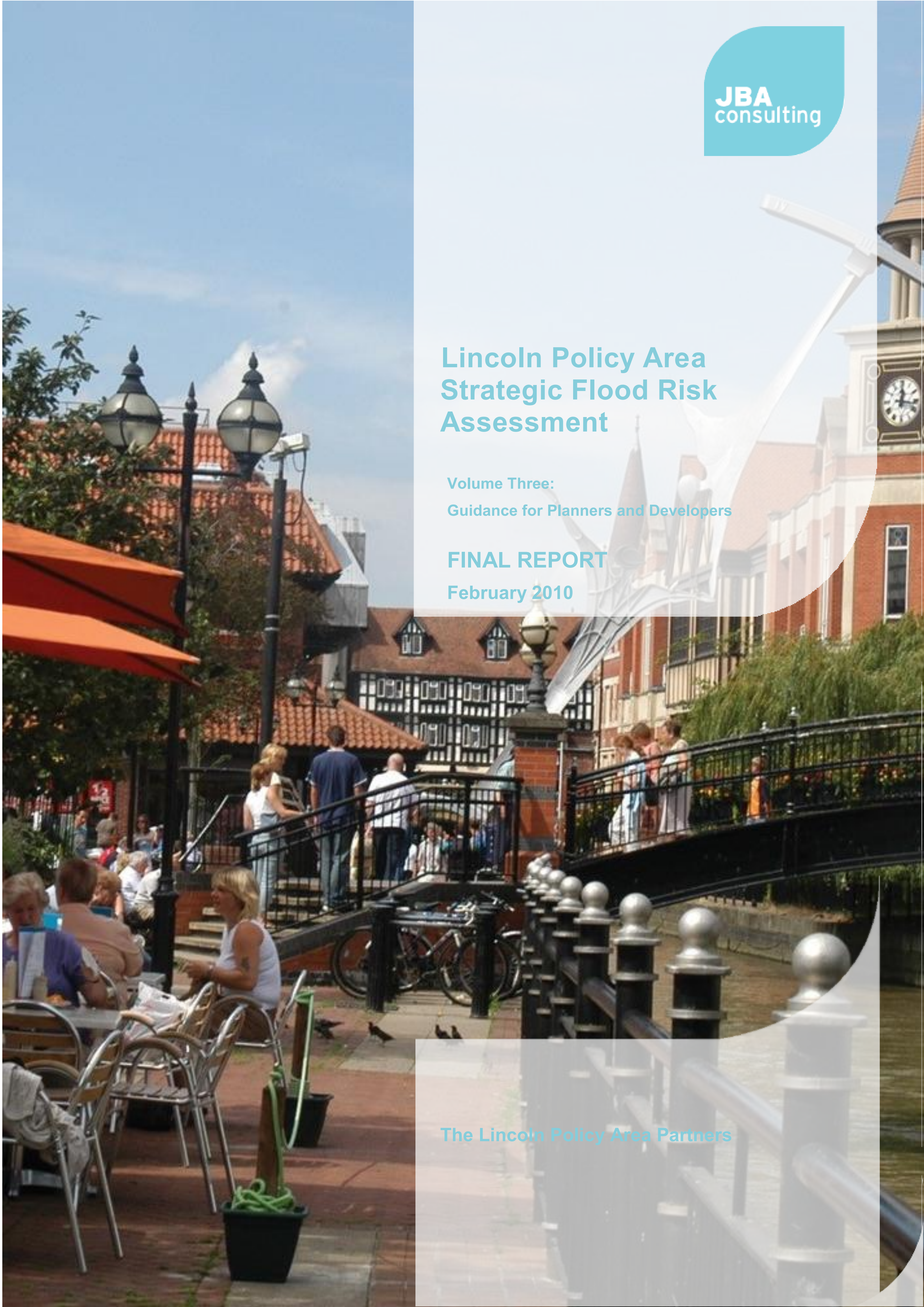

JBA consulting

Lincoln Policy Area Strategic Flood Risk Assessment

Volume Three:

Guidance for Planners and Developers

FINAL REPORT

February 2010

The Lincoln Policy Area Partners

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Contract

This report describes work commissioned by The City of Lincoln Council, on behalf of The Lincoln Policy Area Partners. The City of Lincoln Council 's representative for the contract was Toby Forbes-Turner. Matthew Hemsworth of JBA Consulting carried out this work.

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Purpose

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Executive Summary

This report is a Strategic Flood Risk Assessment (SFRA) for The Lincoln Policy Area. It is a combined Level 1 and Level 2 SFRA that incorporates the requirements of a scoping study SFRA (Level 1) and increased scope SFRA (Level 2). This SFRA has been prepared in accordance with current best practice, Planning Policy Statement 25 Development and Flood Risk (PPS25) and updates the previous SFRA published in 2002.

The SFRA constitutes one of a number of planning tools that enables the local authority to select and develop sustainable site allocations away from areas of greatest vulnerability to flooding in Lincoln. The assessment does not focus on specific development sites. The report discusses the broad scale flood risk within the whole policy area, and also focuses in more detail in an extended area of the City of Lincoln including North Hykeham and the Western Growth Corridor. This allows for an informed decision to be taken when allocating future development sites. It sets out the procedure to be followed when assessing sites in the future. The SFRA will provide the local planning authorities with the necessary detailed information to make informed decisions when considering development and flood risk issues.

The SFRA is intended to be a “live” document, updated when appropriate to reflect changes in the area and as new information becomes available.

Relevant planning, policy and guidance documents have been taken into account in preparing this SFRA. The documents which have been reviewed include national, regional and local planning legislation, together with Environment Agency policy guidance.

A thorough review of existing information and the construction of new hydraulic models has identified the level of flood risk in the Lincoln Policy Area from fluvial (river flooding).

Consultation has been undertaken with the City of Lincoln Council, the Environment Agency, local Internal Drainage Boards (IDB), British Waterways and Anglian Water to assess the current flood risk from all sources.

The Environment Agency Flood Zone Maps are included in the SFRA. The Flood Zone Maps show indicative flood outlines based on a broadscale assessment of fluvial flood risk only and do not take into account the protection offered by any defences. There are three Flood Zones. Flood Zone 1 classifies areas with a low probability of flooding. Flood Zone 2 (1 in 1000yr) is considered suitable for water-compatible, less vulnerable, more vulnerable and essential infrastructure. Highly vulnerable development is only allowed where the Exception Test is passed. Flood Zone 3 is split in to 2 sections; Zone 3a represents areas with a high probability of flooding (ie 1 in 100yr) and Zone 3b represents the functional floodplain. This is normally defined by the 1 in 20 year flood outline where water is able to spill out of the river channel. In Lincoln 1 in 20 year flows remain in channel except for in specified washland areas designed to hold flood waters.

Hydraulic modelling has been undertaken for the level 2 SFRA within the City of Lincoln to establish more realistic indicative flood outlines in key areas that take into account defences and consider how flood water flows within a floodplain. This modelling (which includes allowances for climate change to 2108) calculates expected depths and velocities of flood water across the floodplain and allows consideration of the flood risk to people and properties. Modelled flood outlines also take in to account the effects of climate change.

The flood scenarios considered in the SFRA are 1 in 100 year with climate change and 1 in 1000 year with climate change annual chance flood events, which may also be expressed as 1%+cc and 0.1%+cc Annual Exceedance Probability (AEP) flood events.

An investigation has been carried out into the effect of defences on flood risk and the risk that remains behind them, for example by failure (due to breach) or overtopping. Purpose built, formal defences have been considered and also other features such as privately owned walls and road and rail embankments, which were not built specifically as flood defences, but which have an impact on the flow of flood water due to their elevated level.

The main flood risk within the Lincoln Policy Area is considered to be from fluvial flooding.

Following major flooding in 1947 and 1958, feasibility studies were undertaken in 1977 to investigate flood risk in Lincoln and possible flood alleviation schemes. As a result, a scheme was implemented, which consisted of two controlled washlands constructed upstream of Lincoln City Centre; one at the confluence of the River Witham and Brant, known as the Witham washlands (5km south of Lincoln), and the other on the River Till (7km to the north-west), which provide a 1 in 100-year level of flood protection. The washlands were created by building shallow embankments across the river valley, with control sluices in the rivers, which allow the amount of water in the washlands to be regulated. Pumping stations aid the final draining of the washlands. The scheme was completed in 1991.

