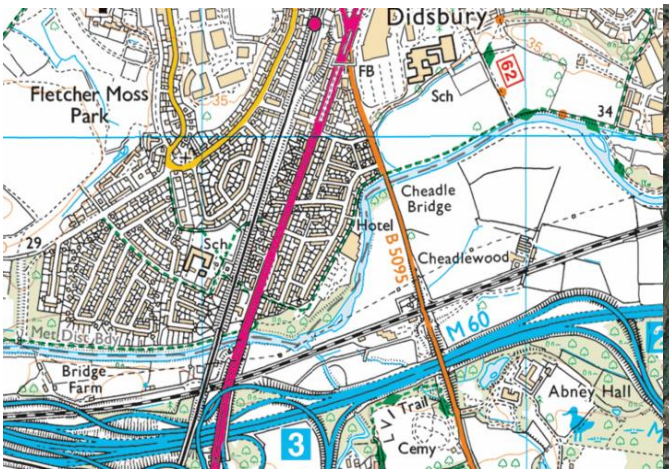
WtFR Ltd

Flood Risk Assessment

Development at

22 Morningside Drive, Manchester, M20 5PL





On behalf of

Miss Wilson

Date: 3rd June 2020

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Issue sheet

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1. Introduction

WtFR Ltd has been commissioned by Miss Wilson to undertake a Flood Risk Assessment (FRA) in connection with the planning application for the proposed development at 22 Morningside Drive, Manchester, M20 5PL.

This FRA has been produced to demonstrate how risks from all sources of flooding to the site and flood risk to others from the development will be managed, in order to satisfy the requirements set out in the National Planning Policy Framework (NPPF).

A full assessment of the flood risk to the site and consideration of the surface water management as a result of the development has been considered as part of this analysis.

Data has been gathered from a number of other sources including: the Environment Agency (EA), the British Geological Society (BGS), National Soil Research Institute (NSRI), aerial photographs, Ordnance Survey (OS), commercially available historical mapping and relevant strategic documents developed by the Manchester City Council, in their capacity as both the Local Planning Authority and Lead Local Flood Authority.

2. Site Description

Area Size: 250m^2 (total) 115m^2 (impermeable)

Grid reference: SJ 85420 89770

The proposals are for the existing garage to be demolished to allow for new single storey extension at 22 Morningside Drive, Manchester, M20 5PL.

Figures 1 and 2 below show location details of the development site. Figure 3 shows an aerial photograph of the development site.

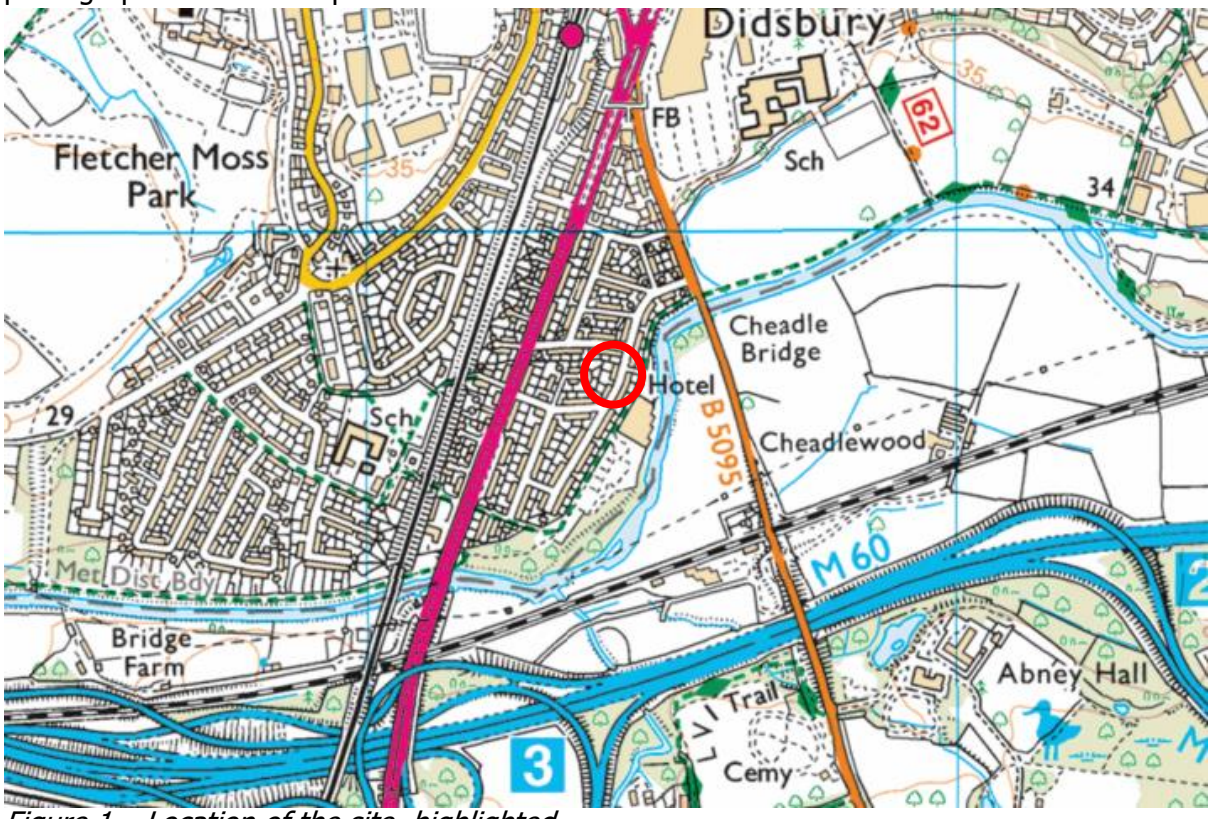

Figure 1 – Location of the site, highlighted.



Figure 2 – detailed location of the development site, highlighted.



Figure 3 – aerial photograph of the development site.

3. Flood Risk Assessment

3.1 National Planning Policy

Paragraph 163 of the NPPF states "When determining any planning applications, local planning authorities should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a site-specific flood-risk assessment[50]. Development should only be allowed in areas at risk of flooding where, in the light of this assessment (the sequential and exception tests, as applicable) it can be demonstrated that:

a) within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;

b) the development is appropriately flood resistant and resilient;

c) it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;

d) any residual risk can be safely managed; and

e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan".

Footnote 50 states "A site-specific flood risk assessment should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving: sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a strategic flood risk assessment as being at increased flood risk in future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use".

Furthermore paragraph 30 of the Planning Practice Guide on Flood Risk and Climate Change states "A site-specific flood risk assessment is carried out by (or on behalf of) a developer to assess the flood risk to and from a development site. Where necessary, the assessment should accompany a planning application submitted to the local planning authority. The assessment should demonstrate to the decision-maker how flood risk will be managed now and over the development's lifetime, taking climate change into account, and with regard to the vulnerability of its users.

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

- whether a 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;
- evidence for the local planning authority to apply (necessary) the Sequential Test, and;
- whether the development will be safe and pass the Exception Test, if applicable".

Continuing paragraph 31 of the Planning Practice Guidance quotes "The information provided in the flood risk assessment should be credible and fit for purpose. Site-specific flood risk assessments should always be proportionate to the degree of flood risk and make optimum use of information already available, including information in a Strategic Flood Risk Assessment for the area, and the interactive flood risk maps available on the Environment Agency's web site.

A flood risk assessment should also be appropriate to the scale, nature and location of the development. For example, where the development is an extension to an existing house (for which planning permission is required) which would not significantly increase the number of people present in an area at risk of flooding, the local planning authority would generally need a less detailed assessment to be able to reach an informed decision on the planning application. For a new development comprising a greater number of houses in a similar location, or one where the flood risk is greater, the local planning authority would need a more detailed assessment".

3.2 Local Planning Policy

Local Authorities consider flood risk through relevant environmental and climate change policies which enforce the requirements of the NPPF. Relevant local policy, as outlined by the Manchester City Council, is contained within the;

i) Strategic Flood Risk Assessment
ii) Local Flood Risk Management Strategy

The Strategic Flood Risk Assessment (SFRA) and the Local Flood Risk Management Strategy (LFRMS) are key sources of flood risk specific information for the area. The SFRA provides a more detailed review of flood risks and recommendations for ensuring developments can be constructed and operated safely in accordance with the NPPF.

3.3 Flood Risk Zones, Vulnerability and Classification

These Flood Zones refer to the probability of river and sea flooding, ignoring the presence of defences. They are shown on the Environment Agency's Flood Map for Planning available on the Environment Agency's web site, as indicated in the table below.

Table 1 – Flood Zones

Flood Zone	**Definition**
Zone 1 *Low Probability*	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 *Medium Probability*	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or Land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a *High Probability*	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map)
Zone 3b *The Functional Floodplain*	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map)

Table 2 – Flood Risk Vulnerability Classification

Essential Infrastructure
• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly Vulnerable
• Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure').
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 and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill* and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable
• Police, ambulance and fire stations which are **not** required to be operational during flooding. • Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'More Vulnerable' class; 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 working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place.

Water Compatible Development
• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • Ministry of 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 and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

* Landfill as defined in Schedule 10 to the Environmental Permitting (England and Wales) Regulations 2010.

Table 3 - Flood risk vulnerability and flood zone 'compatibility'

Flood Zones	**Flood Risk Vulnerability Classification**				
	Essential Infrastructure	**Highly Vulnerable**	**More Vulnerable**	**Less Vulnerable**	**Water Compatible**
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a†	Exception Test required†	✗	Exception Test required	✓	✓
Zone 3b*	Exception Test required*	✗	✗	✗	✓*

Key:

✓ Development is appropriate

✗ Development should not be permitted.

Notes to table 3:

- This table does not show the application of the Sequential Test which should be applied first to guide development to Flood Zone 1, then Zone 2, and then Zone 3; nor does it reflect the need to avoid flood risk from sources other than rivers and the sea;
- The Sequential and Exception Tests do not need to be applied to minor developments and changes of use, except for a change of use to a caravan, camping or chalet site, or to a mobile home or park home site;

- Some developments may contain different elements of vulnerability and the highest vulnerability category should be used, unless the development is considered in its component parts.

† In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

* In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, 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 and not increase flood risk elsewhere.

Minor development in context of Planning Practice Guidance

Section 17 of the Planning Practice Guidance for Flood Risk and Coastal Change states:

Minor development means:

- minor non-residential extensions: industrial/commercial/leisure etc. extensions with a footprint less than 250 square metres.
- alterations: development that does not increase the size of buildings e.g. alterations to external appearance.
- householder development: For example; sheds, garages, games rooms etc. within the curtilage of the existing dwelling, in addition to physical extensions to the existing dwelling itself. This definition excludes any proposed development that would create a separate dwelling within the curtilage of the existing dwelling e.g. subdivision of houses into flats.

Furthermore section 18 of the Planning Practice Guidance for Flood Risk and Coastal Change looks at whether minor developments likely to raise flood risk issues? It states:

Minor developments are unlikely to raise significant flood risk issues unless:

- they would have an adverse effect on a watercourse, floodplain or its flood defences;
- they would impede access to flood defence and management facilities, or;
- where the cumulative impact of such developments would have a significant effect on local flood storage capacity or flood flows.

The Environment Agency's advice on flood risk assessment is helpful for ensuring extensions or alterations are designed and constructed to conform to any flood protection already incorporated in the property and include flood resilience measures in the design.

The Environment Agency's advice for minor developments – household extensions is that to make sure floor levels are either no lower than existing floor levels or 300 millimetres (mm) above the estimated flood level. If your floor levels aren't going to be 300mm above existing flood levels, you need to check with your local planning authority if you also need to take flood resistance and resilience measures.

4. Sources of flooding

4.1 Fluvial/Tidal

The Environment Agency's Flood Map for Planning (Rivers and Sea) identifies fluvial and tidal flood zones, and provides an indication of whether or not these zones are protected, due to the presence of flood defences (also highlighted). Figure 4, below, presents the Flood Map for the surrounding area.

