Figure 17: Existing Barns within Development Area B Viewed South



Image Source: PWA Associates

Table 10: Existing Contributing Areas – Development Area B

Surface Type	% Impermeable	Total Area (Ha)	Contributing Area (Ha)
Roof/Building Footprint	100	0.066	0.066
Semi-permeable (Gravel/Chippings)	50	0.006	0.003
Concrete/Tarmacadam Hardstanding	100	0	0
Landscape	10	0.396	0.040
Total		0.468	0.109

It is estimated therefore that the site is roof and paved to approximately 23% of the total development area.

4.3.8 Estimation of Existing Peak Surface Water Runoff – B

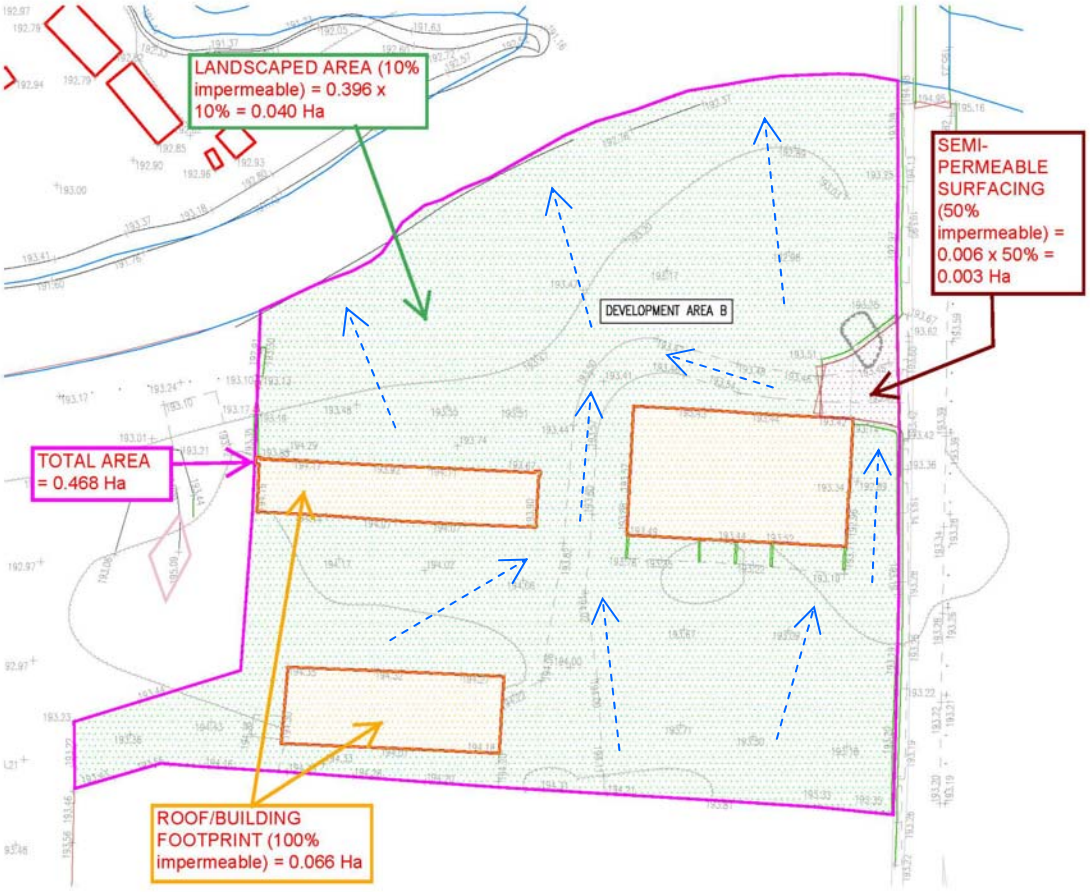
Utilising rainfall profiles obtained from the FEH CD-ROM (Version 3.0) and the Modified Rational Method, the peak surface water flows for a range of probabilities have been calculated and tabulated below. The full calculation spreadsheets are provided for reference within Appendix F of this report.

Table 11: Existing Surface Water Runoff – Development Area B

Return Period	Ex. Peak Runoff Rate (l/s)	30% Reduction (l/s)
1 in 2 year	8.4	5.9
1 in 30 year	24.5	17.2
1 in 100 year	37.6	26.3

In order to accommodate future climate change and provide a betterment to the existing situation, the Environment Agency; Yorkshire Water and Barnsley Council requires the application of a 30% reduction to existing peak runoff rates generated by the existing development.

Figure 18: Existing Areas Contributing to SW Runoff (Development Area B)



Flows in excess of this should be attenuated on-site prior to discharge into the receiving sewer or watercourse.

4.3.10 Post Development Contributing Areas

From the latest Architect Masterplan, the areas contributing to surface water runoff from each development area has been evaluated and tabulated below.

Table 12: Post-Development Contributing Areas

Surface Type	% Impermeable	Total Area (Ha)	Contributing Area (Ha)
Area A1			
Roof & Hardstanding	100	0.268	0.268
Landscape	10	0.231	0.023
Total		0.499	0.291
Comments: Existing area of roof/building footprint = 0.171Ha. Following development this is increased significantly in comparison; however the overall increase in impermeable area within the site only slightly rises from 0.261Ha to 0.291Ha i.e. 58% of the total area available within Development Area A1.			
Areas A2 & A3			
Roof & Hardstanding	100	0.363	0.363
Landscape	10	0.312	0.031
Total		0.675	0.394
Comments: Existing area of roof/hardstanding 0.273Ha. Following development this is increased significantly in comparison; as is the overall increase in impermeable area within the site, which rises from 0.329Ha to 0.394Ha i.e. 58% of the total area available within Development Areas A2 & A3.			
Area B			
Roof & Hardstanding	100	0.187	0.187
Landscape	10	0.281	0.028
Total		0.468	0.215
Comments: Existing area of roof/hardstanding 0.066Ha. Following development this is increased significantly in comparison; as is the overall increase in impermeable area within the site, which rises from 0.109Ha to 0.215Ha i.e. 46% of the total area available within Development Area B.			

It is advised that the contributing areas provided above should be re-evaluated during the detailed design phase to accommodate any changes made to the proposed development plan for each phase.

4.3.11 Attenuation Requirements

Due to the general increase in impermeable area within each phase of the proposed development at Nether Mill Farm, surface water runoff rates will be increased; and consequently will need to be attenuated prior to discharge from the site.

In accordance with Table 5 from the Technical Guidance for the National Planning Policy Framework (2012); peak rainfall intensities should be increased by 30% to accommodate climate change over the lifetime of the development i.e. 100 years for residential development.

The Environment Agency and Local Authority will insist that the proposed 1 in 2 year runoff can be maintained and also insist that the 1 in 30 year event is not allowed to flood the surface; hence the water must remain within the pipes, manholes, and storage systems.

The resulting runoff from the 1 in 100 year event, is allowed to flood the surface, however flood water must not be allowed to enter any of the buildings; or migrate to adjoining development outside of the site boundary.

Using the Wallingford Procedure Modified Rational Method storage volumes for each development area, for the 1 in 2 year, 30 year, 100 year plus climate change events have been calculated and tabulated below. The allowable discharge rates from the proposed development have been set to existing rates for the matching probabilities; or 5l/s whichever is the highest.

Areas A1; A2 and A3

Due to the proposed layout it is suggested that that 3No outfalls would be sufficient to serve the proposed development for areas A1; A2; A3 and C.

Outfall 1: Discharge from Areas A1

The area contributing to Outfall 1 from Development Area A1 is estimated to be 0.102 Hectares i.e. 35% of the overall area calculated for A1 (0.291 Hectares).

Pro-rating the allowable surface water discharge rates calculated within Section 4.3.4 of this report gives 5.0l/s; 14.4l/s; and 22.2l/s respectively for the 1 in 2 year; 1 in 30 year; and 1 in 100 year plus climate change storm events.

Table 13: Indicative Volume of Attenuation: Outfall 1 - Area A1 (0.102 Hectares)

Return Period	Storage Volume (m^3)
1 in 2 year + 30% climate change	3
1 in 30 year + 30% climate change	9
1 in 100 year + 30% climate change	14

Outfall 2: Discharge from Area A1

The area contributing to Outfall 2 from Development Area A1 is estimated to be 0.120 Hectares i.e. 41% of the overall area calculated for A1 (0.291 Hectares).

Pro-rating the allowable surface water discharge rates calculated within Section 4.3.4 of this report gives 8.4l/s; 24.3l/s; and 37.3l/s respectively for the 1 in 2 year; 1 in 30 year; and 1 in 100 year plus climate change storm events.

Table 14: Indicative Volume of Attenuation: Outfall 2 - Area A1 (0.120 Hectares)

Return Period	Storage Volume (m^3)
1 in 2 year + 30% climate change	4
1 in 30 year + 30% climate change	11
1 in 100 year + 30% climate change	16

Outfall 3: Discharge from Area A1; A2 & A3

The area contributing to Outfall 3 from Development Area A1 is estimated to be 0.069 Hectares i.e. 24% of the overall area calculated for A1 (0.291 Hectares).

The allowable surface water discharge rates calculated within Section 4.3.4 of this report gives 3.3l/s; 9.8l/s; and 15.1l/s respectively for the 1 in 2 year; 1 in 30 year; and 1 in 100 year plus climate change storm events.

Similarly the area contributing to Outfall 3 from Areas A2 & A3 is 0.394 Hectares; with allowable surface water discharge rates of 19.0l/s; 55.7l/s; and 85.8l/s respectively for the same rainfall events.

The combined allowable discharge rate from Outfall 3 therefore is 22.3l/s (1 in 2 year); 65.5l/s (1 in 30 year); and 100.9l/s (1 in 100 year) plus 30% climate change.

Table 15: Indicative Volume of Attenuation: Outfall 3 - Areas A1; A2 & A3 (0.463 Hectares)

Return Period	Storage Volume (m^3)
1 in 2 year + 30% climate change	16
1 in 30 year + 30% climate change	42
1 in 100 year + 30% climate change	62

Area B

Due to the proposed layout it is suggested that that a single outfall would be sufficient to serve the proposed development for area B.

Outfall 4: Discharge from Area B

The area contributing to Outfall 4 from Development Area B is estimated to be 0.215 Hectares.

The allowable surface water discharge rate for Development Area B is 5.9l/s; 17.2l/s; and 26.3l/s respectively for the 1 in 2 year; 1 in 30 year; and 1 in 100 year plus climate change event.