Apart from the control gates at the washlands there are also automated control gates at Stamp End and at the upstream end of Sincil Dyke (Bargate Sluices). All of these control gates are used to keep water levels in Lincoln below critical levels, which were set taking account of existing defence levels. The water level in Lincoln is kept between 4.36m AOD and 5.7m AOD. A set of rules and criteria for the operation of the washlands exists. This is held by the Lincs Washlands Operating Team. The control gates at the washlands are operated manually based on levels and flows from telemetry sites upstream.

The present flood risk within the Lincoln Policy Area has been determined with reference to the Environment Agency's Flood Zone Map (FZM) 2009 and overtopping and breach analysis of the flood defences within the City of Lincoln.

Overtopping and Breach analyses have been undertaken showing the possible depths and hazard mapping has been undertaken (taking into account depth and velocity). Overtopping and Breach analyses have been carried out using JBA's in-house raster based 2-D model JFLOW, to enable the production of maps showing overtopping and breach extent. Maps and GIS layers have been provided.

The flood defence condition has also been summarised (in Volume 2) from information received from the Environment Agency. The condition of flood defences throughout Lincoln ranges from Good to Poor.

2D flood modelling within the 'extended' area of the City of Lincoln (including north Hykeham and the Western Growth corridor) for both the 100 year with climate change and 1000 year with climate change flood scenarios has shown that flood defences will overtop. Breach analysis of flood defences has shown flood water to extend over a large area of the existing low land within the City area. The areas to the Western side of the River Witham in Lincoln are at the greatest risk from flood defence failure.

The SFRA provides guidance relating to future development. It provides advice on any site-specific requirements for a Flood Risk Assessment within the different flood zones, and advises the local authorities on the use of the Exception Test, should the Sequential Test be passed.

Guidance for the local authorities on the future management of development with respect to flood risk has been given, relevant to the different flood zones and possible types of development.

In addition, an outline has been given of requirements for developers for Flood Risk Assessments, with supporting guidance on reducing flood risk and making development safe, including Sustainable Drainage Systems (SuDS) and flood mitigation measures. Advice is also given on environmental improvement opportunities and other issues to consider as part of a development proposal.

The SFRA is presented in four volumes: Volume 1 provides a non-technical summary of the SFRA process and findings, Volume 2 provides a technical summary of methods used to produce the SFRA, Volume 3 provides guidance for those using the SFRA and Volume 4 includes the mapped outputs of the SFRA.

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Abbreviations

AEP	Annual Exceedance Probability
AONB	Area of Outstanding Natural Beauty
CC	Climate Change
CFMP	Catchment Flood Management Plan
DEFRA	Department for the Environment, Food and Rural Affairs
EA	Environment Agency
FRA	Flood Risk Assessment
FZ	Flood Zone
Ha	Hectare
JBA	Jeremy Benn Associates Ltd
LDD	Local Development Document
LDF	Local Development Framework
LPA	Local Planning Authority
m AOD	Metres Above Ordnance Datum
MSfW	Making Space for Water
OS NGR	Ordnance Survey National Grid Reference
PPG25	Planning Policy Guidance Note 25
PPS25	Planning Policy Statement 25
RFRA	Regional Flood Risk Appraisal
SFRA	Strategic Flood Risk Assessment
SSSI	Site of Specific Scientific Interest
SuDS	Sustainable Drainage Systems

Definitions

Annual Exceedance Probability	e.g. 1% AEP	Refer to 'probability'.
Brownfield		Brownfield (sites or land) is a term in common usage that may be defined as 'development sites or land that has previously been developed'. Prior to PPS25, the term 'Brownfield' was used in Governmental Guidance and Statements, but in PPS25 has been replaced with 'Previously-developed land'. See 'Greenfield'.

Catchment Flood Management Plan	CFMP	A strategic planning tool through which the Environment Agency will seek to work with other key decision-makers within a river catchment to identify and agree policies for sustainable flood risk management.
Compensatory Storage		A floodplain (flood storage) area introduced to compensate for the loss of storage as a result of filling for development purposes.
Core Strategy	CS	This is the strategic vision of an area and is a central pillar of the Local Development Framework, comprising: A Vision, Strategic Objectives, a spatial land use strategy, core policies and a monitoring and implementation framework. The Core Strategy is a Development Plan Document which will determine overall patterns of future development, identifying broad locations where future growth will take place. All other Development Plan Documents should be in broad conformity with the Core Strategy Document The Core Strategy is a mandatory document, and a timetable for production is set out within the Local Development Scheme.
Defended Area		An area offered a degree of protection against flooding through the presence of a flood defence structure.
Development Plan Documents	DPDs	These documents have Development Plan Status and consequently form part of the statutory development plan for the area. A DPD will be subject to an independent examination. Typical documents that will have DPD status include the Core Strategy, Site-specific Allocations of Land, Proposals Map, and Area Actions Plans (where needed).
Environment Agency	EA	An executive non-departmental public body. It's principle aims are to protect and improve the environment and to promote sustainable development.
Exception Test		An integral part of the risk-based approach at the core of PPS25, the Exception Test is designed to allow for those exceptional circumstances when, for wider sustainability reasons, development not entirely compatible with the level of flood risk may be permitted. For the Exception Test to be passed, all three of its components must be fulfilled.
Flood Estimation Handbook	FEH	Provides current methodologies for estimation of flood flows for the UK.
Flood Hazard		A classification system developed by DEFRA/Environment Agency that gives an assessment of the hazard posed by a flood event at a given location. It is defined using the maximum modelled flood depth, velocity and a factor to allow for debris.
Floodplain		Any area of land over which water flows or is stored during a flood event or would flow but for the presence of defences.
Flood Risk Assessment	FRA	A detailed site-based investigation that is undertaken by the developer at planning application stage.
Flood Risk Management		The introduction of mitigation measures (or options) to reduce the risk posed to property and life as a result of flooding. It is not just the application of physical flood defence measures.
Flood Risk Vulnerability Classification		Refer to Section 3
Flood Zone 1	FZ1	This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).

Flood Zone 2	FZ2	This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1%-0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5%-0.1%) in any year.
Flood Zone 3a	FZ3a	This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
Flood Zone 3b	FZ3b	This zone comprises land where water has to flow or be stored in times of flood. This is land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood.
Fluvial Flooding		Flooding caused by the overtopping of river or stream banks.
Formal Defence		A flood defence asset that is maintained by the Environment Agency.
Freeboard		A 'safety margin' to account for residual uncertainties in water level prediction and/or structural performance, expressed in mm.
Functional Floodplain		An area of land where water has to flow or be stored in times of (fluvial) flooding.
Greenfield		Greenfield (sites or land) is a term in common usage that may be defined as 'development sites or land that has not previously been developed'. Prior to PPS25 the term 'Greenfield' was used in Governmental Guidance and Statements, but in PPS25 has been replaced with 'Undeveloped land' See 'Brownfield'.
Informal Defence		A structure that provides a flood defence function, however is not owned nor maintained by the Environment Agency.
Internal Drainage Board	IDB	An Internal Drainage Board is a statutory body which provides flood protection and water level management services
ISIS		1-Dimensional hydraulic modelling software used to demonstrate flow within river channels
JFLOW		Proprietary 2-Dimensional hydraulic modelling software package developed by JBA, which demonstrates overland flow in floodplains
Local Development Framework	LDF	The Local Development Framework is made up of a series of documents that together will form part of the Development Plan. Broadly, Local Development Framework documents fall into two categories: - Development Plan Documents - Supplementary Planning Documents.
Local Development Scheme	LDS	A Local Development Scheme is a public statement of the Council programme for the preparation of Local Development Documents which will form the Local Development Framework.
Local Planning Authority	LPA	Local authority with responsibility for determining whether proposed developments are approved or otherwise.

