TECHNICAL NOTE

North Keynsham: A4 to A4175 Link Road Level 1 FRA

Prepared for

Bath and North East Somerset Council

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ch2m.SM

Contents

SECTION 0

Flood Risk Assessment

1.1 Introduction

The National Planning Policy Framework (NPPF) (DCLG 2012) and National Planning Practice Guidance (NPPG) set out the Government's planning policies for England and how these are to be applied. As described in the NPPF, inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk. Where development is necessary, it should be made safe without increasing flood risk elsewhere.

The NPPF uses a risk-based approach to identify suitable locations for development and to aid decisions on development control through a Sequential Test. The flood zones are the starting point for this sequential approach.

Flood zones (described in **Table 1**) provide an indication of the likelihood of flooding from the sea and rivers only. The overall aim should be to steer new development to Flood Zone 1. Where there are no reasonably available sites in Flood Zone 1, local planning authorities allocating land in local plans or determining planning applications for development at any particular location should take into account the flood risk vulnerability of land uses (see **Table 2**) and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should the suitability of sites in Flood Zone 3 be considered, again taking into account the flood risk vulnerability of land uses and applying the Exception Test if required.

As set out in the NPPF, the Exception Test allows the wider sustainability benefits of a development to be considered to justify development in a high risk flood zone, as long as the development is not considered vulnerable to flooding. The Exception Test requires that a proposed development provides 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, reducing flood risk overall.

Table 1: Flood Zones (Source: DCLG 2012)

Flood Zone	Definition	Flood Risk Assessment Requirement
1	This zone comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%).	For development proposals on sites comprising one hectare 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 flood risk assessment. This need only be brief unless the factors above or other local considerations require particular attention.
2	This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.	All development proposals in this zone should be accompanied by a flood risk assessment.
3a	This zone comprises land assessed as having a 1 in 100 or greater annual probability of	All development proposals in this zone should be accompanied by a flood risk assessment.

	river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.	
3b	This zone comprises land where water has to flow or be stored in times of flood.	All development proposals in this zone should be accompanied by a flood risk assessment.

Table 2: Flood Risk Vulnerability (Source: DCLG 2012)

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

Note ✓ Development is appropriate. ✗ Development should not be permitted.

CIRIA C624 provides guidance on the implementation and good practice in assessing flood risks through the development process; the aim of the document is to promote developments that are sustainable with regard to flood risk. The document recommends that a FRA should be undertaken in phases and promotes three levels of assessment:

- Level 1 FRA (Screening study)
- Level 2 (Scoping Study)
- Level 3 (Detailed Study)

This report forms the Level 1 FRA (Screening Study) which provides a general indication of the potential flood risk to the site and identifies whether there are any flooding or surface water management issues that may warrant further consideration or may affect the feasibility of a development. The study has referenced readily available information, including the Level 2 SFRA for Keynsham, the Bath and North East Somerset SWMP, and the Environmental Agency Flood Maps.

The FRA only relates to the options explored in this report for the Avon Mill Lane-A4 Bath Road Link Road in North Keynsham.

1.2 The Avon Mill Lane-A4 Bath Road Link Road

The scope of the WP2 study is to consider potential highway alignments for a new link road connecting the A4 Bath Road with the A4175 Keynsham Road on the north side of Keynsham. Three route entry options were considered: A; B; and C, alongside three route options: 1; 2; and 3. This Level 1 FRA has been completed for all options except route entry option B, which was disregarded because it was considered an impractical engineering solution. If anything changes, this can be revisited.

The West of England Combined Authority (WECA) have produced a Joint Transport Study (JTS) for their administrative area, which includes improving transport links in Keynsham. The JTS objectives have been reviewed and tailored into general and corridor/site specific objectives, as follows (CH2M, 2017):

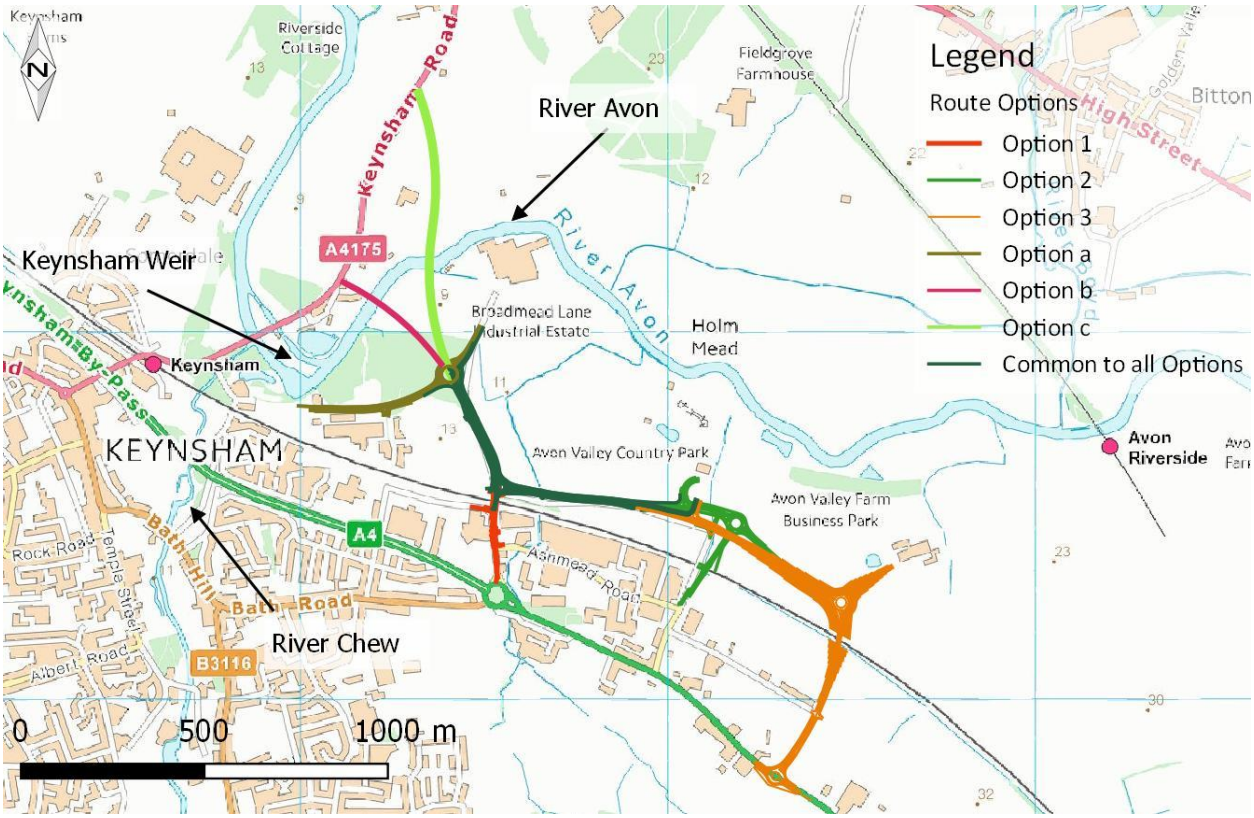
General Objectives

- Improve transport network resilience and journey time reliability.

Specific Objectives

- Provide effective access to the new development area in North Keynsham (a Strategic Development Location);
- Reduce traffic flows and relieve traffic pressures on routes through Keynsham; and
- Deliver improved facilities for pedestrians, cyclists and effective public transport in North Keynsham.

