Doncaster Strategic Flood Risk Assessment

Level 2

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FINAL REPORT

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CONTRACT

This report describes work commissioned by Doncaster MBC under the consultancy agreement dated 19 October 2007. Doncaster MBC's representative for the contract was Steve Butler (Environmental Planning). Steve Rose, Zdenka Rosolova, Chris Isherwood, Peter Grace and Andrew Lloyd and of JBA Consulting carried out the work.

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PURPOSE

This document has been prepared solely as a Level 2 Strategic Flood Risk Assessment for Doncaster Metropolitan Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

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EXECUTIVE SUMMARY

Flood risk in Doncaster is a complicated issue and arises from many potential sources. It is, rightly, a constraint to development, but development could be integrated into the flood risk management options for this area. Great care needs to be taken over the type and form of new development in these flood risk areas. Whilst the Environment Agency Flood Maps cover the council area, the spatial distribution of flood risk across the area is very different.

The River Don and its tributaries provide the greatest risk to central Doncaster, whilst surface water flooding or tidal flooding from the lower Trent also have the potential to be significant in some areas. The potential threat of surface water flooding produced considerable impacts within the council area during the summer 2007 floods.

Significant reaches of the River Don, Trent and together with their major tributaries are defended to a 30-200 year standard. However, **residual risks** are still present. These risks are linked to the overtopping or failure of the current flood defences.

While the Level 1 Strategic Flood Risk Assessment provided the detail for Doncaster Metropolitan Borough Council (MBC) to apply the **Sequential Test** to its development allocations as set out in PPS25, it did not provide the understanding and the level of detail required to carry out the full **Exceptions Test**.

This document was therefore produced to gain a greater understanding of the potential flood mechanisms in areas of strategic development importance and to provide some of the information needed to carry out the **Exceptions Test**.

In order to achieve this, some detailed 1D-2D modelling of the River Don was developed to assess the residual risks. Two main scenarios were investigated - defence overtopping during the 100 year and 1000 year fluvial events and breaching of the defences during the 100 year fluvial event. For some of the sites existing 1D hydraulic models were used for the Level 2 assessment.

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ABBREVIATIONS

AEP	Annual Exceedance Probability
DTM	Digital Terrain Model
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
FZ	Flood Zone
IDB	Internal Drainage Board
LDF	Local Development Framework
LiDAR	Light Detection and Ranging
LPA	Local Planning Authority
MBC	Metropolitan Borough Council
PPS25	Planning Policy Statement 25
SAR	Synthetic Aperture Radar
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection
UDP	Unitary Development Plan

1 INTRODUCTION

1.1 Purpose and Scope of the Study

The purpose of this investigation is to provide a spatial assessment of flood risk within specific parts of Doncaster Metropolitan Borough Council (MBC) by developing on the detail included in the Level 1 Strategic Flood Risk Assessment (SFRA) for Doncaster MBC[1]. This will assist in the formulation of the Local Development Framework (LDF) and the appropriate policies and proposals produced for the development and use of land within the council area.

In particular, a Level 2 SFRA will:

- Provide detailed data and guidance in the application of the PPS25 Exception Test[2] for Doncaster MBC to assess flood risk in specific development sites/areas;
- Supplement current policy guidelines by providing guidance on a risk based approach to development considerations. This is to help ensure that areas allocated for development can be developed in a safe and sustainable manner

The Level 2 report should always be used in conjunction with the Level 1 SFRA report. Doncaster MBC have an on-going commitment to periodically review the SFRA (both Level 1 and Level 2) in order to take account of the emerging River Don and River Trent Catchment Flood Management Plans (CFMPs), the Don and Isle of Axholme Flood Risk Management Strategies, Surface Water Management Plans (SWMPs) and on-going Environment Agency Flood Risk Management operations and maintenance activities. The SFRA review is currently scheduled to take place approximately every 4 years, unless there is a significant flood affecting the areas, giving rise to new information or areas at flood risk, or there are any major national policy changes in flood risk management that require consideration.

1.2 Flood Risk in Doncaster MBC – An Overview

Flood risk is a significant issue in many parts of the Doncaster MBC area and can arise from a number of sources. These include main river flooding from the River Don, Lower Trent and their tributaries. Environment Agency Flood Zone (FZ) maps of this council area are broad indicating the flat, lowland nature of most of the watercourses with both fluvial and tidal components.

The Doncaster MBC area benefits from a large number of flood defences, many of which will be maintained by the Environment Agency into the future. The Doncaster MBC area also contains a significant land area where the land drainage (principally for agricultural production) is controlled and managed by Internal Drainage Boards (IDBs).

While providing a certain standard of protection, defences leave a suite of residual risks including overtopping or failure (breach) of the flood defences or exceedance of culvert capacities. These should be considered in any flood risk assessment, and are critically important in spatial planning over the long term.

Local surface water runoff originating from rural/greenfield land and urban areas can become trapped behind defences, pool in low lying areas, or as a result of pumping station failure can produce additional sources of flooding. The severe flooding that occurred in Doncaster summer 2007 provided clear evidence of a surface water flooding problem within the Doncaster MBC area.

Whilst the Environment Agency Flood Zone maps show considerable parts of Doncaster MBC area potentially at risk of flooding, the scale, type and spatial variation of these risks are evidently very different. The priority of this investigation is therefore to take a step forward from the Level 1 SFRA and the assessments of Environment Agency Flood Zone maps and investigate in more detail the flood risk in some specific areas that have a strategic development importance to Doncaster MBC.

[1] The Doncaster Level 1 SFRA update to PPS25 was published in May 2009.

This then allows a sequential match of flood risk and vulnerability of the intended land use to be prepared.

1.3 Sequential Approach

Planning Policy Statement 25: Development and Flood Risk[2], together with its accompanying Practice Guide, sets out the desired approach of avoidance of development in flood risk areas. If on grounds of wider sustainable development, in what has tended to be historic or industrial areas adjacent to the rivers, PPS25 guides any new investment to have the lowest flood vulnerable land use and as a means of last resort to include mitigation measures within or around that development.

It is rare that this choice is straightforward and the Environment Agency Flood Map is too simplistic when considering the regeneration within existing flood risk areas. A greater understanding of the scale and nature of the flood risks are required. To help achieve this, more detailed modelling of a range of extreme storm events and failure of flood management operational features has been undertaken (discussed in Section 3).

The ability to manage flood risk for new development must consider a wide range of issues, which includes how any evacuation of the occupants would be handled, how the new development fits in with the existing flood management provision and, should there be an event, how quickly the wider area would recover and return to normal. Some areas, either through natural or artificial topography, are easier to integrate flood management measures into the new development, without causing a significant alteration in its design and its place setting. These measures can have the potential to cause an alteration to the flood risk to adjacent property or other areas on the floodplain.

The application of the Sequential Test is primarily concerned with avoidance by finding alternative sites. However, it is clear that many existing uses remain at risk in the Doncaster MBC area, and that the area is still in need of some appropriate schemes of regeneration. Large parts of the Doncaster MBC area is in Flood Zone 2 or 3, and the appropriate uses planned are either permitted under PPS25 or require further testing via the Exception Test. Therefore avoidance of the flood risk by relocation of development to lower risk sites is not always practicable. This strategic assessment has started on the basis that the planning justification is sound and that designing an appropriate mix of development is critical.

