Strategic Flood Risk Assessment

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Strategic Flood Risk Assessment

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Capabilities on project:
Water

Executive Summary

Introduction
The original Boston Strategic Flood Risk Assessment Report (SFRA) was published in November 2002 and has subsequently been used to inform the Council's planning policies.

In August 2005 the Environment Agency entered into discussions with Boston Borough Council and agreement was reached on the need for a revised and updated SFRA which would be used to inform the Core Strategy of the Borough Council's Local Development Framework.

The revised study would be undertaken in accordance with the provisions of Planning Policy Statement 25, (PPS25).

This revised SFRA is organised into the Level 1 and Level 2 divisions in PPS25. The Level 1 is an assessment of the Boroughs area based on the Environment Agency Flood Zones and includes further information on the Flood Hazard, should a breach occur in the defences, and the Relative probability of flooding. The Level 2 SFRA is a more detailed analysis of the flooding issues from those additional pieces of information where normally significant development might be expected to occur over the next five to ten years.

The more detailed assessment of flood risk in Level 2 SFRA will help inform the Exception Test and the Borough Council have nominated ten study areas for a Level 2 SFRA

Development Planning
The most recent Regional Spatial Strategy for the East Midlands (RSS8) was published in March 2009 as the East Midlands Regional Plan and it provided a broad development strategy for the East Midlands up to 2026. The plan had taken account of PPS3 and identified the housing provision for each Housing Market Area (HMA) together with the Borough based provisions.

Policy 13a in the Regional Plan allocated provision of new housing between individual Local Planning Authority, (LPA), areas for the period between 2006 and 2026.

However, at the strategic level the Government revocation of regional plans will increase reliance on a more locally orientated plan making approach. The Secretary of State has stated that housing provision figures contained or proposed in the former regional plans need not apply unless supported locally and future housing supply will be decided at the local level. Unnecessary building in areas of high flood risk should also be prevented.

Level 1 SFRA
The SFRA is at the core of the PPS25 approach. It provides the essential information on flood risk, taking climate change into account that allows the Borough Council to understand the risk across its area so that the Sequential Test can be properly applied.

A level 1 SFRA should be sufficiently detailed to allow the application of the Sequential Test and to identify whether development can be allocated outside high and medium flood risk areas, based on all sources of flooding, or whether the application of the Exception Test is necessary.

Causes of Flooding
The main causes of flooding are described in detail in the report and include overflowing of watercourses, breaching of embankments, mechanical, structural or operational failure, floodlocking and tidelocking and localised flooding.

Sources of Flooding
The Borough of Boston is situated in the Lincolnshire fens, at the downstream end of the River Witham. The Borough straddles the low silt ridge that runs parallel with the western shores of the Wash, separating the Wash from the extensive peat fens on the inland side of the ridge. Boston itself and most of the older village settlements in the Borough are situated along this ridge.

Within Boston Borough flooding could be associated with the River Witham, the South Forty Foot Drain and the East and West Fen Catchwaters / Stonebridge Drain system. Flooding could occur within the pump-drained areas of the South Forty Foot Fens, Holland Fen, and the East, West and Wildmore Fens due to pump failure.

Flood Risk Management

Whilst the Flood Zones, (FZ), ignore the presence of any formal defences there are a number of flood risk management measures in place in the Borough to reduce the level of flood risk. How the flood risk is being managed is considered so that the level of risk is understood.

Sequential Test

PPS25 states that the risk-based Sequential Test should be applied at all stages of planning and the FZs are the starting point for the sequential approach. Where there are no reasonably available sites in FZ 1 decision makers allocating land in spatial plans should take into account the flood risk vulnerability of land uses and consider sites in FZ 2. Only where there are no sites available in FZs 1 and 2 should they consider the suitability of sites in FZ 3, applying the Exception Test if required.

On inspection of the Environment Agency FZs it is apparent that the majority of the Borough Council's area is within FZ3 and in order to assist the Borough Council apply the Sequential Test two additional sets of maps have been produced covering all of their Borough

These two sets show:

- Flood Hazard Zone - should a breach occur in the raised defences taking climate change into account.
- Relative Probability of Flooding - given the presence of the defences.

Flood Hazard Zones

In a major flood event, where a river is confined within flood defences there may be an appreciable difference between the water level on one side of the flood defence and the ground level in the defended area behind that defence. If that defence were then to fail, whether through the collapse of a floodwall or the breaching of an embankment, there would be a sudden inrush of flood water into the defended area. The velocity and depth of water cascading through the breach could, initially at least, be sufficiently great to sweep people off their feet resulting in their death by injury or drowning.

As flood water pours through a breach it will fan out across the hinterland behind the defences, and its velocity and depth will both decrease with distance from the breach. This will be determined by the flood level / ground level difference (head of water), the width of the breach, and the land surface topography behind the breach. PPS25 and its Practice Guide specify the determination of a Rapid Inundation Zone and also refer to Flood Risk in Assessment Guidance for New Development Phase 2 R & D Technical Report FD2320.

For this SFRA the four Flood Hazard zones as referred to in FD2320 will be used as follows:

- Low Hazard, (Hazard Zone 4 in the Lincolnshire Coastal Study)
- Danger for Some, (Hazard Zone 3 in the Lincolnshire Coastal Study)
- Danger for Most, (Hazard Zone 2 in the Lincolnshire Coastal Study)
- Danger for All, (Hazard Zone 1 in the Lincolnshire Coastal Study)

Hazard Zones in specific study areas are a major component of a Level 2 SFRA

Capabilities on project:
Water

Relative Probability of Flooding

The relative probability of flooding has been based upon the results of the hydraulic modelling of 1%, (1 in 100-year) and 0.1%, (1 in 1000-year), flood events in the principal fluvial flood risk sources and hydraulic modelling of the 0.5%, (1 in 200-year) and 0.1%, (1 in 1000-year), tidal flood events in the Wash and Boston Haven.

Flooding was assumed to occur when a flood defence was overtopped. If the defence was an earth embankment then breaching was automatically assumed to follow, as indicated in the analysis in the Environment Agency Wash Banks Strategy 1997. The resultant flood envelope at any point was derived from two-dimensional hydraulic modelling of the passage of the flood wave across the defended area in the hinterland behind the breached or overtopped flood defence. To obtain the continuous flood envelope behind a defence line the modelling process was repeated at numerous points along the defence line.

The results of the modelling therefore show the relative probability of land flooding with the defences in place as follows:

- Low Probability
- Medium probability
- High Probability

Exception Test

PPS25 states that the Exception Test should be applied, only after the Sequential Test, to Local Development Documents site allocations for development and used to draft criteria-based policies against which to consider planning applications.

For the Exception Test to be passed:

a) It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared. If the Development Plan Document has reached the 'submission' stage the benefits of the development should contribute to the Core Strategy's Sustainability Appraisal;

b) The development should be on developable, previously-developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously-developed land; and

c) A Flood Risk Assessment must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Boston Borough Council have identified those parts of the Borough where normally development might be expected to occur over the next five to ten years and therefore where a more detailed assessment of the flood risk is required.

This detailed assessment is based on the Hazard and Relative Probability of Flooding maps and other information.

Level 2 SFRA

PPS25 states that where it is not possible to allocate all proposed development in accordance with the Sequential Test, taking into account the flood vulnerability category of the intended use, it will be necessary to increase the scope of the SFRA to provide information necessary for the application of the Exception Test..

The PPS25 FZs are based on the probability of river and sea flooding to which an area of land is currently subject, ignoring the presence and effect of existing flood defences or other man-made obstructions to flood flows

However, areas within the High Probability Zone (FZ 3), on fluvial or tidal floodplains, may have a standard of protection, due to established flood defences or their location within the floodplain, which reduces their probability of flooding. This degree of flood risk to which these areas are subject may well be significantly less than the PPS25 FZ, provided that those defences are maintained at their current standard of protection.

There is still a residual risk of flooding should the defences breach and this is represented as the Flood Hazard.

The reduced probability of flooding, allowing for the defence, is called Relative Probability of Flooding.

Potential development areas in different parts of FZ 3 may be at different level of flood risks, particularly in an area with flood defences. However, whilst the probability of fluvial flooding may well be less than 1%, (1 in 100 years), because of the defences, the area will still fall within FZ 3. In order to apply the sequential approach to areas within the FZs the LPA will need to rank development according to flood risk.

To give full benefit to the Borough Council's planners, any assessment of flood risk within the study areas identified as being possible locations for potential development will provide an evaluation of the Flood Hazard for the year 2115 and the Relative Probability of Flooding today over the whole of those study areas.

This will enable the Council to apply the Sequential Approach required by PPS25, both as regards the variation of flood risk within a study area and also for the practical purpose of ranking areas within FZs 2 and 3.

Study Areas

The degree of flood risk throughout each of the ten study areas has been assessed from a combination of factors, sources of information and engineering judgment. The detailed assessment of flood risk in the study areas is based on the predicted level of risk in 2115, allowing for the impacts of climate change and further detailed information on flooding is available from the Environment Agency.

Flood risk sources considered in the assessment include all open watercourses (rivers, streams, canals, arterial drains and riparian drains) and, where applicable, principal surface water and combined (foul + surface water) sewers. Possible flooding from foul sewers is not included in the assessments as this can occur from a variety of causes, often with no direct or quantifiable relationship to extreme rainfall events. Flooding from groundwater and canals is of no relevance in the Boston area.

The risk of flooding of a development site is not the only consideration. The potential increased flood risk posed by the urbanisation of a "greenfield" development site to other areas downstream of the development site also has to be evaluated. This risk can arise not only from the additional runoff volumes and higher peak runoff rates generated by newly impermeable areas but also from the reduction in natural floodplain storage capacity if the development takes place in a floodplain.

The individual flood risk assessments for the ten study areas will be presented in a common format under the following headings:

a) General description of the study area

b) Hydrology of the study area (including hydraulic structures etc)

c) Flood Hazard Zones, (2115), within the study area.

d) Relative Probability of Flooding, (current situation), within the Study Area.

e) Flood risks to downstream areas

Boston Town
The study area is all most entirely in flood zone 3. However there is a variation in the flood hazard from Danger to Most to Danger to All and there are areas where the probability of flooding is lower than others.

Bicker
The study area is entirely in flood zone 1, outside of the flood hazard zones and has a low probability of flooding.

Butterwick
The study area is entirely in flood zone 3 however there is a variation in the flood hazard where Danger to Most is predominant with some Danger to All areas and has a low probability of flooding.

Fishtoft
The study area is entirely in flood zone 3 however there is a variation in the flood hazard where Danger to Most is predominant with some Danger to All areas and has a low probability of flooding.

Freiston
The study area is entirely in flood zone 3 and the flood hazard is Danger to All with a small area of Low hazard and has a low probability of flooding.

Kirton
The study area is entirely in flood zone 3 and the flood hazard is Danger to Most with a small area of Low hazard and has a low probability of flooding.

Old Leake
The study area is entirely in flood zone 3 and the flood hazard is mainly Danger to All with the remainder in the Danger to Most category and has a low probability of flooding.

Sutterton
The study area is entirely in flood zone 3. However there is a variation in the flood hazard with some land in Danger to Some, with other areas outside of the hazard zones and has a low probability of flooding.

Swineshead
The study area is mainly in flood zone 1, mainly Low flood hazard and has a low probability of flooding.

Wrangle
The study area is entirely in flood zone 3 and mainly Low flood hazard with some in the Danger to Some category and has a low probability of flooding.

Guidance for Planners and Developers
The purpose of this section is to provide guidance to planners and developers on how to manage flood risk through the design of the development.

Mitigation measures should only be considered after the sequential approach has been applied to development proposals and the location of development should be in areas of lowest flood risk. Only when it has been established that there are no suitable alternative options in lower risk areas should the Exception Test be applied where appropriate. Design solutions will need to be considered to mitigate the identified flood risk and ensure Part C of the test can be passed to allow development to proceed.

A range of measures can be used to manage flood risk at development sites. Boston Borough Council will use the information in this SFRA to establish the design criteria developers will need to meet through Local Development Document, (LDD), policy.

Developers should discuss proposals at the earliest possible stage with the Boston Borough Council, Environment Agency and other key stakeholders so that design issues can be agreed and innovative design solutions considered if necessary.

Sustainable Urban Drainage

Traditional drainage is designed to move rainwater as rapidly as possible from the point at which it has fallen to a discharge point, either a watercourse or soakaway. This approach has a number of potentially harmful effects:

- Runoff from hard paving and roofing can increase the risk of flooding downstream, as well as causing sudden rises in water levels and flow rates in watercourses.
- Surface water runoff can contain contaminants such as oil, organic matter and toxic metals. Although often at low levels, cumulatively they can result in poor water quality in rivers and groundwater, affecting biodiversity, amenity value and potential water abstraction. After heavy rain, the first flush is often highly polluting.
- By diverting rainfall to piped systems, water is stopped from soaking into the ground, depleting ground water and reducing flows in watercourses in dry weather

Sustainable Drainage Systems (SUDS) include tried-and-tested techniques that are already being implemented on a range of projects and they incorporate cost-effective techniques that are applicable to a wide range of schemes.

PPS25 emphasises the role of SUDS and introduces a general presumption that they will be used. SUDS will probably feature increasingly in such guidance documents as they are revised.

As with other key considerations in the planning process incorporating SUDS needs to be considered early in the site evaluation and planning process, as well as at the detailed design stage. The use of Drainage Impact Assessments has been piloted in Aberdeen and Aberdeenshire in Scotland.

Boston Borough Council expect planning applications, whether outline or detailed, to demonstrate how a more sustainable approach to drainage is to be incorporated into development proposals, and for detailed design information to be submitted at the appropriate stage and may use planning conditions to secure the implementation of SUDS.

Conclusions

The original Boston Strategic Flood Risk Assessment Report has been used to inform the Council's planning policies.

This revised study has been undertaken in accordance with the provisions of PPS25.

Flood Zones will continue to be used by the Borough Council as the basis on which the Sequential Test is applied.

The majority of the Borough Council's area is within FZ3.

Two additional sets of maps have been produced covering their entire Borough . These maps show Flood Hazard Zones should a breach occur in the raised defences and the Relative Probability of Flooding given the presence of the defences.

Boston Borough Council identified where a more detailed assessment of the flood risk is required.

This detailed assessment has been based on the Flood Hazard Zones and Relative Probability of Flooding maps and the result for the detailed assessment of the 10 study areas shows:

- Bicker and Swineshead have the least flood risk issues including majority of land at low flood hazard.
- Wrangle and Sutterton have land in the Danger to Some category with a low probability of flooding.
- Kirton has land in the Danger to Most categories but with a low probability of flooding.
- Fishtoft, Freiston and Old Leake all have land in the Danger to All and Low categories but with a low probability of flooding.
- Butterwick has land in the Danger to All and Danger to Most categories but with a low probability of flooding.
- Boston has land in all Flood Hazard categories and ranges from high to low probability of flooding.

1 Introduction

1.1 The original Boston Strategic Flood Risk Assessment Report (SFRA) was published in November 2002 and has subsequently been used to inform the Council's planning policies.

1.2 In December 2006 the Department for Communities and Local Government issued Planning Policy Statement 25 and a revised edition was published in March 2010, ('PPS25'), Development and Flood Risk. PPS25 replaced Planning Policy Guidance Note and is supplemented by a Practice Guide.

1.3 The modelling of the flood defence breach scenarios undertaken in the original 2001/2 study had been undertaken using a one-dimensional hydraulic modelling methodology. At that time two-dimensional (2D) hydraulic modelling techniques for the analysis of flood defence breaches were still in the developmental stage. However 2D modelling techniques have become more generally available and are now routinely employed, where applicable, in strategic flood risk assessments.

1.4 Because of the advances in hydraulic modelling techniques since the publication of the original Boston SFRA Report, the Environment Agency, (EA), were keen to see the Boston SFRA updated, using a 2D modelling methodology to revise the assessment of the flood defence breach scenarios. Two dimensional breach scenario modelling requires a precise ground surface model of the land at risk of flooding, and whereas in 2002 there had been no detailed topographic map coverage (LiDAR) of the Borough available, the Agency's national programme of LiDAR surveys has since been extended to include the Boston area and LiDAR coverage of almost all of the Borough is now available, making the use of 2D breach scenario modelling feasible

1.5 In August 2005 the Environment Agency entered into discussions with Boston Borough Council and agreement was reached on the need for a revised and updated SFRA which would be used to inform the Core Strategy of the Borough Council's Local Development Framework.

1.6 The revised study would be undertaken in accordance with the provisions of PPS25.

1.7 The Environment Agency and Borough Council in consultation with AECOM, (formally Faber Maunsell), then drew up a Brief for the project. The brief was finalised in June 2006 and the five principal objectives of the project can be summarised as follows:

- Evaluate the data used in the original SFRA to ensure that the best available data is still being used.
- Use a select number of flood defence breach scenarios to re-evaluate flood risk throughout the Borough, both at present and in the year 2115.
- Assess the nature, source, depth, velocity, impact and residual risks of potential flooding within the Borough.
- Present a detailed assessment of flood risk for those parts of the Borough where significant urban development might be expected.
- Offer general conclusions as to the nature and degree of present flood risk (including any deficiencies in defence standards and physical conditions) and how the risk is likely to develop over the next hundred years.

1.8 This revised SFRA is organised into the Level 1 and Level 2 divisions in PPS25. The Level 1 is an assessment of the Boroughs area based on the Environment Agency Flood Zones and includes further information on the Flood Hazard, should a breach occur in the defences, and the Relative probability of flooding. The Level 2 SFRA is a more detailed analysis of the flooding issues from those additional pieces of information where normally significant development might be expected to occur over the next five to ten years.

1.9 The more detailed assessment of flood risk in Level 2 SFRA will help inform the Exception Test and the Borough Council have nominated Boston Town, Bicker, Butterwick, Fishtoft, Freiston, Kirton, Old Leake, Sutterton, Swineshead and Wrangle as the ten study areas.

1.11 The 2002 Boston Strategic Flood Risk Assessment and the Environment Agency's latest Flood Zones Maps have been used as the starting point for this study. These have been supplemented by other information supplied by the Borough Council, the Environment Agency, Anglian Water Services and other sources. Due consideration has also been given to the Environment Agency's guidance notes on flood risk assessment issued to Local Planning Authorities.

1.12 The Environment Agency's Flood Zones will continue to be used by the Borough Council as the basis on which the Sequential Test is initially applied to proposed developments in the Borough in accordance with PPS25.

1.13 The Flood Zone Map indicates whether a development site falls within Flood Zones 2 or 3, and gives no indication of actual flood risk within those Zones (i.e. the reduced level of risk due the presence of existing flood defences). This revised SFRA has produced two additional sets of maps to help inform the Sequential and Exception Tests.

1.14 Flood Hazard Maps and Relative Probability of Flooding Maps are described in Sections 8 and 9 respectively.

1.15 The methodologies used to carry out the revision and updating of the SFRA and the individual flood risk assessments for the study areas, together with the results obtained, are described in detail in this study together with more detailed and larger scale flood risk plans for each study area.

1.16 The SFRA has considered the impact of climate change to 2115.

1.17 This Report should be seen as an updated and revised version of the original 2002 SFRA Report.

2 Development Planning

East Midlands Regional Spatial Strategy

2.1 The most recent Regional Spatial Strategy for the East Midlands (RSS8) was published in March 2009 as the East Midlands Regional Plan and it provided a broad development strategy for the East Midlands up to 2026. The plan had taken account of PPS3 and identified the housing provision for each Housing Market Area (HMA) together with the Borough based provisions.

2.2 Policy 13a in the Regional Plan allocated provision of new housing between individual Local Planning Authority areas for the period between 2006 and 2026. Boston Borough Council is part of the Coastal Lincolnshire HMA as shown in Table 1 below.

Coastal Lincolnshire HMA	Annual Apportionment From 2006	Total Housing Provision 2006-2026
Boston	270	2,700
East Lindsey	560	6,000

Table 1 - Future Housing Provision in the Coastal Lincolnshire HMA

2.3 However, at the strategic level the Government revocation of regional plans will increase reliance on a more locally orientated plan making approach. The Secretary of State has stated that housing provision figures contained or proposed in the former regional plans need not apply unless supported locally and future housing supply will be decided at the local level. Unnecessary building in areas of high flood risk should also be prevented.

2.4 Due to flood risk considerations the revoked regional plan contained an interim housing allocation for the Borough. The former policy also required the preparation of a Coastal Strategy which was to provide a ‘long term strategic vision’ for the three coastal districts of Boston, East Lindsey, and South Holland, which would then be incorporated into the next review. Though work on the strategy reached an advanced stage it will not now be given statutory weight through the review process of the regional plan. However, technical analysis underpinning the work done can be taken into account in the preparation of future Local Development Documents.

2.5 Boston because of its size, the range of services it provides, its potential to accommodate further growth, and capacity to support sustainable development objectives has an important role in Lincolnshire as a population, employment and service centre.. The capacity of the town to accommodate an increased rate of housing growth over the longer-term has been called into question by various agencies, because of issues arising from the risks associated with the potential for coastal and fluvial flooding in the Borough.

2.6 At the local level the saved policies from the Boston Local Plan will remain in force until superseded by an adopted Local Development Framework (LDF). Support in principle has been given to the preparation of a joint LDF with a neighbouring area, South Holland, with the aim of producing an up to date sub-regional scale development strategy that will provide for the long-term sustainability and well-being of all communities in these areas. The strategy will balance social, economic and environmental factors to ensure all considerations likely to affect the viability and future of the area are known and tested.

2.7 The make up of the joint LDF in terms of Local Development Documents (LDDs) and the timing of their preparation is to be set out in a Local Development Scheme (LDS).During the production of LDDs the SFRA will be used to inform Sequential and Exception tests used as part of the process of site identification for specific development purposes. Both the projected probability of flooding, and the predicted hazard experienced in the event of a breach, will be taken into account. These factors will also be used in the development control process to assist in the determination of planning applications. The details of how the SFRA is to be used in the LDD and Development Control processes is to be the subject of further discussions involving the Environment Agency, and will be set out in a separate document.

Capabilities on project:
Water

3 Level 1 SFRA - Introduction

Planning Policy Statement 25

3.1 The SFRA is at the core of the PPS25 approach. It provides the essential information on flood risk, taking climate change into account that allows the Borough Council to understand the risk across its area so that the Sequential Test can be properly applied.

Sequential Test

3.2 A level 1 SFRA should be sufficiently detailed to allow the application of the Sequential Test and to identify whether development can be allocated outside high and medium flood risk areas, based on all sources of flooding, or whether the application of the Exception Test is necessary

Flood Zones

3.3 PPS25 defines three distinct Flood Zones, (FZ)s based on the probability of river and sea flooding to which an area of land is currently subjected, ignoring the presence and effect of existing flood defences or other man-made obstructions to flood flows, These three FZs, are given for both fluvial and tidal flood risk in Annexe D to PPS25 (Table D1) and are summarised in Table 2 below :-

Zone	Characteristic	Assigned Annual Probability of Flooding
1	Low Probability	Fluvial & Tidal Less than 0.1% (1 in 1000 or more years)
2	Medium Probability	Fluvial 0.1% to 1% (from 1 in 100 to 1 in 1000 years) Tidal 0.1% to 0.5% (from 1 in 200 to 1 in 1000 years)
3a	High Probability	Fluvial Greater than 1% (1 in 100 or less years) Tidal Greater than 0.5% (1 in 200 or less years)
3b	Functional Floodplain	To be identified by LPA in agreement with Environment Agency

Table 2 - PPS25 Flood Zones

3.4 Following a comprehensive tidal and fluvial flood risk mapping exercise carried out across the country, the Environment Agency issued a set of FZs to each LPA in England and Wales during summer 2004.

3.5 The FZs were prepared using nationally consistent methodologies for the determination of FZs. For fluvial flooding the FZs were derived by using a broad scale model called J-Flow, which estimated the flow in a watercourse that would arise from 1:100 and 1:1000 year flood events, and calculated how much water would be contained within the natural channel and how far the remainder would propagate across the floodplain. The FZs exclude the effect of existing flood defences, and the effects of de-facto defences such as road and railway embankments, major artificial drainage channels etc. These FZs therefore show the probability of flooding which, in areas where defences exist, may be significantly greater than the actual risk of flooding.

3.6 The FZs are not limited to Main Rivers but include all watercourses with a catchment area of more than 3 sq.km.

3.7 As the FZs are regularly updated by the Environment Agency they have not been reproduced in this SFRA.

Capabilities on project:
Water

4 Causes of Flooding

4.1 The main causes of flooding are described in the following sections.

Functional Floodplains and Washlands

4.2 In PPS25, where they form the basis for FZ 3b, Functional Floodplains are defined as "land where water has to flow or be stored in times of flood". PPS25 goes on to state that "SFRAs should identify this FZ (land which would flood with an annual probability of 5%, (1 in 20 years), or greater in any year or is designed to flood in an extreme 0.1%, (1 in 1000 years), flood, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes.)".

4.3 Land "where water has to flow or be stored in times of flood" is commonly known as washland. For the purpose of this study Functional Floodplains have therefore been taken to be any area of land in the Borough used as washland or within which the actual annual probability of flooding equals or exceeds 5%, or at least once in 20 years.

4.4 There are no principle washlands operated by the Environment Agency in the Borough Council's area or functional floodplain.

Overflowing of Watercourses

4.5 When the flow in a river or stream exceeds the capacity of the channel to convey that flow, either because of limited cross-sectional area, limited fall, or a restricted outfall, then the water level in that channel will rise until the point is reached where the banks of the channel are overtopped. Water will then spill over the channel banks and onto the adjoining land. With an upland river the adjoining land is its natural floodplain, which will generally be of limited extent and fairly well defined.

4.6 In the case of a major river, such as the Witham upstream of Lincoln, the floodplain may be a kilometre or more in width, though it may not be equally distributed on either side of the river channel. However, due to local variations in geomorphology, the width of the floodplain may vary considerably from point to point along the river valley. Floodplains are characterised by flat, riparian land along the valley floor. In pre-industrial England, such land was regarded as liable to flooding and was traditionally reserved for grazing and stock rearing and human settlements were almost always established on higher land beyond the edge of the floodplain. In the industrial age and more recent times with different priorities, pressures for development have resulted in the widespread colonisation of floodplains, often with steps taken to mitigate the associated risks of flooding, such as the construction of embankments (floodbanks) on either side of the river channel to confine flood waters within that channel.

4.7 When overtopping of an embanked watercourse, such as the Witham downstream of Lincoln, occurs, the depth of water flowing over the floodbank or floodwall will probably be small, a few centimetres at most. The bank will act like a weir and the rate of flow per unit length of bank will be relatively modest and this, provided that the duration of overtopping is finite, will limit the volume of water cascading over the defences to cause flooding within the defended area. If overtopping does occur and the area liable to flooding is of considerable extent, any flooding which results will often be disruptive rather than disastrous. The situation becomes far more critical if overtopping of an earth embankment erodes its crest, leading to a breach in the embankment. This situation is considered below.

4.8 Because high spring tides occur a number of times in any year, no significant development has taken place on land below the level of the normal high water mark on spring tides (HWMOST), but if a storm tide surge coincides with a spring tide, the flood water at the peak of the tide may reach a level of up to two metres above the high spring tide level. Such an extreme event may only occur once a century but the resultant flooding could, unless tidal flood defences exist, inundate large areas of the coastal plain upon which development directly related to the coastal or maritime economy has taken place. Even where tidal defences exist, they can still be overtopped in an extreme event and flooding of the coastal plain will then occur.

Breaching of Embankments

4.9 An earth embankment may be breached as a direct result of overtopping. Water overflowing a floodbank, especially when concentrated over a short length of bank, results in a rapid flow of water down the rear slope of the bank. This can cause erosion, which starts at the rear of the bank and works its way forward towards the river channel or source of the flooding. As the crest of the bank is washed away the flow through the small initial gap increases and a small breach is created. This becomes steadily bigger as water flows through it, eroding the sides and base of the breach, and a rapid and progressive failure of the embankment follows. In an extreme event, complete collapse of the bank may take only minutes. The contents of the embanked channel then pour through the breach and across the now exposed hinterland.

4.10 A tarmac road or dwarf floodwall along the crest of a floodbank may inhibit the rate of initial erosion and postpone or even prevent the creation of a breach, depending upon the duration of overtopping. Experience, fortunately limited, shows that when a fluvial floodbank breaches, even if not by overtopping, it does so near the peak of the flood when the flow in the river and hence flood levels are at or near their maxima. Experience also suggests that breaches in river embankments usually extend from 20 to 30 metres in length and rarely grow to more than forty metres. Unlike tidal defence floodbanks, once a breach in a fluvial floodbank has occurred there will be a reduction in flood levels in the river as water flows through the breach. This reduces the stress on neighbouring floodbanks along the same reach of river, thus considerably reducing the risk of further breaches in the same area.

4.11 The design of a floodbank (or floodwall) incorporates a certain level of freeboard to allow for uncertainties, bank settlement, wave action, etc. but the height of any floodbank is determined primarily by the peak height of the design flood. Because of freeboard, the return period of the flood which gives rise to overtopping must in reality be somewhat greater than that of the design flood. The return period of flooding from a breach caused by overtopping will be essentially the same as for the far less severe flooding resulting from that overtopping alone, but it must be borne in mind that breaches in earth embankments can occur from causes other than overtopping and may thus have return periods significantly less than the that for which the floodbank was designed. This is known as “residual risk” flooding which will be defined in more detail below.

4.12 Apart from overtopping, breaches in floodbanks can occur where weak spots in the bank have been created over a long period by gradual leakage through the bank at old, forgotten structures buried in the bank such as culverts or sluices (“slackers”), or where the activities of burrowing animals such as rabbits have impaired the integrity of a floodbank. These inherent weaknesses may not be readily apparent under normal conditions but when an exceptional hydraulic gradient through the bank arises during flood conditions, a failure may occur, quickly giving rise to a breach. This may well happen in a flood of considerably lesser magnitude and return period than the design flood.

4.13 Furthermore, since the inherent weakness tends to increase slowly with age, the fact that a bank did not fail in an earlier flood does not guarantee that it will not fail in a comparable (or even a lesser) flood at some time in the future. If, however, a floodbank is of recent construction it may be assumed that it has been properly engineered and, provided that there is an adequate inspection and maintenance regime, the risk of breaching as a result of the factors outlined above is negligible.

4.14 The breaching of tidal flood defence embankments has the same essential causes as those described above for fluvial floodbanks. There are, however, two additional factors which are specific to tidal defences and compound the risk of failure.

4.15 The first of these is the effect of severe wave action on tidal defences, though this will be of greater relevance to defences exposed to the open sea (such as those along the shores of the Wash) than those along tidal estuaries (such as Boston Haven). Under normal tidal conditions the energy released when a wave breaks will be expended on the foreshore (beach, saltings, etc) before it reaches the defence line. Under extreme conditions, such as in a storm surge, the water level at the peak of the tide may be a metre or more higher than the highest normal spring tide. The storm waves may therefore not break until they reach the floodbank itself, the energy released when the wave breaks causing serious physical damage to the embankment.

4.16 Secondly, in a storm surge the peak tide level (as well as the wave heights) will be considerably greater than normal and large volumes of tidal water may wash over the top of the floodbank on the crest of every wave. Although this wave crest overtopping will only occur for a relatively short time at the peak of the tide, while it does occur the floodbank will be subject to severe risk of erosion, and consequent failure, even though the peak tide level itself may still be well below the top of the embankment.

Mechanical, Structural or Operational Failure

4.17 Although less common than overtopping or breaching of defences, flooding can also be caused by the mechanical or structural failure of engineering installations such as land drainage pumps (or their power supplies), sluice gates (or the mechanism for raising or lowering them), lock gates, outfall flap valves etc. Such failures are, by their nature, more random and thus unpredictable than the failures described in the previous sub-Sections, and may occur as a result of any number of reasons. These include poor design, faulty manufacture, inadequate maintenance, improper operation, unforeseen accident, vandalism or sabotage.

4.18 Structural failure, in this context, is also taken to include the failure of "hard" defences in urban areas such as concrete floodwalls. "Hard" defences are most unlikely to fail by the overtopping / erosion / breaching sequence experienced by earth embankments. Their failure tends to be associated with the slow deterioration of structural components, such as rusting of steel sheet piling and concrete reinforcement, or the failure of ground anchors. Such deterioration is often difficult to detect and failure, when it occurs, may well be sudden and unforeseen. Structural failure of "hard" defences is most likely to happen at times of maximum stress, when water levels are at their highest during a flood. Failure of hydraulic structures and "hard" defences can, under certain circumstances, be precipitated by the scouring of material from beneath their foundations by local high velocity flows or turbulence, especially under flood conditions.

4.19 Flooding can also be caused or exacerbated by the untimely or inappropriate manual operation of sluices, or by the failure of the person or organisation responsible to open or close a sluice at a critical time. Responsibility for the operation of sluices rests with various public bodies as well as riparian landowners. Operational failures of this nature generally occur during a flood event and their results are to exacerbate rather than to cause flooding, and their impact is normally limited in extent.

4.20 Flooding, especially that caused by overflowing of watercourses, can be exacerbated by other operational failures. These failures can also include neglected or inadequate maintenance of watercourses resulting in a reduction of their hydraulic capacity. Flooding can also be caused or exacerbated by bridge or culvert blockages, although these are not necessarily due to maintenance failures and may be caused by debris, natural or man-made, swept along by flood flows.

4.21 The risks associated with this category of failures are almost impossible to quantify, especially as experience has shown that there is a joint probability relationship between this class of failure and flooding resulting directly from extreme meteorological events. It can of course be argued that if a risk of this type was quantifiable and found to be finite then action should already have been taken to alleviate the risk. Even an assessment of relative risk for failures of this type must depend on a current and detailed knowledge of the age and condition of plant, its state of maintenance, operating regime etc at a significant number of disparate installations.

Floodlocking and Tidelocking

4.22 During a flood the water level in a river will rise above the ground level in areas defended by floodbanks or floodwalls. Surface water sewer outfalls which discharge through the flood defence line will, of course, be fitted with a non-return flap valve to prevent flood water entering the defended area from the river through the sewer.

4.23 However, if there is heavy rainfall over the defended area (or the surrounding area) while the river is in flood, all surface water runoff from the defended area (or areas draining through the defended area) will be impounded behind the flood defences until such time as the river level falls and gravity discharge can recommence. This phenomenon is known as ‘floodlock’ and can give rise to secondary flooding within the defended area, even though the defences may not have been overtopped or breached.

4.24 If the main flood event is caused by heavy frontal rainfall over the whole river catchment and the defended area is an urban area, the rapid urban runoff from the defended area will probably have entered the river well before the flood peak in the river reaches the defended area, in which case secondary flooding due to 'floodlock' will not occur. Secondary flooding of this nature is therefore only likely to occur if there is a second, subsequent rainstorm over the urban area, or if the main frontal rainfall which caused the river to flood is prolonged and moves slowly down the catchment towards the urban area. In either event, secondary flooding in urban areas due to 'floodlock' is an unusual occurrence.

4.25 The effects of 'floodlock' can be overcome by the installation of land drainage pumps behind the defence line so that the flows in the floodlocked sewers or watercourses can be pumped into the river and thus prevented from accumulating behind the defences and causing secondary flooding there. Without pumping, ponding of surface runoff will start to occur at the lowest points in the defended area. If the ponded runoff originates just from within the defended area the resultant flooding will be relatively shallow and of limited extent, probably only of nuisance value. If, however, the runoff originates from a source outside the defended area - a 'floodlocked' tributary stream with a substantial catchment area - the volume of runoff may be large, in which case the depth and extent of the secondary flooding could, in the extreme, be comparable to that which would have occurred in the defended area had the defences not been present.

