UK Flood Risk
Flood Risk Consultants

Flood Risk Assessment, Sustainable Urban Drainage Systems (SuDS)

Twin Brooks Farm, Upbrooks, Clitheroe BB7 1PL

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Executive Summary

UK Flood Risk Consultants has been commissioned to prepare this Flood Risk Assessment (FRA)/SuDS in support of a proposal consisting of demolition of existing house and replacement with two new dwellings located at Twin Brooks Farm, Upbrooks, Clitheroe BB7 1PL.

The main sources of information to undertake flood risk assessment are the flood maps and data of the Environment Agency and the previous flood studies by the Local Authority.

The proposed development is categorised as ‘more vulnerable’.

The site is located in close proximity to the Mearley Brook with the risk of fluvial flooding.

According to the information available from the SFRA and the Environment Agency, there were no records of flooding events at the site.

The Environment Agency’s Flood Maps show that the site lies within the Flood Zone 3 (high probability flooding). The Environment Agency’s flood risk map indicates that the risk of flooding to the site varies from 'low' to 'medium'.

The Environment Agency’s modelling data indicated that the site is subject to flooding from the 5% AEP (1 in 20 year) event with the maximum flood depth of 0.42m. Similarly, the site is subject to flooding from the 1% AEP (1 in 100 year) plus Central CC event with the maximum flood depth of 0.90m. This implies that the flood hazard to the people and the property from these extreme events is high.

The overall risk of surface water flooding to the site varies from 'medium' to 'high' with the maximum flood depth less than 300mm.

The flood risk from other sources including underground water, sewer and reservoir is low.

In order to afford a level of protection against flooding it is normally recommended that finished floor levels are set a nominal 300mm above the 1 in 100-year annual probability fluvial flood (1% AEP) including an allowance for climate change. The Environment Agency’s modelling data indicated that the 1% AEP (1 in 100 year) plus Central CC water level near the site is 83.20mAOD.

The existing ground levels where the buildings are proposed, vary from 82.30mAOD to 82.76mAOD. Therefore, it is proposed that the finished floor level of the proposed buildings will be set not lower than 83.50mAOD which is 1.20m above the existing ground level of 82.30mAOD.

In order to allow free movement of flood water during the flooding, it is proposed that voids will be provided beneath the ground floor. This will help to minimise the impacts of flooding offsite.

In order to minimise the damage and to enable quick recovery and clean up after the flooding event, it is proposed that flood resilient measures will be implemented.

As the site is located within a flood zone area, it will be necessary to make sure that the occupants are fully aware of the flood risk and flood warning and evacuation during an extreme event. If necessary, during a flood event the first floor will provide a safe haven for the occupants.

The occupants are advised to utilise the Environment Agency's Flood Warning Service available in the area.

The surface runoff will be improved by implementing appropriate SuDS measures. An underground attenuation storage (L=6m, W=5m, D=0.40m) will be implemented in order to improve the surface runoff from the site. The stored water from the storage will be discharged into the watercourse (Mearley Brook). The discharge into the watercourse will be limited to 5 litres/sec by using flow controlling devices such as hydro-brake or vortex control device.

The landowners will be fully responsible for the repair and management of the implemented SuDS throughout the lifetime of the proposed development.

The development will not give rise to backwater affects or divert water towards other properties.

This report demonstrates that the proposal will be safe, in terms of flood risk, for its design life and will not increase the flood risk elsewhere.

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Abbreviations

Abbreviation	Description
mAOD	Metres Above Ordnance Datum
DEFRA	Department for Environment, Food, and Rural Affairs
EA	Environment Agency
FRA	Flood Risk Assessment
LLFA	Lead Local Flood Authority
NPPF	National Planning Policy Framework
SFRA	Strategic Flood Risk Assessment
PFRA	Preliminary Flood Risk Assessment
SuDS	Sustainable Drainage Systems

1.0 Background

UK Flood Risk Consultants has been commissioned to prepare this Flood Risk Assessment (FRA) in support of a proposal consisting of demolition of existing house and replacement with two new dwellings located at Twin Brooks Farm, Upbrooks, Clitheroe BB7 1PL.

This FRA has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF, July 2021) and the Environment Agency's Flood Risk Assessment (FRA) Guidance Notes and the best practices in flood risk management.

The National Planning Policy Framework sets out planning policy in order to avoid inappropriate development in areas at risk of flooding by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere.

2.0 FRA Requirements and Objectives

The site-specific FRA should address the following:

- how flood risk affects the proposed development,
- whether the development type is appropriate for the proposed location,
- whether the site's flood risk is too great for the development,
- whether the proposed development will increase flood risk elsewhere,
- carry out the Sequential Test and the Exception Test where necessary,
- meet the additional flood resistance and resilience requirements where necessary.

The objectives of this site-specific flood risk assessment are to establish:

- whether the proposed development is likely to be affected by current or future flooding from any source,
- whether it will increase flood risk elsewhere,
- whether the measures proposed to deal with these effects and risks are appropriate,

3.0 General Description of the Site and the Proposals

3.1. Description of the site

The proposal site is located at Twin Brooks Farm, Upbrooks, Clitheroe BB7 1PL approximately centred on the OS NGR SD 75397 42255 (**Appendix A Figure 1**). The site is located within the administrative boundary of Ribble Valley Borough Council, which is the Local Planning Authority.

The site occupies an area of approximately 1,113m^2. The area of building footprint is approximately 109m^2 and the area of hardstanding pavement is approximately 291m^2. Approximately 713m^2 area is covered by soft landscaping.

The access to the site is via Upbrooks. The surrounding area consists of mix of residential and commercial uses (**Appendix A Figure 2)**.