Whilst the Exception Test process makes it possible to strategically plan the type and form of the development, it must not been seen as an opportunity to place inappropriate development in flood risk areas. It is a useful planning tool that can justify the acceptability of the residual risks remaining after the mitigation measures have been applied. It is an important evidence base upon which to rely in order to justify where sequentially preferable land uses should be located. This strategic assessment takes a holistic approach to the long term challenges of integrating flood risk management and land use planning. The sequential approach looks at a broader set of flood risk indicators and supports policies and land uses that is intended to resist piecemeal development in flood risk areas. The latter pattern of development inevitably compromises the successful delivery of a managed flood risk regime in the Doncaster MBC area, and would be increasingly difficult to satisfy the EA and the LPA.

[2] Communities and Local Government. 2006 *Planning Policy Statement 25: Development and Flood Risk.* December 2006. pg7. http://www.communities.gov.uk/pub/955/PlanningPolicyStatement25DevelopmentandFloodRisk_id1504955.pdf

2 CURRENT AND RESIDUAL RISK IN DONCASTER MBC

2.1 Current Risk

As discussed in Section 1.2 Doncaster MBC area is currently at risk of flooding from a number of sources identified with the Level 1 SFRA, which include river flooding, tidal flooding and surface water flooding.

The Environment Agency Flood Map shows that the large parts of Doncaster MBC are at risk from fluvial and/or tidal flooding. Due to the low lying nature of its floodplain, Flood Zone 2 and 3 are not particularly constrained by the topography and therefore they have wide outlines. While these outlines show the main Doncaster urban area to be at risk, it does also benefit from a large number of maintained flood defences. These consist of main flood embankments along the River Don, River Trent and some tributaries, together with a number of designated washlands on the River Don system. A considerable amount of more rural/agricultural land around Doncaster is defended by IDBs to a lower level of protection (typically only up to a 1 in 30 year return period).

It is known that the actual Flood Zone 3 outline for parts of the River Don may be in error due to: i) errors in the original topographic survey data used in the flood modelling, and ii) the original method of projecting the flood level across the floodplain from channels that are actually elevated water carriers across wide low lying floodplains. In this instance the extent of the current Flood Zone 3 will be somewhat exaggerated in places. Some on-going 1D and 2D modelling of the Don by JBA Consulting, including a recent and more detailed LiDAR/SAR DTM, should help the Environment Agency to revise the Flood Zone 3 map in this area.

2.2 Residual Risk

Residual risks are the risks that remain after all risk avoidance, substitution and mitigation measures have been taken. The residual risks in Doncaster MBC area are therefore related to the occurrence of events of low probability, such as extreme flood events greater than the design capacity of the constrained river system or the failure of flood defences.

The quality and condition of the existing river flood defences is reasonable in most areas in Doncaster and the probability of flooding is low. However, the consequences of flooding are very large. The topography of the land behind defences, flow routes, land use and access and egress are all key factors in identifying these higher flood risk areas. Areas directly adjacent to the defences could also be subject to high flow velocities should the defence overtop or fail, known as rapid inundation zones, whilst low lying areas further away from the defences are at risk from the sheer depth of flooding. However, there are known sections of the raised flood embankment system within the Doncaster MBC area that are known to be of poor quality. These include the River Don at Newton Farm, Wheatley Park, in Doncaster itself and at Stainforth.

The defences have also been designed to a set level (i.e. a 1 in 30-200 year flood event plus freeboard, depending on location), and there is always the possibility of a larger event occurring and overtopping or breaching the defences, which must be investigated.

Access and egress routes to/from proposed development areas are important to both the population living or working there and to the emergency services responding during a major flood event.

While Environment Agency Flood Maps provide a sufficient starting point in investigating flood risk within the Doncaster MBC area, they do not provide the level of detail needed to assess the residual risk, especially those which lie behind defences. A more detailed investigation is therefore needed of these risks, which influence the sequentially preferable areas for redevelopment and investment.

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3 FLOOD RISK DATA AND ITS ASSESSMENT

3.1 Risk Data

The Doncaster Level 1 SFRA has provided sufficient data and information to enable Doncaster MBC to apply to Sequential Test. This information included:

- Environment Agency Flood Zone maps
- Functional Floodplain (based on designated washlands and flood storage areas)
- SFRA Risk maps (inc. climate change)
- Areas Vulnerable to Surface Water Flooding

The Level 1 SFRA demonstrated that parts of the Doncaster MBC area are at high risk of flooding, and while it allowed Doncaster MBC to apply to Sequential Test at a borough level, it has also demonstrated the potential need to apply the Exception Test in certain areas, especially where economic sustainability is a key consideration. A detailed Level 2 SFRA investigation into flood risk is required into the residual risks. This will further collate the evidence base in parts of the borough to facilitate the application of the Exception Test, and also inform the sequential approach to site layout and the design of possible mitigation measures.

The approach taken is to ensure that key factors of the scale of the residual risks are understood and the flood inundation pathways are assimilated into any development layout. The main part of this investigation will therefore include detailed 1D-2D modelling of defended parts of Doncaster, analysing the residual risk of the area using a number of scenarios, including in most cases:

- Defence failure (breach) during the 1% Annual Exceedance Probability (AEP), or the 1 in 100 year return period fluvial event
- Overtopping during the 1% AEP (1 in 100 year), 1% AEP + climate change, and 0.1% AEP (1 in 1000 year) fluvial events

Breach and overtopping scenarios were only able to be applied to the River Don fluvial model. Detailed hydraulic models of the Trent tributaries within the Doncaster MBC area do not currently exist but may be available in the future as an outcome from the on-going Isle of Axholme Flood Risk Management Strategy. Further modelling may therefore be needed once this strategy is completed.

The Level 1 SFRA identified a number of so-called 'challenging' housing and employment sites within Flood Zone 3 which were mapped as being at high flood risk from the new SFRA risk maps and/or >20% of the site/area was within FZ3b (designated washlands or flood storage areas). These challenging sites were defined as having greater than 25% of their land area within the defended (to a 100 year standard of defence) fluvial flood outline for a 200 year flood event (as defined by the SFRA risk map). In most cases, the final development design and layout can be altered to avoid flooding in up to about 20% of the land area. Of these challenging sites Doncaster MBC have a strategic development interest in a number of them and for which they required a more detailed Level 2 assessment. These sites are, in general, well defended, however in some cases the SFRA risk map for a defended scenario (to a 100 year SoP) and the 200 year fluvial flood event showed them still to be at high risk with flood depths >1m. The potential housing and employment areas that required a more detailed assessment were:

1. Mexborough (Pastures Road) and the former Earth Centre (north of Conisbrough)
2. Bentley Rise (north west of Doncaster centre)
3. Stainforth (north west of Hatfield)
4. Moorends (north of Thorne)
5. Carcroft Common/Adwick-le-Street

3.2 EA ISIS hydraulic model

The River Don had previously been modelled by JBA and others using the industry standard ISIS modelling software. The existing River Don model was used to assess the flood risk at the Mexborough (Pastures Road) sites and the former Earth Centre site.

Defence overtopping and breach analyses were undertaken to more accurately define and differentiate risk to the specific proposed development sites alongside the River Don and its tributaries. Utilising remotely sensed Light Detection and Ranging (LiDAR) Digital Terrain Model (DTM) data, along with the detailed ISIS hydraulic model already in place for the River Don, it was possible to generate inundation extents for a series of breach and overtopping scenarios.

