.125	14.632
BAT1_2978iD	53.455	15.079	53.724	16.035	54.056	16.385
BAT1_2974	53.448	15.213	53.717	16.193	54.006	16.77

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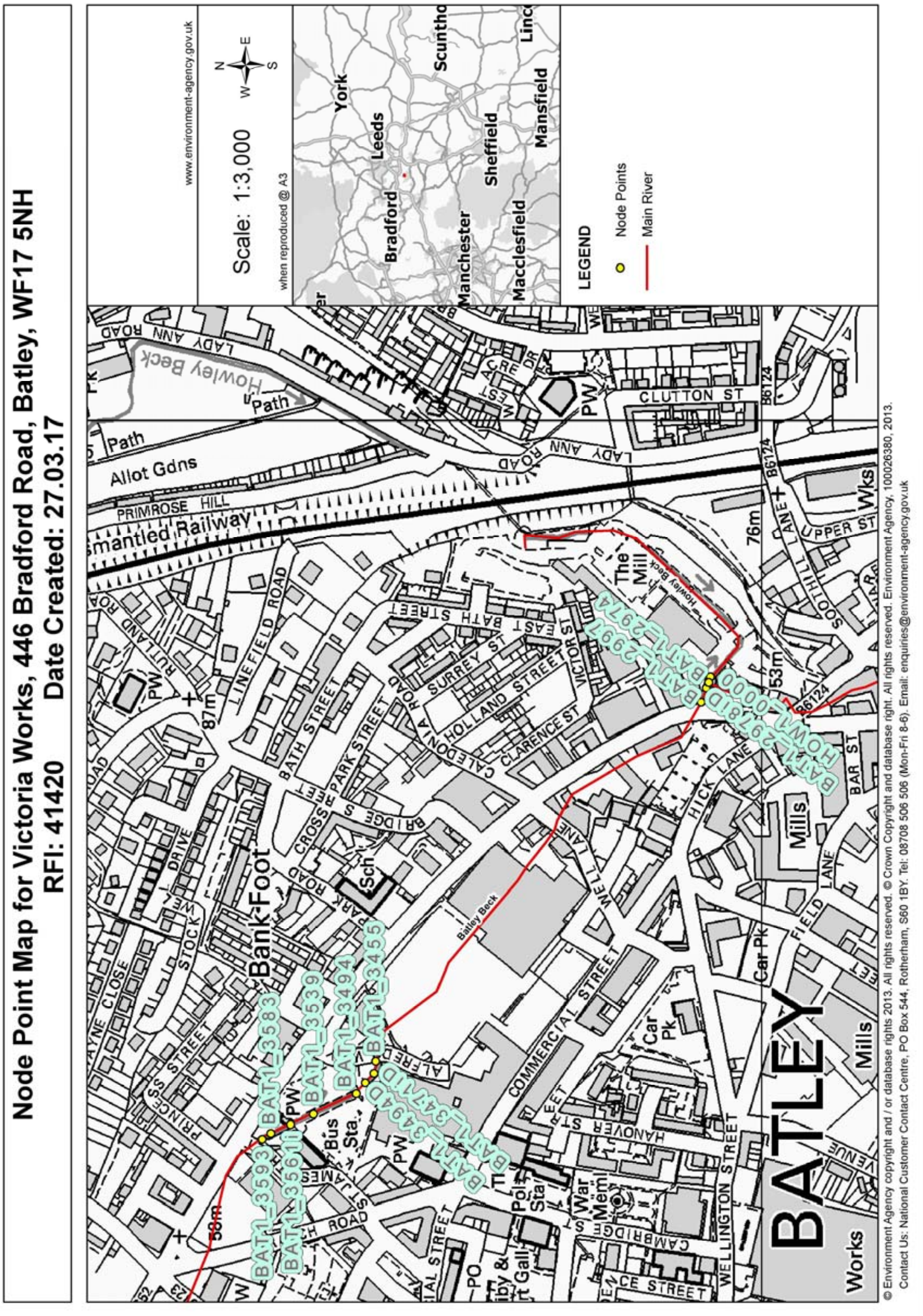
Node Point Map for Victoria Works, 446 Bradford Road, Batley, WF17 5NH
RFI: 41420 Date Created: 27.03.17
www.environment-agency.gov.uk
Scale: 1:3,000
when reproduced @ A3
LEGEND
Node Points
Main River
BATL_3593
BATL_3583
BATL_3561
BATL_3539
BATL_3494
BATL_3455
BATL_3494D
BATL_3471D
BATL_2974
BATL_2991
BATL_2978D
HOWL_0000
Howley Beck
Batley Beck
BATLEY
Bank Foot
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Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Appendix C: - Modified Rational Runoff Calculation Sheet

