Haigh Huddleston & Associates
Civil Structural Engineering Consultants

Firth Buildings, 99-101 Leeds Road, Dewsbury, WF12 7BU t 01924 464342 f 01924 450662
e trevor.haigh@haighhuddleston.co.uk

FLOOD RISK ASSESSMENT

ON

FORMER LIDL STORE
STATION ROAD,
MIRFIELD
WEST YORKSHIRE

FOR

DARREN SMITH HOMES LTD

E17/6788/FR01

JULY 2017

T. Haigh. B.Sc., C.Eng., M.I.C.E.

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1.0 INTRODUCTION

1.1 This report is commissioned to investigate and report on the Flood Risk for this site in accordance with National Planning Policy Framework (2012), and the Flood Risk and Coastal Change PPG issued in March 2014. The proposals are for a residential development on the site which is currently developed as a retail store with associated car parking. The report is based on information supplied by the client and from relevant authorities in both written and verbal format. Some of this information is in verbal form only. No liability can be accepted for information supplied by third parties which is subsequently found to be inaccurate or incorrect.

2.0 THE SITE

2.1 The site is located immediately to the south of Mirfield town centre, and approx. 3miles west of Dewsbury town centre. It is situated around Ordnance Survey grid reference approx. SE 20132 19565. A site location plan is included in Appendix A. The northern boundary of the site abuts the public car park for the town centre, whilst the southern boundary abuts the Mirfield canal which is part of the Hebble and Calder Navigational Canal network. There is existing residential adjacent to the eastern boundary and to the west of the site is a mixture of residential and commercial buildings including former mills.

2.2 The site is roughly rectangular in shape and is currently developed for retail use with a surrounding car park area. The River Calder runs some 300m to the south of the site. The main Leeds to Manchester railway line runs between the site and the river on a raised embankment. There is vehicular underpass on Station Lane that the railway runs over Station Lane. The overall site area to be developed is approximately 0.67ha.

2.3 The site consists of a single storey steel portal framed building with a floor level of 46.25m AOD. The surrounding car park has levels varying from 47 in the north east corner down to 45.0 in the south west corner of the site. The canal footpath adjacent to the site is set around 43.75m AOD and is accessed by a pedestrian ramp down from the site or down a steep banking which has been partially landscaped.

2.4 To the north is a community car park area separated from the development site by a brick and stone retaining wall. The levels of the car park are between 50.3 and 50.7m AOD. There is a small rectangular area that forms a pedestrian access from the site up to the communal car park. Access for vehicles to the site is taken from Station Road which has a level at the entrance of 57m AOD. The levels rise from the site entrance to the town centre in the north. The levels to the south also rise slightly over the bridge over the canal, before dropping down to the underpass beneath the railway line and Mirfield station.

3.0 PREVIOUS FLOODING AND CONSTRINTS

3.1 The last major flooding incident in Mirfield was in December 2015 when large areas of West Yorkshire was inundated with flood waters. According to Environment Agency data the flood waters at Ledgard Bridge Gauging Site approx. 600m upstream of the site reached a level of 45.08m AOD. This is almost identical to the modelled flood water levels for the 1 in 100 year probability event for the River Calder

3.2 Previous flooding in 2007 allowed waters to overtop the upstream lock gates and whilst large areas of Mirfield where flooded the canal did not overtop its banks and any flood waters were due to the river overtopping is northern bank and flowing overland to the north i.e from the south of the site. The route to the site is partially blocked by the railway embankment to the south but the vehicular underpass affords a route for flood waters to pass through.

3.3 The British Hydrological Society Chronology, the EA, Kirklees council and the Canal and River Trust have no records of this site flooding in recent years. They do have records of flooding in Station Road but this lies well below the site levels.

3.4 The water levels in the canal (Mirfield Cut) are controlled by Ledgard Flood Lock to the west and Shepley Bridge Lock to the east. The canal and River Trust report that these lock gates are closed whenever the river is rising rapidly. This prevents high flows from passing through the canal system and protects the adjacent land. Flooding from this source would not be expected

up to the 1 in 100 year flood event. There are no records of flooding affecting this site from the canal.

3.5 During January 2008 a similar flood event occurred; the River Calder again burst its banks, causing closure of the Huddersfield to Leeds railway line due to flooding of the car park at Mirfield station and in close proximity to the site further to the east. The river also flooded the area to the south of the River, up stream of Ledgard Bridge, where new housing developments where under construction. Homes and businesses on the south side of the river and between the river and the main railway line were severely affected. Among these were residents of Steanard Lane and Lowlands Road, who experienced flooding up to a depth of two feet. Additionally, commercial property located within Lowlands Road was evacuated as the flood waters rose. The flood waters left the river channel to the east of Ledgate Bridge and after flooding the allotment areas on its northern bank, flooded the area around Mirfield station to a depth of 1.2m making Station Road impassable.

3.6 The flood water levels at the Flood Lock gates at Newgate Bridge where around 600mm above the top of the weirs. This would be close to 45.35m level and water was passing over the lock gates and around the towpath to the side of the lock. The water flowed in to the canal basin but the water levels in the canal were not affected. A slight rise of approx. 150mm, in water levels was all that was noticed in the canal. The flood water from the south did not reach the canal despite widespread flooding to the south and further east in the valley.

3.7 The modelled flood water levels obtained from the EA show that closest to the site, at CAHN061496u the 1 in 100 year flood event level are 44.23m for the 100 year event, rising to 44.4m when climate change is taken into account; and 46.55m AOD for the 1 in 1000 year event. Similar figures appear at the upstream node of the canal CAHN06_1419 with levels of 43.73, 43.92 and 46.49 respectively. The large jump in flood levels is due to the backwater effects of the River Calder for such an extreme event and floodwaters backing up along the canal from the eastern Shepley Bridge.

3.8 By assessing these modelled levels and combined with the visual footage available, it shows that for events close to the 100 year flood event, the site remained completely dry and did not flood even during extreme events.

3.9 There is a combined sewer running through the site which had previously been diverted to accommodate the Lidl Store but will require further diversions to accommodate the proposed development. The existing site all drains to this sewer and it is proposed to use the same outfall for the redeveloped site. A 3m easement will be required to this sewer through the development.

3.10 The British Geological map has been consulted and we would report as follows:-
The site is underlain by Upper Carboniferous Lower Coal Measures with layers of Mudstone and Sandstone with overlying superficial deposits of Alluvium consisting of soft Clay and occasional isolated Sand and Gravel deposits at depth. Made ground deposits are also indicated to underlie the site. Whilst the Site Investigation shows there is a layer of sand beneath the upper clays and fills, the upper clays layer is up to 2-4m thick. Normally sands and gravels create the possibility of the use of infiltration methods, but the depth of these deposits has overridden the possible use of infiltration systems on this site.

4.0 **FLOOD RISK**

4.1 On reviewing the Environmental Agency websites flood risk maps, the site currently falls within flood zones 1, 2, and 3. Zone 3 being at the western end of the site and zone 1 being at the eastern end of the site. The extent of flood zone 3 in very limited whilst flood zone 2 extends over 60% of the remainder of the site. The site is not considered to form part of the designated flood plains and is therefore designated as Flood Zone 3a at the western end. Part of the site may be considered to be at risk from fluvial flooding from rivers or sea for the 1 in 100 year event and most of the remaining site for the 1 in 1000 year flood event. These are not confirmed by the modelling and recent flood events and the normal variances between modelled and observed data is noted. The proposed use of the site would be classified as More Vulnerable in Table 2 of the National Planning Policy Framework March 2012. In accordance with NPPG the majority of the proposed development would be considered to be

appropriate for that portion of the site. The only problem may arise when considering the portion that falls within flood zone 3e major portion of the site. This report will outline how this will be overcome with the proposed development.