The map shown in the figure below indicates the options, the River Avon, other main rivers in the study area and the location of Keynsham Weir.



Methodology

The methodology adopted in the flood risk assessment comprises:

- A review of associated policy documentation.
- A desk study review of the current site conditions.
- Identification of potential sources of flooding.
- Preliminary calculations to substantiate the current and permitted surface water run-off rates, including an assessment of attenuation volumes necessary to control the rate of run-off as a result development.

- Identification of applicable sustainable urban drainage systems (SUDS).
- Recommendations & conclusions

2.1 Policy Review

2.1.1 National Planning Policy Framework

The National Planning Policy Framework (NPPF) published in March 2012 sets out the Government's planning policies for England and how these are to be applied, with an aim towards sustainable development and flood risk mitigation.

The NPPF uses a risk based approach to identify suitable locations for development and to aid decisions on development control through a sequential test. The NPPF uses three flood zones to assist in applying sequential tests in flood sensitive locations. The flood zones provide an indication of the likelihood of flooding and predicted extent of the natural flood plain and extreme flood events.

The NPPF also categorises the vulnerability of each type of development to define the most suitable uses of land within each flood zone. The review of the flood risk vulnerability classification provided within "Table 2: Flood Risk Vulnerability" of Planning Practice Guidance to NPPF (updated in 2014), indicated the proposed routes would be classified as "Essential Infrastructure" type of development. Referring to the "Table 3: Flood Risk Vulnerability and Flood Zone Compatibility", this type of development is permitted within zones 1 & 2, but requires an Exception Test for the development to occur under Zone 3.

Please refer to Section 1.1 for further detail on Flood Zones, Flood Risk Vulnerability and the Exception Test..

2.1.2 Climate Change

NPPF and supporting planning practice guidance on Flood Risk and Coastal Change explain when and how flood risk assessments should be used. This includes demonstrating how flood risk will be managed now and over the development's lifetime, taking climate change into account. Local planning authorities refer to this when preparing local plans and considering planning applications. The latest guidance on the use of climate change allowances in flood risk assessments and strategic flood risk assessments was updated in 2017 by the Environment Agency.

This advice updates previous climate change allowances to support NPPF. The NPPF states that the effects of climate change need to be considered as part of any new development. In general, climate change is expected to result in an increase in rainfall intensity, higher peak river flows and a rise in net sea levels. Below is the guidance on use of climate change allowances for peak river flows, peak rainfall intensity and sea level rise related to our study area. However, further consultation with the Environment Agency is recommended to determine if High++ allowances for peak river flood flow and mean sea level should be used in subsequent site-specific flood risk assessments.

2.1.2.1 Peak river flows

Table 1 in the EA guidance states that for the Severn river basin, the peak river flow allowances are as follows:

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)**
Upper end	25%	40%	70%

Higher central	15%	25%	35%
Central	10%	20%	25%

For Flood Zone 2, the higher central and upper end categories should be used to assess a range of allowances for essential infrastructure.

For Flood Zones 3a and 3b, the upper end allowance should be used for essential infrastructure.

2.1.2.2 Peak rainfall intensity allowance

Table 2 in the EA guidance states that for small and urban catchments, the peak rainfall intensity allowances are as follows:

Applies across all of England	**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)**
Upper end	10%	20%	40%
Central	5%	10%	20%

2.1.2.3 Sea level allowances

Table 3 of the guidance provides a single regional allowance for each epoch or time frame for sea level rise:

Area of England	1990 to 2025	2026 to 2055	2056 to 2085	2086 to 2115	Cumulative rise 1990 to 2115 / metres (m)
South West	3.5 (122.5 mm)	8 (240 mm)	11.5 (345 mm)	14.5 (435 mm)	1.14 m

2.1.3 Strategic Flood Risk Assessment and Preliminary Flood Risk Assessment

A Level 2 Strategic Flood Risk Assessment (SFRA) was carried out for Bath and North East Somerset Council in May 2009 by Capita Symonds for the town of Keynsham. The SFRA was produced to identify areas at risk from flooding and act as a guidance document to planners and developers. It highlighted areas where site specific FRA's would help inform planning process.

A Preliminary Flood Risk Assessment (PFRA) was prepared by Bath and North East Somerset Council in 2011 and built on the findings from the Level 1 and 2 SFRAs. The PFRA identified areas at risk from historic and future surface water, groundwater and watercourse flooding to prioritise areas for further investigation. The Level 2 SFRA and PFRA have been used as a source of data for this assessment of flood risk.

2.1.4 Surface Water Management Plan

A Surface Water Management Plan (SWMP) was produced in 2015 (JBA) for Bath and North East Somerset Council. The SWMP collated a large amount of data related to flood incident records and modelled flood risk. It highlighted a number of drainage areas where further investigation is required to provide a better understanding of flood risk – Keynsham was not one of these areas. The SWMP also produced a series of Infiltration Potential Maps to identify areas where infiltration should be considered and areas where it shouldn't be considered. The Infiltration Potential Map for Keynsham is shown in the Drainage Strategy section.

2.1.5 Local Flood Risk Management Strategy

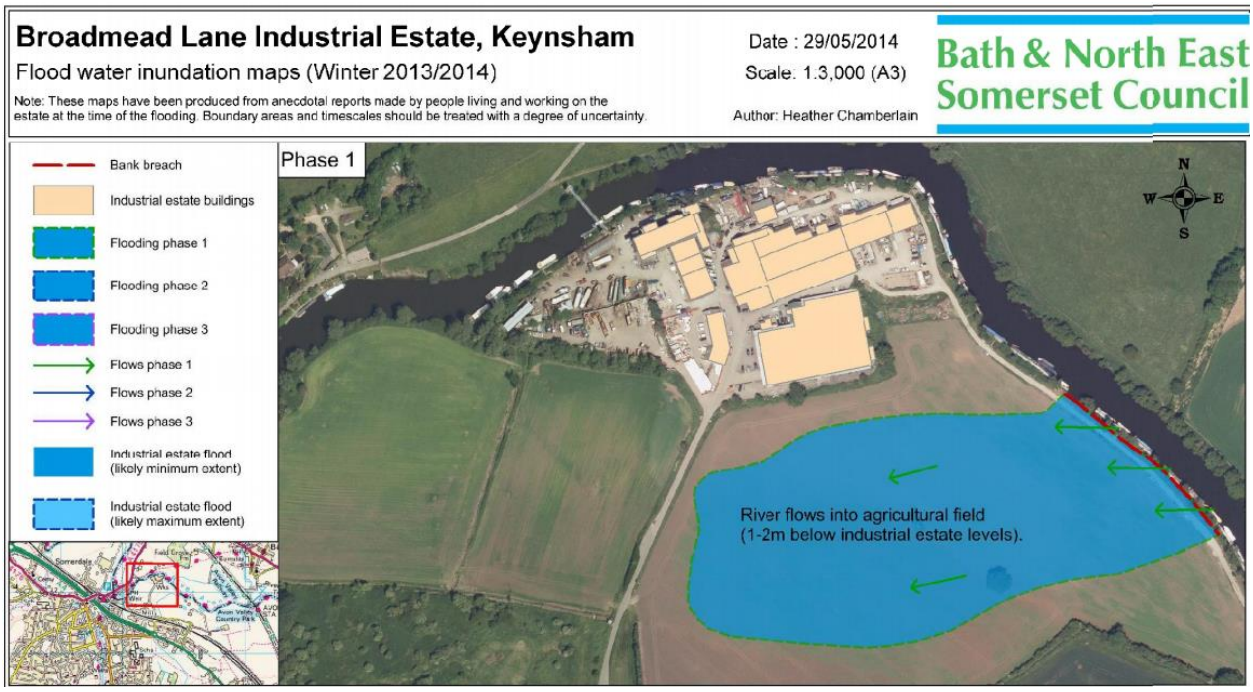
A Local Flood Risk Management Strategy (2015-2025) was developed for Bath and North East Somerset Council in 2015 by CH2M. The SWMP was used to inform this strategy, with recent flood events analysed to help identify "wet-spots" – the areas most at risk of local flooding. In East Keynsham, the A4 was identified as a "wet-spot" given its history of localised flooding from sources such as fluvial interactions, pluvial runoff and highway gully blockage. The LFRMS recommended that future flooding incidents be monitored, and if flooding continues to cause disruptions, the highway drainage may need to be upgraded.