Modified Rational Method

Return Period flood 1 years
Post Development Rainfall 2 years

Length (m)	85	m
Area (ha)	0.305	Ha
Max Height	58.5	mAOD
Min Height	54.2	mAOD
DeltaH	4.3	
Slope (%)	5.09	
Te (mins)	8.60	mins
ARF	0.998	
SAAR	708.000	mm
UCWI	53	mm
PIMP	100.0	%
SOIL	0.40	
Percentage Runoff PR	76.33	
DEEPSTOR	0.32	

Cv	0.76334	
Cr	1.3	
allowable outflow		
1 year	31.03	l/s

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.16	0.007	5.9	5.9	36.9	31.0	101.7
0.25	0.010	6.92	6.9	27.7	23.3	76.4
0.5	0.021	8.83	8.8	17.7	14.9	48.7
0.75	0.031	10.16	10.1	13.5	11.4	37.4
1	0.042	11.22	11.1	11.2	9.4	31.0
1.25	0.052	12.11	12.0	9.7	8.2	26.7
1.5	0.063	12.9	12.8	8.6	7.2	23.7
1.75	0.073	13.59	13.5	7.8	6.5	21.4
2	0.083	14.23	14.1	7.1	6.0	19.6
2.25	0.094	14.81	14.7	6.6	5.5	18.2
2.5	0.104	15.35	15.2	6.1	5.2	16.9
2.75	0.115	15.85	15.7	5.8	4.8	15.9
3	0.125	16.33	16.2	5.4	4.6	15.0
3.25	0.135	16.78	16.7	5.2	4.3	14.2
3.5	0.146	17.2	17.1	4.9	4.1	13.6
3.75	0.156	17.61	17.5	4.7	4.0	13.0
4	0.167	18	17.9	4.5	3.8	12.4
4.25	0.177	18.37	18.2	4.3	3.6	11.9

Modified Rational Method

Return Period flood 30 years
Post Development Rainfall 50 years

Length (m)	85	m
Area (ha)	0.305	Ha
Max Height	58.5	mAOD
Min Height	54.2	mAOD
DeltaH	4.3	
Slope (%)	5.09	
Te (mins)	8.60	mins
ARF	0.998	
SAAR	708.000	mm
UCWI	53	mm
PIMP	100.0	%
SOIL	0.40	
Percentage Runoff PR	76.33	
DEEPSTOR	0.32	

Cv	0.76334	
Cr	1.3	
allowable outflow		
30 year	104.12	l/s

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.16	0.007	19.8	19.6	123.8	104.1	341.4
0.25	0.010	22.39	22.2	89.6	75.4	247.1
0.5	0.021	26.94	26.7	53.9	45.3	148.6
0.75	0.031	29.97	29.7	40.0	33.6	110.2
1	0.042	32.29	32.0	32.3	27.2	89.1
1.25	0.052	34.21	33.9	27.4	23.0	75.5
1.5	0.063	35.86	35.6	23.9	20.1	66.0
1.75	0.073	37.31	37.0	21.3	17.9	58.8
2	0.083	38.6	38.3	19.3	16.2	53.2
2.25	0.094	39.78	39.5	17.7	14.9	48.8
2.5	0.104	40.87	40.6	16.3	13.8	45.1
2.75	0.115	41.87	41.5	15.2	12.8	42.0
3	0.125	42.81	42.5	14.3	12.0	39.4
3.25	0.135	43.69	43.4	13.4	11.3	37.1
3.5	0.146	44.52	44.2	12.7	10.7	35.1
3.75	0.156	45.3	45.0	12.1	10.2	33.3
4	0.167	46.05	45.7	11.5	9.7	31.8
4.25	0.177	46.76	46.4	11.0	9.3	30.4