4.2 The site does not benefit from maintained flood defences to the River Calder but the railway embankment does afford a measure of protection from the possible speed of flooding of the area.

4.3 As recently as 2015 flood events have occurred in Mirfield. In December 2015 during widespread flooding in West Yorkshire large areas of Mirfield were under water. The EA recorded the peak water level at Ledgard Bridge some 200m to the west of the site as 45.08m AOD which is close to the modelled flood level for the 1 in 100 year flood event for this location. During that event the flood waters in the canal did not encroach onto the canal. Whilst some flooding occurred to the underpass in Station Road, to the south east of the site, this did not encroach into the canal or onto the site. Aerial photographs and video footage taken at the time show that the extent of the flooding closely followed the EA Flood maps of this area.

4.3 The site does not fall within an area subject to surface water flooding according to the latest long term Flood Risk Information Maps

4.3 The site does appear to fall within an area subject to flooding from reservoirs according to the EA maps. Given the high level of regulation and regular inspection we consider the risk of such a source of flooding would be low. The site does fall within a flood warning zone and a suitable Flood evacuation plan should be provided to the residents for events in excess of the 1 in 100 year event.

5.0 DISCUSSION OF FLOOD RISKS

5.1 Flood Risk from Watercourses, River & Tidal

5.1.1 The majority of the development area does fall within the 0.1% probability Flood Risk Maps (Zone 2) as published by the Environment Agency. This part of the site is therefore considered to be at low risk from fluvial flooding for the once in 1000 year flood even and the development is considered appropriate. The modelled in 100 year flood levels with allowances for climatic change for this area are well below the occupied floor levels because there is car parking only at ground floor level. There will always be access from the buildings because the ground floor levels are set at 46.15m AOD or above, cf with 1 in 100 year flood level of 44.61m AOD, or the 1 in 1000year flood level of 46.18m. Whilst there is some allowance for flood water modelling, usually 200 to 400mm, the estimated flood water levels would not affect the residential areas of the development.

5.1.2 The south western most building would fall within the EA flood Zone 3. The levels around the building would almost match the existing site levels and vary from 45.0 to 46m AOD. Outside of the building foot print, there would be no change in flood risk. These are above the modelled 1 in 100 year flood events including for climate change.

5.1.3 The blocks are all designed so that the residential elements are all at first floor level i.e. floor levels around 49m AOD or above. The access into these buildings are all at a level of 46.15 or above and therefore not affected by flood events up to the 1 in 100 year event.

5.1.4 There is portion of the site which is shown as zone 3 but the existing site levels externally would remain unchanged from existing levels. Internally the ground floor level could be slightly lower than the 1 in 100 year flood levels to compensate for any flood water dispersion cause by the redevelopment. This would be a nominal 2-300mm to provide a similar volume of flood water displacement based on the current levels of the site. In times of flood risk it would be advisable to ensure the car park area is clear of vehicles.

5.2 **Risk of Flooding from overland flows or from existing drainage systems.**

5.2.1 The site has a combined and foul water outfall from the development that connects into the existing main sewers passing through the site. During times of flood these would still be viable outfall points for the site but lower sections may become surcharged due to the flood waters.

5.2.2 The site lies lower that the adjacent community car park to the north but elsewhere the topography is such that flood waters would not be channelled into the site. During extreme storms, rainwater may leave the systems and flow towards the site from this area. It would therefore be prudent to ensure there is a flood water route through the site from north to south and from east to west, to ensure there is no flooding from these events. The sewerage systems up stream of the site are generally designed to cater for a 1 in 30 year event so this scenario would only appear during severe storms in excess of this criteria, or from blocked sewers.

5.2.3 The EA Flood risk maps show the site not to be affected by surface water run off even for the low risk events may gather in the courtyards during the flood event, but the relative times of concentration of the storms means that these would have left the site prior to the peak flood water levels in the River Calder arriving at the site.

5.3 **Risk of Flooding from Rainwater Falling on Site**

5.3.1 The normal hierarchy for surface water discharge is primarily the use of infiltration systems, in accordance with current policies of the EA and Kirklees MDC. There has been a site investigation for this site but the report information would suggest that due to the depth of overlying clays, infiltration systems would not be suitable for the site. The possibility that a suitable geological formation to allow soakaways for the site may exist is considered to be low. For the purposes of this report we have considered the site not to be suitable for infiltration systems.

5.3.2 If infiltration systems are not feasible, then storm water attenuation systems should be utilised to ensure the flows from the site to a suitable watercourse, or surface water sewer, are reduced to agreed discharge rates. These rates are normally at 70% of existing runoff from the site. The attenuation of flows means that storage facilities are required. Whilst there has been a slight reduction in run off from the site this does not achieve the required reduction in run off. The storage facilities can take the form of open swales, ponds, or detention basins but these do tend to take a substantial area of developable land. The systems would therefore have to utilise underground tanks and over-sized pipes to provide adequate storm-water before discharge at agreed rates to a suitable outfall.

5.3.3 These systems would all have to limit flows down to an acceptable level. At present there is a substantial impermeable surface on the site. The provision of open space on sites would have probably allow the use of open swales and ponds for such a purpose, subject to suitable adoption arrangements but in this instance there is insufficient space to achieve this. A storage facility would have to be provided in the form of a concrete tank, rain crates or a series of oversized pipes. These may not provide a suitable level of treatment of the run off from the site and biological systems at source may be needed to ensure suitable discharge contaminants are dealt with. Primary treatment for the roads would be the use of trapped gullies for all hard standings and filter drains to the sided of car park areas to allow the run off a level of primary biological treatment.

5.3.4 The size of the storm water storage facilities would need to be determined accurately in the final detailed designs. And copies of these preliminary estimates are discussed later. These should be all in accordance with the NPPG guidance issued in March 2014. The volumes of storage can include flooding to roads and designated areas such as carpark areas or public open space, but must ensure that no buildings are flooded.

5.3.5 The proposed discharge point and discharge rates from the site needs to be formally agreed with Yorkshire Water and the Local Land Drainage Authority, prior to detail design being undertaken.

5.3.6 The risk of flooding from water falling on site and not being able to leave the site is relatively low. The existing site area is around 6710 sq.m. with an impermeable area of the site is around 4625 sq.m. whilst the proposed impermeable area after development is 4455 sq. m. Whilst the change is relatively small and flows from the site would be reduced current policy is to reduce run off to 70% of existing during the redevelopment of the site. The reduction in impermeable areas does not quite achieve this reduction in run off volumes.

5.3.2 The existing run offs from the site for the annual storm would be 65.6 lit per second which when reduced by 30% gives an allowable discharge of 45.9lit/s. To attenuate the flows from the site down to this level the surface water flows from the would require 28.5 cu.m for the 1 in 30 year storm, 50cu.m for the 1 in 100 year storm and 60 cu.m for when climatic effects are taken into account.

