UK Flood Risk
Flood Risk Consultants

Flood Risk/Sustainable Urban Drainage Systems (SuDS) Assessment

Lincoln Way, Clitheroe BB7 1QD

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Prepared by	SG	Senior Flood Risk Consultant	26/11/2019

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Executive Summary

UK Flood Risk Consultants has been commissioned to prepare this Flood Risk Assessment (FRA) in support of a proposal consisting of erection of workshop building located at Lincoln Way, Clitheroe BB7 1QD.

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.

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The proposed development is categorised as ‘less vulnerable’.

The nearest main river from the site is the Worston Brook with the risk of fluvial flooding.

According to the information available from the SFRA and the Environment Agency, there were some flooding events in the area. However, 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 2 (medium probability flooding) and Flood Zone 3 (high probability flooding). The Environment Agency’s flood risk map indicates that the risk of flooding to the site varies from 'medium' to 'high'.

The flood maps also show that site is located in an area not benefiting from the flood defences.

The Environment Agency’s modelling data indicated that the proposed building is not subject to flooding from the 1% AEP (1 in 100 year). Similarly, the building is not subject to flooding from any of the 1% AEP plus 30% Central and 35% Higher Central CC events. This implies that the flood hazard to the people and the property is low.

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 30% Central CC water levels are 80.45mAOD and 80.72mAOD in the defended and undefended conditions respectively. Therefore, it is proposed that the finished floor level of the proposed workshop building will be set not lower than 81.30mAOD which is 580mm above the 1%AEP plus Central CC water level of 80.72mAOD (undefended condition).

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. Safe evacuation can be provided via Lincoln Way to the north which remains outside of the flood risk zone.

The surface runoff will be improved by implementing appropriate SuDS measures. Permeable paving with underground storage in car parking area and an attenuation storage will be implemented in order to improve the surface runoff from the site.

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 erection of workshop building located at Lincoln Way, Clitheroe BB7 1QD.

This FRA has been carried out in accordance with the requirements of the Revised National Planning Policy Framework (NPPF) published on 24 July 2018 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 Lincoln Way, Clitheroe BB7 1QD approximately centred on the OS NGR 375166, 442191 (**Appendix A Figure 1**). The site is located within the administrative boundary of Ribble Valley Borough Council, which is the Local Planning Authority.

Total site area is approximately 2,868m^2. The access to the site is via Lincoln Way. The surrounding area consists of mix of residential and commercial uses (**Appendix A Figure 2**).

The nearest watercourse from the site is the Worston Brook with the risk of fluvial flooding. The site topography is relatively level with the general elevation varying from 79.60mAOD to 80.36mAOD. Further details about the existing site are provided in **Appendix B**.

3.2. Proposed Development

The proposal consists of erection of workshop building. The footprint area of the proposed building is approximately 574.5m^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 revised National Planning Policy Framework was published on 24 July 2018 and 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 minor extension, the Sequential Test will not be required.

The Exception Test, as set out in paragraph 102 of 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 site is located in Flood Zone 2 (medium probability flooding) and Flood Zone 3 (high probability flooding). The proposed development is categorised as 'less vulnerable' (**Table 2**). The proposed development is therefore considered appropriate at this location (**Table 3**). 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**). There were no records of any historic flooding events in the area.

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/Tidal Flooding

The site is located in close proximity to the Worston Brook with the risk of fluvial flooding. The Environment Agency's Flood Map around the site is shown in **Appendix A Figure 3** which shows that the site lies within the Flood Zone 2 (medium probability flooding) and Flood Zone 3 (high probability flooding). The Flood Zone 2 outline shows a land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding. Similarly, 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 maps also show that the site is located in an area not benefiting from the flood defences. **Figure 4** shows the Environment Agency's flood risk map which indicates that the risk of flooding to the site varies from 'medium' to 'high'.

5.3. Modelled Water Levels

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 2018. The modelled flood extent maps

for a range of events and 2D flood levels near the site are shown in **Appendix C**.

Comparison of Modelled Water Levels and Finished Floor Level/Site Levels

The modelled water levels (floodplain) have been compared against the existing finished floor levels (**Table 4**). The information on the site levels have been taken from the topographic map provided in **Appendix B**.