Table 16: Indicative Volume of Attenuation: Outfall 4 - Area B (0.215 Hectares)

Return Period	Storage Volume (m^3)
1 in 2 year + 30% climate change	14
1 in 30 year + 30% climate change	34
1 in 100 year + 30% climate change	48

General Comment

It is noted that the storage volumes provided are indicative only at this stage and should be recalculated during the detailed design stage to reflect the following:

- Planning Conditions
- Agreed allowable discharge from the site
- The finalised development proposals,
- The extent of impermeable areas and runoff to be generated.

4.4 Overland Flow

Spicer Hill is situated to the north west of the proposed development, with a top elevation of 349mAOD; and Hartcliff Hill to the south west with a crest level approximating 364mAOD.

From the Ordnance Survey Maps for the area, it is identified that surface water from these elevated areas is collected by a network watercourses and reservoirs.

Furthermore existing development at Thurlstone and within Penistone lies in between the site and these points; and so it is considered that surface water runoff along the overland flow routes will be intercepted by existing infrastructure, such as road gullies; highway drains and the public sewer network.

It is noted however that more immediate to the Nether Mill farm site, open field areas immediately to the north side of Development Areas A2 & A3 slope down towards the site boundary; providing an overland flow route.

In conclusion overland flows are considered to present a flood risk to the proposed development.

4.5 Groundwater

The following text in relation to the potential for groundwater flooding at the proposed development has been extracted from the Level 1 SFRA for Barnsley.

'*Groundwater flooding is caused by the emergence of water originating from underground, and is usually very local and governed by the local geology.*

Unlike flooding from rivers and the sea, groundwater flooding does not generally pose a significant risk to life, but is more associated with significant damage to property, with flooding persisting over a number of weeks for some types of groundwater flooding.

Groundwater flooding is a significant but localised issue that has attracted an increasing amount of public concern in recent years; and can also exacerbate fluvial flooding in certain circumstances.

Groundwater flooding arises from:

- *Natural exceptional rises in groundwater level, reactivating springs and short lived watercourses (often referred to as 'clearwater' flooding);*
- *Rising groundwater (rebound) following reductions in historic abstraction; Mine water recovering to natural levels following cessation of pumping; and*
- *Local shallow drainage/flooding problems unrelated to deep groundwater responses.*

Key issues are:

- *Groundwater flooding is sporadic in time and location, but when it occurs, it usually lasts longer than surface water flooding and interferes with property and infrastructure (such as roads).*
- *In most cases groundwater flooding cannot be easily managed or lasting solutions engineered.*

There are many other localised and site-specific reasons for water to emerge at the surface or to appear in basements, for example, leaking water mains and sewers, blocked drains, and impedance of natural drainage routes by urban development or deepening of cellars to below the natural water table.

Likely candidates for groundwater flooding in the Barnsley MBC area are:

- *Kingstone area of Barnsley*
- *Kingwell area of Worsbrough*
- *Millhouses area of Hoyland*
- *Upperwood area of Darfield*

The Coal Authority was consulted with respect to the possibility of flooding caused by the re-emergence of mine waters from the formerly very important South Yorkshire mining region following the cessation of mine water pumping. These discussions indicated that The Coal Authority have a comprehensive network of groundwater monitoring boreholes across South Yorkshire and, by working in partnership with the Environment Agency and other local coal

mining interests are developing a strategic forward plan to manage mine water levels to minimise the risk of re-emerging mine waters causing both flooding and/or initiating water quality problems in the major Sherwood Sandstone water resource aquifer.'

In conclusion groundwater flooding is deemed to present a low flood risk to all of the proposed development areas within the Nether Mill Farm site.

4.6 Reservoirs

The following text in relation to the potential for flooding from reservoirs at the proposed development has been extracted from the Level 1 SFRA for Barnsley.

'According to the Environment Agency's Register of Reservoirs, there are 19 operational 'large raised reservoirs' located within the boundaries of the Barnsley MBC boundary ranging in capacity between about 35,250m3 and 8,296,000m3.

Reservoirs can both store and attenuate flows in a similar manner to washlands and floodplains, depending upon how they are managed. At present these reservoirs are often full in winter and so would therefore provide little potential attenuation for flooding. Service reservoirs are not included in this register.

Reservoirs can also act as a major source of floor risk, as experienced recently during the 2007 summer floods in England and Wales, where 18 reservoirs were affected.

Reservoir flooding is therefore an important source of flood risk which has been noted within Pitt Review.

Whilst the probability of dam failure or breaching occurring is very small, the consequences of such an event can be devastating hence presenting a risk of flooding which has to be considered.

Currently the Water Act 2003, which amended the Reservoirs Act 1975, requires all reservoir undertakers to prepare reservoir flood plans for those reservoirs where the dam failure could put people's lives at risk or lead to major damage.

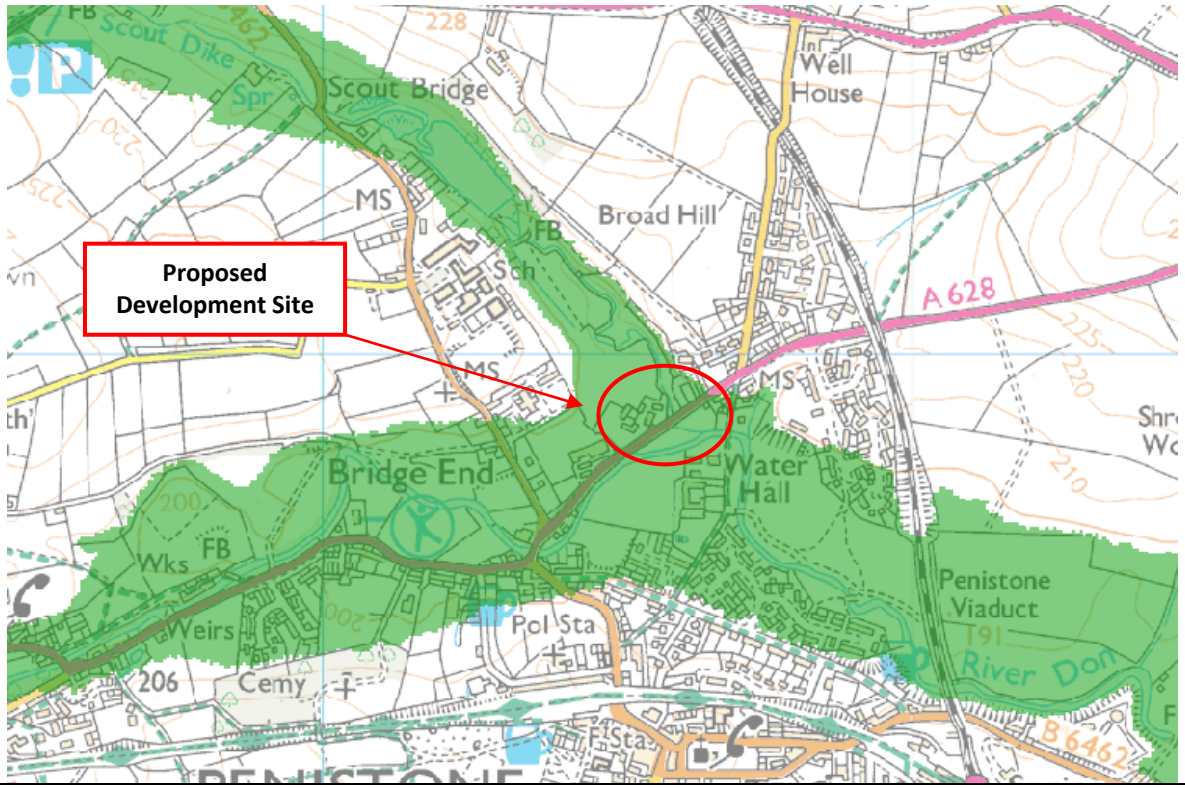
These plans are expected to become a legal requirement in spring 2009. DEFRA is currently funding a project to produce a 'Guide to Emergency Planning for UK Reservoirs', which will ultimately use the reservoir flood plans.

The reservoir flood plan includes:

- An inundation analysis to identify the extent and severity of flooding which could result from an uncontrolled release of water (i.e. breaching or failure).
- An on-site plan setting out what the undertaker would do in an emergency to try and to contain and limit the effects of the incident, and
- A communications plan with external organisations, mainly the emergency services.'

It is noted that there are a series of reservoirs upstream of the proposed development; the nearest being Scout Dike, located approximately 150 metres from the north boundary of Development Area A3; although Windleden Lower; Royd Moor; Ingbirchworth; Winscar; Windleden Upper; and Broadstone Reservoirs also impact the potential risk of flooding within the area surrounding the development site.

Figure 19: Risk of Flooding from Reservoirs



Souce: www.environment-agency.gov.uk

All of the reservoirs named are Yorkshire Water assets.

The map shown within Figure 19 above illustrates the largest area that might be flooded if a reservoir were to fail and release the water it holds. Since this is a prediction of a worst case scenario, it's unlikely that any actual flood would be this large.

In conclusion reservoir flooding is extremely unlikely. There has been no loss of life in the UK from reservoir flooding since 1925; and since this time reservoir safety legislation has been introduced to make sure reservoirs are well maintained.

As such the flood risk at the proposed development site presented by this source is considered to be low.

4.7 Ponding

The topographical survey indicates that in general there are no low points where localised ponding during heavy rainfall is likely to happen; with the exception of the access from Barnsley Road into Development Area A3.

Following redevelopment it is recommended that proposed levels are carefully designed to avoid any ponding within the site boundary from occurring; and where this is unavoidable suitable arrangements are incorporated within the design for drainage.