5.4 **Impact on existing drainage systems.**

5.4.1 If the site is to be developed with attenuation systems and an agreed discharge rate, there would be no increase in the flood risk to properties off site or in the drainage networks downstream of the site. In real terms there would be slight reduction in flood risk to adjacent land due to the attenuation provided for the 1 in 100 year storms with the discharge rate cut to 70 % of the current discharge tare, which falls below the current 1 in 1 year storm discharge rate.

6.0 CONCLUSIONS

6.1 The major portion of the site is considered to be within flood zone 2 and not likely to be flooded in the 1 in 100 year event. Only a small section of the site is classified as flood zone 3 but these parts of the sites have not been flooded even when recent events have achieved similar 1 in 100 year flood modelling levels. The whole site is therefore considered to be appropriate for the proposed residential development. The residential areas floors are all above the 1 in 1000 year flood water level, with access provisions also well above the 1 in 100 year flood level.

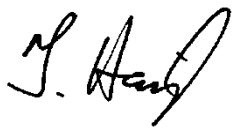
6.2 The site is considered to be accessible for the 1 in 100 year even after allowances are made for climatic effects. All residential occupancy areas are above the modelled 1 in 1000 years flood event and well above the 1 in 100 year events.

6.3 There is a low risk of flood waters leaving the northern drainage systems may pass through the site, and floor levels should be provided a minimum of 200mm above the external ground levels with a designated flood route designed through the site.

6.4 The required 30% reduction in runoff from the site has not been achievable on the site layout and the provision of attenuation storage with a hydraulic flow control device utilised to limit discharges to the agreed rates. There would be no increase in the flood risk downstream of the development because of this. The storage is likely to be provided in the form of Buried "Storm Crates" laid beneath the car park areas.

6.5 The residents should be made aware of a requirement to remove cars from the site during any severe flood warning. If any flood warning are issued by the EA. Residents should be made aware of their responsibilities and follow any flood evacuation procedures as part of their purchase agreement.

6.3 The site will remain at risk of flooding for flood events in excess of the 1 in 1000 year event but would not be flooded during the 1 in 100 year event allowing for climate effects. There is still a route away from the site for pedestrians should such an event occur and this would be from the access to the east of the site.



Trevor Haigh B.Sc., C.Eng., M.I.C.E.

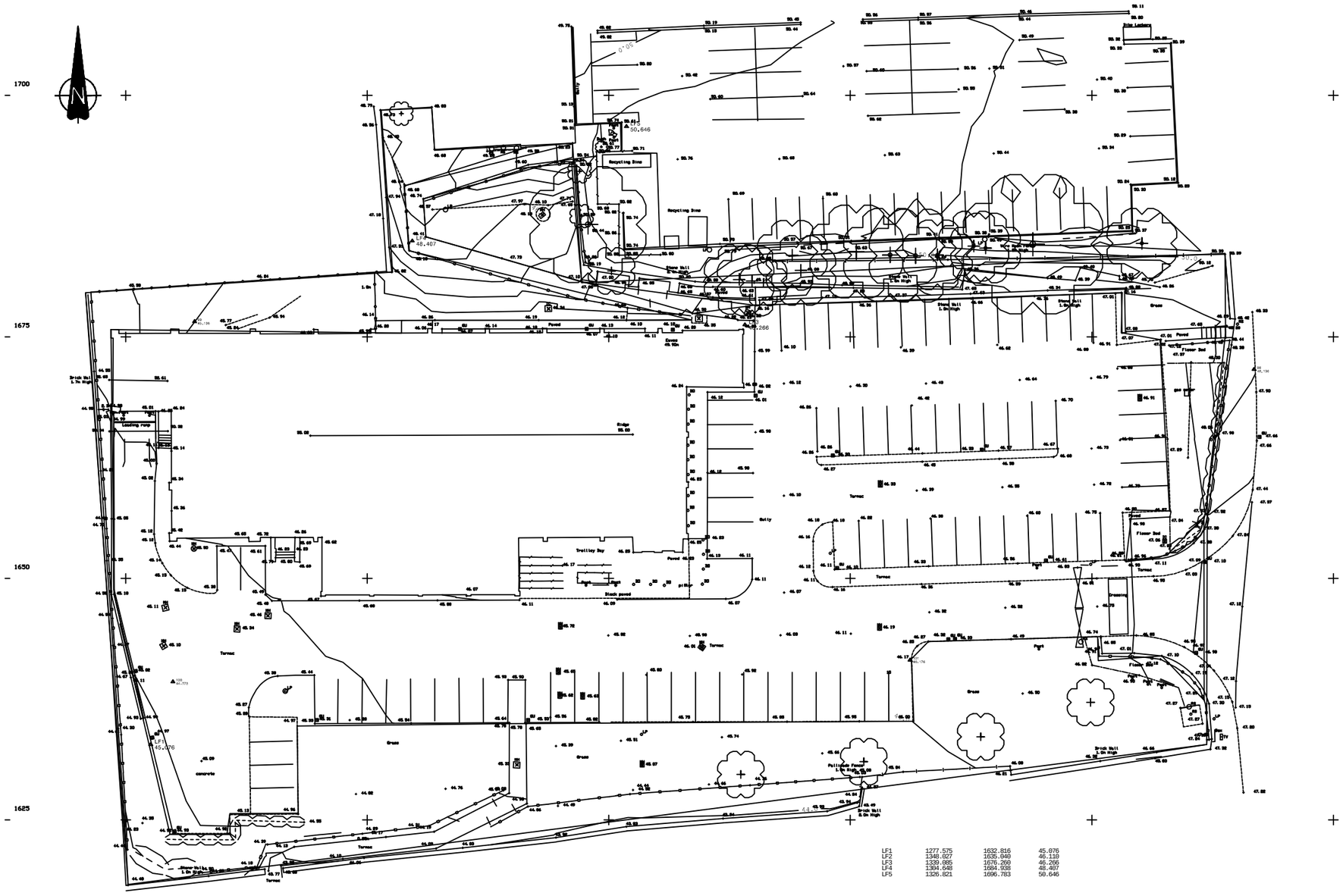
APPENDIX A

LOCATION PLAN

Mirfield, Kirklees, England

APPENDIX B

SITE SURVEY



LF1	1277.575	1632.816	45.076
LF2	1348.627	1635.040	46.110
LF3	1339.085	1676.259	46.266
LF4	1304.648	1684.938	48.407
LF5	1326.821	1696.783	50.646

APPENDIX C

SITE LAYOUT

Supermarket

Car Park

FFL 49.50

GFL 46.25

GFL 46.15

FFL 49.75

GFL 46.50

GFL 46.30

GFL 46.75

PROPOSED SEWER DIVERSION

EXISTING LINE OF SEWER TO BE DIVERTED

1 in 3 slope

LF1	1277.575	1632.816	45.076
LF2	1348.027	1635.040	46.110
LF3	1330.695	1676.260	46.266
LF4	1304.648	1684.938	48.407
LF5	1326.821	1696.783	50.646

APPENDIX D

FLOOD RISK MAPS

GOV.UK

Flood map for planning

BETA This is a new service – your feedback (/feedback) will help us to improve it.