Table 4 below shows that the proposed building is not subject to flooding from the 1% AEP (1 in 100 year). Similarly, the building is not subject to flooding from any of the 1% AEP plus 30% Central and 35% Higher Central CC events. This implies that the flood hazard to the people and the property is low.

Table 4 – Comparison of modelled water levels against the FFL/site levels

Events	Modelled levels, mAOD	Proposed FFL, mAOD	Max flood depth, m
Defended Condition			
1% AEP (1 in 100 year)	80.32	81.30	No internal flooding
#1% AEP (1 in 100 year) plus 30% CC	80.45	81.30	No internal flooding
#1% AEP (1 in 100 year) plus 35% CC	80.51	81.30	No internal flooding
0.1 %AEP (1 in 1000 year)	81.71	81.30	No internal flooding
Undefended Condition			
1% AEP (1 in 100 year)	80.32	81.30	No internal flooding
#1% AEP (1 in 100 year) plus 30% CC	80.72	81.30	No internal flooding

30% Central and 35% Higher Central climate change allowances applicable for this site, see **Chapter 5.10**.

5.4. Risk of Tidal Flooding

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

5.5. Risk of Flooding From Artificial Water Bodies

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

5.6. 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.

5.7. 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 5 and Figure 6** which indicate that the risk of surface water flooding to the site varies from 'medium' to 'high'. However, the flood depth is likely to be less than 300mm.

5.8. Risk of flooding from Reservoirs

The Environment Agency's reservoir flood map in **Appendix A Figure 7** 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.

5.9. 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.

5.10. Impact of Climate Change

The Environment Agency released new climate change guidance for flood risk assessments on 19th February 2016 outlining the allowances for the impact of climate change on peak river flows, peak rainfall intensities, sea level rise, offshore wind speeds and extreme wave height. They are based on climate change projections and different scenarios of carbon dioxide (CO2) emissions to the atmosphere. There are different allowances for different epochs or periods of time over the next century.

The range of allowances in **Table 5** below 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.

Table 5 - Peak river flow allowances by river basin district (use 1961 to 1990 baseline)

River basin district	Allowance category	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)
Northumbria	Upper end	20%	30%	50%
	Higher central	15%	20%	25%
	Central	10%	15%	20%
Humber	Upper end	20%	30%	50%
	Higher central	15%	20%	30%
	Central	10%	15%	20%
Anglian	Upper end	25%	35%	65%
	Higher central	15%	20%	35%
	Central	10%	15%	25%
South East	Upper end	25%	50%	105%
	Higher central	15%	30%	45%
	Central	10%	20%	35%
Thames	Upper end	25%	35%	70%
	Higher central	15%	25%	35%
	Central	10%	15%	25%
South West	Upper end	25%	40%	85%
	Higher central	20%	30%	40%
	Central	10%	20%	30%
Severn	Upper end	25%	40%	70%
	Higher central	15%	25%	35%

	Central	10%	20%	25%
Dee	Upper end	20%	30%	45%
	Higher central	15%	20%	25%
	Central	10%	15%	20%
North West	Upper end	20%	35%	70%
	Higher central	20%	30%	35%
	Central	15%	25%	30%
Solway	Upper end	20%	30%	60%
	Higher central	15%	25%	30%
	Central	10%	20%	25%
Tweed	Upper end	20%	25%	45%
	Higher central	15%	20%	25%
	Central	10%	15%	20%

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 zone 2

Essential infrastructure – use the higher central and upper end to assess a range of allowances

Highly vulnerable – use the higher central and upper end to assess a range of allowances

More vulnerable – use the central and higher central to assess a range of allowances

Less vulnerable – use the central allowance

Water compatible – use none of the allowances

In flood zone 3a

Essential infrastructure – use the upper end allowance

Highly vulnerable – development should not be permitted

More vulnerable – use the higher central and upper end to assess a range of allowances

Less vulnerable – use the central and higher central to assess a range of allowances

Water compatible – use the central allowance

In flood zone 3b

Essential infrastructure – use the upper end 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 site is located within the North West River Basin District. As the proposed development is categorised as 'less vulnerable' and the site is located in Flood Zone 2 and 3 (high probability flooding), the guideline recommends to use the Central and Higher Central allowances for assessing the impact of climate change. The Central and Higher Central allowances for the North West River Basin District are 30% and 35% respectively for the period between 2070 and 2115. These allowances have been used for assessing the impact of climate change to the flood risk to the site in **Chapter 5.3** above.