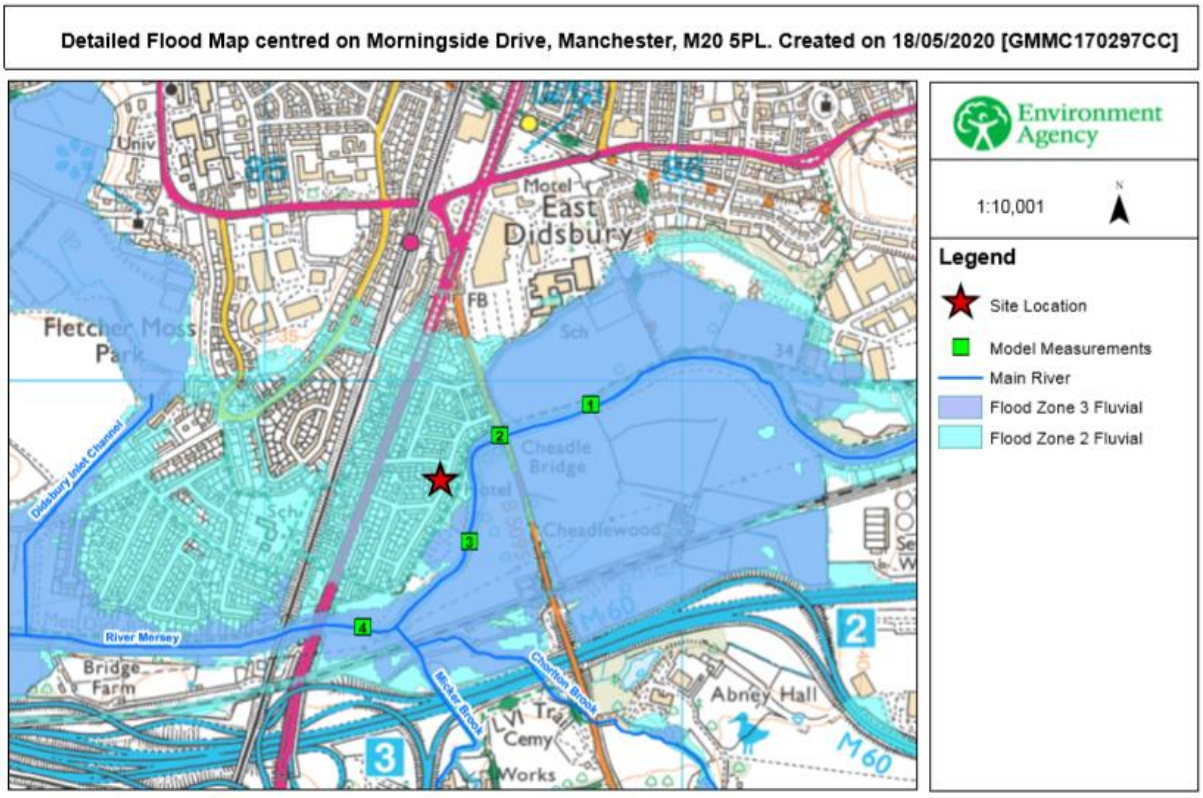

Figure 4 – Fluvial/tidal flood risk – EA Flood Map.

The EA Flood Map identifies the development site to lie within Flood Zone 2, where the chance of flooding in any given year is between 1 in 1000 (0.1%) and 1 in 100 (1%) in a flood event.

Modelled flood information is also available from the Upper Mersey Study, which was completed in 2017 using a 1D ISIS - TUFLOW model.

Figure 4, above, provides a map with the model node location points shown, with corresponding modelled flood levels for a range of Annual Exceedance Probability events provided in Table 4.

Map Reference	Model Node Reference	Easting	Northing	Data	1 % AEP (1 in 100 year)	1 % AEP (1 in 100 year) + 30% Increase in Flow	1 % AEP (1 in 100 year) + 35% Increase Flow	1 % AEP (1 in 100 year) + 70% Increase Flow	0.5 % AEP (1 in 200 year)	0.1 % AEP (1 in 1000 year)	0.1 % AEP (1 in 1000 year) + 30% Increase in Flow
1	ea013_0243_MERS04_5299	385783	389941	Modelled Water Level (m aodN)	34.87	35.34	35.37	35.48	35.14	35.55	36.12
				Modelled Flow (cumecs)	273.83	314.82	326.65	436.96	275.46	453.93	563.12
2	ea013_0243_MERS04_5068	385562	389867	Modelled Water Level (m aodN)	34.12	34.72	34.84	35.21	34.27	35.32	35.89
				Modelled Flow (cumecs)	366.64	401.27	402.91	398.67	385.63	403.87	425.33
3	ea013_0243_MERS04_4990	385492	389611	Modelled Water Level (m aodN)	34.00	34.68	34.80	35.17	34.16	35.29	35.85
				Modelled Flow (cumecs)	357.04	381.53	382.46	383.05	370.77	388.34	407.16
4	ea013_0243_MERS04_4403d	385238	389409	Modelled Water Level (m aodN)	33.69	34.26	34.34	34.86	33.88	35.00	35.62
				Modelled Flow (cumecs)	395.88	467.96	485.42	520.73	416.15	521.46	543.04
SITE	2D	385420	389762	Modelled Water Level (m aodN)		34.05	34.29	35.03			

Table 4 – Modelled flood levels.

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Node 2 is the closest point to the development site that indicates flooding, with a flood level of 34.12mAOD for the 1% event. However, it is normal to consider the latest climate change guidance, which was updated in December 2019, when assessing long term flood risk. Table 5 below provides an extract from the latest guidance, giving a range of percentage increases to flood levels over varying timescales.

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)
North west	Upper end	20%	35%	70%
	Higher central	20%	30%	35%
	Central	15%	25%	30%

Table 5 – Climate change allowances (February 2016).

For more vulnerable developments in Flood Zone 2 the 'central' (30%) climate change allowance is the EA minimum benchmark for flood risk mitigation. In sensitive locations it may be necessary to use the 'higher central' (35%) allowance. Table 4 gives a flood level of 34.72mAOD for the central (30%) allowance.

It is considered that the predicted flood level of 34.72mAOD, equating to 1 in 100+30%CC, is appropriate in this instance. However, it is important to note that this is assuming a universal floodplain of a same and steady gradient. In reality it is likely that flood depths will be lower than the above due to the increased size of the floodplain that the floodwater has to flow into. Therefore, the predicted and assessed levels above are very much a worse case estimate.

It is proposed that the floor level is set as high as possible but no lower than existing as in line with EA guidance. Furthermore, it is recommended flood resistance and resilience measures are incorporated into the development. Section 9.4 of this report provides further information.

4.2 Surface Water Flooding

The Environment Agency's updated Flood Map for Surface Water (uFMfSW) identifies pluvial flood risk. Figure 5, below, presents the uFMfSW for the development site and the surrounding area.

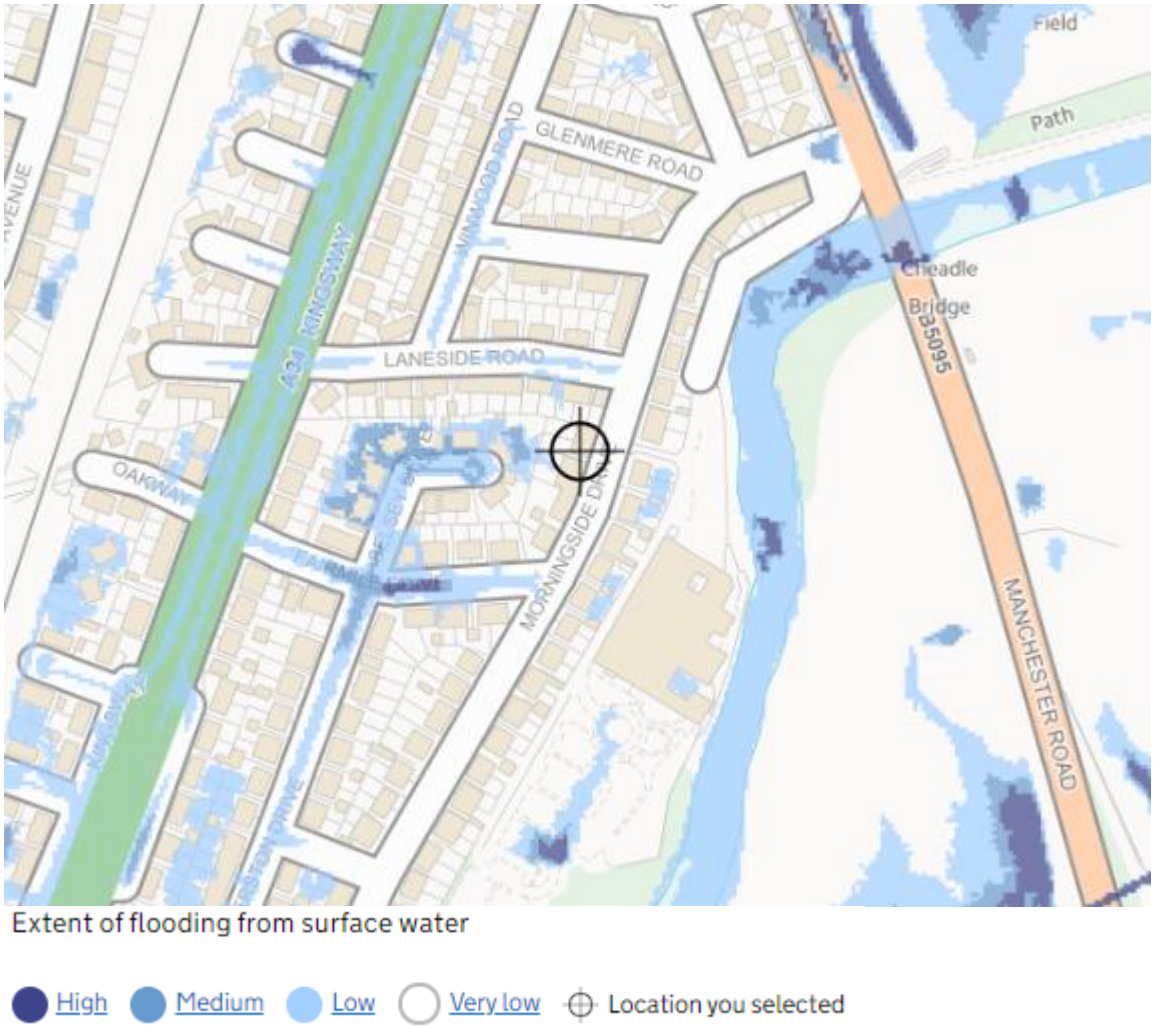


Figure 5 – Flooding from surface water sources, uFMfSW, site highlighted.

The uFMfSW shows that area in the vicinity of the development site is at low risk of surface water flooding. Low risk means that the probability of flooding in any given year is between 1 in 1000 (0.1%) and 1 in 100 (1%).

4.3 Historic Flooding

The EA does not have records of historic flood events from rivers affecting the area local to this property. Further analysis of strategic flood risk documents developed by the Manchester City Council does not indicate flooding from other sources.

4.4 Reservoir

The Environment Agency's Risk of Reservoir Flooding Map identifies the maximum extent of flooding that may be expected in the unlikely event that a reservoir dam failed. Figure 7 below, presents the risk map for development site and the surrounding area. The development is at risk of flooding.