Modified Rational Method

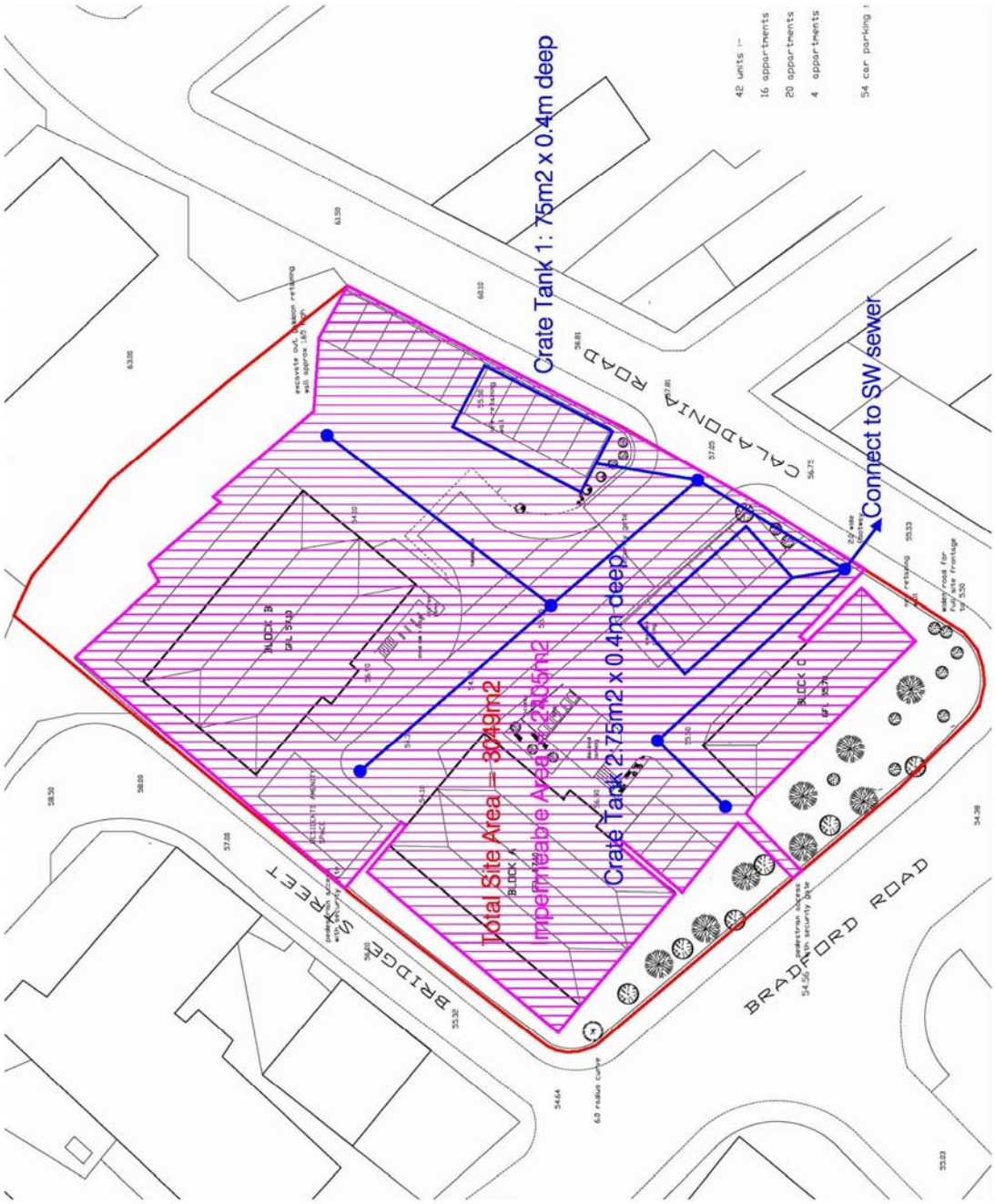
Return Period flood 100 years
Post Development Rainfall 140 years

Length (m)	85	m
Area (ha)	0.305	Ha
Max Height	58.5	mAOD
Min Height	54.2	mAOD
DeltaH	4.3	
Slope (%)	5.09	
Te (mins)	8.60	mins
ARF	0.998	
SAAR	708.000	mm
UCWI	53	mm
PIMP	100.0	%
SOIL	0.40	
Percentage Runoff PR	76.33	
DEEPSTOR	0.32	