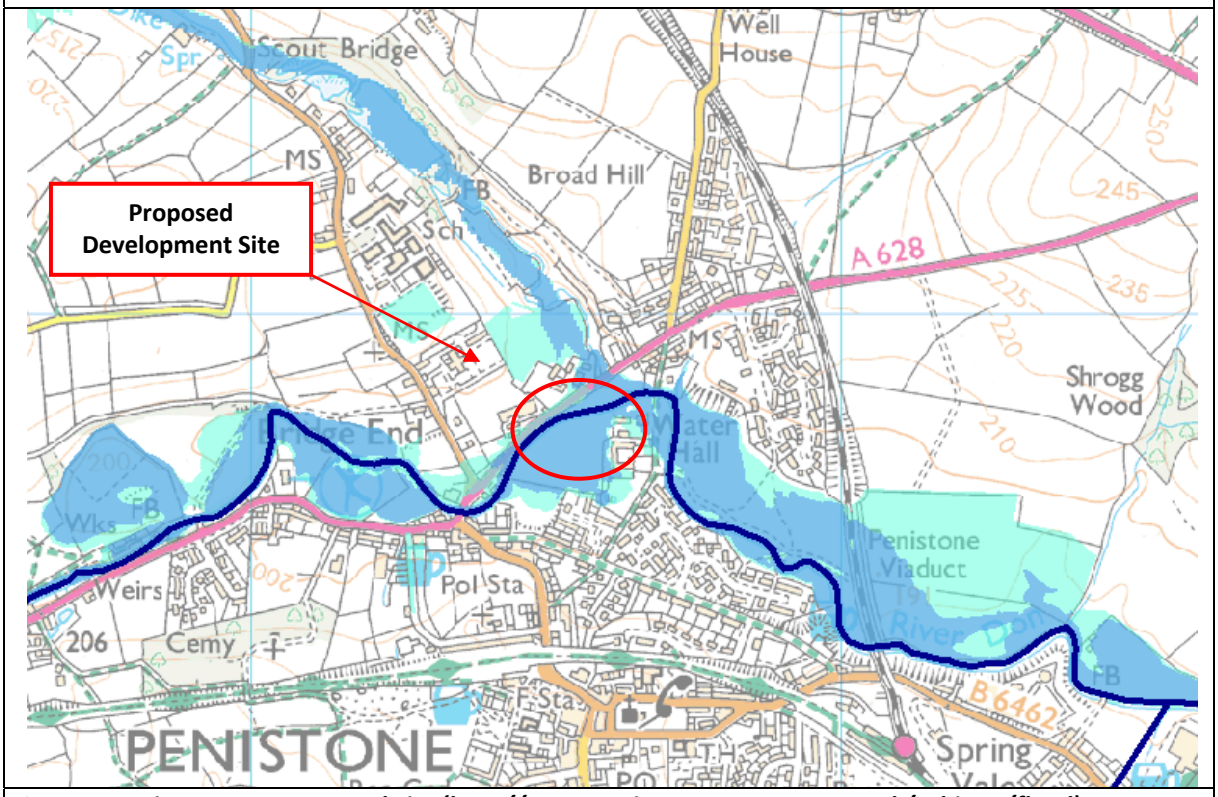
5.0 Material Consideration In Respect of the National Planning Policy Framework

5.1 Climate Change

Published evidence suggests that winters will become wetter over the whole of the UK, by as much as 20% by the year 2050. In making an assessment of the impact of climate change, flooding from rivers and land will give a peak flow allowance of up to 20% increase in rainfall for a given return period by 2050 and 30% by 2110. These considerations will provide an appropriate precautionary assessment for climate change impact on flood flows and rainfall intensities.

5.2 Environment Agency Flood Map

Figure 20: Environment Agency Flood Map



Source: Environment Agency website (http://www.environment-agency.gov.uk/subjects/flood)

Key

- Flooding from rivers or sea without defences (Flood Zone 3)
- Extent of extreme flood (Flood Zone 2)
- Flood defences
- Areas benefiting from flood defences
- Main rivers

The Environment Agency flood zone map indicates that Development Areas A3 and B lie partially within Flood Zone 3, being land and property with a high probability of flooding and is defined as land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

5.3 Finished Floor Levels

5.3.1 Area A1

Development Area A1 is located within Flood Zone 1; and consequently the finished ground floor levels may be retained as existing (former mill building A14 & A15) or set at an elevation of 150mm above external ground levels (new buildings A8 – 9; A10; A11 – 13; and A16-20), in accordance with the Building Regulations.

5.3.2 Area A2 & A3

The finished ground floor levels may be retained as existing within the stable and farmhouse buildings i.e. A4 & A5; and existing adjoining house and cottage; or set at an elevation of 150mm above external ground levels (new buildings A6 & A7), in accordance with the Building Regulations.

For the east section of the development area, which is shown to lie within Flood Zone 3; and was flooded during July 2012; the ground floor level of proposed residential accommodation should be set at a minimum of 600mm above the modelled or historic flood level; whichever is the highest.

The 1 in 100 year flood level is estimated at 193.758mAOD; increasing to 193.857mAOD with the application of climate change. The flood level during the July 2012 event was observed at 500m above the threshold level of the tractor shed i.e. 193.26mAOD + 0.5 = 193.76mAOD.

As such in accordance with the Environment Agency's requirements, the ground floor level within the affected buildings should be set at a minimum 194.457mAOD.

It is noted that the buildings which are affected by this flood risk comprise a listed barn structure (A2 & A3); and the tractor shed (A1), both of which will be redeveloped to provide residential accommodation.

The Architect has advised that the ground floor level within the barn cannot be altered due to its listed status; however, proposals involve building up of existing door and window openings on the front and gable elevations so that no opening will have a threshold that is lower than 194.0mAOD.

Flood resistance/resilience measures will be incorporated into the refurbishment of the building, where appropriate to a level of 194.457mAOD i.e. the 1 in 100 year plus climate change flood level, to reduce the risk of flooding. It is also noted that there will be no sleeping accommodation incorporated into the redevelopment works at ground floor level within the barn.

Due to constraints within the existing building, it is advised that the ground floor level within the existing tractor shed can be elevated to a maximum level of 193.8mAOD.

It is further advised that and all doorway threshold levels will be set at a minimum level of 194.00mAOD. Flood resistance/resilience measures will be incorporated into the building design to a level of 194.457mAOD i.e. 600mm above the 1 in 100 year plus climate change event, to minimise the impact of flooding within the refurbished building.

Again it is noted that there will be no sleeping accommodation at ground floor level within the tractor shed building.

5.3.3 Area B

Information obtained from the Architect indicates that the finished ground flood level within all of the proposed dwellings for this area of the Nether Mill Farm development will be set at 194.5mAOD.

The 1 in 100 year plus climate change flood level within the River Don adjacent to the site ranges from 193.775 – 193.867mAOD.

As such the footprint of the proposed dwellings is considered to be elevated more than the required 600mm to provide a suitable freeboard above the design flood level.

5.4 Flood Resistance/Resilience Measures

In areas of medium to high flood risk, it is usual to recommend the implementation of flood proofing within the proposed refurbishment plans or building design to reduce the residual damages if an extreme flood was to occur.

Owing to limiting site constraints, it is considered impractical to elevate ground levels within the footprint of the listed barn and tractor shed buildings within Development Area A3, to achieve a level 600mm above the 1 in 100 year plus climate change flood level i.e. 194.457mAOD; to provide sufficient freeboard.

Therefore to provide the minimum required level of protection in accordance with general

Environment Agency requirements it is recommended that flood resistance/resilience techniques are incorporated into the design for redevelopment.

Flood resistance/resilience measures within this area of the development works should therefore be designed to a minimum level of 194.457mAOD.

Flood proofing is a technique by which buildings are designed to withstand the effects of flooding. There are two main categories of flood proofing, which are dry proofing and wet proofing.

Dry proofing methods are designed to keep water out of the building, and wet proofing methods are designed to improve the ability of the property to withstand the effects of flooding once the water has entered the building.

Where wet proofing is required it is important that a flood warning and evacuation plan should be prepared and practised regularly, so that the occupants and any valuable and/or sentimental items can be moved to areas above the 1 in 100 year plus climate change flood level if required.

In addition fixtures and fittings should be built to withstand immersion in water or designed to be easily replaced.

The differential pressures across load bearing walls and the flotation effect that will occur during flood events should be taken into account when considering dry proofing techniques. For most existing properties this means that dry flood proofing should only be considered if the expected flood depth is under 0.9m.

The table below summarises the recommendations for flood proofing measures which can be incorporated within the design. Such measures are put forward in accordance with 'Development and Flood Risk Guidance for the Construction Industry' CIRIA C624, London 2004.

Table 17: Typical Flood Proofing Measures

Feature	Considerations To Improve Flood Proofing
External Walls	Careful consideration of materials: use low permeability materials to limit water penetration if dry proofing required. Avoid using timber frame and cavity walls. Consider applying a water resistant coating. Provide fitting for flood boards or other temporary barriers across openings in the walls.
Internal Walls	Avoid use of gypsum plaster and plasterboards; use more flood resistant linings (e.g. hydraulic lime, ceramic tiles). Avoid use of stud partition walls.

Table 17 cont'd

Floors	Avoid use of chipboard floors. Use concrete floors with integrated and continuous damp proof membrane and damp proof course. Solid concrete floors are preferable; if a suspended floor is to be used, provide facility for drainage of sub-floor void. Use solid insulation materials.
Fitting, Fixtures and Services	If possible, locate all fittings, fixtures and services above design floor level. Avoid chipboard and MDF. Consider use of removable plastic fittings. Use solid doors treated with waterproof coatings. Avoid using double-glazed window units that may fill with flood water. Use solid wood staircases. Avoid fitted carpets. Locate electrical, gas and telephone equipment and systems above flood level. Fit anti-flooding devices to drainage systems.

It would be preferable to avoid external doors as this would remove a potential point of flood inflows. However should openings be provided where ingress of water is possible, it is recommended that, flood resistant doors and/or the use of flood resistant stop logs or flood boards should be considered.

5.5 Flood Protection Equipment

Figure 21: Typical Example of a Flood Barrier



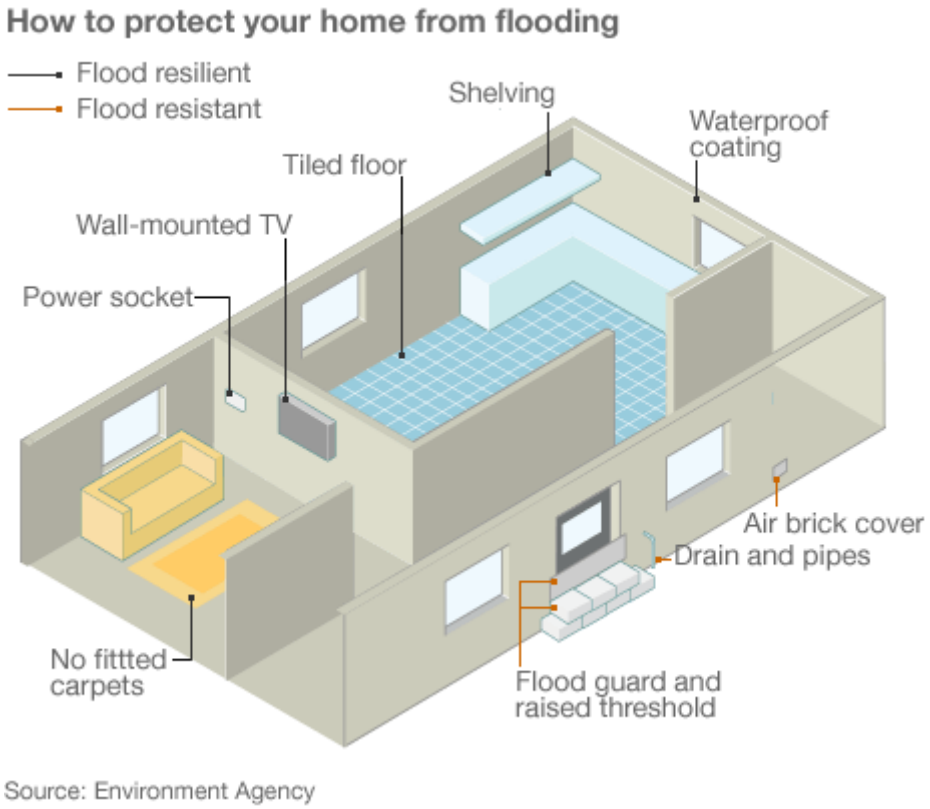
Source: www.floodmaster.co.uk

Keeping water out of the refurbished buildings or limiting the ingress of floodwater is recommended when considering flood protection measures. Excluding water will help to reduce damage to the internal fabric of the buildings and their contents. Such measures are referred to as dry-proofing and include:

- Temporary flood barriers.
- Measures to reduce seepage through walls and floors.
- The installation of non-return valves on sewers.