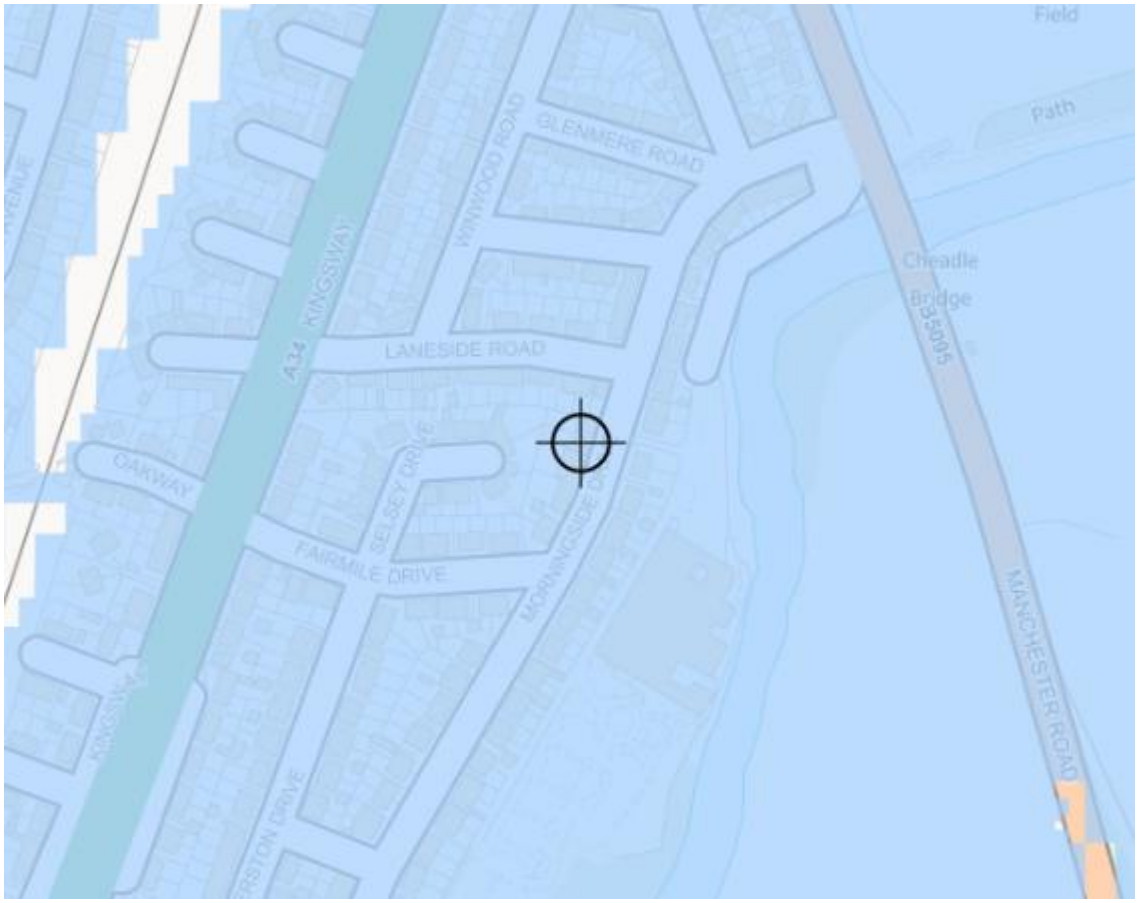


Figure 7 – Flooding from reservoir flooding.

The development is at risk of flooding from the Errwood, Fernilee, Rhodeswood, Torside and Woodhead reservoirs which are owned by the United Utilities Water plc.

Reservoir flooding is extremely unlikely to happen. There has been no loss of life in the UK from reservoir flooding since 1925. All large reservoirs must be inspected and supervised by reservoir panel engineers. As the enforcement authority for the Reservoirs Act 1975 in England, the Environment Agency ensures that reservoirs are inspected regularly, and essential safety work is carried out.

4.5 Groundwater

The Environment Agency's Groundwater Vulnerability Map indicates that the development site is situated over a medium-high groundwater vulnerability, as shown in Figure 8. Further analysis shows that the development site is not situated over a Groundwater Source Protection Zone as shown in Figure 9.

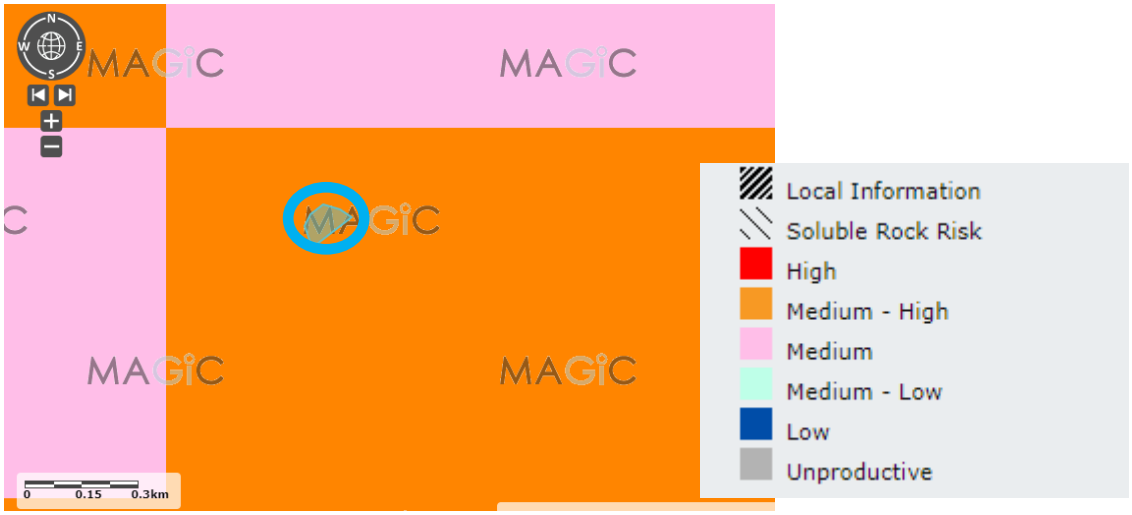


Figure 8 – Groundwater vulnerability map, site highlighted.

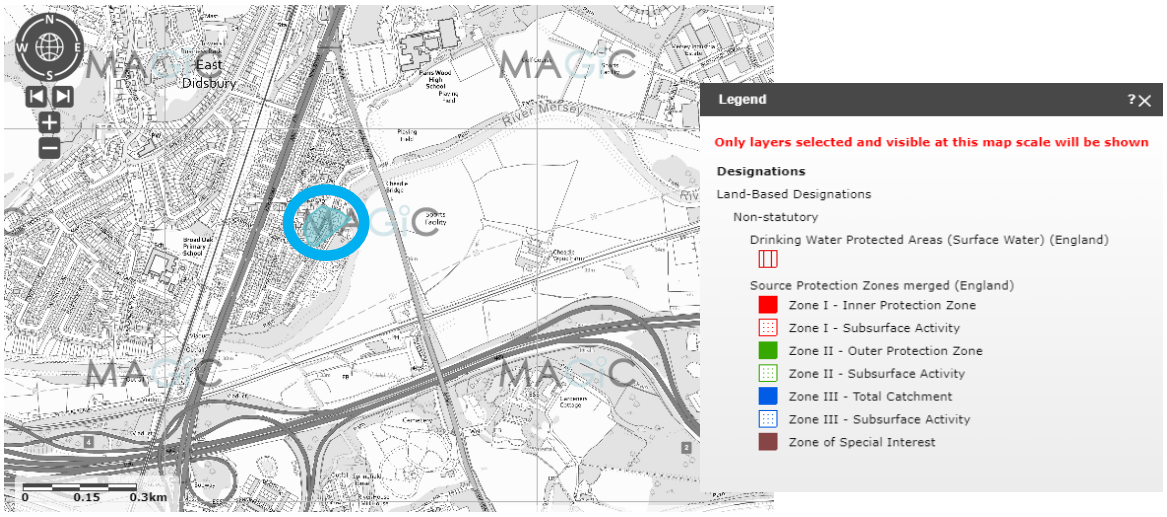


Figure 9 – Groundwater source protection zones, site highlighted.

Due to the minimal groundworks required for this development the impact on groundwater is considered to be negligible.

However, it is recommended that a groundwater mitigation plan is developed that may be implemented if groundwater is encountered during constriction.

4.6 Geology

Figures 10 and 11 present information from the British Geological Survey.

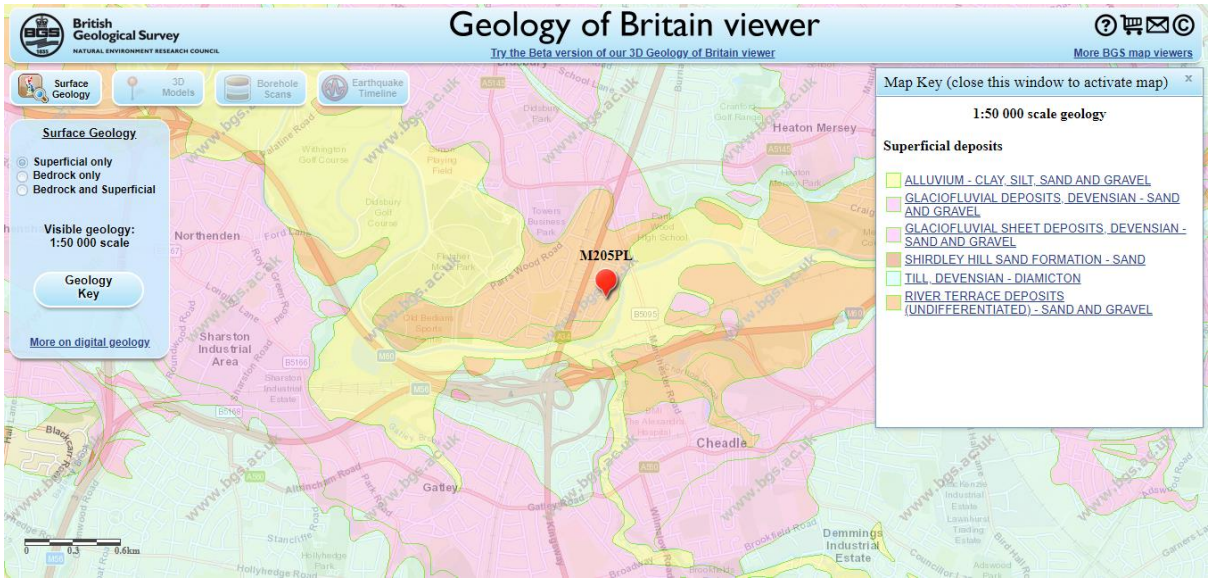


Figure 10 – Superficial Geology of the development.

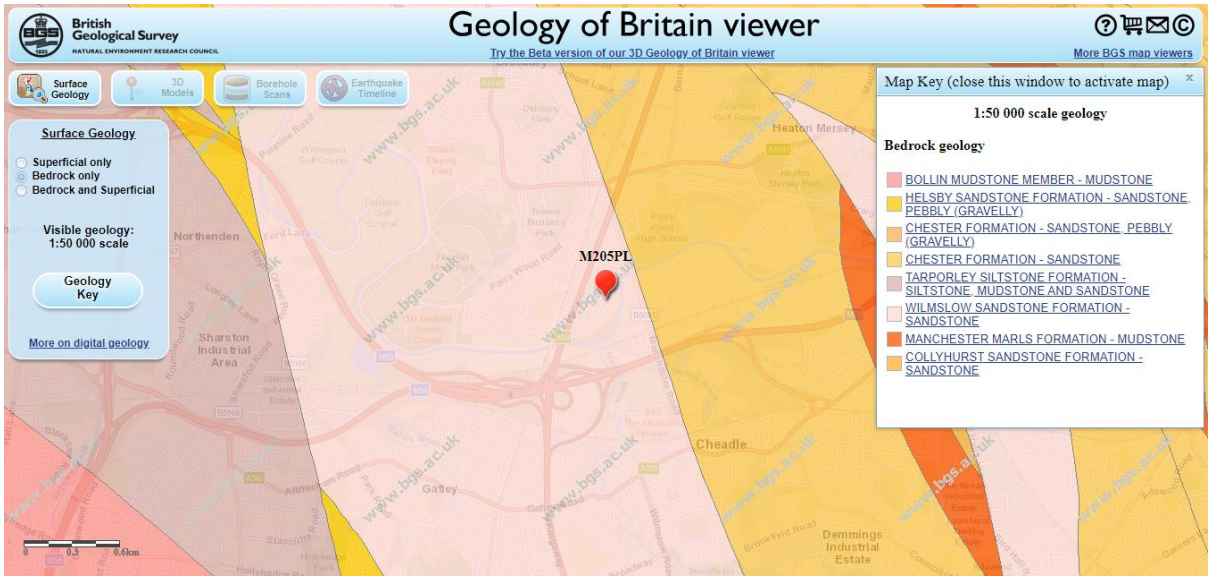


Figure 11 – Bedrock geology of the development.