Cv	0.76334	
Cr	1.3	
allowable outflow		
100 year	148.82	l/s

Rainfall Duration (hours)	Rainfall Duration (days)	Rainfall Depth (mm)	Effective Depth (mm)	Rainfall Intensity (mm/hr)	FLOW (l/s)	FLOW (l/s/ha)
0.16	0.007	28.3	28.1	176.9	148.8	487.9
0.25	0.010	31.59	31.3	126.4	106.3	348.6
0.5	0.021	37.36	37.1	74.7	62.9	206.1
0.75	0.031	41.14	40.8	54.9	46.2	151.3
1	0.042	44.02	43.7	44.0	37.0	121.4
1.25	0.052	46.38	46.0	37.1	31.2	102.4
1.5	0.063	48.39	48.0	32.3	27.1	89.0
1.75	0.073	50.15	49.8	28.7	24.1	79.1
2	0.083	51.72	51.3	25.9	21.8	71.3
2.25	0.094	53.15	52.7	23.6	19.9	65.2
2.5	0.104	54.45	54.0	21.8	18.3	60.1
2.75	0.115	55.66	55.2	20.2	17.0	55.8
3	0.125	56.78	56.3	18.9	15.9	52.2
3.25	0.135	57.83	57.4	17.8	15.0	49.1
3.5	0.146	58.82	58.4	16.8	14.1	46.4
3.75	0.156	59.76	59.3	15.9	13.4	44.0
4	0.167	60.65	60.2	15.2	12.8	41.8
4.25	0.177	61.49	61.0	14.5	12.2	39.9

Appendix D: - Drainage Strategy Drawing



Appendix E: - WinDes Calculation Sheets

EWE Associates Ltd		Page 1
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 15/07/2017 19:41	Designed By Lea	
File 100yr+cc30% crate...	Checked By	
Micro Drainage	Source Control W.12.4	

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

Half Drain Time : 33 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	53.413	0.413	0.0	19.5	19.5	58.8	O K
30 min Summer	53.435	0.435	0.0	19.5	19.5	61.6	O K
60 min Summer	53.433	0.433	0.0	19.5	19.5	61.4	O K
120 min Summer	53.394	0.394	0.0	19.5	19.5	56.2	O K
180 min Summer	53.351	0.351	0.0	19.3	19.3	50.0	O K
240 min Summer	53.313	0.313	0.0	18.9	18.9	44.6	O K
360 min Summer	53.256	0.256	0.0	17.5	17.5	36.5	O K
480 min Summer	53.220	0.220	0.0	16.0	16.0	31.3	O K
600 min Summer	53.195	0.195	0.0	14.6	14.6	27.8	O K
720 min Summer	53.177	0.177	0.0	13.3	13.3	25.2	O K
960 min Summer	53.155	0.155	0.0	11.5	11.5	22.0	O K
1440 min Summer	53.128	0.128	0.0	9.1	9.1	18.2	O K
2160 min Summer	53.106	0.106	0.0	7.2	7.2	15.1	O K
2880 min Summer	53.093	0.093	0.0	6.0	6.0	13.2	O K
4320 min Summer	53.074	0.074	0.0	4.3	4.3	10.5	O K
5760 min Summer	53.063	0.063	0.0	3.4	3.4	9.0	O K
7200 min Summer	53.056	0.056	0.0	2.8	2.8	8.0	O K
8640 min Summer	53.051	0.051	0.0	2.5	2.5	7.2	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	155.504	16
30 min Summer	91.418	27
60 min Summer	53.743	44
120 min Summer	31.594	78
180 min Summer	23.155	110
240 min Summer	18.574	140
360 min Summer	13.613	200
480 min Summer	10.919	260
600 min Summer	9.203	320
720 min Summer	8.003	378
960 min Summer	6.565	500
1440 min Summer	4.966	738
2160 min Summer	3.756	1104
2880 min Summer	3.082	1468
4320 min Summer	2.208	2200
5760 min Summer	1.743	2936
7200 min Summer	1.450	3672
8640 min Summer	1.248	4336