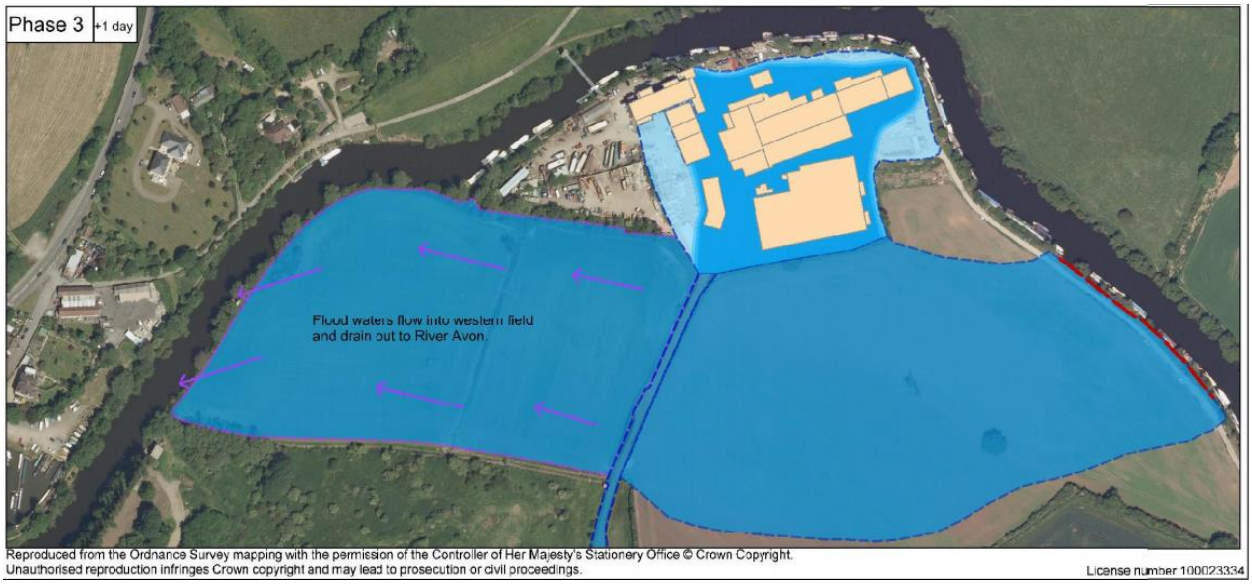
2.2 Assessment of Flood Risk (All Sources)

2.2.1 Historic Flooding Incidents

An interactive map of local flood incidents was published as part of the Bath and North-East Somerset Council Surface Water Management Plan (2015). However, it has not been possible to access the map of local flood incidents for the study area for this FRA.

A Section 19 Flood Investigation Report for flooding to the Broadmead Lane Industrial Estate in winter 2013/14 has also been published. It includes maps showing the extent of flooding, and the likely flood flow route. These are shown below. These indicative maps show that Route Entry Option C would have been affected by the flooding.





2.2.2 Tidal Flood risk

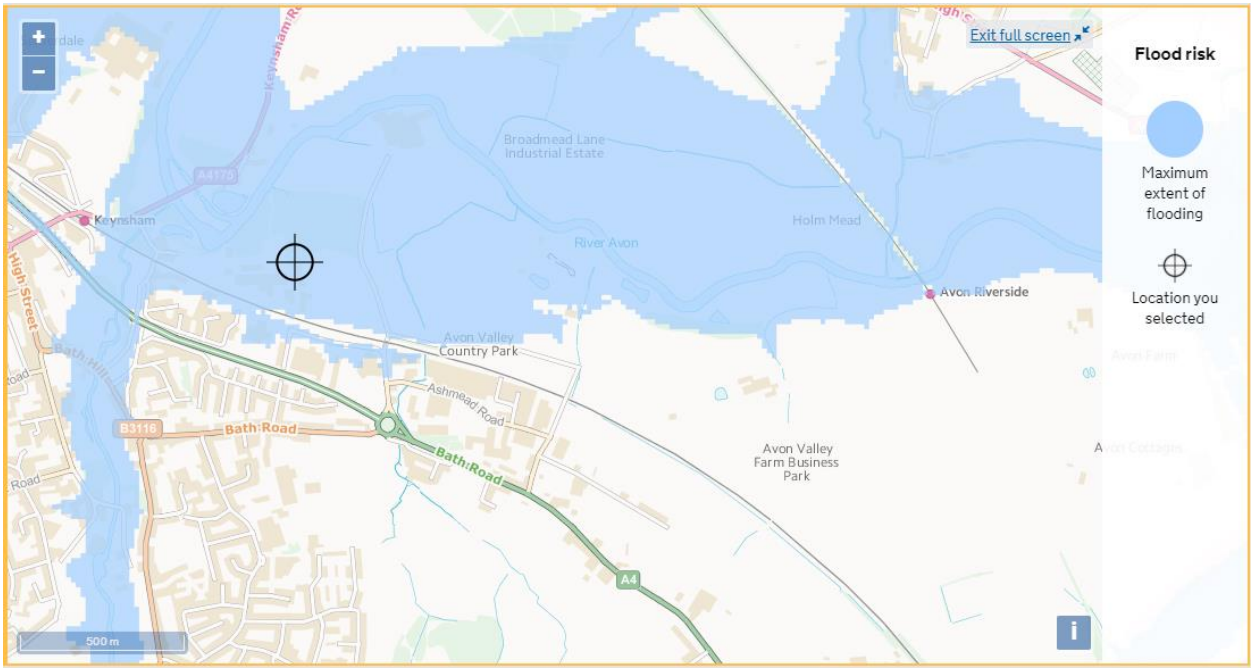
The Level 2 SFRA states that Keynsham Weir is the tidal limit of the River Avon during high spring tides. Although tidal flooding should be considered, it is not expected to present a risk to Keynsham now or in the near future. Fluvial flood risk from the River Avon is more significant in Keynsham. However, although the impact of tidal events on their own is low, a combined tidal-fluvial event may have a more significant impact, particularly in the future due to predicted sea level rise. As such, a joint probability assessment of tidal and river flooding would be required.