The superficial deposit records at the development site are described as River Terrace Deposits (undifferentiated) - Sand and Gravel. The superficial deposits formed up to 3 million years ago in the Quaternary Period. The local environment was previously dominated by rivers (U).

With regards to the bedrock, the site is underlain by the Wilmslow Sandstone Formation - Sandstone. The sedimentary bedrock formed approximately 247 to 252 million years ago in the Triassic Period. The local environment was previously dominated by hot deserts.

5. Proposed development

This FRA is prepared to support a planning application for the existing garage to be demolished to allow for new single storey extension at 22 Morningside Drive, Manchester, M20 5PL.

Buildings used for dwellings are classified as being a **More Vulnerable** development within Table 2 of the National Planning Practice Guidance. More Vulnerable developments are acceptable within Flood Zone 2.

Figure 12 shows the existing floor layouts and Figure 13 shows the proposed floor layouts.



Figure 12 – Existing floor layouts.

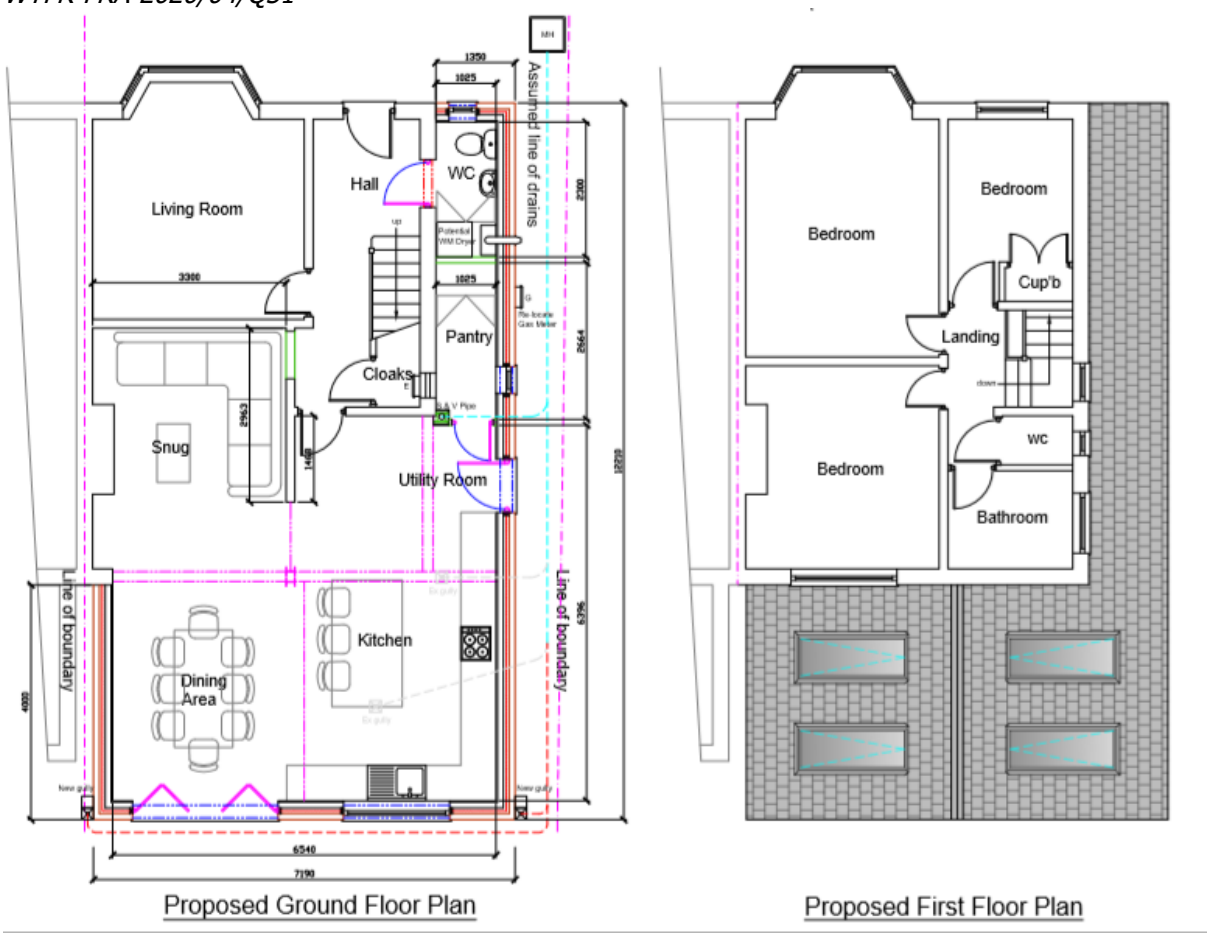


Figure 13 – Proposed floor layouts.

6. Surface Water Drainage

The existing runoff rate from the site can be calculated using the Modified Rational Rainfall Method. Where Q = 2.78 * Cv * Cr * Ri * A

Cv = **0.75** – Fully impermeable areas i.e. existing roads and hardstanding

Cr = **1.3** – Routing Coefficient (CIRIA C697 recommends a value of 1.3)

Ri = **120**mm Rainfall intensity

A = **0.0195**ha current impermeable area

Q = 2.78 * 0.75 * 1.3 * 120 * 0.0195

Q = 6.34l/s

It is assumed that the existing arrangement for the discharge of surface water from the development is into the public sewerage system. The impermeable area of the site will not be increased due to building over existing hardstanding and the method of surface water dosposal will be as existing.

On this basis the proposed discharge of surface water from the development will not see any surface water flooding on site in the 1 in 30 years and 1 in 100 year plus climate change events. Therefore, it will not increase the risk of surface water / sewer flooding elsewhere.

7. Hierarchy of disposing surface water

The Planning Practice Guidance and part H of the Building Regulations state that "generally, the aim should be to discharge surface run off as high up the following hierarchy of drainage options as reasonably practicable:

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

7.1 Infiltration

Due to the lack of permeable ground and with the site being over an aquifer, infiltration is not a viable option.

7.2 Surface Water Body

There are no accessible watercourses within the immediate vicinity of the development.

7.3 Surface Water or Combined Sewer

It is assumed that a public surface water or combined sewer is available and serves the other dwellings in the vicinity of the proposed development. As such, it is proposed that surface water is discharged into the public sewerage system.

8. Use of SuDS

The NPPF, Planning Practice Guide and the Ministerial Statement all look at the use of SuDS as a priority to aid the disposal of surface water from new developments.

Due to the minor nature of the development proposal there is limited capacity to include SuDS measures although permeable paving and the use of water butts may be considered for use, where appropriate, to minimise surface water runoff from the site.

9. Management of flood risk

9.1 Fluvial

The analysis of flooding from fluvial and tidal sources shows that the building is in Flood Zone 2 and hence is at a risk of flooding from events between the 1 in 1000 (0.1%) and 1 in 100 (1%) year events.

Table 2 of this report details that residential developments are classified as More Vulnerable; Table 3 of the report shows that More Vulnerable developments in Flood Zone 2 are acceptable.

The results from the Upper Mersey Study indicate that the long-term flood level in the vicinity of the development site is 34.72mAOD, equating to 1 in 100+30%CC.

It is proposed that the floor level is set as high as possible but no lower than existing as in line with EA guidance. Furthermore, it is recommended flood resistance and resilience measures are incorporated into the development. Section 9.4 of this report provides further information.

9.2 Surface Water

The vicinity of the development site is described as being at low risk from surface water flooding, which means that the flood risk is between 1 in 1000 (0.1%) and 1 in 100 (1%) in any year.

It is assumed that a public surface water or combined sewer is available and serves the other dwellings in the vicinity of the proposed development. As such, it is proposed that surface water is discharged into the public sewerage system.

Due to the small scale of the development, on-site attenuation is not necessary.

Appropriate SuDS features and measures may be considered within the development to minimise surface water discharges. Due to the small-scale nature of the development this would be limited to permeable paving and water butts, if appropriate.

The proposed development will not increase the risk of flooding elsewhere from surface water sources.

9.3 Safe access and egress

The proposed development is for a 2-storey dwelling. In the event of flooding, all residents will have access to safe refuge on the first floor of the dwelling.

It is recommended that residents of the property register for the EA Flood Warning Service, which is available within the area and which aims to give a minimum 2 hours advance notification of potential flooding, giving adequate time to implement safety procedures.

In the event of having to evacuate the building, a suitable emergency egress route is available by turning North onto Morningside Drive, at the end of this road turn North West onto Wilmslow Road and travel for approximately 70m to reach Flood Zone 1.

9.4 Flood Resistance and Resilience Measures

It is recommended that the proposed works incorporate flood resilience and resistance measures. This would ensure that any extreme flooding and flooding in exceedance events could be mitigated against.

Floodwater will always follow a path of least resistance and will enter a building at the weakest points in the construction, particularly through masonry and construction joints, and any voids and gaps. The following summarises the main entry points.

Current building regulations and traditional construction do not require the use of materials and design details that can withstand long-term immersion in flood water. Water could enter via:

● brickwork and blockwork

● party walls of terraced or semi-detached buildings if the attached building is flooded

● expansion joints between walls where different construction materials meet or between the floor slab and wall

● suspended timber ground floors via the interface between timber and mortar for built-in joists or along the interface between timber and metal plate where a joist hanger is used. Water will be absorbed through the exposed end grain of a built-in timber joist.

Specific features encourage air flow and therefore may provide a pathway for water. Routes include:

- vents, airbricks
- inadequate seals between windows, doors and frames
- door thresholds

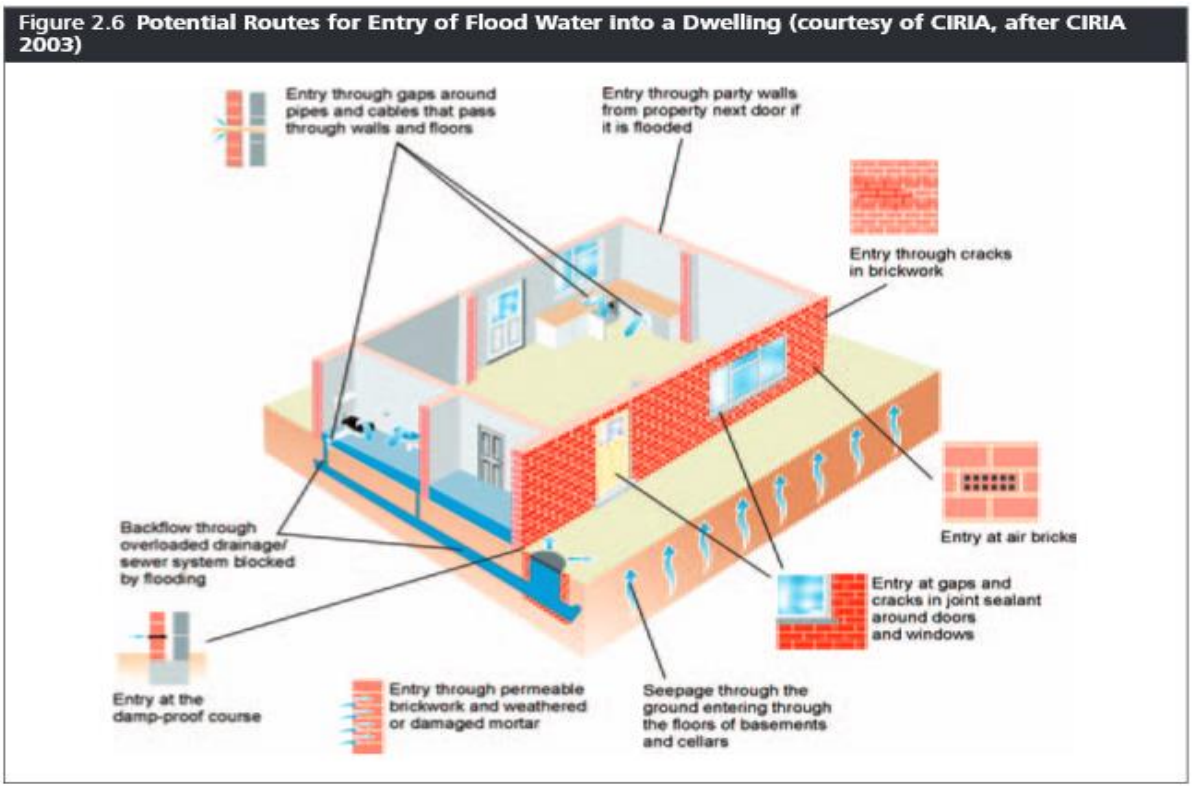
Cracks and openings due to settlement, poor construction, and services all provide water entry routes, such as:

- cracks in external walls
- flaws in wall construction
- cracks and gaps at the interface between brick, stone and block units and their bedding mortar due to inadequate bonding. These can be as a result of movement caused by thermal expansion/contraction, moisture or settlement
- damp proof course (d.p.c.), where the lap between the wall damp proof course and floor membrane is inadequate
- services entries e.g. utility pipes, ventilation ducts, electricity and telephone cables
- gaps in mortar in masonry, stonework and blockwork walls, usually at perpends.