The British Geological Survey's geological maps are provided in **Appendix A Figure 3**. The geological maps show that the bedrock of the site comprises Clitheroe Limestone Formation and Hodder Mudstone Formation – Mudstone that formed between 346.7 and 337 million years ago during the Carboniferous period. The superficial deposits of Alluvium - Clay, silt, sand and gravel that formed between 11.8 thousand years ago and the present during the Quaternary period.

The site is located in close proximity to the Mearley Brook with the risk of fluvial flooding.

The site has a gently sloping with the general elevation varying from 80.03mAOD along the southern boundary up to 82.76mAOD along the north-east boundary. The site elevation where the buildings are proposed vary from 82.30mAOD to 82.76mAOD. Further details about the existing site are provided in **Appendix B**.

3.2. Proposed Development

The proposal consists of demolition of existing house and replacement with two new dwellings. The total footprint area of the proposed building is approximately 246m^2. Further details about the proposals have been provided in **Appendix B**.

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4.0 Development and Flood Risk Policy

4.1. National Planning Policy Framework (NPPF)

The National Planning Policy Framework (NPPF, July 2021) sets out the government's planning policies for England. The NPPF sets out planning and policies related to development planning and flood risk using a sequential characterisation of risk based on planning zones and the Environment Agency's Flood Maps. The aim of the flood risk assessment is to identify which Flood Zones the site is located in and vulnerability classification relevant to the proposed development, based on an assessment of current and future conditions.

4.2. Flood Zones

The Flood Zones refer to the probability of river and sea flooding which ignores the presence of defences. The national flood maps have been developed by the Environment Agency that shows the risk of tidal and/or fluvial flooding across England and Wales for different return period events. The Environment Agency's Flood Maps are the maps which have been developed using broad scale hydraulic modelling. It is therefore important to understand that the flood maps may not be very accurate at a site-specific level which may need further field observation and measurements. The Flood Zones do not take into account of the climate change impacts which must be considered in any flood risk assessment as required by the NPPF.

4.3. Sequential and Exception Tests

As set out in the NPPF, the overall aim of the Sequential Test should be to steer new development to Flood Zone 1 (Low Probability Flooding). Where there are no reasonably available sites in Flood Zone 1, the Local Authority should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required. Where there are no reasonably available sites in Flood Zones 1 or 2, the suitability of sites in Flood Zone 3 should be considered, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required.

As the proposal consists of redevelopment of the site with replacement buildings, the Sequential Test will not be required.

The Exception Test, as set out in the Framework, is a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily, while

allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available. There are two requirements to meet for the Exception Tests. The proposed development will provide wider sustainability benefits to the community that outweigh flood risk, and that it will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.

4.4. Vulnerability of Use and Flood Risk Assessment

The proposed development is categorised as 'more vulnerable' (**Table 2**). The site is located in Flood Zone 3 (high probability flooding). It should be ensured that all types of flood risk are considered as part of the Flood Risk Assessment: *'A site-specific Flood Risk Assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall'.*

This FRA aims to demonstrate that the proposal will remain safe for its lifetime and will not increase flood risk elsewhere.

4.5. NPPF Flood Zones

Table 1 below shows the NPPF Flood Zones and the requirements and policy aims in terms of undertaking site-specific flood risk assessment.

Table 1 - NPPF Flood Zones and Requirements (NPPF Technical Guidance Table 1)

Zone 1: Low Probability Flood Zone	**This is defined as the land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).**
Appropriate uses	All uses of land are appropriate in this zone.
FRA requirements	For development proposals on sites comprising 1 ha or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a FRA.
Policy aims	Developers and local authorities should seek opportunities to reduce the overall level of flood risk through the layout and form of the development, and

	the appropriate application of sustainable drainage techniques.
Zone 2: Medium Probability Flood Zone	**This is defined as the land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1%) in any year.**
Appropriate uses	The water-compatible, less vulnerable and more vulnerable uses of land and essential infrastructure in Table 2 are appropriate in this zone. Highly vulnerable uses in Table 2 are only appropriate in this zone if the Exception Test is passed.
FRA requirements	All proposals in this zone should be accompanied by a FRA.
Policy aims	Developers and local authorities should seek opportunities to reduce the overall level of flood risk through the layout and form of the development, and the appropriate application of sustainable drainage techniques.
Zone 3a: High Probability Flood Zone	**This is defined as the 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.**
Appropriate uses	The water-compatible and less vulnerable uses of land in Table 2 are appropriate in this zone. The highly vulnerable uses (Table 2) should not be permitted in this zone. The more vulnerable and essential infrastructure uses in Table 2 should only be permitted in this zone if the Exception Test is passed.
FRA requirements	All proposals in this zone should be accompanied by a FRA.
Policy aims	Developers and local authorities should seek opportunities to:

	❖ reduce the overall level of flood risk through the layout and form of the development and the appropriate application of sustainable drainage techniques; ❖ relocate existing development to land with a lower probability of flooding; ❖ create space for flooding to occur by allocating and safeguarding open space for flood storage.
Zone 3b: Functional Floodplain	**This is the land where water has to flow or be stored in times of flood. This zone is generally defined as the land which would flood with an annual probability of 1 in 20 (5%AEP) or greater in any year. The Local Council may define the Functional Floodplain area with a different annual probability of event.**
Appropriate uses	Only the water-compatible uses and the essential infrastructure listed in Table 2 that has to be there should be permitted. It should be designed and constructed to: ❖ remain operational and safe for users in times of flood; ❖ result in no net loss of floodplain storage; ❖ not impede water flows; ❖ not increase flood risk elsewhere.
FRA requirements	All proposals in this zone should be accompanied by a FRA.
Policy aims	In this zone, developers and local authorities should seek opportunities to: ❖ reduce the overall level of flood risk through the layout and form of the development and the appropriate application of sustainable drainage techniques; ❖ relocate existing development to land with a lower probability of flooding.