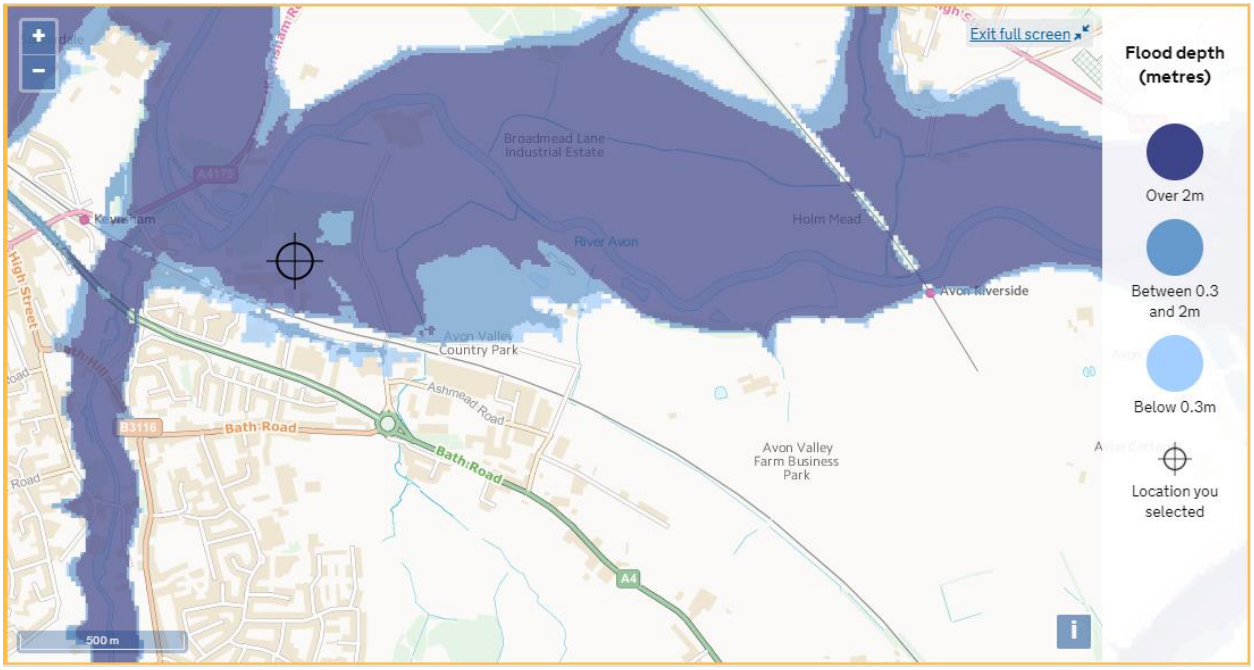
2.2.3 Reservoir Flood Risk

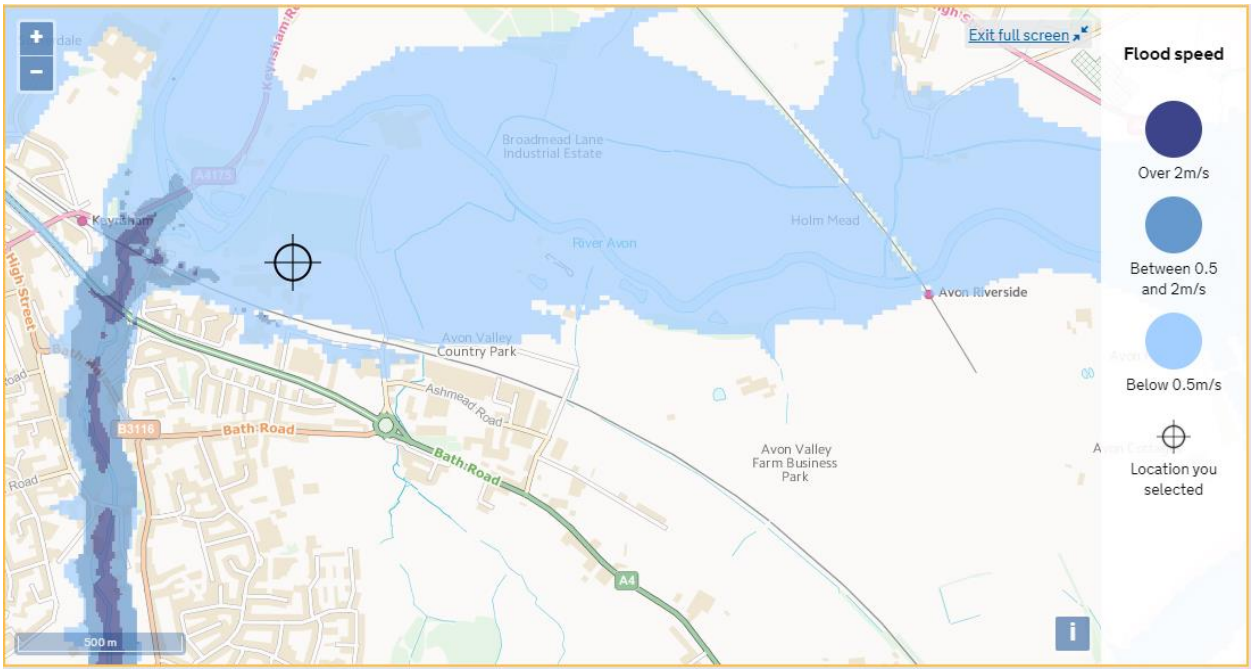
The Level 2 SFRA suggests that there is a significant source of flood risk from the head of the River Chew Catchment in the Chew Valley Lake, and to a less severe scale, from the Chew Magna Reservoir. Although the Chew Magna Reservoir overtopped in 1968, the probability of failure for these reservoirs is low. There is no history of flooding from the Chew Valley Lake, however the consequences of failure would be severe.

The maps below are from the Environment Agency's *website*, showing the extents, depths and speed of flood risk if the reservoirs were to fail. This is largely via the River Chew, which connects Chew Valley Lake with the River Avon, joining the River Avon just downstream of Keynsham Weir.

All Route Entry and Route Options considered by this study would be affected by such a failure, with Route Entry Option A and Route Option 1 being most affected.