Other entry routes include:

- seepage from below ground through floors and basements
- sanitary appliances from backflow from surcharged drainage systems

Figure 2.6 Potential Routes for Entry of Flood Water into a Dwelling (courtesy of CIRIA, after CIRIA 2003)



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Building materials

Table 6.1 presents the characteristics of common building materials, tested in the laboratory, classified as having good, medium or poor performance with regard to water penetration, drying ability and integrity.

Definitions of the characteristics used in Table 6.1 are:

● water penetration – the seepage (rate and volume) through the material (note that this is different from "water absorption")

● drying ability – the capability to regain its original moisture condition (assessed by the average drying rate and the time taken to reach the original value)

● retention of pre-flood dimensions, integrity – the lack of deformation or change in form or appearance of the material

Table 6.1 Flood resilience characteristics of building materials (based on laboratory testing)

Material	Resilience characteristics*		
	Water penetration	Drying ability	Retention of pre-flood dimensions, integrity
Bricks			
Engineering bricks (Classes A and B)	Good	Good	Good
Facing bricks (pressed)	Medium	Medium	Good
Facing bricks (handmade)	Poor	Poor	Poor
Blocks			
Concrete (3.5N, 7N)	Poor	Medium	Good
Aircrete	Medium	Poor	Good
Timber board			
OSB2, 11mm thick	Medium	Poor	Poor
OSB3, 18mm thick	Medium	Poor	Poor
Gypsum plasterboard			
Gypsum Plasterboard, 9mm thick	Poor	Not assessed	Poor
Mortars			
Below d.p.c. 1:3(cement:sand)	Good	Good	Good
Above d.p.c. 1:6(cement:sand)	Good	Good	Good

* Resilience characteristics are related to the testing carried out and exclude aspects such as ability to withstand freeze/thaw cycles, cleanability and mould growth

- Water exclusion strategy – where emphasis is placed on minimising water entry whilst maintaining structural integrity, and on using materials and construction techniques to facilitate drying and cleaning. This strategy is favoured when low flood water depths are involved (not more than 0.3m). According to the definitions adopted in this Guidance, this strategy can be considered as a resistance measure but it is part of the aim to achieve overall building resilience
- Water entry strategy – where emphasis is placed on allowing water into the building, facilitating draining and consequent drying. Standard masonry buildings are at significant risk of structural damage if there is a water level difference between outside and inside of about 0.6m or more. This strategy is therefore favoured when high flood water depths are involved (greater than 0.6m).

Water exclusion strategy

A general principle for flood resilient design where predicted flood water depths are relatively small (no greater than 0.3m above floor level) is to minimise the entry of water through permeable elements of the foundation. Any concrete blocks placed below ground-bearing concrete floor slabs provide a potential path for water to ingress into wall cavities, as these blocks are considerably more permeable than concrete slabs. Figures 6.2 and 6.3, illustrating a ground bearing slab and a concrete suspended floor slab, show a potential flow path from the ground adjacent and under a dwelling, through porous substructure and into the wall cavity. The use of concrete or another impermeable material to seal the blocks may resolve this problem. The figures highlight the fact that measures taken above ground level may not fully prevent the ingress of water.

Figure 6.2 **Water ingress into properties through the ground – ground bearing floor**

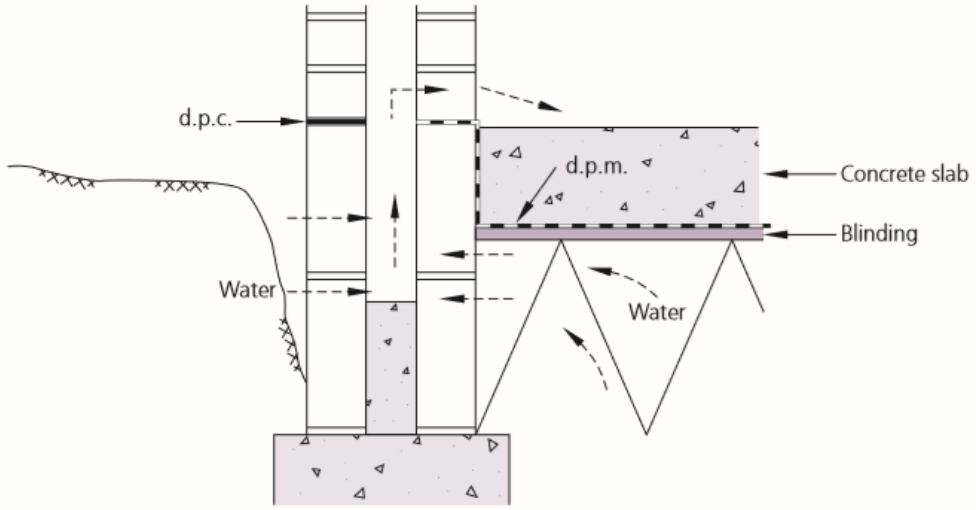
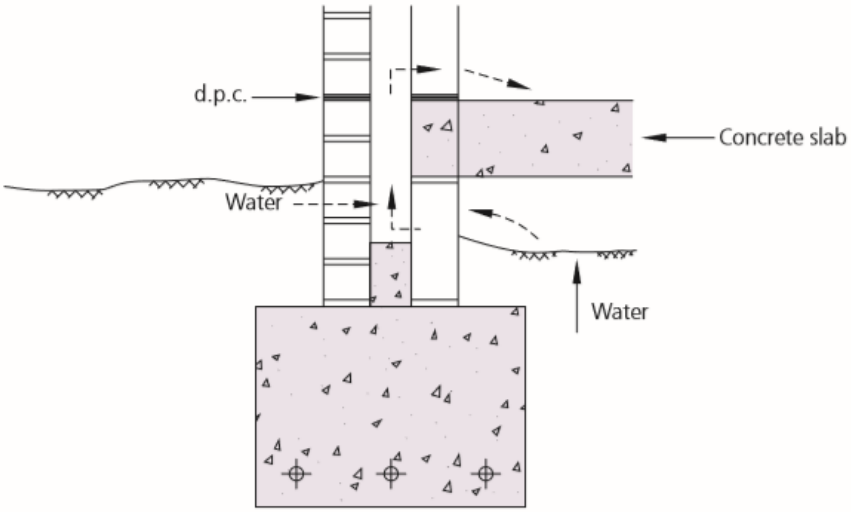


Figure 6.3 **Water ingress into properties through the ground – suspended floor**



> **General advice for resilient design**
>
> Where concrete ground floor slabs are used, the blockwork substructure is often the weakest point in terms of water penetration from the ground into a dwelling. Whereas there is a general perception that water can ingress through the blockwork structure of the external face of a wall into the property, it is less apparent, but equally possible, that water will penetrate from the ground on the inside of the property. Figures 6.2 and 6.3 illustrate these flow paths for two types of ground floor (ground bearing floor and suspended concrete floor), and different types of foundation (typical for construction in England).
>
> Concrete blocks used in foundations should be sealed with an impermeable material or encased in concrete to prevent water movement from the ground to the wall construction.

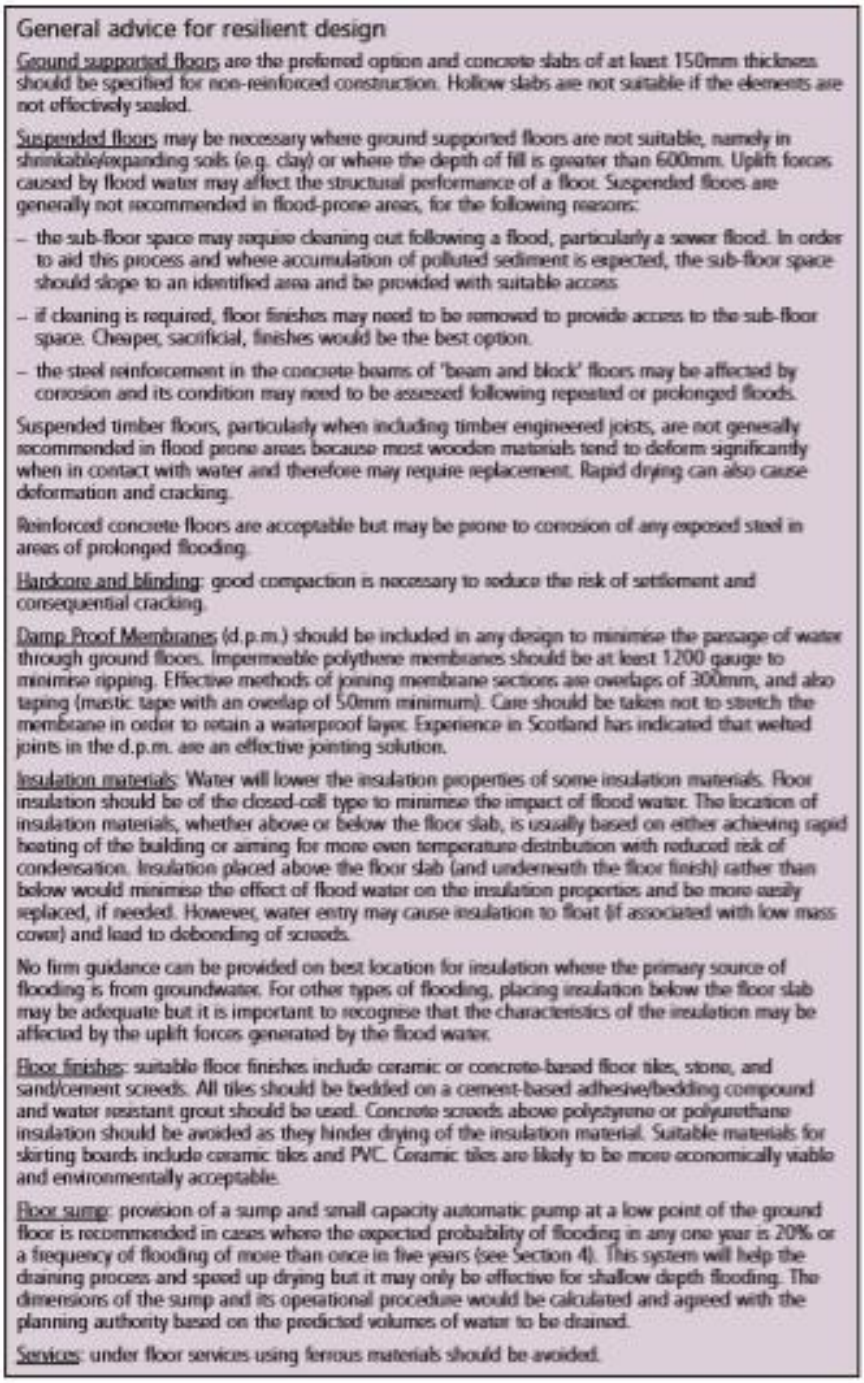
Water entry strategy

> **General advice for resilient design**
>
> A general principle for flood resilient design where predicted flood water depths are high is to provide durable materials that will not be affected by water and use construction methods and materials that promote easy draining and drying.
>
> Standard methods and good quality building materials will generally comply with these requirements but good workmanship is essential.