Movable flood barriers can be very effective in preventing or reducing the volume of floodwater entering through doors and other external openings in walls, such as windows and airbricks, as long as a good quality product is installed in accordance with the manufacturer's instructions.

Figure 22: Typical Flood Resilience/Resistance Measures



Source: Environment Agency

Although barriers may not totally prevent the ingress of water into a building, they can provide valuable time in which to move people, vehicles, expensive possessions and other essential items to higher levels before floodwater rises inside the building.

In order to compensate for the unfeasibility for elevating floor levels within the existing barn and tractor shed buildings (A1, A2 & A3) located within Development Area A3, it is recommended that the installation of flood protection up to a level of 2194.457mAOD is considered.

Flood barriers on wall openings can also reduce the amount of contaminated silt and debris entering a property. Water that seeps through the ground or walls is likely to be filtered to some extent and therefore is usually cleaner than floodwater entering larger openings such as gaps around doors and airbricks.

There are many suppliers and various types of flood doors and barriers which may be utilised at the application site; and a few examples of typical products are provided within Figures 21 & 22.

5.6 Emergency Access and Egress during Times of Flood

During normal flood conditions i.e. the 1 in 100 year plus climate change event; it has been determined that Barnsley Road is elevated above the anticipated flood level from Scout Dike and the River Don; and therefore dry access and egress from Development Areas A1 and A2 is possible.

This is not the case however for Development Area A3, where the courtyard area between the tractor shed and the site access is likely to become inundated; or Development Area B, where the site access onto Water Lane is liable to flooding.

5.6.1 Flood Hazard Rating Calculations

Where a dry route is not possible and a route with low flood hazard is identified, the route should not have any service covers that could be removed, or other underwater hazards. It is often difficult to see underwater hazards even in shallow water, particularly at night or if the water is silty.

In addition, the route should be clearly marked, for example using painted posts.

Vehicles should not be used when:

- The presence of water stops the engine functioning;
- The vehicle floats; or
- The vehicle becomes difficult to control.

Cars will stop and/or float in water as shallow as 0.5m, whilst some emergency vehicles may survive in water of 1m. A fire engine remains controllable in depths of 0.5m up to a flow velocity of 5 m/sec, due to high-level air intakes/exhausts.

The data and information required in assessing safe access and exit depends on the complexity of the approach undertaken, as follows:

Simple Approach

- Flood levels for suitable annual probabilities (advisable to look at the 1% and 0.1% annual probabilities for fluvial flooding or the 0.5% and 0.1% for tidal/coastal flooding).
- Minimum ground levels along access and exit routes.

Intermediate Approach

- Flood depths and velocities for suitable annual probabilities across the development site and surrounding the development site, determined from hydraulic modelling.
- Simple lookup table relating depth and velocity to danger to people.

Detailed Approach

- Flood depths and velocities across the development site and surrounding the development site, determined from hydraulic modelling.
- An appropriate means for determining the hazard factor for the site should be determined from the Flood Risks to People report.

Due to the scope of development proposed, an intermediate approach to assessing the safety of the site escape routes has been adopted.

Intermediate Approach: Methodology

Danger to people is assessed using flood hazard, which can be expressed as a combination of flood depth and velocity.

Hydraulic modelling or the use of results from an existing assessment is needed to predict flood depth and velocity.

The Flood Risks to People project has developed the following equation to relate the flood hazard to flood depth and velocity:

$$\text{Flood Hazard Rating} = ((v + 0.5) \times D) + DF$$

Where:
v = velocity (m/s)
D = depth (m)
DF = debris factor

The following table extracted from FD2321/TR1 provides guidance with regard to the appropriate debris factors to be applied.

Table 18: Guidance on Debris Factors for Different Flood Depths, Velocities and Dominant Land Uses (Table 3.1 FD2321/TR1)

Depths	Pasture/Arable	Woodland	Urban
0 to 0.25m	0	0	0
0.25 to 0.75m	0	0.5	1
>0.75m and/or V>2	0.5	1	1

Using the guidance provided by FD2320/TR2, the following velocities are sufficient for such calculations:

- 0.5 m/s for lowland flat floodplains
- 2.0 m/s for steeper catchment

Based on this, the hazard rating equation has been applied to various combinations of flood depth and velocity to produce a matrix of hazard ratings.

Applying thresholds to these hazard ratings defines the danger to people at various depths and velocities as shown in the following table, extracted from FD2320/TR2.

Table 19: Velocity, Depth and Flood Hazard Matrix

Velocity (m/s)	Depth (m)									
	DF = 0			DF = 1.0						
	0.1	0.2	0.25	0.5	0.75	1.00	1.25	1.50	1.75	2.00
0.00	0.05	0.10	0.13	1.25	1.38	1.50	1.63	1.75	1.88	2.00
0.50	0.10	0.20	0.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
1.00	0.15	0.30	0.38	1.75	2.13	2.50	2.88	3.25	3.63	4.00
1.50	0.20	0.40	0.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
2.00	0.25	0.50	0.63	2.25	2.88	3.50	4.13	4.75	5.38	6.00
2.50	0.30	0.60	0.75	2.50	3.25	4.00	4.75	5.50	6.25	7.00

Low	<0.75	Low flood hazard (caution is required)
Class 1	0.75 – 1.25	Moderate hazard - Danger for some (children, the elderly & infirm)
Class 2	1.25 – 2.00	Significant hazard - Danger for most (the general public)
Class 3	>2.00	Extreme hazard - Danger for all (includes the emergency services)

The location of the proposed development is at the base of the Upper Don Valley; and so it is considered that the catchment for watercourse is considered to be fairly steep and therefore a velocity of 2.0m/s has been utilised.

Figure 23: Flood Escape Routes for Development Areas A2 & A3



5.6.2 Escape Route along Barnsley Road: Development Areas A1; A2 and A3

The potential escape route directs pedestrians westwards along Barnsley Road away from the area of potential flooding (purple route depicted in Figures 23 & 24). The assessed points are as follows:

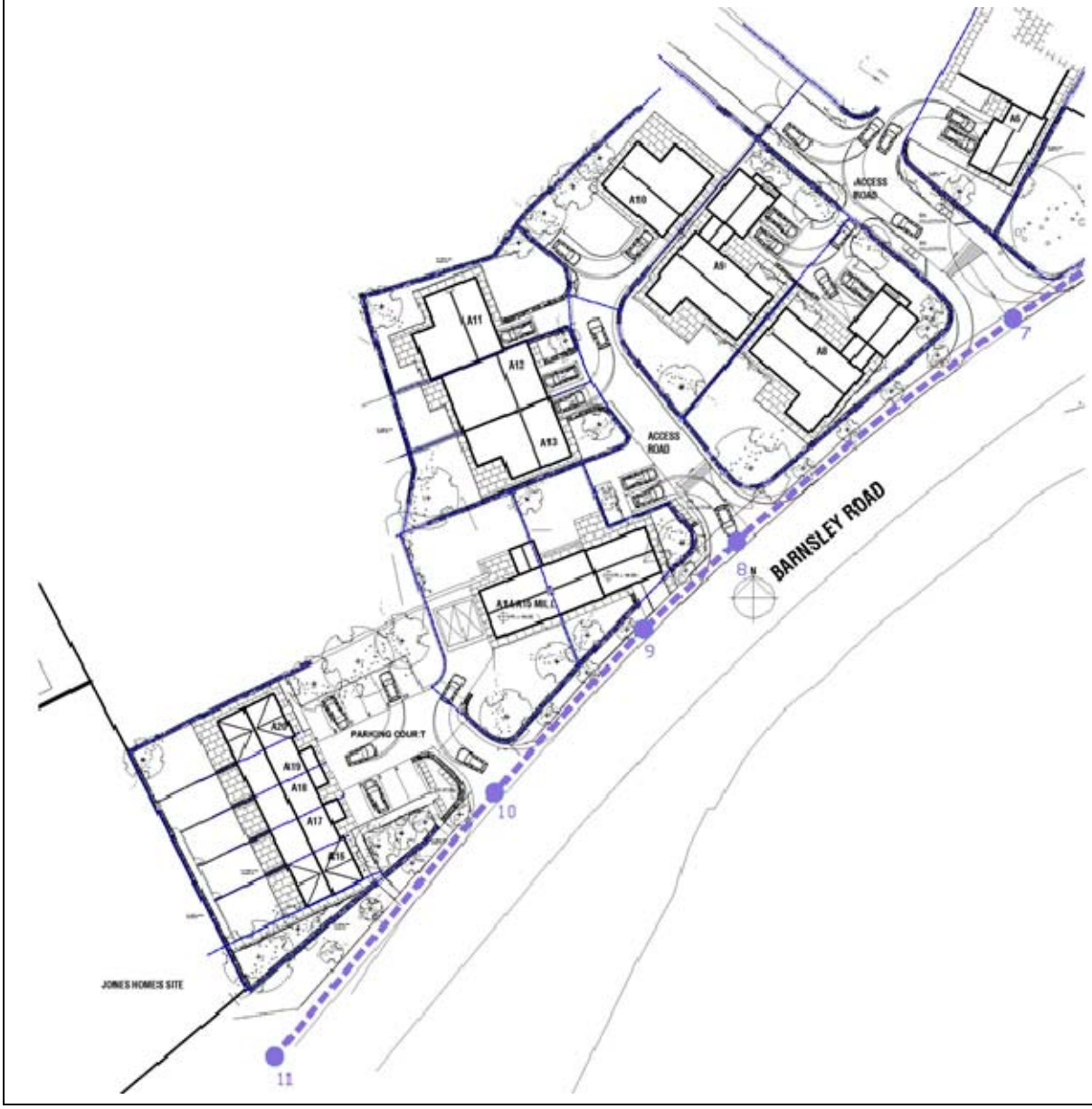
- Point 1 – threshold of redeveloped tractor shed (unit A1)
- Points 2 to 4 – on-site access road serving units A1 – A5, plus the existing house and cottage within Development Area A2 & A3.
- Point 5 – access into Development Areas A23 & A3 from Barnsley Road.
- Points 6 to 11 – north footpath Barnsley Road leading westwards.