4.26 'Tidelock' is essentially similar to 'floodlock' except that the obstruction of the local gravity drainage outfall is due to a high tide rather than a fluvial flood. Whereas floodlocking is, by definition, a relatively rare occurrence, tidelocking is a regular and frequent occurrence. 'Tidelock' flooding can occur during a normal high tide if the peak of the tide coincides with a rainstorm over the tidelocked area, but because the period of tidelock is confined to the peak of the tide its duration is generally limited and any flooding is both minor and localised. Longer periods of tidelock may occur during a storm surge and in that case the resultant flooding could have a greater impact, but would depend upon the coincidence of the peak of the storm surge with heavy rainfall.

Localised Flooding

4.27 Almost all localised flooding of a serious nature occurs as a result of a severe convective storm, localised in extent and duration and generally during the summer. This flooding can, however, be exacerbated by two factors, blockages in the local surface water drainage system or by 'floodlocking'. Each of these factors is considered separately below. In some instances, in what would otherwise have been a relatively moderate rainstorm, these factors can themselves be the cause of flooding.

4.28 Intense storm rainfall, particularly in urban areas, can create runoff conditions which temporarily overwhelm the capacity of the local sewerage and drainage systems to cope with the sudden deluge. Localised "flash" flooding then occurs.

4.29 Localised flooding can also occur in urban areas where a stream or watercourse has been extensively culverted. In its natural state, if the channel capacity of a stream is exceeded the channel will overflow along a considerable length and the resultant flooding is distributed over a wide area. If, however, the stream runs through a long culvert and the hydraulic capacity of that culvert is exceeded under flood conditions the culvert becomes surcharged at its upstream end. Water levels will then rise rapidly and localised flooding upstream of the culvert, often quite serious, can occur. The flood water, in attempting to follow the natural line of the culverted watercourse, may also flow through the built-up area above the line of the culvert. This applies equally to many larger surface water sewerage systems in urban areas which are, in effect, culverted watercourses.

4.30 Local flooding is often exacerbated by deficiencies in the local surface water drainage system, but these can usually be remedied by relatively minor works once they have been exposed by a flooding event. Local flooding can also be caused by temporary blockages or obstructions in a drainage system, especially one that has been extensively culverted. Such flooding can therefore be virtually random in its occurrence, although the prevalence of blockages at a particular location would suggest a systematic problem, justifying action to modify the drainage system at that location in order to resolve it.

4.31 Because of the Borough's relatively flat topography, many of the local drainage systems are either pumped into the receiving watercourse, or discharge under gravity into a watercourse which is itself pump-drained. In either case 'floodlocking' as described above will only occur in a few areas.

5 Sources of Flooding in Boston Borough

Introduction to Boston Borough

5.1 The Borough of Boston is situated in the Lincolnshire fens, at the downstream end of the River Witham. The Borough straddles the low silt ridge that runs parallel with the western shores of the Wash, separating the Wash from the extensive peat fens on the inland side of the ridge. Boston itself and most of the older village settlements in the Borough are situated along this ridge.

5.2 Within Boston Borough flooding could be associated with the River Witham, the South Forty Foot Drain and the East and West Fen Catchwaters / Stonebridge Drain system. Flooding could occur within the pump-drained areas of the South Forty Foot Fens, Holland Fen, and the East, West and Wildmore Fens.

Tidal Flooding

5.3 Tidal flooding occurs when an exceptionally high tide, almost always accompanied by a storm tide surge, overtops and/or breaches the tidal defences along a coastline or tidal estuary.

5.4 Another potential tidal influence is determined by the ability of the River Witham to discharge via its tidal outfall at Boston (Grand Sluice). The River Witham's discharge can be restricted for significant periods of time when there is a high tide which has implications for fluvial flood risk upstream.

Fluvial Flooding

5.5 Fluvial flooding can occur as a result of the overflowing or breaching of river or stream banks when the flow in the watercourse exceeds the capacity of the river channel to accommodate that flow.

Potential Sources of Flooding

5.6 The potential sources of flooding which are considered to present a significant strategic flood risk within the Borough of Boston are :-

Tidal Flood Risk Sources

- Wash Banks
- Boston Haven (& Witham Outfall Channel)
- Welland Estuary (Outfall Channel)

Fluvial Flood Risk Sources

- River Witham (upstream of Grand Sluice)
- South Forty Foot Drain
- North Forty Foot Drain
- Old & New Hammond Becks
- Maud Foster Drain,
- Hobhole, Cowbridge and Frith Bank Drains

5.7 Each of these potential sources of flooding was described in detail in Section 3 of the original SFRA Report and their significance as a primary or secondary source evaluated. Those considered to be a primary flood risk were the River Witham, the South Forty Foot Drain, Boston Haven and the Wash Banks

Internal Drainage Board Arterial Drains

5.8 Internal Drainage Boards mainly operate in the lower parts of the country where the drainage is often pumped into the higher level main rivers. Land in pump-drained catchments is subject to two main but distinct types of flood risk. The first and more serious is inundation resulting from the overtopping or breaching of the flood defences of the high-level embanked watercourse into which the catchments are pumped. The second is flooding which can arise if the runoff entering the arterial drainage system exceeds the capacity of the pumps or that of the drainage channels leading to the pumping station. Residual risk flooding could also occur as a result of a mechanical or electrical failure at the pumping station.

5.9 There are four Internal Drainage Boards (IDBs) which lie within Boston Borough. These are:

- Black Sluice
- Witham Fourth
- Welland and Deepings
- Lindsey Marsh

These IDBs maintain their drains for a standard of flood protection between a 10%, (1 in 10 year) and a 1.3%, (1 in 75 year) standard. The IDBs pumped catchment boundaries shown in the plans included in this SFRA are approximate and should not be taken as exact.

Flood Risk in Pump-Drained Systems

5.10 Since the original SFRA Report was issued in November 2002 the Black Sluice IDB and Witham Fourth District IDB have both commissioned detailed studies of the responses of their arterial drainage systems to flood events. These studies involved hydrological and hydraulic modelling of the networks of main arterial drainage channels in each Drainage District and gave results in the form of flood levels for given return periods at specific locations in the network. Although these arterial drainage systems are secondary ("Class 2") sources of flooding, the results of the studies are nevertheless of relevance to this SFRA.

5.11 Selected modelling results were provided by the two IDBs who cover the majority of the area and those results that are relevant to flood risk in Boston Borough are summarised below.

Black Sluice Drainage District

5.12 The Black Sluice study provided estimated flood levels at key locations for the 1%, (1 in100-year), event (including an allowance for the effects of climate change). These are summarised in Table 3 below

Catchment	Watercourse	Location	Flood Level (m OD)
Wyberton Marsh		Wyberton Marsh PS	2.12
	Frampton Towns Drain	Frampton village	2.55
	Boundary Drain	Low Road / Hall Lane jn.	2.63
	Minor Drain	Wyb'ton Low Rd (Old Dairy)	2.50
	Minor Drain	Westfield House	2.63
	Minor Drain	Marsh Lane	2.49
	Minor Drain	Slippery Gowt Lane	2.53
Kirton Marsh		Kirton Marsh PS	1.73
	Kirton Drain	Kirton Bypass (A16)	2.55
Chain Bridge		Chain Bridge PS	1.39
	Wyberton Towns Drain	White House Farm.	1.56
	ditto	Old London Road (B1397)	1.61
	ditto	Wyberton Bypass (A16)	1.63
	Frampton Towns Drain	300m N of Ralphs Lane	1.43
	ditto	Kirton Bypass (A16)	1.46
	Kirton Drain	Kirton End	2.21
	ditto	Kirton Bypass (A16)	2.52
	Old Hammond Beck	Frampton Bank (Friths Fm)	1.43
	ditto	Kirton Holme	1.46
	New Hammond Beck	Kirton Holme	1.40
Cooks Lock		Cooks Lock PS	1.26
	North Forty Foot Drain	Punchbowl Lane	1.28
	ditto	Langrick Road (B1192)	1.31
	ditto	Gill Syke	1.33
	Minor Drain	Endeavour Park, Boston	1.31

Swineshead		Swineshead PS	1.07
	Hammond Beck	Skerth Drain	1.04
	Hammond Beck	Bicker Eau	1.33
	Hammond Beck	Hardwick Plot	1.30
	Old Hammond Beck	Kirton Holme	1.37
	Simon Wier Drain	Blackjack Road (B1391)	1.75
	Four Towns drain	Pyewipe/Fishmere End	2.00
	Minor Drain	Drayton Road (A16)	2.04
	Minor Drain	South Street	3.32
	Bicker Eau	Bicker Village	1.83
	Bicker Eau	360m S of Mill Lane (B1181)	2.98
Kirton, Frampton & Wyberton		Chain Bridge P.S.	1.39
(Chain Bridge)	New Hammond Beck	Kirton Holme	1.40
	Old Hammond Beck	Frampton Bank (Friths Farm)	1.43
	Old Hammond Beck	Kirton Holme	1.46
	Wyberton Towns Drain	White House Farm	1.56
	Wyberton Towns Drain	London Road (B1397)	1.61
	Frampton Towns Drain	300m N of Ralphs Lane	1.43
	Frampton Towns Drain	Kirton Bypass (A16)	1.46
	Kirton Drain	Kirton End	2.21
	Kirton Drain	Kirton Bypass (A16)	2.51
Wyberton Marsh		Wyberton Marsh P.S.	2.12
	Frampton Towns Drain	Frampton Village	2.55
	Boundary Drain	Low Road/Hall Lane Junction	2.63
	Wyberton Towns Drain	Wyberton Bypass (A16)	1.63
	Minor Drain	Heron Way	2.53
	Minor Drain	Wyberton low Road (Old Dairy)	2.50
	Minor Drain	Marsh Lane	2.49
	Minor Drain	St. Thomas Drive	2.63
Kirton Marsh		Kirton Marsh P.S.	1.73
	Kirton Drain	Kirton Bypass A16	2.55

Holland Fen		Holland Fen P.S.	0.60
	Clay Dyke	Gill Syke New Cut	.0.86
	Maryland Drain	Kyme Eau	0.88
	Gill Syke	Kirton Drove	1.10
	North Forty Foot	Harts Ground	1.26
Boston West		Cocks Lock P.S.	1.26
(Cocks Lock)	North Forty Foot	Langrick Road	1.27
	North Forty Foot	Langrick Road	1.31
	North Forty Foot	Gill Syke	1.33
	Minor Drain	Punchbowl Lane	1.56
	Minor Drain	Endeavour Park	1.31

Table 3 - Arterial Drainage System Flood Levels - Black Sluice District

Witham Fourth Drainage District

5.13 The Witham Fourth District study provided estimated flood levels at key locations in their main drains for the 1%, (1 in 100-year), event (including a 20% increase in runoff to allow for the effects of climate change). These are summarised in Table 4 below.

Catchment	Watercourse	Location	Flood Level (m OD)
East Fen	Hobhole Drain	Hobhole PS	0.20
	Ditto	Cowbridge Drain jn	0.56
	Ditto	Lade Bank PS (d/s)	1.04
West Fen	Cowbridge Drain	Cowbridge (golf course)	0.68
	Frith Bank Drain	Antons Gowt	0.81

Table 4 - Arterial Drainage System Flood Levels - Witham Fourth District

5.14 The Board noted that the modelling of the 1%, (1 in 100-year), event gave results similar to the flooding experienced in 1981, although the drainage system has been considerably enhanced and improved since then. The modelling showed no flooding from the Board's arterial drainage system in Boston Borough for all scenarios up to and including the 0.5%, (1 in 200-year), (+climate change) event.

5.15 The modelling made no allowance for flood storage within privately maintained watercourses. This means that the modelling results obtained are somewhat conservative - i.e. in any scenario the actual flood levels will be somewhat lower than the estimated levels.

5.16 For more information on each of the IDBs see their respective websites.

Minor Sources of Flooding

5.17 In addition to the major sources of flooding outlined above, there are a number of other potential sources of flooding which although relatively minor, must nevertheless be considered in their potential strategic context. These various minor flood risk sources are considered in the following paragraphs.

Critical Ordinary Watercourses

5.18 In recent years some urban watercourses considered to be particularly at risk from such blockages were designated "Critical Ordinary Watercourses" (COWs) although this designation did not have any statutory status. COWs were designated in their respective areas by Local Authorities and Internal Drainage Boards, as well as by the Environment Agency. The Environment Agency has subsequently been adopting all COWs, identified by Local Authorities, as Main Rivers, for which the Agency is responsible. Where a COW was separated from the previous Main River system by a length of non-Main River the intervening watercourse has also been en-mained.

5.19 Although COWs no longer exist as such, they are still of considerable interest as they indicate watercourses which have at some time been considered by a responsible statutory authority to present potential problems with a flooding problem or impaired drainage capability. The Environment Agency have, however, stated (letter dated 1st December 2006) that there are no Critical Ordinary Watercourses in Boston Borough that have either been en-mained or are due to be en-mained.

Groundwater Flooding

5.20 Groundwater flooding is often very different to flooding from rivers. It is generally not closely linked to recent rainfall amounts and it is difficult to predict its spatial extent. Groundwater flooding can often be of a much longer duration than fluvial flooding, lasting for several weeks, with significant social disruption. It is also harder to predict, so flood warning may not be provided.

5.21 Groundwater flooding occurs when the water table rises above the ground level and flows or ponds on the ground surface. Long term high rainfall totals are the primary cause of high groundwater levels, which means groundwater flooding is more likely during the winter months when we receive the majority of rainfall.

Surface Water Flooding

5.22 Surface water flooding happens when excess rainwater runs off across the surface of the land, rather than overflowing from a watercourse. It can be difficult to identify as it may be linked to fluvial flooding, groundwater flooding or sewer flooding. It can also occur on agricultural land, which means it is not recorded. Surface water flooding is likely to be of short duration and shallow depth, unless combined with fluvial, groundwater or tidal flooding or tidelocking.

5.23 The main mechanisms of surface water flooding are considered to be:

- Runoff during intense storms (e.g. summer thunderstorms) leading to the build-up of surface water. Properties at the foot of steep slopes may be particularly vulnerable. Urban areas are particularly susceptible to this type of flooding due to the high proportion of impermeable surfaces (e.g. roads, roofs) and the limited capacity of storm water drainage systems. This means that drains can often back up and watercourses may rapidly fill up and flood.
- Blockage of surface water drainage systems or drainage ditches during periods of high rainfall. This causes drains to backup and spill out elsewhere.
- High rainfall/local groundwater levels leading to the ponding of water in low-lying areas. This type of flooding can often occur seasonally to agricultural land. In fenland areas the pumped drainage system is designed to remove this excess water, but in particularly wet periods it may not be able to cope, leading to waterlogging or surface water flooding.

5.24 Surface water flooding is highly localised and widely distributed. It can cause regular and serious flooding locally, but there is little information recorded on previous flood events.

Areas Susceptible to Surface Water Flooding

5.25 The Pitt Review of the summer 2007 flooding emergency recommended that the Environment Agency, supported by local authorities and water companies should urgently identify the areas that are at highest risk from surface water flooding.

5.26 In July 2009 the Environment Agency issued a series of maps available to local authorities as the first deliverable from the national project set up to respond to this recommendation.

5.27 The Environment Agency defines surface water flooding as follows; “A surface water flood event that results from rainfall generated overland flow before the runoff enters any watercourse or sewer. Usually associated with high intensity rainfall (typically >30mm/hr) resulting in overland flow and ponding in depressions in the topography, but can also occur with lower intensity rainfall or melting snow where the ground is saturated, frozen, developed or otherwise has low permeability. Urban underground sewerage/drainage systems and surface watercourses may be completely overwhelmed, preventing drainage. Surface water flooding does not include sewer surcharge in isolation.” This means surface water flooding can occur almost anywhere when it rains hard enough for the local topography and circumstances to be unable to absorb the rainfall.

5.28 The map has been produced using a simplified method that excludes underground sewerage and drainage systems, and smaller over ground drainage systems, excludes buildings, and uses a single rainfall event – therefore it only provides a

general indication of areas which may be more likely to suffer from surface water flooding. The map provides three bandings, indicating 'less' to 'more' susceptible to surface water flooding.

5.29 The maps will provide general information on surface water flooding at this level and can be used for:

- Assessing the suitability of the map as an indicator for surface water flooding for your area before you make decisions based upon it;
- Informing SFRAs.

5.30 The maps must not be used :-

- For the sole evidence for any specific planning decision at any scale without further supporting studies or evidence;
- For the identification of individual properties susceptible to surface water flooding;
- Alone to show expected areas of surface water flooding;
- To interpret the maps as defining the flood extent for a specific probability;
- For consulting on applications with the Environment Agency;
- To incorporate into fluvial or tidal flooding maps in SFRAs, keep them separate;
- With a more detailed base map scale than 1:50,000. For example, do not use it with a 1:10,000 scale base map. But you can use it with 1:250,000.

5.31 The Environment Agency suggest that the use of the maps in planning will be to highlight areas where more detailed study of surface water flooding may be appropriate within SFRA. They are not appropriate to act as the sole evidence for any specific planning decision at any scale without further supporting studies or evidence.

5.32 The maps have only recently been issued to the LPAs and have not been assessed as part of this SFRA.

Sewer Flooding

5.33 Flooding from urban sewer systems depends on a number of factors, such as network capacity, system blockages and water levels at their outlets.

5.34 In urban areas, surface water (rainwater) and foul sewage were historically drained by a single sewer pipe. This is known as a combined sewer. However more recent developments have installed separate foul and surface water systems. Combined sewers generally have insufficient capacity to convey all flows during a significant flood event. During such times, excess flows are discharged into adjacent drainage systems, usually a watercourse, via combined sewer overflows. When operating correctly, the discharge from combined sewer overflows is usually highly diluted due to the large volume of surface water present in the effluent. During large flood events, excess flood water can flood out of the combined sewer system at manholes and flood adjacent roads and houses and the risk of sewer flooding is generally restricted to urban areas.

River Witham Catchment Flood Management Plan

5.35 The Environment Agency has prepared Catchment Flood Management Plans (CFMPs) for the whole of England and is preparing them for Wales. These documents present catchment-based policies for the future management of flood risk throughout that catchment over the next hundred years. The River Witham CFMP final report has recently been completed.

5.36 The River Witham starts south of Grantham and flows northwards, through Lincoln, before turning south-east and discharging into the Haven at Boston and eventually the Wash. The CFMP area is predominantly rural with the main urban areas being Lincoln and Boston. The majority of the urban drainage within the CFMP area is managed by Anglian Water with five Internal Drainage Boards maintaining non main rivers and the Environment Agency being responsible for sea defences and works on main rivers.

Current Flood Risk

5.37 The CFMP states that significant flooding problems are associated with the River Witham, its tributaries and the sea. The report identifies river flooding from the River Witham, South Forty Foot Drain, Stonebridge Drain and their tributaries. Particular areas at risk are Horncastle and Lincoln.

5.38 The report also identifies that tidal flooding from the Haven and overtopping the tidal defences could inundate large parts of Boston.

5.39 The flood risk identified in the CFMP take flood defences into account, unlike the Flood Maps available on the Environment Agency's website that do not take flood defences into account.

Future Flood Risk

5.40 The CFMP reports that climate change will cause the biggest increase in flood risk in the future in the River Witham CFMP area, through a combination of higher peak river flows and more extreme sea levels.

CFMP Flood Risk Management Policies

5.41 The River Witham CFMP area is divided into fourteen policy units, two of which influence the flood risk management for Boston Borough Council. Each unit represents similar types of flood risk, in terms of mechanisms of flooding, the level of flood risk etc. Each of the units has been assigned an appropriate flood risk management policy.

5.42 There are six pre-defined policies which the Environment Agency can choose from to apply to different parts of the CFMP area. These are:

CFMP Policy 1 **No active intervention** (including flood warning and maintenance). Continue to monitor and advise.

This policy may be selected for natural catchments where the river is connected to its floodplains and flooding has positive effects (e.g. it is beneficial for natural habitats). It may be applied where it has been recognised that the harm posed by flooding is not high, nor will it be in the future. In these instances costly interventions to manage low risks would not be appropriate.

CFMP Policy 2 **Reduce existing flood risk management actions** (accepting that flood risk will increase over time).

This policy may be selected for places where current and future risks do not warrant as much intervention (e.g. routine maintenance) as there is at present and it is clearly not worth continuing. Here the risk of flooding will be allowed to increase naturally over time.

CFMP Policy 3 **Continue with existing or alternative actions to manage flood risk at the current level** (accepting that flood risk will increase over time from this baseline).

This policy may be selected where the risks are currently managed appropriately and where the risk of flooding is not expected to increase significantly in the long term.

CFMP Policy 4 **Take further action to sustain the current level of flood risk into the future** (responding to the potential increases in risk from urban development, land use change and climate change).

This policy may be selected in places where the risk is currently managed appropriately, but flood risk is expected to rise significantly in the long term. In these circumstances, more would need to be done in the future to reduce the increase in risks.

CFMP Policy 5 **Take further action to reduce flood risk** (now and/or in the future).

This policy may be selected in places where the existing or future flood risk is too high. Action will need to be taken in the short and long term to reduce this level of risk, now and/or in the future.

CFMP Policy 6 **Take action with others to store water or manage runoff in locations that provide overall flood risk reduction or environmental benefits, benefits locally or elsewhere in the catchment.**

This policy may be selected in places, either local to a flooding problem or some distance away where flooding is not a problem. However, the principle behind this policy is that flood risk is transferred to places where flooding can bring benefits, which reduce the risk in areas where it is a problem. This may mean that floodplains can be restored and habitats improved, reducing the negative impacts of flooding elsewhere within the catchment. This may also include changing the way the land is used to hold water for longer within that part of the catchment, reducing flood risk elsewhere.

5.43 The two policy units and their assigned policy are:

Policy Unit 8 - The Fens

5.44 The Fens policy unit includes all of the study areas outside of Boston Town. Within Boston Borough Council much of this policy unit is defended by raised flood defence embankments.

5.45 The Witham CFMP states that there is currently a relatively low risk of flooding within The Fens policy unit, although this statement may reflect the sparsely populated nature of the defended fenland rather than the significant probability of its flooding at present.

5.46 The CFMP recommends for this policy area the adoption of **Policy 4** to take further action to sustain the current level of flood risk now and/or in the future.

Policy Unit 10 - Boston

5.47 This policy unit covers Boston Town, and includes the tidal Haven.

5.48 The CFMP states that there is a substantial risk from tidal flooding within this policy unit and climate change will significantly increase the flood risk to Boston.

5.49 The CFMP recommends the adoption of **Policy 5** to take further action to reduce flood risk and adopting this policy will allow the tidal flood risk in Boston to be reduced, including the impact of climate change.

The Wash Shoreline Management Plan

5.50 A Shoreline Management Plan, (SMP), is a plan for managing flood and erosion risk for a particular stretch of shoreline over the short, medium and long term. SMPs identify the best way to manage the risk to property and people.

5.51 The outcome of the SMP will be the “intent of management” for the shoreline that achieves the best possible balance of all values and features.

5.52 In the Wash SMP the intention is to sustain the flood defences around the Wash including an increase in management as required to sustain the current level of flood risk in the face of climate change.

6 Flood Risk Management

6.1 Whilst the FZs ignore the presence of any formal defences there are a number of flood risk management measures in place in the Borough to reduce the level of flood risk. Having considered the sources of flooding in the previous chapter we will now look at how the flood risk is being managed to begin to understand the level of risk.

Inappropriate Development in the Floodplain

6.2 One of the most effective ways to reduce flood risk is to limit the amount of development in the floodplain, thereby reducing the consequences of flooding. This is through the planning process and the SFRA and LDFs are an important vehicle to help achieve this. Where development is required, because of other sustainable reasons, it may be necessary to reduce the probability of flooding, and the consequences of flooding, through other measures.

6.3 The following paragraphs identify what measures are currently in place to reduce the flood risk to the existing developments in the Borough.

Flood Storage Areas

6.4 At the time the original SFRA Report was published in 2002, nearly all the flood alleviation schemes described below were already in place, the exception being the Lower Witham Scheme. Improvements to Grand Sluice and Fiskerton Sluice circa 1980 have also contributed to the reduction of flood risk in the Lower Witham.

Upstream of Lincoln – the Lincoln Flood Alleviation Scheme
The Lincoln Flood Alleviation Scheme (FAS) was constructed in the late 1980s specifically to provide flood alleviation for the more low-lying parts of the city of Lincoln and involved the construction of two off-line flood storage reservoirs.

Although the primary function of the Lincoln FAS is to reduce flood risk in Lincoln, the retention of a large volume of flood water upstream of Lincoln will inevitably have some beneficial effect on flood risk along the Lower Witham as far downstream as Boston.

Downstream of Lincoln – Branston Island
Branston Island is the 87 hectare 'island' of farmland north of Bardney Lock enclosed between the loop of the old channel of the River Witham and its high level navigation channel above Bardney Lock.

The controlled flooding of Branston Island is intended to reduce fluvial flood peaks on the Lower Witham and thereby reduce flood risk as far downstream as Boston. However, the timing of the opening of the Branston Island sluices and the flooding of the island is critical, and is complicated by the cyclical tidelocking of the Lower Witham at Grand Sluice.

Downstream of Lincoln – the Lower Witham Flood Alleviation Scheme
As a result of a strategy study undertaken in the 1990s, a scheme was implemented to raise all the floodbanks along the Lower Witham to give a minimum defence standard of the 1 in 10 year flood level, plus freeboard, everywhere along the river.

This provides a substantial degree of flood risk attenuation in the Boston area where the defence standards provided by the river's floodbanks is considerably higher than that further upstream.

Raised Defences

Flood Defence Condition Rating

6.5 The majority of the Main Rivers and Sea Defences in this area have raised earth embankments or concrete floodwalls to reduce the probability of flooding. Without these defences adjoining land would be at risk of flooding at frequent intervals and the Environment Agency have permissive powers to provide, maintain and improve these defences.

6.6 The Agency's flood defences are subject to inspection at regular intervals. During an inspection the physical condition of each component of a defence line is assessed and a condition grade from 1 to 5 is ascribed to that component. These components include not only flood defence embankments and floodwalls but also sluice, weirs, culverts etc or any structure whose failure could jeopardise the physical integrity or derogate the standard of protection provided by the defence line.

6.7 Descriptions of each component of all Main River flood defences and the results of these inspections (i.e. the condition rating) are stored on the Agency's National Fluvial and Coastal Defence Database (NFCDD). The five condition rating grades used in the NFCDD are defined in Table 5 below.

Condition Grade	Condition Rating	Description
1	Very Good	Cosmetic defects that will have no effect on performance.
2	Good	Minor defects that will not reduce the overall performance of the asset.
3	Fair	Defects that could reduce the performance of the asset.
4	Poor	Defects that would significantly reduce the performance of the asset. Further investigation needed.
5	Very Poor	Severe defects resulting in complete performance failure.

Table 5. - Environment Agency NFCDD Flood Defence Condition Rating

6.8 Condition ratings from the NFCDD for raised flood defences in Boston Borough are available from the Environment Agency and are summarised in the following tables:

Condition Grade	Length (Km)	%
1	28.17	75
2	9.50	25
3		
4		
5		
Total	37.67	100

Table 6 – River Witham Fluvial flood defence Condition

Condition Grade	Length (Km)	%
1	12.46	35
2	19.15	53
3	4.38	12
4		
5		
Total	35.99	100

Table 7 – South Forty Foot Fluvial flood defence Condition

6.9 The Haven provides the outfall for the entire fluvial River Witham Catchment, but is defended to reduce the risk of tidal flooding. Downstream of the Black Sluice and Maud Foster Sluice the defences are primarily earth embankments with extensive toe revetments to minimise tidal scour. Upstream of these sluices a range of hard defences are utilised to provide a standard of protection of 0.66% (1 in 150 years). The Boston Combined Strategy is an ongoing project to investigate the provision of a tidal barrier to provide an improved standard of protection for Boston. Maintenance on the Haven is routinely reactive repairs, mechanical and electrical maintenance and frequent revetment replenishment works. Many of the embankments downstream of the town were historically grazed, but this practice appears to be in decline.

6.10 The tidal defences along the Haven are thought to provide a 0.66% (1 in 150 years) standard of protection, fluvial raised defences along South Forty Foot Drain, Stonebridge Drain and the River Witham provide a 10 per cent standard of protection. There is also extensive maintenance works carried out regarding the 3 sluice gates that mark the tidal limit of the South Forty Foot Drain, Stonebridge Drain and the River Witham.

CFMP Policies

6.11 The River Witham Catchment Flood Management Plan (CFMP), identifies the policies proposed for the long term management of flood risk in Boston. These policies identify where future investment is required. For Boston Town the policy is to take further action to reduce flood risk based on the risk from the tidal Haven. The action required is to build a tidal barrier. For the Lower Witham Fens the policy is to take further action to sustain flood risk at its present level now and/or in the future. The action required to achieve this is to produce a detailed strategy to manage flood risk.

SMP Policies

6.12 The Wash SMP identifies a policy to sustain the current level of flood risk and take account of climate change. The action required to achieve this in the short term is to hold the existing sea bank alignments.

Operational and Emergency Planning

6.13 In Boston, as elsewhere in the Anglian Region, the Environment Agency has issued flood defence and land drainage emergency operational plans in conjunction with the local authority. These documents are intended to clarify areas of responsibility for the operation and maintenance of flood defence structures within the local authority's area and summarise the agreed joint emergency response by each of the public bodies involved.

6.14 Serious flooding in Boston or the surrounding area could trigger the declaration of a major incident. Should a major incident be declared, the Lincolnshire County Council (LCC)'s Emergency Plan and Boston Borough Council's Emergency Plan would both be implemented.

6.15 The LCC's Emergency Plan may be found on the County Council's website, www.lincolnshire.gov.uk . Advice on action to be taken in the event of flooding may be found on this website and on the Borough Council's website, www.boston.gov.uk .

6.16 Specific responsibilities and actions by the Environment Agency (EA), County Council and Borough Council are detailed in the following documents:

a) The EA's Floodline Warnings Direct' flood warning system.

b) The EA's 'Flood Defence & Land Drainage Operational and Emergency Contact

Arrangements for the Boston Borough Area'.

c) Boston Borough Council's 'Flood Response Plan'.

6.17 There are currently flood warning provisions in place for the Boston area under which telephoned warnings can on request be sent to any property considered to be at risk of flooding. This is achieved by means of the Environment Agency's Automatic Voice Messaging (AVM) "Warnings Direct" flood warning system and permits residents to take precautionary measures in advance of possible flooding.

7 Sequential Test

7.1 PPS25 states that the risk-based Sequential Test should be applied at all stages of planning and the FZs are the starting point for the sequential approach. Where there are no reasonably available sites in FZ 1 decision makers allocating land in spatial plans should take into account the flood risk vulnerability of land uses and consider sites in FZ 2. Only where there are no sites available in FZs 1 and 2 should they consider the suitability of sites in FZ 3, applying the Exception Test if required.

7.2 On inspection of the Environment Agency FZs it is apparent that the majority of the Borough Council's area is within FZ3 and in order to assist the Borough Council apply the Sequential Test two additional sets of maps have been produced covering all of their Borough

7.3 These two sets show:

- Flood Hazard Zones should a breach occur in the raised defences.
- Relative Probability of Flooding given the presence of the defences.

7.4 These two sets of maps are described in detail in the following sections.

Development Planning Sequential Test

7.5 Boston Borough Council have identified those parts of the Borough where normally significant development might be expected to occur over the next five to ten years and therefore where a more detailed assessment of the flood risk is required based on the above maps and other information.

7.6 This more detailed assessment of flood risk within specific study areas constitutes a Level 2 SFRA as described in PPS25

Development Control Sequential Test

7.7 Paragraph 4.17 of the PPS 25 practice guide states that "at the local level the Sequential Test should be applied to the whole LPA area". Also paragraph 4.18 states that "for individual planning applications where there has been no Sequential Testing of the allocations in the LDD, the area to apply the Sequential Test will be defined by local circumstances relating to the catchment area for the development".

7.8 Paragraph 4.34 states that "Through the Sequential Test, LPAs should identify areas where windfall development would be constituted as appropriate development i.e. defining the type of windfall development which would be acceptable in certain flood risk areas and what the broad criteria should be for submitting a planning application under these circumstances".

7.9 Whilst this SFRA has considered the Sequential Test for potential land allocations it will still be necessary for the Sequential Test to be applied to individual planning applications.

Capabilities on project:
Water

8 Flood Hazard

Flood Hazard Zones

8.1 In a major flood event, where a river is confined within flood defences there may be an appreciable difference between the water level on one side of the flood defence and the ground level in the defended area behind that defence. If that defence were then to fail, whether through the collapse of a floodwall or the breaching of an embankment, there would be a sudden inrush of flood water into the defended area. The velocity and depth of water cascading through the breach could, initially at least, be sufficiently great to sweep people off their feet resulting in their death by injury or drowning. The premature failure of a flood defence structure is by its nature a residual risk, but its potentially fatal consequences dictate that it be considered in flood risk assessment.

8.2 As flood water pours through a breach it will fan out across the hinterland behind the defences, and its velocity and depth will both decrease with distance from the breach. This will be determined by the flood level / ground level difference (head of water), the width of the breach, and the land surface topography behind the breach. PPS25 and its Practice Guide specify the determination of a Rapid Inundation Zone and also refer to Flood Risk in Assessment Guidance for New Development Phase 2 R & D Technical Report FD2320.

8.3 For this SFRA the four Flood Hazard Zones as referred to in FD2320 will be used as follows:

- Low Hazard
- Danger for Some
- Danger for Most
- Danger for All

8.4 Hazard Zones in specific study areas are a major component of a Level 2 SFRA and are shown on Figure 1

8.5 The definition of the Hazard Zones is that contained in FD2320 which uses a matrix of flood flow velocities and depths to define the categories of ‘Danger for Some’, ‘Danger for Most’ and ‘Danger for All’. Technical Report FD2320 also presents an equation which gives a quantitative definition of Flood Hazard in terms of velocity, depth and a ‘debris factor’ which is intended to take into account the impact of flood-borne debris on flood hazard.

8.6 In order to determine the extent of the Hazard Zone at any location it is necessary to set up a dynamic two-dimensional (2D) hydraulic model of the breach scenario, from the moment when the breach occurs to the time when the velocities and depths of the flood water pouring through the breach have reached their maximum values at all points across the hinterland or flood compartment into which the water is flowing. Setting up this model for each breach scenario requires a knowledge of the head of water in the high-level watercourse at the moment the breach occurs and during the time when water is flowing through the breach. It also requires a detailed representation of the topography of the land surface in the flood compartment behind the breached defence. The river models used to provide an estimate of the head of water and the sources of data used to provide the topographical details are described later in this Section.

8.7 In the 1%, (1 in100-year) and 0.5%, (1 in 200 year), flood event scenarios for which the Hazard Zone was determined, in the great majority of cases the creation of a Hazard Zone would be as a direct result of a breach. Overtopping of itself would rarely result in flooding both deep and fast flowing enough to meet the Environment Agency’s hazard criteria. However, in a residual risk event a flood defence could breach prematurely, well before that defence is overtopped. The “Hazard Zone” is therefore independent of the probability of flooding and, irrespective of mapping clarity considerations, should properly be plotted separately.

8.8 In order to give a realistic representation of the Hazard Zone it was assumed that the breach occurred at the peak of the flood hydrograph in the embanked river and that the head of water driving the flow through the breach did not remain constant after the breach but diminished thereafter in accordance with the flood hydrograph in the embanked river and the release of water from the ponded section of river. The effects of secondary and tertiary defence lines in obstructing the passage of flood water across the land surface were also allowed for in the ground surface model.