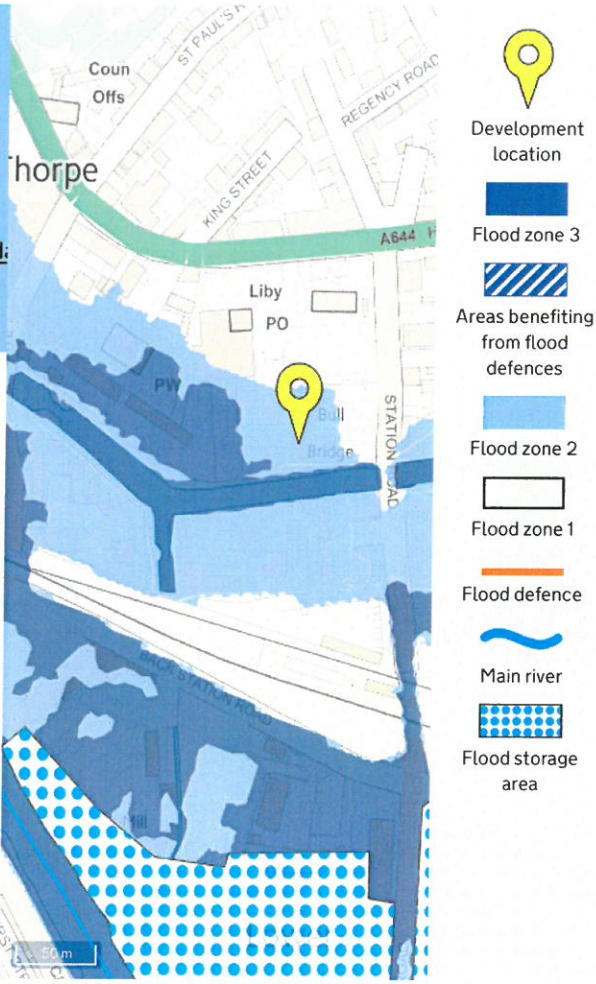
Flood probability

Your proposed development is in an area with a medium probability of flooding

FLOOD ZONE 2

Land and property in flood zone 2 have a medium probability of flooding

More information about flood zones (http://planningguidance.communities.gov.uk/blog/guid risk-and-coastal-change/flood-zone-and-flood-risk-tables/table-1-flood-zones)



1 You must carry out a flood risk assessment (https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications) for development in flood zone 2

2 For some types of development in flood zone 2 you must follow the Environment Agency's standing advice for carrying out a flood risk assessment (https://www.gov.uk/guidance/flood-risk-assessment-standing-advice)

3 You can also read more about flood risk assessments for planning applications (https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications)

Learn more about the potential sources of flood risk in this area (https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=420332&northing=419641)

Enter another location to view the probability of it flooding

Enter a postcode, place or NGR

Check a location ›

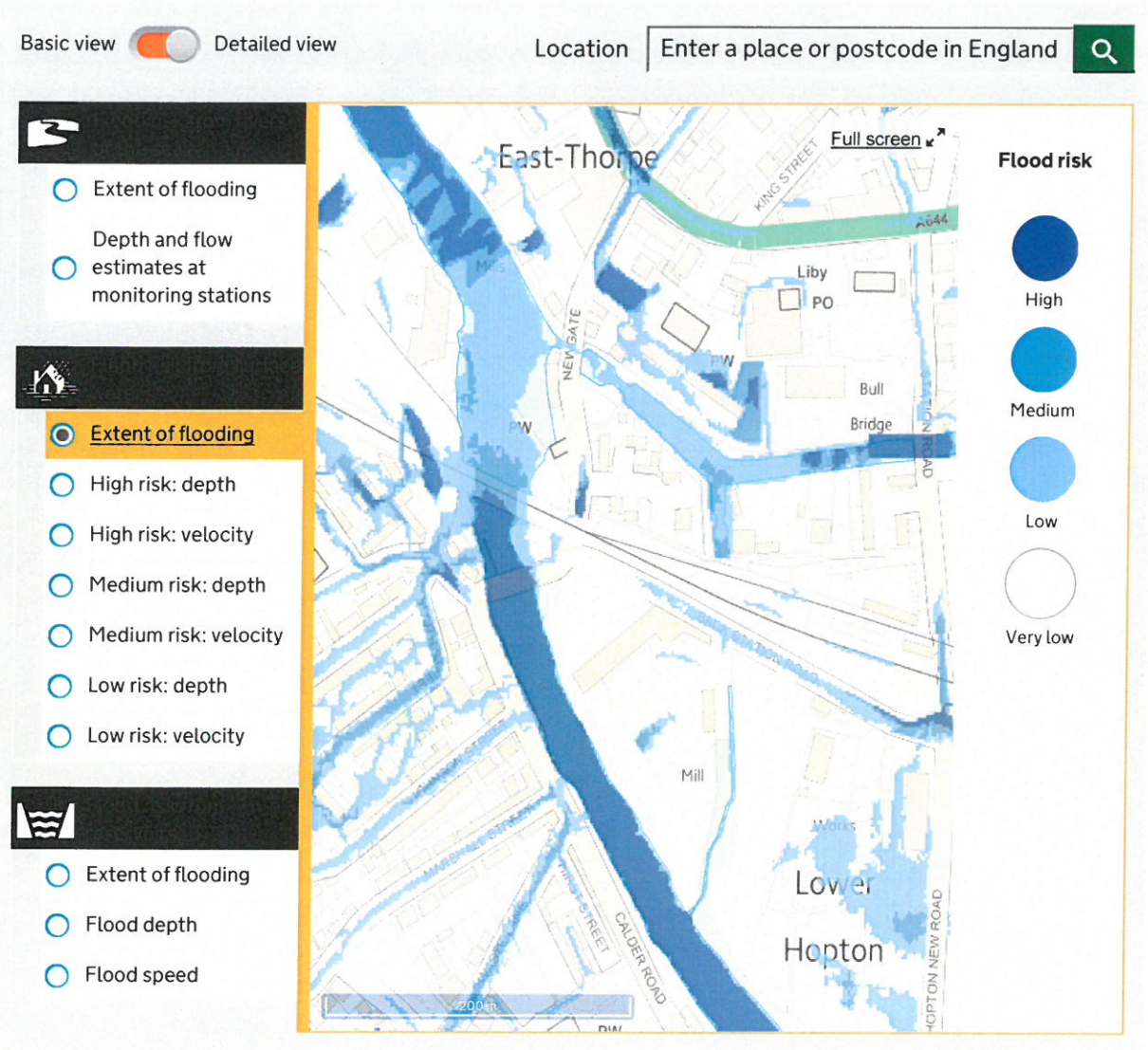
▶ Terms of use

GOV.UK
Long term flood risk information

Learn more about this area's flood risk

From the list on the left, select the information you're interested in. The map view will then update.

'Detailed view' shows more options.