The recommended flood defence breach widths are shown in Table 3-1 with the defences being assumed to collapse down to the natural ground level, leaving a rectangular shaped breach.

Table 3-1**.** Recommended Flood Defence Breach Widths *(Source: The Environment Agency)*

Location	Defence type	Breach width (m)
Fluvial river	Earth bank	40
	Hard	20
Tidal river	Earth bank	50
	Hard	20

In order to model these scenarios, the existing ISIS-TUFLOW model for the River Don was used to model the breach and overtopping at Bentley Rise and Moorlands. The extent of the TUFLOW part of this existing model did not cover Stainforth and therefore an additional TUFLOW model was built and linked to the existing ISIS-TUFLOW model to simulate the scenarios at this site.

3.3 Un-Linked TUFLOW to Don Model

Modelling the area around Moorlands was relatively straightforward. It required a TUFLOW model domain to be created using the LiDAR data and TUFLOW boundary data that could be generated from the existing Don model. As there was already floodplain schematised around the area, the boundary data for the overtopping scenario could be generated by outputting the flow over the nearby lateral spills from the existing ISIS model. For the breach model though, the spill to be breached needed to be edited to the required shape before re-running the model and again outputting the data. A constant breach was decided upon as the best approach as this would result in the greatest volume to floodplain and be the worst case scenario.

This boundary data was then fed into the TUFLOW model domain for the area and the resulting flood extents were subsequently outputted.

3.4 Linked TUFLOW to Don Model

For the other areas (Bentley Rise and Stainforth), a linked model was deemed necessary as flow could exit the channel at one location and possibly re-enter further downstream. The coupling of the ISIS model with the TUFLOW model combined with the higher resolution grid and improved DTM serves to enable a much more detailed assessment and provide more accurate predictions of flow and water level. This approach is more complex than the un-linked one, due to the fact that a dynamic link has to be built between the 1D ISIS model the 2D TUFLOW model domain. The linked approach does not require the generation of boundary condition data, instead it considers the 1D ISIS and 2D TUFLOW models and calculates the flux across the link for each time step. The TUFLOW model domain was again generated using LiDAR with the 1D/2D links being digitised via MapInfo, a full explanation of the techniques involved in the link generation is beyond the scope of this report, although separate breach and overtopping scenarios could be generated . This linked 1D/2D model was then run for the different scenarios and the flood extents exported. The Stainforth area modelling utilised an LIDAR DTM that up been updated since the production of the Level 1 SFRA Report.

3.5 Residual Risk

In addition to the Environment Agency Flood Zone maps, the Level 1 SFRA provided a set of new SFRA risk maps as a complementary suite of broad scale flood risk information.

The SFRA fluvial flood extent and depths maps created show the potential scale of flood inundation for overtopping of different standards of flood defence (given by the notation Sn, where n = return period in years) during a range of fluvial flood events (given the notation Qn, where n = return period in year). Example include: S2Q100 - 1% (1:100y) flood event assuming no flood defences exist; and S100Q200 - 0.5% (1:200y) flood event assuming flood defences exist providing 1% (1:100y) standard of defence. In other words, while the Environment Agency Flood Maps provide undefended outlines for the 1 in 100 year (FZ3) and the 1 in 1000 year events (FZ2), this mapping provides a basic understanding of the residual risks as a result of the overtopping of defences or surcharging of the culvert system.

The methods used to create the depths grids are reasonably similar to those used to create the original Flood Zone maps and while the hydrology and underlying DTMs have been edited to create an improved representation of flood risk, it still lacks sufficient detail of the interaction between the river channel and the floodplain and the effect of culverts and bridges within the arterial drainage network. However, it gives a good representation of the volume of water on the floodplain, and therefore provides realistic flood depths and identifies important flow paths.

3.6 Surface Water Flooding

To gain a better understanding of other sources of flooding, the Doncaster Level 1 SFRA undertook a simple assessment of areas which are naturally vulnerable to surface water flooding.

The surface water modelling carried out in the Level 1 SFRA has been used to simulate a rain storm event to assess the risk of flash flooding during a high volume intense storm, which is normally associated with the summer months. As discussed in the Level 1 SFRA, the rainfall data generated are based on a hypothetical storm, using Flood Estimation Handbook (FEH) calculations, and is based on a 1 in 100 year rainfall event over a 6 hour period. The function of the local drainage system is simplistically represented by removing a fixed volume from the modelled rainfall input. It is assumed that the local drainage (storm sewer) network has a capacity equivalent to a 1 in 10 year rainfall storm with the same duration. The modelling technique includes the presence of flood defences and how water may pond behind these defences. This modelling should only be regarded as indicative because we are not modelling the sewer drainage processes accurately.

By placing the volume of water over a 3D representation of the Doncaster MBC area, it is possible to generate depth data and a clear indication of how the flood progresses over the urban area. Probably the most important output from this modelling technique is identifying crucial flow paths and where flood waters are likely to pool in low lying areas or, more importantly in some parts, behind defences.

In future, a Surface Water Management Plan (SWMP) may be developed for Doncaster, which would address all aspects of surface water flood risk in great detail.

3.7 Strategic area assessments

3.7.1 Mexborough (Pastures Road) and the former Earth Centre

The particular sites for detailed assessment were:

E27	Mexborough – Pastures Road (Housing)
H338	Mexborough - Pastures Road (Employment)
E112	Mexborough Power Station (Employment)
H414	Earth Centre (west) (Housing)
E20	Earth Centre (adj.) (Employment)
H120	Conisbrough, Wingate Hill (Housing)

For the sites in question it was not deemed appropriate to undertake any specific 2-d hydraulic modelling of overtopping or breach scenarios. The data and interpretation from existing modelling studies were considered to be adequate to provide a strategic assessment of the flood risk at each site.

According to the Environment Agency Flood all the sites have at least 48% of their area within the Environment Agency Flood Zone 3 (1 in 100 year) outline and at least 67% within the Environment Agency Flood Zone 2 (1 in 1000 year) outline.

All of the sites have ≥35% of their land area within the highest risk Flood Zone 3b (FZ3b) functional floodplain (as defined as being designated washlands and flood storage areas). Under PPS25 only water compatible development is an appropriate land use within FZ3b. Even for Essential Infrastructure the Exception Test would be required to be passed in order for the development to be deemed appropriate. All other development types are not appropriate for FZ3b. Based on PPS25 all the development sites would need their footprints significantly altered to avoid the FZ3b area, or this type of development should be re-located to an area of lower flood risk. For a number of the sites (especially H338 and H414) this might make the proposed developable area uneconomic to pursue as too great a proportion of the area is within the designated FZ3b. The FZ3b designation is the most significant factor affecting of the proposed development sites in this area. In addition, 30% of E112 and 30% of H338 is within the designated Doncaster Greenbelt area.

All sites have greater than ≥25% of their area flooded within the modelled undefended 100 year flood extent (SFRA Risk Map S2Q100 scenario, Map A-1). For three sites (E112, E20 and H414) the mean depth of the flooded area is >1.5m. For E20, all of the flooded area is north of the river and the area to the south of the river flood embankments on the south bank is not flooded. The mean flood depth for E27 and H338 is 0.01-0.5m, which could be mitigated against if the development type was deemed appropriate.