8.9 It should be emphasised that the Hazard Zone is simply the area behind a flood defence line within which people could be at risk following a breach in that defence line. Since a breach can occur either as a result of overtopping or as a result of a premature (residual risk) failure of a flood defence, the Hazard Zone is not associated with a specific probability of occurrence. It is a worst-case representation of the Hazard Zone envelope derived from the assumption of a series of breaches at intervals along the primary defence line in that area.

Impact of Climate Change

8.10 Climate change is predicted to increase river flows and sea level over the next 100 years. These increases will increase the probability of overtopping and therefore the chance of a breach.

8.11 Information on the Flood Hazard Zone for the current situation has been provided to Boston Borough Council. The impact of Climate change on the Flood Hazard generally across the Borough is to significantly increase the extent of each of the Flood Hazard Zones.

8.12 The SFRA will be used to inform long term development proposals and therefore for each of the individual study areas only the Flood Hazard Zone for 2115 has been used.

8.13 Information of the depth and velocity of flooding and other flood risk information can be obtained from the Environment Agency

Topographical Survey Data Available For Hazard Mapping

8.14 A number of sources of data and information are available which can be used to establish the topographical component of the 2D breach scenario models used to establish the various envelopes shown on the Hazard Zone maps. These are :-

LiDAR data

8.15 The Environment Agency has established a national database of topographical spot-level data derived from an airborne laser imaging process. Contoured plots of LiDAR (Light Detection and Ranging) data are found to be of greatest use in open country as the presence of buildings is found to give rise to clearly anomalous results in built-up areas, even with automated filtering of the data to remove the effects of buildings, trees and other obstructions. LiDAR data is available with a vertical resolution of $\pm$ 0.1m on a 2m horizontal grid.

8.16 Even though the LiDAR data coverage does not extend over the whole country, it has now reached the point where the great majority of Zone 2 and 3 areas are included. When the original SFRA was undertaken there was virtually no LiDAR coverage in Boston Borough. Since 2002 this situation has been remedied and when the current study was carried out the LiDAR coverage of the Borough, supplied in electronic format by the Environment Agency, was complete, apart from a sizeable gap in the Freiston / Butterwick area.

Ordnance Survey Maps

8.17 1/25,000 scale OS maps are contoured at 5m intervals which is adequate to give a general indication of the shape of the fluvial or tidal floodplain at any location. The contours are supplemented by spot heights to the nearest 1m on roads. Unfortunately since most fenland is below 5m AOD, contours are of limited use in this area. It should also be noted that road levels, particularly in floodplains and fenland, can be significantly higher than adjacent land levels.

8.18 A complete 1/2,500 scale OS map coverage of Boston was provided by the Borough Council on CD which can be accessed using "MapInfo" software. These maps are not contoured but include spot heights on roads to the nearest 0.1m (though some of these metric spot heights are conversions from earlier imperial units and are therefore only accurate to the nearest 1ft / 0.3m). The Borough Council also supplied OS mapping of the Borough at 1/50,000 scale.

Ordnance Survey ‘SAR’ Data

8.19 Ordnance Survey Synthetic Aperture Radar (SAR) data coverage is obtained from aircraft or earth observation satellites. It is, however, less accurate than LiDAR data, with a vertical resolution of only $\pm$ 0.5m and a 5m horizontal grid.

9 Relative Probability Of Flooding

Introduction

9.1 In order to establish the relative probability of flooding it is necessary to understand how flooding is developed within the Borough, understand the history of flooding, and establish any effect man-made features can have.

9.2 Boston Borough Council, the Environment Agency, the Black Sluice and Witham Fourth District Internal Drainage Boards and Anglian Water were all contacted during the original SFRA study to obtain information on flooding records and drainage problems in the Borough. The responses received were summarised in the 2002 SFRA Report.

9.3 As far as we are aware, there has been no significant or widespread flooding from either fluvial or tidal sources within the Borough since 2002. This has been confirmed by the Borough Council and the two IDBs.

9.4 Despite the extreme weather conditions and resultant severe flooding that affected much of Lincolnshire, Nottinghamshire and Yorkshire on 25th/27th June 2007, no serious flooding of a strategic nature (i.e. from tidal or fluvial sources) was reported in the Borough of Boston. There were, however, flooding incidents involving 172 properties in Boston at this time. A detailed record of these incidents was compiled by the Borough Council and became available for analysis in October 2007. All of these incidents were the result of a combination of factors associated with the heavy rainfall, such as inadequate surface water drainage capacity, saturated soil conditions and possibly flood(tide)lock conditions.

9.5 Analysis of this record revealed that the main areas affected by the June 2007 flooding were the Fishtoft Ward of Boston town, particularly Eastwood Road and Eastwood Drive, and parts of Fishtoft village. Some properties in outlying areas of Old Leake and Wrangle were also affected. The results of the analysis are summarised in Table 8.

Nature of Damage	Total
Water in house - above floor level	24
Water in house - below floor level	25
Water in house - in cellar	2
Water in outbuildings	3
Water in garden or yards	9
Speculative claims (leaking roof etc)	7
No report of damage	102
Grand Total	**172**

Table 8 - Summary of Reports of Flooding in Boston, June/July 2007

9.6 Of the 172 households from which reports of flooding or anticipated flooding were received by the Council, the majority appear to have been precautionary requests for sandbags, and only 70 of the reports received mentioned actual flooding in or around the property. The great majority of these incidents prompted requests for compensation claim forms. Although in half of the dwellings where flood waters entered the building the flooding was below ground floor level, it usually resulted in damage to carpets and electrical circuit failures. The seven claims considered to be “speculative” (and for which compensation claims were made) involved leakage of rain through roofs or windows and one report of “water damage to ceiling in living room”. It is possible that the reporting of flooding incidents may have been influenced by the availability of compensation from public funds.

9.7 Black Sluice IDB has also reported flooding of a small number of properties in Wyberton Low Road in June 2007. These properties have floor levels ranging from 2.2m AOD to 2.4m AOD. The Board are of the opinion that this flooding resulted from the surcharging of the foul/combined sewerage system in that area.

Man Made Flood Risk Sources

9.8 Many other flood risk sources, other than structures specifically intended as flood defences, may also have a significant effect on flood risk and create a local discrepancy between inherent and actual flood risk. These man-made sources, which should be taken into account in site-specific FRAs, are summarised below.

IMPOUNDING RESERVOIRS

9.9 There are no large impounding reservoirs in the Witham or South Forty Foot catchments which could have a significant influence on flood flows in either catchment. The canal feeder reservoir on a tributary of the River Witham at Denton, near Grantham, is too small to warrant further consideration.

CANALS

9.10 The Fossdyke Canal connects the River Trent at Torksey to the Witham at Lincoln. This waterway is, in effect, a backwater of the River Witham and in hydraulic continuity with it as there are no locks between Lincoln and Torksey. Although the western end of the canal is largely man-made the eastern end appears to be a canalisation of the River Till, a natural tributary of the Witham.

9.11 This section of the canal is also embanked above the adjacent fenland. The Fossdyke Canal is unlikely to have any significant effect on flood flows in the Witham at Boston unless a breach in the embanked section of the canal occurred, which would have a considerable attenuating effect on flood flows in the Lower Witham.

9.12 The Sleaford and Horncastle Canals are, for all practical purposes, navigable sections of the Rivers Slea and Bain respectively. Although both these rivers are major tributaries of the Witham the Bain is no longer navigable and the Slea is only navigable at its downstream end. Their canalisation now has virtually no effect on flood flows in the River Witham.

LOCKS, WEIRS & SLUICES ALONG THE WITHAM

9.13 The River Witham is a navigable river from Lincoln to the Wash. When the river navigation was improved in the eighteenth century, locks were constructed (or reconstructed) at Lincoln (Stamp End), Bardney, Kirkstead and Boston (Grand Sluice). The lock at Kirkstead was removed when the river was subsequently widened and deepened. None of the locks were associated with mill weirs. The Stamp End and Grand Sluice locks are integral with sluice structures through which the full range of river flows is discharged. Bardney Lock is associated with a more complex configuration of channels as described below.

9.14 On the upstream side of Lincoln flood flows in the River Witham are diverted into a low level flood relief channel, the Sincil Dyke, through a sluice at Bargate Weir. Downstream of Lincoln the Sincil Dyke (here known as the South Delph) converges with the Witham and they follow closely parallel but independent routes to Horsley Deeps, immediately downstream of Bardney Lock, where the South Delph joins the Lower Witham, with which it is in hydraulic continuity.

9.15 The main channel of the River Witham flows through Lincoln and down the river's high level navigable channel between Stamp End and Bardney Lock. At Fiskerton Sluice, 2km upstream of Bardney Lock, the old course of the River Witham diverges from the navigable channel which it rejoins at Horsley Deeps, below Bardney Lock. The embanked 'island' between the high-level navigable channel and the old low-level river channel is known as Branston Island

9.16 Although the sluices at Bargate, Stamp End and Fiskerton are used to control flood flows in the River Witham and apportion flows between the navigable channel, old river channel and Sincil Dyke (South Delph), all three channels converge at Horsley Deeps, 36km upstream of Boston, to form the Lower Witham. The operation of these sluices will not, therefore, have a significant impact on flood risk at Boston.

FLOOD ALLEVIATION WORKS IN THE LINCOLN AREA

9.17 The three principal flood alleviation schemes in the Lincoln area will be considered in two categories, those upstream of Lincoln and those downstream of Lincoln. Each scheme will be described in outline in the following paragraphs.

Upstream of Lincoln – the Lincoln Flood Alleviation Scheme

9.18 The Lincoln Flood Alleviation Scheme (FAS) was constructed in the late 1980s specifically to provide flood alleviation for the more low-lying parts of the city of Lincoln which, despite the presence of the Sincil Dyke, had been subject to occasional flooding from the River Witham. The scheme was designed to give a 1%, (1 in 100-year), standard of protection to areas previously at risk of more frequent flooding and involved the construction of two off-line flood storage reservoirs upstream of Lincoln.

9.19 One of the two reservoirs is located at Aubourn, about 7km upstream of Lincoln, at the confluence of the Upper Witham and the River Brant where both rivers flow in embanked channels. When flood flows in the Witham reach a predetermined level a sluice across the river downstream of the confluence is operated, diverting flood water from the river into the flood storage reservoir. When the flood peak has passed, water is released from the reservoir back into the river. The second of the two flood storage reservoirs is located adjacent to the River Till near Saxilby, about a kilometre upstream of the confluence of the Till and the Fossdyke Canal, where the River Till flows in an embanked channel. The mode of operation of this reservoir is virtually identical to that of the other reservoir on the Upper Witham.

Downstream of Lincoln – Branston Island

9.20 Branston Island is the ‘island’ of farmland north of Bardney Lock between the loop of the old channel of the River Witham and its high level navigation channel above Bardney Lock. Since both channels are embanked watercourses which entirely surround it, the ‘island’ is at considerable risk of flooding. For this reason Branston Island is used as a flood storage reservoir. When water levels in the Lower Witham reach a critical level, Branston Island Sluice, situated in the right bank of the Old River Witham, is opened and flood water from the river is allowed to inundate the island. The sluice remains open to allow the flood water to re-enter the river as water levels fall. Any water still remaining on the ‘island’ after the flood event has passed is pumped back to the river with the sluice closed.

9.21 The flooding of Branston Island is intended to reduce fluvial flood peaks on the Lower Witham and thereby reduce flood risk as far downstream as Boston. However, the timing of the opening of the Branston Island sluices and the flooding of the island is critical, and is complicated by the cyclical tidelocking of the Lower Witham at Grand Sluice.

Downstream of Lincoln – the Lower Witham Flood Alleviation Scheme

9.22 As a result of a strategy study undertaken in the 1990s, a scheme was implemented to raise all the floodbanks along the Lower Witham to give a minimum defence standard of the 1-in-10 year flood level, plus freeboard, everywhere along the river. It should of course be emphasised that in many places the defence standard exceeds this standard by a considerable margin.

9.23 The majority of places where the defence standard has been raised to the minimum level are at the upstream end of the Lower Witham, between Kirkstead and Bardney. It had originally been proposed to provide formal overspill sections with locally reduced crest levels at selected locations along the west bank of the river so that controlled flooding would occur in predetermined flood compartments but implementation of this work has been deferred on economic grounds until further studies have been undertaken.

Residual Risk Flooding

9.24 Residual risks of flooding arise either from extreme events with exceptionally high return periods (e.g. 200+ years) or from events which, due to their unpredictable nature, their probability of occurrence is not readily amenable to quantitative evaluation. This type of event may arise from premature structural failure, serious operational or equipment failures and incidents of sabotage, vandalism etc, or freak accidents which cannot be foreseen.

9.25 The principal residual risk in the Boston area would be a premature failure of a flood defence embankment, either fluvial or tidal, well before the embankment was overtopped. Such a failure would occur during an event significantly less severe than that for which the embankment had been designed, although the actual probability of the residual risk event

occurring could still be very small indeed. Such a failure could arise from a variety of causes - burrowing animals, structural weaknesses or human action. Clearly the residual risk of such premature failure can be reduced to insignificance if the embankment has been competently constructed, regularly inspected and adequately maintained.

9.26 The failure of pumping plant at land drainage pumping stations also constitutes a potential residual risk, but any resultant flooding is generally slow to materialise and there is usually adequate time for the responsible authority to take emergency action to repair or replace the defective equipment.

9.27 The failure of a major tidal outfall sluice, either a mechanical failure of the sluice gates or a collapse of the structure itself, is also a residual risk, but the likely nature of the failure would be such as to restrict the rate of inflow of tidal water through the sluice. Since there would almost certainly be a large ponded reach of river upstream of the sluice the impact of a restricted inflow over a single tide peak would be relatively minor. It would, however, be essential to take emergency action to prevent further inflows on successive tide peaks.

9.28 The replacement of the traditional timber sea doors (with their 'mitre gate' design) with modern steel vertical lifting gates at Grand Sluice and Maud Foster Sluice since 1980 has greatly reduced the residual risk previously associated with potential operating errors at those sluices.

Relative Probability of Flooding General Methodology

9.29 The relative probability of flooding has been based upon the results of the hydraulic modelling of 1%, (1 in 100-year) and 0.1%, (1 in 1000-year), fluvial flood events in the principal fluvial flood risk sources and hydraulic modelling of the 0.5%, (1 in 200-year) and 0.1%, (1 in 1000-year), year tidal flood events in the Wash and Boston Haven.

9.30 Flooding was assumed to occur when a flood defence was overtopped. If the defence was an earth embankment then breaching was automatically assumed to follow, as indicated in the analysis in the Environment Agency Wash Banks Strategy 1997. The resultant flood envelope at any point was derived from two-dimensional hydraulic modelling of the passage of the flood wave across the defended area in the hinterland behind the breached or overtopped flood defence. To obtain the continuous flood envelope behind a defence line the modelling process was repeated at numerous points along the defence line.

9.31 For each principal flood risk source the latest estimates of peak flood level were used as input to the model.

9.32 The LiDAR data supplied by the Environment Agency was used to construct a detailed terrain model of the entire Borough which was an essential component of the hydraulic modelling of the flood wave propagation process. The gap in the LiDAR data in the Freiston / Butterwick area was filled using Ordnance Survey SAR data.

9.33 The two-dimensional modelling was capable of producing two types of result. These were Impact Cells and Impact Zones. Impact Cells represent the final at-rest flood situation (i.e. when the initial inrush of water has ceased). Impact Zones represent the maximum impact of flood water experienced at any point, even though that impact could be very transient (e.g. the rapid passage of relatively shallow sheets of flood water through the built-up areas in the centre of Boston town following the overtopping (but not breaching) of the 'hard' defences along the Haven.)

Relative Probability of Flooding

9.34 The results of the modelling therefore show the relative probability of land flooding with the defences in place as follows:

- Low Probability
- Medium probability
- High Probability

9.35 The Impact Zone flooding type tended to give the worst case results and was therefore used to derive the Relative Probability of Flooding maps which are shown as Figure 2

10 Exception Test

Application of the Exception Test

10.1 PPS25 states that the Exception Test should be applied, only after the Sequential Test, to Local Development Documents site allocations for development and used to draft criteria-based policies against which to consider planning applications.

10.2 For the Exception Test to be passed:

a) It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared. If the Development Plan Document has reached the 'submission' stage the benefits of the development should contribute to the Core Strategy's Sustainability Appraisal;

b) The development should be on developable, previously-developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously-developed land; and

c) A Flood Risk Assessment must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

10.3 Boston Borough Council have identified those parts of the Borough where normally development might be expected to occur over the next five to ten years and therefore where a more detailed assessment of the flood risk is required.

10.4 This detailed assessment is based on the Flood Hazard Zones and Relative Probability of Flooding maps and other information.

10.5 The ten study areas are shown in Table 9 below

Study Area	**Area** (ha)
Boston Town (including Skirbeck, Skirbeck Quarter, Wyberton, Chain Bridge & Eastwood Road)	2,262
Bicker	78
Butterwick	93
Fishtoft	42
Freiston	19
Kirton	349
Old Leake	66
Sutterton	159
Swineshead	311
Wrangle	121

Table 9 - Study Areas in Boston Borough

10.6 This detailed assessment of flood risk constitutes a Level 2 SFRA for the 10 study areas.

Capabilities on project:
Water

11 Level 2 SFRA Introduction

Planning Policy Statement 25

11.1 PPS25 states that where it is not possible to allocate all proposed development in accordance with the Sequential Test, taking into account the flood vulnerability category of the intended use, it will be necessary to increase the scope of the SFRA to provide information necessary for the application of the Exception Test..

11.2 The PPS25 FZs are based on the probability of river and sea flooding to which an area of land is currently subject, ignoring the presence and effect of existing flood defences or other man-made obstructions to flood flows

11.3 However, areas within the High Probability Zone (FZ 3), on fluvial or tidal floodplains, may have a standard of protection, due to established flood defences or their location within the floodplain, which reduces their probability of flooding. This degree of flood risk to which these areas are subject may well be significantly less than the PPS25 FZ, provided that those defences are maintained at their current standard of protection.

11.4 There is still a residual risk of flooding should the defences breach and this is represented as the Flood Hazard.

11.5 Potential development areas in different parts of FZ 3 may be at different levels of flood risk, particularly in an area with flood defences. However, whilst the probability of fluvial flooding may well be less than 1%, (1 in 100 years), because of the defences, the area will still fall within FZ 3. In order to apply the sequential approach to areas within the FZs the LPA will need to rank development according to actual flood risk.

11.6 To give full benefit to the Borough Council's planners, any assessment of flood risk within the study areas identified as being possible locations for potential development will provide an evaluation of the Flood Hazard for the year 2115 and the Relative Probability of Flooding today over the whole of those study areas.

11.7 This will enable the Council to apply the Sequential Approach required by PPS25, both as regards the variation of flood risk within a study area and also for the practical purpose of ranking areas within FZs 2 and 3.

Capabilities on project:
Water

12 Study Areas

12.1 The degree of flood risk throughout each of the ten study areas has been assessed from a combination of factors, sources of information and engineering judgment. The detailed assessment of flood risk in the study areas is based on the predicted level of risk in 2115, allowing for the impacts of climate change and further detailed information on flooding is available from the Environment Agency.

12.2 Flood risk sources considered in the assessment include all open watercourses (rivers, streams, canals, arterial drains and riparian drains) and, where applicable, principal surface water and combined (foul + surface water) sewers. Possible flooding from foul sewers is not included in the assessments as this can occur from a variety of causes, often with no direct or quantifiable relationship to extreme rainfall events. Flooding from groundwater and canals is of no relevance in the Boston area.

12.3 The risk of flooding of a development site is not the only consideration. The potential increased flood risk posed by the urbanisation of a "greenfield" development site to other areas downstream of the development site also has to be evaluated. This risk can arise not only from the additional runoff volumes and higher peak runoff rates generated by newly impermeable areas but also from the reduction in natural floodplain storage capacity if the development takes place in a floodplain.

12.4 The individual flood risk assessments for the ten study areas will be presented in a common format under the following headings:

a) General description of the study area

b) Hydrology of the study area (including hydraulic structures etc)

c) Flood Hazard Zones, (2115), within the study area.

d) Relative Probability of Flooding, (current situation), within the Study Area.

e) Flood risks to downstream areas

12.5 In a built-up area, the flow of water into the defended area behind a breach is very unlikely to conform to a uniform pattern. The actual pattern of flow through a breach, and hence the width of the hazard zone at that point, will be distorted by the presence of buildings, walls, street furniture, parked vehicles, etc. Although strategic representations of the Hazard Zones have been derived a more precise assessment of the Hazard Zone should, where applicable, still be attempted in any site-specific flood risk assessment.

12.6 The flood risk assessments of the study areas made for strategic planning purposes do not preclude the necessity for site-specific flood risk assessments of individual development sites within the wider study areas. The flood risk assessments of the study areas should nevertheless be used as a general framework within which site-specific flood risk assessments are undertaken.

12.7 The location of the ten study areas for which flood risk assessments are required have been listed in Table 9 and are shown in Figure 3.

12.8 All but two of these study areas are situated along the line of the low silt ridge that runs from SSW to NNE through Boston itself, parallel with the western shore of the Wash. The two exceptions are Swineshead and Bicker, which are located on a subsidiary silt ridge SW of Boston, parallel with the coastal ridge but about 5km further inland. Five of the study areas (Butterwick, Fishtoft, Freiston, Old Leake and Wrangle) lie north of Boston and the remainder (Bicker, Kirton, Sutterton and Swineshead) south of Boston.

12.9 The ten study areas range in size from 2,262 to 19 hectares. All the study areas apart from Boston Town (2,262ha) are smaller than 350ha and five are smaller than 100ha. All of the designated study areas consist of a single parcel of land.

With the exception of Boston itself, all of the potential study areas comprise the whole of the built-up area of the named village and the adjacent undeveloped fringe around that village. Hence all of the study areas consist of a mixture of ‘brownfield’ and ‘greenfield’ land.

12.10 Urban development within a floodplain also raises the question of ‘displaced water’ and the potential loss of natural flood storage volume within the floodplain, though if the development is within a defended floodplain the issue only arises with floods of greater magnitude than that for which the floodplain's defences were designed. If the loss of floodplain storage can be shown to be of significance for flood risk elsewhere then consideration should be given to the provision of compensatory flood storage volume within the floodplain to mitigate the effects of the ‘displaced water’.

12.11 It should, however, be noted that statically ‘displaced water’ is not a significant issue with flooding from a tidal source, except perhaps at the head of a narrow tidal estuary, as the flood risk source - in this case the North Sea - is semi-infinite in extent and capacity. On the other hand, dynamically displaced water (e.g. the diversion of a fast moving stream of flood water by a development in the vicinity of a breach) and its impact on adjacent property should be taken into consideration in both the tidal and fluvial flooding situations.

12.12 Many small surface watercourses within urban areas in Boston Borough have been partially or wholly culverted in the past. When the previous SFRA was being undertaken many of these watercourses had been designated as Critical Ordinary Watercourses (COWs). However, all of these COWs appear to have been IDB-maintained drains but, unlike COWs designated by LPAs, were not adopted as Main River by the Environment Agency.

12.13 Other culverted watercourses, particularly in Boston, now form part of Anglian Water's surface water sewer network, with outfalls direct to IDB-maintained drains or Main Rivers. In some areas these sewers can be of considerable size at their downstream ends and thus constitute potential flood risks over a significant area, but past experience has shown that this does not appear to be the case in Boston Borough. The larger surface water sewers have nevertheless been taken into account in the study area flood risk assessments and, where appropriate, are shown on the study area plans.

13 Boston Town

General Description of the Study Area

13.1 The Boston Town study area includes not only the town centre but extends to include the whole of the built-up area around the town including the suburbs of Skirbeck, Skirbeck Quarter, Wyberton, Chain Bridge and the Marsh lane Industrial Area. The study area has a population of about 37,000 (including Skirbeck and Wyberton) and covers an area of 2,262 hectares (22.6 sq.km), more than six times the size of the next largest study area. A location plan is shown in Figure 3.1.

13.2 The study area is irregular in shape but roughly circular and is equally distributed on either side of the River Witham and Boston Haven, the river's tidal outfall channel. The study area also includes the downstream ends of the South Forty Foot and Maud Foster Drains and their tidal outfalls to the Haven. The study area is shown in Figure 4.

13.3 As well as all the residential areas in Boston and its suburbs, the Boston Town study area also includes Boston docks and the extensive modern industrial area (Marsh Lane Industrial Estate) between Wyberton Low Road and the Haven. The recently developed retail and commercial area at Chain Bridge on the western edge of the town also falls within the study area.

13.4 Boston Town study area includes a number of undeveloped areas of farmland. The largest of these include substantial areas on either side of the Maud Foster Drain, south of Rawsons Lane and Pilleys Lane; arable land between Wainfleet Road and Eastwood Road and south of Eastwood Road along Toot Lane. West of the Witham there are still smaller but significant areas of undeveloped land south of the Marsh Lane Industrial Estate and between the new A16 and the old London Road. One of the largest areas of undeveloped land in the study area is the farmland on either side of Wyberton West Road and West End Road. To the north west of the town, in the angle between the South Forty Foot Drain and the Witham, a large area of Wyberton Fen and a smaller area in Boston West also remain undeveloped.

13.5 Boston town centre has developed along both sides of the Haven since the early middle ages. Centuries of successive development and redevelopment has resulted in a gradual accretion of material in the town centre so that land levels in a substantial part of the town centre are now above 5m AOD, rising to above 6m AOD at the south end of the Market Place. From the town centre the ground falls away towards the areas of more recent development in the suburbs and on the outskirts of the town and the surrounding fens where ground levels are generally between 2m and 3m AOD. The implications of this for flood risk in the study area have been discussed previously in this Report and will be considered further in this sub-section.

13.6 Within the study area the town centre 'island' of land within which ground levels are above 3m AOD extends in a 600m wide strip from north to south along the river, with branches stretching along Wide Bargate to the Maud Foster Drain, along Fydell / Castle Streets, along West Street, and along Skirbeck Road. Smaller, isolated 'islands' of land above 3m AOD occur at Burton Corner, the east end of Eastwood Road, Skirbeck Quarter, Wyberton West End, Wyberton (Parthian Avenue) and Hall Hills.

13.7 Significant basins of low-lying land (below 2m AOD) exist within the study area in the Tower Road area, Wyberton (West Road and Five House Lane), Wortleys Lane and Wyberton Fen. In the latter two basins ground levels fall in places to below 1.5m AOD.

Hydrology of the Study Area

13.8 The hydrology of the Boston Town study area is dominated by the primary flood risk sources identified and evaluated previously in this Report - the River Witham, Boston Haven, the South Forty Foot Drain, the North Forty Foot Drain and the Maud Foster Drain. The following paragraphs will therefore deal with the secondary flood risk sources within the study area.

13.9 The River Witham / Boston Haven forms the boundary between the Witham Fourth District and Black Sluice IDBs and the study area is divided roughly equally between the two Drainage Districts. The whole of the study area lies within one or other of the two Districts, although surface water runoff from much of the older, central part of the town drains into the public sewerage system.

13.10 East of the Witham a substantial part of the built-up area lies within the catchment served by the Witham Fourth District IDB's Boston East pumping station. This station, established in 1984, is situated on the SE side of Bargate Bridge and discharges into the Maud Foster Drain at that point. The Boston East catchment includes the low lying area of the town centred on Tower Road. Those parts of the study area east of the Witham outside the Boston East catchment drain to the Board's wider arterial drainage system in the area west of Hobhole Drain and south of Cowbridge Drain, finding its way by gravity to those two drains. Surface water runoff from this area is pumped to the Haven at Hobhole pumping station.

13.11 A similar situation exists in the Black Sluice IDB's area west of the River Witham and north of the South Forty Foot Drain. Although this area drains generally to the North Forty Foot Drain there is a small pump-drained catchment in the Fydell Street / Carlton Road area which is served by the Allan House pumping station. This station, which has recently been rebuilt in connection with the Asda supermarket development in that area, discharges to the Boston Haven just downstream of Grand Sluice. Flows in the North Forty Foot Drain are pumped into the South Forty Foot Drain at Cook's Lock pumping station (PS).

13.12 That part of the study area within the Black Sluice Drainage District but south of the South Forty Foot Drain is served by two separate pump-drained catchments. The boundary between the two catchments follows the line of the Old London Road as far south as Wyberton (Saundergate Lane) and along the new A16 road thereafter. These are the Chain Bridge and Wyberton Marsh catchments which lie west and east of this boundary respectively.

13.13 The Chain Bridge catchment is served by Chain Bridge PS, situated on the south bank of the South Forty Foot Drain 300m downstream of Wyberton High Bridge. Within the study area the principal arterial drains are the Wyberton Towns Drain and the downstream ends of the Old and New Hammond Becks which all converge a short distance upstream of the pumping station. The Frampton Towns Drain runs along the southern boundary of the study area. The Old and New Hammond Becks are physically continuous across the western boundary of the catchment which is the nominal boundary between the Board's Chain Bridge and Swineshead catchments. Flows in the two Hammond Becks can also be discharged to the South Forty Foot Drain at Swineshead PS, 7.5km upstream of Chain Bridge PS.

13.14 Wyberton Marsh PS, situated on the south side of Boston Haven nearly opposite Hobhole, serves the Wyberton Marsh catchment. Within the study area this catchment includes the extensive Marsh Lane Industrial Estate. The Wyberton and Frampton Towns Drains are also continuous across the boundary with the Chain Bridge catchment and runoff from the Wyberton area can, in practice, flow in either direction. These hydraulic interconnections between adjacent pump-drained catchments give the IDB's arterial drainage systems a considerable degree of resilience under flood conditions.

13.15 Much of Boston town centre's sewerage system, although currently subject to a programme of renewal, is a combined-flow system in which surface water runoff from roads, roofs and paved areas is discharged into pipes which also convey foul sewage. The Boston sewerage system relies on a series of sewage pumping stations to pump flows to the town's sewage treatment works on the north bank of the Haven at Blue Anchor Bight, 3km downstream of the town. Efficient operation of a modern sewage treatment works relies on a steady flow of sewage of a consistent concentration.

13.16 In extreme rainfall events large volumes of surface water runoff enter the town's combined sewerage system. In order to prevent the treatment works and the pipe network becoming overloaded, the sewerage system has been provided with storm water overflows from which excess runoff is discharged to Boston Haven. At times of high tide these storm overflows may become tidelocked and the discharge then has to be pumped to the Haven. Since 2002 these storm water overflows have been supplemented by underground storm water storage tanks.

Flood Hazard Zones, (2115), within the Study Area.

13.17 If a breach in the Haven's tidal defences or the River Witham's floodbanks occurred within the study area the majority of land to the south and west would be in the Danger to All category with some pockets in the Danger to Most category. Land in the east would be in the Danger to Most category with a small portion in the Danger to All category. This is shown on the Flood Hazard Zone Figure 1, Sheet 2.

13.18 There is a possibility of localised flooding from the sewerage system but recent improvements to the town's sewerage system, including the provision of emergency runoff storage tanks, have significantly reduced the risk of flooding from this source

Relative Probability of Flooding, (current situation), within the Study Area

13.19 The Environment Agency's Flood Zone Map shows the majority of the Boston Town study area to be in Flood Zone 3. However the Relative Probability of Flooding Figure 2, Sheet 2 and Sheet 2A shows a complex pattern of tidal and fluvial flood risk across the study area. This pattern is summarised below.

East of Maud Foster Drain

13.20 Mainly tidal flood risk with a medium probability of flooding except for a substantial area of land with a Low probability of flooding along Fishtoft SE from Skirbeck Church and islands with a Low probability of flooding at the E end of Eastwood Road, Burton Corner and Cowbridge.

Between Maud Foster Drain and River Witham / Boston Haven

13.21 This area is almost all at a medium probability of tidal flooding south of Wide Bargate, with a mixture medium probability of tidal flooding and high probability of fluvial flooding north of Wide Bargate, although there is a large area of land with a low probability of flooding along Tattershall Road.

West of River Witham / Boston Haven and North of the South Forty Foot Drain

13.22 West of the railway this area is mainly tidal flood risk with a medium probability of flooding except for a substantial area with a low probability of flooding in the Carlton Road area and islands with a low probability of flooding of along Matthew Flinders Way and the west end of Sleaford Road. However the town centre between the railway and the Haven is almost wholly tidal flood risk with a high probability of flooding.

South of the South Forty Foot Drain (Chain Bridge Catchment)

13.23 This area largely has a low probability of flooding except for a small intrusion of tidal flood risk with a medium probability of flooding to land east of Old London Road in Wyberton.

South of Boston Haven (Wyberton Marsh Catchment)

13.24 Most of this area is at tidal flood risk with a medium probability of flooding with a few small islands with a low probability. There are a handful of very small areas with a high probability on Marsh Lane and Wyberton Low Road reflecting localised flood risk from the arterial drainage system.

13.25 It should be emphasised that any tidal flooding in areas of tidal flood risk towards the centre of Boston Town study area (e.g. the area west of the Haven, between the river and the railway station) will be of a transient nature, characterised by fast flowing sheets of fairly shallow water along roads and across paved areas, unless a breach occurs.

13.26 Recent estimates of the 0.1% (1 in 100 years) plus climate change flood levels in the arterial drainage system in the Black Sluice IDB area give a flood level of 1.26m AOD in the North Forty Foot Drain at Cooks Lock, rising to 1.28m AOD at Langrick Road and 1.31m AOD at Endeavour Park. In the Hammond Beck at Chain Bridge pumping station the estimated flood level is 1.39m AOD, rising to 1.43m AOD at Frampton West End. Corresponding flood levels of 2.49m AOD and 2.50m AOD are predicted at Wyberton Low Road and Marsh Lane respectively. These levels are not such as to give rise to serious flooding on adjacent land.

Boston Tidal Barrier

13.27 It is our understanding that the proposed tidal barrier will be erected across the reach of the Haven. The proposed barrier would protect those parts of Boston upstream of the barrier against tidal flooding in an extreme storm surge event and the proposed scheme includes the improvement of the existing defences through the town where required. On completion of the scheme the barrier will protect Boston Town from a tidal flood event in excess of 0.5%, (1 in 200 years).

Flood Risk to Downstream Areas

13.28 Since much of the existing Boston urban area drains directly to tidal waters (Boston Haven) any redevelopment within this area will have no effect on flood risk elsewhere. The same applies to the relatively small areas which drain to high level Main River watercourses such as the Maud Foster Drain. The exceptions to this are the more recent suburban developments around the outskirts of the town which drain to arterial drainage systems, almost all of which are pump-drained, such as the North Forty Foot Drain to the west of the town and the Hobhole system east of the town.

13.29 Since any large scale new development within the study area will inevitably take place on 'greenfield' land around the periphery of the area, it follows that the additional surface water runoff generated by such developments will be discharged into the arterial drainage systems, thereby increasing the demands on the pumped-drainage infrastructure at critical periods and diminishing the current standards of flood protection within those already partially urbanised catchments. The design of the new drainage systems associated with this greenfield development will therefore need to incorporate runoff retention and flow retarding features.

Conclusion

13.30 The study area is almost entirely in flood zone 3. However there is a variation in the flood hazard from Danger to Most to Danger to All.

13.31 The use of the Relative Probability of Flooding maps indicates that there are areas where the likelihood of flooding is low.

14 Bicker

General Description of the Study Area

14.1 The village of Bicker is situated 12km south west of Boston, on the western edge of the Borough, and 2.5km north east of the larger village of Donington in the neighbouring district of South Holland. Bicker lies just north of the A52, the main road from Grantham to Boston as shown on the location plan, Figure 3.3.