Floors

Water exclusion strategy

When applying a "water exclusion strategy" (i.e. minimising water ingress through ground floor slabs), for predicted water depths above the floor of greater than 0.3m, it is important to carry out structural checks assuming a flood depth of 1m minimum above the slab, even in areas where the design flood water depth is lower. Usual safety factors must be applied in all such calculations (floors and walls). Laboratory evidence on small slabs (0.5m by 0.5m) indicated that 150mm thick concrete slabs on supporting soil can withstand such forces without allowing water ingress. However, for larger slabs, uplift forces may cause deformation and induce cracking and lead to preferential paths for water ingress.



General advice for resilient design

Ground supported floors are the preferred option and concrete slabs of at least 150mm thickness should be specified for non-reinforced construction. Hollow slabs are not suitable if the elements are not effectively sealed.

Suspended floors may be necessary where ground supported floors are not suitable, namely in shrinkable/expanding soils (e.g. clay) or where the depth of fill is greater than 600mm. Uplift forces caused by flood water may affect the structural performance of a floor. Suspended floors are generally not recommended in flood-prone areas, for the following reasons:

- the sub-floor space may require cleaning out following a flood, particularly a sewer flood. In order to aid this process and where accumulation of polluted sediment is expected, the sub-floor space should slope to an identified area and be provided with suitable access
- if cleaning is required, floor finishes may need to be removed to provide access to the sub-floor space. Cheaper, sacrificial, finishes would be the best option.
- the steel reinforcement in the concrete beams of 'beam and block' floors may be affected by corrosion and its condition may need to be assessed following repeated or prolonged floods.

Suspended timber floors, particularly when including timber engineered joists, are not generally recommended in flood prone areas because most wooden materials tend to deform significantly when in contact with water and therefore may require replacement. Rapid drying can also cause deformation and cracking.

Reinforced concrete floors are acceptable but may be prone to corrosion of any exposed steel in areas of prolonged flooding.

Hardcore and blinding: good compaction is necessary to reduce the risk of settlement and consequential cracking.

Damp Proof Membranes (d.p.m.) should be included in any design to minimise the passage of water through ground floors. Impermeable polythene membranes should be at least 1200 gauge to minimise ripping. Effective methods of joining membrane sections are overlaps of 300mm, and also taping (mastic tape with an overlap of 50mm minimum). Care should be taken not to stretch the membrane in order to retain a waterproof layer. Experience in Scotland has indicated that welted joints in the d.p.m. are an effective jointing solution.

Insulation materials: Water will lower the insulation properties of some insulation materials. Floor insulation should be of the closed-cell type to minimise the impact of flood water. The location of insulation materials, whether above or below the floor slab, is usually based on either achieving rapid heating of the building or aiming for more even temperature distribution with reduced risk of condensation. Insulation placed above the floor slab (and underneath the floor finish) rather than below would minimise the effect of flood water on the insulation properties and be more easily replaced, if needed. However, water entry may cause insulation to float (if associated with low mass cover) and lead to debonding of screeds.

No firm guidance can be provided on best location for insulation where the primary source of flooding is from groundwater. For other types of flooding, placing insulation below the floor slab may be adequate but it is important to recognise that the characteristics of the insulation may be affected by the uplift forces generated by the flood water.

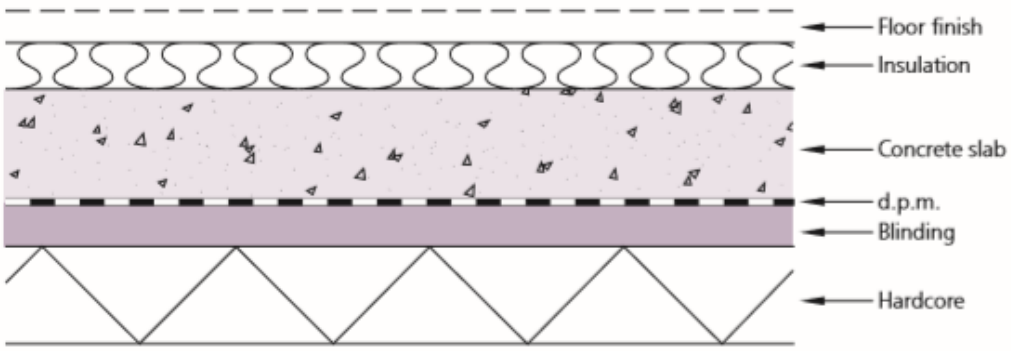
Floor finishes: suitable floor finishes include ceramic or concrete-based floor tiles, stone, and sand/cement screeds. All tiles should be bedded on a cement-based adhesive/bedding compound and water resistant grout should be used. Concrete screeds above polystyrene or polyurethane insulation should be avoided as they hinder drying of the insulation material. Suitable materials for skirting boards include ceramic tiles and PVC. Ceramic tiles are likely to be more economically viable and environmentally acceptable.

Floor sump: provision of a sump and small capacity automatic pump at a low point of the ground floor is recommended in cases where the expected probability of flooding in any one year is 20% or a frequency of flooding of more than once in five years (see Section 4). This system will help the draining process and speed up drying but it may only be effective for shallow depth flooding. The dimensions of the sump and its operational procedure would be calculated and agreed with the planning authority based on the predicted volumes of water to be drained.

Services: under floor services using ferrous materials should be avoided.

Recommended ground-supported and acceptable suspended floor arrangements are presented in Figures 6.4 to 6.6. If suspended timber flooring is a favoured option, then a combination of construction elements that is likely to minimise problems associated with flooding is shown in Figure 6.6. This is referred to as a "Restricted option"

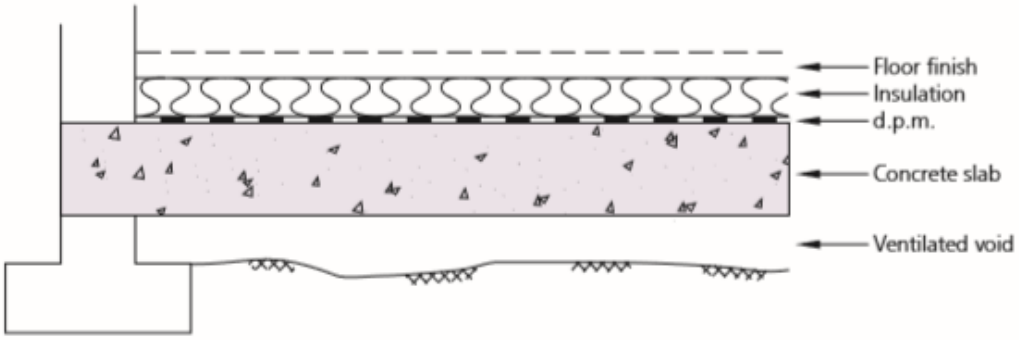
Figure 6.4 Ground-supported floor – Preferred option



- Hardcore bed at least 100mm thick of well compacted inert material, blinded with fine inert material to provide a smooth base
- Damp proof membrane of polythene at least 1200 gauge
- Concrete slab at least 150mm thick
- Insulation as rigid closed-cell material
- Ceramic tiles or stone floor finishes and skirting boards.

Figure 6.4 shows floor insulation above slab and there is laboratory evidence to support this location but there is currently no sound evidence to prevent the use of below slab insulation.

Figure 6.5 Suspended Concrete Floor – Acceptable option



- Reinforced concrete slab at least 150mm thick and complying with structural requirements for uplift forces
- Damp proof membrane of polythene at least 1200 gauge
- Insulation as rigid closed-cell material
- Ceramic tiles or stone floor finishes and including skirting boards.

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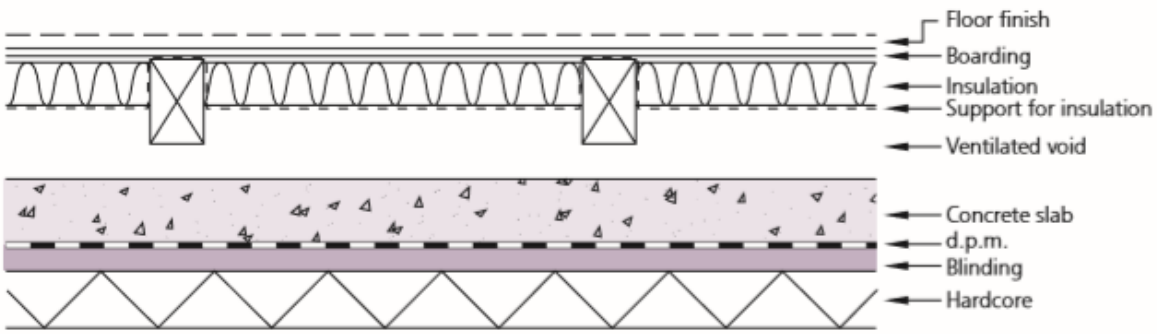
Figure 6.6 Suspended Timber Floor – Restricted option



- Hardcore bed at least 100mm thick of well compacted inert material, blinded with fine inert material to provide a smooth base
- Concrete slab at least 150mm thick
- Insulation as rigid, closed cell material and supported with battens, plastic mesh or corrosion-resistant fixings
- Boarding consisting of WBP Plywood and preservative treated timber
- Stainless steel hangers

Water entry strategy

General advice for resilient design

Materials that retain their integrity and properties when subjected to flood water (such as concrete) or those that can be easily replaced (sacrificial materials), should be specified. Construction should allow easy access for cleaning, (e.g. below suspended floors), and drainage.

Concrete ground-supported floors are the preferred option and concrete slabs of at least 100mm thickness should be specified.

Suspended floors may be necessary where ground-supported floors are not suitable, namely in shrinkable/expanding soils (e.g. clay soils) or where the depth of fill is greater than 600mm. In cases of prolonged floods, where flood water is heavily silted, or from sewer flooding, the sub-floor space may require cleaning out following a flood; to aid this process, it should slope to an identified low point and be provided with suitable access. If cleaning is required, floor finishes may need to be removed to provide access to the sub-floor space and therefore cheaper, sacrificial, finishes would be the best option. Alternatively, external access to the sub-floor space can be considered as a design option.

Suspended steel floors may be adequate provided they incorporate resilient features such as anti-corrosion properties and comply with required structural capability.

Suspended timber floors, particularly when including timber engineered joists, are not generally recommended in flood prone areas because most wooden materials tend to deform significantly when in contact with water and therefore may require replacement. Rapid drying can also cause deformation and cracking.

Hardcore and blinding: good compaction should be achieved to reduce the risk of settlement and consequential cracking.

Damp Proof Membranes (d.p.m.) should be included in any design to minimise the passage of water through ground floors. Impermeable polythene membranes should be at least 1200 gauge to minimise ripping. Effective methods of joining membrane sections are: overlaps of 300mm or taping with mastic tape with an overlap of 50mm minimum. Care should be taken not to stretch the membrane in order to retain a waterproof layer. Experience in Scotland has indicated that welted joints in the d.p.m. are an effective jointing solution but the quality of the welts is very dependent on workmanship.

Insulation materials: Water will lower the insulation properties of some insulation materials. Floor insulation should be of the closed-cell type to minimise the impact of flood water. The location of insulation materials, whether above or below the floor slab, is usually based on either achieving rapid heating of the building or aiming for more even temperature distribution with reduced risk of condensation. It is recommended that insulation be placed above the floor slab (and underneath the floor finish) rather than below would minimise the effect of flood water on the insulation properties and be more easily replaced, if needed.