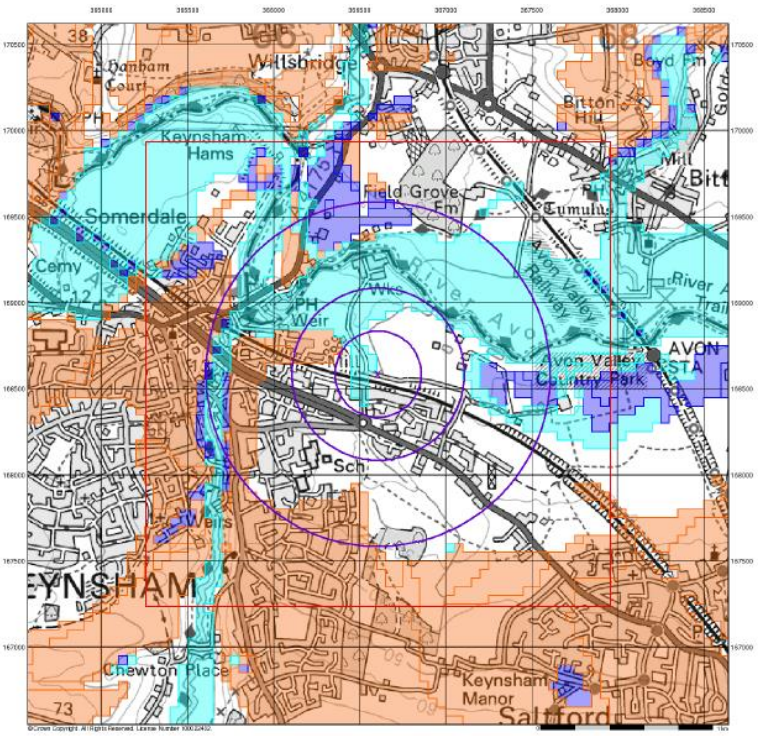


2.2.4 Groundwater Flood Risk

Groundwater flooding occurs when water levels in the ground rise above surface elevations. An assessment of risk from groundwater flooding can be difficult to undertake due to a lack of groundwater record data, variable geological conditions and a lack of predictive groundwater modelling tools.

The Level 2 SFRA described the groundwater flood risk in Keynsham being low. It stated that the Environment Agency did not hold any records of groundwater flooding in Keynsham, and did not consider it a significant issue in the area. The BGS map below, however, which identifies the susceptibility to groundwater flooding, shows groundwater flooding could be an issue in the river's floodplain.

Given that the BGS map shows potential for groundwater flooding, this should be studied further at a later stage.



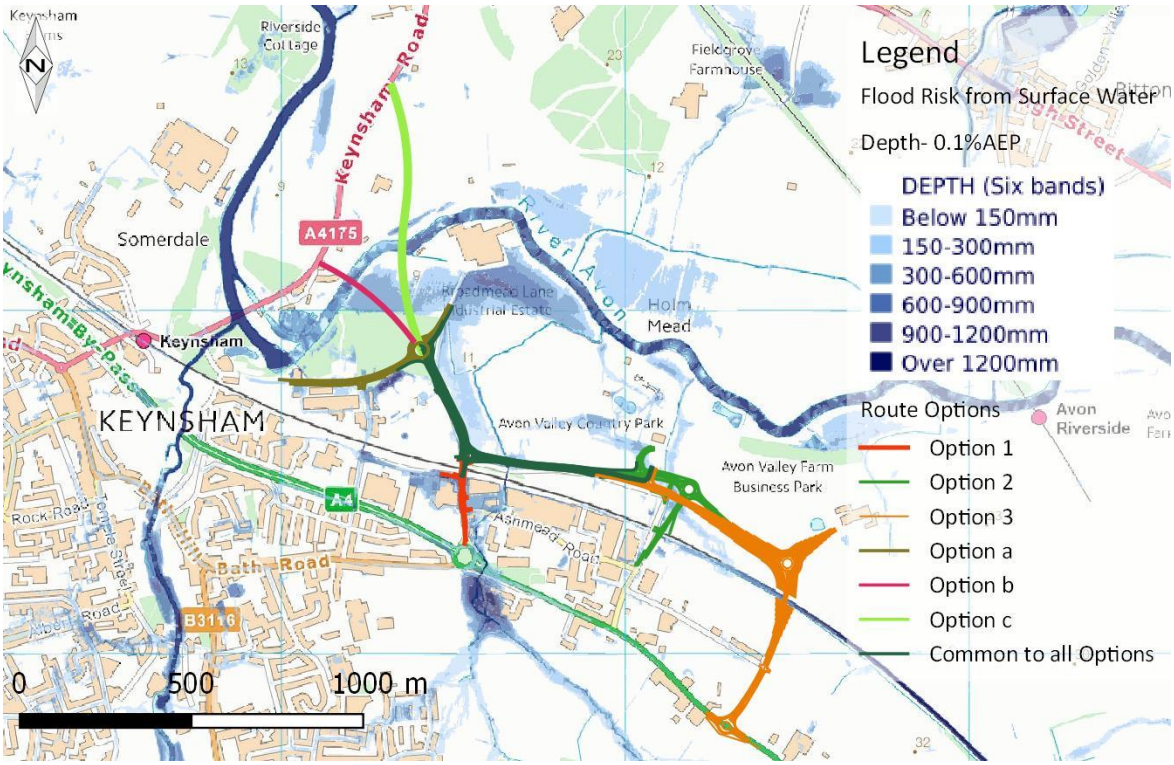
2.2.5 Surface Water Flood Risk

Both risk from surface water to the proposed options and the effect the works would have on surface water need to be understood and addressed.

In terms of surface water flood risk to the road, this is not expected to be a significant constraint on the plans. The map above shows surface water flooding for an extreme event (0.1% AEP). Fluvial flood depths are expected to be higher in most of these areas, and will therefore be the main design constraint requiring the roads to be built at a higher elevation. An exception to this would be option 1, which would be built below ground level.

Surface water flooding will however need be assessed further in a more detailed study. The surface water flood map above shows the results of the Risk of Flooding from Surface Water (RoFSW) mapping for the area, a dataset developed at national level. The level of local detail included in the model is therefore very limited.

Addressing the effects on surface water flood risk elsewhere will require limiting the runoff rates and allowing surface water to flow across the future road where it currently does. The section on drainage strategy below has more detail on limiting runoff.



The situation for each of the options is described in more detail below:

Option A: The route passes through a zone of surface water flood risk north of the recycling center; the drainage strategy should ensure all surface water flooding is attenuated or conveyed away from the road.

Option C:. The route passes through a zone of surface water flood risk south of the river crossing. Culverts or ditches will be required to prevent ponding of surface flood water.

Option 1: A key concern is the lowering of the road under the railway. This would form a low spot of the road that is potentially lower than the watercourse that any drainage would discharge into. Pumping is likely to be required to manage surface water flows.