Table 2 - Flood Risk Vulnerability Classification (NPPF Technical Guidance Table 2)

Essential Infrastructure	Essential transport infrastructure and strategic utility infrastructure, including electricity generating power stations and grid and primary substations.
Highly Vulnerable	❖ Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations and emergency dispersal points. ❖ Basement dwellings, caravans, mobile homes and park homes intended for permanent residential use. ❖ Installations requiring hazardous substances consent.
More Vulnerable	❖ Hospitals, residential institutions such as residential care homes, children's homes, ❖ Social services homes, prisons and hostels. ❖ Buildings used for: dwelling houses, student halls of residence, drinking establishments, nightclubs, hotels and sites used for holiday or short-let caravans and camping. ❖ Non–residential uses for health services, nurseries and education. ❖ Landfill and waste management facilities for hazardous waste.
Less Vulnerable	❖ Buildings used for shops, financial, professional and other services, restaurants and cafes, offices, industry, storage and distribution, and assembly and leisure. ❖ Land and buildings used for agriculture and forestry. ❖ Waste treatment (except landfill and hazardous waste facilities), minerals working and processing (except for sand and gravel). ❖ Water treatment plants and sewage treatment plants (if adequate pollution control measures are in place).

Water-compatible Development	❖ Flood control infrastructure, water transmission infrastructure and pumping stations. ❖ Sewage transmission infrastructure and pumping stations. ❖ Sand and gravel workings. ❖ Docks, marinas and wharves, navigation facilities. ❖ MOD defence installations. ❖ Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location ❖ Water-based recreation (excluding sleeping accommodation). ❖ Lifeguard and coastguard stations. ❖ Amenity open space, nature conservation and biodiversity, outdoor sports and recreation. ❖ Essential sleeping or residential accommodation for staff required by uses in this category, subject to a warning and evacuation plan.

Table 3 - Flood Risk Vulnerability and Flood Zone 'compatibility'

Vulnerability Classification (Refer Table 2)		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zones	Flood Zone 1	✓	✓	✓	✓	✓
	Flood Zone 2	✓	✓	Exception Test	✓	✓
	Flood Zone 3a	Exception Test	✓	×	Exception Test	✓
	Flood Zone 3b	Exception Test	✓	×	×	×

✓ Development is appropriate

× Development should not be permitted

5.0 Assessment of Flood Risk

5.1. History of Flooding

The Ribble Valley Borough Council's Strategic Flood Risk Assessment (Level 1 SFRA, May 2010), hereafter referred to as SFRA, has provided a brief overview of the flooding history in the area. A record of the major floods that have affected the Ribble catchment since 1600 has been put together from the British Hydrological Society's "Chronology of British Hydrological Events" and from the Environment Agency Section 105 – River Ribble Survey in 1998. The Environment Agency study found major flood events that had been reported in local newspapers. The major flood events occurred in 1771 (Ribble), 1775 (Ribble), 1866 (Ribble Calder), 1881 (Ribble, Calder, Hodder), 1923 (Ribble, Calder), and in 1936, 1995, 2000 and 2002. Despite these events, there were no records of flooding at the site.

In addition, information on historic floods was obtained from the Environment Agency (**Appendix C**). However, there were no records of flooding around the site.

Information on the past flooding event was also obtained from the landowner. They were not aware of any flooding issues at the site.

5.2. Risk of Fluvial Flooding

The site is located in close proximity to the Mearley Brook with the risk of fluvial flooding. The Environment Agency's Flood Map around the site is shown in **Appendix A Figure 4** which shows that the site lies within the Flood Zone 3 (high probability flooding). The Flood Zone 3 fluvial outline shows a 1 in 100 chance of flooding at a location in any one given year (i.e., a 1% annual probability of flooding).

The flood map also shows that the site is located in an area not benefiting from the flood defences. **Figure 5** shows the Environment Agency's flood risk map which indicates that the risk of flooding to the site varies from 'low' to 'medium'.

5.3. Impact of Climate Change

In May 2022 the 'Flood Risk Assessments: Climate Change Allowances' were updated from the originally published Climate Change allowances on GOV.UK. The guidelines outline the peak river flow climate change allowances by management catchment. The range of Climate Change allowances is based on percentiles. A percentile is a measure used in statistics to describe the proportion of possible scenarios that fall below an allowance level. The 50th percentile is the point at which half of the possible

scenarios for peak flows fall below it and half fall above it. The central allowance is based on the 50th percentile, higher central is based on the 70th percentile and the upper end is based on the 90th percentile.

The proposal site is located within the Ribble Management Catchment and North West river basin district. The relevant climate change allowances are summarised in **Table 4** below.

Table 4 - Peak river flow allowances by Management Catchment and river basin district

Management Catchment Name / River Basin District	Climate Change allowance	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Ribble / North West	Upper end	27%	44%	71%
	Higher central	19%	29%	46%
	Central	16%	23%	36%

Using peak river flow allowances for flood risk assessments

The guideline suggests to consider the flood zone and the appropriate flood risk vulnerability classification to decide which allowances applies to the development or plan.