Main River		A watercourse designated as such by DEFRA that is regulated and maintained by the Environment Agency using their permissive powers.
Measure		A deliverable solution that will assist in the effective management (reduction) of risk to property and life as a result of flooding, e.g. flood storage, raised defence, effective development control and preparedness, and flood warning.
Mitigation		The management (reduction) of flood risk.
Option		Refer to 'measure'.
PAG2		Project Appraisal Guidance (PAG) 2 (Strategic Planning) outlines the DEFRA requirements against which the Environment Agency must demonstrate that they are managing flood risk in a strategic (catchment wide) manner.
Probability	e.g. 1%	A measure of the chance that an event will occur. The probability of an event is typically defined as the relative frequency of occurrence of that event, out of all possible events. Probability can be expressed as a fraction, percentage or a decimal. For example, the probability of obtaining a six with the shake of a fair die is 1/6, 16% or 0.166. Probability is often expressed with reference to a time period, for example, annual exceedance probability. For example, a 1% AEP event is an event with a 1% chance of occurring or being exceeded in any one year.
Proposals Map		This is an Ordnance Survey based map that spatially illustrates policies and proposals within LDDs. The Proposals Map will show planning policy designations and land allocations identified within DPDs, statutory land use and landscape designations and other land and area based designations. It will form part of the statutory development plan.
Residual Risk		The risk that inherently remains after implementation of a flood mitigation measure (option).
Return Period	e.g. 1 in 100-Year	The expected (mean) time (usually in years) between the exceedance of a particular extreme threshold. Return period is traditionally used to express the frequency of occurrence of an event, although it is often misunderstood as being a probability of occurrence.
Risk		The threat to property and life as a result of flooding, expressed as a function of probability (that an event will occur) and consequence (as a result of the event occurring).
Sequential Flood Risk Test	SFRT	The assessment and 'categorisation' of flood risk on a catchment-wide basis in accordance with PPS25.
Site Specific Allocations Development Plan Document		A mandatory document, the Allocations Development Plan Document is a high priority item for preparation, details of which are provided in the Local Development Scheme. Prepared in conformity with the Core Strategy, once approved, the Allocations Document will identify sites for development as part of the delivery of the overall planning strategy for the area.
Standard of Protection	SoP	The return period to which properties are protected against flooding
Strategic Flood Risk Assessment	SFRA	The assessment of flood risk on a catchment-wide basis for proposed development in a District

Strategic Flood Risk Management	SFRM	Considers the management of flood risk on a catchment-wide basis, the primary objective being to ensure that the recommended flood risk management 'measures' are sustainable and cost effective
Supplementary Planning Documents	SPD	Supplementary Planning Documents, or SPD, support DPDs in that they may cover a range of issues, both thematic and site specific. Examples of SPDs may be design guidance or development briefs. SPDs may expand policy or provide further detail to policies in a DPD. They will not be subject to independent examination.
Sustainable Drainage Systems	SuDS	Current 'best practice' for new development that seeks to minimise the impact upon the localised drainage regime, e.g. through the use of pervious areas within a development to reduce the quantity of runoff from the development.
TUFLOW		2-Dimensional hydraulic modelling software package with links to ISIS, which demonstrates overland flow in floodplains
Uncertainty		A reflection of the (lack of) accuracy or confidence that is considered attributable to a predicted water level or (modelled) flood extent.
Washlands		Areas which are not susceptible to flooding in a 20 year flood event and hence not classified as Flood Zone 3b, but are considered of vital importance as floodplains and should therefore be treated as functional floodplain
Windfall Sites		Sites that become available for development unexpectedly and are not included in a planning authority's development plan as allocated land.

1 Guidance for Allocation of Development Land

1.1 Background

The City of Lincoln Council has not advised JBA of any specific locations to consider for possible future development land. The advice below therefore discusses generic considerations for land within each of the Flood Zone categories.

The overarching aim of PPS25 is to guide development away from high flood risk through the use of the Sequential Test. The LPA should carry out the Sequential Test, whilst considering wider issues that may affect availability of development sites. The SFRA is designed to provide a basis for the Test.

Flood risk is only one of many factors that influence land-use decisions and this SFRA is designed to assist planners in considering flood risk. The use of the SFRA ensures that flood risk at a local level is assessed with regard to policy documents, guidance notes and legislation issued at regional and national scales.

Volumes 1 (Non-Technical) and 2 (Technical) of the SFRA summarises the objectives of the Lincoln SFRA in relation to current policies, guidance, strategies and plans. An assessment of flood risk across the district is presented, an explanation of the maps generated as part of the assessment and how they should be used. The maps are contained within Volume 4.

Volume 3 of the SFRA contains guidance on how to use the SFRA to select and develop sustainable allocations away from the highest flood risk areas and sets out the procedure to be followed when assessing sites for development in the future. The starting point for applying the Sequential Test is to determine the fluvial flood risk using the Flood Zone Maps in Volume 4. These have been annotated to guide the user to more detailed modelling (ie: overtopping and breaching modelling) where available as summarised below:

- **Flood Zone Maps** – These are provided for the whole of the Lincoln Policy Area. They include the latest Environment Agency Flood Zone 3 (100 year) and Flood Zone 2 (1000 year) outlines, which have been generated using broad scale modelling techniques and do not include the effect of any defences. They should be used as the starting point for application of the Sequential and Exception Tests for all areas within the Lincoln Policy Area.

- **Overtopping Depth and Hazard Maps -** These are provided for the 'extended' City of Lincoln area (to include the City, North Hykeham and the Western Growth Corridor). These maps have been produced by 2D modelling for both the 100yr with climate change and the 1000yr with climate change flooding scenarios. The modelling outputs include flood depth maps (which map show the variation in flood depth as a result of flood defence overtopping) and flood hazard maps (which show the degree of flood hazard as a result of the overtopping). The hazard rating is dependent on flood depth and velocity and has been calculated according to the methodology given in the DEFRA report FD2320. Four hazard categories are displayed – very low hazard, danger for some, danger for most and danger for all.

- **Breaching Depth and Hazard Maps -** These are provided for the 'extended' City of Lincoln area (to include the City, North Hykeham and the Western Growth Corridor). These maps have been produced by 2D modelling for both the 100yr with climate change and the 1000yr with climate change flooding scenarios. These maps demonstrate the effects of failure of the flood defences.

When the fluvial flood risk at the site has been determined, an assessment should be made of whether the proposed development type is appropriate within the flood zone category.

1.2 Flood Zone 1

The guidance contained in Section 1.1shall be applicable to any development allocations the LPA may make that are entirely within Flood Zone 1. PPS25 defines Flood Zone 1 as 'land assessed as having a less than 1 in 1000 annual probability of river flooding in any year (<0.1% AEP).' From a flood risk perspective all land uses are acceptable within Flood Zone 1. Flood risk is not considered to be a significant constraint to development and all land uses listed below are appropriate in this zone.

- Essential infrastructure
- Highly vulnerable
- More vulnerable
- Less vulnerable
- Water compatible development.

It should be noted however that Flood Zone outlines have not been defined in some areas. The EA Flood Zone Maps do not cover smaller watercourses with a catchment smaller than $3km^2$ and in order to determine the flood risk at sites close to un-mapped watercourses, additional modelling may be required.

1.3 Flood Zone 2

Development in Flood Zone 2 should only be considered if no suitable alternative sites exist in Flood Zone 1.

Subject to application of the Sequential Test, PPS25 specifies suitable types of development in this zone as:

- Essential infrastructure
- More vulnerable
- Less vulnerable
- Water compatible development
- Highly vulnerable, subject to the Exception Test

The LPA will be required to assess whether the development location will pass parts a. and b. of the Exception Test. The LPA must be able to demonstrate the need for development through the spatial planning process.

A FRA may be required to inform and justify allocation in Flood Zone 2, to address part c of the Exception Test.

1.4 Flood Zone 3

Development in Flood Zone 3 should only be considered if no suitable alternative sites exist in Flood Zone 2.