The nearest population centre lies west within the town at Penistone; however owing to the potential for flooding of the route from the River Don, it is recommended that residents are advised to avoid this; and should be directed northwards at Huddersfield Road towards Penistone Grammar School which lies within Flood Zone 1.

Undertaking a hazard rating exercise along the escape route indicates that the internal access road serving Development Area A3 exhibits a significant hazard for flood events as low as the 1 in 10 year event; increasing to an extreme hazard rating during the 1 in 25 year flood event.

This will impact residents within proposed units A1 to A5 including the existing house and cottage located within Development Area A3.

Figure 24: Flood Escape Route for Development Areas A1 and A2



Consequently an alternative escape route will need to be provided for residents located within this area.

External to the development, the footpath along the north side of Barnsley Road indicates a low flood hazard for pedestrians during all potential flood events.

It is noted that residents within proposed units A6 to A20, located within Development Areas A1 & A2; and future development within area C will be able to gain dry access and

egress from the site for flood events up to the 1 in 100 year + climate change event; with low hazard access and egress available during the extreme 1 in 1000 year event.

In order to lower the hazard to residents of unit A5, the farmhouse, it is suggested that a pedestrian access gate leading on to Barnsley Road is provided from the rear driveway area.

Table 20: Summary Flood Hazard: Barnsley Rd - 1 in 5 to 75 yr Flood Event

Point Ref.	1 in 5 year	1 in 10 year	1 in 25 year	1 in 50 year	1 in 75 year
1	Low	Low	Low	Low	Low
2	Low	Class 2	Class 3	Class 3	Class 3
3	Low	Low	Class 2	Class 3	Class 3
4	Low	Low	Low	Class 2	Class 3
5	Low	Low	Low	Low	Low
6	Low	Low	Low	Low	Low
7	Low	Low	Low	Low	Low
8	Low	Low	Low	Low	Low
9	Low	Low	Low	Low	Low
10	Low	Low	Low	Low	Low
11	Low	Low	Low	Low	Low

Table 21: Summary Flood Hazard: Barnsley Rd - 1 in 100 to 1000 yr Flood Event

Point Ref.	1 in 100	1 in 200 year	1 in 100 year + CC	1 in 1000 year
1	Low	Low	Low	Low
2	Class 3	Class 3	Class 3	Class 3
3	Class 3	Class 3	Class 3	Class 3
4	Class 3	Class 3	Class 3	Class 3
5	Low	Low	Low	Class 3
6	Low	Low	Low	Low
7	Low	Low	Low	Low
8	Low	Low	Low	Low
9	Low	Low	Low	Low
10	Low	Low	Low	Low
11	Low	Low	Low	Low

5.6.3 Escape Route Avoiding Site Access into Development Area A3

In order to provide a suitable means of escape from Development Area A3; an alternative route around the north side of the existing house and cottage; and proposed units A3 and A3, emerging onto Barnsley Road has been investigated.

The route is depicted as an orange dotted line within Figure 23; and the assessed points are as follows:

- Point 1 – threshold of redeveloped tractor shed (unit A1) – north west frontage.
- Points 2 to 7 – access pathways to the rear of the existing house and cottage buildings.
- Points 8 & 9 – rear of former barn (unit A3).
- Points 10 to 12 – along the front & through the driveway of unit A54, the farmhouse.
- Point 13 – existing footpath along the north side of Barnsley Road.

Table 22: Summary Flood Hazard: Development Area A3 - 1 in 5 to 75 yr Flood Event

Point Ref.	1 in 5 year	1 in 10 year	1 in 25 year	1 in 50 year	1 in 75 year
1	Low	Low	Low	Low	Low
2	Low	Low	Low	Low	Low
3	Low	Low	Low	Low	Low
4	Low	Low	Low	Low	Low
5	Low	Low	Low	Low	Low
6	Low	Low	Low	Low	Low
7	Low	Low	Low	Low	Low
8	Low	Low	Low	Low	Low
9	Low	Low	Low	Low	Low
10	Low	Low	Low	Low	Low
11	Low	Low	Low	Low	Low
12	Low	Low	Low	Low	Low
13	Low	Low	Low	Low	Low

Table 23: Summary Flood Hazard: Development Area A3 - 1 in 100 to 1000 yr Flood Event

Point Ref.	1 in 100	1 in 200 year	1 in 100 year + CC	1 in 1000 year
1	Low	Low	Low	Low
2	Low	Low	Low	Low
3	Low	Low	Low	Low
4	Low	Low	Low	Low
5	Low	Low	Low	Low
6	Low	Low	Low	Low
7	Low	Low	Low	Low
8	Low	Low	Low	Low
9	Low	Low	Low	Low
10	Low	Low	Low	Low
11	Low	Low	Low	Low
12	Low	Low	Low	Low
13	Low	Low	Low	Low

This alternative escape route away from the potential flooding within the access road of Development Area A3 is shown to have a low hazard rating during flood incidents up to and including the extreme 1 in 1000 year event.

Access to this escape route should be made available for the residents at all times via openings in walls and hedges.

5.6.4 Escape Route along Water Hall Lane: Development Area B

Due to the location of Development Area B, i.e. immediately adjacent to the River Don; it is essential that the escape route from the site towards Barnsley Road via Water Hall Lane is considered safe i.e. a low hazard.

The route is depicted as a cyan coloured dotted line within Figure 25; and the assessed points are as follows:

- Point 1 – threshold of unit B3.
- Points 2 & 3 – along access road within Development Area B.
- Point 4 – junction of Water Hall Lane with site access.
- Points 5 to 8 – route northwards along Water Hall Lane.

Figure 25: Flood Escape Route for Development Area B

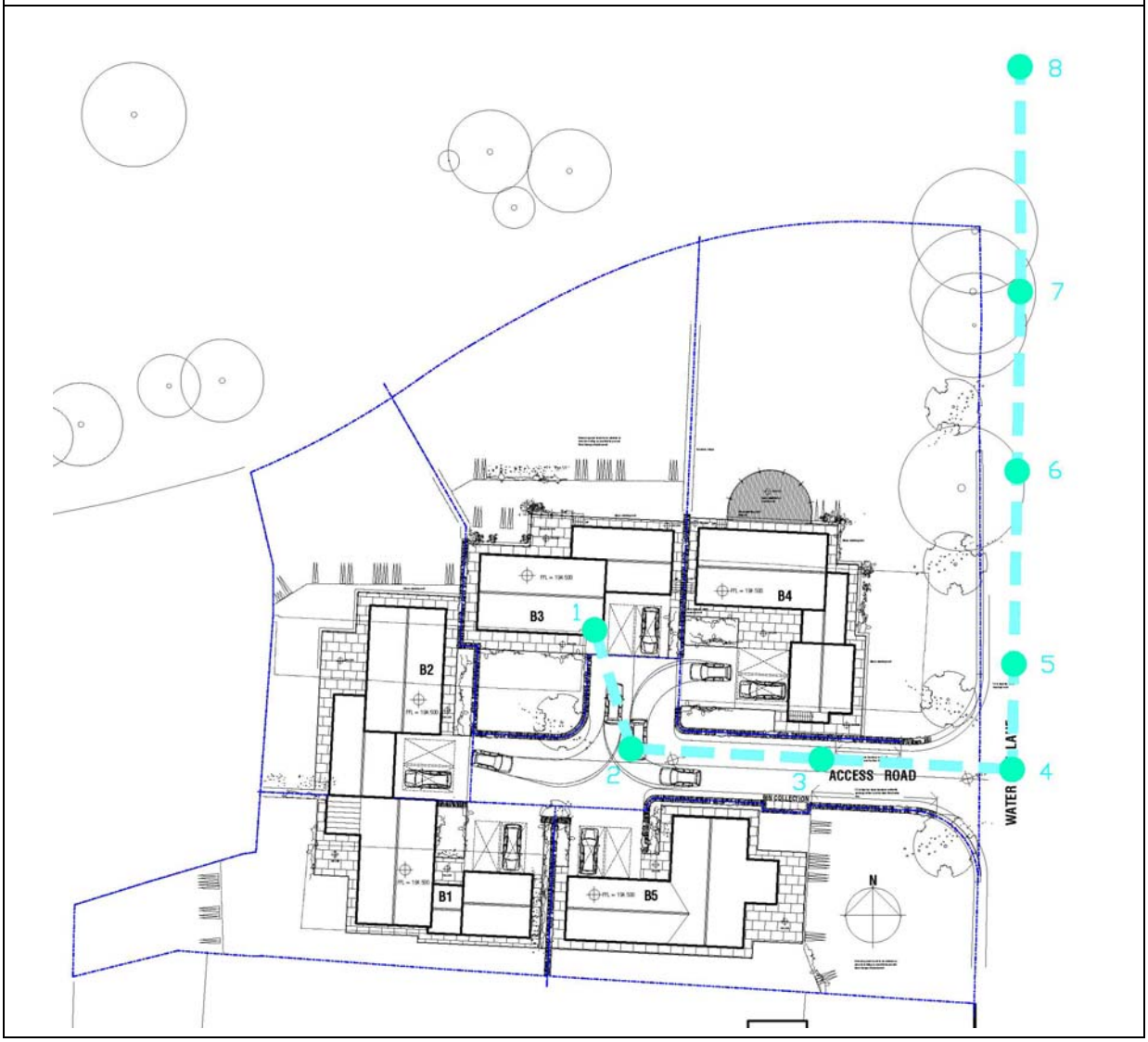


Table 24: Summary Flood Hazard: Development Area B - 1 in 5 to 75 yr Flood Event

Point Ref.	1 in 5 year	1 in 10 year	1 in 25 year	1 in 50 year	1 in 75 year
1	Low	Low	Low	Low	Low
2	Low	Low	Low	Low	Low
3	Low	Low	Low	Low	Low
4	Low	Low	Low	Low	Class 2
5	Low	Low	Low	Low	Low
6	Low	Low	Low	Low	Low
7	Low	Low	Low	Low	Low
8	Low	Low	Low	Low	Low

Table 25: Summary Flood Hazard: Development Area B - 1 in 100 to 1000 yr Flood Event

Point Ref.	1 in 100	1 in 200 year	1 in 100 year + CC	1 in 1000 year
1	Low	Low	Low	Low
2	Low	Low	Low	Low
3	Low	Low	Low	Low
4	Class 2	Class 2	Class 2	Class 2
5	Low	Class 2	Class 2	Class 2
6	Low	Low	Low	Low
7	Low	Low	Low	Low
8	Low	Low	Low	Low

Flood events up to and including the 1 in 50 year event are considered to present a low hazard to pedestrians accessing and egressing Development Area B along Water Hall Lane.