EWE Associates Ltd		Page 2
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 15/07/2017 19:41	Designed By Lea	
File 100yr+cc30% crate...	Checked By	
Micro Drainage	Source Control W.12.4	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	53.047	0.047	0.0	2.2	2.2	6.6	O K
15 min Winter	53.487	0.487	0.0	19.5	19.5	66.7	O K
30 min Winter	53.552	0.552	0.0	19.5	19.5	70.4	O K
60 min Winter	53.516	0.516	0.0	19.5	19.5	68.8	O K
120 min Winter	53.419	0.419	0.0	19.5	19.5	59.6	O K
180 min Winter	53.350	0.350	0.0	19.3	19.3	49.9	O K
240 min Winter	53.296	0.296	0.0	18.6	18.6	42.2	O K
360 min Winter	53.226	0.226	0.0	16.4	16.4	32.2	O K
480 min Winter	53.188	0.188	0.0	14.1	14.1	26.8	O K
600 min Winter	53.164	0.164	0.0	12.3	12.3	23.4	O K
720 min Winter	53.147	0.147	0.0	10.9	10.9	21.0	O K
960 min Winter	53.127	0.127	0.0	9.1	9.1	18.1	O K
1440 min Winter	53.104	0.104	0.0	7.0	7.0	14.8	O K
2160 min Winter	53.085	0.085	0.0	5.3	5.3	12.1	O K
2880 min Winter	53.074	0.074	0.0	4.4	4.4	10.6	O K
4320 min Winter	53.060	0.060	0.0	3.2	3.2	8.5	O K
5760 min Winter	53.051	0.051	0.0	2.5	2.5	7.3	O K
7200 min Winter	53.045	0.045	0.0	2.1	2.1	6.4	O K
8640 min Winter	53.041	0.041	0.0	1.8	1.8	5.8	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Summer	1.100	5040
15 min Winter	155.504	17
30 min Winter	91.418	30
60 min Winter	53.743	48
120 min Winter	31.594	84
180 min Winter	23.155	116
240 min Winter	18.574	148
360 min Winter	13.613	206
480 min Winter	10.919	266
600 min Winter	9.203	324
720 min Winter	8.003	384
960 min Winter	6.565	504
1440 min Winter	4.966	738
2160 min Winter	3.756	1104
2880 min Winter	3.082	1472
4320 min Winter	2.208	2200
5760 min Winter	1.743	2920
7200 min Winter	1.450	3624
8640 min Winter	1.248	4352

EWE Associates Ltd		Page 3
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 15/07/2017 19:41 File 100yr+cc30% crate...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Winter	53.038	0.038	0.0	1.6	1.6	5.4	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Winter	1.100	5144

EWE Associates Ltd		Page 4
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 15/07/2017 19:41 File 100yr+cc30% crate...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	424600 424300 SE 24600 24300
C (1km)	-0.024
D1 (1km)	0.344
D2 (1km)	0.422
D3 (1km)	0.288
E (1km)	0.298
F (1km)	2.351
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+30

Time / Area Diagram

Total Area (ha) 0.241

Time (mins)	Area (ha)
0-4	0.241

EWE Associates Ltd		Page 5
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 15/07/2017 19:41 File 100yr+cc30% crate...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 54.170

Cellular Storage Structure

Invert Level (m) 53.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	150.0	150.0	2.600	0.0	174.5
0.200	150.0	159.8	2.800	0.0	174.5
0.400	150.0	169.6	3.000	0.0	174.5
0.600	0.0	174.5	3.200	0.0	174.5
0.800	0.0	174.5	3.400	0.0	174.5
1.000	0.0	174.5	3.600	0.0	174.5
1.200	0.0	174.5	3.800	0.0	174.5
1.400	0.0	174.5	4.000	0.0	174.5
1.600	0.0	174.5	4.200	0.0	174.5
1.800	0.0	174.5	4.400	0.0	174.5
2.000	0.0	174.5	4.600	0.0	174.5
2.200	0.0	174.5	4.800	0.0	174.5
2.400	0.0	174.5	5.000	0.0	174.5

Hydro-Brake® Outflow Control

Design Head (m) 1.000 Diameter (mm) 189
Design Flow (l/s) 21.7 Invert Level (m) 53.000
Hydro-Brake® Type Md5 SW Only

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.6	1.200	23.6	3.000	37.2	7.000	56.8
0.200	14.9	1.400	25.4	3.500	40.2	7.500	58.8
0.300	18.6	1.600	27.2	4.000	43.0	8.000	60.7
0.400	19.5	1.800	28.8	4.500	45.6	8.500	62.6
0.500	19.3	2.000	30.4	5.000	48.0	9.000	64.4
0.600	19.2	2.200	31.9	5.500	50.4	9.500	66.2
0.800	20.1	2.400	33.3	6.000	52.6		
1.000	21.8	2.600	34.6	6.500	54.8		