Floor finishes: there are two possible approaches that depend on an assessment of the likely frequency of flooding and cost of material and installation: use of sacrificial materials or reliance on high quality durable materials – see Section 4. Sacrificial floor finishes can include timber flooring and soft furnishings such as carpets. Materials that are likely to withstand exposure to floodwater without significant deterioration are ceramic or concrete-based floor tiles, marble or stone. All tiles should be set on a bed of sand and cement render and water resistant grout should be used. Concrete screeds above polystyrene or polyurethane insulation should be avoided as they hinder drying of the insulation material due to the relative impermeability.

Suitable materials for skirting boards include ceramic tiles and PVC. Ceramic tiles are likely to be more economically viable and environmentally acceptable. Replacement timber may be a suitable option, for cases where a strategy to use of sacrificial materials is adopted.

Floor sump: provision of a sump and small capacity pump in the floor at a low point of the ground floor is recommended in cases where the expected frequency of flooding is high; this system will help the draining process and speed up drying but it may only be effective for shallow depth flooding. The dimensions of the sump and its operational procedure would be calculated and agreed with the Planning Authority based on the predicted volumes of water to be drained.

Services: under floor services using ferrous materials should be avoided.

Walls

Table 6.2, based on the laboratory evidence, classifies wall components as good, medium or poor with regard to water penetration, surface drying and structural integrity.

Definitions of the characteristics used in Table 6.2 are:

● water penetration – the leakage (rate and volume) through the entire wall thickness (note that this is different from "water absorption")

● drying ability – the capability to regain its original surface moisture condition (assessed by the average drying rate and the time taken to reach the original value)

● retention of pre-flood dimensions, integrity – the lack of deformation or change in form or appearance of the wall panel.

Table 6.2 **Flood resilience characteristics of walls (based on laboratory testing)**			
Material	Resilience characteristics*		
	Water penetration	Drying Ability	Retention of pre-flood dimensions, integrity
External face			
Engineering bricks (Classes A and B)	Good	Good	Good
Facing bricks (pressed)	Medium	Medium	Good
Internal face			
Concrete blocks	Poor	Medium	Good
Aircrete	Medium	Poor	Good
Cavity insulation			
Mineral fibre	Poor	Poor	Poor
Blown-in expanded mica	Poor	Poor	Poor
Rigid PU foam	Medium	Medium	Good
Renders/Plaster			
Cement render – external	Good	Good	Good
Cement/lime render – external	Good	Good	Good
Gypsum Plasterboard	Poor	Not assessed	Poor
Lime plaster (young)	Poor	Not assessed	Poor
* Resilience characteristics are related to the testing carried out and exclude aspects such as ability to withstand freeze/thaw cycles, cleanability and mould growth			

Water exclusion strategy

This strategy is applicable to design flood depths of up to 0.3m or up to 0.6m, if allowed by the structural assessment of the design.

General advice for resilient design

Ensure high quality workmanship at all stages of construction.

Masonry walls:

Ensure mortar joints are thoroughly filled to reduce the risk of water penetration. If frogged bricks are used, they should be laid frog up so that filling becomes easier and coverage more certain. Bricks manufactured with perforations should not be used for flood resilient design.

Where possible, use engineering bricks up to predicted flood level plus one course of bricks to provide freeboard (up to maximum of 0.6m depth above floor level); this will increase resistance to water penetration. Blocks (and dense facing bricks) have much improved performance when covered with render.

Aircrete blocks allow less leakage than typical concrete blocks but concrete blocks dry more quickly. Therefore, design of blockwork walls needs to take into account these two opposite types of behaviour and consider whether drying or resistance to water is most relevant in each situation. For a "water exclusion strategy", the expected amount of leakage is minimal and therefore, Aircrete blocks are recommended, although they may retain moisture for longer than concrete blocks, Compared with heavier blocks, Aircrete may offer less restraint to floor/slab edges which under the action of uplift forces could promote the opening up of floor/wall junctions.

Do not use highly porous bricks such as hand made clay bricks.

Solid masonry walls are a good option but will need to be fitted with internal or external wall insulation in order to comply with Building Regulations.

Clear cavity walls, i.e. with no insulation in the cavity, have better flood resilience characteristics than filled or part filled cavity walls as they dry more quickly. The requirements for insulation can be satisfied by external insulated renders or internal thermal boards.

There is evidence that thin layer mortar construction (or thin joint, as it is also commonly known) is a good flood resilience option.

Framed walls: Avoid timber framed walls containing construction materials that have poor performance in floods, for example oriented strand board and mineral fibre insulation. Timber framed walls are not recommended in a "water exclusion strategy". Steel framed walls may offer a suitable alternative option but specialist advice needs to be sought on how to incorporate resilient materials/construction methods in the design, in particular with regard to the insulation.

Reinforced concrete wall/floor construction should be considered for flood-prone areas, i.e. where the frequency of flooding is predicted to be high (see Chapter 4). This form of construction is effective at resisting forces generated by floodwater and will provide an adequate barrier to water ingress (provided service ducts and other openings into the building are adequately sealed). Design details for this type of construction are beyond the scope of this document.

External renders are effective barriers to water penetration and should be used with blocks (or bricks) at least up to the predicted flood level plus the equivalent of a course of bricks as freeboard. Structural checks may be necessary to ensure stability, because of the external water pressures that could occur for design flood depths above 0.3m. External cement renders with lime content (in addition to cement) can induce faster surface drying.

Insulation:

External insulation is better than cavity insulation because it is easily replaced if necessary.

Cavity insulation should preferably incorporate rigid closed cell materials as these retain integrity and have low moisture take-up. Other common types, such as mineral fibre batts, are not generally recommended as they can remain wet several months after exposure to flood water which slows down the wall drying process. Blown-in insulation can slump due to excessive moisture uptake, and some types can retain high levels of moisture for long periods of time (under natural drying conditions).

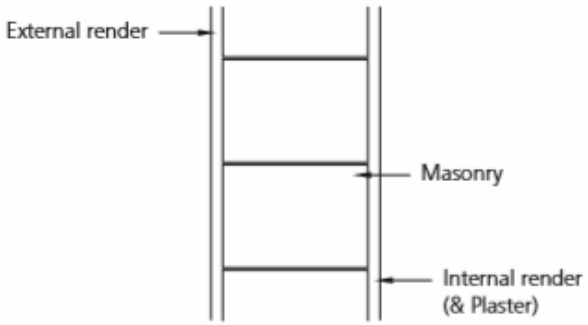
Internal linings:

Internal cement renders (with good bond) are effective at reducing flood water leakage into a building and assist rapid drying of the internal surface of the wall. The extent to which render prevents drying of other parts of the wall is not currently clear. This may be important, particularly for solid wall construction. This applies also to external renders.

Avoid standard gypsum plasterboard as it tends to disintegrate when immersed in water. Splash proof boards do not necessarily offer protection against flood waters, which may remain for some time and exert pressure on the board.

Anecdotal evidence suggests that internal lime plaster/render can be a good solution. Lime plaster depends on contact with the air to set and harden. Because of this, full strength lime plaster, which typically requires over 6 months, was not possible to test. Consequently, no assurance can be given for its performance. Tests performed when young showed that it crumbles very easily under high water pressure.

Figure 6.7 Solid External Walls



- External cement based render, preferably with lime content. Composition depends on masonry. The following mixes have good resilient properties:

  1 cement : 6 sand on bricks;

  1 cement : 4 sand: ½ lime on concrete blockwork or bricks;

  1 cement : 6 sand: 1 lime on Aircrete blocks.

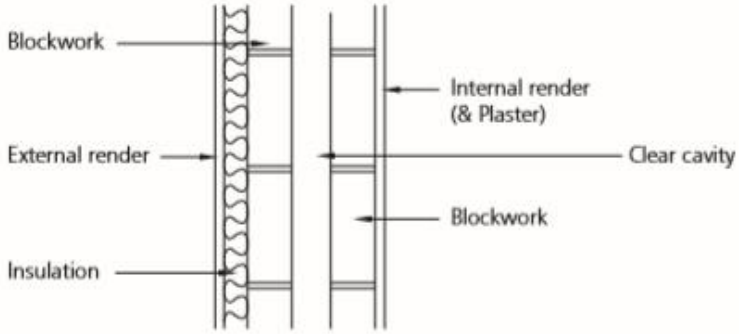
- Masonry with minimum thickness of 300mm (thin mortar joint construction using Aircrete blocks is effective as demonstrated in laboratory tests) or alternatively reinforced concrete wall
- Internal cement-based render, preferably with lime content. Composition depends on masonry; the following mix is effective for flood resilience:

  1 cement : 6 sand: 1 lime on Aircrete.

  Apply external and internal renders, following good practice guidance, ensuring minimum total thickness of 20mm and at least two coats.

- Use external insulation in preference to internal insulation.

Figure 6.8 Cavity External Walls – Clear cavity



Clear cavity

- External cement based render, preferably with lime content. Composition depends on masonry; the following mixes are effective for flood resilience:

  1 cement: 4 sand: ½ lime on concrete blockwork (or bricks);

  1 cement: 6 sand: 1 lime on Aircrete.

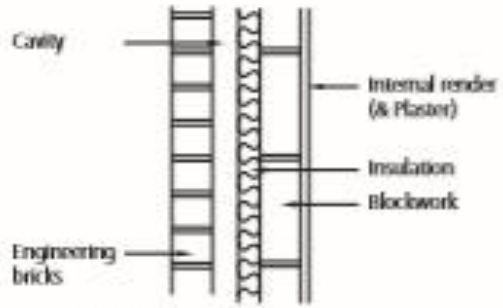
  Apply render following good practice guidance, ensuring minimum total thickness of 20mm and two coats.

- Internal cement based render, preferably with lime content. Composition depends on masonry. The following mix works well:

  1 cement: 6 sand: 1 lime on Aircrete.

- Stainless steel wall ties should be used to minimise corrosion and consequent staining.

Figure 6.9 Cavity External Walls – Part-filled cavity



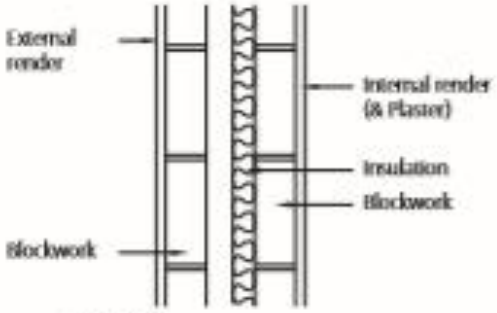
Option A

Part-filled cavity

Part-filled cavity – Option A

- External face consisting of engineering bricks up to required level for flood protection (up to 0.6m maximum above floor level plus one course). Other external facing materials can be used above this level, but ensure interface is watertight.
- Rigid insulation.
- Internal face consisting of blocks.
- Internal cement based render, preferably with lime content. Composition depends on masonry; the following mix is effective:

  1 cement : 6 sand: 1 lime on Aircrete.
- Ensure stainless steel wall ties are used to minimise corrosion and consequent staining.
- Sacrificial plasterboard can be used, but it needs to be removed between ground floor and flood level. The board should be fitted horizontally to make removal easier. In some cases a dado rail can be used to cover the joints.



Option B

Part-filled cavity – Option B

- External cement based render, preferably with lime content. Composition depends on masonry; the following mixes are effective:

  1 cement : 4 sand: ½ lime on concrete blockwork

  1 cement : 6 sand: 1 lime on Aircrete.
- External face consisting of blocks.
- Rigid insulation.
- Internal face consisting of blocks.
- Internal cement based render, preferably with lime content. Composition depends on masonry; the following mix is effective for flood resilience:

  1 cement : 6 sand: 1 lime on Aircrete.
- Ensure stainless steel wall ties are used to minimise corrosion and consequent staining.

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Water entry strategy

This strategy is applicable to design flood depths above 0.6m, or above 0.3m if the structural assessment of the design shows that the integrity of the building would be compromised by a "water exclusion strategy".

General advice for resilient design

Ensure high quality workmanship at all stages of construction.

Masonry walls:

Use good quality facing bricks for the external face of cavity walls.