A 20% increase in fluvial flows, as a consequence of climate change, does not change the flood extents much in the development areas (Map B-1). The biggest increase in the flood extent occurs in sites E27 and H338, though the additional flooded area only has a flood depth of 0.1-0.5m. However, the banded flood depths do change for some of the areas. E112 would have more land in the 0.5-1.0m flood depth band, rather than the 0.1-0.5m depth band.

Surface water flooding (Map C-1) would only potentially affect sites E20 and E112 causing water to pond to a reasonable depth (>0.5m) in restricted areas within the site boundary.

Given the importance of the locations of these development sites within a confined floodplain it was decided that the use of the existing detailed hydraulic models for this part of the River Don and River Dearne was the most appropriate for this assessment. Map D-1 provides information from existing hydraulic models of the Rivers Don and Dearne, with all the defences in place to their current crest levels. The model output shows that the site E20 has considerable flood risk problems in terms of deep flood water (>1.5m), to the north of the Don flood embankments on the north bank. E112 also has some areas of deep flooding (>1.5m), both to the north and south of the Don. If the Don embankment breached in this area then these sites would be inundated very quickly given the very confined nature of the floodplain here. Site H414 has a very small area of flooding within the site boundaries. For site E27 and H338 any water overtopping or breaching the south bank of the Dearne defences in this area and flowing south-south east would be trapped between the defences and Pastures Road. Some of this flood water could potentially reach the northern edge of sites E27 and H338.

In conclusion, sites E112, E20 and H414 all occupy high flood risk land on the Don floodplain (including the highest risk functional floodplain, FZ3b) which is closely confined between two significant physical barriers, i.e. the Sheffield & South Yorkshire Navigation/Mexborough New Cut to the north and the railway line to the south. Any water either overtopping or breaching through the Don embankments in this area would very quickly enter these development areas and inundate them and to a considerable depth. Therefore, the residual flood risks in these areas, including access/egress issues for both people and emergency services during flood events, are considerable and would require careful attention in a detailed site specific flood risk assessment.

3.7.2 Bentley Rise

The particular sites for detailed assessment were:

E25	Bentley, Hunt Ings (Employment)
E26	Bentley, Hunt Rd (Employment)
H442	Willow Bridge Caravan Park (Housing)
H9	Bentley, Dons Rugby Ground (Housing)

H389 Doncaster, Power Station Rd (Housing)

H386 Doncaster, Power Station Rd, land off the Ings (Housing)

E69 Bentley Ings (Employment)

H35 Bentley, Roseholme Phase 3 (Housing)

E121 Bentley, East Bentley Rd (Employment)

E71 The Ings (Employment)

All sites have greater than ≥25% of their area flooded within the modelled undefended 100 year flood extent (SFRA Risk Map S2Q100 scenario, Map A-2).

Surface water flooding (Map C-2) would only affect parts of sites H35 and 121. The western edge of H35 had some flooding to depth up to 1m and E121 had areas of shallow flooding up to about 0.3m depth.

Of these sites, H35 was not flooded in any of the 2D TUFLOW overtopping or breach modelling scenarios, as it is too far north of the River Don and also north of Swaith Dyke that is also well defended. However, H35 would be at high residual risk of flooding from overtopping or breaching to North Swaith Dyke, another defended watercourse which borders this area.

All of the other sites were inundated to varying degrees of severity during the overtopping events. The results are given in Table 3-2.

The most at risk site in Bentley Rise is H442 with an average flood depth in excess of 1m for all the scenarios. The location of this site between the River Don to the south and the railway embankment to the north means that if the river did overtop its banks then the water would rapidly inundate the site and to a considerable depth. The other sites all have average flood depths of less than 1m for all the scenarios. Of the sites that flooded H389 and H386 had the lowest risk of flooding due to overtopping.

Table 3-2. TUFLOW overtopping results for Bentley Rise sites

Site ID	100 year				100 year + Climate Change				1000 year			
	% area flooded	Max. depth (m)	Avg. depth (m)	Min. depth (m)	% area flooded	Max. depth (m)	Avg. depth (m)	Min. depth (m)	% area flooded	Max. depth (m)	Avg. depth (m)	Min. depth (m)
E25	55	0.5 - 1	0.01 - 0.5	< 0.01	85	0.5 – 1	0.01 - 0.5	< 0.01	90	1 - 1.5	0.5 – 1	< 0.01
E26	8	0.01 - 0.5	0.01 - 0.5	< 0.01	50	1 - 1.5	0.5 - 1	< 0.01	75	1 - 1.5	0.5 – 1	< 0.01
H442	100	0.01 - 0.5	1 - 1.5	0.01 - 0.5	100	> 1.5	1 - 1.5	0.01 - 0.5	100	> 1.5	> 1.5	0.5 - 1
H9	60	< 0.01	0.01 - 0.5	< 0.01	75	> 1.5	0.01 - 0.5	< 0.01	75	> 1.5	0.5 – 1	< 0.01
H389	10	< 0.01	0.01 - 0.5	< 0.01	65	0.5 – 1	0.01 - 0.5	< 0.01	93	1 - 1.5	0.01 - 0.5	< 0.01
H386	0	N/A	N/A	N/A	20	0.01 - 0.5	0.01 - 0.5	< 0.01	93	1 - 1.5	0.01 - 0.5	< 0.01
E69	0	N/A	N/A	N/A	60	> 1.5	0.01 - 0.5	< 0.01	65	> 1.5	0.5 – 1	> 0.01
H35	0	N/A	N/A	N/A	0	N/A	N/A	N/A	0	N/A	N/A	N/A
E121	0	N/A	N/A	N/A	0	N/A	N/A	N/A	80	> 1.5	1 - 1.5	0.01 - 0.5
E71	10	0.01 - 0.5	0.01 - 0.5	< 0.01	35	> 1.5	0.01 - 0.5	< 0.01	70	> 1.5	0.5 - 1	< 0.01

The breach location chosen was on the northern Don defence very near to Power Station Road. All the sites were affected by a flood caused by a breach of the Don flood defences south of Bentley Rise (Table 3-3).

As with the overtopping results site H442 would be at high risk as a result of a breach in the Don defences with rapid flooding and deep flooding (>1m average depth). H9 would flood to a depth of 0.5-1m average depth. Flooding of the other sites would be far less severe (average flood depth <0.5m), indicating that it should be possible to mitigate against this flooding through appropriate site design and layout.

Table 3-3. TUFLOW breach results for Bentley Rise sites

Site ID	100 year breach			
	% area flooded	Max. depth (m)	Avg. depth (m)	Min. depth (m)
E25	55	0.05 - 1	0.01 - 0.5	< 0.01

Site ID	100 year breach			
	% area flooded	Max. depth (m)	Avg. depth (m)	Min. depth (m)
E26	10	0.01 - 0.5	0.01 - 0.5	< 0.01
H442	100	> 1.5	1 - 1.5	0.01 - 0.5
H9	75	> 1.5	0.5 - 1	< 0.01
H389	93	0.5 - 1	0.01 - 0.5	< 0.01
H386	75	0.5 - 1	0.01 - 0.5	< 0.01
E69	2	0.01 - 0.5	0.01 - 0.5	< 0.01
H35	0	N/A	N/A	N/A
E121	0	N/A	N/A	N/A
E71	55	> 1.5	0.01 - 0.5	< 0.01

3.7.3 Stainforth

The particular sites for detailed assessment were:

H56 Stainforth, Finkle St (Housing)

H50 Stainforth, Doncaster Rd (Housing)

H486 Stainforth, Poultry Packing Station (Housing)

E51 Stainforth, Poultry Packing Station (Employment)

Hatfield-Stainforth Triangle (Employment)

All sites, apart from the Hatfield-Stainforth Triangle, have greater than ≥25% of their area flooded within the modelled undefended 100 year flood extent (SFRA Risk Map S2Q100 scenario, Map A-3), with flood depths generally <1m. Parts of the Stainforth area can be affected by tidal flooding. However, the Environment Agency NE Strategic Catchment Modelling Tool does not model tidal climate change scenarios so it was deemed inappropriate to include a climate change map for the Stainforth area as the TUFLOW 2d modelling only considers fluvial flooding.