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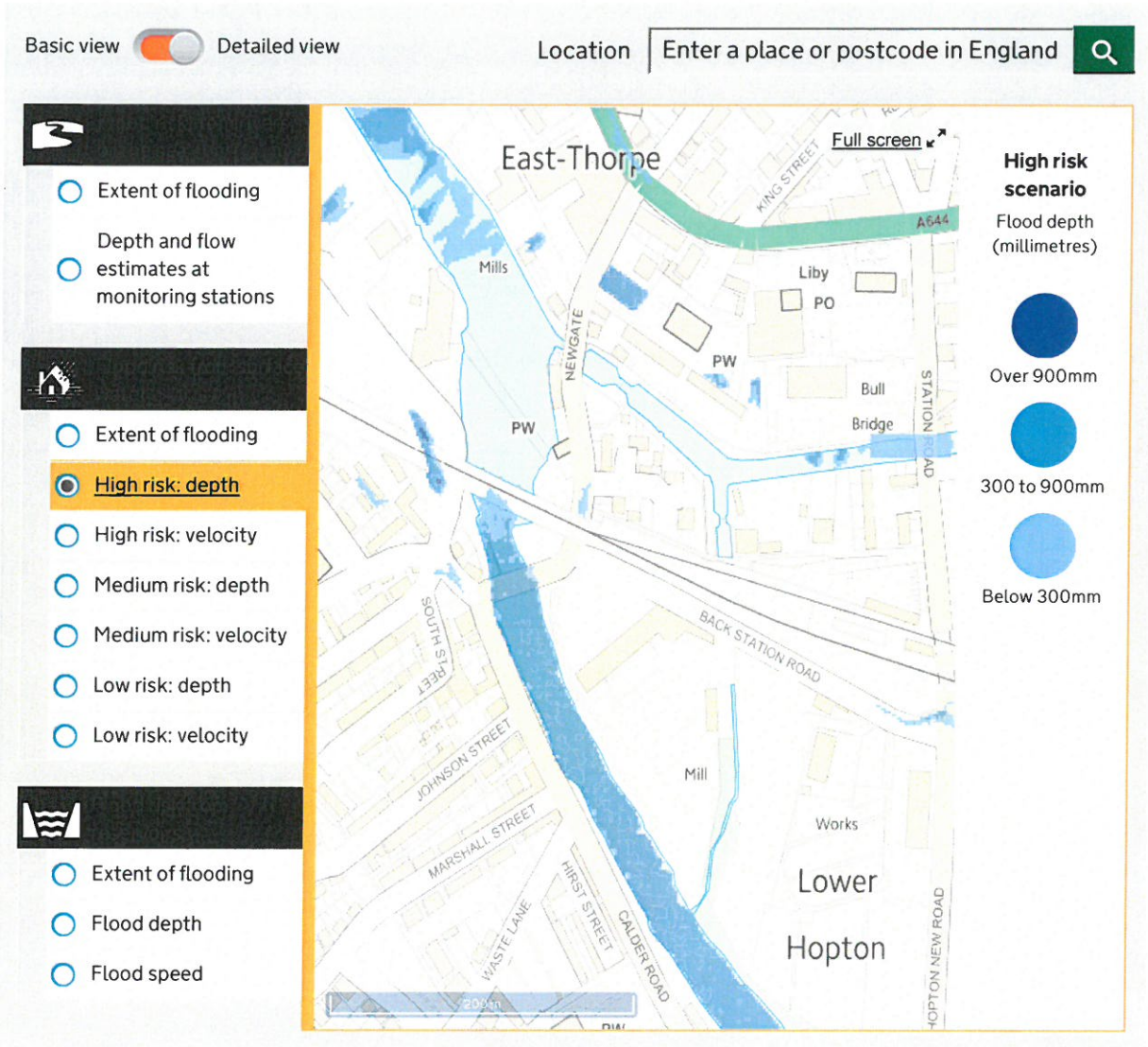

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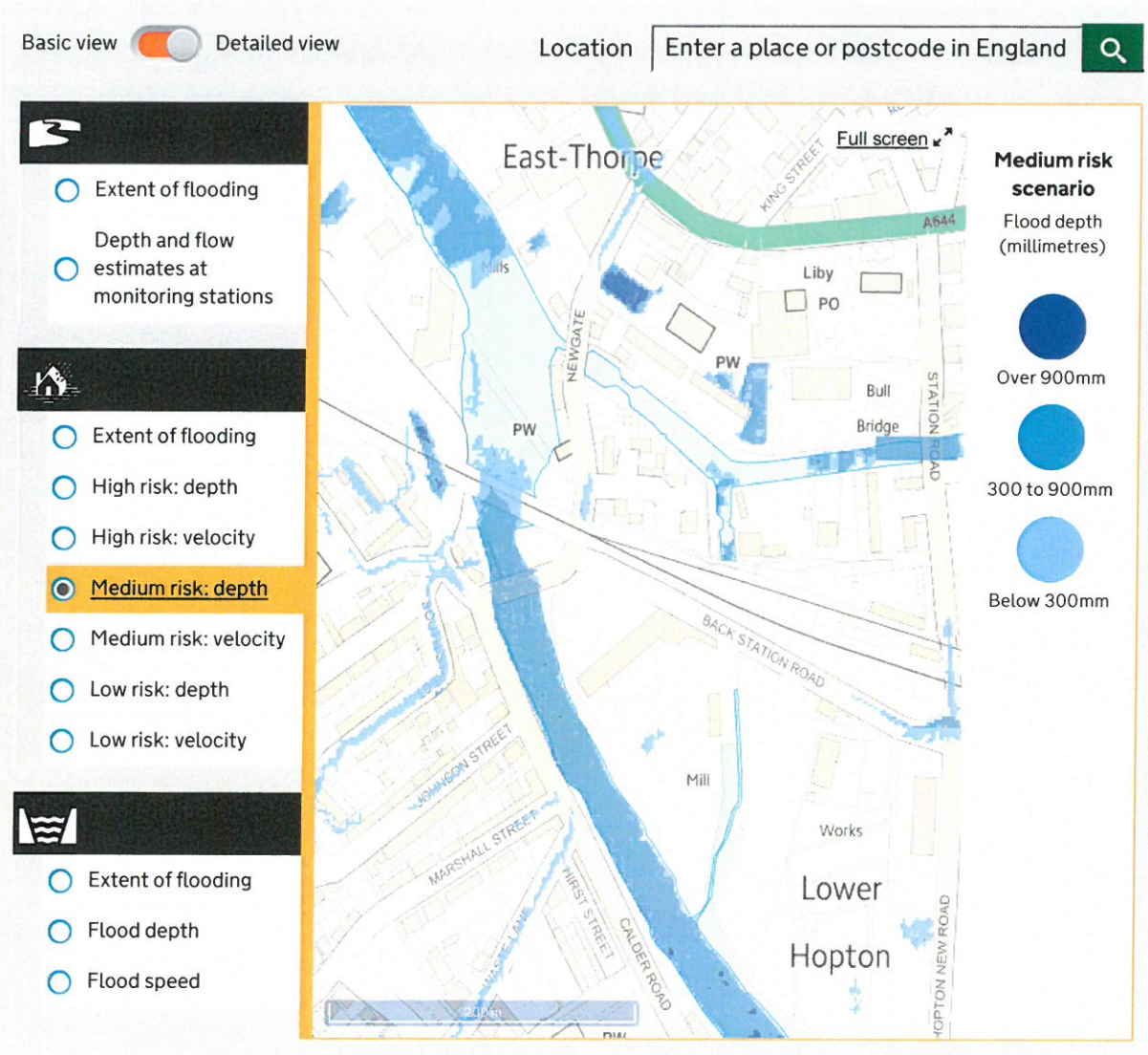