Flood Zone 3 is subdivided into Flood Zones 3a and 3b. Flood Zone 3a is potentially suitable for water-compatible and less vulnerable land uses. The more vulnerable and essential infrastructure uses should only be permitted in this zone if the Exception Test is passed. Highly vulnerable development should not be permitted in this zone. Only water-compatible uses and the essential infrastructure (subject to Exception Test) should be permitted in Flood Zone 3b.

A FRA may be required to inform and justify allocation in Flood Zone 3, to address part c of the Exception Test.

1.5 Locations spanning more than one Flood Zone

If a site spanning more than one flood zone passes the Sequential Test, the Test should then be applied within the site boundary.

In accordance with PPS25, development should be located in the area of the site at lowest risk of flooding. Where this is the case, the LPA may consider the following:

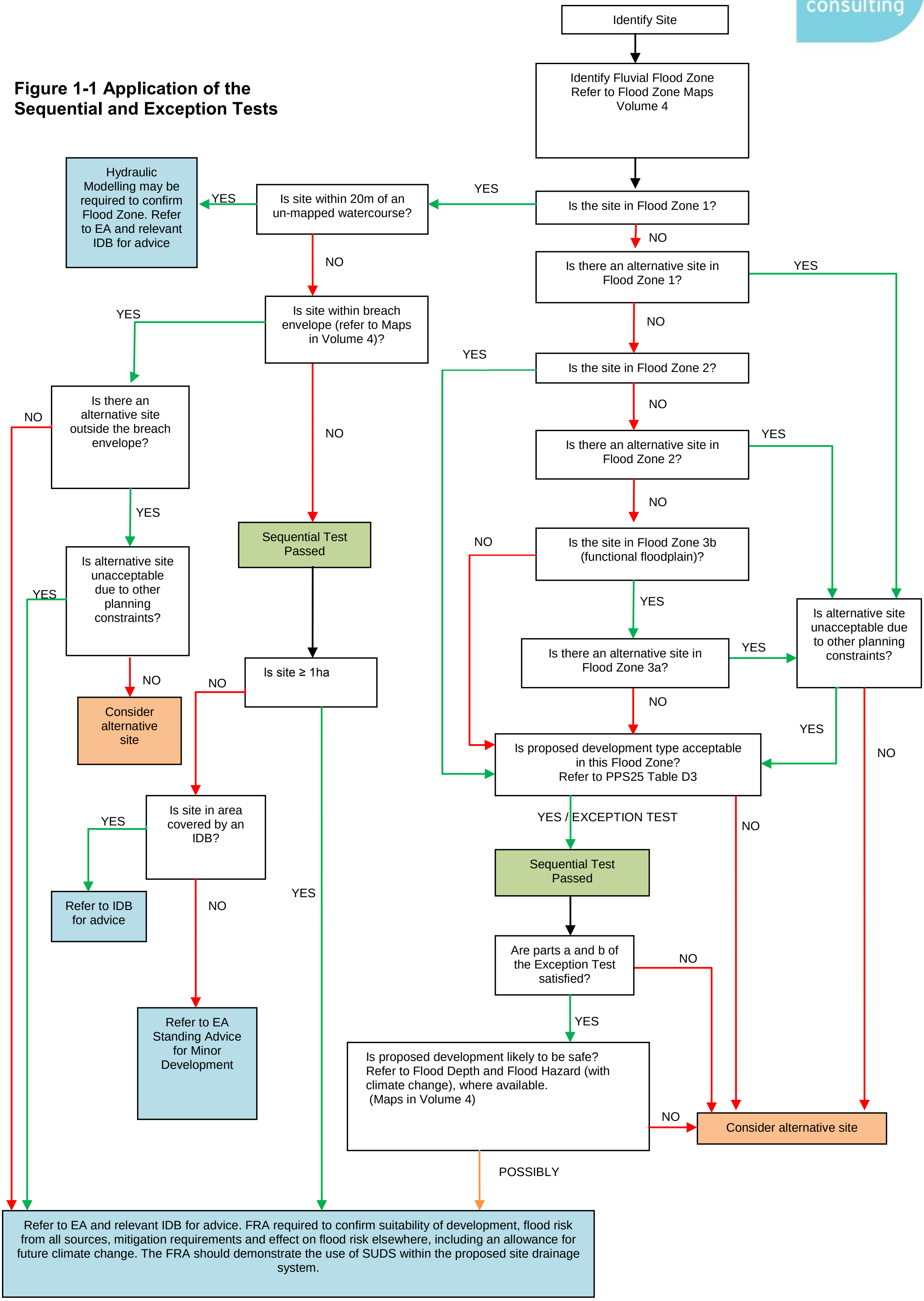
- Adjust the development footprint for each site so that the allocated area is contained in Flood Zones 1 and 2 only. This option may include using areas vulnerable to flooding as areas of public open space and for habitat creation and environmental improvement.
- Consider the requirements of the Exception Test (where this is applicable) and whether it is likely that this can be passed.

1.6 Summary of Flood Risk and Development Land Allocation

- **The aim of PPS25 is to guide developments away from high flood risk areas through the application of the sequential test**
- **It may be necessary to carry out further modelling to determine the flood zones associated with smaller watercourses**
- **All possible alternative sites in lower risk flood zones must be considered before allocating sites in Flood Zones 2 or 3**
- **The vulnerability of proposed developments must be considered**
- **The expected life of developments must be considered and the possible effects of climate change over the lifetime**
- **More guidance on the application of the sequential test is given in Volume 1**

The following flow chart (Figure 1-1) guides the site selection process and application of the Sequential and Exception Tests. It continues beyond this stage and is equally applicable to the consideration of development applications, making recommendations for the provision of FRAs in accordance with the procedural recommendations of the SFRA.

Figure 1-1 Application of the Sequential and Exception Tests



2 Guidance for Planning Applications

2.1 General

The aims of planning policy on development and flood risk are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk (PPS25). This includes adopting a precautionary approach avoiding flood risk where possible and accommodating the impacts of climate change.

Development applications for sites allocated by the LPA in accordance with the SFRA can be assumed to have been tested sequentially. Elsewhere, application of the Sequential Test will be required by the developer. The Exception test and a FRA may be required dependent on the development type and location.

It should be acknowledged that a FRA may show that a site is not appropriate for a particular type of development or indeed for any development at all. Where the FRA shows that a site is not appropriate for a particular usage, a lower vulnerability classification might be appropriate.

2.2 Future Planning Applications

The first document that local planners should refer to when considering future planning applications is the Environment Agency's Flood Risk Standing Advice for Local Planning Authorities PPS25 (national) version 2.1 – January 2009, which can be accessed on the Environment Agency website.

The Standing Advice sets out when the Environment Agency need to be consulted, what information the consultation should contain and gives guidance on the application of the Sequential Test. The web-based format is an easy to follow step by step process which guides the user through a series of questions relating to the development size, the location in relation to the flood zones and the vulnerability of the end-users on the proposed development.

The SFRA should be consulted and the Flood Zone confirmed. Where necessary the application should be accompanied by a FRA demonstrating that the Sequential and Exception Tests have been passed.

It should be demonstrated that proposed developments are not at risk of flooding and that developments do not increase flood risk elsewhere. The surface water drainage from proposed developments should be designed such that peak run-off rates and volumes are attenuated in accordance with the current EA Standing Advice.

Planning conditions should be imposed requiring the construction of any flood mitigation or surface water attenuation proposals prior to occupations and to put in place appropriate measures to minimise silt run-off and pollution of watercourses and groundwater during construction.

Removal of Permitted Development Rights is justified where development threatens to have a direct, significant and adverse effect on a flood risk, flood defences or management of surface water. This includes the cumulative impact of minor development

The assessment of development applications should follow the flow chart at the end of this chapter.

2.3 Assessment of Flood Risk

Fluvial flood risk dominates within the Lincoln Policy Area, therefore when considering future development in the Lincoln Policy Area, the design criterion is generally to the design event coinciding with a 1 in 100 year annual chance (or 1% AEP) flood event, including the impacts of climate change. Where defences exist it may be necessary to consider the likelihood and consequences of breach of the defences. The responsibility to decide what level of residual risk will be acceptable lies with the local planning authority, in agreement with the Environment Agency.