14.2 The wedge-shaped study area extends over 78.3 hectares and includes almost all of the village of Bicker. The parish has a population of about 850, making it one of the smaller study areas, although there are no outlying settlements of any size and the great majority of the population live in the core village.

14.3 The A52 road, which now bypasses Bicker, forms the south eastern boundary of the study area. The study area's western boundary runs north along field boundaries from the A52 at St Bernard's House to Rookery Road. The northern boundary follows an arc from Rookery Road across Milking Hill Lane and nearly as far north as Dark Lane before turning south east on an irregular line to meet the A52 again at its junction with Horseham's Lane. The study area is shown in Figure 5.

14.4 Although the study area consists principally of residential properties, there is a large vegetable processing plant on the eastern side of the village to the north of Monument Lane and a smaller plant nearer the centre of the village in Lowgate Lane. There is also a warehousing complex adjacent to the A52 in the south-western corner of the study area. The study area includes a periphery of arable fields around the perimeter of the built-up area, particularly along the western and north eastern sides of the study area. There is a substantial area of grazed parkland to the south of Monument Lane.

14.5 Bicker village stands on slightly elevated silt land at the head of Bicker Haven, what was once a tidal inlet from the Wash at the mouth of the River Welland. Centuries of siltation and land reclamation have left Bicker Haven as dry but low-lying farmland bounded by marginally higher land on either side. Land levels at the southern end of the village along the line of the A52 rise to between 4m and 5m AOD, falling gradually to 3m AOD at the northern end of the village. Lower land outside the study area to the north and east of the village falls to 2m AOD in places.

14.6 The village's most prominent and attractive physical feature is Bicker Eau (or Old Eau), a stream which runs on a meandering course from north to south through the centre of the village and study area. For most of its length public roads run along one or both banks of the channel. Its winding course indicates that it was originally a natural fenland watercourse providing an outfall into Bicker Haven for surplus water from the fens beyond the village. The hydrological significance of Bicker Eau will be discussed in the following paragraphs.

Hydrology of the Study Area

14.7 Like the village itself, the hydrology of the Bicker study area is dominated by the presence of the Bicker (or Old) Eau. This watercourse drains the area around Bicker village NW into the Hammond Beck, the principal arterial drain in the Swineshead catchment which has a pumped outfall to the South Forty Foot Drain at the Black Sluice IDB's Swineshead Pumping Station, 5km north of Bicker. (The Bicker Eau does not drain into the smaller Bicker Fen catchment which lies between Hammond Beck and the South Forty Foot Drain NW of Bicker.)

14.8 In the Bicker area the Hammond Beck runs on a course parallel with the South Forty Foot Drain and approximately 2km SE of it. This watercourse is a principal component of the Black Sluice IDB's arterial drainage system and interconnects adjoining pump-drained catchments, providing a substantial element of resilience in the system and, if necessary, enabling runoff from Bicker Eau to be pumped to the South Forty Foot at the neighbouring Chain Bridge and Donington North Ings Pumping Stations.

14.9 The upstream end of Bicker Eau is at Ten Acre Drove in a low-lying area of what was once Bicker Haven, 4km SE of Bicker village. In recent years the IDB has found it necessary to provide a small land drainage pumping station (Bicker Eau PS) at the SE (upstream) end of the village in order to drain the upstream end of the Bicker Eau catchment more effectively.

14.10 Although Bicker village is sewered, there are no public surface water sewers of any significance in the village.

Flood Hazard Zones, (2115), within the Study Area.

14.11 There are no raised formal flood defence banks, only spoil heaps, on this section. However, the modelled water levels used in this study are shown to be higher than these spoil banks and the modelling therefore assumes a breach is possible, although the integrity of the spoil heaps will reduce this possibility.If a breach in the nearest point on the South Forty Foot Drain occurred on Bicker Fen (2km from the western boundary of the study area) the study area would not fall within the Hazard Zone. The Environment Agency have recently updated the flood levels within the South Forty Foot drain and further information is available from them..

Relative Probability of Flooding, (current situation), within the Study Area

14.12 The Environment Agency's Flood Zone Map shows the whole of the study area to be in Flood Zone 1. The Relative Probability of Flooding Figure 2, Sheet 4 shows the whole of the study area to be at a low probability of flooding.

14.13 The village is situated towards the upstream end of Bicker Eau which runs in a deep, well incised channel through the village. The impact of any residual risk failure at Bicker Fen PS would be felt in the fen and the impact would not reach the study area. Similarly, any residual risk failure at Bicker Eau PS would only be felt in the low land in Bicker Haven, remote from the village. The small village sewerage system poses no flood risk within the study area.

Flood Risk to Downstream Areas

14.14 There are no built-up areas downstream of the Bicker study area within the Swineshead pump-drained catchment. Between Bicker village and Swineshead PS the Bicker Eau and Hammond Beck flow entirely through open farmland, thus there is no direct increase in flood risk to properties downstream.

14.15 Despite this, the discharge capacity of Swineshead PS under flood conditions is finite, as is the hydraulic capacity of the South Forty Foot Drain into which it discharges and ultimately Black Sluice PS. These constraints will therefore have to be taken into account in the drainage design for any large scale development on 'greenfield' land within the study area to avoid increasing flood risk generally in the wider Swineshead and South Forty Foot catchments.

Conclusion

14.16 The study area is entirely in flood zone 1 and outside of the flood hazard..

14.17 The use of the Relative Probability of Flooding maps show that the study area is at a low probability of flooding.

15 Butterwick

General Description of the Study Area

15.1 The village of Butterwick is situated 6km east of Boston, 1km south of the main A52 (Boston to Skegness) road and 3km from the shore of the Wash, as shown in Figure 3.2.

15.2 The roughly circular 93.3 hectare study area is centred on the village of Butterwick but includes a substantial ring of agricultural land around the south, west and north of the built-up area. Butterwick is one of the larger silt ridge villages north of Boston and the parish has a population of about 1,400, the great majority of whom live within the study area. A plan of the study area is given in Figure 6.

15.3 Butterwick is a long, narrow parish and the study area extends right across the parish along its Benington Road – School Lane (NE to SW) axis. (The study area includes small parcels of land in Freiston parish along its western boundary.) On the south the study area extends along Girls School Lane to Pinchbeck House and to the Doves Lane / Sea Lane junction. In the north the study area extends up Mill Lane as far as Marshall's vegetable processing plant. The diameter of the study area varies between about 900m and 1,100m.

15.4 Unlike many of the villages in the Borough, the built-up area of Butterwick is rather compact and incorporates no significant open spaces or areas of undeveloped farmland. The built-up area stretches in a crescent concentrated on the south and west sides of Brand End Road / Sea Lane, with extensions along both sides of School Lane and Benington Road. The historic village core lies at the intersection of these four roads. On the eastern edge of the village, at the junction of Watery Lane and Sea Lane, there is a cluster of light industrial premises. Butterwick's major industrial site lies just outside the northern boundary of the study area.

15.5 Although, typical of the silt ridge, there are perceptible local variations in ground level across the area, there is very little overall variation in elevation within the study area with all spot heights on the OS 1/10,000 map shown as 3m AOD. The highest point in the study area is 3.4m AOD in the centre of the village. Unlike Wrangle and Old Leake further north, there is also very little variation in land level between the study area and the Wash. Further inland, however, land levels decrease northwards across the A52 and towards the East Fen.

Hydrology of the Study Area

15.6 Like most of the villages along the crest of the silt ridge north of Boston, there are relatively few arterial drains of any size within the Butterwick study area which appears to straddle the watershed between the Wash and the East Fen. The two principal arterial drains on the northern side of the study area, the Benington Road and the Brand End Drains, both flow north to cross the A52 on either side of the A52 / Mill Lane junction. Both drains merge north of the A52 and the combined drain discharges to the Hobhole Drain just upstream (NW) of Haltoft End. Flood flows in the Hobhole Drain are discharged to the mouth of Boston Haven at the Witham Fourth District IDB's Hobhole PS.

15.7 The southern side of the study area drains via a network of minor IDB drains to the Witham Fourth District IDB's land drainage pumping station (Benington PS) which is situated on the shores of the Wash near Butterwick Sea End, 3km east of the study area. However, the IDB drains in the Butterwick area are continuous across the watershed and within the study area the areas of land draining in each direction can vary depending on prevailing conditions.

15.8 Butterwick village is served by a modern sewerage system, but this conveys only foul sewage. Surface water runoff from roofs and paved areas in the study area is piped to the nearest open watercourse or riparian ditch or disposed of by soakaways.

Flood Hazard Zones, (2115), within the Study Area

15.9 If a breach in the nearest point on the Wash tidal defences occurred at Butterwick Sea End (1.75km from the SE boundary of the study area) the majority of land would be in the Danger to All category with some pockets in the Danger to Most category. This is shown on the Flood Hazard Zone Figure 1, Sheet 2

Relative Probability of Flooding, (current situation), within the Study Area

15.10 The Environment Agency's Flood Zone Map shows the whole of the study area to be in Flood Zone 3. However the Relative Probability of Flooding Figure 2, Sheet 2 shows the whole of the study area to be at a low probability of flooding.

15.11 The location of the village and study area on the silt ridge watershed and the absence of any substantial drains or watercourses in the study area mean that flood risk from local sources will be minimal. Any flooding that did occur would be shallow, localised and largely confined to waterlogging.

15.12 An extreme flood event during which the discharge capacity of Benington PS was exceeded or if a residual risk equipment failure occurred should not have any impact on the study area which is situated remote from the pumping station at the head of the catchment.

Flood Risk to Downstream Areas

15.13 Irrespective of whether the additional runoff generated by large scale development in the Butterwick study area is discharged to IDB drains flowing north to the Hobhole Drain or south to the Wash, all of this runoff will pass through essentially agricultural areas and thus it will pose no direct flood risk to existing developed areas.

15.14 However, the Hobhole Drain and the smaller drainage networks to the south of Butterwick are all pump-drained, and the discharge capacity of Hobhole PS and the smaller pumping stations discharging to the Wash under flood conditions is finite. These constraints will therefore have to be taken into account in the drainage design for any large scale development on 'greenfield' land within the study area to avoid increasing flood risk generally in the wider Hobhole and smaller Wash-bank catchments.

15.15 Given the relatively small sizes of the IDB drains in the Butterwick area and the relatively large area of 'greenfield' land in the study area, it would be advisable to verify the hydraulic capacity of the local surface water drainage networks before development occurs.

Conclusion

15.16 The study area is entirely in flood zone 3 However there is a variation in the flood hazard where Danger to Most is predominant with some Danger to All areas

15.17 The use of the Relative Probability of Flooding maps show that the study area is at a low probability of flooding.

16 Fishtoft

General Description of the Study Area

16.1 Fishtoft village is situated on the SE outskirts of Boston, 3.5km from the town centre, in the angle between Boston Haven (1.5km) and the Hobhole Drain (0.5km). The location of the 42.2 hectare study area is shown in Figure 3.2.

16.2 The study area, shown on Figure 7. includes almost all of the village of Fishtoft. Although the total population of Fishtoft parish is about 6,350, this figure includes a considerable portion of the northern and eastern suburbs of Boston (Pilleys Lane, Eastwood Road and part of Skirbeck). Hence the population of the Fishtoft village and study area is only a small proportion of the population of the whole parish, probably only around 800.

16.3 The study area is roughly Y-shaped. The base of the Y extends south along Gaysfield Road to just beyond the Scalp Road / Cut End Road junction at the old chapel. The eastern arm of the Y extends along Clamp Gate Road to the Wythes Lane junction, and the larger, western arm extends along Fishtoft Road to near Ivy Farm and north along Church Green Road to Norwood House. Most of the boundaries of the northern half of the study area are coincident with minor watercourses.

16.4 Apart from a small food processing plant at the northern extremity of the study area, all the developed land enclosed within the study area consists at present of residential property, including the village school, parish church, public house etc. The study area includes an open space in the angle of the Y, now a playing field, although the eastern side of the original open space has recently been developed for housing. The study area also includes an arable field north of Fishtoft Road, two small arable fields off Church Green Road, and a pair of small fields, one grass and one arable, at the south end of Burton Croft Road just north of the church.

16.5 The eastern half of the village is marginally higher than the western half. From the highest point at the church (5m AOD) a ridge of slightly elevated land extends south along Clamp Gate Road and Gaysfield Road. Ground levels across the western half of the village are uniformly at about 3m AOD. There is a slight fall in level to the north and west of the study area but not to the east and south.

Hydrology of the Study Area

16.6 The principal hydrological feature of the Fishtoft study area is the small arterial drain known as the Graft. This watercourse originates in the Southfield Lane area about 1.5km south of Fishtoft and flows northwards through the centre of the village to a gravity outfall to the Hobhole Drain midway between Clamp Gate Bridge and Freiston Bridge, some 750m NE of Fishtoft. The Graft drains much of the agricultural land between the eastern edge of Boston and the Hobhole Drain but also a substantial part of Boston's eastern suburbs in the Woodthorpe Avenue area. A substantial section of the Graft has been culverted in its passage through the centre of the village, including a recently culverted section along the eastern edge of the recreation area.

16.7 Although the village is sewered, there are no significant public surface water sewers in the study area. Surface water runoff from existing development is assumed to be piped to the Graft or riparian ditches connected to it, or disposed of to soakaways.

Flood Hazard Zones, (2115), within the Study Area

16.8 If a breach in the nearest point on the Boston Haven tidal defences occurred at Corporation Point (1.25km from the SE boundary of the study area) the majority of land would be in the Danger to All category with some pockets in the Danger to Most category. There is a small area of higher land which would be in the low hazard category. This is shown on the Flood Hazard Zone Figure 1, Sheet 2.

Relative Probability of Flooding, (current situation), within the Study Area

16.9 The Environment Agency's Flood Zone Map shows the whole of the study area to be in Flood Zone 3. However the Relative Probability of Flooding Figure 2, Sheet 2 shows the whole of the study area to be at a low probability of flooding.

16.10 Although the Hobhole Drain is a mere 250m from the eastern edge of the village, flood risk from the Drain can be disregarded. Between Haltoft End and Hobhole the Drain was excavated through the silt ridge. The Drain's channel is deeply incised along this section and there is a very large amount of freeboard between water level and bank top compared with the section of the Drain upstream of Haltoft End.

Flood Risk to Downstream Areas

16.11 The Graft, the small arterial drain that flows northwards and southwards – fig 7 through the centre of the study area, passes through nothing but agricultural land on its route to its outfall into the Hobhole Drain and thus poses no direct flood risk to existing developed areas.

16.12 However, although the runoff storage capacity of the Hobhole Drain is exceptionally large, it serves a very large catchment and the discharge capacity of Hobhole PS under flood conditions is finite. Even though the volume of additional runoff likely to be generated by development in one of the smallest of the study areas is relatively minimal, the general principles regarding the discharge of additional runoff into a pump-drained catchment will still apply and the need for runoff attenuation will have to be taken into account in the design of the drainage system for any significant development on 'greenfield' land within the study area.

Conclusion

16.13 The study area is entirely in flood zone 3 However there is a variation in the flood hazard where Danger to Most is predominant with some Danger to All areas

16.14 The use of the Relative Probability of Flooding maps show that the study area is at a low probability of flooding.

17 Freiston

General Description of the Study Area

17.1 With an area of only 18.9 hectares, this is the smallest of the study areas. Freiston is situated 4.5km east of Boston, 1.5km east of the Hobhole Drain and 2.5km NW of the Wash at Freiston Shore, as shown in Figure 3.2.

17.2 Although Freiston parish extends from the Borough boundary to the Wash it has a relatively small population (1,250) which is concentrated in two main settlements, Freiston village and Haltoft End, situated on the main Boston to Skegness (A52) 1km north of Freiston village. The study area which is centred on the village is shown in Figure 8.

17.3 Freiston village consists of a rectangle of roads; Church Road, Church View, Butterwick Road and Park Lane enclosing a large open space consisting of sports fields / recreation ground and an adjoining grass field. There has been some residential development at the south end of the open space in recent years. The study area encloses the whole of the rectangle described above, as well as a small outward extensions NE along Butterwick Road, north along Church Road and west along Priory Road but the boundaries of the study area are drawn fairly tightly around the existing built-up area.

17.4 Most of the property within the study area is residential, except for a substantial commercial and light industrial development to the north of Priory Road - the Freiston Enterprise Park and an adjacent cold store. The study area also includes the grass field inside the rectangle and two small arable fields on either side of Church Road, in the extension north of the junction with Park Lane.

17.5 The historic centre of the village rises to an elevation of 4m AOD along Church View. Elsewhere in the village and its surroundings the land, although gently undulating, is at a general level of 3m AOD, with the exception of a length of Priory Road beyond the western edge of the study area where ground levels fall to 2m AOD. South of the village, towards the Wash, and north of the A52 road land levels fall gradually to around 2m AOD.

Hydrology of the Study Area

17.6 Although Freiston is situated on an ‘island’ of slightly elevated land on the silt ridge, it does not straddle a well defined watershed between the Wash and the East Fen. The whole of the Freiston area from the Wash banks to the A52 road is drained to the Hobhole Drain by a network of minor IDB watercourses.

17.7 The western side of the study area, west of Church Road, drains to a gravity outfall to the Hobhole Drain 800m south (downstream) of Freiston Bridge. The east side of the study area is served by an IDB drain which runs east alongside Shore Road.

17.8 Flows in the Shore Road drain can either continue along this drain towards Butterwick and thence via Brand End into the Hobhole Drain 600m upstream (north) of the A52 at Haltoft End. Alternatively flows in the Shore Road drain can also flow south and then west into the IDB drain which crosses Church Road 350m south of the study area to connect up with the network of minor drains west of Freiston. The latter drain is also interconnected across the watershed into the Benington PS catchment, giving the drainage network on the east side of the study area access to three possible drainage outfalls.

Flood Hazard Zones, (2115), within the Study Area

17.9 If a breach in the nearest point on the Wash tidal defences occurred at Freiston Shore (2.5km from the SE boundary of the study area) the majority of land would be in the Danger to All category with a small area of higher land which would be in the low hazard category or outside of the hazard zone. This is shown on the Flood Hazard Zone Figure 1, Sheet 2.

Relative Probability of Flooding, (current situation), within the Study Area

17.10 The Environment Agency’s Flood Zone Map shows the whole of the study area to be in Flood Zone 3. However the Relative Probability of Flooding Figure 2, Sheet 2 shows the whole of the study area to be at a low probability of flooding.

17.11 Even though Hobhole Drain is situated only 600m west of the village, flood risk from the Drain can be discounted. Between Haltoft End and Hobhole the Hobhole Drain was excavated through the silt ridge. The Drain’s channel is deeply incised at Freiston and there is an exceptional amount of freeboard between water level and bank top compared with land upstream of Haltoft End.

17.12 Freiston's location on the watershed formed by the silt ridge and the absence of any substantial drains or watercourses in the village and the study area indicate that flood risk from local sources will be minimal. Any flooding that did occur from these sources would be shallow, localised and probably no more than waterlogging.

Flood Risk to Downstream Areas

17.13 The few small IDB drains and riparian ditches that flow through the study area or around its periphery and the larger drains into which they discharge pass only through agricultural land on their way to their outfalls into the Hobhole Drain or the Wash. Runoff from new development in this smallest of the study areas thus poses no direct flood risk to existing property or urban development.

17.14 The minor drainage network to the south of Freiston is pump-drained, and the discharge capacity of the small pumping station at Freiston Shore under flood conditions is limited. This constraint will have to be taken into account in the drainage design for any significant development on 'greenfield' land within the study area in order to avoid increasing flood risk generally in the Freiston Shore PS catchment.

17.15 By contrast, the runoff storage capacity of the Hobhole Drain is exceptionally large, but it serves a very large catchment and the discharge capacity of Hobhole PS under flood conditions is also finite. Even though the volume of additional runoff likely to be generated by development in the smallest of the study areas is minimal, the general principles which apply to the discharge of additional runoff into a pump-drained catchment will still apply and the need for runoff attenuation will have to be taken into account in the design of the drainage system for any significant development on 'greenfield' land within the study area.

Conclusion

17.16 The study area is entirely in flood zone 3 and the flood hazard is Danger to All with a small area of low hazard or outside of the hazard zone.

17.17 The use of the Relative Probability of Flooding maps show that the study area is at a low probability of flooding.

18 Kirton

General Description of the Study Area

18.1 Both as regards extent and population, Kirton is the largest of the study areas outside Boston itself. It is situated on the silt ridge 6km south of Boston town centre and 5km from the shores of the Wash. Until fairly recently the main A16 (Grimsby to Peterborough) road ran through Kirton, but between Boston and Spalding the A16 has now been re-routed along the line of the old Boston to Peterborough railway and now bypasses Kirton on the south. A location plan is given in Figure 3.3.

18.2 The Kirton study area covers an area of 349 hectares centred on the village of Kirton but including a small portion of Frampton parish. Although described here as a 'village' for consistency, the parish's population of 4,002 in 2001 makes it now a small town rather than a village. The study area is roughly rectangular in shape with its principal axis aligned from SW to NE. The study area's maximum dimensions are approximately 2.5km in length and 1.5km wide. The study area is shown in Figure 9.

18.3 The north-western boundary of the study area runs along the line of Hill Lane and Bungley Lane. East of the old London Road (B1397) and north of Middlegate Road East the study area boundary follows the line of Frampton Towns Drain for some distance. South of Middlegate Road the boundary runs along Coupledyke Lane for a short distance and then cuts across open country via Hall Weir to Eleven Acre Lane where it follows Princess Road to the A16 where the study area boundary turns SW to Drainside South. The study area's south western boundary runs from the A16 to Hill Lane, parallel but to the south of Drainside South and crossing Meres Lane en route at Langley House.

18.4 The new A16 road runs through the study area from NE to SW and the village centre and most of the built-up area lie to the NW of this road. The village is chiefly residential, serving as a dormitory village for Boston, although there are a number of service industries within the village and a large food processing plant on the SW edge of the village. Almost all of the study area north of Middlegate Road is arable land, and although development has extended along Station Road, Horseshoe Lane and Middlegate Road East much of the study area east of the A16 is also still undeveloped farmland. There are also a considerable number of arable fields along the NW edge of the study area.

18.5 The land in the centre of Kirton rises to 5m AOD at the Market Place and parish church and most of the village core is at an elevation of 4m AOD. Elsewhere in the village, apart from one or two isolated locations, land levels are generally at around 3m AOD. The same general level continues between Kirton and the Wash, except between the primary and secondary tidal defence lines where levels increase to about 4m AOD. The study area is bounded on the north by the Frampton Towns Drain and to the south by the Kirton Drain.

Hydrology of the Study Area

18.6 The two principal watercourses in the study area, the Frampton Towns Drain and the Kirton Drain are situated at the northern and southern ends of the study area respectively. The new A16 road (Kirton bypass) now forms the boundary between the Black Sluice IDB's Wyberton Marsh and Kirton Marsh catchments to the east of the road and their Kirton & Frampton (Chain Bridge) catchment to the west.

18.7 Frampton Towns Drain forms the northern boundary of the study area on both sides of the A16 road under which it is culverted, thus linking the Wyberton Marsh and Kirton & Frampton catchments. The eastern end of this drain is connected to Wyberton Marsh PS which discharges to Boston Haven. Its western end drains via the Old Hammond Beck to Chain Bridge PS which discharges to the South Forty Foot Drain.

18.8 Kirton Drain skirts the southern edge of Kirton village on a natural, meandering course. It, too, is culverted beneath the new A16 road and the nominal catchment boundary along the line of the road. Although, like Frampton Towns Drain, the western end of Kirton Drain is connected to the arterial drainage system in the Chain Bridge catchment, the eastern end of Kirton Drain is part of the arterial drainage system in the Kirton Marsh catchment. Kirton Marsh PS is situated on the banks of the Wash at the mouth of the Welland estuary near Hundred Acre Farm.

18.9 There are a number of smaller IDB drains within Kirton village, many of which are wholly or partly culverted. These are all tributaries of either Kirton Drain or Frampton Towns Drain and they all flow away from the 'island' of higher land in the centre of the village.

18.10 Although Kirton village is sewered (the sewage treatment works is situated about 700m north of the village, adjacent to Frampton Towns Drain) there are no public surface water sewers of any hydrological significance in the village.

Flood Hazard Zones, (2115), within the Study Area

18.11 If a breach in the nearest point on the Wash tidal defences occurred on Kirton Marsh (4km from the SE boundary of the study area) the majority of land would be in the Danger to Most category. This is shown on the Flood Hazard Zone Figure 1, Sheet 5.

Relative Probability of Flooding, (current situation), within the Study Area

18.12 The Environment Agency's Flood Zone Map shows the whole of the study area to be in Flood Zone 3. However the Relative Probability of Flooding Figure 2, Sheet 5 shows the whole of the study area to be at a low probability of flooding.

18.13 The latest estimates of the 1%, (1 in100 years), plus climate change flood levels in the arterial drainage system in the Kirton area have been provided by Black Sluice IDB. In the Kirton Drain water levels fall in both directions from 2.55m AOD at the new A16 road to 2.21m AOD in the Drain at Kirton End and, in the opposite direction, to 1.73m AOD at Kirton Marsh PS. Flood levels in the Frampton Towns Drain fall similarly away from the A16 road, in a westerly direction to 1.43m AOD at Ralphs Lane, Wyberton, and in an easterly direction to 2.55m AOD at Sandholme Lane, Frampton, and 2.12m AOD at Wyberton Marsh PS. These levels are less than those which would cause significant flooding on the adjacent land.

18.14 A number of the smaller IDB tributary drains in the built up area of Kirton are culverted and blockages of these culverts could create minor localised flooding problems. These are, however, residual risk events and routine maintenance of these drains by the IDB should greatly reduce the risk.

Flood Risk to Downstream Areas

18.15 Although there is a large concentration of 'greenfield' in the north of the study area it is distributed around the entire perimeter of the study area. As most of the additional surface water runoff generated by new development in the study area will come from 'greenfield' sites, the impact of this additional runoff on each of the three pump-drained catchments which are straddled by the Kirton study area has to be considered separately.

18.16 Only the small SE corner of the study area drains to the upper end of the Kirton Marsh PS catchment. This is an almost wholly rural catchment and although development in this part of the study area will have little or no direct impact on property downstream it will, nevertheless, have a minor but more diffuse impact on flood risk in the catchment. For this reason, and to ensure consistency of approach within the study area, all 'greenfield' development in this pump-drained catchment should be subject to the same planning constraints as other development within the study area.

18.17 The majority of the study area, including much of the existing village, lies west of the Kirton bypass (A16) and falls within the Kirton & Frampton (Chain Bridge) catchment. Although this pump-drained catchment is already partially urbanised, the land along the Kirton and Frampton Towns Drains downstream of the study area is still predominantly agricultural. Nevertheless, even though 'greenfield' development in the study area west of the A16 may not pose any direct risk to properties downstream, the more general impact of this development within the Chain Bridge PS catchment on the arterial drainage infrastructure could be considerable. Flow retarding and runoff retention features should therefore be incorporated into the on-site drainage design of all major developments in this area.

18.18 A significant area of 'greenfield' land in the NE section of the study area falls within the Wyberton Marsh PS catchment. Although the land between the study area and the pumping station is largely agricultural, the northern end of the catchment is now largely urbanised, with suburban development in Skirbeck Quarter and Wyberton and the still-growing Marsh Lane Industrial Estate discharging substantial volumes of runoff into the arterial drainage system. Recent hydrological and hydraulic studies of this catchment for Black Sluice IDB have shown that the existing standard of protection falls locally below 100 years in a few places. It is clear that any further urban development in this catchment will have to incorporate drainage systems designed so as not to increase the volume and rate of runoff currently reaching Wyberton Marsh PS under flood conditions.

Capabilities on project:
Water

Conclusion

18.19 The study area is entirely in flood zone 3 and the flood hazard is Danger to Most with a small area of low hazard.

18.20 The use of the Relative Probability of Flooding maps show that the study area is at a low probability of flooding.

Capabilities on project:
Water

19 Old Leake

General Description of the Study Area

19.1 The village of Old Leake is situated on the silt ridge 10km NE of Boston and 8km NW of the Wash, although the parish extends from the shores of the Wash as far inland as Lade Bank in the East Fen. The Old Leake study area is centred on the historic core of the village which lies just to the north of the main Boston – Skegness (A52) road as shown on the location plan, Figure 3.2.

19.2 The 65.6 hectare study area is compact but irregular in shape, as shown in Figure 10. The great majority of the study area is to the north west of the A52 but it also includes a small enclave of arable farmland south east of the main road. The study area extends for 1,200m along its principal axis from NW to SE and for 900m (maximum) from SW to NE. Although the population of Old Leake parish is 1,800, a considerable proportion of the population, possibly up to half, live in the large outlying settlement of Leake Commonside 2.5km NW of the village centre.

19.3 The southern boundary of the study area, apart from the enclave south of the A52, extends along the A52 from Columbia House to the Old Main Road / A52 junction. The north east and south west boundaries of the study area follow field boundaries around the edge of the built-up area, meeting at the Raysors Lane / Church Road junction.

19.4 Most of the study area is residential in character, although it includes an animal feed mill on the north east side of Church Road (B1184). The study area also encompasses a limited number of small arable and pasture fields around the periphery of the area, notably along its eastern edge, in its south west corner and in the enclave south of the A52. The centre of the village is dominated by the large parish church and the Giles School, a county secondary school, and its grounds. There is also a primary school in the village. The open land in the northern apex of the study area is occupied by football pitch and recreation area. The principal residential areas are centred around St Mary's Way at the north end of the study area, along Pode Lane /Hawthorn Road / School Lane on the west side of the village, and in the Old Main Road / B1184 / A52 triangle.

19.5 The highest point in the study area is about 3.5m AOD in the village centre, from where a slight ridge (3m AOD) extends SW to and along the A52 at Columbia House in the SW corner of the study area. Elsewhere the land, although slightly undulating, is all at around 2m AOD. There is, however, an area of marginally higher land around Leverton Outgate between village and the Wash.

Hydrology of the Study Area

19.6 The principal feature of the hydrology of the Old Leake study area is the arterial IDB drain that originates in the Hurns End area SE of the village from where it flows NW along Shaw Lane, is culverted beneath the A52 road, and then continues in open channel along School Lane before turning west along Pode Lane. West of the parish church the arterial drain is joined by a minor IDB drain which flows west along Old Main Road, NW along Church Road from where it has recently been culverted under the north side of the churchyard. From near the western end of Pode Lane this drain heads north across open land to Faunt Bridge, 1,400m NW of the village centre.

19.7 The northern edge of the study area is served by an IDB drain which originates on Church Road and flows east along Furlongs Lane, culverted until it reaches the edge of the built-up area. It then flows north and then west across farmland to approach Faunt Bridge from the north east.

19.8 From Faunt Bridge, where the two drains described above meet, the combined arterial drain flows SW in a substantial channel alongside the B1184 road (Leake Gride) to discharge to the Hobhole Drain at Leake Gride Bridge, 4km downstream of Lade Bank PS. Thus the whole of the study area is within the southern section of the Hobhole catchment from which flood flows are pumped to the mouth of Boston Haven at the Witham Fourth District IDB's Hobhole PS.

19.9 Although Old Leake village is served by its own sewerage system - the sewage treatment works is situated just beyond the SW edge of the village - there are no significant surface water sewers within the study area.

Flood Hazard Zones, (2115), within the Study Area

19.10 If a breach in the nearest point on the Wash tidal defences occurred seaward of Leake Hurns End (3.5km from the SE boundary of the study area) some land would be in the Danger to All category with the remainder in the Danger to Most category. This is shown on the Flood Hazard Zone Figure 1, Sheet 3.

Relative Probability of Flooding, (current situation), within the Study Area

19.11 The Environment Agency's Flood Zone Map shows the whole of the study area to be in Flood Zone 3. However the Relative Probability of Flooding Figure 2, Sheet 3 shows the whole of the study area to be at a low probability of flooding.

19.12 There is no flood risk to the study area from the East Fen.

19.13 The position of the village and study area on the silt ridge, although at a relatively modest elevation, and the presence of a substantial arterial drainage channel through the village suggest that flood risk from local sources is minimal. Any flooding that did occur would be both minor and localised and a result of a residual risk event such as a blocked or collapsed culvert.

Flood Risk to Downstream Areas

19.14 All surface water drainage from the Old Leake study area eventually finds its way to the Hobhole Drain from Faunt Bridge by means of the Leak Gride Drain, one of the Witham Fourth District IDB's principal arterial drains in the area. The ponded reach of the Hobhole Drain into which the Leake Gride Drain discharges stretches for nearly 15km between Lade bank and Hobhole. Even ignoring its tributaries, the volumetric capacity of this channel is immense when compared to the additional runoff likely to be generated by development of large 'greenfield' sites in the Old Leake study area. Nevertheless, the whole of the extensive Hobhole catchment is pump-drained, and the discharge capacity of Hobhole PS is finite. For this reason it may in principle be necessary to ensure that surface water runoff discharged from all new development in the study area is attenuated to 'greenfield' rates and volumes to avoid increasing flood risk generally in the wider Hobhole catchment.

19.15 The drainage route from the majority of the study area to Faunt Bridge is via the School Lane / Pode Lane Drain. This is a substantial arterial drainage channel capable of conveying substantial flood flows. Any increased risk of flooding of the farmland downstream of the study area can therefore be disregarded.

19.16 As regards the eastern side of the study area, the situation is somewhat different. The drainage route to Faunt Bridge via the Furlongs Lane Drain is considerably longer and the drainage channels smaller. Even though this drainage route is also through predominantly agricultural land, the hydraulic capacity of this drainage path may need to be verified.

Conclusion

19.17 The study area is entirely in flood zone 3 and the flood hazard is mainly Danger to All with the remainder in the Danger to Most category.

19.18 The use of the Relative Probability of Flooding maps show that the study area is at a low probability of flooding.

20 Sutterton

General Description of the Study Area

20.1 This 159 hectare study area includes not only the village of Sutterton but also its smaller, adjoining neighbour, Algarkirk. Sutterton is situated on the southern edge of the Borough, 9km southwest of Boston and 5km northwest of the Welland estuary at Fosdyke Bridge. At one time the A16 (Grimsby to Peterborough) and A17 (Newark to Kings Lynn) trunk roads intersected in the centre of Sutterton but both roads now bypass the village. The locations of Sutterton and Algarkirk are shown in Figure 3.3.

20.2 The combined population of the two parishes is about 1550, of which only 400 live in Algarkirk. Although their parishes cover an extensive area with many outlying farms and cottages, the villages themselves are the only centres of population. The closely adjacent village of Wigtoft is not included in the study area. A plan of the study area is given in Figure 11.

20.3 Although irregularly shaped, the study area is compact and centred on Sutterton. Algarkirk village lies just inside the eastern boundary of the study area. The boundary of the study area runs south from the Wigtoft Road / Blows Lane junction at Sandpit Farm to Reed Point, then east along Spalding Road (B1397) for 300m before heading SE across open country to the Station Road / Love Lane junction at Limes Farm. From here the boundary turns NE, follows closely round the edge of the built-up area of Algarkirk, then runs along Eleys Lane and Hall Lane for a short distance before heading across farmland along field boundaries to Boston Road (B1397) at Nusseys Cottages. West of the B1397 the study area boundary follows a farm track to Rainwalls Lane and runs south along Rainwalls Lane for 300m before cutting across to end on Wigtoft Road.