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 30% Central CC water levels are 80.45mAOD and 80.72mAOD in the defended and undefended conditions respectively. Therefore, it is proposed that the finished floor level of the proposed workshop building will be set not lower than 81.30mAOD which is 580mm above the 1%AEP plus Central CC water level of 80.72mAOD (undefended condition).

6.2. 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.

6.3. 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. Safe evacuation can be provided via Lincoln Way to the north which remains outside of the flood risk zone.

6.3.1. 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

6.3.2. 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 8).** 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.

6.4. Surface Water Runoff (SuDS)

6.4.1. Changes in Land Cover

The changes in land cover have been summarised in **Table 8** below. It can be seen that the proposed development will lead to an increase in the impermeable surface area by approximately 575m^2. This means the surface runoff will be increased as a result of the proposed development.

Table 8 Changes in Land Cover

Land Cover	Pre-development, m^2	Post-development, m^2	Change, m^2
Impermeable Surface Area			
Hard-standing	0.0	0.0	
Building footprint	0.0	575	
Total Impermeable	**0.0**	**575**	**(+) 575**
Permeable Surface Area			
Grass cover	2,868	1526	
Permeable surface cover	0	767	
Total Permeable	**2,868**	**2,293**	**(-) 575**
Total Area	2,868	2,868	

6.4.1. Estimation of peak surface runoff

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 x P x 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 for the existing and proposed site conditions are summarised in **Table 9** below. An impermeability factor of 0.90 has been used for the site. A rainfall intensity of 100 mm per hour has been utilised. The impermeable areas in **Table 8** have been used as effective catchment area. **Table 9** shows that the peak runoff rate will be increased by 14 litres/sec from the site post-development.

Table 9 Estimation of Peak Runoff Rates from the site

Parameters	Pre-development	Post-development
# Rainfall intensity Ri, mm/hr	100	100
Effective catchment area, Ar m^2	0	575
Impermeability factor, P	0.90	0.90
Peak Runoff, m^3/s	=0.0 m^3/s = 0 litres/sec	(Ar x P x Ri/1000)/3600 = (575 x 0.90 x 100/1000) / 3600 =0.014m^3/s = 14 litres/sec

The rule of thumb is to use a constant rainfall intensity of 35mm/hr for initial sizing of conveyance system. 100mm/hr has been used and provides a more conservative solution (see Environment Agency 2003, Rainfall runoff management for developments, Report-SC030219).

6.4.2. 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 10** below.

Table 10 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 11 below presents the feasibility assessment of the SuDS measures for the site.

Table 11 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.	Permeable paving in car parking area will improve the surface runoff from the site.	Yes
Site and Regional Control Infiltration/detention basins/ balancing ponds/ wetlands/underground storage/swales/retention ponds.	Balancing pond/storage will not be feasible due to limited space available. Geo-cellular underground storage can be implemented to store surface runoff from extreme rainfall event (1 in 100 year plus climate change)	No Yes

6.4.3. Proposed SuDS

Based on the general assessment of the potential SuDS measures above, it is proposed that permeable paving and an 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**.

7.0 Outline Design of SUDS

7.1. 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 12** below. The total site area of 0.28ha 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 12 – Greenfield Runoff Rates for the site

Events	Greenfield runoff rates (l/s) (Estimated)
Qbar	2.64
1 in 1 year	2.30
1 in 30 year	4.49
1 in 100 year	5.49

7.2. Surface Runoff Storage Requirements

Surface water storage requirement has been estimated using the HR Wallingford's Storm water Storage Analysis tool. The aim of the tool is to provide flow rate and storage volume information for a site based on a minimum amount of data so that anybody can use the tool. A flow rate discharge constraint is usually required for storm water runoff from a site, resulting in attenuation volume being needed.