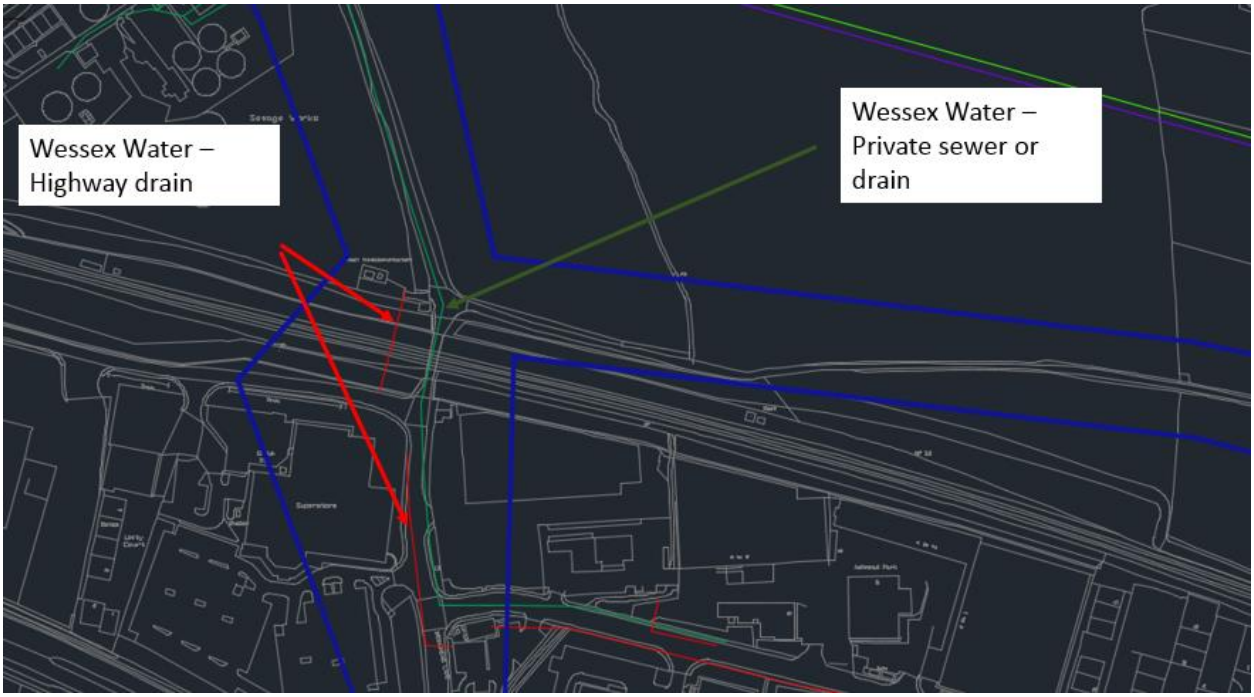
Option 2: The route passes through a zone of surface water flood risk near the entrance to the Avon Valley Country Park, but is raised in this section. Culverts or ditches will be required to prevent ponding of surface flood water.

Option 3: The route passes through a zone of surface water flood risk near the entrance to the Avon Valley Country Park, but is raised in this section. Culverts or ditches will be required to prevent ponding of surface flood water.

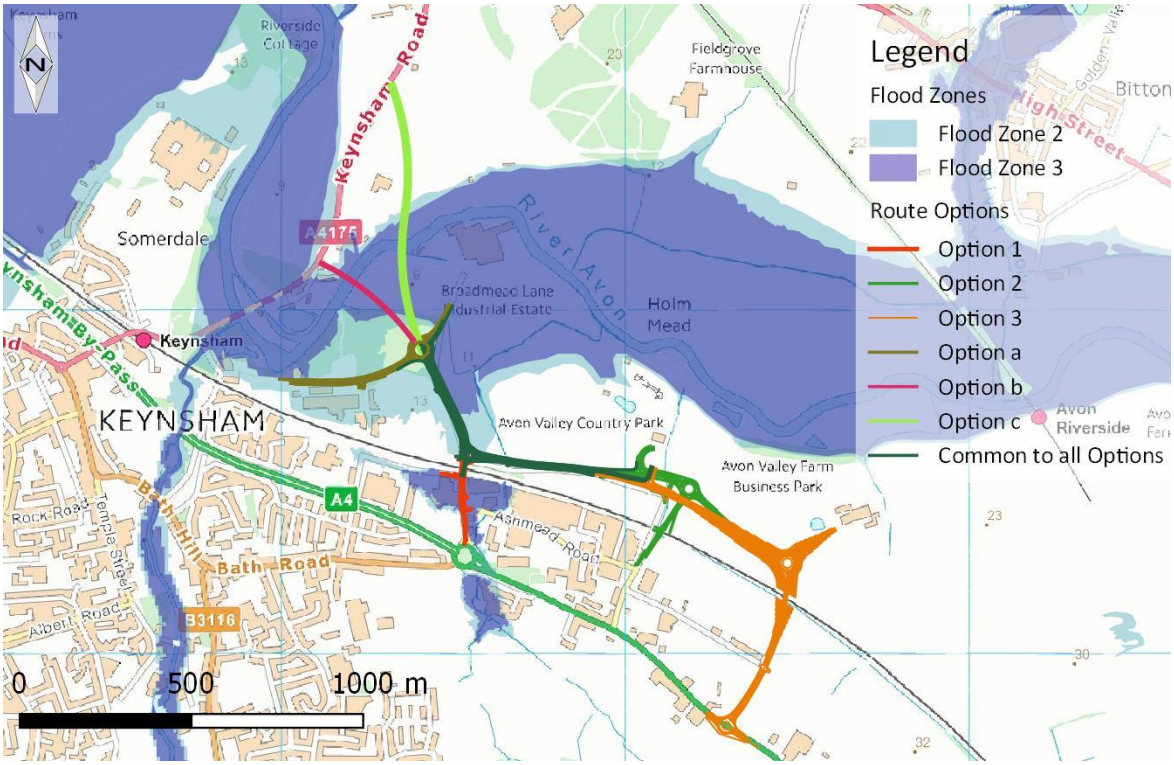
2.2.6 Risk of flooding from sewers

The Level 2 SFRA for Keynsham identified that there were a higher than average number of recorded incidents of sewer flooding in Keynsham, but these were largely in the town centre, along the River Chew. This does not affect any of our options. The SWMP Interactive Map of Local Flood Incidents provided locations of 44 incidents of sewer flooding in the period 2014-2015 in Bath and North East Somerset. However, plans received from Wessex Water show many sewers near the proposed Route Entry and Route Options. This is less of a concern for Route Options 2 and 3 and Route Entry Option C as they will largely be raised on embankments, and more of a concern for Route Entry Option A and Route Option 1 as these will be at existing ground level and potentially vulnerable to sewer flooding.

Route Option 1 is most at risk from sewer flooding given there is a private sewer along the road under the railway bridge, as well as highway drains in close proximity to this underpass (see below). As Route Option 1 involves lowering the road, this would lead to increased depths of flooding in a sewer-flooding event.



2.2.7 Fluvial flood risk



As discussed in section 1.3, significant sections of the route options are located within Flood Zones 2 and 3. The construction may therefore compromise natural flood storage, and impact flows on this section of the river and flood plain. The road itself will also be subject to flooding from the river.

The degree to which the alignment occupies the flood plain depends on the options analysed. Out of the Route Entry Options, where most of the interaction with the river and flood plain would be, Option C has the largest impact, as it proposes a new link across Flood Zone 3, including a new river crossing. Option A on the other hand would be built mostly over existing roads and occupy flood zone 2 areas instead of Flood Zone 3. Of the Route Options, only Option 1 would present interactions with the Flood Zones 2 and 3. Flood risk to this option would be significant as the road's level would be below that of the watercourse beside it to allow it to cross under the railway.

The situation for each of the options is described in more detail below:

Option A: This option passes through Flood Zone 2, with very limited encroachment into Flood Zone 3 towards the western end. Some compensatory storage will be required.

Option C: This option has the greatest impact on fluvial flows – it passes through an area that has experienced recent fluvial flooding. It involves crossing Flood Zone 3 and the river Avon raised above the flood level (assumed to be raised to 14m for this study). Compensatory storage will be required, though this can be reduced if the road is raised on piers rather than an embankment. Detailed modelling will be required to assess the impact of the road (and the river crossing) on fluvial flood flows. If an embankment is proposed, culverts would be required to convey flows under the road. Sizing of these culverts should be informed by fluvial modelling.

Option 1 North of the railway, this option passes through Flood Zone 2, with some encroachment into Flood Zone 3. Some compensatory storage will be required, as well as culverts under any potential embankments to allow flows to pass through.