Surface water flooding (Map C-3) would only affect parts of sites H50 and the Hatfield-Stainforth Triangle. Any flooding in these sites was generally shallow, up to 0.5m depth.

None of these sites were flooded as a result of any of the 2D TUFLOW overtopping scenarios due to the presence and height of the existing flood defences in the area. However, it should be noted that the TUFLOW model domain for the Stainforth area was adapted slightly to allow some water to leave the model domain to the east based on the natural land gradient rather than being retained within 'glass walls' and increasing flood depths locally. This was seen to be a more realistic representation of the very low and flat land surface in this area.

Under the breach scenario the southern Don defences were breached in at a point just to the north of Stainforth (Map X – 1). The pattern of flooding is very much controlled by the very low and flat nature of the land surface in this area forcing the water the move eastwards and southwards. The flow of water past both the raised railway line and the M18 motorway is affected by the presence, number, location and size of the openings and culverts through these embankments. Flood water will affect residential areas of eastern Stainforth and northwest Hatfield.

All the sites, except H50, were affected by the breach scenario with an average flood depth of 0.5m for sites H486 and E51; and 0.5m-1m for sites H56 and the Hatfield Triangle (

Table 3-4), indicating that some appropriate development might be possible through careful site layout and design. Flood water from the breach moves quickly eastwards and southwards from the Don to reach the M18 motorway embankment. Because there are only a few small openings in this embankment the water cannot flow further eastwards freely and as a result it is then forced to pool in all the local topographic depressions, including the Hatfield-Stainforth Triangle. The pattern of flooding in the Stainforth area under this scenario is far more extensive than the undefended situation (S2Q100, Map A-3) because in the undefended situation a large volume of flood water would get onto the floodplain (both north and south of the Don) thereby reducing the flood extent in the Stainforth area. The flood water would also inundate the railway line and disrupt the rail network in this area.

Table 3-4. TUFLOW breach results for Stainforth sites

Site ID	100 year breach			
	% area flooded	Max. depth (m)	Avg. depth (m)	Min. depth (m)
H56	99	1 – 1.5	0.5 - 1	0.01 - 0.5
H50	0	N/A	N/A	N/A
H486	91	0.5 - 1	0.01 – 0.5	< 0.01
E51	91	0.5 - 1	0.01 – 0.5	< 0.01
Hatfield-Stainforth Triangle	75	> 1.5	0.5 – 1	< 0.01

3.7.4 Moorends

The particular sites for detailed assessment were:

H201 Moorends, Bloomhill Rd (Housing)

H21 Moorends, Marshland Rd (Housing)

E54 Moorends, adj. Dutchman (Employment)

H179 Moorends, North Common 2a (Housing)

All sites have greater than ≥25% of their area flooded within the modelled undefended 100 year flood extent (SFRA Risk Map S2Q100 scenario, Map A-2), though flood depths are generally low (<0.5m). The Moorends area can also be affected by tidal flooding. However, the Environment Agency NE Strategic Catchment Modelling Tool does not model tidal climate change scenarios so it was deemed inappropriate to include a climate change map for the Moorends area as the 2d TUFLOW modelling only considers fluvial flooding.

Surface water flooding (Map C-2) would not affect any of the sites.

Both H201 and H21 were not flooded in any of the 2D TUFLOW overtopping or breach modelling scenarios as they are protected by the railway embankment immediately to the west of them. This outcome considerably lowers the residual risk at these sites.

Sites E54 and H179 were not flooded at all for the three overtopping scenarios from the Don. However, following a breach of the River Don defences to the west of Moorends both these sites would be flooded (Table 3-5). Site E54 would be flooded to considerable depth, with an average flood depth of about 1.5m, making it a high risk site. Site H179 would experience much shallower flooding (0.01-0.5m average depth) and raising floor levels (for example) would negate this risk across much of the area.

Table 3-5. TUFLOW breach results for Moorends sites

Site ID	100 year breach			
	% area flooded	Max. depth (m)	Avg. depth (m)	Min. depth (m)
H201	0	N/A	N/A	N/A
H21	0	N/A	N/A	N/A
E54	100	> 1.5	> 1.5	0.5 - 1
H179	55	1 - 1.5	0.01 - 0.5	< 0.01

3.7.5 Carcroft Common/Adwick-le-Street

The particular sites for detailed assessment were:

E134 Carcroft Common – Extension (Employment)

E115 Carcroft Common (Employment)

E95 Carcroft Common North (Employment)

H87 Adwick-le-Street, Church Street (Housing)

E40 Adwick-le-Street, The Park (Employment)

This part of Ea Beck benefits from a formal flood warning service and is generally well defended. All the sites have greater than ≥50% of their area flooded within the modelled undefended 100 year flood extent (SFRA Risk Map S2Q100 scenario, Map A-5) and there are areas of considerable deep flooding (>2m) in all the sites. Sites H87 and E40 are the worst affected with the entire site flooded to an average depth of 1-1.5m. Site E134 is the least affected with only 50% of the area flooded, with an average flood depth of 0.5-1m.

Under the S2Q100 + climate change scenario the flood extents did not change much within the development sites, only the depth of flooding in some areas really changed (Map B – 5). The two sites that were most affected were E115 and E95, with larger areas of deep flooding (mean flood depth >1.5m). Given the overall size of these development areas it may be possible through appropriate site design and layout to avoid placing any vulnerable areas within the areas that may experience the deeper flooding.

Surface water flooding could affect all of the sites (Map C – 5). Sites E40 and H87 would be worst affected with potentially deep water (1-1.5m mean depth) in a sink (depression) area along the south eastern boundary. Site E134 would have some deeper flooding (0.5-1m mean depth) in the north of the area, whereas any flooding in E95 and E115 would be shallow (generally less than 0.5m mean depth)

An existing hydraulic model of Ea Beck was also used to look at the defended 100 year flood outline. This shows that only H87 and E40 would be affected in this scenario, with mean flood depths in excess of 1.5m. These results suggest that any non-water compatible development in sites H87 and E40 would not seem to be an appropriate development type in this location. At all the other sites appropriate development behind the existing defences in this area should be possible through careful site layout and design.

4 SUMMARY OF FLOOD RISK IN STRATEGIC DEVELOPMENT AREAS

4.1 Flood Risk

Flood risk within the Doncaster MBC area is a complicated issue. As discussed in the Level 1 SFRA report and investigated in detail above there are a number of sources and levels of flood risk across the area. Flooding from the River Don and its tributaries provides the highest risk, both in terms of defences overtopping or breaching during larger events, while surface runoff is also an important issue is many parts of the area. Flood risk is discussed below with relevance to specific development areas identified with Doncaster MBC as requiring Exception Testing.