In flood zones 2 or 3a for:

- essential infrastructure – use the higher central allowance
- highly vulnerable – use central allowance (development should not be permitted in flood zone 3a)
- more vulnerable – use the central allowance
- less vulnerable – use the central allowance
- water compatible – use the central allowance

In flood zone 3b for:

- essential infrastructure – use the higher central allowance

- highly vulnerable – development should not be permitted
- more vulnerable – development should not be permitted
- less vulnerable – development should not be permitted
- water compatible – use the central allowance

Assessment of Climate Change Impact for the Site

The proposal site is located within the Ribble Management Catchment and North West river basin district. As the proposed development is categorised as 'more vulnerable' and the site is located in Flood Zone 3 (i.e. high probability flooding), the guideline recommends to use the Central allowance for assessing the impact of climate change. The Central allowance for the Ribble/North West River Basin District is 36% for the period between 2070 and 2115 (**Table 4**). However, as information on 36% Climate Change allowance was not available, a 35% CC allowance is considered as equivalent to the Central CC for the site and has been used for assessing the impact of climate change to the flood risk to the site.

5.4. Modelled Water Levels and Assessment of Hazard

Information on modelled water levels was obtained from the Environment Agency (**Appendix C**). The site-specific modelled flood levels at the proposed development site have been taken from the Mearley Brook Study 2017. The modelled flood extent maps for a range of events are shown in **Appendix C**.

Appendix C also contains a 1D and 2D model node location maps near the site. The map shows that the nearest model node from the site is PEBR 01_04266.

Comparison of Modelled Water Levels and the Site Levels

The modelled water levels at the nearest 2D nodes have been compared against the existing site levels (**Table 5**). The information on the site levels have been taken from the topographic map provided in **Appendix B**.

Table 5 below shows that the site is subject to flooding from the 5% AEP (1 in 20 year) event with the maximum flood depth of 0.42m. Similarly, the site is subject to flooding from the 1% AEP (1 in 100 year) plus Central CC event with the maximum flood depth of 0.90m. This implies that the flood hazard to the people and the property from these extreme events is high.

Table 5 – Comparison of modelled water levels against the site levels

Events	Modelled levels, mAOD	General Site Level, mAOD	Max flood depth, m
5% AEP (1 in 20 year)	82.72	82.30-82.76	0.42
1% AEP (1 in 100 year)	83.03	82.30-82.76	0.73
♯1% AEP (1 in 100 year) plus CC	83.20	82.30-82.76	0.90
0.1 %AEP (1 in 1000 year)	83.39	82.30-82.76	1.09

♯ 35% climate change allowance is considered equivalent to the Central CC for this site, see **Chapter 5.10**.

5.5. Risk of Tidal Flooding

The Mearley Brook is not influenced by tidal waves at this location. The risk of tidal flooding is therefore low.

5.6. Risk of Flooding From Artificial Water Bodies

There were no known flood risks from any artificial water bodies near the site.

5.7. Risk of Groundwater Flooding

In recent years groundwater has been recognised as a significant source of flooding in the UK. According to the British Geological Survey, groundwater flooding occurs when the water table in permeable rocks rises to enter basements/cellars or comes up above the ground surface. Groundwater flooding is not necessarily linked directly to a specific rainfall event and is generally of longer duration than other causes of flooding (possibly lasting for weeks or even months).

In accordance with the SFRA, the groundwater flooding was not considered by the Environment Agency to be a significant flood risk factor in this area.

Evidence of historical groundwater flooding within the SFRA is very limited, however it is important to recognise that the risk of groundwater flooding is highly variable and heavily dependent upon local conditions at any particular time.

According to the information available from the landowner, there were no records of any groundwater flooding incidents around the site. Based on these evidences and information, it is reasonable to consider that the risk of groundwater flooding to the site is low.

5.8. Risk of Surface Water Flooding

The surface water flooding arises when the infiltration capacity of land or the drainage capacity of a local sewer network is exceeded and the excess rainwater flows overland. The severity of surface water flooding depends on several factors such as the degree of saturation of the soil before the event, the permeability of soils and geology, hill slope steepness and the intensity of land use.

Information on the risk of surface water flooding is held by the Environment Agency. The Environment Agency's Surface Water Flood Risk Maps are provided in **Appendix A Figure 6 and Figure 7** which indicate that the risk of surface water flooding to the site varies from 'medium' to 'high'. The flood depth is likely to be less than 300mm.

5.9. Risk of flooding from Reservoirs

The Environment Agency's reservoir flood map in **Appendix A Figure 8** indicated that the proposal site is located outside of the maximum extent of flooding from reservoir. According to the Environment Agency, the reservoir flooding is extremely unlikely to happen and reservoirs in the UK have an extremely good safety record; indeed there has been no loss of life in the UK from reservoir flooding since 1925. The Environment Agency is the enforcement authority for the Reservoirs Act 1975 in England and Wales. All large reservoirs must be inspected and supervised by reservoir panel engineers on a regular basis. It is therefore assumed that these reservoirs are regularly inspected and essential safety work is carried out. These reservoirs therefore present a managed residual risk.

5.10. Flood Risk from Sewers

Sewer flooding is often caused by excess surface water entering the drainage network causing sewers to surcharge. The SFRA has provided very limited information on sewer flooding within the area, however, there were no records of sewer flooding incidents at the site. It is important to note that previous sewer flood incidents or the lack thereof do not indicate the current or future risk to the site as upgrade work could have been carried out to alleviate any issues or conversely in areas that have not experienced sewer flooding incidents the local drainage infrastructure could deteriorate leading to future flooding.

According to the information obtained from the landowner, there were no records of sewer flooding incidents at the site in the past.