A climate change allowance factor of 1.4 has been used. The estimated attenuation storage volumes are summarised in **Table 13** below. Input information and further details about the calculations have been provided in **Appendix E**.

Table 13 Estimated Surface Runoff Storage Volumes

Storage	Long-term storage (m^3)
Attenuation Storage (1/100 year)	73
Long-term Storage (1/100 year)	0
Total Storage (1/100 year)	73

From **Table 10** above, it is estimated that a total attenuation storage of 73m^3 will be required in order to store the surface runoff from the 6-hour 1 in 100 year plus 40% climate change design event.

7.3. Proposed SuDS

The following SuDS will be implemented:

Permeable Paving with underground storage

Permeable paving will be provided in car parking area. The proposed layout is shown in **Appendix F**.

Underground Attenuation Storage

An underground geo-cellular storage will be implemented to temporarily store surface runoff water from the site.

Based on the estimate in **Table 13**, an attenuation storage with the total storage volume of 73m^3 will be provided as shown in **Appendix F**.

The location and layout of the storage and its dimensions (area and depth) can be changed to suit the site conditions. This will be to the client's discretion ensuring 73m^3 of attenuation storage is provided.

The stored water from the storage will be discharged into the watercourse (Worston Brook) subject to the consent from the Environment Agency as shown in **Appendix F**. The discharge into the watercourse will be limited to the greenfield rate of 2.64 lit/sec by using flow controlling devices such as hydro-brake or vortex control device (**Table 12**).

7.4. 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 14** provides further details on the regular maintenance of the Geo-cellular storage system.

Table 14 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 15** provides further details on the regular maintenance of the flow control structures/devices.

Table 15 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.

Permeable Paving

The landowners will be fully responsible for regular maintenance of the proposed permeable paving. **Table 16** provides further details on the regular maintenance of the proposed Permeable Paving.

Table 16 Regular Maintenance and remedial measures for permeable paving

Regular Maintenance	Actions/Remedial measures
Monthly	• Refer to manufacturer specifications • For sealed systems, inspection of outfalls should be undertaken.

Six Monthly	• Brushing and vacuuming to manufacturer requirements. Re-grit where necessary after brushing.
As Required	• Inspect/check all inlets, outlets, inspection chambers, surface and overflows (where required) to ensure that they are in good condition, free from blockages and operating as designed. Take action where required (for 3 months following installation) • Removal of weeds where required • Stabilizing and mowing of contributing areas where required.
Following all significant storm events	• Inspect and carry out essential recovery works to return the feature to full working order

8.0 Conclusion

The proposal consists of erection of workshop building located at Lincoln Way, Clitheroe BB7 1QD.

The proposed development is categorised as ‘less vulnerable’.

The nearest main river from the site is the Worston Brook with the risk of fluvial flooding.

According to the information available from the SFRA and the Environment Agency, there were some flooding events in the area. However, 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 2 (medium probability flooding) and Flood Zone 3 (high probability flooding). The Environment Agency’s flood risk map indicates that the risk of flooding to the site varies from 'medium' to 'high'.

The flood maps also show that site is located in an area not benefiting from the flood defences.

The Environment Agency’s modelling data indicated that the proposed building is not subject to flooding from the 1% AEP (1 in 100 year). Similarly, the building is not

subject to flooding from any of the 1% AEP plus 30% Central and 35% Higher Central CC events. This implies that the flood hazard to the people and the property is low.

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 30% Central CC water levels are 80.45mAOD and 80.72mAOD in the defended and undefended conditions respectively. Therefore, it is proposed that the finished floor level of the proposed workshop building will be set not lower than 81.30mAOD which is 580mm above the 1%AEP plus Central CC water level of 80.72mAOD (undefended condition).

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. Safe evacuation can be provided via Lincoln Way to the north which remains outside of the flood risk zone.

The surface runoff will be improved by implementing appropriate SuDS measures. Permeable paving with underground storage in car parking area and an attenuation storage will be implemented in order to improve the surface runoff from the site.

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 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 Surface Water Storage Requirements

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Appendix F Proposed Surface Water Improvement (SuDS) Measures