4.2 Mexborough (Pastures Road) and the former Earth Centre

Sites E112, E20 and H414 all occupy high flood risk land on the Don floodplain (including the highest risk functional floodplain, FZ3b). The floodplain in this area is closely confined between two significant physical barriers, i.e. the Sheffield & South Yorkshire Navigation/Mexborough New Cut to the north and the railway line to the south. Any water either overtopping or breaching through the Don embankments in this area would very quickly enter the proposed development areas here and inundate them to a considerable depth. Therefore, the residual flood risks in these three areas (especially for housing developments), including access/egress issues for both people and emergency services during flood events, are considerable and would require careful attention in a detailed site specific flood risk assessment.

For sites E27 and H338 any water overtopping or breaching the south bank of the Dearne defences in this area and flowing south-south east would be trapped between the defences and Pastures Road. Some of this flood water could potentially reach the northern edge of these sites. Both these sites, together with H120 have ≥40% of their land area within the functional floodplain (FZ3b), which could significantly affect their potential for non-water compatible development types.

4.3 Bentley Rise

Of these sites, H35 was not flooded in any of the 2D TUFLOW overtopping or breach modelling scenarios, as it is too far north of the River Don and also north of Swaith Dyke that is also well defended. However, H35 would be at high residual risk of flooding from overtopping or breaching to North Swaith Dyke, another defended watercourse which borders this area.

The most at risk site in Bentley Rise is H442 with an average flood depth in excess of 1m for all the defence overtopping scenarios. The location of this site between the River Don to the south and the railway embankment to the north means that if the river did overtop its banks then the water would rapidly inundate the site and to a considerable depth. The other sites all have average flood depths of less than 1m for all the scenarios. Of the sites that flooded H389 and H386 had the lowest risk of flooding due to overtopping.

Non-water compatible developments in sites E69 and E26 are not appropriate as both these sites are wholly within the functional floodplain (FZ3b).

As with the overtopping results site H442 would be at high risk as a result of a breach in the Don defences with rapid flooding and deep flooding (>1m average depth). H9 would flood to a depth of 0.5-1m average depth. Flooding of the other sites would be far less severe (average flood depth <0.5m), indicating that it should be possible to mitigate against this flooding through appropriate site design and layout.

4.4 Stainforth

None of these sites were flooded as a result of any of the 2D TUFLOW overtopping scenarios due to the presence and height of the existing flood defences in the area.

All the sites, except H50, were affected by the breach scenario with an average flood depth of up to 0.5m for sites H486 and E51; and 0.5m-1m for sites H56 and the Hatfield Triangle, indicating that

some appropriate development might be possible through careful site layout and design. Flood water from the breach moves quickly eastwards and southwards from the Don to reach the M18 motorway embankment. Because there are only a few small openings in this embankment the water cannot flow further eastwards freely and as a result it is then forced to pool in all the local topographic depressions, including the Hatfield-Stainforth Triangle.

The Environment Agency Stainforth Flood Alleviation scheme, completed in November 2009, has reduced the risk of flooding due to breach occurrence to a residual risk level. The scheme has consisted of replacement of poor condition defences with new piled wall defences at Stainforth. The risk of flooding due to overtopping from the River Don is below a 1% annual exceedance probability. Flows in excess of this probability are accommodated by the overspill into rural land on the opposite bank, as intended by the original design of the Lower Don defence system.

Land drainage of the Hatfield/Stainforth area predominately consists of pumping arrangements, that eventually discharge by pumping into the River Trent. The Isle of Axholme Flood Risk Management Strategy, being undertaken by the Environment Agency, has identified an issue with the long term sustainability of this system. Although work for this Strategy is ongoing, solutions for surface water management need to be sought to alleviate this problem.

4.5 Moorends

Both H201 and H21 were not flooded in any of the 2D TUFLOW overtopping or breach modelling scenarios as they are protected by the railway embankment immediately to the west of them. This outcome considerably lowers the residual risk at these sites.

Sites E54 and H179 were not flooded at all for the three overtopping scenarios from the Don. However, following a breach of the River Don defences to the west of Moorlands both these sites would be flooded. Site E54 would be flooded to considerable depth, with a mean flood depth of about 1.5m, making it a high risk site. Site H179 would experience much shallower flooding (0.01-0.5m average depth) and site layout and design (such as raising floor levels) would negate this risk across much of the area.

4.6 Carcroft Common/Adwick-le-Street

This area of the Ea Beck network is generally well defended. However, the existing 1D hydraulic model of the network in this area shows that sites H87 and E40 are at considerable risk of deep flooding (>1.5m mean depth) due to the overtopping of defences during the 100 year event. These two development sites are also at risk of surface water flooding. Therefore, development of a non-water compatible type in these two sites would not be deemed appropriate. The other sites appear to have areas where appropriate development (i.e. employment) could take place through suitable site layout and design.

5 FLOOD MANAGEMENT OPTIONS AND LAND USE

5.1 Exception Testing

SFRAs are undertaken at two levels. A scoping exercise is undertaken initially, and the original SFRA for the Doncaster MBC area has collated where the major risk issues are. Where for reasons of sustainable development flood risk cannot be avoided by allocating in lower flood risk zones a more detailed strategic assessment is required. This is the purpose of this report.

Essentially, these assessments look at not just an individual plot but at the wider spatial issues into which development is planned. They are primarily focussing on:

- Will the development be safe?
- Can all the risks be designed out and can the residual risks to people and property be managed by an emergency plan, or by limiting the type of land use?
- Will the site be deliverable? This involves a review of economic and design aspects, together with an understanding of how complicated the assessment will need to be and how "exceptional" the development would need to be.
- How well does the development fit with the current mix of land uses in the area and the future provision of flood management measures?
- Can the development help reduce flood risk to other areas or will it require further more expensive provision of flood defence infrastructure?

These are all elements that will need to be considered in the delivery of the Exception Test, but an SFRA needs to be suitably precautionary, applying a longer term holistic approach to ensuring development does not compromise future flood management measures and *vice versa*. The Exception Test is not black and white, and needs to assess the acceptability of the residual risks. Where the residual risks are significant it is unlikely that further investment would exceptionally be justified, particularly if it introduces significantly more people into the flood risk area.

To provide this longer term view to spatial planning in flood risk areas a number of indicators have been developed (as detailed in the Level 1 report) to allow a comparison of the appropriate land uses in each development area and how they would fare within the PPS25 Exception Test. These indicators are as follows:

Development is within existing flood risk area – existing flood warning and evacuation in place. Importantly, how easily will the area recover following an event. New development may lose local services for up to 12 months should an event occur.

Residual risk measures are easily applied and within a norm – Low depths of flooding can be easily designed out by modest alteration of ground or floor levels. 1st floor accommodation has implications for the urban design and place setting of the development.

Egress and access. Impact on emergency planning provision and whether development would be safe – This is a key issue and prime test in the PPS25 Exception Test. Access routes need to be natural and accessible to the emergency services during a flood.

Change in the number of people at risk as result of development – Introduction of more people will put a greater strain on the emergency services in a major flood event. Whilst they may be accommodated at high elevation they will require support very quickly even after the inundation has stopped.