It is noted however that the hazard to people increases to Class 2 i.e. a significant hazard, for flood events in excess of the 1 in 75 year event. This hazard classification is not shown to increase up to the extreme 1 in 1000 year flood event within the River Don.

In order to reduce the hazard rating of the escape route to an acceptable level i.e. low for flood events up to the 1 in 100 year plus climate change event, Water Lane within the vicinity of the site access needs to be elevated to a minimum level of 193.290mAOD; increasing to 193.342mAOD to provide a low hazard escape route for the more extreme 1 in 1000 year event.

This will also benefit residents within the adjoining residential development known as Wordsworth Court; through provision of a low hazard means of escape to higher ground.

However, it is considered that this may have a detrimental impact on flood storage volumes and conveyance routes within the site.

Due to the proximity of Scout Dike and the River Don to the proposed development, particularly Development Areas A3 & B; it is highly recommended that residents are advised sign up to receive flood warnings from the Environment Agency.

Furthermore, it is advised that the residents devise and practice a personal flood evacuation plan; to move away from the site if instructed to do so.

5.7 Flood Warning

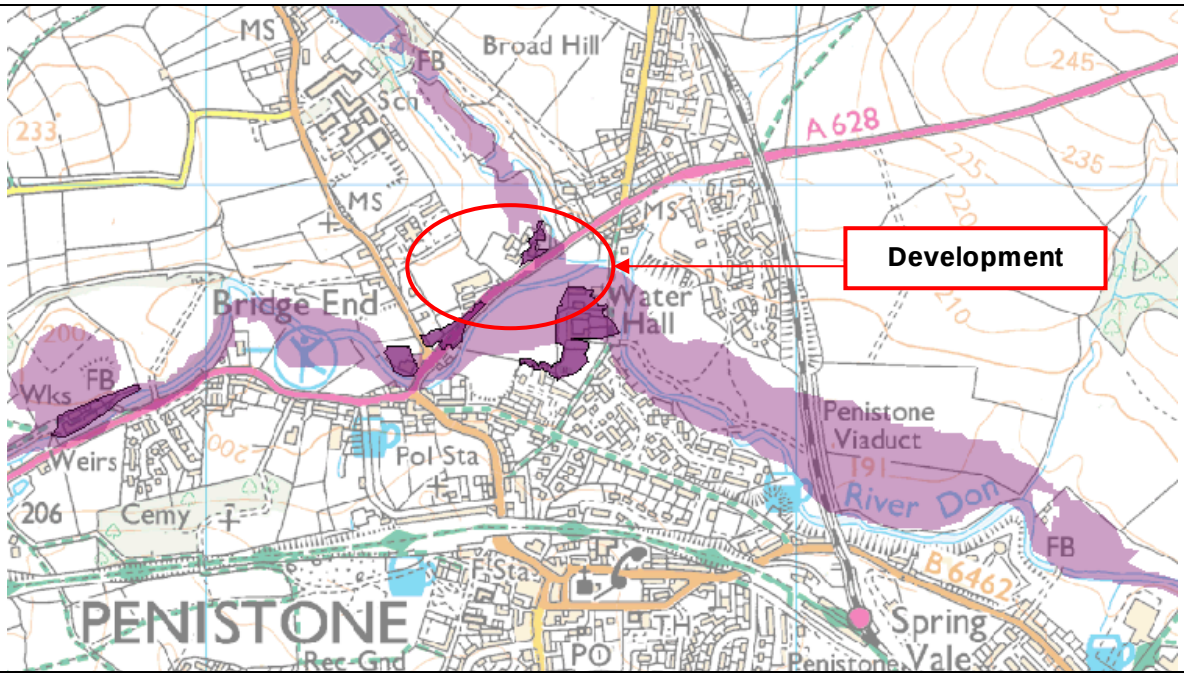
In general residents from Development Areas A1 and A2 will be able to access and egress from the development during the 1 in 100 year plus 20% climate change event with a low flood hazard. This is not possible for residents from Development Areas A3 and B; for the reasons described within the previous sections of this report.

It is therefore recommended that prospective property owners/residents are advised to register an interest in receiving flood warnings via the Environment Agency's Flood Warning's Direct Service.

This is a free service which enables the Environment Agency to send a direct message when flooding is expected and may affect the development. Flood warnings are designed to provide businesses the time to prepare for flooding. Flood warnings can be sent by telephone, mobile, email, SMS text message or fax.

The Environment Agency also provides the **Floodline 0845 988 1188** service, where the site owner/occupiers can listen to recorded flood warning information for the area or speak to an operator for advice 24 hours a day.

Figure 26: Environment Agency Flood Warning Coverage Map



Source: Environment Agency website (http://www.environment-agency.gov.uk)

How are Flood Warnings and Alerts issued?

- **Direct to you** - receive warnings by phone, text, email or fax. Sign up for the Environment Agency's **FREE** Floodline Warnings Direct service via this website link: https://fwd.environment-agency.gov.uk/app/olr/register or by calling Floodline on **0845 988 1188.**
- **On the flood warnings website** - view up-to-date information about flood warnings in force, monitor the river or sea levels in your area and check out the latest flood risk forecast for your county.
- **By calling Floodline on 0845 988 1188** - you can listen to recorded information on the latest warnings and predictions or speak to an operator for more general information 24 hours a day. Environment Agency operators can also provide a quick dial number which gives you faster access to information for your area.
- **Through the media** - you may see or hear Environment Agency warnings on television and in radio broadcasts.
- **Flood Wardens** - in some areas Flood Wardens are there to alert and support their local community when a flood warning is issued. Call Floodline on **0845 988 1188** to find out if this service is available in your area.
- **Sirens/loudhailers** - in some areas the Environment Agency uses loudhailer or siren systems to warn people that a flood warning has been issued. Call Floodline on 0845 988 1188 to find out if this type of service operates in your area.
- **Flood warning feeds** - Flood warning (RSS) feeds shows national and regional flood warnings in force and are updated every 15 minutes. The feeds contain a brief summary and link to the full information on the Environment Agency website.

Table 26: Environment Agency Flood Warning Codes

Flood Warning Code	What it means	When it's used	What to do
	Flooding is possible. Be prepared.	2 hours – 2 days in advance of flooding.	• Be prepared to act on your flood plan • Prepare a flood kit • Monitor local water levels and the flood forecast of the EA website
	Flooding is expected. Immediate action is required.	½ hour – 1 day in advance of flooding.	• Move people to a safe place • Turn of gas, electricity and water supplies if safe to do so • Put flood protection equipment in place
	Severe flooding. Danger to life.	When flooding poses a significant threat to life.	• Stay in a safe place with means of escape • Be ready to evacuate • Co-operate with the emergency services • Call 999 if you are in immediate danger

Table 26 cont'd

Warnings no longer in force	No further flooding is currently expected in your area	When river or sea conditions begin to return to normal	• Be careful as flood water may still be around for several days • If you have been flooded, ring your insurance company as soon as possible

5.8 Evacuation Plan

In the event of fluvial flooding at the application site, for health and safety reasons during flood conditions there is a preference to evacuate, as failure to do so, would put the site's occupants; visitors and others (e.g. rescuers) at risk of injury.

Therefore, it is recommended that the development's occupants are advised to devise individual flood evacuation plans to enable relocation from the site to a safe area away from Scout Dike and the River Don, should a flood warning or alert be issued by the Environment Agency.

It is noted that during evacuation, all persons vacating the development to the north side of Barnsley Road should be directed towards Penistone Grammar School located along Huddersfield Road and away from the flood zone.

In contrast, persons evacuating away from Development Area B, are not advised to cross Scout Dike along Barnsley Road due to the potential of flooding across the carriageway. Consequently, residents are advised to move eastwards at Barnsley Road, towards the population centre located off Barnsley Road at this location at Well House Lane and Wordsworth Road; which are elevated above the estimated extent of flooding from the watercourses.

Practical advice is available from the Environment Agency website:
http://www.environment-agency.gov.uk/homeandleisure/floods/31624.aspx

The various possible escape routes from each of the development areas are provided within Figures 23-25.

5.9 Compensatory Flood Storage

Development Areas A3 & B are found to be located within Flood Zone 3.

Proposals for area A3 situated within Flood Zone 3 involve redevelopment of existing buildings; and consequently there will be no displacement of flood water attributed to this part of the site.

Proposals for Development Area B involve demolition of existing farm buildings; and construction of 5No new residential units.

It is proposed that the ground floor level of the properties is elevated to a minimum level of 194.50mAOD i.e. 600mm above the 'worst case' design flood level for the 1 in 100 year plus 20% climate change event within the River Don.