Before embarking on detailed hydraulic modelling, and in light of this SFRA, proposals for development should be discussed in detail with the Environment Agency and any local IDB's at an early stage. It may be the case that the results of the modelling undertaken for this SFRA would be sufficient, depending on the type and scale of development proposed.

2.4 Pre- Planning Guidance for Developers

Early consideration of flooding and drainage issues is imperative. The flood risk at a site and the type of development that would be appropriate should be considered prior to site acquisition; as should the “land-take” required for flood storage, above ground surface water attenuation and SuDS, thus allowing a more informed assessment of the possible development density and of the land value.

2.4.1 Desk Studies, Site Investigations and Surveys

Contact should be made with the relevant council planners, the Environment Agency Planning Liaison / Development and Flood Risk Team, Anglian Water (AW) and IDB's for guidance on local flooding issues and drainage problems. If the proposed development is large and falls within the Lincoln Policy Area, ideally contact should be made with the Lincoln Drainage Group where all key agencies and organisations as listed above are represented.

The location of the site within either Flood Zone 1, 2 or 3 should be established by consulting the Flood Zone Maps in Volume 4 to determine whether the development proposals will pass the sequential test. The Flood Zones relate only to fluvial (river) flooding. It is possible that further modelling will be required to determine flood risk associated with smaller watercourses (with a catchment less than 3 km^2).

It is possible the site will require a Flood Risk Assessment or Drainage Impact Assessment depending on the development size, type and location. Drainage Impact Assessments will be required where there are known capacity issues with receiving drains and there is the potential for additional flow from new development to exacerbate the problem. Advice should be sought as early as possible from Anglian Water (AW), the relevant local authority engineers, the Environment Agency and local IDB's and a surface water drainage strategy produced which incorporates any attenuation requirements or upgrading work to existing infrastructure.

It should be noted that some development end-users are classed as more vulnerable than others as described in PPS 25. Reference should be made Figure 2.4 which details where standing advice should be sought from the EA and / or IDB's and when a flood risk assessment is required.

During a site walkover survey, the slope of the ground should be assessed. Note should be taken of what lies around the site, whether the site could be vulnerable to flooding sources off site or whether adjacent land could be vulnerable to flooding generated on the site. It might be necessary to make provisions for intercepting surface run-off from adjacent land at a higher level. It will be necessary to make space on site for storing all flows generated on the site in the 1 in 100 year event with climate change.

The existing surface water drainage outfall from the site needs to be established. For brownfield sites, any existing drainage should be surveyed and recorded. The impermeable areas that are positively drained should be recorded and the outfall positions recorded, whether these are to soakaways, connections to off-site sewers or direct to watercourses. For greenfield sites, a topographical survey will be required and details of the infiltration capacity of the ground.

During trial pit investigations, carry out soakaway tests in accordance with BRE365 or CIRIA 156. These will be required in order to establish the suitability of infiltration techniques on the site.

2.4.2 Development Layout

The layout design can play a significant part in the management of any residual risk of flooding to the development, for example due to blockage or failure of drainage systems. More vulnerable development should be positioned in areas of the site at least risk of flooding. Gaps between buildings can be strategically positioned for flood water to flow though, causing minimum damage. Boundary treatments can be designed to allow flow through rather than "trap" flood water in low areas of the site; hence railings might be more appropriate than solid walls. The layout should be designed with some thought towards the proposed site levels. Ideally, buildings should not be placed in low spots or with doorways facing a slope.

The Sketch Layout should be produced in conjunction with the preparation of a drainage strategy and an assessment of flood risk. The proposals for surface water drainage can have a fundamental impact on the development layout. If drainage is not considered until after a layout has been produced, it can result in inappropriate or restricted choice of drainage techniques.

The choice of surface water conveyance system, underground pipes or above ground swales; the choice of surface water attenuation, above ground or below ground; the use of infiltration techniques such as soakaways or porous paving; will all have an effect on the development layout.

Currently AW will adopt surface water attenuation within the adoptable sewer network. The EA will require attenuation on site up to the 1 in 100 year storm with an allowance for climate change and space must be made on the site for this additional volume of water.

Reference should be made to the later section on SuDS

2.5 Guidance for Flood Risk Assessments

The aim of a FRA is:

- To assess the flood risk at a proposed development location both now and in the future.
- To demonstrate that the proposed development will not increase flood risk elsewhere, whether this is on adjacent land or land upstream or downstream of the site.
- To assess what measures are required to safely manage flood risk.
- To assess whether the proposed development is safe at the location. For development to be considered appropriate there must not be an unacceptable risk of flooding during the design event. The design event for Lincoln is the 1 in 100 year (1% AEP) annual chance flood with climate change.

FRAs for proposed development in the Lincoln Policy Area should follow the approach recommended by:

- PPS25 and its Practice Guide Companion.
- The Environment Agency National Standing Advice to Local Planning Authorities for Planning Applications – Development and Flood Risk in England
- The SFRA

The above documents describe as a minimum when a FRA is required. The SFRA goes beyond the requirements of the EA Standing Advice where there are known problems within the policy area. All proposed development sites require at least an initial assessment of flood risk. A FRA will be required for all developments that fall in the medium (Zone 2) and high (Zone 3) flood risk zones. A FRA will be required for sites in Flood Zone 1 which are greater than 1 ha or within 20m of an un-mapped watercourse. A

FRA will be required for sites, regardless of size or flood zone, where sources of flooding other than fluvial flooding are considered to be a significant issue by the LPA, the EA or the IDB.

FRAs should consider all sources of flood risk, such as fluvial (flooding from watercourses), surface water runoff (over-land flow following extreme rainfall), flooding from drainage (which might be under-capacity or prone to blockage), the canal, groundwater, lakes or reservoirs. It might be necessary to undertake survey work and hydraulic modelling to demonstrate this. The assessment must include consideration of existing flood defences which provide protection to the site and the residual risk, should those defences fail or not be maintained in the future. Reference should also be made to records of past flood events

FRAs should include details of the anticipated design life of the development, allowing a reasonable estimation to be made of the effects of future climate change over that design life.

Where a localised drainage issue is identified by Anglian Water, Local Authority Drainage Engineers or IDB's, further development has the potential to exacerbate the existing problem by increasing discharge and altering the flow regime of the watercourse, sewer or the floodwater path. All proposed developments need to consider mitigation measures to ensure flood risk is not increased either upstream or downstream of the proposed development, and wherever possible reduced. The FRA should include an assessment of the scale of the impact, and the recommended approach to controlling surface water discharge from a proposed development in the form of a surface water drainage strategy or Drainage Impact Assessment.

It should be acknowledged that the type of storm which causes the worst flooding on a particular development might differ from that which causes the worst flooding from watercourses downstream. In these instances it will be necessary to estimate the effects of development during site critical storms and the overall watercourse catchment critical storms.

FRAs should thoroughly investigate the impact of any proposed mitigation measures and how any residual risks are managed. The sanction of any residual risks is to be agreed with the LPA and Environment Agency. FRAs should pay particular attention to the management of any residual risks, flood warning arrangements and evacuation plans should be considered.

It is in the Developer’s interest to discuss flood risk issues with the LPA as early as possible and ideally before the planning application stage.

The following table gives an indication of information required for a Flood Risk Assessment. The information required will depend on the scale of the development and whether detailed proposals for the development are available.