20.4 At the centre of Sutterton village is a large open area known as The Pools. Most of this area is grassland, either grazing land or a public recreation area, but it also includes a large pond, Bell Mere Pool, now a managed conservation area, on its eastern side and the roundabout where the A16 and A17 roads once crossed.

20.5 Although Sutterton is mainly residential there is a modern trading estate, Sutterton Enterprise Park, on the southern edge of the village off Station Road, and the small Spalding Road Industrial Estate on the western edge of the village. Algarkirk village consists of about three dozen dwellings is a clustered around the church, little larger than a hamlet, but recent residential development on the eastern side of Sutterton has almost closed the gap between the two villages which are now linked by a broad, paved footpath. With the exception of Algarkirk village on the eastern edge of the study area, Sutterton village is circled by a ring of arable farmland between the built-up area and the boundary of the study area.

20.6 Both Sutterton and Algarkirk are situated on the silt ridge on the northern edge of what was once Bicker Haven. The land in the middle of Sutterton rises to an elevation of 4m AOD with similar heights along Station Road and Boston Road. Elsewhere in the study area, including Algarkirk, land levels are everywhere at 3m AOD.

Hydrology of the Study Area

20.7 The Sutterton study area is situated largely within the Welland & Deepings Drainage District, in that part of the Borough that lies to the north of the tidal outfall channel of the River Welland. The IDB's Five Towns catchment, which includes the villages of Wigtoft, Sutterton, Algarkirk and Fosdyke, has its outfall at Five Towns PS. This pumping station is situated on the left bank of the Welland, just upstream of Fosdyke Bridge, from where flood flows in the catchment are discharged to the tidal waters of the Welland estuary. The majority of the study area is in the Five Towns catchment.

20.8 The principal watercourse in the study area is the Three Towns Drain, an arterial drainage channel of the Welland & Deepings IDB. In its present form this watercourse originates within the village of Sutterton and flows east from Sutterton and along the western edge of Algarkirk village. Downstream of Algarkirk the Drain flows south to a confluence with the Two Towns Drain near Sutterton Dowdyke, and then continues eastwards towards Fosdyke Bridge. Another arterial watercourse, the Five Towns Drain, serves Fosdyke and the area NE of the study area. This watercourse joins the Three Towns Drain 600m upstream of their combined outfall to the tidal Welland at Five Towns PS.

20.9 A small area of land on the northern edge of the study area falls within the Black Sluice IDB's Swineshead catchment. This area drains north via Simon Weir Drain to the Old Hammond Beck at Kirton Holme and thence to Swineshead PS which discharges to the South Forty Foot Drain.

20.10 The large open space in the centre of Sutterton village is known as the Pools. Most of this area is now rough grazing land or public recreational area but the in the area east of the roundabout in the angle between Station Road and Boston Road is a large pond, Bell Mere Pool. This pond is managed as a local conservation and amenity area. As far as we are aware, there is no surface water sewerage system in either Sutterton or Algarkirk.

Flood Hazard Zones, (2115), within the Study Area

20.11 If a breach in the nearest point on the Welland Estuary tidal defences occurred at Risegate Outfall (3.5km from the SE boundary of the study area) parts of the study area would fall within the Danger to Some category and some outside of the hazard zones. This is shown on the Flood Hazard Zone Figure 1, Sheet 4.

Relative Probability of Flooding, (current situation), within the Study Area

20.12 The Environment Agency's Flood Zone Map shows the whole of the study area to be in Flood Zone 3, even though the neighbouring study areas of Bicker and Swineshead are wholly or partly with Zone 1. However the Relative Probability of Flooding Figure 2, Sheet 4 shows the whole of the study area to be at a low probability of flooding.

20.13 An extreme flood event during which the discharge capacity of Fosdyke PS was exceeded or if a residual risk equipment failure occurred at that station should not have any impact on the study area which is situated remote from the pumping station and at the head of the catchment.

20.14 Where it appears as an open channel on the eastern side of Sutterton, the Three Towns Drain has a substantial, deeply incised and well maintained channel. The risk of flooding from this upper end of the Drain where the contributory catchment is still very small is therefore minimal. Any flood risk would arise from excess runoff in minor riparian ditches which feed into the Three Towns Drain and any resultant flooding would be very localised and have only minor impact.

Flood Risk to Downstream Areas

20.15 The small village of Fosdyke is situated 2km north of Fosdyke Bridge and Fosdyke PS. The Two/Three Towns Drain passes within less than 1km of the village but is separated from it by the main A17 road. Apart from Fosdyke there are no settlements downstream of Algarkirk. Any increased flood risk to Fosdyke as a result of large scale development within the study area will almost certainly be minimal.

20.16 The Three Towns Drain catchment is part of the larger Fosdyke catchment which is pump-drained and the discharge capacity of Fosdyke PS under flood conditions is finite. This constraint will make it necessary for runoff storage and attenuation features to be incorporated in the design of the surface water drainage systems associated with any significant development on 'greenfield' land within the study area in order to avoid increasing flood risk generally in the Fosdyke catchment.

20.17 That part of the study area north of Post Office Lane, most of which is currently arable land will, if developed, generate a significant volume of additional runoff which will be discharge into the head of the Black Sluice IDB's Swineshead catchment. Although this runoff will flow through farmland for 6km before reaching Kirton Holme, by which time the peak flow will have become substantially attenuated, the same runoff control features described in the paragraph above should be incorporated into the development's drainage design.

Conclusion

20.18 The study area is entirely in flood zone 3. However there is a variation in the flood hazard with some land in Danger to Some with other areas outside of the hazard zones.

20.19 The use of the Relative Probability of Flooding maps show that the study area is at a low probability of flooding.

21 Swineshead

General Description of the Study Area

21.1 Swineshead is a large village situated 10km south west of Boston, towards the western edge of the Borough. Compared with most of the other villages in the Borough, Swineshead is some distance inland and lies on its own silt island, separated from the main NE to SW silt ridge parallel with the northern shore of the Wash. The location of the Swineshead study area is shown in Figure 3.3.

21.2 The 311 hectare study area has an elongated shape, reflecting the shape of Swineshead village which developed along the line of the old A17 (Newark to Kings Lynn) road. The modern A17 now bypasses the village on the west. The population of the parish is approximately 2,450, the great majority of whom live within the study area. The historic core of Swineshead lies around the church and market place with subsidiary settlements strung out along the main road north (North End and Tarry Hill) and south (Drayton) of the central core, but all are now part of the continuous built-up area and included in the study area. The only exception is the separate settlement of Swineshead Bridge where the A17 road crosses the South Forty Foot Drain 3.5km north of the centre of the village. The study area is shown in Figure 12.

21.3 The A17 (Swineshead bypass) from the Drayton (A17/A52) roundabout at the southern extremity of the study area to Hammond Beck in the north forms the western boundary of the study area. The eastern boundary extends along the A52 (Grantham to Boston) road from Drayton roundabout to Abbey Road from where the study area's north eastern boundary runs west along Abbey Road for 200m before following a series of field boundaries to Boston Road at North End. The short northern boundary runs along Boston Road and then continues west to meet Hammond Beck just downstream of High Bridge.

21.4 The elongated village of Swineshead and the main road along which it became established follow the crest of a narrow silt ridge running from south to north. In the core of the village the market place and parish church stand on an 'island' of land rising to just above 5m AOD. There is a smaller 'island' at North End which rises to 6m AOD and land levels at Drayton (W end of Bullens Lane) also rise to 5m AOD. Elsewhere along the crest of the ridge ground levels do not fall significantly below 4m AOD. On the flanks of the ridge, towards the edges of the study area, ground levels fall to between 3m and 4m AOD.

Hydrology of the Study Area

21.5 Although the study area lies within the catchment of the Black Sluice IDB's Swineshead pumping station it is unlikely that the South Forty Foot Drain, into which the pumping station discharges, will have any substantial influence on the study area as a whole. This is because of the distance of the study area from the Drain (1.25km at the area's northern tip), the relative elevated land levels in the study area, and the presence of the channel of the Hammond Beck between the Drain and the study area.

21.6 Surface water runoff from the low ridge of marginally higher land upon which Swineshead is situated drains either east or west into networks of minor IDB drains in the lower land on either side of the ridge. Both networks are intercepted by the Hammond Beck which flows through the Swineshead catchment on a line parallel with the South Forty Foot Drain, and generally between 1 and 2km from the drain. At its closest point to the drain an engine drain (Skerth Drain) connects the Hammond Beck to the South Forty Foot at Swineshead PS. Because the Hammond Beck has a continuous course across a number of the IDB's pumped catchments, flood flows in the Beck can continue eastwards to Chain Bridge PS.

21.7 Surface water drainage from different parts of the study area has a variety of potential routes to the Hammond Beck. Runoff from the area north of the Market Place will drain via Station Road Drain (west of High Street) or the via the North End and Creasy Plot Drains to Sykemouth (east of High Street). Runoff from the area south of the Market Place west of the High Street will drain via a network of minor IDB drains in the Stump Cross area to Hammond Beck near Bicker Gauntlet. The area south of the Market Pace but east of the High Street drains to Sykemouth via the Fenhouses and Hardwick Drains. Runoff from the southern end of the study area at Drayton has a very roundabout route to Sykemouth along the Guildford, Four Towns and Simon Weir Drains and the Old Hammond Beck. Sykemouth, 1.5km NE of the study area, is where Hammond Beck, the Old and New Hammond Becks, the Creasy Plot Drain and the Hardwick Drain all converge.

21.8 There are no surface water sewerage systems of any significance in the study area.

Flood Hazard Zones, (2115), within the Study Area

21.9 There are no raised formal flood defence banks, only spoil heaps, on this section. However, the modelled water levels used in this study are shown to be higher than these spoil banks and the modelling therefore assumes a breach is possible, although the integrity of the spoil heaps will reduce this possibility. If a breach in the nearest point on the South Forty Foot Drain occurred at Swineshead Bridge (1km from the most northerly point of the study area) the Hazard Zone would reach the northern extremity of the study area at North End, from High Bridge to Boston Road. This is shown on the Flood Hazard Zone Figure 1, Sheet 4. The Environment Agency have recently updated the flood levels within the South Forty Foot drain and further information is available from them

Relative Probability of Flooding, (current situation), within the Study Area

21.10 The Environment Agency's Flood Zone Map shows the majority of the Swineshead study area to be in Flood Zone 1, although some parts of the study area fall in Zone 2 and a few in Zone 3.

21.11 The Relative Probability of Flooding Figure 2, Sheet 4 shows the whole of the study area to be at a low probability of flooding.

21.12 The position of the study area along its relatively narrow strip of elevated land means that, except perhaps along the eastern edge of the study area, the risk of flooding from local sources will be minimal. The local topography will ensure that any localised flooding that did occur as the result of a residual risk event would be shallow and of short duration. Development on 'greenfield' land along the lower eastern edge of the study area may however require slightly raised floor levels to provide an acceptable degree of freeboard.

Flood Risk to Downstream Areas

21.13 The northerly extension of the low silt ridge along which the Swineshead study area is situated is the highest land within the Swineshead pump-drained catchment. The lower land which surrounds the study area on three sides is almost wholly open farmland through which any runoff from the study area must flow on its way to Swineshead PS. There is thus no direct increase in flood risk to properties downstream.

21.14 However, as is the case with the Bicker study area which lies on another part of the silt ridge but within the Swineshead catchment, the discharge capacity of Swineshead PS under flood conditions is finite, as is the hydraulic capacity of the South Forty Foot Drain and Black Sluice PS further downstream. These more general constraints will have to be taken into account in the design of the on-site drainage system for any large scale development on 'greenfield' land within the study area, in order to avoid increasing flood risk generally in the wider Swineshead and South Forty Foot catchments.

Conclusion

21.15 The study area is mainly in flood zone 1 and mainly outside of the hazard zones.

21.16 The use of the Relative Probability of Flooding maps show that the study area is at a low probability of flooding

22 Wrangle

General Description of the Study Area

22.1 The village of Wrangle is situated on the north eastern edge of the Borough, 12 km from Boston. The village itself lies astride the silt ridge, some 3.5km from the edge of the Wash. The main A52 (Boston – Skegness) road passes through the village but just to the north of the village centre. The location of the study area is shown in Figure 3.2.

22.2 Although, like Old Leake, the parish stretches from the Wash to the edge of the East Fen the Wrangle study area occupies an area of 121 hectares covering only the village itself. The parish has a population of around 1,300, most of whom are resident in the study area, which does not include the small outlying settlements of Wrangle Bank and Wrangle Lowgate. The study area is compact but irregular in shape, as shown in Figure 13.

22.3 From its southwest corner on the A52 at Joy Hill, the study area is bounded approximately by Brick Lane, Green Gate, Broadgate, Soulby Lane, Gowt Bank, and Boston road (A52). At its eastern end the study area extends for a short distance beyond Broadgate along the Skegness road (A52). The study area extends for a maximum distance of 1,800m along its A52 (SW to NE) axis and for a maximum distance of 1,100m in the NW to SE direction.

22.4 The study area consists at present of two distinct settlements. At the west end of the study area the historic core of the village, centred on the parish church, lies south of a bend in the main road with a cluster of more recent residential development around the Church Lane / Brick Lane junction south east of the church. At the east end of the study area there is a somewhat larger settlement centred on the Broadgate / A52 crossroads but including the built-up area along both sides of Tooley Lane. The two settlements are linked by ribbon development along the main road. A number of medium sized arable fields occupy the gaps between the two settlements and between areas of linear development within the study area.

22.5 Although the village is primarily residential, the study area includes a handful of farmsteads around its periphery and a large vegetable processing plant between the A52 and Gowt Bank.

22.6 Like most silt ridge villages, the land surface undulates gently within the village. The highest land (3m to 4m AOD) lies in the historic core and Joy Hill areas in the south west part of the study area. Elsewhere in the study area the land is somewhat lower, mostly around 2m AOD. North of the study area the land falls gently towards the East Fen. South east of the study area, between the village and the Wash, there is a slight ridge of higher land (about 4m AOD) along a SW to NE axis through Hall End.

Hydrology of the Study Area

22.7 As the Wrangle study area is situated on the crest of the silt ridge it straddles the natural watershed between the Wash and the East Fen, approximately coincident with the line of the A52 road. However the relative arterial drainage watershed between the Wash and the East Fen lies along the subsidiary and parallel silt ridge which runs along Hall Lane and Hall End Road, about 400m SE of the boundary of the study area. The whole of the village and study area therefore drains northwards to the East Fen. The Witham Fourth District IDB's Wrangle PS, located at the Horseshoe, a point on the shores of the Wash 4.5km east of Wrangle village, serves an extensive area of agricultural land on Wrangle Marsh SE of the village but not the study area or the village itself.

22.8 Wrangle village and the study area drain initially northwards into the network of minor IDB drains north of the village in Wrangle Low Grounds. These drains are intercepted by Common Drain, an arterial drain that runs on an east – west line on the south side of Wrangle Common. Common Drain is in turn linked by two north-south arterial drains, Wrangle Drain and Upright Drain, across the fens of Wrangle Common to Lade Bank Drain. This major arterial drain flows from east to west along the Borough boundary and southern margin of the East Fen to the IDB's Lade Bank PS, where flow in the Lade Bank Drain is pumped into the southern (downstream) end of the Hobhole Drain.

Flood Hazard Zones, (2115), within the Study Area

22.9 If a breach in the nearest point on the Wash tidal defences occurred on Toft Marsh (3km from the SE boundary of the study area) some land would be outside the hazard zones with some in the Danger to Some category. This is shown on the Flood Hazard Zone Figure 1, Sheet 3

Relative Probability of Flooding, (current situation), within the Study Area

22.10 The Environment Agency's Flood Zone Map shows the whole of the study area to be in Flood Zone 3. However the Relative Probability of Flooding Figure 2, Sheet 3 shows the whole of the study area to be at a low probability of flooding.

22.11 The position of the village and study area close to the silt ridge watershed means that the contributory catchments of all local watercourses within the study area are small. This indicates that flood risk from local sources will be minimal. Any flooding that did occur would be a result of a residual risk event such as a blocked or collapsed culvert, and would be both localised and shallow, with minimal impact.

Flood Risk to Downstream Areas

22.12 The minor drainage networks in Wrangle Low Grounds to the north of Wrangle flow through agricultural land. Wrangle Common, between Common Drain and Lade Bank Drain, is similarly wholly agricultural. There is, however, a minor settlement, Wrangle Bank, at the east end of Common Drain at its junction with Upright Drain.

22.13 Although the combined runoff storage capacity of the Lade Bank and Hobhole Drains is exceptionally large, the Hobhole Drain upstream of Lade Bank PS serves a large low-lying catchment and the discharge capacity of Lade Bank PS under flood conditions is finite. On a large scale, the same constraints apply to Hobhole PS where the Hobhole Drain is discharged to the Wash.

22.14 Even though the volume of additional runoff likely to be generated by development in the Wrangle study area is relatively small compared to the runoff from the East Fen as a whole, all additional runoff from the study area has to be pumped twice before it reaches tidal waters and the general principles which apply to the discharge of additional runoff into a pump-drained catchment will most certainly apply and the need for runoff attenuation must be taken into account in the design of the drainage system for any development on 'greenfield' land within the study area

Conclusion

22.15 The study area is entirely in flood zone 3 and mainly outside of the flood hazard zone with some in the Danger to Some category.

22.16 The use of the Relative Probability of Flooding maps show that the study area is at a low probability of flooding.

23 Guidance for Planners and Developers

23.1 The purpose of this section is to provide guidance to planners and developers on how to manage flood risk through the design of the development.

23.2 These mitigation measures should only be considered after the sequential approach has been applied to development proposals and the location of development should be in areas of lowest flood risk. Only when it has been established that there are no suitable alternative options in lower risk areas should the Exception Test be applied where appropriate. Design solutions will need to be considered to mitigate the identified flood risk and ensure Part C of the test can be passed to allow development to proceed.

23.3 A range of measures can be used to manage flood risk at development sites. Boston Borough Council will use the information in this SFRA to establish the design criteria developers will need to meet through LDD policy.

23.4 Developers should discuss proposals at the earliest possible stage with the LPA, Environment Agency and other key stakeholders so that design issues can be agreed and innovative design solutions considered if necessary.

Development Sites

23.5 A number of measures which can be used to manage flood risk at new development sites are discussed below.

23.6 Appendix A3 in CIRIA (2004) Report C624 *Development and flood risk – guidance for the construction industry* provides further details of mitigation measures for flood risk management.

23.7 Important flood risk factors to consider which will influence the design of new developments are:

- flood mechanism (how the site would flood);
- predicted flood level;
- duration;
- frequency;
- velocity of flood water;
- depth; and
- amount of warning time of flooding.

Flood Avoidance

23.8 The best way to avoid flood risk is to locate the development outside areas of flood risk i.e. FZ 1.

Site Layout

23.9 Where the Sequential Test shows that there are no suitable available alternative sites in lower flood risk areas and development is required, the sequential approach should be applied within the development site to locate the most vulnerable elements of a development in the lowest risk areas. Residential areas may contain a variety of land uses, including dwellings, vehicle and pedestrian access, parking areas, shops, schools and other community facilities. Layout should be designed so that the most vulnerable uses are restricted to higher ground at lower risk of flooding, with more flood-compatible development (parking, open space etc.) in the highest risk areas.

23.10 In designing site layout the use of low-lying ground in waterside areas for recreation, amenity and environmental purposes can provide important flood conveyance and storage as well as providing connected green spaces with consequent social and environmental benefits. This green infrastructure has the potential to raise the profile and profitability of a development and contribute to other sustainability objectives.

23.11 Landscaping of public access areas subject to flooding should allow for easy access to higher land as flood waters rise and avoid local features that could become isolated islands. Fences, hedges and walls should be designed so that they do not cause obstructions to escape routes. Any essential structures, such as shelters and seats, should be designed to be flood resilient and firmly attached to the ground.

23.12 The planning permission should make provision for future management of such areas through planning conditions or Section 106 agreements, with particular regard to safety signing, permitted and prohibited structures and the management of vegetation.

23.13 PPS25 requires safe access and escape to be available to and from new developments in flood risk areas.

23.14 Where large areas are identified for development a more detailed site specific FRA should identify key flow routes which can be planned on a strategic basis. This facilitates linking of surface water drainage systems and making allowance for overloading of piped systems. It also enables these to be safeguarded for the future by protecting them from development and other obstruction.

23.15 Development proposals should include surface water drainage systems designed to incorporate key overland flow routes.

23.16 Car parking may be appropriate in areas subject to flooding, provided flood warning is available and signs are in place. Car parks should ideally not be subject to flood depths in excess of 300mm depth since vehicles can be moved by water of this depth. Car parks located in areas that flood to greater depths should be designed to prevent vehicles floating out of the car park

23.17 When considering car parking within flood risk areas, the ability of people to move their cars within the flood warning time should be considered. Long-term and residential car parking is unlikely to be acceptable in areas which regularly flood to a significant depth, due to the risk of car owners being away from the area and being unable to move their cars when a flood occurs. Like other forms of development, flood risk should be avoided if possible. If this is not feasible, the FRA should detail how the design makes the car park safe.

Raising Floor Levels

23.18 Where there is small scale development it is likely that avoidance and site layout are not possible. In this instance raising floor levels above the flood level is a possible option to manage flood risk to new developments. Raised floor levels can be used both as a primary flood risk management method and also to manage the residual flood risk from a failure of the defence, but safe access must be provided.

23.19 Provided there is adequate flood warning available it may be reasonable to design development with parking or other flood-compatible uses at ground level and residential or other people-intensive use above the flood level. Where developments incorporate open space beneath the occupied level, measures such as legal agreements need to be in place to prevent inappropriate use or alteration of the ground floor that would impede flood conveyance or reduce flood storage.

23.20 Single-storey residential development is generally more vulnerable to flood damage and occupants do not have the opportunity to retreat to higher floor levels. Safe refuge above flood level should be designed into new developments within flood risk zones.

Modification of Ground Levels

23.21 Risk to the development may be reduced by raising land by civil engineering operations above the level of flood risk, or to reduce the depth of flood water in extreme conditions to acceptable levels. This will need to be considered early in the design stage. Care is needed to avoid the formation of islands which would become isolated in flood conditions and to ensure there is safe access and egress. Land raising may not be viable if existing buildings or other features at existing ground level need to be retained. Any proposal to modify ground levels will have to demonstrate in the FRA that there is no increase in flood risk to the development itself, or to any existing buildings which are known to, or are likely to flood. The calculation of the impacts on floodplain storage volumes should be included in the FRA, which should show how the overall design mitigates any impacts.

23.22 Unless the development is located in an area which is subject to tidal flooding and which serves no conveyance function, land raising must be accompanied by compensatory provision of flood storage either on site or in the vicinity of the site

Development Behind Floodwalls and Embankments

23.23 Wherever possible the construction of new defences to enable development to take place should be avoided, so that residual risks are not created. Developers proposing this solution will need to show that other options, such as upstream storage and attenuation of flows, have been considered, justify why they are not feasible and that the proposal is compatible with the long-term plans for general flood risk management in the area, such as CFMPs, SMPs and IDB management.

Upstream Flood Storage

23.24 The provision of upstream flood storage, either on or off the line of a river or watercourse may be an effective way to manage water levels at a development site. Such upstream storage areas can consist of flood storage reservoirs, controlled washlands or less formal (and less hydraulically efficient) flood storage areas such as wetlands. Such facilities also have the potential to provide additional habitat and amenity uses.

Building Design

23.25 The final step is to mitigate through building design. This represents the least preferred option for new development as although buildings can be designed for reducing the impacts of flooding, hazards still remain, particularly for access and utility supply.

23.26 Communities and Local Government have published guidance on *Improving the Flood Performance of New Buildings: flood resilient construction* (2007). This provides detailed guidance on approaches to building design regarding flood risk.

23.27 Buildings should be designed to withstand the effects of flooding. In areas of high velocity water, buildings should be structurally designed to withstand the expected water pressures, potential debris impacts and erosion which may occur during a flood event. Particular care should be taken in the design of any building located in the Danger To All flood hazard zone.

Flood Resistance and Resilience

23.28 Since any flood management measures only manage the risk of flooding rather than remove it, flood resistance and flood resilience may need to be incorporated into the design of buildings and other infrastructure behind flood defence systems. Flood resistance, or dry proofing, stops water entering a building. Flood resilience, or wet proofing, will accept that water will enter the building but through careful design will minimise damage and allow the re-occupancy of the building quickly.

23.29 Resistance and resilience measures are unlikely to be suitable as the only mitigation measure to manage flood risk, but they may be suitable in some circumstances, such as:

- water-compatible and less vulnerable uses where temporary disruption is acceptable and an appropriate flood warning is provided.
- in some instances where the use of an existing building is to be changed and it can be demonstrated that no other measure is practicable.
- as a measure to manage residual flood risk.
- developments which are designed with raised floor levels should be constructed using flood resilient methods to above the predictive extreme flood level.

23.30 In order to decide which resilience measures would be effective, it is necessary to know the potential depth and duration of flooding that is likely to occur. *Improving the flood performance of new buildings: flood resilient construction* (Communities and Local Government, 2007) gives guidance on flood proofing measures that are applicable to different ranges of flood depths outside a building, i.e. :

- less than 0.3m
- above 0.3m but less than 0.6m
- above 0.6m.

23.31 This is because the pressure exerted by greater depths of water, or where it is flooded for a long time, can result in the failure of flood resistant construction, either by seepage of water through walls and barriers, or causing structural damage. Flood resistance becomes more practicable for shallower water, and buildings affected by deep water will need to consider resilience.

23.32 Flood resistance measures should be used with caution. To work successfully, people must have the knowledge and ability to ensure the flood resistance elements (such as barriers, drop in boards, or wall mounted plates to cover air bricks) are put in place and maintained in a good state. Warning systems will be needed to ensure that adequate time is allowed to deploy any resistance measure. This approach would not be suitable in areas of surface water flooding which can occur very quickly. The impact of the loss of flood storage, including the requirement for the provision of compensatory flood storage, should be considered if it is intended that a proposed development should use flood resistance methods to prevent flooding of a building.

23.33 Flood repairable construction is important to avoid people being excluded from their homes for long periods after flooding has occurred, and the stress and potential health problems this can cause. (CIRIA guidance *Repairing buildings following flooding*).

24 Sustainable Drainage Systems

24.1 Traditional drainage is designed to move rainwater as rapidly as possible from the point at which it has fallen to a discharge point, either a watercourse or soakaway. This approach has a number of potentially harmful effects:

- Runoff from hard paving and roofing can increase the risk of flooding downstream, as well as causing sudden rises in water levels and flow rates in watercourses.
- Surface water runoff can contain contaminants such as oil, organic matter and toxic metals. Although often at low levels, cumulatively they can result in poor water quality in rivers and groundwater, affecting biodiversity, amenity value and potential water abstraction. After heavy rain, the first flush is often highly polluting.
- By diverting rainfall to piped systems, water is stopped from soaking into the ground, depleting ground water and reducing flows in watercourses in dry weather

24.2 Sustainable Drainage Systems (SUDS) include tried-and-tested techniques that are already being implemented on a range of projects and they incorporate cost-effective techniques that are applicable to a wide range of schemes.

24.3 Planning Policy Statement 25 emphasises the role of SUDS and introduces a general presumption that they will be used. SUDS will probably feature increasingly in such guidance documents as they are revised.

24.4 As with other key considerations in the planning process incorporating SUDS needs to be considered early in the site evaluation and planning process, as well as at the detailed design stage. The use of Drainage Impact Assessments has been piloted in Aberdeen and Aberdeenshire in Scotland.

24.5 Boston Borough Council expect planning applications, whether outline or detailed, to demonstrate how a more sustainable approach to drainage is to be incorporated into development proposals, and for detailed design information to be submitted at the appropriate stage and may use planning conditions to secure the implementation of SUDS.

24.6 Building Regulations on Drainage and Waste Disposal for England have been modified to introduce a surface water drainage hierarchy, with infiltration on site as the preferred disposal option, followed by discharge to watercourse and then connection to a sewer.

24.7 The SUDS approach to drainage incorporates a wide variety of techniques and as a result, there is no one correct drainage solution for a site. In most cases, a combination of techniques, using the Management Train principle, will be required.

24.8 The elements of the Management Train are outlined below.

Source Control

Green Roofs and Rainwater Re-use

24.9 Green roofs can improve water quality and reduce the peak flow and the total volume discharged from a roof.

24.10 In addition, they can enhance insulation and increase the lifespan of the roof. Rainwater reuse (or harvesting) involves the collection and storage of rainwater on site and its use as a substitute for mains water, for example in watering gardens or for flushing toilets.

Permeable Pavements

24.11 The need for surface water drains and off-site sewers can be reduced or eliminated where runoff is encouraged to permeate through a porous pavement, such as permeable concrete blocks, crushed stone or porous asphalt.

24.12 Depending on the ground conditions, the water may infiltrate directly into the subsoil or be stored in an underground reservoir (for example, a crushed stone layer) before slowly soaking into the ground. If infiltration is not possible or appropriate (for example, because of ground contamination), an impermeable membrane can be used with an overflow to keep the pavement free from water in all conditions. Pollutant removal occurs either within the surfacing or sub-base material itself, or by the filtering action of the reservoir or subsoil.

Infiltration Techniques

Infiltration Trenches

24.13 An infiltration trench is a shallow, excavated trench that has been filled with stone to create an underground reservoir.

24.14 Stormwater entering the trench is gradually infiltrated into the ground. Their longevity can be enhanced by providing pre-treatment of the stormwater using a filter strip, gully or sump pit to remove excessive solids.

Filter Drains

24.15 Filter drains are widely used by highway authorities for draining roads.

24.16 They are similar structures through which a perforated pipe runs. This facilitates the storage, filtering and some infiltration of water passing from the source to the discharge point. Pollutants are removed by absorption, filtering and microbial decomposition in the surrounding soil. Systems can be designed to successfully incorporate both infiltration and filter systems.

Swales and Basins

24.17 These can be created as features within the landscaped areas of the site, or they can be incorporated into ornamental, amenity and screen-planted areas where they would be looked after as part of the normal maintenance contract. Swales and basins are often installed as part of a drainage network connecting to a pond or wetland, prior to discharge to a natural watercourse.

Swales

24.18 Swales are grassed depressions which lead surface water overland from the drained surface to a storage or discharge system, typically using the green space of a roadside margin.

24.19 They may be used to replace conventional roadside kerbs, saving construction and maintenance costs. Compared to a conventional ditch, a swale is shallow and relatively wide, providing temporary storage, conveyance, treatment and the possibility of infiltration under suitable conditions.

Basins

24.20 A basin is designed to hold back storm runoff for a few hours and to allow the settlement of solids.

24.21 They are dry outside of storm periods. They provide temporary storage for storm water, reduce peak flows to receiving waters, facilitate the filtration of pollutants (deposited and incorporated into the substrate) and encourage microbial decomposition, as well as allowing water infiltration directly into the ground.

Ponds and Wetlands

24.22 Ponds or wetlands can be designed to accommodate considerable variations in water levels during storms, thereby enhancing flood-storage capacity.

24.23 Although these can be designed as wet or dry ponds, or wetlands, they are most likely to contribute to visual amenity and biodiversity where they include a permanent water body. By allowing adequate detention time, the level of solids removal can be significant. The algae and plants of wetlands provide a particularly good level of filtering and nutrient removal. Ponds and wetlands can be fed by swales, filter drains or piped systems. The use of inlet and outlet sumps enhances performance by trapping silt and preventing clogging of the outlet. Removal of collected sediment from the inlet sump may be needed, although typically this is unlikely to be more than once every seven years.

Geology

24.24 The effectiveness and suitability of some of the above SUDS techniques will depend on the ground conditions into which the water permeates. The ground is made up of different layers and the material within each layer will determine how groundwater flows through the catchment. The bedrock is made up of compacted rocks. Above this are less compact rocks, known as drift geology. The top layer is soil. Drift deposits are not always present and when this is the case, the soil is positioned directly on top of the solid geology.

24.25 Some types of solid geology can be more permeable than others (e.g. sandstone compared to clay). Permeable bedrock absorbs and stores water, which reduces runoff and can result in rivers taking longer to respond to rainfall events. This reduces peak flows in rivers, and reduces the flood risk as a result.

24.26 Where no storage is available, in the less permeable bedrock, less rainfall is absorbed and it can run through the shallow soil strata to the nearest watercourse. The same applies to drift geology (e.g. peat is highly permeable).

24.27 The mudstone and clay areas are not very permeable, and as a result cannot store large quantities of water and are not suited to the infiltration methods. Consequently these areas will generate runoff and lead to high river flows which can pose a flood risk. The limestone area is much more permeable than the mudstone and clay and can absorb and store rainwater, thereby reducing the flood risk.

Adoption and Maintenance

24.28 For SUDS to provide consistent and effective long-term attenuation of runoff from a development, they have to be maintained in an efficient condition for the life of the development. This may involve the control of weed growth in ponds and lagoons, the frequent removal of debris, both natural and man-made, from watercourses and weedscreens, the clearance of blockages, sometimes at short notice, from pipes and culverts, and the repair of malicious damage and vandalism. A routine inspection regime is essential to ensure that any such problems are identified and dealt with in a timely manner.

24.29 If widespread urban development takes place in the catchments upstream of Boston it could have a material effect on fluvial flood risk in Boston Borough. SUDS should be fully incorporated into the surface water drainage systems of all new development to reduce the flood risk to existing properties.

24.30 Following the publication of the Pitt Review, the Government made a commitment to resolve some of the barriers to SUDS through the draft Floods and Water Bill. This included an announcement that Upper Tier Local Authorities would be given a duty to adopt SUDS drainage systems constructed for new developments. This is an important commitment which will go some way to reducing the impact of new developments on surface water quality and flood risk.

Capabilities on project:
Water

25 Conclusions

The original Boston Strategic Flood Risk Assessment Report has been used to inform the Council's planning policies.

This revised study has been undertaken in accordance with the provisions of PPS25.

The Environment Agency's Flood Zones will continue to be used by the Borough Council as the basis on which the Sequential Test is applied.