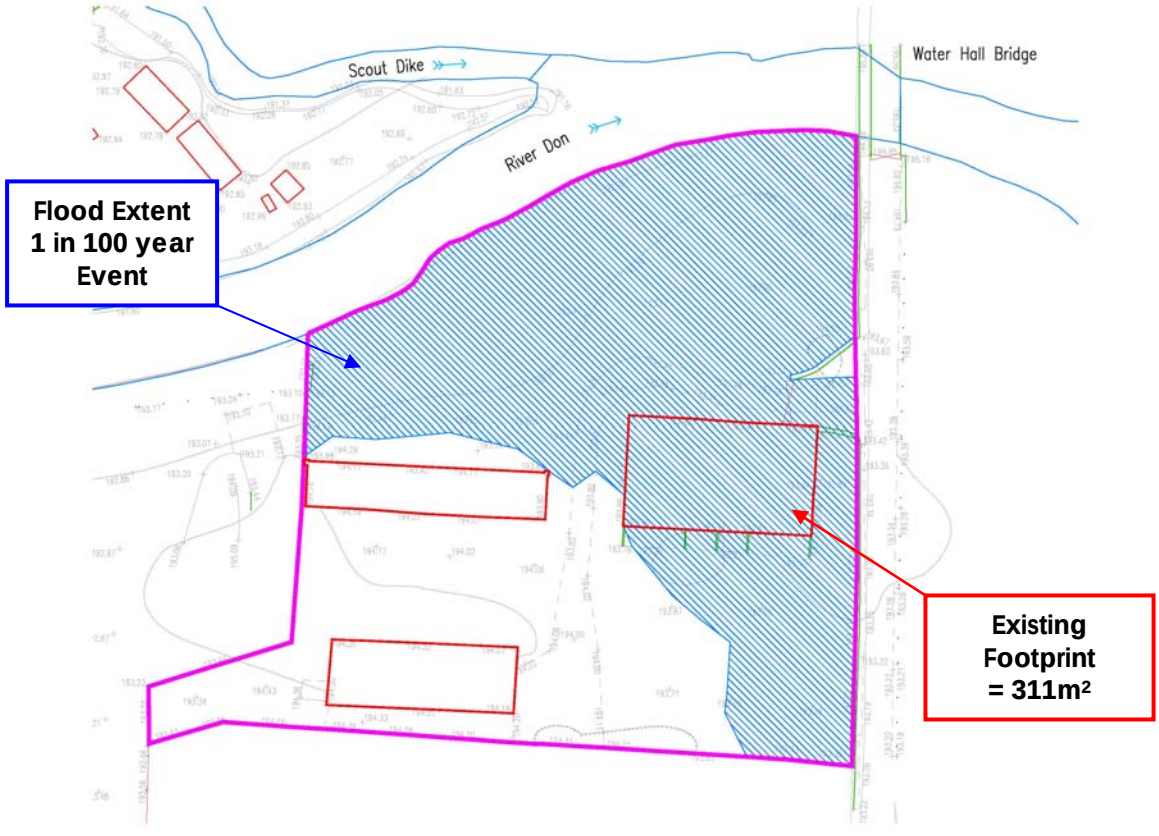
However proposals for this development area clearly encroach into the floodplain, potentially causing a displacement of flood water.

In simple terms, the footprint of the existing barn located within Flood Zone 3 measures 311m^2. Measuring the footprint of the current development proposals situated within the floodplain, the building footprint covers an area of only 262m^2; however an overall area of 560m^2 is shown to lie at a level above 194mAOD; thereby confirming flood water displacement from the site.

More detailed calculations have therefore been undertaken to quantify the volume of flood water displaced by the existing buildings and proposed development during flood conditions within the River Don; using series of cross sections through the site.

The volumes have been calculated on a level-by level basis utilising the modelled flood levels provided for the River Don for the 1 in 5 year to 1 in 100 year return period; and are tabulated within Sections 5.9.1 and 5.9.2 of this report.

Figure 27: Existing Flood Storage – Development Area B



5.9.1 Pre-development Flood Storage Capacity: Area B

Table 27: Summary of Pre-development Flood Water Storage within Area B

Return Period	Volume Stored (m^3)
1 in 5 year	116.9
1 in 10 year	199.4
1 in 25 year	416.3
1 in 50 year	359.8
1 in 75 year	165.9
1 in 100 year	82.3
Total	**1340.6**

5.9.2 Post-development Flood Storage Capacity: Area B

Table 28: Summary of Post-development Flood Water Storage within Area B

Return Period	Volume Stored (m^3)
1 in 5 year	125.9
1 in 10 year	250.2
1 in 25 year	474.2
1 in 50 year	381.2
1 in 75 year	170.8
1 in 100 year	83.7
Total	**1486.0**

Through careful consideration of design levels; along with the removal of a large earth mound adjoining the west side of Development Area B; and provision of conveyance routes where required; the volume of flood storage within the plot can be balanced.

This is essential to prevent displacement of flood waters outside of the site; which may otherwise exacerbate flooding within the adjoining residential development.

Cross Sections and full calculations are provided within Appendix L of this report.

5.10 Preliminary Drainage Strategy

5.10.1 Building Regulations Hierarchy

The impermeable area and hence surface water flows from the proposed development are considered to increase following completion of the development.

The hierarchy for disposal of surface water from new development is outlined within The Building Regulations Approved Document H and specifies the following methods in order of preference:

- Infiltration via soakaway or other suitable infiltration device
- Discharge to watercourse
- Discharge to public sewer.

Infiltration

A site investigation report for the proposed development is not currently available. Therefore in order to assess the potential for infiltration methods to dispose of surface water from the development, an investigation of the general ground conditions within the Bacup area was undertaken.

Catchment wide data for the site was obtained from the FEH CD-ROM (V3.0), which indicates that, the SPRHOST (Standard Percentage Runoff) for the site has a value of 38.7%; with a value of 45% indicated by MicroDrainage Source Control**.** These values are fairly high and are considered generally to represent ground which is not suited for dissipation of surface water flows into the ground.

To further investigate, a review of historical borehole logs within the general vicinity of the development from the British Geological Society records indicates that ground is predominantly underlain by impermeable siltstone.

A copy of the borehole logs which have been reviewed is provided within Appendix M of this report.

Information from the National Soil Resource Institute: www.landis.org.uk/soilscapes details the development area as being situated on slowly permeable seasonally wet acid and loamy and clayey soil with impeded drainage characteristics.

It is noted however that the large number of natural streams which emanate from the high areas surrounding Penistone do not provide a positive case for infiltration; as it is considered likely that most surface water drainage within the area is discharged to watercourse.

Watercourse & Sewer

The existing drainage regime within development Area A1, A2 and A3, suggest that surface water is currently directed to the public combined sewer located within Barnsley Road.

Due to local topography and the route to watercourse intercepted by a primary traffic route i.e. Barnsley Road, it is considered impractical to discharge surface water from the north side of the highway to watercourse. Consequently it is considered that surface water should be directed to the public sewer system, through the re-utilisation of exiting outfalls.

It is proposed that surface water runoff rates discharged from the development via this manner will be reduced to provide a betterment in comparison to the existing situation.

It is noted however that Yorkshire Water do not have to accept surface water runoff from the development into the public sewer network; and as such in the event that this is the only viable solution for disposal of surface water from the site; then it is highly recommended that the Developer undertakes discussions with Yorkshire Water at the earliest opportunity.

Surface water runoff emanating from Development Area B will be directed to the River Don via a new outfall.

5.10.2 Surface Water Drainage Design Criteria

The following criteria for designing surface water drainage systems for new development have been extracted from the Joint DEFRA/EA R&D Technical Report 'Preliminary Rainfall Runoff Management for Developments' (W5-074/A/TR/1) published in January 2012.

1. Discharge Rate

The Environment Agency normally require that, for the range of annual flow rate probabilities, up to and including the 1% annual probability (1 in 100 year event) the developed rate of runoff into a watercourse should be no greater than the undeveloped rate of runoff for the same event based on the calculation of QBAR or QMED and the use of FSSR growth curves.

Exceptions only apply where it is not practical to achieve this due to either constraints on the size of the hydraulic control unit, or excessive storage volumes. The purpose of this is to retain a natural flow regime in the receiving watercourse and not increase peak rates of flow for events of an annual probability greater than 1%. Three annual probabilities are used to define discharge compliance limits though the critical criteria are for the lowest and highest frequency events; 100% (1 year), 3.33% (30 year) and 1% (100 year).

2. 1 in 1 year Design Event

The 1 in 1 year event is the highest probability event to be specifically considered to ensure that flows to the watercourse are tightly controlled for frequent events to provide good morphological conditions.

3. 1 in 30 year Design Event

The 1 in 30 year event is of importance because of its linkage with the level of service requirement of Sewers for Adoption 7th Edition, which requires that surface water sewers should be capable of carrying the 1 in 30 year flows generated by a development within the system without causing flooding to any part of the site.

4. 1 in 100 year Design Event

The 1 in 100 year event has been selected since it represents the boundary between high and medium risks of fluvial flooding defined by the National Planning policy Framework (2012) and also recognises that it is not practicable to fully limit flows for the most extreme events. Also Sewers for Adoption 7th Edition recognises that, during extreme wet weather, the capacity of surface water sewers may be inadequate.

Sewers for Adoption 7th Edition requires that the site layout should be such that internal property flooding does not result, by demonstrating safe above ground flow paths.

The return period for this analysis is not specified, but it is recommended that 1% annual probability event (i.e. an event with a return period of 100 years) is used.

5. Flood Flows

Runoff up to the 1 in 100 year return period should preferably be managed within the site at designated temporary storage locations unless it can be shown to have no material impact by leaving the site in terms of nuisance or damage, or increase river flow during periods of fluvial flooding. Analysis for overland flood flows within the site will need to use appropriate duration events which may be different to critical events for designing surface water control storage structures.

6. Surface Water Runoff Volume

Theoretically the surface water runoff volume from a site should be limited to the greenfield runoff volume for all event frequencies. However this is technically extremely difficult to achieve and therefore compliance to two criteria on runoff volume is required.

a. **Interception:** Where possible, infiltration or other techniques are to be used to try and achieve zero discharge to receiving waters for rainfall depths up to 5mm.

b. **Additional Runoff Due to Development:** The difference in runoff volume pre- and post-development for the 100 year 6 hour event, (the additional runoff generated) should be disposed of by way of infiltration, or if this is not feasible due to soil type, discharged from the site at flow rates below 2 l/s/ha, unless Point 9 (See below) is applicable to the development.

7. Climate Change

In accordance with Table 5 of the Technical Guidance for the NPPF (2012), a 20% increase to rainfall intensities should be applied for development with a lifetime up to 2085; and 30% for development with a prospective lifetime beyond this date.

Residential development is generally expected to have a design life of 100 years; and as such an additional 30% must be applied within the drainage design for the proposed development situated off Burnley Road in Bacup.

8. Urban Creep

Urban creep is now an acknowledged issue which results in an increase in runoff from an estate over time. An allowance should be made by factoring the impermeability percentage by 1.1 (10% increase) unless a more precautionary requirement is specified by the local planning authority.

9. Minimum Limit of Discharge Rate

A practicable minimum limit on the discharge rate from a flow attenuation device is often a compromise between attenuating to a satisfactorily low flow rate while keeping the risk of blockage to an acceptable level.

This limit is set at 5 litres per second, using an appropriate vortex or other flow control device.