Table 2-1: Information Checklist for a FRA

Information	
Site location map, showing development site boundary	
Development proposals, showing layout and proposed road levels, building floor levels, boundary levels and proposed spot levels across remaining development area	
Topographic Survey to GPS	
Reference to Flood Zone	
Reference to Sequential Test and Exception Test and how these have been met	
Consultation responses from Planning Authority, Environment Agency, IDB's and statutory sewerage undertaker.	
Evaluation of flood risk to the Site	
Evaluation of flood risk from the site	
Consideration of Climate Change	
Information on historical flooding	
Reference to previous flood studies	
River modelling if required	
Information on flood defences	
Flood flow and flood level estimates	
Residual risks	
Consideration of safe Access and Egress	
Assessment of Flood Hazard	
Reference to Emergency Planning	
Advice on mitigation measures	
Plan of existing site drainage system including ground levels, calculation of run-off rates, run-off volumes and point of discharge from site	
Site investigation report (including percolation tests)	
Plan and calculations for proposed site drainage system including run-off rates, run-off volumes and point of discharge. This should consider a range of return periods up to the 100 yr + climate change event	

2.6 Flood Resilience Techniques

In many instances the construction of permanent and structural flood defences is not sustainable or practical. In this situation flood resilience measures are crucial to managing flood risk and reducing the consequences of flooding. Several different forms of flood resilience techniques exist:

- Temporary defences
- Property flood protection – door and window barriers, air bricks etc
- Flood resilient construction
- Flood resilient drainage designs and techniques

The following publications on flood resilience techniques are available:

'Improving the Flood Performance of New buildings' available at:

http://www.planningportal.gov.uk/uploads/br/flood_performance.pdf

'Preparing for Floods' available at:

http://www.planningportal.gov.uk/uploads/odpm/4000000009282.pdf?lang=_e

It is critical to raise awareness of the groups vulnerable to flooding by informing them of flood resilience measures and advising subscription to the flood warning and forecasting systems provided by the Environment Agency.

2.7 Mitigation Measures

Mitigation measures should be seen as a last resort to address flood risk issues at a site. Assuming the site itself has passed the Sequential Test and no other site with less risk is available, consideration should next be given to minimising risk by planning sequentially within a site. Once risk has been minimised, only then should mitigation measures be considered (see Figure 2-1).

Where development remains in high risk Flood Zone areas, it needs to be demonstrated in a detailed FRA that technically feasible flood mitigation options are available. These measures must be designed to provide an appropriate level of flood protection to a site for the lifetime of the development. The measures required may result in some practical constraints on development and/or require significant financial cost where flood risk is high. The minimum acceptable standard of protection against flooding for new property within flood risk areas is the 1 in 100 year (1%) annual probability for fluvial flooding, with allowance for climate change over the lifetime of the development.

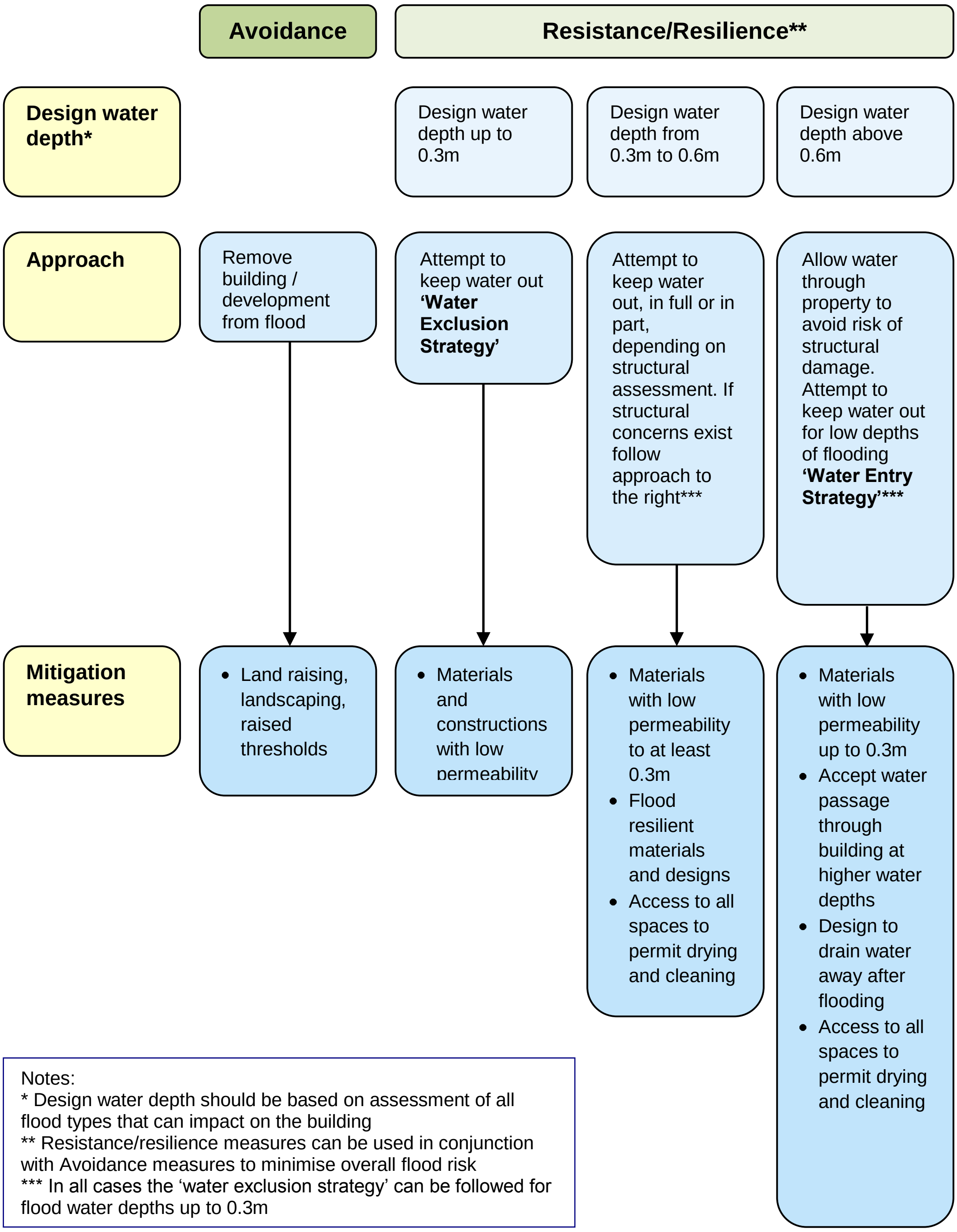
Normally, suitable mitigation measures for a proposed development will be determined through assessment of flood depths via hydrological and hydraulic modelling (or use of existing models) carried out as part of a FRA, although it may be acceptable to use the information contained in the SFRA where it is available.

Often the determining factor in deciding whether a particular development can or cannot proceed is the financial feasibility of flood risk mitigation rather than technical limitations. Detailed technical assessments are required in the FRA to assess this feasibility, together with a commercial review by the developer of the cost of the mitigation works.

It is not assumed that floor level raising will continue to be the traditional mitigation measure. It should be noted that the Environment Agency see actual land raising as a last option. Thought will also be required to ensure safe access and egress is available for flood events including climate change in accordance with PPS25.

Whilst flood mitigation measures can be implemented in most sites, it is worth noting that in some instances the findings of individual FRAs may determine that the risk of flooding to a proposed development is too great or that the introduction of mitigation has an adverse effect elsewhere and in these circumstances mitigation measures are not feasible.

Figure 2-1: Rationale for Flood Resilient and/or Resistant Design Strategies



Notes:
* Design water depth should be based on assessment of all flood types that can impact on the building
** Resistance/resilience measures can be used in conjunction with Avoidance measures to minimise overall flood risk
*** In all cases the 'water exclusion strategy' can be followed for flood water depths up to 0.3m

2.8 Reducing Flood Risk

The minimum acceptable standard of protection against flooding for new property within flood risk areas is 1% annual probability for fluvial flooding, with allowance for climate change over the lifetime of the development.

The measures chosen will depend on the nature of the flood risk. Some of the more common measures appropriate to Lincoln are outlined here, and more detail is given in Chapter 6 of the PPS25 Practice Guide.

2.8.1 Reducing Flood Risk through Site Layout and Design

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development.

The PPS25 Practice Guide states that a sequential, risk-based approach should be applied to try to locate more vulnerable land use to higher ground, while more flood-compatible development (e.g. vehicular parking, recreational space) can be located in higher risk areas.

Waterside areas, or areas along known flow routes, can be used for recreation, amenity and environmental purposes, allowing the preservation of flow routes and flood storage, and at the same time providing valuable social and environmental benefits contributing to other sustainability objectives. Landscaping should ensure safe access to higher ground from these areas, and avoid the creation of isolated islands as water levels rise.