The majority of the Borough Council's area is within FZ3 and in order to assist the Borough Council apply the Sequential Test two additional sets of maps have been produced covering all of their Borough

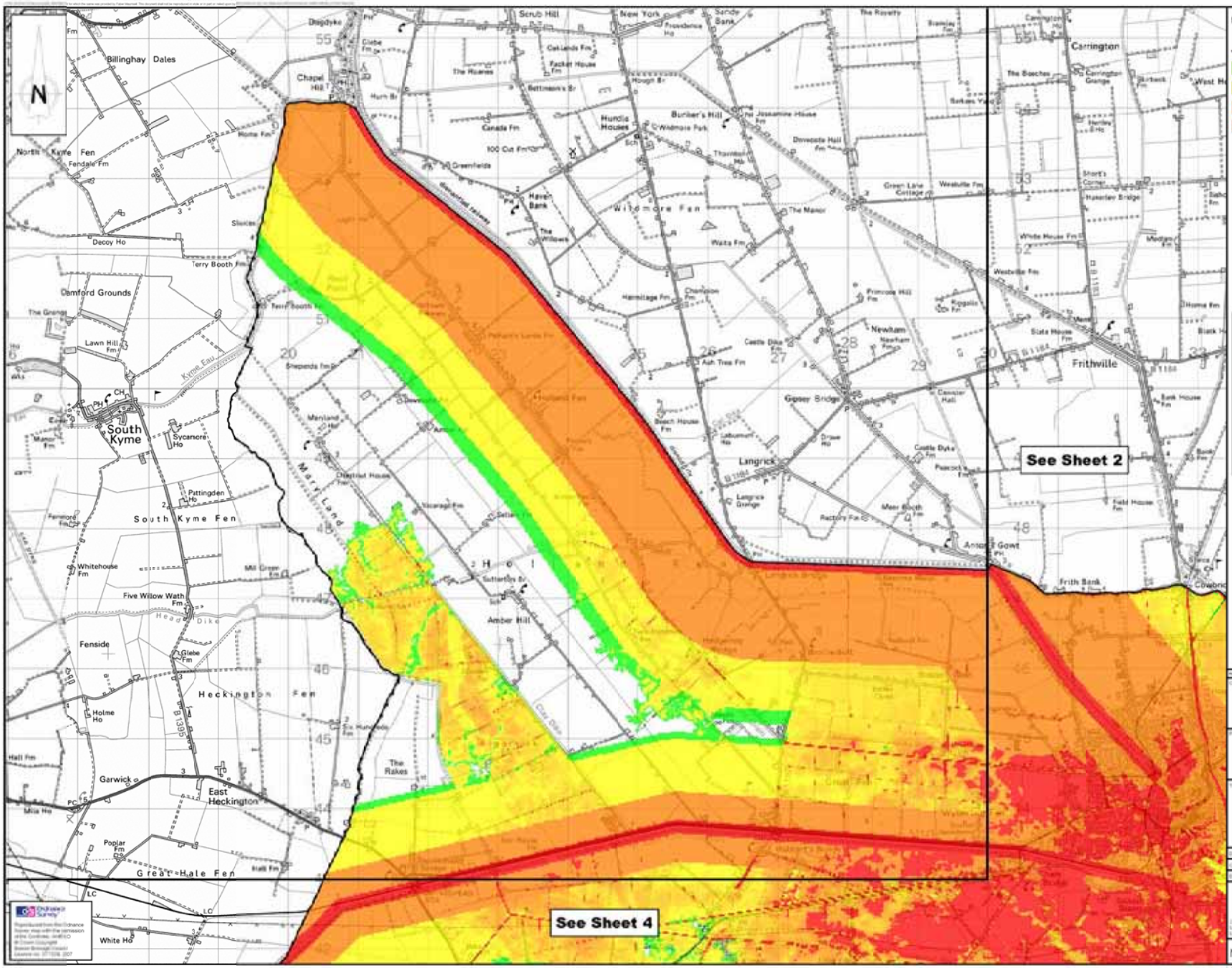
- Flood Hazard Zones should a breach occur in the raised defences.
- Relative Probability of Flooding given the presence of the defences.

Boston Borough Council identified where normally significant development might be expected to occur and therefore where a more detailed assessment of the flood risk is required.

This detailed assessment has been based on the Flood Hazard Zones and Relative Probability of Flooding maps.

The results for the detailed assessment of the 10 study areas shows:

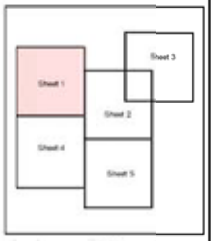
- Bicker and Swineshead have the least flood risk issues including majority of land at low flood hazard.
- Wrangle and Sutterton have land in the Danger to Some category with a low probability of flooding.
- Kirton has land in the Danger to Most category but with a low probability of flooding.
- Fishtoft, Freiston and Old Leake all have land in the Danger to All and Low categories but with a low probability of flooding.
- Butterwick has land in the Danger to All and Danger to Most categories but with a low probability of flooding.
- Boston has land in all Flood Hazard categories and ranges from high to low probability of flooding.



Key

Flood Hazard (2115)

- Boston Borough Council Boundary
- <0.75 - Low Hazard
- 0.75 - 1.25 - Danger for Some
- 1.25 - 2 - Danger for Most
- >2 - Danger for All



Key Plan

No.	Date	Issue	Made	Chk'd	Appd

Client: BOSTON BOROUGH COUNCIL

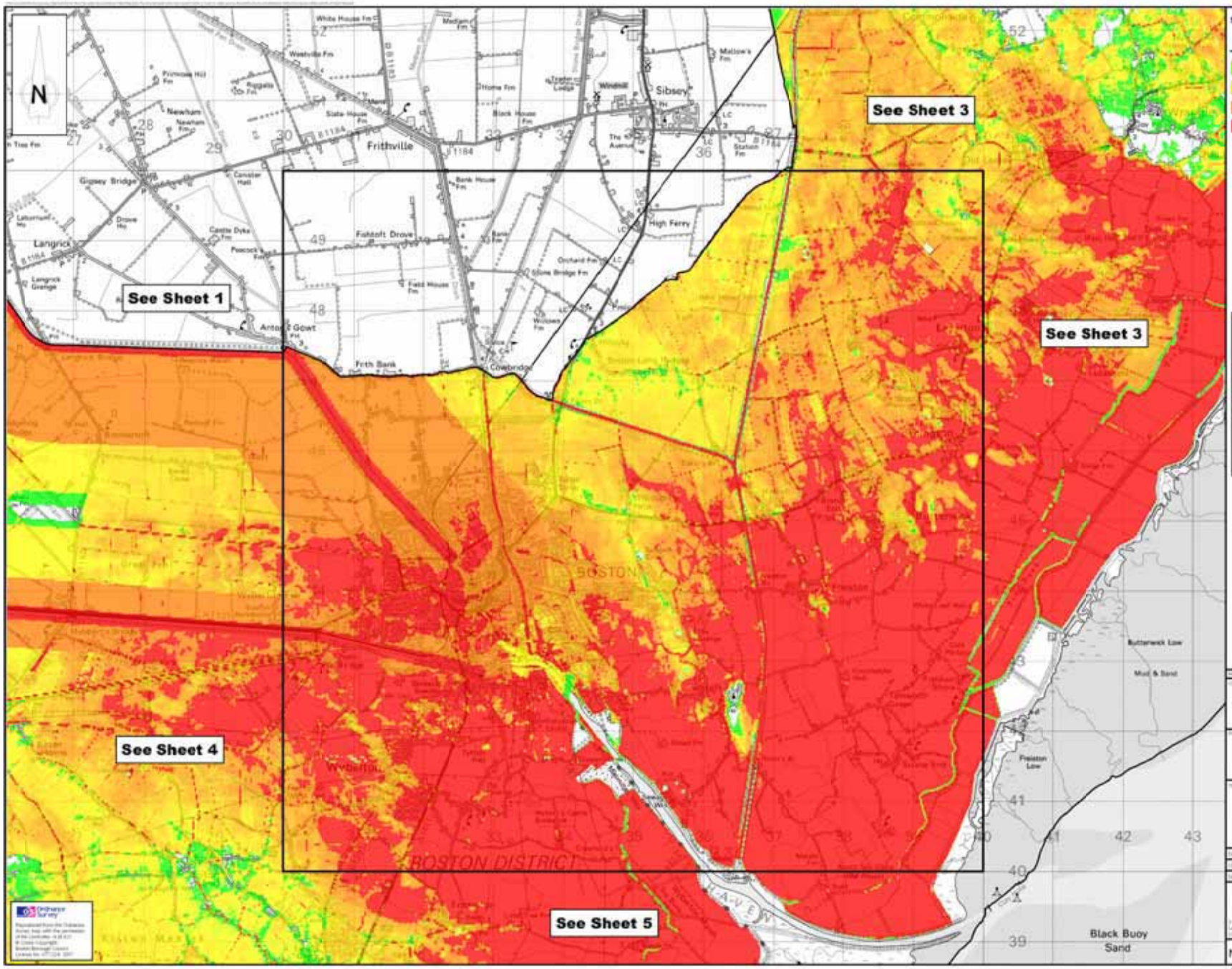
Project: STRATEGIC FLOOD RISK ASSESSMENT

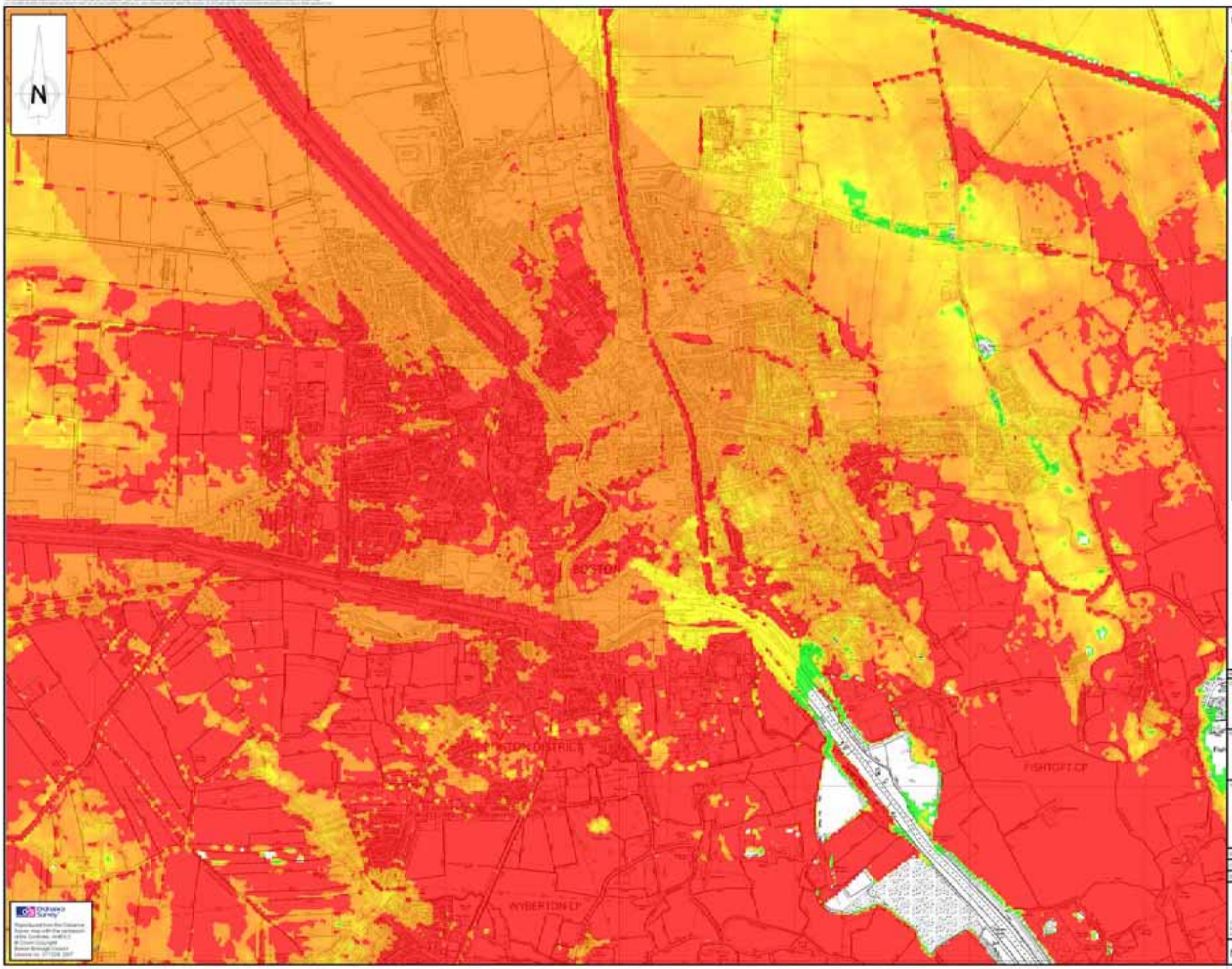
Title: FIGURE 1.1 FLOOD HAZARD MAP SHEET 1 OF 5

Design: ARP | CAD: ARP
Check: RL | Appd: AY
Date: JULY 2010 | Scale: 1:25,000

AECOM

No. 60034187/ BBC / 101 | Rev: 01


N
See Sheet 1
See Sheet 3
See Sheet 3
See Sheet 4
See Sheet 5
Frithville
Sibsey
Langrick
Gipsey Bridge
Fishtoft Drove
Frith Bank
Coalbridge
High Ferry
Wyberton
BOSTON
BOSTON DISTRICT
Butterwick Low
Mud & Sand
Freiston Low
Black Buoy Sand
Key
Flood Hazard (2115)
Boston Borough Council Boundary
<0.75 - Low Hazard
0.75 - 1.25 - Danger for Some
1.25 - 2 - Danger for Most
>2 - Danger for All
Key Plan
Sheet 1
Sheet 2
Sheet 3
Sheet 4
Sheet 5
BOSTON BOROUGH COUNCIL
STRATEGIC
FLOOD RISK ASSESSMENT
FIGURE 1.2
FLOOD HAZARD MAP
SHEET 2 OF 5
AECOM
No. 60034187 / BBC / 102
01



Key

Flood Hazard (2115)

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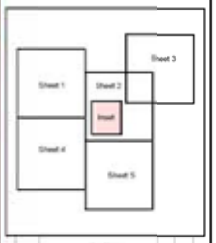
- 0.75 - 1.25 - Danger for Some
- 1.25 - 2 - Danger for Most
- >2 - Danger for All



Key Plan

No.	Date	Issue	Made	Chk'd	App'd

Client: BOSTON BOROUGH COUNCIL

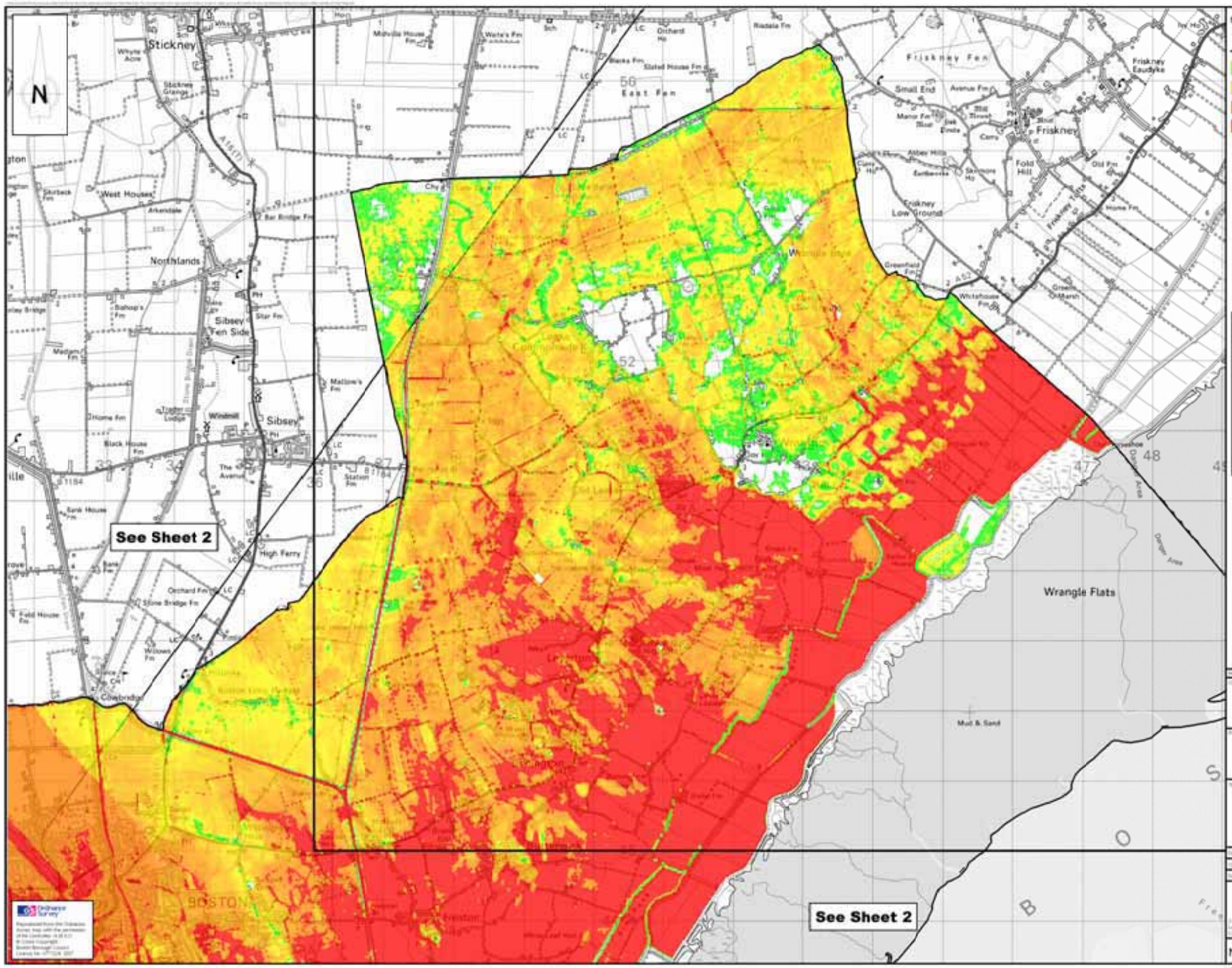
Project: STRATEGIC FLOOD RISK ASSESSMENT

Title: FIGURE 1.2A FLOOD HAZARD MAP SHEET 2 (INSET)

Design: ARP	CAD: ARP
Chk'd: GL	App'd: AY
Date: 24.11.2010	Scale: 1 : 10,000

AECOM

No. 60034187 / BBC / 102A | Rev: 01



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Flood Hazard (2115)

- Boston Borough Council Boundary
- <0.75 - Low Hazard
- 0.75 - 1.25 - Danger for Some
- 1.25 - 2 - Danger for Most
- >2 - Danger for All

Key Plan

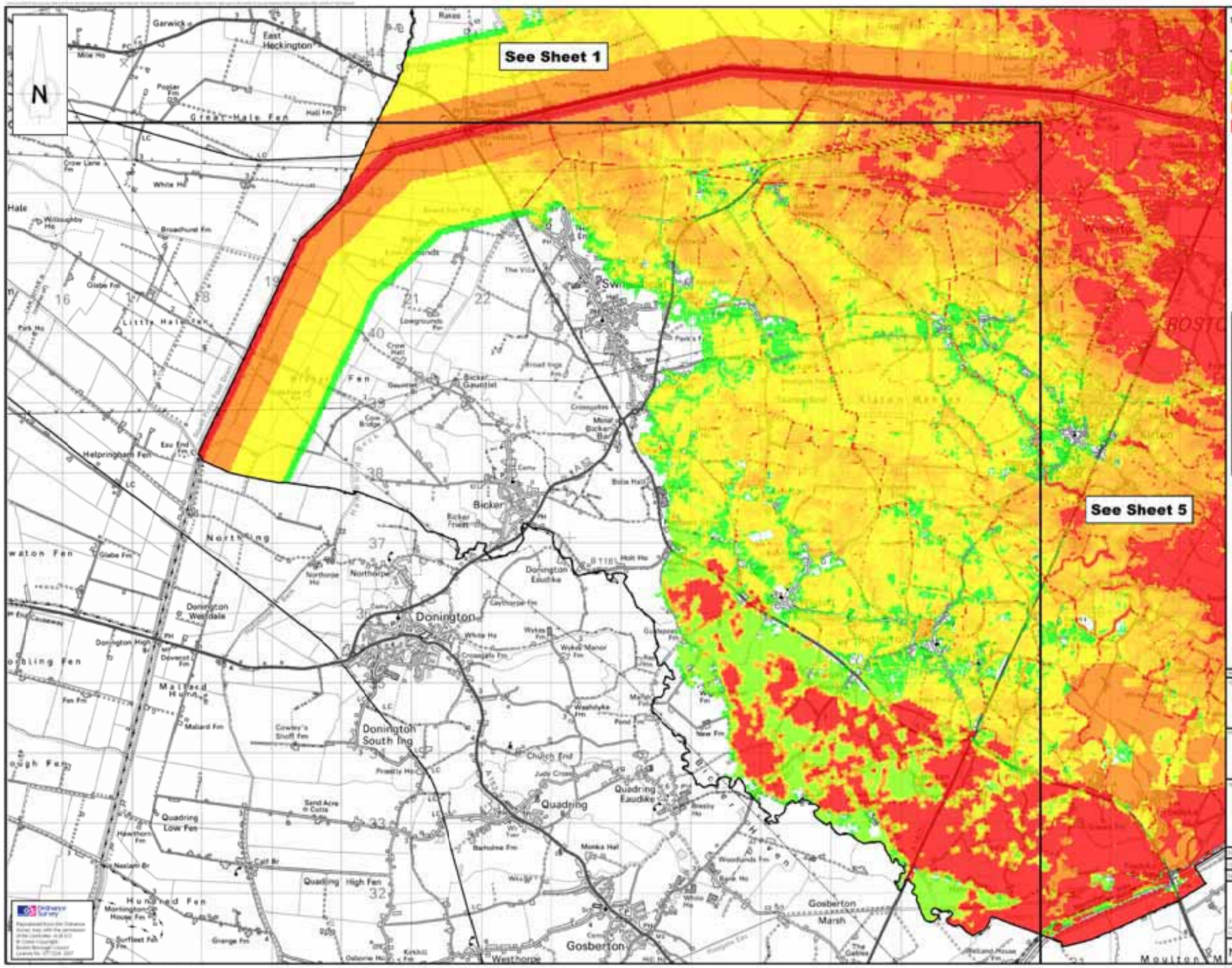
BOSTON BOROUGH COUNCIL

STRATEGIC FLOOD RISK ASSESSMENT

FIGURE 1.3
FLOOD HAZARD MAP
SHEET 3 OF 5

AECOM

No. 60034187 / BBC / 103 | 01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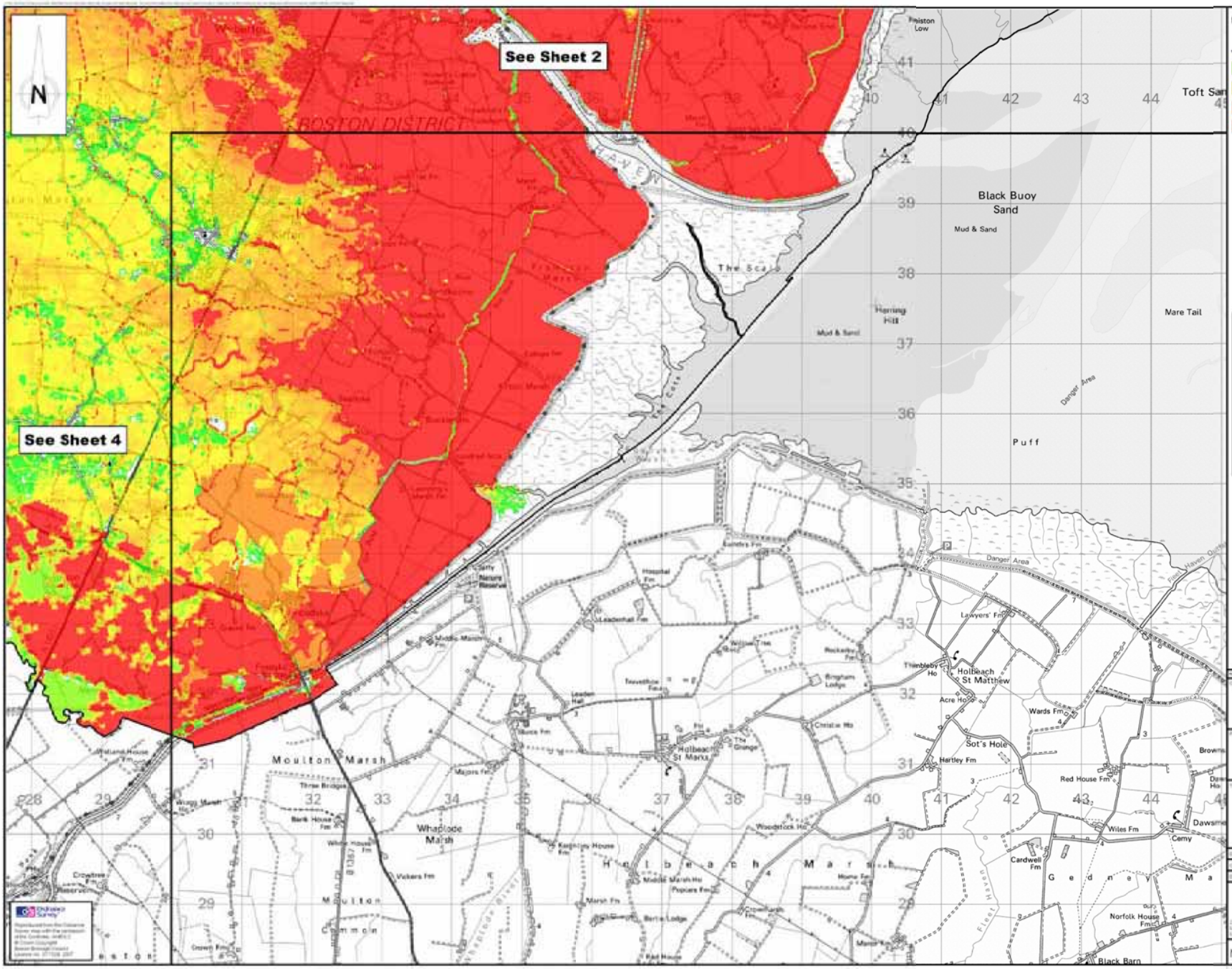
Key
Flood Hazard (2115)
Boston Borough Council Boundary
<0.75 - Low Hazard
0.75 - 1.25 - Danger for Some
1.25 - 2 - Danger for Most
>2 - Danger for All
Key Plan
Sheet 1
Sheet 2
Sheet 3
Sheet 4
Sheet 5
Garwick
East Heckington
Great Hale Fen
Hale
Little Hale Fen
Helpringham Fen
Swineshead
Bicker
Donington
Donington South Ing
Donington Eaudike
Donington Westdale
Northorpe
Quadring
Quadring Eaudike
Quadring Low Fen
Quadring High Fen
Gosberton
Gosberton Marsh
Westhorpe
Moulton
Hundred Fen
Malard Hunds
Fen
Ordnance Survey
BOSTON BOROUGH COUNCIL
STRATEGIC
FLOOD RISK ASSESSMENT
FIGURE 1.4
FLOOD HAZARD MAP
SHEET 4 OF 5
AECOM
No. 60034187 / BBC / 104
01



BOSTON BOROUGH COUNCIL

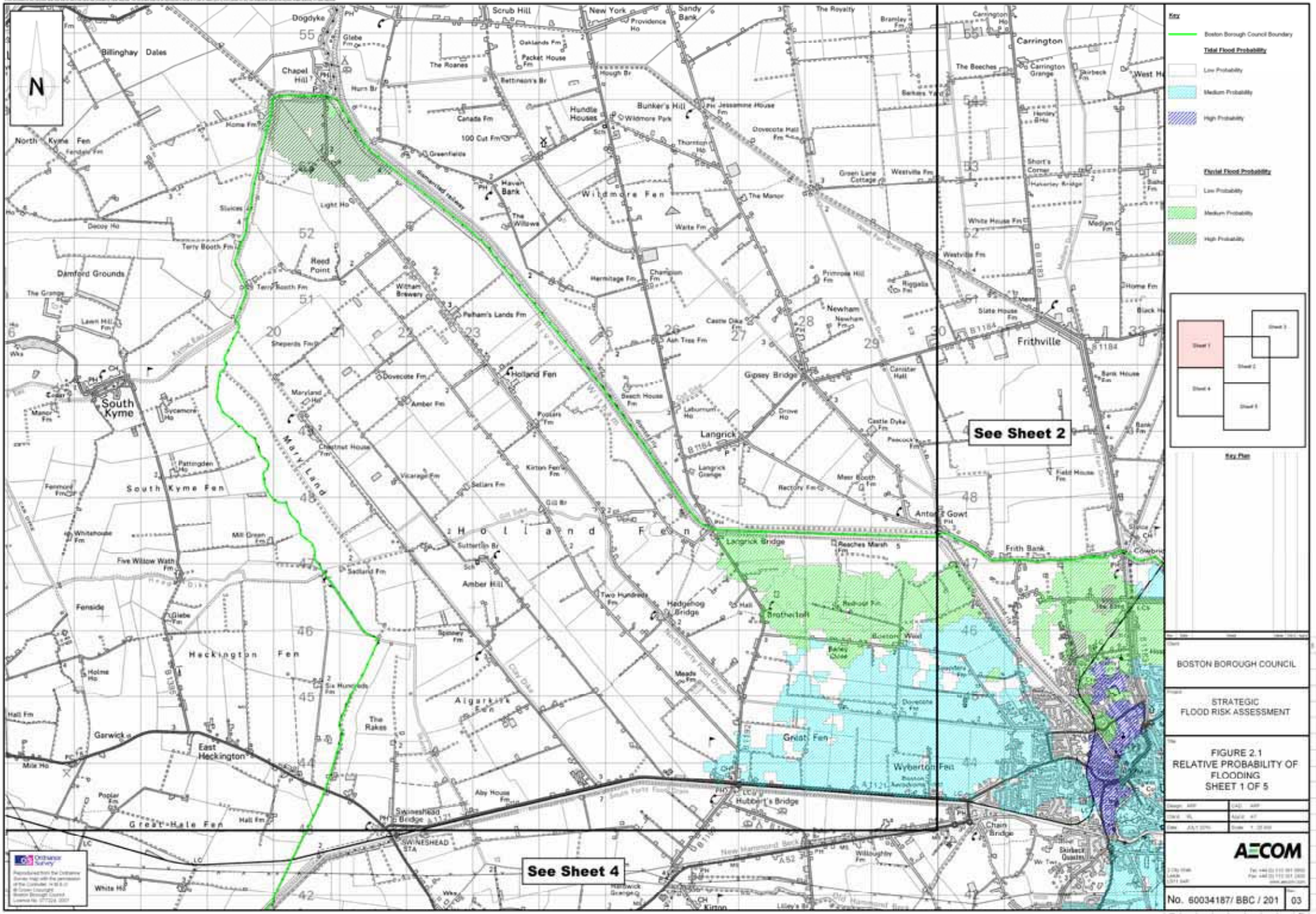
STRATEGIC FLOOD RISK ASSESSMENT

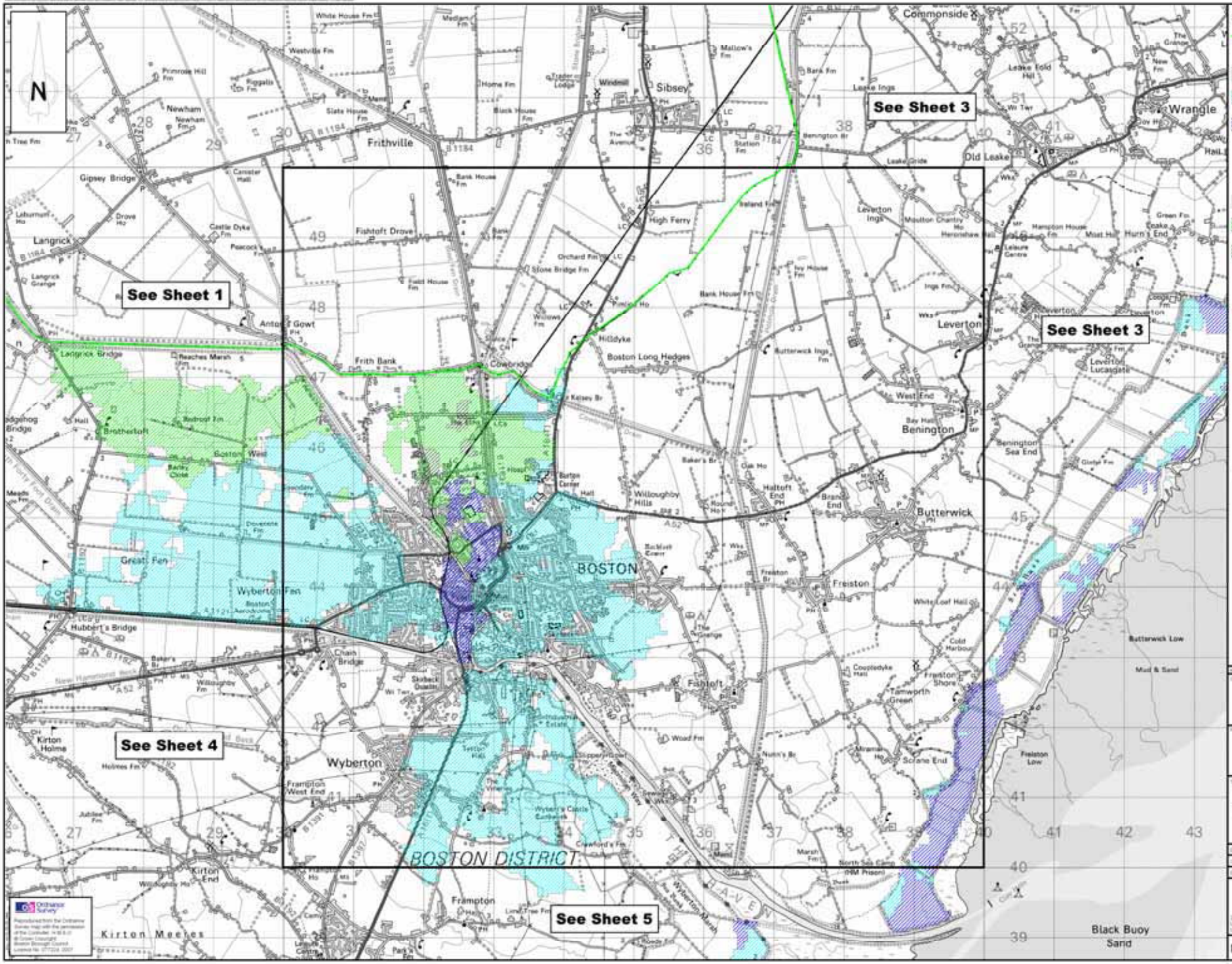
FIGURE 1.5
FLOOD HAZARD MAP
SHEET 5 OF 5