Where sedimentation could be an issue, the minimum size of orifice for controlling flow from an attenuation device should normally be 150mm laid at a gradient not flatter than 1 in 150, which meets the requirements of Sewers for Adoption 7th Edition.

5.10.3 Sustainable Urban Drainage Systems (SUDS)

Due to the nature of the proposals, the impermeable area within the site will be increased following development. There will therefore be an increase in surface water runoff rates and volumes from the site when it is developed.

The Statutory Authorities will request that the runoff from the proposed development is restricted to existing greenfield runoff rates or a minimum of 5l/s.

Additionally, the Local Authority; United Utilities and Environment Agency will require that adequate pollution control is incorporated into the drainage system in order to prevent deterioration of the quality of the water environment.

To reduce the impact of surface water runoff from the development in accordance with the requirements of the Statutory Authorities, the employment of SUDS techniques to limit runoff volumes and rates from the site are recommended.

This section provides an indication of the possible SUDS techniques which could be employed on the site to balance flows within the proposed development. SUDS techniques are also able to provide treatment to the runoff to remove a proportion of the pollution and protect the quality of the downstream watercourses. Following guidance from CIRIA Report C522 the following levels of treatment should be provided:

- Roofs – 1 level
- Driveways – 1 level
- Roads and communal parking areas – 2 levels.

The level of treatment indicates the number of SUDS techniques that will be used to treat pollution. For example if two levels are required the runoff may enter a filter drain that leads to a basin or pond before outfall.

The implementation of source control techniques means in practice there will be little outflow for a 1 in 1 year storm as most of the rainfall will be held within the system and will disperse via evapotranspiration.

Undertaking an assessment using the SUDS Planner Module within MicroDrainage Windes revealed that a number of different methods would be suitable for inclusion within the proposed drainage strategy for the development. A summary of the results is tabulated below:

Table 29: SUDS Planner Results

SUDS Criteria	Rank 1	Rank 2	Rank 3
Hydrological	Permeable Paving	Green Roof	Infiltration Trench/Soakaway
Land Use	Online/Offline Storage	Wet Ponds	Stormwater Wetlands
Site Features	Green Roofs	Filtration Techniques	Online/Offline Storage
Community & Environment	Online/Offline Storage	Grassed Filter Strip	Bioretention area
Economics & Maintenance	Wet Ponds	Grassed Filter Strip	Dry Detention
Total	**Permeable Paving**	**Online/Offline Storage**	**Green Roof**

It is noted that the precise combination of methods used will be dependent upon the site constraints identified at the final design stage.

1. Permeable Paving

Groundwater recharge via infiltration is not a viable option for this site, due to underlying ground conditions.

However, permeable paving may be used to provide shallow attenuation of surface water runoff; prior to discharge into a receiving watercourse or on-site drainage system.

It is unlikely that Yorkshire Water will adopt a permeable paving drainage solution as part of a Section 104 Agreement; and an underground storage structure is their favoured method for providing attenuation volume within a drainage system which will become part of the public sewer network.

It is recommended therefore that permeable paving is restricted to car park spaces, within the proposed development plan.

2. Online/Offline Storage

Due to the limited space available within the development to provide sufficient volume to attenuate flows to greenfield run off rates; online structures such as oversized pipes or box culvert sections may be easily placed within proposed road network within the development to provide ease of access for maintenance purposes.

Alternatively shallow attenuation structures such as Hydro-Internationals Stormcell System may be used as an alternative.

3. Green Roof

Green roofs comprise a multi-layered system that covers the roof of a building with vegetation cover, and/or landscaping over a drainage layer.

They are designed to intercept and retain rainfall thereby reducing the volume and attenuating peak surface water flows.

The following information regarding green roof technology has been extracted from CIRIA Document C697 ‘The SUDs Manual’.

Key Design Criteria:

- Designed for interception storage.
- Minimum roof pitch 1 in 80, maximum 1 in 3.
- Structural roof strength must provide for the additional load of saturated green roof media.
- Hydraulic design to BS EN 12056-3.

- Multiple outlets to reduce the risk from blockage.
- Lightweight soil medium and appropriate vegetation.
-

Advantages:

- Mimic pre-development state of the building footprint (greenfield development).
- Good removal capability if atmospherically deposited urban pollutants.
- Can be applied in high density developments.
- Can sometimes be retro-fitted.
- Provides ecological, aesthetic and amenity benefits.
- No additional land take required.
- Improves air quality.

- Helps to retain higher humidity levels in city areas.
- Insulated buildings against temperature extremes.
- Reduces the expansion/contraction of roof membranes.
- Provides sound absorption.

Disadvantages:

- Increased cost compared to traditional roof materials.
- Inappropriate for steep sloping roofs.
- Opportunities for retro-fitting may be limited by existing roof structure.
- Maintenance of roof vegetation.
- Any damage to the waterproof membrane is critical, since water is encouraged to remain on the roof.

Maintenance Requirements:

- Irrigation is required during establishment of vegetation.
- Inspection for bare patches and replacement of plants.
- Litter removal (depending on setting and use).

Whilst it is recommended that this SUDS technique is considered by the developer, it is noted that the cost of installation; along with the structural strength requirements of the proposed roof structures may be prohibitive for the inclusion of green roof technology for this development.

4. Rainwater Harvesting

Following development the volume of surface water runoff leaving the site is likely to be increased; owing to an increase in roof and hardstanding areas within the site.

It is therefore recommended that rainwater harvesting is considered for inclusion within the drainage strategy for the development to provide a source of non-potable water for purposes such as car washing; and watering gardens etc…

This SUDS solution, like green roof technology, is also designed to provide interception storage i.e. acts to reduce the volume of surface water leaving the proposed development; thereby helping to alleviate the current pressures on the receiving field dyke.

In the event that the proposed development is to be assessed as part of BREEAM's Code for Sustainable Homes; the inclusion of rainwater harvesting, will help to achieve the mandatory requirements set out for Category 4 SUR1 Surface Water, within the Code.

It is noted that collection of rainwater via water butts is not classed as a rainwater harvesting solution.

5.10.4 Residual Flood Risk

In order to prevent exacerbation of surface flooding within the development site and along Barnsley Road during extreme rainfall events, it is recommended that the proposed drainage system is designed such that there will be no residual risk from flooding due to surface water discharge for storms with a return period of 100 years or less (with a 30% increase for climate change).

5.11 Foul Drainage

Yorkshire Water Sewer Records indicate that 225mm and 100mm diameter public combined sewers currently traverse through Development Area B; and as such, it is envisaged that these sewers will need to be diverted as part of the drainage strategy for this area.

The proposed diversion works will need to be approved by Yorkshire Water; and undertaken under a Section 185 agreement.

It is proposed that wastewater flows from Development Area B will be discharged into the diverted public sewer.

Furthermore, it is proposed that wastewater flows from Development Areas A1, A3 and A3, will be directed to the 225mm diameter public combined sewer located within Barnsley Road.

5.12 Easements

Existing public sewers will require an easement approximating 3 metres either side of the pipe.

The Environment Agency requires an 8 metre easement from the top of the river bank; and any works within this area will require formal consent.

No structures will be permitted within the easement areas.

5.13 Maintenance

Any part of the proposed drainage system within the redevelopment at Nether Mill Farm in Penistone which is not to form part of Section 104 agreement with Yorkshire Water i.e. private drainage system, must be inspected and maintained on a regular basis, to prevent siltation at gullies and flow control chambers; thereby reducing the risk of surface flooding.

It is also noted that the current site owners propose to undertake works within the channel of Scout Dike at Barnsley Road Bridge, to remove excess silt, in order to reduce the risk of fluvial flooding from the watercourse as witnessed during June 2012.

Any works proposed within the channel at this location must be approved by the Local Lead Flood Authority i.e. Barnsley Council.

6.0 Conclusions and Recommendations

The primary sources of flood risk to the proposed development site at Nether Mill Farm in Penistone are identified to be the River Don and its tributary Scout Dike.

Detailed assessment concludes that Development Areas A1 and A2 are located within Flood Zone1; whist Development Areas A3 and B are located within Flood Zone 3.

The following measures have been recommended to mitigate against residual flooding within these development areas:

- Development Area A3 comprises existing buildings to be refurbished to provide residential accommodation. Floor levels are to elevated where possible within the constraints of each individual building. Where this is not possible; flood resistance/resilience methods will be incorporated into the works to delay or prevent inundation, up to 600mm above the appropriate 1 in 100 year plus climate change flood level.
- Development Area B comprises new residential development. floor levels are to be elevated a minimum 600mm above the appropriate 1 in 100 year plus climate change flood level.
- Flood evacuation routes to be provided and suitable marked.
- Residents advised to sign up to receive flood warnings via the Environment Agency's Free Flood Warnings Directs Service.
- Personal Flood Plans to be devised and practices as appropriate.

In regard to Development Area B; calculations indicate that due to careful design, there is minimum impact to flood storage volumes within the development.

Overall impermeable areas within the site will be increased, therefore increasing surface water runoff rates and volumes generated by the site.

Within the areas designated as brownfield development; surface water runoff must be restricted to existing rates, incorporating a 30% reduction to accommodate future climate change; and lessen the burden on the receiving watercourse and sewer systems.

Surface water runoff from previously undeveloped areas must be restricted to greenfield runoff rates or a minimum of 5l/s.

Flows in excess of these values must be attenuated on-site prior to discharge to watercourse or sewer.

An assessment of SUDS methods indicates that permeable paving; online/offline storage; green roof technology and rainwater harvesting are the most appropriate for this particular site.

In accordance with Approved Document H of the Building Regulations, surface water from the development must be dispose of via a) infiltration; b) watercourse; and c) sewer in order of preference.

An initial evaluation indicates that infiltration methods such as soakaways will not be feasible at the location of the proposed development.

Owing to topography and other constraints it is proposed that surface water from the development areas to the north side of Barnsley Road is directed via existing outfall arrangements to the 225mm diameter public surface water sewer within the adjacent highway.

In contrast, it is proposed that surface water runoff from Development Area B, will be directed via a new outfall into the River Don.

Foul or wastewater flows will be directed to the existing public combined system located within the vicinity of the development.

Yorkshire Water records indicate that a couple of public combined sewers currently traverse Development Area B; and as such any proposed diversion works will need to be undertaken under a Section 185 Agreement.

The Environment Agency requires an 8 metre easement from the south bank of the River Don; and any works within this easement will require formal consent.

The measures outlined within this report will mitigate residual flood risk at the development to acceptable levels.

APPENDIX A
Existing Site:
Topographical Survey