6.0 Mitigation Measures

6.1. Recommended Finished Floor Level

In order to afford a level of protection against flooding it is normally recommended that finished floor levels are set a nominal 300mm above the 1 in 100-year annual probability fluvial flood (1% AEP) including an allowance for climate change. The Environment Agency's modelling data indicated that the 1% AEP (1 in 100 year) plus Central CC water level near the site is 83.20mAOD. The existing ground levels where the buildings are proposed, vary from 82.30mAOD to 82.76mAOD (**Appendix B**). Therefore, it is proposed that the finished floor level of the proposed buildings will be set not lower than 83.50mAOD which is 1.20m above the existing ground level of 82.30mAOD.

6.2. Provision of Voids

In order to allow free movement of flood water during the flooding, it is proposed that voids will be provided beneath the ground floor. This will help to minimise the impacts of flooding offsite.

6.3. Flood Resilient Measures

The following flood resilient measures will be adopted to minimise the damage and to enable quick recovery and clean up after the flooding event:

- Water, electricity and gas meters will be located above predicted flood level.
- Non-return valves will be used in the drainage system to prevent back-flow of diluted sewage in situations where there is an identified risk of the foul sewer surcharging.
- All service entries will be sealed (e.g. with expanding foam or similar closed cell material).
- Closed cell insulation will be used for pipes which are below the predicted flood level.

- Boiler units and ancillary devices will be installed above predicted flood level and preferably on the first floor of two-storey properties.
- Wiring for telephone, TV, Internet and other services will be protected by suitable insulation to minimise damage.
- Building materials that are effective for a 'water exclusion strategy' will be used which include: engineering bricks, cement-based materials including water retaining concrete and dense stone.

6.4. Flood Warning and Evacuation

As the site is located within a flood zone area, it will be necessary to make sure that the occupants are fully aware of the flood risk and flood warning and evacuation during an extreme event. If necessary, during a flood event the first floor will provide a safe haven for the occupants.

6.4.1. Flood Warnings Direct

The occupants are advised to utilise the Environment Agency's Flood Warnings Direct which is a free flood warning service called Floodline Warnings Direct (FWD). This service generally gives an advance notice of when flooding is likely to happen and time to prepare for a flood event. Property owners on the proposed development site will be able to sign up to FWD online using the following contact details (**Table 6**):

Table 6- Contacts for flood warning services

Methods	Remarks
Online	https://fwd.environment-agency.gov.uk/app/olr/register
Telephone	0345 988 1188

6.4.2. Flood Warning Service

The Flood Warning Service is provided by the Environment Agency across England and Wales in areas at risk of flooding from rivers or the sea. This is provided using up to date rainfall, river level and sea condition monitoring 24 hours a day to forecast the possibility of flooding. If flooding is forecast, the Environment Agency will issue warnings using a set of three different warning types **(Table 7).** Many areas of England are covered by the full four stages of the Environment Agency's Flood Warning Service. The site is located in an area covered by the Flood Alert Services **(Appendix A Figure 9).** The Environment Agency's Flood Warning target lead time; the time

between a flood warning being issued and the onset of flooding is approximately two hours. Providing the Environment Agency can meet their target Flood Warning lead time, the occupants of the proposed development will have two hours to ensure that property is relocated to minimise risk and evacuation to safe locations can be carried out.

Table 7 - Environment Agency's Flood Warning Codes

Flood Warning Code	Meaning	Actions to be taken
	Flooding is possible. Be prepared.	• Be prepared to act on your flood plan. • Prepare a flood kit of essential items. • Monitor local water levels and the flood forecast on our website.
	Flooding is expected. Immediate action required.	• Move family, pets and valuables to a safe place. • Turn off gas, electricity and water supplies if safe to do so. • Put flood protection equipment in place.
	Severe flooding. Danger to life.	• Stay in a safe place with a means of escape. • Be ready should you need to evacuate from your home. • Co-operate with the emergency services. • Call 999 if you are in immediate danger.
Warnings no longer in force	No further flooding is currently expected in your area.	• Be careful. Flood water may still be around for several days. • If you've been flooded, ring your insurance company as soon as possible.

7.0 Sustainable Urban Drainage Systems Policy

7.1. Flood and Water Management Act 2010

The method of drainage of surface water from the site is bound by the Flood and Water Management Act 2010. Schedule 3 Paragraph 5 of the Flood and Water Management Act 2010 states that the following hierarchy is to be applied to surface water runoff in the following order or priority:

- Discharge into the ground (infiltration)
- Discharge to a surface water body (lake, river, drain);
- Discharge to a surface water sewer, highway drain or another drainage system; or Discharge into a combined sewer.

7.2. Drainage Hierarchy

Development proposals should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy as set out by the Non-Statutory Technical Standards for Sustainable Drainage Systems (March 2015):

1. rainwater harvesting (including a combination of green and blue roofs)
2. infiltration techniques and green roofs
3. rainwater attenuation in open water features for gradual release
4. rainwater discharge direct to a watercourse (unless not appropriate)
5. rainwater attenuation above ground (including blue roofs)
6. rainwater attenuation below ground
7. rainwater discharge to a surface water sewer or drain
8. rainwater discharge to a combined sewer.

8.0 Sustainable Urban Drainage Systems (SuDS)

The Ribble Valley Borough Council strongly encourages the principles of SuDS on all forms of development. The developer should seek the most sustainable SuDS solution in order to reduce flood risk, improve water quality and improve the environment overall. The Lancashire County Council, in its role as Lead Local Flood Authority (LLFA), is a statutory consultee in the planning process for major development proposals which have surface water implications. The LLFA encourages the developers to provide SuDS on major developments while paying due regard to the National Planning Policy Framework (NPPF), Planning practice guidance, Non-statutory technical standards for sustainable drainage systems and the District local plan policies.