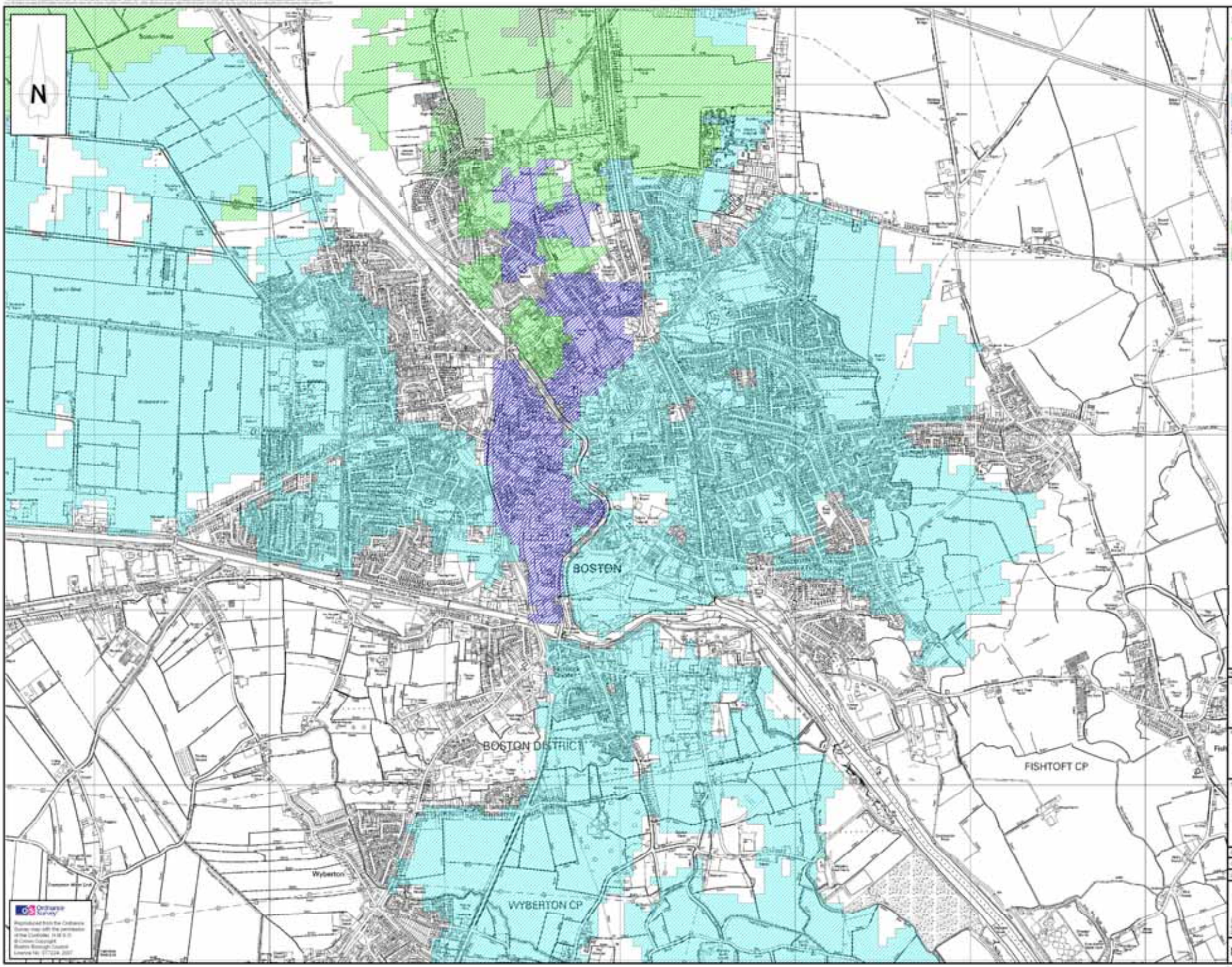
AECOM

No. 60034187 / BBC / 105

01


N
See Sheet 2
See Sheet 4
Key
Boston Borough Council Boundary
Tidal Flood Probability
Low Probability
Medium Probability
High Probability
Fluvial Flood Probability
Low Probability
Medium Probability
High Probability
Key Plan
Sheet 1
Sheet 2
Sheet 3
Sheet 4
Sheet 5
BOSTON BOROUGH COUNCIL
STRATEGIC FLOOD RISK ASSESSMENT
FIGURE 2.1
RELATIVE PROBABILITY OF FLOODING
SHEET 1 OF 5
AECOM
No. 60034187/ BBC / 201
03
Billinghay Dales
North Kyme Fen
Dogdyke
Chapel Hill
Scrub Hill
New York
Sandy Bank
The Royalty
Carrington
Wildmore Fen
Langrick
Frithville
South Kyme
South Kyme Fen
Holland Fen
Heckington Fen
East Heckington
Great Fen
Wyberton Fen
Great Hale Fen
Langrick Bridge
Hubbert's Bridge
Chain Bridge
Swineshead Bridge
Gipsey Bridge
Antons Gowt
Frith Bank
Boston West
Skirbeck Quarter
Mary Land
Kyme Eau
Hobhole Drain
Boston Haven
Maud Foster Drain
Old Hammond Beck
New Hammond Beck
Ordnance Survey


N
See Sheet 1
See Sheet 3
See Sheet 3
See Sheet 4
See Sheet 5
BOSTON
BOSTON DISTRICT
Wyberton
Frithville
Sibsey
Wrangle
Leverton
Benington
Butterwick
Freiston
Fishtoft
Langrick
Kirton Holme
Kirton End
Kirton Meeres
Frampton
Black Buoy Sand
Key
Boston Borough Council Boundary
Tidal Flood Probability
Low Probability
Medium Probability
High Probability
Fluvial Flood Probability
Low Probability
Medium Probability
High Probability
Key Plan
BOSTON BOROUGH COUNCIL
STRATEGIC FLOOD RISK ASSESSMENT
FIGURE 2.2
RELATIVE PROBABILITY OF FLOODING
SHEET 2 OF 5
AECOM
No. 60034187 / BBC / 202
03



Key

Boston Borough Council Boundary

Tidal Flood Probability

Low Probability

Medium Probability

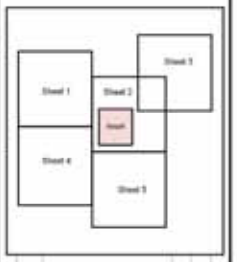
High Probability

Fluvial Flood Probability

Low Probability

Medium Probability

High Probability



Key Plan

Client: BOSTON BOROUGH COUNCIL

Project: STRATEGIC FLOOD RISK ASSESSMENT

Title: FIGURE 2.2A RELATIVE PROBABILITY OF FLOODING SHEET 2 (INSET)

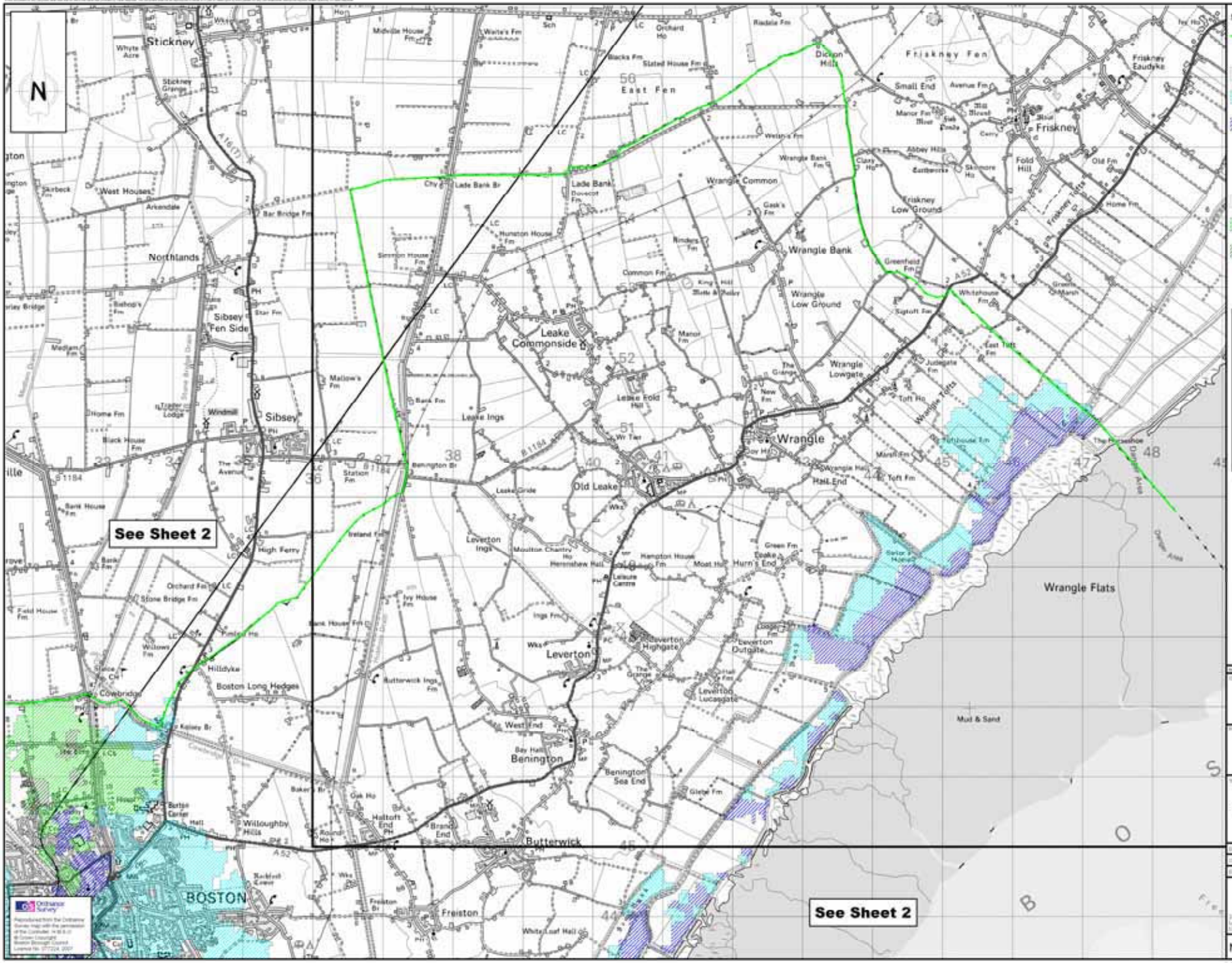
Drawn: AKH | Chkd: AKH

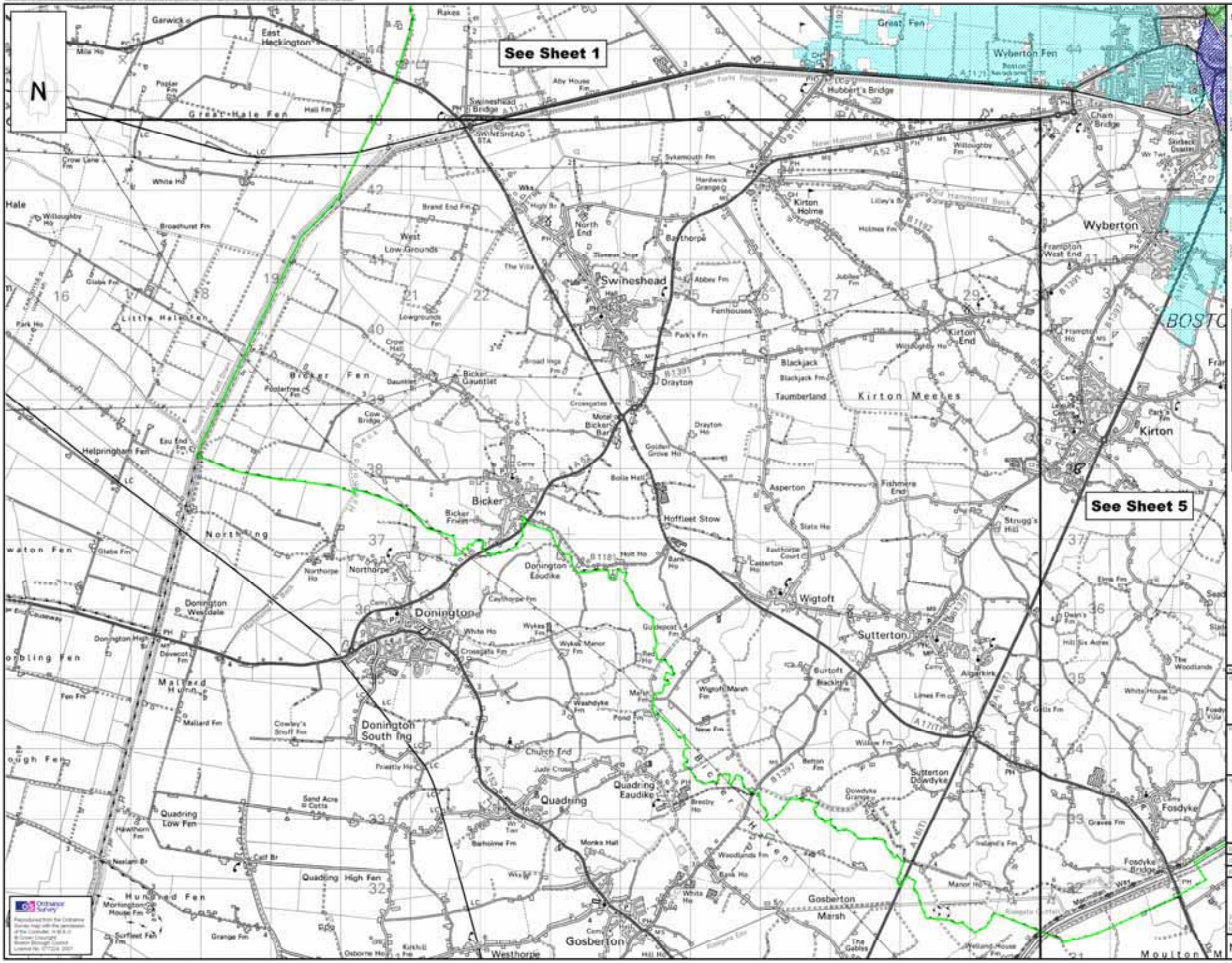
Chkd: RL | Rpt'd: KT

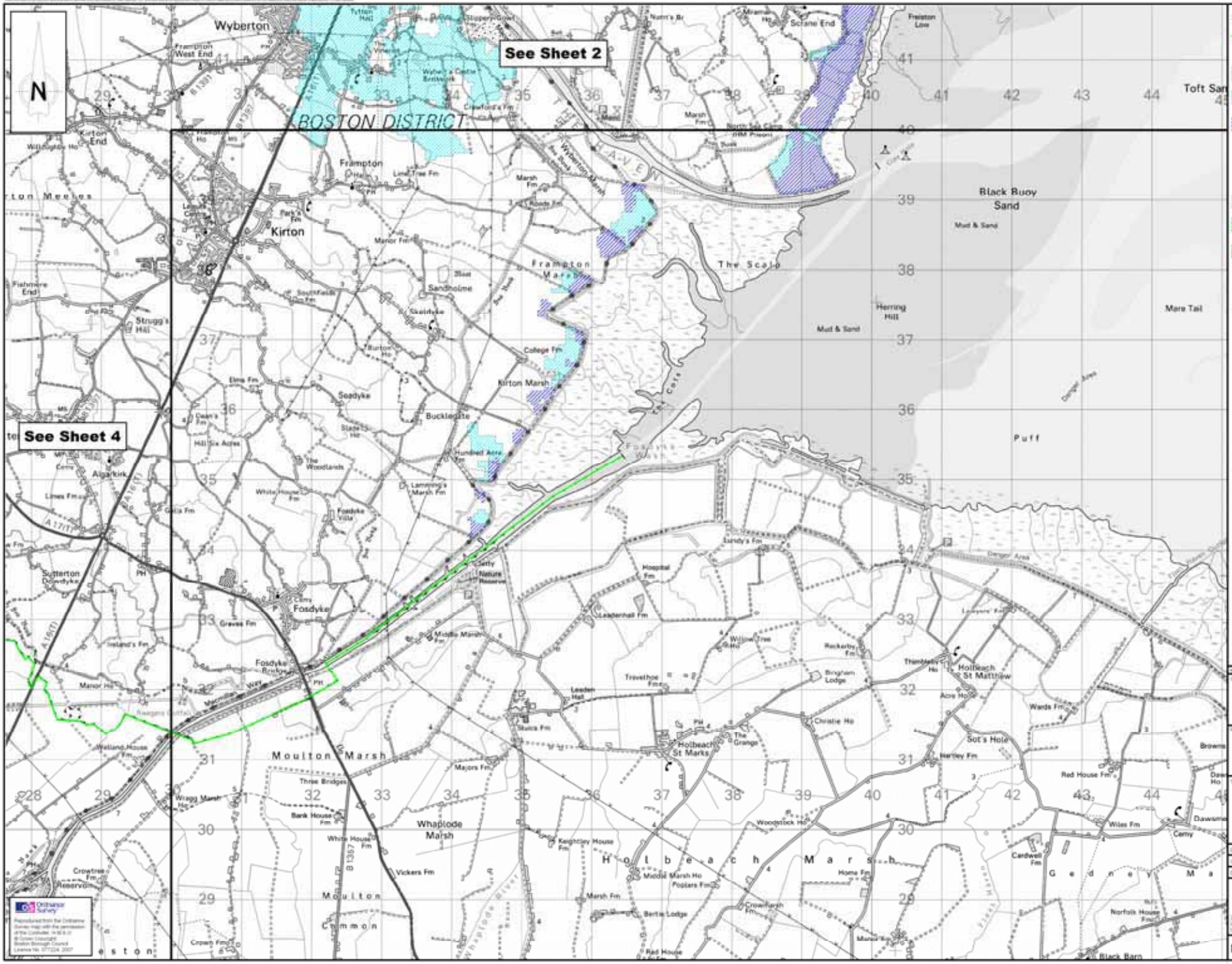
Date: JULY 2010 | Scale: 1 : 10,000

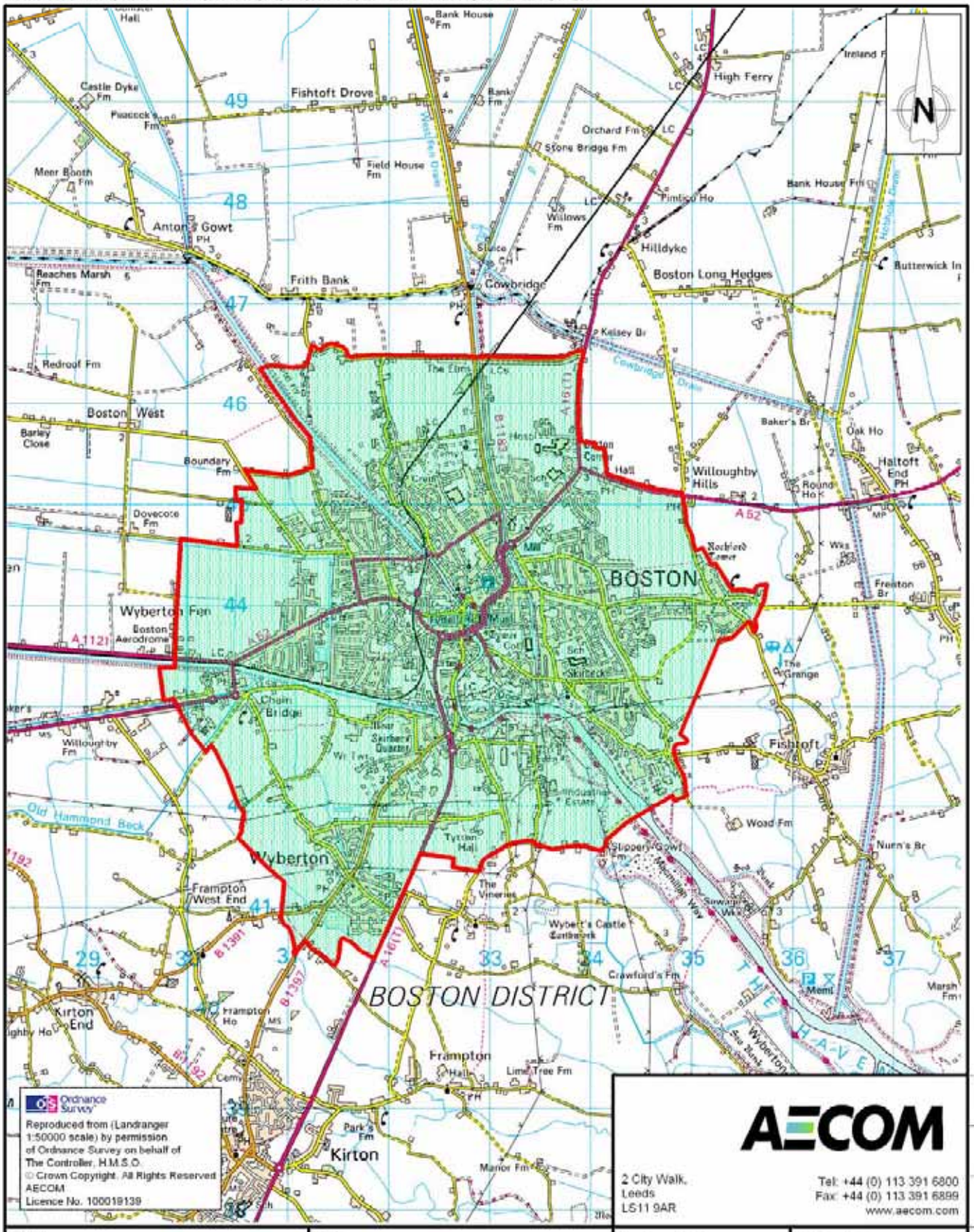
AECOM

No 60034187 / BBC / 202A | 02


N
Stickney
Stickney Grange
Whyte Acre
West Houses
Arkendale
Northlands
Sibsey Fen Side
Sibsey
Windmill
Black House Fm
Home Fm
Bank House Fm
Orchard Fm
Stone Bridge Fm
Field House Fm
Willows Fm
Hilldyke
Boston Long Hedges
Cowbridge
Burton Carter
Willoughby Hills
Rackett Lower
BOSTON
Freiston
Freiston Br
White Leaf Hall
Butterwick
Brand End
Round Ho
Halltoft End
Baker Br
Oak Ho
Benington
Bay Hall
West End
Benington Sea End
Benington Br
Station Fm
Mallow's Fm
Bar Bridge Fm
Bishop's Fm
Medium Fm
Star Fm
Ireland Fm
High Ferry
Kailey Br
Leverton
Leverton Ings
Butterwick Ings Fm
Ivy House Fm
Ings Fm
Leverton Highgate
Leverton Outgate
Leverton Lucasgate
The Grange
Hall Fm
Moulton Chantry Ho
Hemenshaw Hall
Leisure Centre
Hampton House Fm
Moat Ho
Hurn's End
Green Fm
Lake Fm
Sailor's Home
Old Leake
Leake Gate
Leake Ings
Leake Fold Hall
Leake Commonside
Leake Bank
Leake Bank Br
Dovecot Fm
Hunston House Fm
Simon House Fm
Common Fm
Manor Fm
Wr Tier
Wrangle
Wrangle Hall
Hall End
Toft Fm
Marsh Fm
Toft Ho
Wrangle Tofts
Wrangle Lowgate
Judgate Fm
Sigtoft Fm
Whitehouse Fm
Greenfield Fm
Wrangle Low Ground
Wrangle Bank
Wrangle Common
Gask's Fm
Rinders Fm
King Hill
Wrangle Bank Fm
Welton's Fm
East Fen
Dickon Hills
Blacks Fm
Slated House Fm
Orchard Ho
Radale Fm
Waite's Fm
Midville House Fm
Friskney Fen
Friskney Eaudyke
Small End
Avenue Fm
Manor Fm
Friskney
Fold Hill
Old Fm
Abbey Hills
Eastbourne
Skimore Ho
Clary Ho
Friskney Low Ground
Friskney Tofts
Home Fm
East Tofts Fm
Wrangle Flats
Mud & Sand
The Horseshoe
See Sheet 2
See Sheet 2
Key
Boston Borough Council Boundary
Tidal Flood Probability
Low Probability
Medium Probability
High Probability
Fluvial Flood Probability
Low Probability
Medium Probability
High Probability
Sheet 1
Sheet 2
Sheet 3
Sheet 4
Sheet 5
Key Plan
BOSTON BOROUGH COUNCIL
STRATEGIC FLOOD RISK ASSESSMENT
FIGURE 2.3
RELATIVE PROBABILITY OF FLOODING
SHEET 3 OF 5
AECOM
No. 60034187 / BBC / 203
03


See Sheet 1
See Sheet 5
N
Key
Boston Borough Council Boundary
Tidal Flood Probability
Low Probability
Medium Probability
High Probability
Fluvial Flood Probability
Low Probability
Medium Probability
High Probability
Sheet 1
Sheet 2
Sheet 3
Sheet 4
Sheet 5
Key Plan
Swineshead
Swineshead Bridge
Swineshead Bridge STA
Hubbert's Bridge
Chain Bridge
Wyberton
Wyberton Fen
Great Fen
Great Hale Fen
Kirton
Kirton Holme
Kirton End
Kirton Meeres
Taumberland
Drayton
Bicker
Bicker Fen
Donington
Donington Eaudike
Donington South Ing
Donington Westdale
Northorpe
Wigtoft
Sutterton
Sutterton Dowdyke
Quadring
Quadring Eaudike
Quadring Low Fen
Quadring High Fen
Gosberton
Gosberton Marsh
Westhorpe
Fosdyke
Fosdyke Bridge
Hoffleet Stow
Asperton
Fishmere End
Strugg's Hill
Helpringham Fen
Northing
Mallard Hunn
Hundred Fen
Little Hale Fen
West Low Grounds
Lowgrounds
Garwick
East Heckington
Rakes
Hale
BOSTO
Boston Borough Council
STRATEGIC FLOOD RISK ASSESSMENT
FIGURE 2.4
RELATIVE PROBABILITY OF FLOODING
SHEET 4 OF 5
AECOM
No. 60034187 / BBC / 204
03


N
See Sheet 2
See Sheet 4
BOSTON DISTRICT
Wyberton
Frampton West End
Kirton End
Kirton
Frampton
Frampton Marsh
Sandholme
Kirton Marsh
Buckleate
Seadyke
Fosdyke
Algarkirk
Sutterton Dowdyke
Moulton Marsh
Whaplode Marsh
Holbeach Marsh
Holbeach St Marks
Holbeach St Matthew
Black Buoy Sand
Mud & Sand
The Scalp
Herring Hill
Mare Tail
Puff
Toft Sand
Scane End
Freiston Low
Key
Boston Borough Council Boundary
Tidal Flood Probability
Low Probability
Medium Probability
High Probability
Fluvial Flood Probability
Low Probability
Medium Probability
High Probability
Sheet 1
Sheet 2
Sheet 3
Sheet 4
Sheet 5
Key Plan
BOSTON BOROUGH COUNCIL
STRATEGIC FLOOD RISK ASSESSMENT
FIGURE 2.5
RELATIVE PROBABILITY OF FLOODING
SHEET 5 OF 5
AECOM
No. 60034187 / BBC / 205
03



AECOM

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Leeds
LS11 9AR

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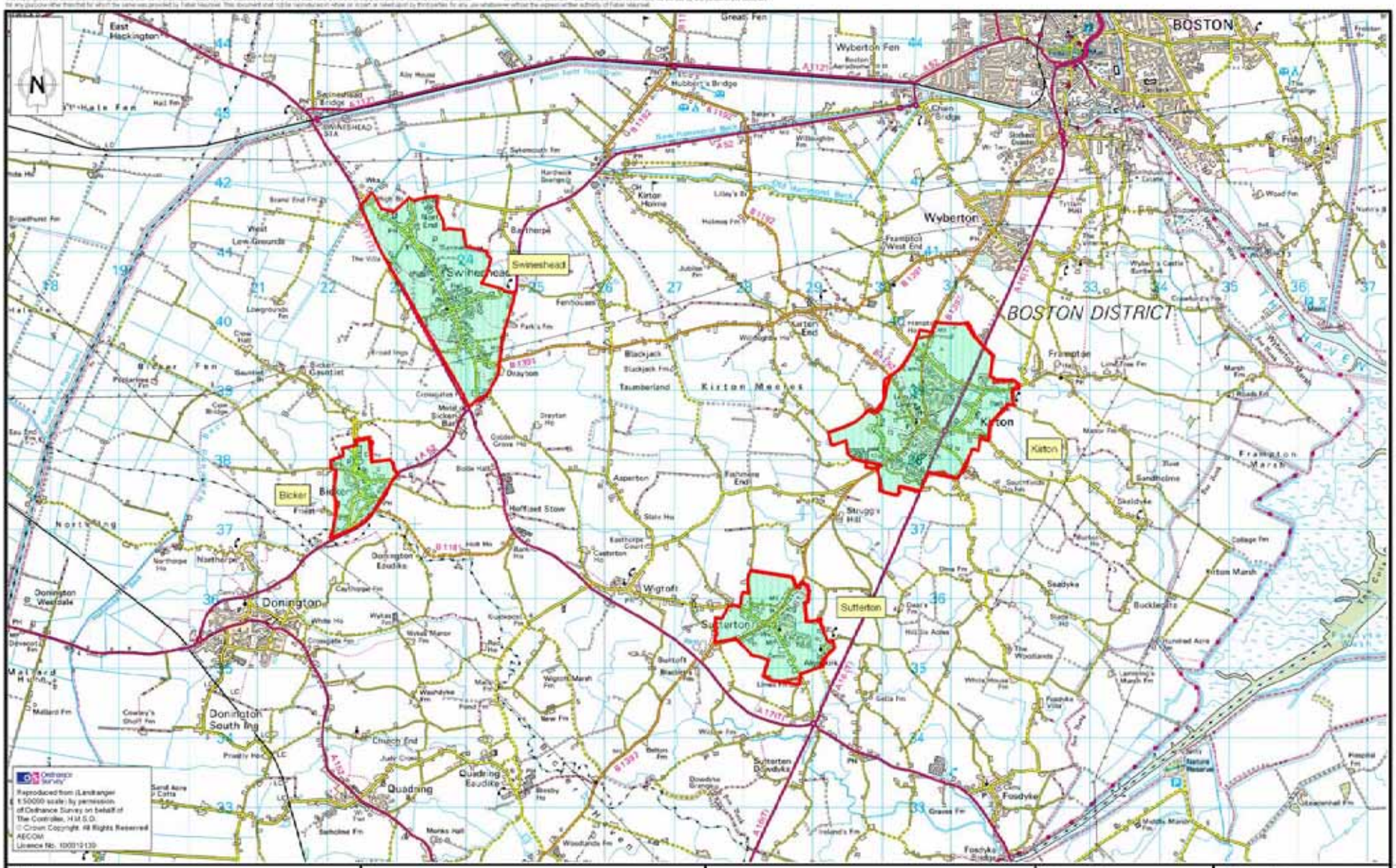
Fax: +44 (0) 113 391 6899
www.aecom.com

Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 3.1 STUDY AREA (BOSTON TOWN)
Project: STRATEGIC FLOOD RISK ASSESSMENT	

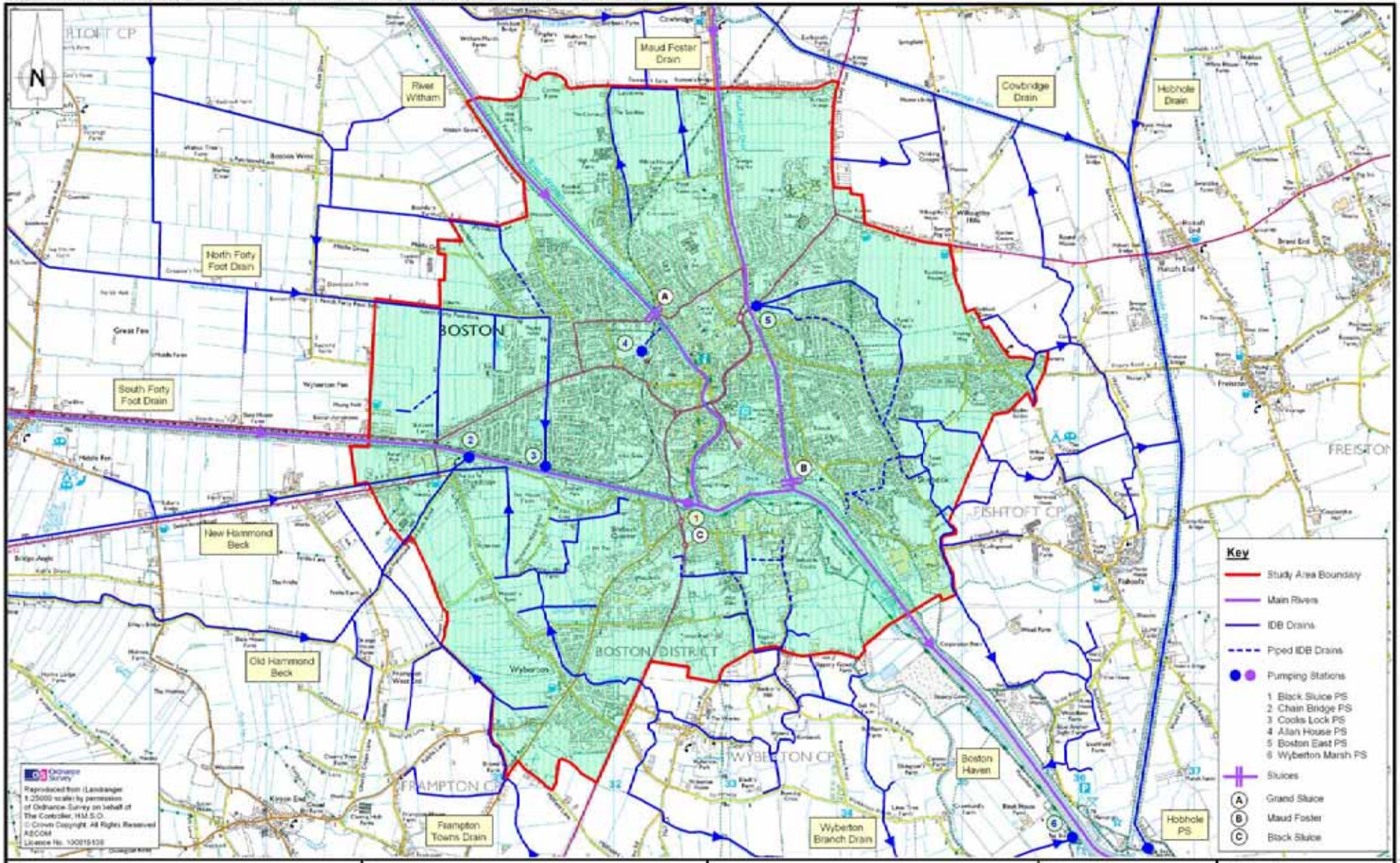
Design: ARP	CAD: ARP
Chk'd: RL	App'd: AJY
Date: JUNE 2010	Scale: 1 : 50 000
No. 60034187 / BBC / 3.1	Rev: 02

cm | A4

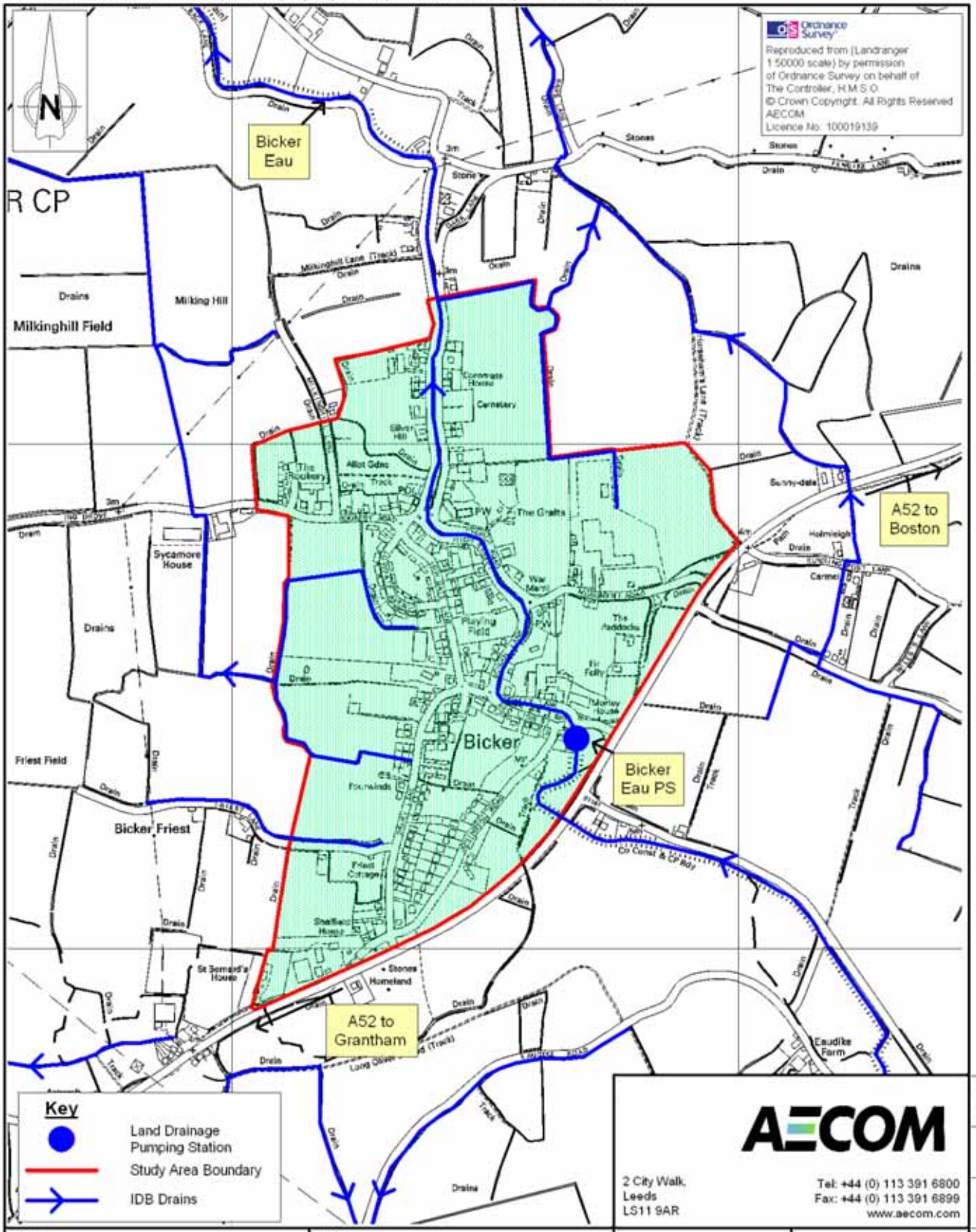
Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 3.2 STUDY AREA (NORTH)	AECOM	Design: ARP / MapInfo: ARP
Project: STRATEGIC FLOOD RISK ASSESSMENT		2 City Walk, Leeds, LS11 9AR. Tel: +44 (0) 113 391 6800 Fax: +44 (0) 113 391 6899 www.aecom.com	Chk'd: RL / App'd: AJY
			Date: JUNE 2010 / Scale: 1 : 50 000
			No. 60034187 / BBC / 3.2 — Rev: 02
			cm / A3



Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 3.3 STUDY AREA (SOUTH)	AECOM	Design: ARP / MapInfo: ARP
Project: STRATEGIC FLOOD RISK ASSESSMENT		2 City Walk, Leeds, LS11 9AR. Tel: +44 (0) 113 391 6800 Fax: +44 (0) 113 391 6899 www.aecom.com	Chk'd: RL / App'd: AJY
			Date: JUNE 2010 / Scale: 1 : 50 000
			No. 60034187 / BBC / 3.3 — Rev: 02
			cm — A3



Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 4 BOSTON TOWN STUDY AREA	AECOM	Design: ARP	MapInfo: ARP
Project: STRATEGIC FLOOD RISK ASSESSMENT		2 City Walk, Leeds, LS11 9AR. Tel: +44 (0) 113 391 6800 Fax: +44 (0) 113 391 6899 www.aecom.com	Chk'd: RL	App'd: AJY
			Date: JUNE 2010	Scale: 1 : 30 000
			No. 60034187 / BBC / 4	Rev: 02
			cm	A3



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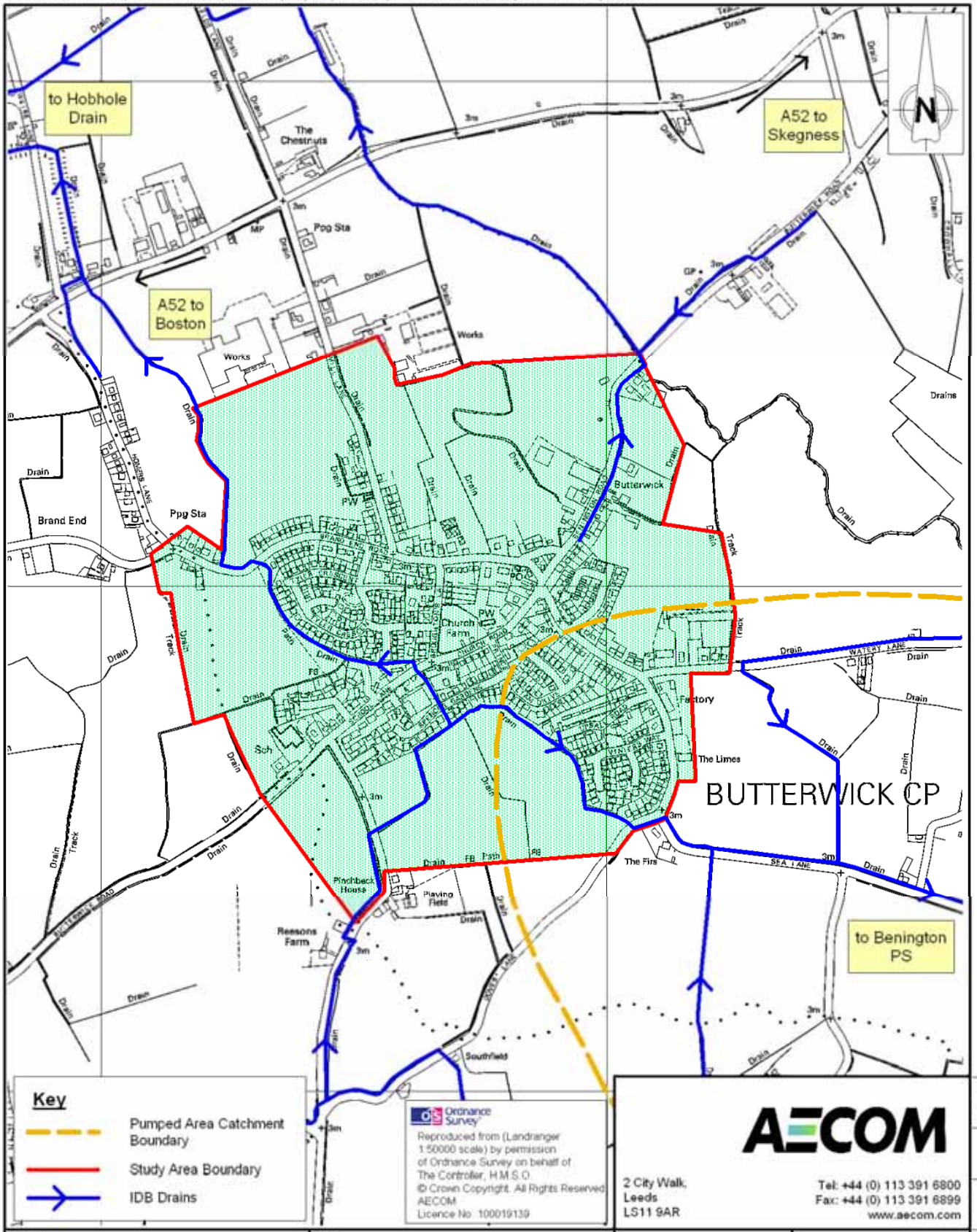
Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 5 BICKER STUDY AREA
Project: STRATEGIC FLOOD RISK ASSESSMENT	

Design: ARP	CAD: ARP
Chk'd: RL	App'd: AJY
Date: JUNE 2010	Scale: 1 : 10 000
No. 60034187 / BBC / 5	Rev: 02

cm A4



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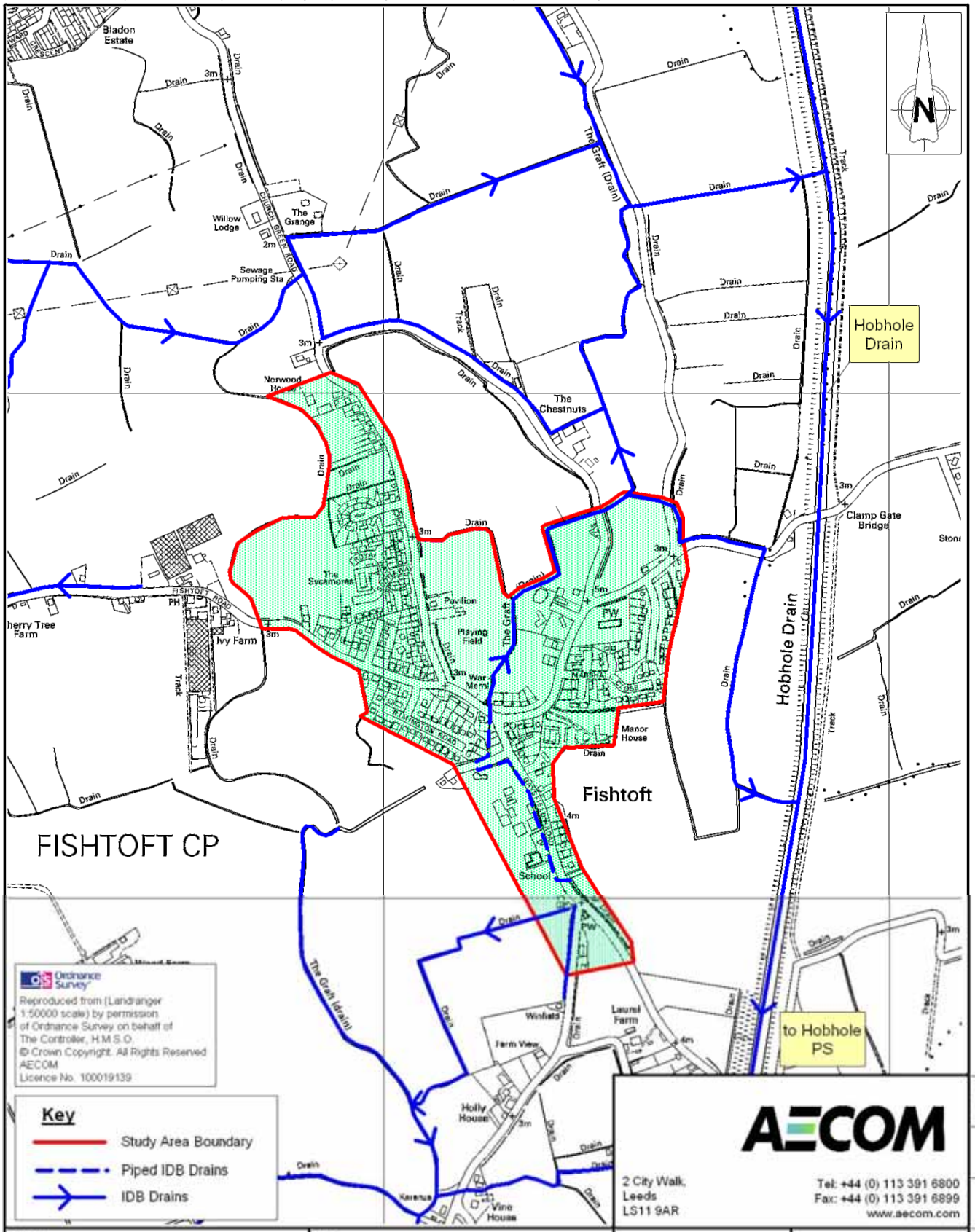
Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 6 BUTTERWICK STUDY AREA
Project: STRATEGIC FLOOD RISK ASSESSMENT	

Design: ARP	CAD: ARP
Chk'd: RL	App'd: AJY
Date: JUNE 2010	Scale: 1 : 10 000
No. 60034187 / BBC / 6	Rev: 02

cm A4



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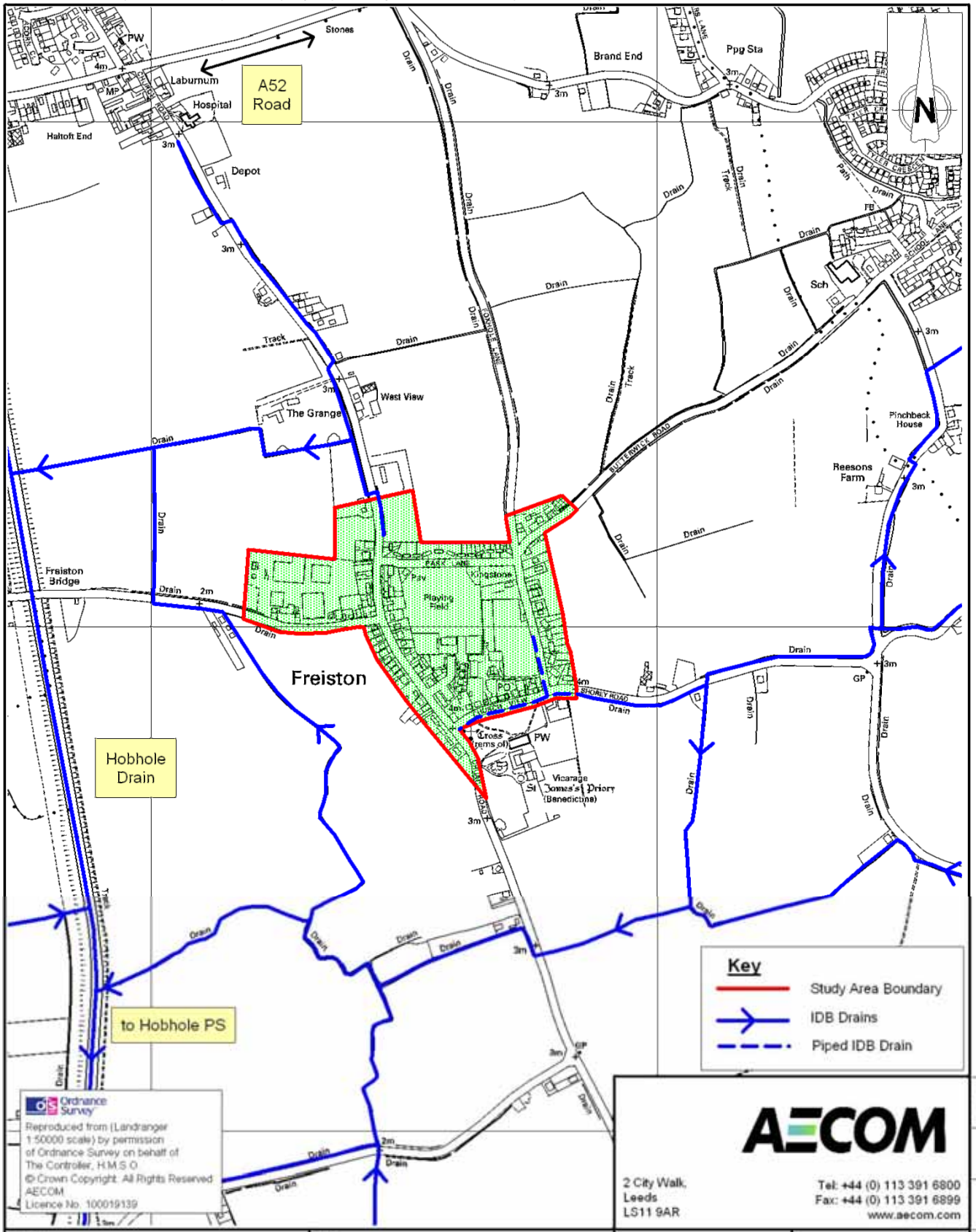
Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 7 FISHTOFT STUDY AREA
Project: STRATEGIC FLOOD RISK ASSESSMENT	

Design: ARP	CAD: ARP
Chk'd: RL	App'd: AJY
Date: MARCH 2011	Scale: 1 : 10 000
No. 60034187 / BBC / 7	Rev: 02

cm A4



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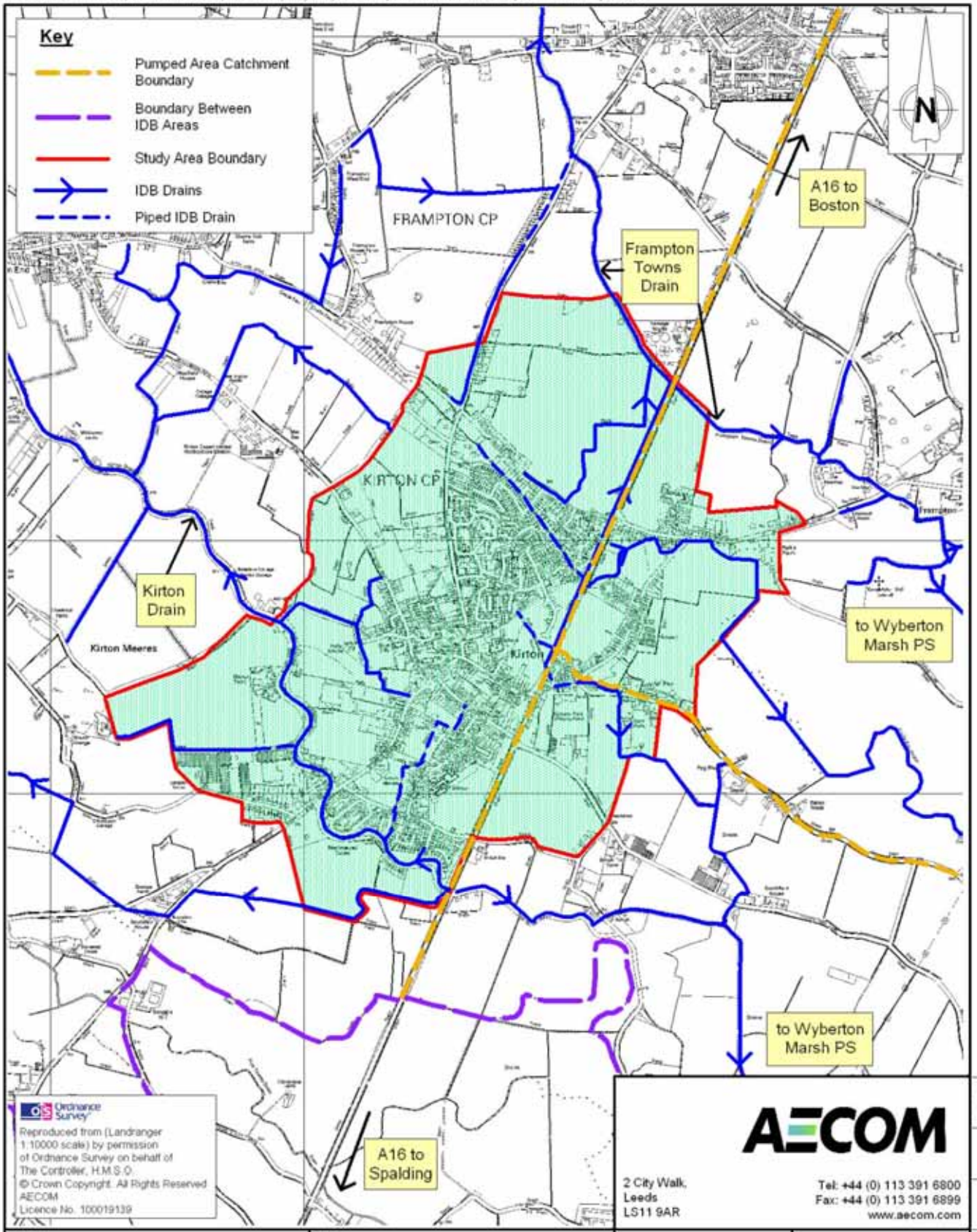
Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 8 FREISTON STUDY AREA	Design: ARP	CAD: ARP
		Chk'd: RL	App'd: AJY
Project: STRATEGIC FLOOD RISK ASSESSMENT		Date: JUNE 2010	Scale: 1 : 10 000
		No. 60034187 / BBC / 8	Rev: 02

cm A4



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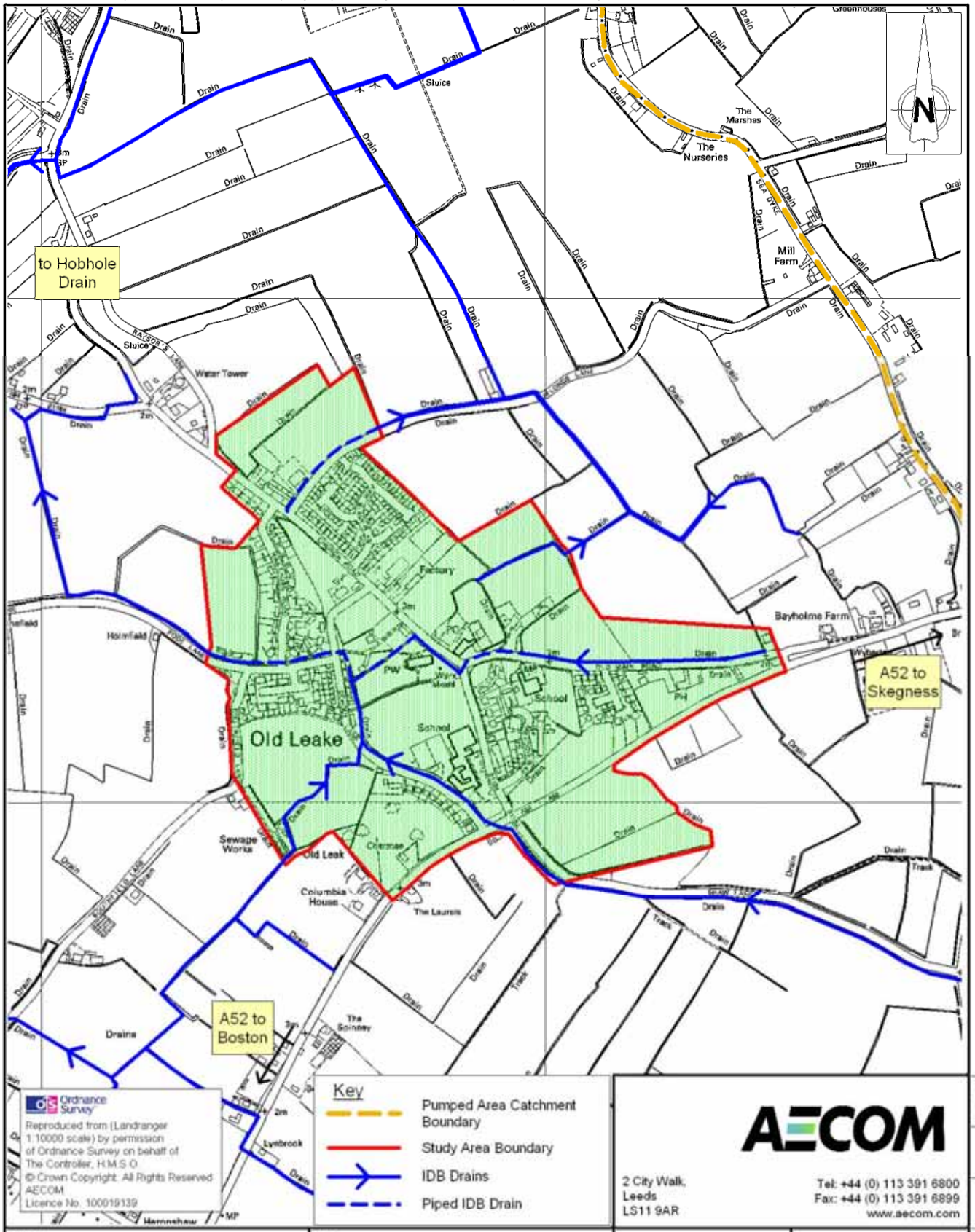
Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 9 KIRTON STUDY AREA	Design: ARP	CAD: ARP
		Chk'd: RL	App'd: AJY
Project: STRATEGIC FLOOD RISK ASSESSMENT		Date: JUNE 2010	Scale: 1 : 20 000
		No. 60034187 / BBC / 9	Rev: 02

cm A4



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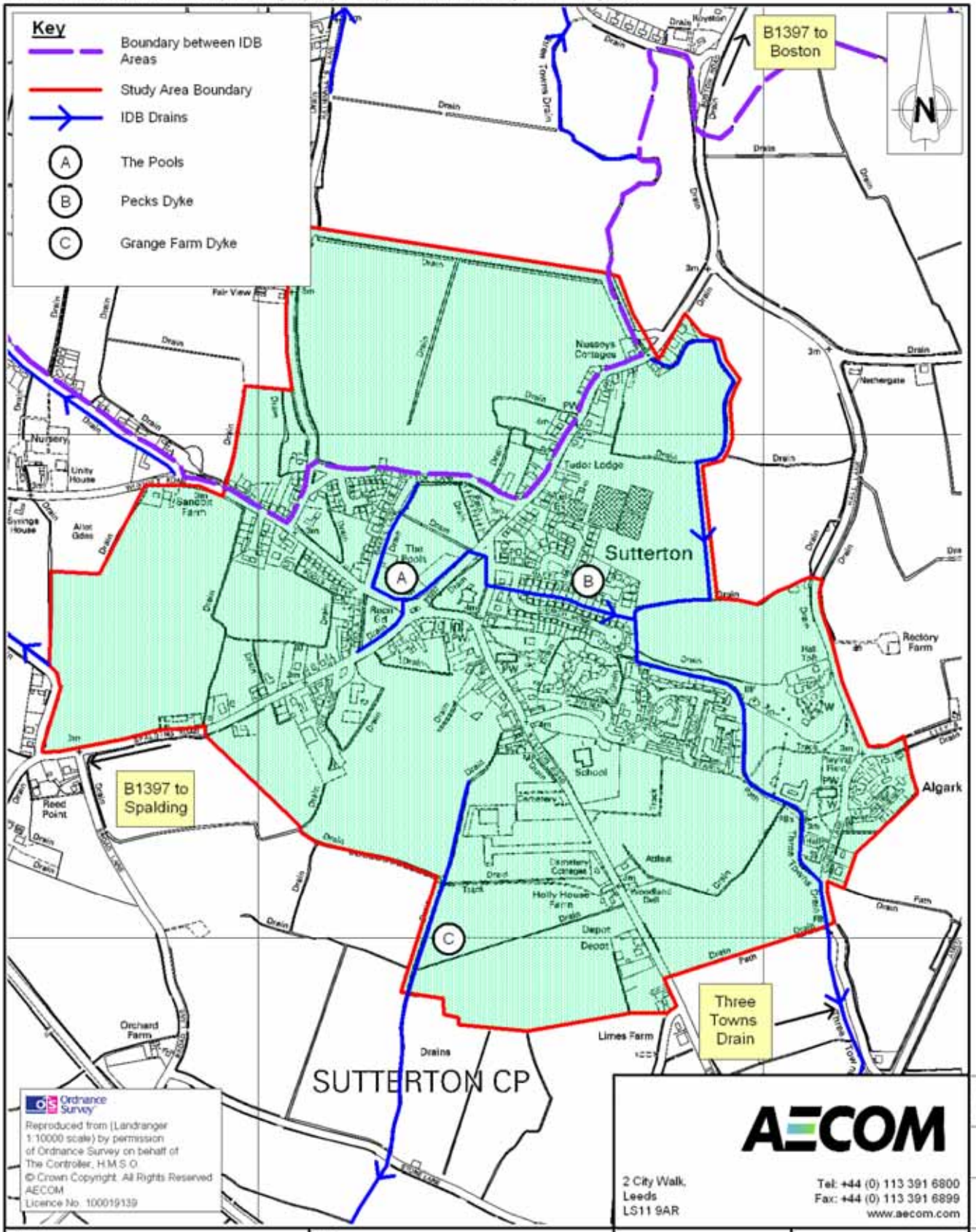
Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 10 OLD LEAKE STUDY AREA
Project: STRATEGIC FLOOD RISK ASSESSMENT	

Design: ARP	CAD: ARP
Chk'd: RL	App'd: AJY
Date: JUNE 2010	Scale: 1 : 10 000
No. 60034187 / BBC / 10	Rev: 02

cm A4



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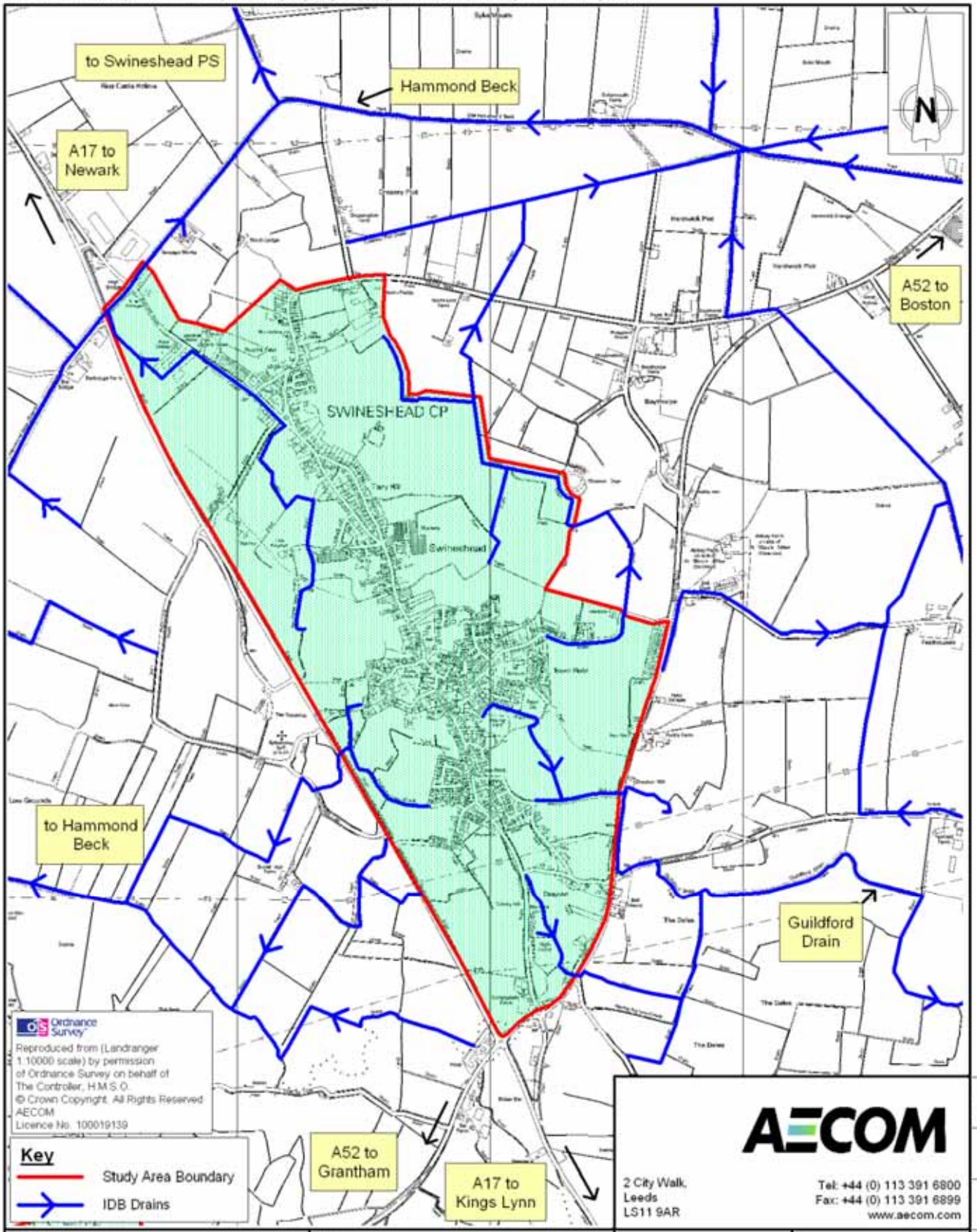
Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 11 SUTTERTON STUDY AREA	Design: ARP	CAD: ARP
		Chk'd: RL	App'd: AJY
Project: STRATEGIC FLOOD RISK ASSESSMENT		Date: JUNE 2010	Scale: 1 : 10 000
		No. 60034187 / BBC / 11	Rev: 02

cm A4



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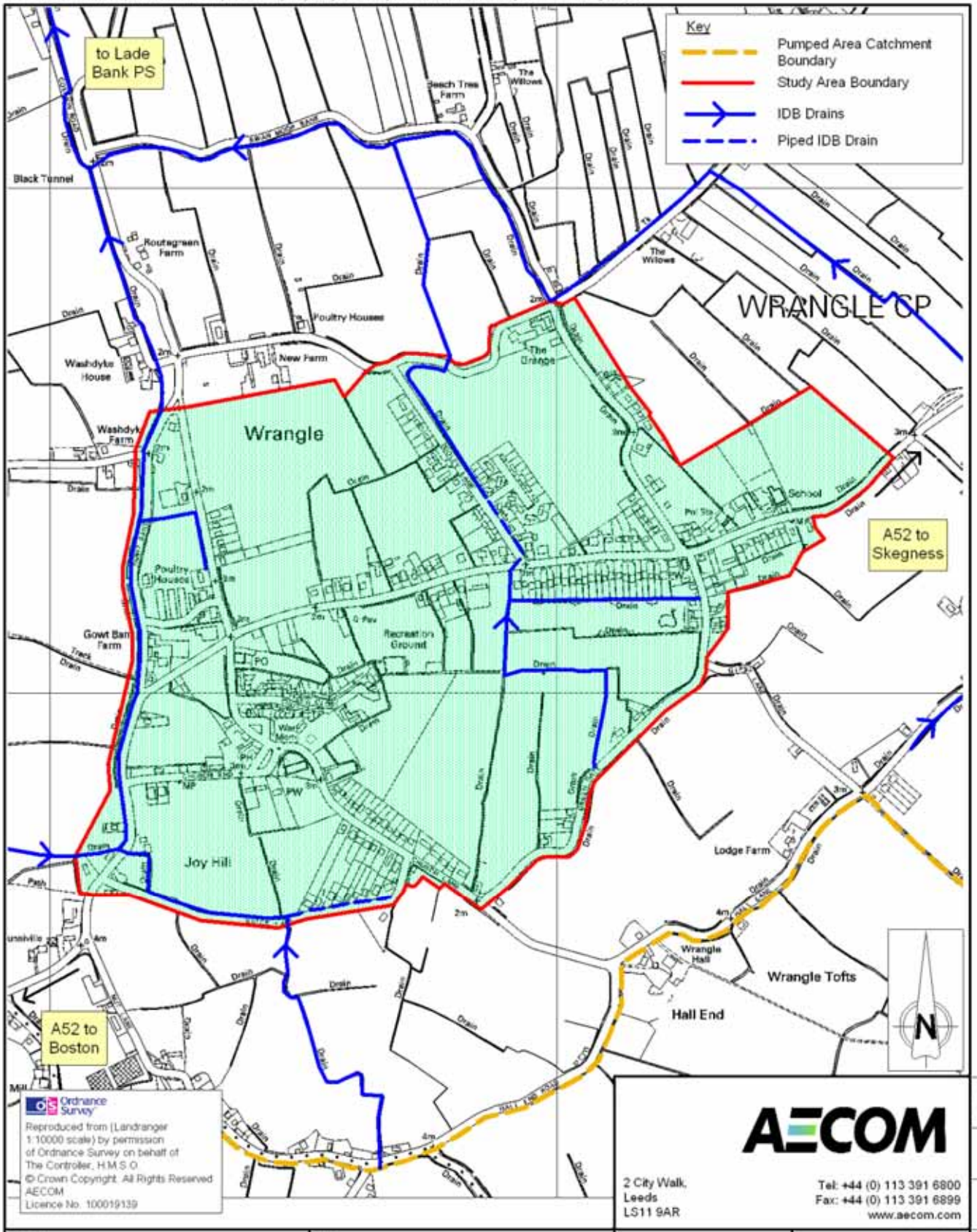
Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 12 SWINESHEAD STUDY AREA
Project: STRATEGIC FLOOD RISK ASSESSMENT	

Design: ARP	CAD: ARP
Chk'd: RL	App'd: AJY
Date: JUNE 2010	Scale: 1 : 20 000
No. 60034187 / BBC / 12	Rev: 02

cm A4



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Client: BOSTON BOROUGH COUNCIL	Title: FIGURE 13 WRANGLE STUDY AREA	Design: ARP	CAD: ARP
		Chk'd: RL	App'd: AJY
Project: STRATEGIC FLOOD RISK ASSESSMENT		Date: JUNE 2010	Scale: 1 : 10 000
		No. 60034187 / BBC / 13	Rev: 02

cm A4