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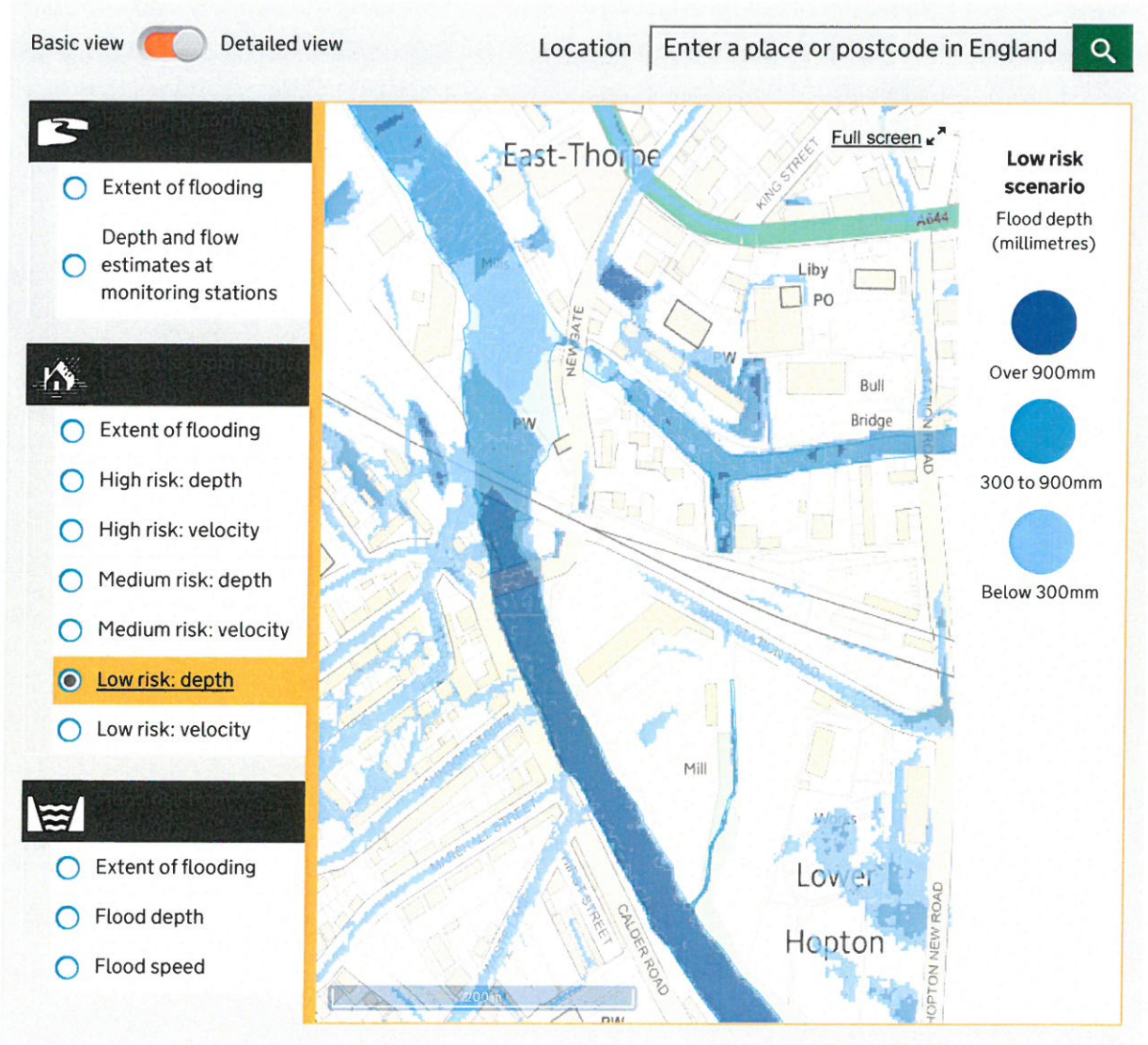

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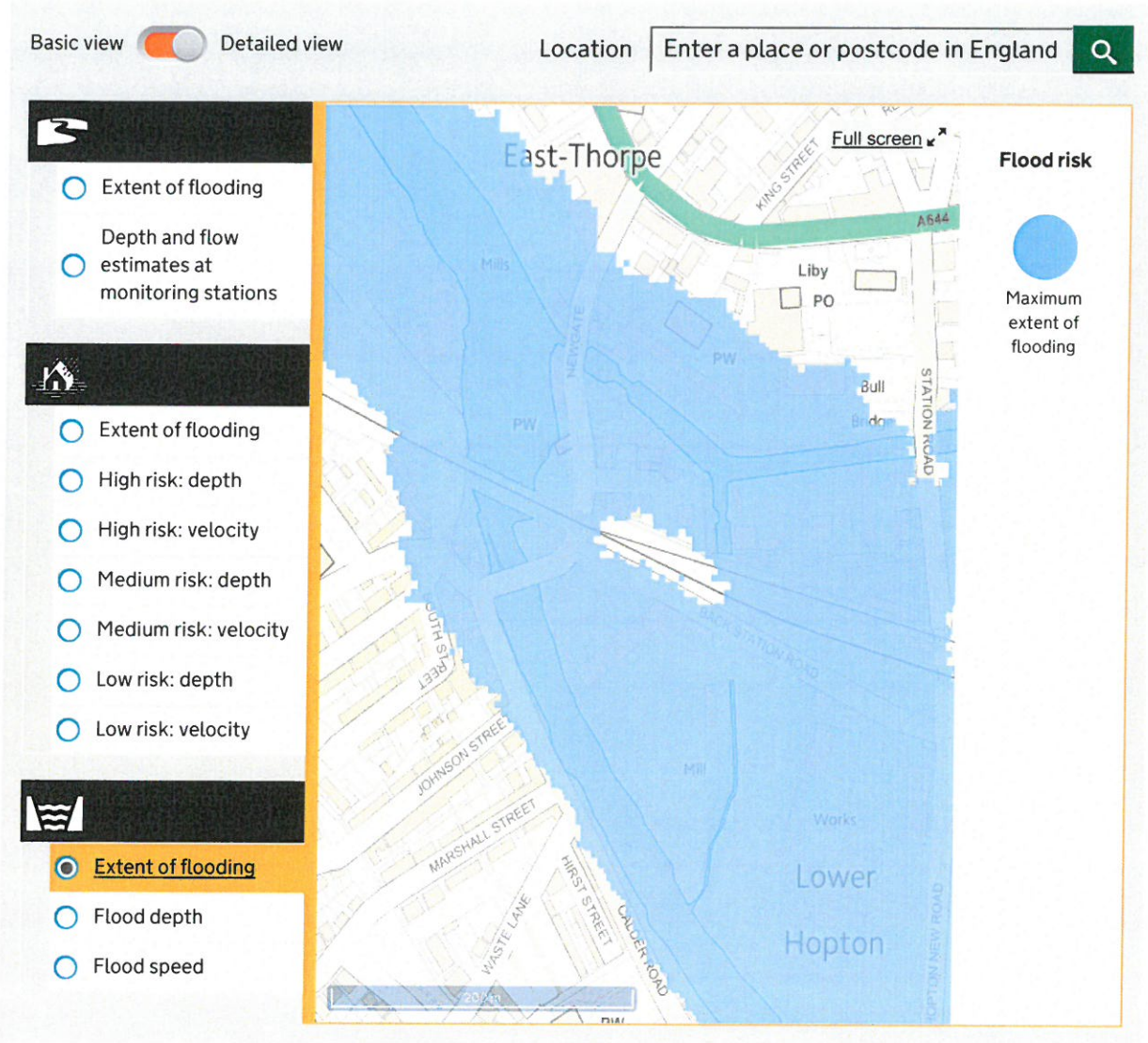