As the route passes under the railway, it will require widening and lowering of the road, which is already in Flood Zone 3. Measures will be essential to ensure fluvial flood water does not flood the tunnel for events of up to 1% AEP. The source of this flooding is from the south of the railway. Compensatory storage on this side of the railway will also be required to account for the loss of flood plain storage between the railway and the A4.

Option 2 Refer to Option 1 (north of railway) for section of route that is in common. From the roundabout to Bath Road, the route is outside of Fluvial Flood Zones 2 and 3.

Option 3 Refer to Option 1 (north of railway) for section of route that is in common. From the roundabout to Bath Road, the route is outside of Fluvial Flood Zones 2 and 3.

Regardless of the options selected, a detailed study of the impacts will be necessary to understand both flood risk to the road itself and the changes in flood risk building this road could produce in other areas. The conclusions of the detailed study will recommend compensating for the loss of flood plain storage, and maintaining the flows through the provision of flood relief culverts and clear-span bridges where the road crosses the river.

2.3 Guidance received from the Environment Agency

During the production of this Level 1 FRA, two sets of guidance were received from the Environment Agency as summarised below.

2.3.1 Site-specific guidance

On the 9th February 2018, a Preliminary Opinion was received from the EA on a transport scheme in the general study area. The key points from this were:

A Flood Risk Assessment would be needed to support any future planning application. This should consider the following specific points:

- *Flood risk from all sources*
- *Flood modelling to demonstrate no increase in flood risk elsewhere*
- *Essential infrastructure should remain operational during times of flood*
- *Floodplain compensation (this is an important floodplain)*
- *Any bridges would need to be above the 1%AEP flood level plus climate change. (need to look at a range of allowances).*

It also stated that under the Environmental Permitting (England and Wales) Regulations 2010, permission from the Environment Agency may be required should any site/site infrastructure works take place in, under, over or within 8 metres of the bank top of the River Avon and Broadmead Brook, designated main rivers.

2.3.2 EA comments on Joint Spatial Plan

Below are Environment Agency's key comments on the WECA Joint Spatial Plan related to flood risk management in North Keynsham:

- *The Agency would advise that any development will be required to avoid the Keynsham Hams and Broadmead floodplains. Any development within other designated fluvial floodplain will be required to provide floodplain compensation. Any new bridges should be clear span in construction with soffit levels set above the 1 in 100yr climate change flood level*
- *Any new roads or associated transport improvements would be required to avoid fluvial floodplain and ensure floodplain connectivity*

This indicates that as Route Entry Option C crosses the Broadmead floodplain, it may not be permitted by the Environment Agency. Further engagement with the Environment Agency's Planning team will be required if this option is to be considered further.

2.4 Flood Risk Summary

The main flood risks to the routes considered are fluvial and surface water. Route Entry Option C involves a new crossing over the River Avon, with a significant proportion of the alignment through Flood Zones 2 and 3. The Route Options 1, 2 and 3 fall largely outside of Flood Zones 2 and 3, though surface water flooding becomes a more significant issue. In particular, Route 1 requires the widening and lowering of the road as it passes under the railway lines, which could increase the risk and depths of surface water flooding under the railway. This is exacerbated by the fact that the road would be lowered below the level of the main river that passes to the east of the alignment.

From the information discussed, it has been concluded that the scheme will have an impact on the existing risk of flooding. As such, flooding issues shall be further investigated. Since this section of the feasibility study acts as a level one flood risk assessment, it can be concluded that a level two flood risk assessment is required, in accordance with CIRIA Report 624: Development and Flood Risk – Guidance for the Construction Industry.

Compensatory Flood Storage Areas

Based on high-level calculations, the compensatory flood storage area that would be required for each option has been estimated:

Option	Volume of compensatory flood storage required	Other comments
A	No compensatory storage volumes identified at this stage.	This will need to be reviewed with more detailed data at later stages.
C	North of Avon: 1500m^3 South of Avon: 21000m^3	
1	North of Railway: 1750m^3 South of Railway: 350m^3	Pumping station would be required to mitigate, surface water and groundwater flooding.
2	1750m^3	Compensatory storage for section in common with opt. 1
3	1750m^3	Compensatory storage for section in common with opt. 1

Conceptual Drainage Strategy

4.1 Introduction

A comparison of pre- and post-development surface water runoff rates associated with the rural and urban elements of the site has been undertaken. This has allowed an estimate of attenuation volumes to be calculated for each option, so that the rate of surface water discharge from the site does not exceed the existing greenfield run-off, whilst giving due consideration to climate change.

4.2 Existing surface water runoff rates and volumes

The existing catchments predominantly comprise open farmland. The design of the surface water drainage system in these areas is thus required to give due consideration to the NPPF and criteria contained within the SUDS Manual which state that the post-development flow, including an allowance for climate change, is to be no greater than the existing greenfield discharge rate for all storms.

The SUDS Manual recommends the use of the IH Report 124 to derive peak flows and volumes for greenfield sites of less than 200ha and the Flood Estimation Handbook (FEH) for areas larger than 200ha. Since all of the catchments are less than 200ha in area, the IH Report 124 method has been used for greenfield calculations.

The required greenfield runoff rates and attenuation volumes were calculated using MicroDrainage 17.1.2 software. In terms of the parameters used, the catchment descriptors from the Wallingford Maps (HR Wallingford, 1981) provide a SAAR of 771mm and SOIL of 0.47. A climate change allowance of 40% has been adopted based on the guidance specified in Section 2.1.2.2.

Based on the methodology described above, the following greenfield runoff rates were calculated.