2.8.2 Modification of Ground Levels

Modifying ground levels to raise the land above the required flood level is a very effective way of reducing flood risk to the site in question.

However, in most areas of fluvial flood risk, conveyance or flood storage would be reduced by raising land above the floodplain, adversely impacting on flood risk downstream. Compensatory flood storage must be provided, and should be on a level for level, volume for volume basis on land that does not currently flood but is adjacent to the floodplain (in order for it to fill and drain). It should be in the vicinity of the site and within the red line of the planning application boundary (unless the site is strategically allocated).

Where the site is entirely within the floodplain it is not possible to provide compensatory storage at the maximum flood level and ground raising will not be a viable mitigation option.

Compensation schemes must be environmentally sound.

2.8.3 Raised Defences

Construction of raised floodwalls or embankments to protect new development is not a preferred option, as a residual risk of flooding will remain. Compensatory storage must be provided where raised defences remove storage from the floodplain.

Temporary or demountable defences are not acceptable flood protection for a new development unless flood risk is residual only.

2.8.4 Developer Contributions to Flood Defences

In some cases, it may be necessary for the developer to make a contribution to the improvement of flood defence provision that would benefit both the development in question and the local community.

2.8.5 Building Design

The raising of floor levels within a development avoids damage occurring to the interior, furnishings and electrics in times of flood. Subject to EA approval of this mitigation technique, building finished floor levels should be raised **at least 300mm** above the maximum water level during a 1% annual flood event plus climate change. This additional height that the floor level is raised is referred to as the ‘freeboard’.

Making the ground floor use of a building water compatible (for example a garage), is an effective way of raising living space above flood levels.

Putting a building on stilts is not considered an acceptable means of flood mitigation for new development. However it may be allowed in special circumstances if it replaces an existing solid building, as it can improve flood flow routes. In these cases attention should always be paid to safe access and egress and legal protection should be given to ensure the ground floor use is not changed.

2.8.6 Resistance and Resilience

There may be instances where flood risk remains to a development. For example, where the use is water compatible, where an existing building is being changed, where residual risk remains behind defences, or where floor levels have been raised but there is still a risk at the 0.1% annual probability. In these cases (and for existing development in the floodplain), additional measures can be put in place to reduce damage in a flood and increase the speed of recovery. These measures should not be relied on as the only mitigation method.

The 2007 document 'Improving the Flood Performance of New Buildings' provides further details on possible resistance and resilience measures.

Temporary Barriers

Temporary barriers consist of moveable flood defences which can be fitted into doorways and/or windows. The permanent fixings required to install these temporary defences should be discrete and keep architectural impact to a minimum. On a smaller scale temporary snap on covers for airbricks and air vents can also be fitted to prevent the entrance of flood water.

Permanent barriers

Permanent barriers can include built up doorsteps, rendered brick walls and toughened glass barriers.

Wet-proofing

Interior design to reduce damage caused by flooding, for example:

- Electrical circuitry installed at a higher level with power cables being carried down from the ceiling rather than up from the floor level.
- Water-resistant materials for floors, walls and fixtures.

If redeveloping existing basements, new electrical circuitry installed at a higher level with power cables being carried down from the ceiling rather than up from the floor level to minimise damage if the development floods.

Resilience measures will be specific to the nature of flood risk at a site, and as such will be informed and determined by the FRA.

2.9 Making Development Safe

2.9.1 Safe Access and Egress

The developer must ensure that safe access and egress is provided to an appropriate level for the type of development. This may involve raising access routes to a suitable level.

As part of the FRA, the developer should review the acceptability of the proposed access arrangements in consultation with the Environment Agency and Lincoln Emergency Planning Officers, in accordance with advice in paragraph 2.57 of PPS25 Practice Guide.

2.9.2 Flood Warning and Evacuation

Emergency/evacuation plans should be in place for all properties, large and small, at residual risk of flooding; those developments which house vulnerable people (i.e. care homes and schools) will require more detailed plans. Advice should be sought from the Lincoln Emergency Planning team when producing an emergency/evacuation plan for developments as part of an FRA. Detailed emergency/evacuation plans for developments should undertake consultation not only with the Lincoln emergency planning team but also the emergency services so they know what is expected of them in the event of an emergency.

Flood warnings supplied by the Environment Agency's Floodline Warnings Direct service can be provided to homes and businesses within Flood Zones 2 and 3, although the service is not able to provide flood warnings for the entirety of Flood Zones 2 and 3. Developers should encourage those owning or occupying developments, where flood warnings can be provided, to sign up to receive them. This applies even if the development is defended to a high standard.

Further information and contact details are available through the Environment Agency's website, (**www.environment-agency.gov.uk/subjects/flood/**) and the Floodline telephone number is 0845 988 1188.

2.10 Managing Flood Risk from Other Sources

2.10.1 Surface Water and Sewer Flooding

The 'Pitt Review', 'PPS25', the 'Making Space for Water Integrated Urban Drainage' pilots and the 'Draft Flood and Water Management Bill' recognise the need for clearer roles and responsibilities for different sources of flood risk, with the current legislative framework leading to a fragmented and piecemeal approach for managing urban flood risk. A local leadership role for local flood risk issues has emerged whereby local authorities will need to have in place a strategy to manage these risks, of which a Surface Water Management Plan (SWMP) is an integral part.

Flooding from surface water run-off occurs when rainwater cannot enter the drainage system and consequently flows over-land. This can occur when the drainage infrastructure is full to capacity or when pipes or gullies are blocked. Surface water flooding can also occur where there is no drainage infrastructure, for example run-off from steeply sloping land when the ground is saturated

Sewer flooding is usually a localised problem, where rainwater can enter the system but the capacity of one or more pipes is exceeded. This usually results in flooding from manholes or gullies upstream of the under-capacity pipe due to water backing up in the drainage system.

The developer might be asked to contribute to improvements to the existing sewer networks where they are under-capacity to serve additional development. The development should improve the drainage infrastructure to reduce flood risk on site. It is important however that a drainage impact assessment shows that this will not increase flood risk elsewhere, and the drainage requirements regarding runoff rates and SuDS for new development are met.

A residual surface water flood risk will always remain even when the drainage design criteria are adhered to. There will be a residual risk of blockage or exceedance of any drainage network during very severe storms and therefore the likely flow routes across the site should be modelled. The site should be designed so that these flow routes are preserved. Careful consideration should be given to the position and orientation of buildings and the ground levels around buildings, to allow clear passage of water and flow away from building thresholds. Building design should provide resilience against this residual risk. Boundary walls and fences should also be designed appropriately, and should not form an obstruction where clear passage of water is required.

When redeveloping existing buildings, the installation of some permanent or temporary flood proofing and resilience measures could prevent against both surface water and sewer flooding. Non-return valves prevent water entering the property from drains and sewers. Non-return valves can be installed within gravity sewers or drains, within the property's private sewer upstream of the public sewerage system. These need to be carefully installed and must be regularly maintained. The CIRIA publication, 'Low cost options for prevention of flooding from sewers', provides further information. Additionally, manhole covers within the property's grounds could be sealed to prevent flooding.

2.10.2 Groundwater

Groundwater flooding has a very different flood mechanism to any other, as it rises up from below ground level, and for this reason many conventional flood defence and mitigation methods are not suitable. The only way to fully reduce flood risk would be through building design, ensuring that floor levels are raised above the water levels caused by a 1% annual probability fluvial plus climate change event. Site design would also need to preserve any flow routes followed by the groundwater overland and make sure flood risk is not increased downstream.

When redeveloping existing buildings it may be acceptable to install pumps in basements as a resilience measure. However for new development this is unlikely to be considered an acceptable solution.

2.11 Drainage Strategies and Drainage Impact Assessments

Opportunities for developing an integrated strategy for surface water drainage across development site boundaries should be explored, and a catchment led approach should be adopted. This approach has been recognised in the consultation paper by DEFRA, Making Space For Water. An integrated approach to controlling surface water drainage can lead to a more efficient and reliable surface water management system as it enables a wider variety of potential flood mitigation options to be used. In addition to controlling flood risk, integrated management of surface water has potential benefits, including improved water quality and a reduction of water demand through grey water recycling.