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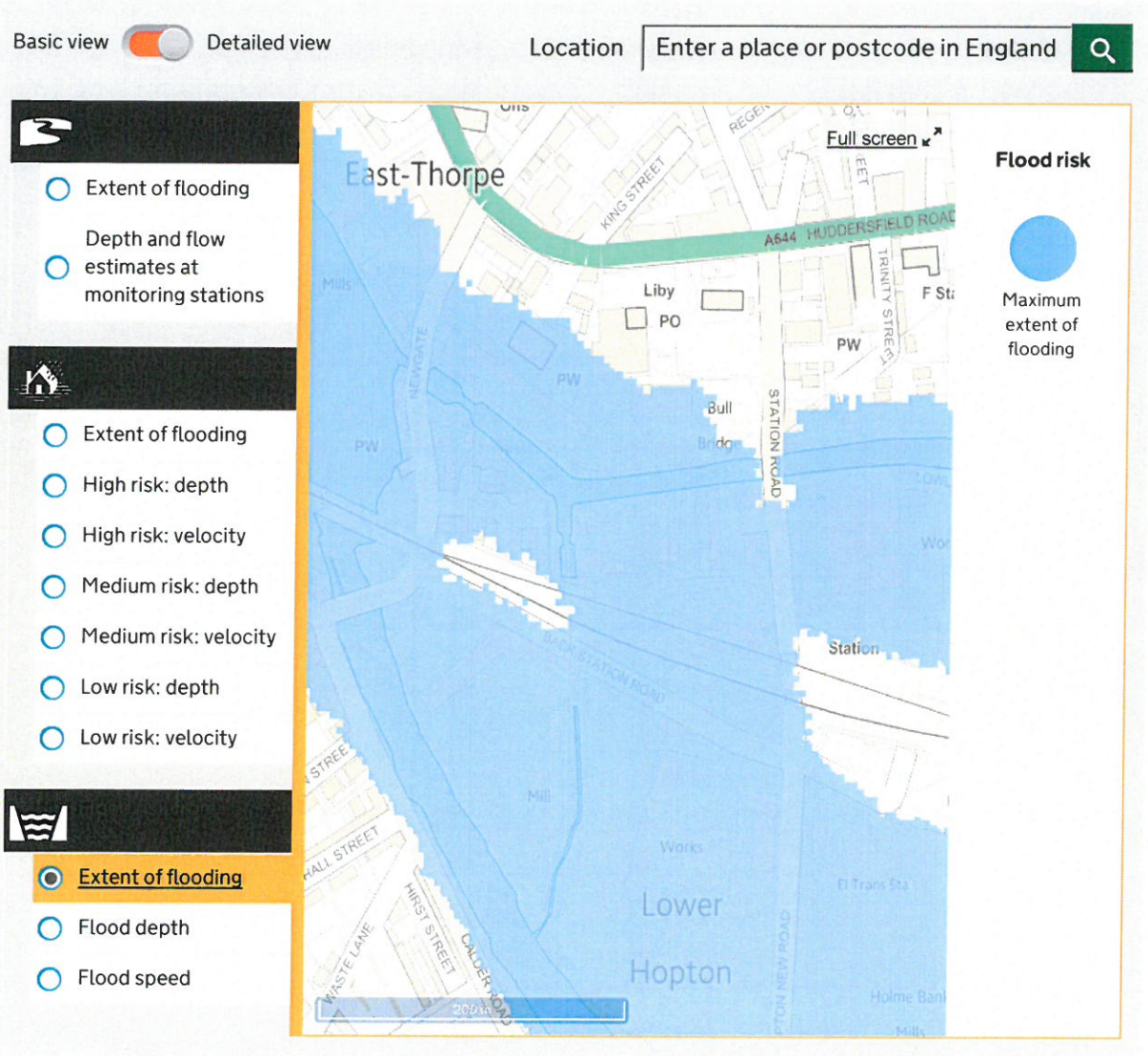

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Flood Zones	Flood Risk Vulnerability Classification				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	✗	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	✗	✗	✗	✓*

Key:

✓ Development is appropriate

✗ Development should not be permitted.

APPENDIX E

MODELLED FLOOD LEVELS

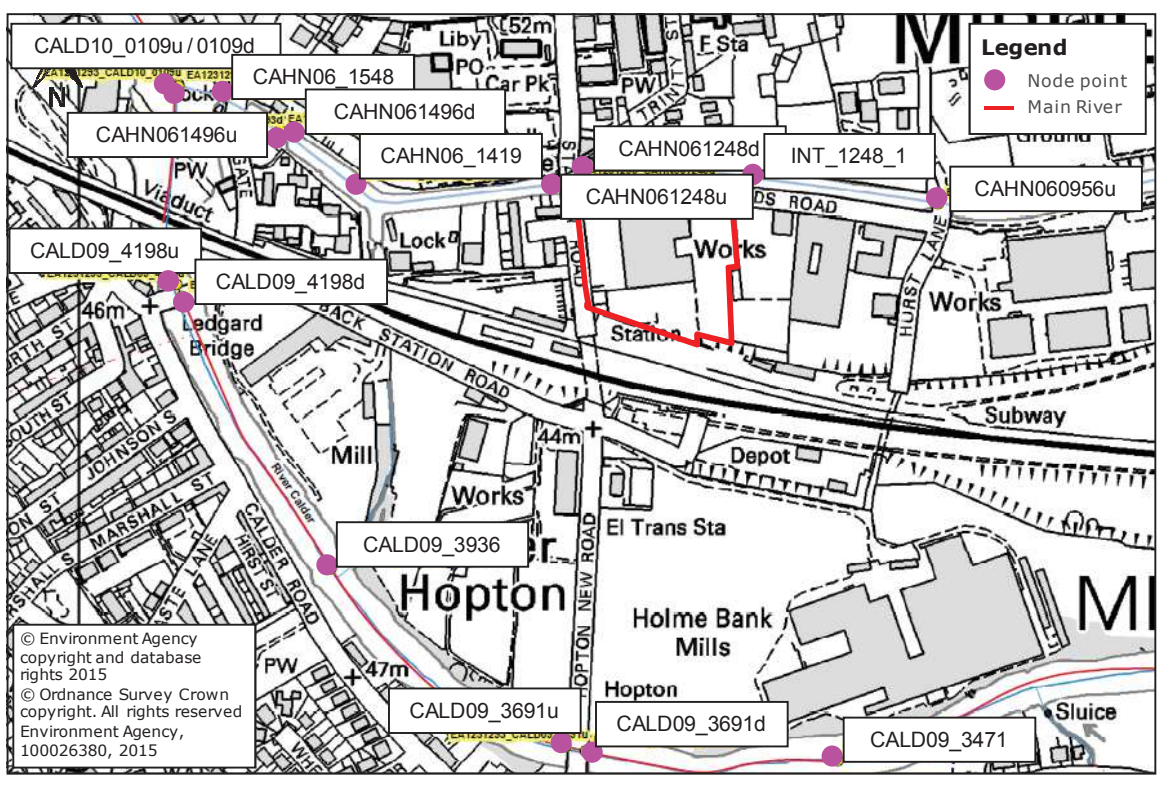
CALD10_0109u / 0109d
CAHN06_1548
CAHN061496d
CAHN061496u
CAHN06_1419
CAHN061248d
INT_1248_1
CAHN061248u
CAHN060956u
CALD09_4198u
CALD09_4198d
CALD09_3936
CALD09_3691u
CALD09_3691d
CALD09_3471
Legend
Node point
Main River
Hopton
Holme Bank Mills
Ledgard Bridge
Viaduct
Lock
Works
Station
Subway
Depot
Mill
El Trans Sta
Sluice
River Calder
BACK STATION ROAD
HURST LANE
CALDER ROAD
HOPTON NEW ROAD
MARSHALL ST
JOHNSON S
46m
44m
47m
52m
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Table 1: River Calder and Canals Modelled Flood Levels (Defended)