Change in number of properties at risk in 1% and 0.1% event before and after. Assumes mitigation measures put in place – From an economic viewpoint development can replace existing property with lower vulnerability land uses and also development that is designed to be flood resistant or resilient. A reduction in economic risk can be achieved.

Scale and nature of flood risks – The SFRA risk maps indicate likely depths and flow routes. From running the surface water screening assessment the scale and extent of the surface water

flood risks can be considered.

Impact of mitigation measure on other areas – Any mitigation measure needs to be assessed in terms of the possible impacts both upstream and downstream of the development.

This simple assessment would allow a sequential approach to be delivered against flood risk criteria and a hierarchy of recommended land uses delivered. This would support appropriate policies and land use allocations within the Doncaster MBC area. This would provide some evidence for the Local Planning Authority (LPA) in reviewing any subsequent planning applications that decide to use the Exception Test to justify the need for alternative land uses in these areas, and also will avoid the need for a Sequential Test for any of the recommended land uses in these Flood Zone areas in order to satisfy the LPA and EA.

It should be noted that a detailed site specific Flood Risk Assessment (FRA) will always be required for almost all new development (as clearly defined in PPS25), but would need to follow the guidance given in Section 6 below.

Table 5-1. Sequential approach to proposed land use and strategy for flood risk management

Develoment area	Proposed land use	Flood risk indicators adopted as measure of Acceptability *(-ve indicates flood risk is unacceptable or results in difficulty of delivery of a site)* See Table 5.2							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**Recommendation**
		Development is within existing flood risk area	Residual risk measures are easily applied and within a norm	Egress and access. Impact on emergency planning provision and whether development would be safe	Change in the number of people at risk as result of development	Change in number of properties at risk in 1% and 0.1% event before and after. Assumes mitigation measures put in place	Scale and nature of flood risks.	Impact of mitigation measure on other areas d/s and adjacent	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended **Sequentially not preferred, where limited land uses maybe possible** **Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA **Acceptable with some detailed consideration of flood risk issues in FRA** **Acceptable** subject to FRA
Mexborough/ Earth Centre									
E27	Employment	-	+	-	-	+	-	=	**Acceptable with some detailed consideration of flood risk issues in FRA**
H338	Housing	--	-	-	-	-	--	-	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended
E112	Employment	-	--	--	-	-	--	-	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended
H414	Housing	-	--	--	-	-	--	-	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not

Develoment area	Proposed land use	Flood risk indicators adopted as measure of Acceptability *(-ve indicates flood risk is unacceptable or results in difficulty of delivery of a site)* SeeTable 5.2							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**Recommendation**
		Development is within existing flood risk area	Residual risk measures are easily applied and within a norm	Egress and access. Impact on emergency planning provision and whether development would be safe	Change in the number of people at risk as result of development	Change in number of properties at risk in 1% and 0.1% event before and after. Assumes mitigation measures put in place	Scale and nature of flood risks.	Impact of mitigation measure on other areas d/s and adjacent	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended **Sequentially not preferred, where limited land uses maybe possible** **Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA **Acceptable with some detailed consideration of flood risk issues in FRA** **Acceptable** subject to FRA
									recommended
E20	Employment	-	--	--	-	-	--	-	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended
H120	Housing	-	+	-	-	+	-	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
Bentley Rise									
E25	Employment	-	+	-	-	-	-	=	**Acceptable with some detailed consideration of flood risk issues in FRA**
E26	Employment	--	-	-	-		--	-	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended
H442	Housing	--	--	--	-	-	--	-	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not

Develoment area	Proposed land use	Flood risk indicators adopted as measure of Acceptability *(-ve indicates flood risk is unacceptable or results in difficulty of delivery of a site)* SeeTable 5.2							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**Recommendation**
		Development is within existing flood risk area	Residual risk measures are easily applied and within a norm	Egress and access. Impact on emergency planning provision and whether development would be safe	Change in the number of people at risk as result of development	Change in number of properties at risk in 1% and 0.1% event before and after. Assumes mitigation measures put in place	Scale and nature of flood risks.	Impact of mitigation measure on other areas d/s and adjacent	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended **Sequentially not preferred, where limited land uses maybe possible** **Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA **Acceptable with some detailed consideration of flood risk issues in FRA** **Acceptable** subject to FRA
									recommended
H9	Housing	--	--	-	-	-	--	-	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended
H389	Housing	-	-	-	-			=	**Sequentially not preferred, where limited land uses maybe possible**
H386	Housing	-		-	-				**Sequentially not preferred, where limited land uses maybe possible**
E69	Employment	--	-	-	-	-	--	-	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended
H35	Housing	-	-	-	-	-	-	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
E121	Employment	-	-	-	-	+	-	=	**Acceptable with some detailed consideration of flood risk issues in FRA**

Develoment area	Proposed land use	Flood risk indicators adopted as measure of Acceptability *(-ve indicates flood risk is unacceptable or results in difficulty of delivery of a site)* See Table 5.2							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**Recommendation**
		Development is within existing flood risk area	Residual risk measures are easily applied and within a norm	Egress and access. Impact on emergency planning provision and whether development would be safe	Change in the number of people at risk as result of development	Change in number of properties at risk in 1% and 0.1% event before and after. Assumes mitigation measures put in place	Scale and nature of flood risks.	Impact of mitigation measure on other areas d/s and adjacent	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended **Sequentially not preferred, where limited land uses maybe possible** **Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA **Acceptable with some detailed consideration of flood risk issues in FRA** **Acceptable** subject to FRA
E71	Employment	-	-	-	-	+	-	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
Stainforth									
H56	Housing	-	-	-	-	-	-	=	**Sequentially not preferred, where limited land uses maybe possible**
H50	Housing	-	-	-	-	+	=	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
H486	Housing	-	-	-	-	-	-	=	**Sequentially not preferred, where limited land uses maybe possible**
E51	Employment	-	-	-	-	+	=	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
Hatfield Triangle	Employment	-	-	-	-	-	--	-	**Sequentially not preferred, where limited land uses maybe possible**
Moorends									

Develoment area	Proposed land use	Flood risk indicators adopted as measure of Acceptability *(-ve indicates flood risk is unacceptable or results in difficulty of delivery of a site)* See Table 5.2							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**Recommendation**
		Development is within existing flood risk area	Residual risk measures are easily applied and within a norm	Egress and access. Impact on emergency planning provision and whether development would be safe	Change in the number of people at risk as result of development	Change in number of properties at risk in 1% and 0.1% event before and after. Assumes mitigation measures put in place	Scale and nature of flood risks.	Impact of mitigation measure on other areas d/s and adjacent	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended **Sequentially not preferred, where limited land uses maybe possible** **Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA **Acceptable with some detailed consideration of flood risk issues in FRA** **Acceptable** subject to FRA
H201		-	+	-	-	+	-	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
H21		-	+	-	-	+	-	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
E54		-	+	-	-	+	--	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
H179		-	+	-	-	+	-	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
Carcroft Com/ Adwick-le-St									
E134	Employment	-	-	-	-	=	=	=	**Acceptable with some detailed consideration of flood risk issues**