The Lancashire County Council's Planning Advisory Note on Surface Water Drainage, Flood Risk Management and Watercourses (May 2015) set out the policy for the SuDS hierarchy with the preferential destination of surface water as follows: 1. Discharge into the ground (infiltration); 2. Controlled discharge to a surface water body/watercourse or the sea; 3. Controlled discharge to a surface water sewer.

8.1. Existing Drainage

The proposal site comprises a building along with hardstanding area. Much of the surface runoff discharges into the adjoining watercourse following the natural slope gradient towards the watercourse.

9.0 Outline Design of SUDS

9.1. Greenfield Runoff Estimation

The estimation of the Greenfield Runoff rate has been undertaken using the HR Wallingford's Greenfield Runoff Estimation tool available on the website: http://www.uksuds-.com/greenfieldrunoff_js.htm. The aim of the tool is to provide flow rate information based on a minimum amount of data so that anybody can use the tool. The methodology is built around the concept that a flow rate discharge constraint is needed for storm water runoff from a site, resulting in attenuation volume being needed. In addition, current drainage criteria include the requirement for the 100 year 6hr volume to be controlled.

The tool is based on the results of simple model analysis and correlating the results against key known site parameters. As such the results need to be treated as providing indicative information only and should not be used to produce final designs of drainage systems without additional modelling being carried out.

The peak flow estimation can now be estimated using two different formulae.

1) The formula developed in IH124 (IH 1994) and use of the FSSR growth curve information for regions of the UK (FSSR 14),

2) The use of FEH statistical correlation equation revised in 2008.

However, only the IH124 method can be used without providing specific parameter values. Therefore, this method has been used for estimating greenfield runoff rate from the proposed development site. Details about the parameters used in the estimation are provided in **Appendix D** and the results are summarised in **Table 8** below. The total site area of 0.11ha has been used. The proposed development will consider the greenfield runoff rates for addressing surface water discharge requirements from the developed site. The greenfield runoff rates will also be utilised for developing the drainage strategy for the site.

Table 8 – Greenfield Runoff Rates for the site

Events	Greenfield runoff rates (l/s) (Estimated)
Qbar	1.04
1 in 1 year	0.90
1 in 30 year	1.76
1 in 100 year	2.16

9.2. Estimation of Permeable and Impermeable Areas

The changes in land cover have been summarised in **Table 9** below. It can be seen that the proposed development will not lead an increase in the impermeable area. This means the surface runoff will not be increased as a result of the proposed development.

Table 9 Changes in Land Cover Areas

Land Cover	Pre-development, m^2	Post-development, m^2	Change, m^2
Impermeable Surface Area			
Hard standing	945	854	
Building footprint	155	246	
Total Impermeable	**1100**	**1100**	**0**
Permeable Surface Area			
Grass cover	0	0	
Total Permeable	**0**	**0**	**0**
Total Area	1100	1100	

9.3. Estimation of peak surface runoff rates

Pre-development Peak Runoff Rates (based on land cover area)

The Rational Method has been used in order to estimate the peak surface runoff from the site.

The Rational Equation is given by:

$Q = Ar \times P \times Ri$

Where, Ar = Effective catchment area, m^2

P= Impermeability factor

Ri= Rainfall Intensity, mm/hr, Q= Peak surface runoff, m^3/s

The peak surface runoff rates for the existing site condition are summarised in **Table 10** below. An impermeability factor of 0.90 has been used for the site. Information on

the maximum rainfall intensity for a range of return period events has been taken from the MicroDrainage Model developed for the site which is provided in **Appendix E**. The impermeable surface areas in **Table 9** have been used as catchment for the calculations.

Table 10 Estimation of Peak Runoff Rates from the site (Pre-development condition) based on the land cover area

Return Periods	Max Rainfall Intensity, Ri mm/hr	Catchment Area, A m^2	Impermeability factor, P	# Peak Runoff, Q, m^3/sec	Peak Runoff, Q, litres/sec
1/ 1 year	26.25	1100	0.9	0.00722	7.22
1/2 year	33.98	1100	0.9	0.00934	9.34
1/5 year	43.93	1100	0.9	0.01208	12.08
1/10 year	50.87	1100	0.9	0.01399	13.99
1/30 year	64.18	1100	0.9	0.01765	17.65
1/50 year	71.5	1100	0.9	0.01966	19.66
1/100 year	82.79	1100	0.9	0.02277	22.77
1/100 year + 40% CC	124.19	1100	0.9	0.03415	34.15

Q = (Ri/1000 x A x P)/3600

Ri taken from MicroDrainage model (**Appendix E**).

Post-development Peak Runoff Rates (with attenuation storage)

The greenfield runoff rate for the site is 1.04 litre/sec (**Table 8**). This rate is a very small discharge rate that may lead to the blockage issues in the drainage system. Therefore, an outflow control rate of 5 litres/sec has been used with the implementation of the attenuation storage system. The surface runoff rates for the site post-development are summarised in **Table 11** below.

Table 11 Summary of Peak Runoff Rates from the site (Post-development condition with the provision of attenuation storage)

Return Periods	Peak Runoff Rates, Q, litre/sec
1/ 1 year	5
1/2 year	5
1/5 year	5
1/10 year	5
1/30 year	5
1/100 year	5
1/100 year + 40% CC	5

9.4. Hierarchy of SuDS Measures

The surface runoff from the site will be improved by implementing appropriate SuDS. The requirements for SuDS will ensure that any redevelopment or new development does not negatively contribute to the surface water flood risk of other properties and instead provides a positive benefit to the level of risk in the area. It will also ensure that appropriate measures are taken to increase the flood resilience of new properties and developments in surface water flood risk areas, such as those identified as being locally important flood risk areas.