Model Node	Annual Probability Flood Level (m AOD)		
	1 in 100	1 in 100 climate change	1 in 1,000
CALD10_0109u	45.69	45.89	46.84
CALD10_0109d	45.69	45.89	46.84
CALD09_4198u	45.32	45.58	46.86
CALD09_4198d	45.10	45.31	46.54
CALD09_3936	*44.78*	*44.84*	*46.17*
CALD09_3691u	*44.59*	*44.61*	*46.18*
CALD09_3691d	44.50	44.49	45.74
CALD09_3471	44.34	44.27	45.43
CAHN06_1548	45.69	45.89	46.84
CAHN061496u	44.23	44.40	46.55
CAHN061493d	43.71	43.94	46.49
CAHN06_1419	43.71	43.93	46.49
CAHN061248u	*43.71*	*43.91*	*46.31*
CAHN061248d	*43.71*	*43.91*	*46.30*
INT_1248_1	*43.70*	*43.90*	*46.34*
CAHN060956u	43.70	43.89	46.40

APPENDIX F

STORMWATER STORAGE CALCULATIONS

Haigh, Huddleston Associates **Stormwater Storage Calculations** july 2017

Client **Darren Smith Homes Ltd** E17/ 6788

Site **Station Road, Mirfield**

Design storm	100	M5-60	19	mm			
		r	0.35				
Site area sq m.	6710	existing impermeable	4625			Annual peak flow	l/s
Imp Area sq m.	4455		existing Discharge	65.5733	lit/sec		l/s
T of Conc min	5	Time to Flow					
Allow Discharge	45.90	Lit / sec	Imp Ratio	0.66			

									100 year storm					100year plus climate				
Storm Duration	**Intensity**	**Depth**	**Vol In**	**Vol Out**	**Storage**	**Q**	**t**		**Intensity**	**Depth**	**Vol In**	**Vol Out**	**Storage**	**Intensity**	**Depth**	**Vol In**	**Vol Out**	**Storage**
Mins	**mm/hr**	**mm**	**cu.m**	**cu.m**	**cu.m.**				**mm/hr**	**mm**	**cu.m**	**cu.m**	**cu.m.**	**mm/hr**	**mm**	**cu.m**	**cu.m**	**cu.m.**
10	81.8	13.63	60.74	35.07	25.66	101.31	2.3		101.27	16.88	75.19	35.07	40.12	111.25	18.54	82.60	35.07	47.53
20	59.8	19.93	88.80	60.32	28.49	74.06	3.1		74.03	24.68	109.94	60.32	49.62	81.33	27.11	120.77	60.32	60.45
30	47.6	23.80	106.03	85.67	20.36	58.95	3.9		58.93	29.46	131.26	85.67	45.59	64.74	32.37	144.20	85.67	58.53
50	34.4	28.67	127.71	136.64	-8.93	42.60	5.4		42.59	35.49	158.10	136.64	21.47	46.78	38.99	173.69	136.64	37.05
60	30.3	30.30	134.99	162.17	-27.18	37.53	6.1		37.51	37.51	167.11	162.17	4.94	41.21	41.21	183.58	162.17	21.41
120	18.7	37.40	166.62	316.97	-150.35	23.16	9.9		23.15	46.30	206.27	316.97	-110.70	25.43	50.86	226.60	316.97	-90.37
180	14.1	42.30	188.45	473.31	-284.86	17.46	13.1		17.46	52.37	233.30	473.31	-240.01	19.18	57.53	256.29	473.31	-217.02
240	11.5	46.00	204.93	630.37	-425.44	14.24	16.1		14.24	56.95	253.70	630.37	-376.67	15.64	62.56	278.70	630.37	-351.66
300	9.8	49.00	218.30	787.92	-569.62	12.14	18.9		12.13	60.66	270.25	787.92	-517.67	13.33	66.64	296.88	787.92	-491.03
360	8.7	52.20	232.55	946.58	-714.02	10.77	21.3		10.77	64.62	287.90	946.58	-658.68	11.83	70.99	316.27	946.58	-630.31
420	7.9	55.30	246.36	1105.88	-859.52	9.78	23.5		9.78	68.46	305.00	1105.88	-800.88	10.74	75.21	335.05	1105.88	-770.83
480	7.5	60.00	267.30	1267.68	-1000.38	9.29	24.7		9.29	74.28	330.92	1267.68	-936.76	10.20	81.60	363.53	1267.68	-904.15
540	6.9	62.10	276.66	1427.01	-1150.35	8.55	26.9		8.54	76.88	342.50	1427.01	-1084.51	9.38	84.46	376.25	1427.01	-1050.75
600	5.5	55.00	245.03	1573.42	-1328.40	6.81	33.7		6.81	68.09	303.34	1573.42	-1270.08	7.48	74.80	333.23	1573.42	-1240.19
900	4	60.00	267.30	2364.85	-2097.55	4.95	46.3		4.95	74.28	330.92	2364.85	-2033.93	5.44	81.60	363.53	2364.85	-2001.32
1200	3.2	64.00	285.12	3159.17	-2874.05	3.96	57.9		3.96	79.23	352.98	3159.17	-2806.20	4.35	87.04	387.76	3159.17	-2771.41
1440	2.8	67.20	299.38	3797.37	-3497.99	3.47	66.2		3.47	83.19	370.63	3797.37	-3426.74	3.81	91.39	407.15	3797.37	-3390.22

				Storage	**28.49**						**Storage**	**49.62**					**Storage**	**60.45**
Length of 1800		11.19					Length of 1800	19.4996			Length of 1800	23.7571						
Length of 1500		16.12	Culvert	2.4*1.5m	7.91		Length of 1500	28.0819			Length of 1500	34.2132						
Length of 1200		25.19	culvert	3.6*1.8m	4.40		Length of 1200	43.8733			Length of 1200	53.4524						
Length of 1050		32.89					Length of 1050	57.30			Length of 1050	69.8091						
Length of 900		44.79					Length of 900	78.02			Length of 900	95.0545						
Length of 750		64.45					Length of 750	112.26			Length of 750	136.775						
Length of 600		100.66					Length of 600	175.34			Length of 600	213.621						

tank 1500mm deep				sq.m		area of 500mm deep aquacrates		
Area req'd	1 in 30 yr	18.9903783	Pond 900mm deep	31.6506	30 year	30 year	56.97113	
	1 in 100 yr	33.0804543		55.1341	100 year	100 year	99.24136	
	1 in 100 yr + c/c	40.3030983		67.1718	100 year plus climatic	100 year plus 30%	120.9093	7.5 m square
						2 deep gives 5m x 12m of crates		