Develoment area	Proposed land use	Flood risk indicators adopted as measure of Acceptability *(-ve indicates flood risk is unacceptable or results in difficulty of delivery of a site)* SeeTable 5.2							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**Recommendation**
		Development is within existing flood risk area	Residual risk measures are easily applied and within a norm	Egress and access. Impact on emergency planning provision and whether development would be safe	Change in the number of people at risk as result of development	Change in number of properties at risk in 1% and 0.1% event before and after. Assumes mitigation measures put in place	Scale and nature of flood risks.	Impact of mitigation measure on other areas d/s and adjacent	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended
									Sequentially not preferred, where limited land uses maybe possible
									Sequentially not preferred but a range of land uses could be put forward after careful consideration and FRA
									Acceptable with some detailed consideration of flood risk issues in FRA
									Acceptable subject to FRA
									in FRA
E115	Employment	-	-	-	-	=	-	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
E95	Employment	-	-	-	-	=	-	=	**Sequentially not preferred** but a range of land uses could be put forward after careful consideration and FRA
H87	Housing	-	--	-	-	-	-	=	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended
E40	Employment	-	--	-	-	-	-	=	**Counter** to strategic approach, flood risk unacceptable. Exception Test would be difficult to pass. Not recommended

Table 5-2. Key to scoring system used in review of acceptability

Indicator						
A	**B**	**C**	**D**	**E**	**F**	**G**
+= no risk **-** = risk area within resilient communities **--** = vulnerable community, which would struggle to recover – reverse upward trend	**++**= None required **+** = Measures could reduce risk to existing development **-** =standard, no major alteration to layout and form **--** = flood resistance is dominant in design	**+** = no special provisions, safe **-** = needs to be managed, should be safe, must be proven in FRA **--** = special provision, natural response will not be obvious. Safety not guaranteed, and may not convince LPA/EA	**+** = reduction **-** = increase	**+** = reduction (preferable outcome in PPS25) **-** = increase	**+ +** =Benign, and understood **--** = difficult to warn, unpredictable, may result in operational failure of defences, from multiple sources	**+** = reduction **=** neutral impact **-** = inc in flood risk elsewhere (Exception test requires no impact)

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6 FRA RECOMENDATIONS

6.1 Introduction

In accordance with current planning guidance, the planning process encourages only appropriate development in areas vulnerable to flooding. This includes adopting a precautionary approach to decisions based on estimates of the present and future impact of flood risks.

Whilst the Level 1 SFRA focused on delivering a strategic assessment of flood risk within the Doncaster MBC area, this Level 2 SFRA has gone one step further in investigating the residual risks associated with strategic development areas and their vulnerability to other sources of flooding, including surface water run off.

This SFRA has strengthened the need for a site specific flood risk assessment even where the development is defended by the recent EA scheme.

A general FRA guidance for developers was supplied within the Level 1 SFRA, which must be referred to. Elements of the FRA guidance are outlined below:

- Appropriate land use in flood risk areas
- Undefended areas – Flood risk mitigation
- Defended areas
- Overtopping
- Breaching
- Public Safety and rapid inundation
- Feasibility of flood risk mitigation

Using the information supplied by both levels of SFRA there are a number of key flood risk issues which should be included in a FRA for any development in Doncaster MBC.

6.2 Assessment of Fluvial and Tidal Flood Risk

As discussed, the Rivers Don and Lower Trent (with their tributaries) provide the main source of fluvial risk to the Doncaster MBC area. However, parts of the Doncaster MBC area are also at risk from tidal flooding, though this is considered to be of lesser significance to the fluvial risk when considering flood defence overtopping or failure (breach) scenarios. While the main rivers are generally well defended, there is still the need to consider the residual risks.

As noticed within this assessment a 1D hydraulic model will not be detailed enough to fully assess the flood risk throughout Doncaster MBC area. The River Don has a 1D ISIS fluvial model but this must be combined with a 2D model to assess the residual risks associated with the flood defences for any site within the floodplain, not only to gain an accurate representation of flood depths and velocities but also the potential impact the development will have on current overland flow routes. Defence overtopping and breaching scenarios are advised for site specific FRAs.

Some on-going Environment Agency strategies will be providing more detail on the flood risk from the Lower Trent within the Doncaster MBC, which is not currently available, and this can be incorporated into a future review of Doncaster SFRA.

6.3 Surface Water Assessments

As outlined within the Level 1 SFRA there are a number of important locations in Doncaster MBC area where surface water (derived from direct rainfall inputs) could provide a significant source of flood risk. This SFRA has identified a number of key areas within the borough where past events, the presence of defences, culverts and significant flows paths mean that surface water assessments will be a crucial part of a site specific FRA. In general, it has been concluded from the screening exercise that the Flood Zone map is heavily indicative of the likelihood of surface

water flooding. Flat floodplains adjacent to rivers are generally susceptible to many forms of flooding, and protection from the fluvial source does not reduce or remove the other as significant sources.

While the general approach is to control the surface water originating on the development site, it has to be noted that where developments are located over identified flow paths then the development proposals must also incorporate their impact on surface water originating further afield into their mitigation plans.

An integrated approach to controlled surface water drainage (through the development of Surface Water Management Plans) can also lead to a more efficient and reliable surface water management system as it enables a wider variety of potential flood mitigation options to be used. Doncaster MBC is actively addressing the Surface Water Management issues within the borough.

6.4 Emergency Planning

Much of the Doncaster MBC main river system is defended with these defences being maintained by the Environment Agency and Internal Drainage Boards into the future. However, residual risks, as discussed earlier in this assessment, are still present. Defences heights are finite and there is always the risk that a very large event will occur to overtop or breach them, stressing the importance of alternative solutions in reducing the flood risk to people and property lying behind them.

The difficulties associated with safe access and egress in parts of the Doncaster MBC area means that appropriate emergency planning must be incorporated into any flood management proposals for further development within the borough. Emergency planning can be a crucial tool in reducing the residual risk to both people and property. Current flood response plans must be considered if development is going to place a greater number of people in areas of high risk whether the actual risk can be managed or not.

7 CONCLUSIONS

7.1 Conclusions

This document has been produced to support the earlier Level 1 Strategic Flood Risk Assessment by providing a detailed investigation into sources, pathways and receptors of flood risk within the Doncaster MBC area. Together, these documents will assist the Local Development Framework (LDF) and the policies and proposals produced for the development and use of land within Doncaster MBC area.

To better understand the residual flood risks with the borough, detailed 1D-2D modelling was used to assess the impacts of both overtopping and failure (breach) of the existing flood defences. Surface water modelling was also undertaken to assess the wider impacts of flash flooding within the borough. This process has allowed the SFRA to increase its scope to identifying flood risk areas outside of the undefended Environment Agency Flood Zone Maps.

The general findings from this SFRA are outlined below:

- Doncaster MBC area is at risk from flooding from a number of fluvial and tidal flood sources, including defence overtopping and failure. It is also vulnerable to surface water flooding.
- Certain areas are at risk from deep fast flowing water during the overtopping or failure of flood defences in larger events.
- Surface water flooding is clearly an on-going issue in parts of Doncaster MBC area (as experienced during the severe Summer 2007 floods) and the council is currently actively addressing this in the most vulnerable areas.
- A proper appreciation of access and egress issues and emergency planning will be important to a number of the proposed strategic development areas.

The findings of this SFRA will provide the evidence base for Doncaster MBC to apply the Exception Test to the sites/areas identified for development. It will also help the implementation of a sequential approach towards allocation and planning individual sites/areas within the borough.

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MAPS