The SuDS hierarchy and management train has been discussed in the SuDS Manual (C753) which aims to mimic the natural catchment processes as closely as possible. The general hierarchy of the SuDS measures is provided in **Table 12** below.

Table 12 General Hierarchy of SuDS Measures

Measures	Definition/Description
Prevention	The use of good site design and housekeeping measures to prevent runoff and pollution (e.g. rainwater harvesting/reuse).
Source control	Control of runoff at or very near its source (e.g. soakaways, porous and pervious surfaces, green roofs).
Site control	Management of water in a local area on site (e.g. routing water to large soakaways, infiltration or detention basins)

Regional control	Management of runoff from a site or several sites (e.g. balancing ponds, wetlands).

Table 13 below presents the feasibility assessment of the SuDS measures for the site.

Table 13 General Assessment of SuDS measures for the site

SuDS Measures	Issues/Description	Feasibility for the site
Source Control Porous and pervious materials/soakaways/green roof/infiltration trenches/disconnect downpipes to drain to lawns or infiltrate to soakaway.	Infiltration SuDS such as Permeable paving and Soakaway will improve the surface runoff from the site.	No. Due to the underlying soil condition, mostly composed of clay, the infiltration SuDS will not be feasible for the site.
Site and Regional Control Infiltration/detention basins/ balancing ponds/ wetlands/underground storage/swales/retention ponds.	Balancing pond/storage will help attenuate the surface runoff from the site. Geo-cellular underground storage can be implemented to store surface runoff from extreme rainfall event (1 in 100 year plus climate change).	No. Due to limited space available, balancing pond will not be feasible. Yes. There is a potential for an underground attenuation storage to improve the surface runoff condition.

9.5. Proposed SuDS

Based on the general assessment of the potential SuDS measures above, it is proposed that an underground attenuation storage will be implemented in order to improve the surface runoff from the site from the design 1 in 100-year 6-hour rainfall event plus 40% Climate Change. The layout of the proposed SuDS measures has been provided in **Appendix F**.

9.6. Outline Design of Proposed SuDS

Attenuation Storage

An open ground attenuation storage will not be feasible at the site due to the limited space available. Therefore, an underground geo-cellular storage will be implemented in order to temporarily store storm water from the site.

The proposed scheme will therefore include an underground Geo-cellular attenuation storage with the controlled outflow discharge by using a Hydrobrake. The size of the proposed attenuation storage is as follows:

Length = 6m, Width = 5m, Depth = 0.40m

The maximum flow control of 5 litres per second has been adopted for all events up to and including 1% AEP + 40%CC with no flooding. The proposed SuDS drainage layout plan has been provided in **Appendix F.**

The controlled outflow from the attenuation storage will be discharged into the existing watercourse (Mearley Brook) using a 150mm linear drainpipe as shown in **Appendix F.**

Hydraulic Modelling

The proposed drainage scheme has been modelled by using Micro Drainage Source Control to understand the evolving flow regime under flood conditions and the potential for flooding. The site area considered for the modelling is 0.06ha which is approximately 50% of the total site area of 0.11ha as the aim is to reduce the surface runoff by at least 50% for this already developed site. The attenuation storage has been modelled considering the 1 in 100 year (1%AEP) plus 40% climate change event. Both summer and winter profiles of the storm events have been considered for a range of duration, from 15 minutes to 8640 minutes. All input parameters (i.e. rainfall and model details) have been provided in **Appendix G**. The summary of the model output for the 1 in 100 year plus 40% climate change event is provided in **Table 14** below.

It can be seen from **Table 14** that for the maximum volume of 17.70m^3 will be generated by the 120 minutes Winter event, and there will be no flooding for this event. Therefore, the adopted attenuation storage will provide full storage for the surface runoff generated from the design event of 1 in 100 year plus 40% climate change event.

Table 14 – Summary of Model Output (1 in 100 year plus 40% climate change)

Events	Rainfall mm/hr	Max Volume m^3	Discharge Volume M^3	Flooded Volume M^3
120 min (Winter)	36.60	17.70	36.90	0.0

The location and layout of the proposed storage and its dimensions (area and depth) can be changed to suit the site conditions. This will be to the client's discretion ensuring that the required attenuation storage volume is provided within the site. The controlled outflow from the attenuation storage will be discharged into the existing watercourse (Mearley Brook) using a 150mm linear drainpipe as shown in **Appendix F.**

Exceedance Flow Paths

It is inevitable that as a result of heavy or extreme rainfall, the capacities of sewers and other drainage systems will be exceeded on occasion. Drainage exceedance will occur when the rate of surface water runoff exceeds the inlet capacity of the drainage system, when the receiving water or pipe system becomes overloaded, when the outfall becomes restricted due to flood levels in the receiving water, or due to poor maintenance of the SuDS features.

The proposed attenuation storage has been designed for the 1 in 100 year plus 40% climate change event. Any extreme event greater than this design event may lead to the situation where the rate of surface water runoff exceeds the inlet capacity of the drainage system. In such circumstances, the flow routes from the rear and front of the site will naturally follow to the south towards the watercourse (i.e. Mearley Brook), as this will be the only open area for the floodwater to flow across the site. The flow routes from the access drives will also flow towards the watercourse. The exceedance flow routes are shown in **Appendix H.**

9.7. Management and Maintenance Plan

The owners will be fully responsible for regular repair and maintenance of the proposed SuDS measures as required for the lifetime of the development. The SuDS at this site have been designed for easy maintenance to comprise:

Geo-cellular Storage System

Remedial work for repairing damage will be carried out whenever necessary. The repair and maintenance will include regular inspection of silt traps, manholes, pipework and pre-treatment devices, with removal of sediment and debris as required. **Table 15** provides further details on the regular maintenance of the Geo-cellular storage system.