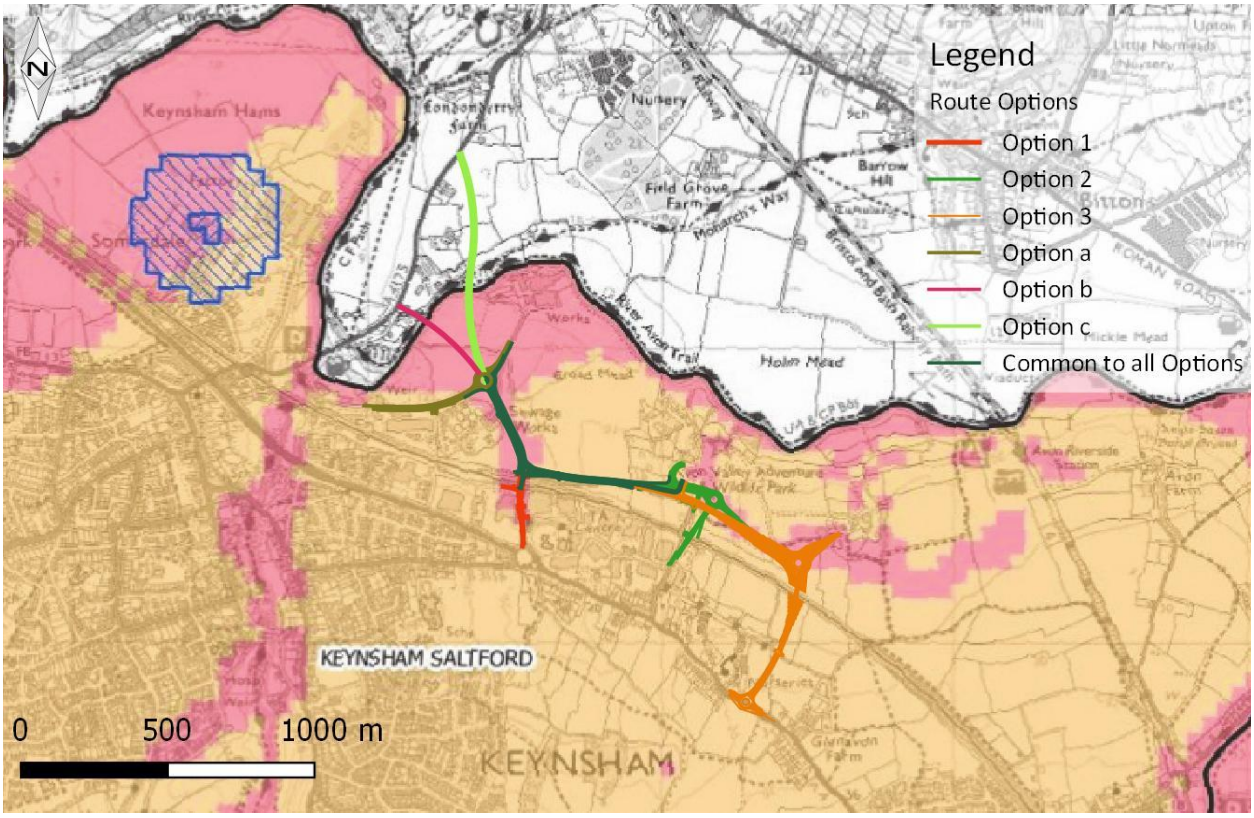
Return Period (years)	Greenfield Site Runoff for all catchments (l/s/ha)
QBAR	5.4
1:1	4.2
1:30	10.3
1:100	13.1

4.3 Proposed drainage strategy

Attenuation volumes will be required to limit flow to the greenfield runoff rates mentioned above. The following volumes were estimated for the options being considered. Only the sections of new carriageway to be built on greenfield sites have been considered for volume attenuation (a part of the new routes will be built over existing highways).

Option	Area (ha)	Greenfield Runoff (l/s) 100yr Event	Proposed Attenuation (m^3) 100yr Event + 40% CC	Other comments
A	0.74	9.7	520	
C - North of river	0.72	9.4	500	These sections are on Flood Zone 3, storage will need to be found in a different location.
C - South of river	0.5	6.6	350	
1	0.26	3.4	180	Pumping station would be required to mitigate fluvial, surface water and groundwater flooding.
2	1.3	17.0	910	
3	2.15	28.2	1500	

A sustainable surface water drainage strategy should be promoted where viable, giving due consideration to the nature of the development site, extent of flood plain and proposed highway vertical alignment. The map below shows the suitability of the area to infiltration SuDS. It is likely that infiltration drainage will not be a viable solution for Route Entry Option C and Route Option 1 as they are located in areas with very significant constraints on infiltration SuDS. In these cases, the volumes shown above would have to be stored in tanks or chambers before discharging at greenfield rates directly to watercourses.



Drainage Summary

- Highly compatible for infiltration SuDS
- Probably compatible for infiltration SuDS
- Very significant constraints are indicated

Groundwater Source Protection Zones

- SPZ I
- SPZ II, III or IV

Infiltration potential maps have been based on the British Geological Survey Infiltration SuDS Map data with the permission of the British Geological Survey

Conclusions

The table below includes the flood risk issues and measures required for each of the options.

Option	High-level flood risk summary	Floodplain compensation required?	Drainage attenuation required 100yr Event + 40% CC
A	**Fluvial**: This option passes through Flood Zone 2, with very limited encroachment into Flood Zone 3 towards the western end. Some compensatory storage will be required. **Surface water**: Attenuation volumes have been calculated based on new impermeable areas only. The route passes through a zone of surface water flood risk north of the recycling center; the drainage strategy should ensure all surface water flooding is attenuated or conveyed away from the road.	No compensatory storage volumes identified at this stage.	520 m^3

C	**Fluvial**: This option has the greatest impact on fluvial flows – it passes through an area that has experienced recent fluvial flooding. It involves crossing Flood Zone 3 and the river Avon raised above the flood level (assumed to be raised to 14m for this study). Compensatory storage will be required, though this can be reduced if the road is raised on piers rather than an embankment. Detailed modelling will be required to assess the impact of the road (and the river crossing) on fluvial flood flows. If an embankment is proposed, culverts would be required to convey flows under the road. Sizing of these culverts should be informed by fluvial modelling. **Surface water**: Attenuation volumes have been calculated based on new impermeable areas only, with separate volumes provided for north and south of the river. The route passes through a zone of surface water flood risk south of the river crossing. Culverts or ditches will be required to prevent ponding of surface flood water.	North of Avon: 1500m^3 South of Avon: 21000m^3	North of Avon: 500m^3 South of Avon: 350m^3
1	**Fluvial**: North of the railway, this option passes through Flood Zone 2, with some encroachment into Flood Zone 3. Some compensatory storage will be required, as well as culverts under any potential embankments to allow flows to pass through. As the route passes under the railway, it will require widening and lowering of the road, which is already in Flood Zone 3. Measures will be essential to ensure fluvial flood water does not flood the tunnel for events of up to 1% AEP. The source of this flooding is from the south of the railway. Compensatory storage on this side of the railway will also be required to account for the loss of flood plain storage between the railway and the A4. **Surface water**: Attenuation volumes have been calculated based on new impermeable areas only. A key concern is the lowering of the road under the railway. This would form a low spot of the road that is potentially lower than the watercourse that any drainage would discharge into. Pumping is likely to be required to manage surface water flows. **Groundwater:** The route falls in an area with potential for groundwater flooding at surface. Lowering the road under the railway increase this potential.	North of Railway: 1750m^3 South of Railway: 350m^3	180 m^3

2	**Fluvial:** Refer to Option 1 (north of railway) for section of route that is in common. From the roundabout to Bath Road, the route is outside of Fluvial Flood Zones 2 and 3. **Surface Water:** Attenuation volumes have been calculated based on new impermeable areas only. The route passes through a zone of surface water flood risk near the entrance to the Avon Valley Country Park, but is raised in this section. Culverts or ditches will be required to prevent ponding of surface flood water.	1750m^3	910 m^3
3	**Fluvial:** Refer to Option 1 (north of railway) for section of route that is in common. From the roundabout to Bath Road, the route is outside of Fluvial Flood Zones 2 and 3. **Surface water:** Attenuation volumes have been calculated based on new impermeable areas only. This option requires the greatest volume of attenuation. The route passes through a zone of surface water flood risk near the entrance to the Avon Valley Country Park, but is raised in this section. Culverts or ditches will be required to prevent ponding of surface flood water.	1750m^3	1500 m^3

Recommendations

Given the impact on the existing risk of flooding the proposed work will have, a level two flood risk assessment is required, in accordance with CIRIA Report 624: Development and Flood Risk – Guidance for the Construction Industry. It is recommended that the Environment Agency's Sustainable Places team are consulted with at the next stage, to address any concerns there may be with building new transport infrastructure through Flood Zone 3 in North Keynsham. This is particularly important given their comments on the Joint Spatial Plan.