Do not use soft bricks, such as hand made clay bricks, which can easily crumble when subjected to water.

Concrete blocks dry more quickly than Aircrete blocks. However, Aircrete blocks allow less leakage. Therefore, design of blockwork walls needs to take into account these two opposite types of behaviour and consider whether drying or resistance to water is most relevant in each situation. For a "water entry strategy" which is aimed at allowing water passage through the property, concrete blocks are recommended.

Clear cavity walls, i.e. with no insulation, have better resilience characteristics than filled or part filled cavity walls as they dry more quickly.

Framed walls: Avoid timber framed walls containing construction materials that have poor performance in floods, namely oriented strand board and mineral fibre insulation. Timber framed walls are generally not recommended, unless a sacrificial approach is adopted whereby some materials will be stripped to allow drying.

Steel framed walls may offer a suitable alternative option but specialist advice needs to be sought on how to incorporate resilient materials/construction methods in the design. The possible use of bituminous paint on steel plates may be a means of preventing corrosion.

External renders should not be used as they provide a barrier to water penetration and may induce excessive differences in depth between outside and inside of the property resulting in possible structural problems.

Insulation:

External insulation is better than cavity insulation because it is easily replaced if necessary; however it is generally protected by rigid lining which may create a barrier to water.

Cavity insulation should incorporate rigid closed cell materials as these retain integrity and have low moisture take-up. Other common types, such as mineral fibre batts, are not generally recommended as they can remain wet several months after exposure to flood water which slows down the wall drying process. Blown-in insulation can slump due to excessive moisture uptake, and some types can retain high levels of moisture for long periods of time (under natural drying conditions).

Internal linings:

Avoid internal cement renders as these can prevent effective drying.

Use standard gypsum plasterboard up to the predicted flood level (plus freeboard of 50mm) as a sacrificial material. For this purpose, the use of a dado rail to separate the above and below flooded area may be useful. Splash proof boards do not necessarily offer better protection against flood waters, which may remain for some time and exert pressure on the board.

Above predicted flood level (plus freeboard) the use of plasterboard or internal cement renders is appropriate.

Anecdotal evidence suggests that internal lime plaster/render can be a good solution. Lime plaster depends on contact with the air to set and harden. Because of this, full strength lime plaster, which typically requires over 6months, was not possible to test. Consequently, no assurance can be given for its performance. Tests performed when young showed that it crumbles very easily under high water pressure.

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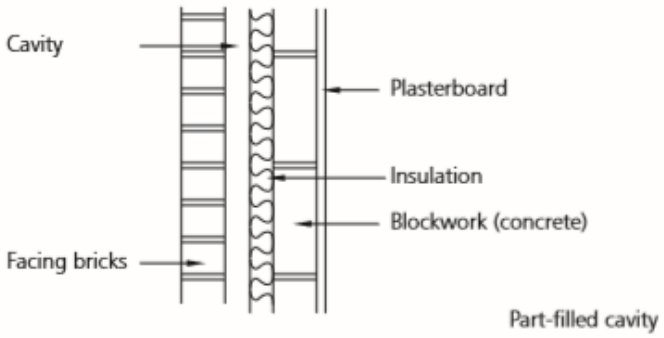
Figure 6.10 Cavity External Walls – Part-filled cavity with sacrificial plasterboard



Part-filled cavity

- External face consisting of engineering bricks up to required level for flood protection (up to d.p.c.). Other external facing materials can be used above this level, but ensure transition is watertight.
- Rigid insulation
- Internal cement based render, preferably with lime content. Composition depends on masonry; the following mix is effective:

  1 cement : 6 sand: 1 lime on concrete blocks.
- Stainless steel wall ties should be used to minimise corrosion and consequent staining.
- Sacrificial plasterboard can be used, but it needs to be removed between ground floor to flood level. The board should be laid horizontally to make removal easier.

Doors and windows

General advice for resilient/resistant design

Doors: Raising the threshold as high as possible, while complying with level access requirements, should be considered as the primary measure. In addition, sealed PVC external framed doors should be used and, where the use of wooden doors is a preferred option, all effort should be made to ensure a good fit and seal to their frames.

Hollow core timber internal doors should not be used where the predicted frequency of flooding is high. Where sufficient flood warning is given, butt hinges, that allow internal doors to be easily removed and stored in dry areas prior to a flood, should be used. Where the frequency of predicted flooding is low or where there is no warning (e.g. overland or sewer flooding) it may be necessary to replace the doors after the flood.

Windows/patio doors: Windows and patio doors are vulnerable to flood water and similar measures to those used for doors should be taken. Special care should be taken to ensure adequate sealing of any PVC window/door sills to the fabric of the house. Of particular concern would be excessive water pressure on the glazing of patio doors. Double glazing conforming to the relevant standards would in principle adequately resist the pressures generated by flood waters; debris carrying flows may cause damage.

Air vents: special designs of air vent are available in the market to prevent water ingress in circumstances where the predicted flood depth is low (i.e. < 0.3m); e.g. periscopic air vent, see Figure 6.11. Careful consideration should be given to effectively sealing any associated joints.

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Fittings

Water exclusion strategy

General advice for resilient design

The main principle is to use durable fittings that are not significantly affected by water and can be easily cleaned (e.g. use of plastic materials or stainless steel for kitchen units). The cost of these units may need to be balanced against the predicted frequency of flooding.

Place fittings (e.g. electrical appliances, gas oven) on plinths as high as practicable above floor so that they are out of reach of flood water.

Ensure adequate sealing of joints between kitchen units and surfaces to prevent any penetration of water behind fittings.

Ensure high quality workmanship in the application of fittings.

Water entry strategy

General advice for resilient design

Although a sacrificial approach can be adopted whereby fittings are designed to be replaced after a flood, it is advisable to specify durable fittings that are not appreciably affected by water and can be easily cleaned (e.g. use of plastic materials or stainless steel for kitchen units). The cost of these units may need to be balanced against the predicted frequency of flooding. Avoid wood fibre based carcases and use easily removable solid wood doors and drawers.

Place fittings (e.g. electrical appliances, gas oven) as high as practical above floor to minimise the risk of being affected by flood water.

When allowing water in, it is important to provide means for effective drainage and cleaning. Providing gaps behind kitchen units will facilitate drainage and will allow access for forced drying, if proved to be necessary.

Ensure high quality workmanship in the application of fittings.

Services

General advice for resilient design

Where possible, all service entries should be sealed (e.g. with expanding foam or similar closed cell material).

Pipework: Closed cell insulation should be used for pipes which are below the predicted flood level.

Drainage services: Non-return valves are recommended in the drainage system to prevent back-flow of diluted sewage in situations where there is an identified risk of the foul sewer surcharging. Maintenance of these valves is important to ensure their continued effectiveness.

Water, electricity and gas meters: should be located above predicted flood level.

Electrical services: electrical sockets should be installed above flood level for ground floors to minimise damage to electrical services and allow speedy re-occupation (see Figure 6.13. Note a dado rail which provides a limit for replacement of any wall covering). Electric ring mains should be installed at first floor level with drops to ground floor sockets and switches.

Heating systems: boiler units and ancillary devices should be installed above predicted flood level and preferably on the first floor of two-storey properties. Underfloor heating should be avoided on ground floors and controls such as thermostats should be placed above flood level. Conventional heating systems, e.g. hot water pipes are unlikely to be significantly affected by flood water unless it contains a large amount of salts. The less common, hot air duct heating would remain effective provided it is installed above the design flood level.

Communications wiring: wiring for telephone, TV, Internet and other services should be protected by suitable insulation in the distribution ducts to prevent damage. Any proposed design solution for flood insulation on all potentially vulnerable wiring should be discussed with the relevant service providers.

9.5 Flood plan

As the development is situated in Flood Zone 2 it would be prudent for a flood warning and evacuation plan to be set up and implemented post development. This plan would include residents signing up to the Environment Agency flood warning service.

The flood warning service has three types of warning that will help you to prepare for flooding and take action.

Flood Warning	Flood Alert	Flood Warning	Severe Flood Warning
			
What it means?	Flooding is possible. Be prepared.	Flooding is expected. Immediate action required.	Severe flooding. Danger to life.
When it's used?	Two hours to two days in advance of flooding.	Half an hour to one day in advance of flooding.	When flooding poses a significant threat to life.
What to do?	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.	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.	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.

Recommended Flood Plan:

Before a flood

- Find out if you are at risk of flooding;
- Find out if you can receive flood warnings;
- Prepare and keep a list of all your contacts to hand or save them on your mobile phone/tablet;
- Think about what items you can move now and what you would want to move to safety during a flood such as pets, cars, furniture and electrical equipment;
- Know how to turn off gas, electricity and water supplies;
- Prepare a flood kit of essential items and keep it handy. It can include copies of important documents, a torch, a battery-powered or wind-up radio, blankets and warm clothing, waterproofs, rubber gloves and a first aid kit including all essential medication.

On receipt of a flood warning

- Tune into your local radio station on a battery or wind-up radio;
- Fill jugs and saucepans with water;
- Grab your already prepared flood kit;

- Collect blankets, torch, first aid kit, medication and food;
- Move important documents, personal items, valuables and lightweight belongings upstairs or to high shelves;
- Raise large items of furniture, or put him in large bags if you have them;
- Move people, outdoor belongings, cars and pets to higher ground;
- Switch off water, gas and electricity at mains when water is about to enter your home. Do not touch sources of electricity when in standing water;
- Fit flood protection products, if you have them, for example flood boards, airbrick covers and sandbags;
- If you do not have non-return valves fitted, plug water inlet pipes with towels or cloths; Know your means of escape;
- Listen to the advice of the emergency service and evacuate if told to do so;
- Avoid walking or driving through flood water. 300mm of fast flowing water can knock over an adult and two feet of water can move a car.

<u>After a flood</u>

- If you have flooded, contact your insurance company as soon as possible;
- Take photographs and videos of your damaged property as a record for your insurance company;
- If you don't have insurance, contact your local authority for information on grants and charities that may help you;
- Flood water can contain sewage, chemicals and animal waste. Always wear waterproof outwear, including gloves, wellington boots and a face mask;
- Have your electrics, central heating and water checked by qualified engineers before switching them back on.

10. Conclusions

The analysis of flooding from fluvial and tidal sources shows that the building is in Flood Zone 2 and hence is at a risk of flooding from events between the 1 in 1000 (0.1%) and 1 in 100 (1%) year events.

Table 2 of this report details that residential developments are classified as More Vulnerable; Table 3 of the report shows that More Vulnerable developments in Flood Zone 2 are acceptable.

The results from the Upper Mersey Study indicate that the long-term flood level in the vicinity of the development site is 34.72mAOD, equating to 1 in 100+30%CC.

It is proposed that the floor level is set as high as possible but no lower than existing as in line with EA guidance. Furthermore, it is recommended flood resistance and resilience measures are incorporated into the development.

The vicinity of the development site is at low risk of surface water flooding.

Surface water disposal will be to the public sewerage system.

Due to the small scale of the development, on-site attenuation is not necessary.

It is recommended that appropriate SuDS measures should be incorporated in the development to minimise surface water discharges.

The proposed development will not increase the risk of flooding elsewhere from surface water sources.

There is no evidence of historic flooding of the development site.

The development is at low risk of groundwater flooding.

The development is not at risk from reservoir flooding.

The proposed development is for a 2-storey dwelling. In the event of flooding, all residents will have access to safe refuge on the first floor of the dwelling.

It is recommended that residents of the property register for the EA Flood Warning Service, which is available within the area and which aims to give a minimum 2 hours advance notification of potential flooding, giving adequate time to implement safety procedures.

In the event of having to evacuate the building, a suitable emergency egress route is available by turning North onto Morningside Drive, at the end of this road turn North West onto Wilmslow Road and travel for approximately 70m to reach Flood Zone 1.

Based on the likely flooding risk, it is considered that the proposed development can be operated safely in flood risk terms, without increasing flood risk elsewhere and is therefore appropriate development in accordance with the NPPF.

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