Table 15 Regular Maintenance and remedial measures for Geo-cellular storage system

Regular Maintenance	Actions/Remedial measures
Monthly	• Inspect and identify any areas that are not operating correctly. If required, take remedial action. (for 3 months following installation) • Debris removal from catchment surface (where may cause risks to performance) • Inspect systems as specified by the manufacturer • Where rainfall infiltrates into blocks from above, check surface of filter for blockage by silt, algae or other matter. Remove and replace surface infiltration medium as necessary.
Six monthly	• Inspect and identify any areas that are not operating correctly. If required, take remedial action (following initial 3 month period).

Annually	• Remove sediment from pre-treatment structures (e.g. upstream silt- traps or Vortex flow control upstream) and geocellular system where required (High pressure water jetting) • Inspect and document the presence of wildlife.
Following all significant storms	• Inspect and carry out essential recovery works to return the feature to full working order.

Flow control structures

Remedial work for repairing any damage to flow control structures/devices will be carried out whenever necessary. **Table 16** provides further details on the regular maintenance of the flow control structures/devices.

Table 16 Regular Maintenance and remedial measures for flow control structures

Regular Maintenance	Actions/Remedial measures
Monthly	• Inspect and identify any areas that are not operating correctly. If required, take remedial action (for 3 months following installation).
Six monthly	• Inspect and identify any areas that are not operating correctly. If required, take remedial action. • Remove sediment from pre-treatment structures.
Following all significant storms	• Inspect and carry out essential recovery works to return the feature to full working order.

10.0 Assessment of Impact on flow of floodwater

The proposed development consists of demolition of existing house and replacement with two new dwellings. In order to ensure that the proposed development will not increase flood risk elsewhere the mitigations will ensure that all flood water, surface water and rainwater is processed on-site and not redirected elsewhere through the use of appropriate measures such as permeable paving and attenuation storage. The development will not give rise to backwater affects or divert water towards other properties.

11.0 Conclusion

The proposals consist of demolition of existing house and replacement with two new dwellings located at Twin Brooks Farm, Upbrooks, Clitheroe BB7 1PL.

The proposed development is categorised as ‘more vulnerable’.

The site is located in close proximity to the Mearley Brook with the risk of fluvial flooding.

According to the information available from the SFRA and the Environment Agency, there were no records of flooding events at the site.

The Environment Agency’s Flood Maps show that the site lies within the Flood Zone 3 (high probability flooding). The Environment Agency’s flood risk map indicates that the risk of flooding to the site varies from 'low' to 'medium'.

The Environment Agency’s modelling data indicated that the site is subject to flooding from the 5% AEP (1 in 20 year) event with the maximum flood depth of 0.42m. Similarly, the site is subject to flooding from the 1% AEP (1 in 100 year) plus Central CC event with the maximum flood depth of 0.90m. This implies that the flood hazard to the people and the property from these extreme events is high.

The overall risk of surface water flooding to the site varies from 'medium' to 'high' with the maximum flood depth less than 300mm.

The flood risk from other sources including underground water, sewer and reservoir is low.

In order to afford a level of protection against flooding it is normally recommended that finished floor levels are set a nominal 300mm above the 1 in 100-year annual probability fluvial flood (1% AEP) including an allowance for climate change. The Environment Agency's modelling data indicated that the 1% AEP (1 in 100 year) plus Central CC water level near the site is 83.20mAOD. The existing ground levels where the buildings are proposed, vary from 82.30mAOD to 82.76mAOD. Therefore, it is proposed that the finished floor level of the proposed buildings will be set not lower than 83.50mAOD which is 1.20m above the existing ground level of 82.30mAOD.

In order to allow free movement of flood water during the flooding, it is proposed that voids will be provided beneath the ground floor. This will help to minimise the impacts of flooding offsite.

In order to minimise the damage and to enable quick recovery and clean up after the flooding event, it is proposed that flood resilient measures will be implemented.

As the site is located within a flood zone area, it will be necessary to make sure that the occupants are fully aware of the flood risk and flood warning and evacuation during an extreme event. If necessary, during a flood event the first floor will provide a safe haven for the occupants.

The occupants are advised to utilise the Environment Agency's Flood Warning Service available in the area.

The surface runoff will be improved by implementing appropriate SuDS measures. An underground attenuation storage (L=6m, W=5m, D=0.40m) will be implemented in order to improve the surface runoff from the site. The stored water from the storage will be discharged into the watercourse (Mearley Brook). The discharge into the watercourse will be limited to 5 litres/sec by using flow controlling devices such as hydro-brake or vortex control device.

The landowners will be fully responsible for the repair and management of the implemented SuDS throughout the lifetime of the proposed development.

The development will not give rise to backwater affects or divert water towards other properties.

This report demonstrates that the proposal will be safe, in terms of flood risk, for its design life and will not increase the flood risk elsewhere.

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Appendix A Collection of Flood Maps and Figures

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Appendix B Existing Site and Proposed Plans

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Appendix C Environment Agency's Data and Information

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Appendix D Greenfield Runoff Rates

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Appendix E Rainfall Runoff Summary

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Appendix F Proposed Surface Water Improvement (SuDS) Measures

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Appendix G Attenuation Storage Modelling Summary

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Appendix H Exceedance Flow Routes