Integrated drainage strategies may be considered suitable for catchments where other development is being planned or constructed, and where on-site measures are set in isolation of the systems and processes downstream.

Drainage impact assessments are required where proposed development may be susceptible to flooding from surface water drainage systems. The capacity of and potential impact upon systems downstream of the development must be addressed.

The requirements for surface water drainage assessments and drainage impact assessments will need to be discussed with the Environment Agency, Anglian Water, local authority Engineers and IDB's. For brownfield sites, consideration should be given to whether flows must be limited to the 'Greenfield' runoff rate, providing betterment, or to the current site run-off rate.

2.12 SuDS

2.12.1 Introduction

New developments often involve replacing vegetated areas with hard surfaces, such as roofs, roads and paved areas. This increase in impermeable area reduces the potential for rainwater to infiltrate into the ground and increases the rate at which surface water runs off into watercourses. This increase in run-off volumes and run-off rates can have a detrimental effect on watercourse quality and significantly increase flood risk.

Developers are responsible for ensuring that development does not increase flood risk elsewhere through the addition of hard surfaces. The Building Regulations Part H (Drainage and Waste Disposal) states that there is a preferred hierarchy for the disposal of surface water arising from development. Consideration should be given in the first instance to the onsite disposal of surface water via infiltration techniques. Offsite disposal should be considered only if site conditions are unsuitable for infiltration. Consideration should next be given to disposal to a local watercourse. Disposal to a sewer system should only be considered if neither infiltration techniques nor disposal to a watercourse are viable.

2.12.2 Principles of Sustainable Urban Drainage Systems

To reduce storm runoff from impermeable drainage areas a range of techniques known as Sustainable Urban Drainage Systems (SuDS) can be utilised.

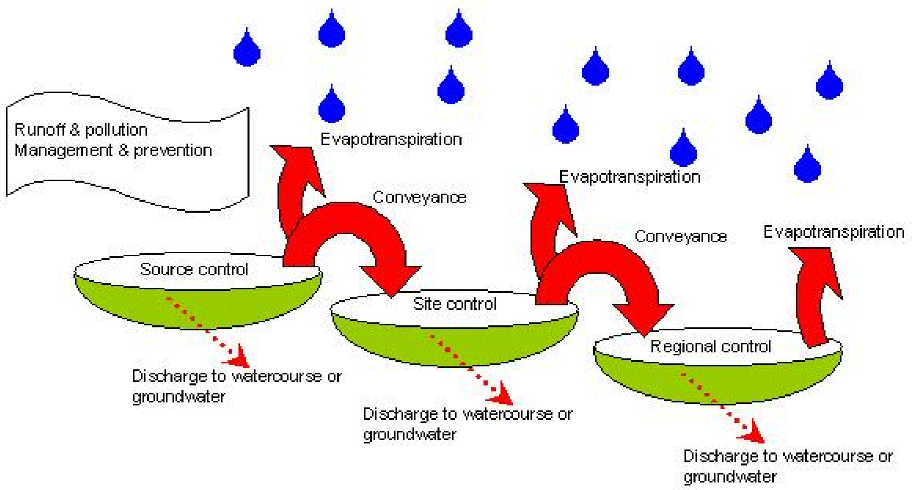
SuDS enable surface water to be drained in a way which mimics, as closely as possible, the run-off prior to site development. They can reduce run-off rates and run-off volumes from developments. They can reduce pollutant concentrations in stormwater run-off and act as a buffer for accidental spills on developments, both during and after construction, thus protecting receiving watercourses. They can be integrated into landscape plans, providing amenity and aesthetic value to developments, habitats for wildlife and opportunities for biodiversity enhancement.

SUDS are often physical structures and fall into 4 broad groups, comprising;

- Prevention. The objective is to prevent runoff and pollution form entering a watercourse.
- Source Control Techniques. These aim to reduce the quantity of runoff and include porous pavements, infiltration trenches, basin or ponds,
- Permeable Conveyance Systems which slow the velocity of the runoff to allow settlement filtering and infiltration, such as filter drains, French drains or swales, and
- Passive Treatment Systems are end of pipe systems and provide passive treatment to collected surface water before discharge into a watercourse and include basins, ponds and wetlands.

A useful concept used in the development of drainage systems is the surface water management train, illustrated below. Just as in a natural catchment drainage techniques can be used in series to change the flow and quality characteristics of the run-off in stages.

Figure 2-2: SUDS Management Train



The management train starts with prevention, or good housekeeping measures, for individual premises; and progresses through local source controls to larger downstream site and regional controls. Runoff need not pass through all the stages in the management train. It could flow straight to a site control, but as a general principle it is better to deal with runoff locally, returning the water to the natural drainage system as near to the source as possible.

2.12.3 Prevention

The objective is to prevent runoff and pollution from entering a watercourse and the methods can include minimising paved areas, rainwater recycling and infiltration devices.

For infiltration SuDS techniques it is imperative that the water table is low enough and a site-specific infiltration test is undertaken in accordance with BRE365 or CIRIA 156. Where sites lie within or close to groundwater protection zones or aquifers further restrictions may be applicable, and guidance should be sought from the Environment Agency

2.12.4 Source Control

The objective of source control systems is to attenuate runoff volumes and return storm water to the natural water cycle by the use of shallow infiltration systems rather than allowing for surface runoff. These can be linked with conveyance methods. The available methods include permeable pavement surfaces, infiltration trenches and techniques such as disconnecting down pipes to drain to lawns or to infiltrate to soakaways. In some circumstances, for example on contaminated land, close to water supply boreholes or in vulnerable aquifer areas, infiltration may not be appropriate.

Source control techniques are designed to counter increased discharge from developed sites at source and to minimise the quantity of water discharged. These systems work best when dealing with small quantities of water and are most effective when distributed throughout a catchment at the point where runoff arises. For example, uncontaminated water from roofs can be fed directly into soakaways and infiltration trenches where soil conditions permit, rather than using off-site disposal.

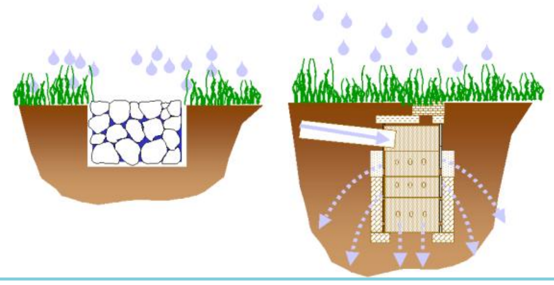
For areas such as drives, access roads and car parking areas the use of porous materials can reduce the need to collect runoff in drains, therefore cost savings can be made through the reduction in size, or even elimination, of off-site surface water sewers.

Such installations need not be designed to receive very large storms. A system which is designed to accept a twice per year storm before an overflow or bypass takes effect will still have significant environmental benefits. It will greatly reduce the frequency of discharge; provide protection from the highly polluting "first flush" and delay the time of discharge to the watercourse, more closely mimicking greenfield run-off. With good source control techniques, runoff from new developments need have little impact on the hydrology of a catchment.

Source control systems can include;

An ***infiltration trench*** is a shallow excavated trench backfilled with stone or gravel to create an underground reservoir. Stormwater runoff is diverted into the trench and gradually infiltrates into the subsoil. An emergency overflow may be provided for extreme rainfall which exceeds the capacity of the trench.

The performance of the trench depends largely on the permeability of the soil and the depth to the water table. In common with other source control techniques, infiltration trenches usually serve small catchment areas of up to 2-3 hectares. The longevity of the trench may be enhanced by providing pre-treatment for the inflow, such as a filter strip, gully or sump pit, to remove excessive solids but regular maintenance will be required for such pre-treatment facilities. The amount of water that can be disposed of by an infiltration device within a specified time depends mainly on the infiltration potential of the surrounding soil. The size of the device and the voids ratio of any fill material will govern storage capacity and will require a site investigation and hydraulic calculations.

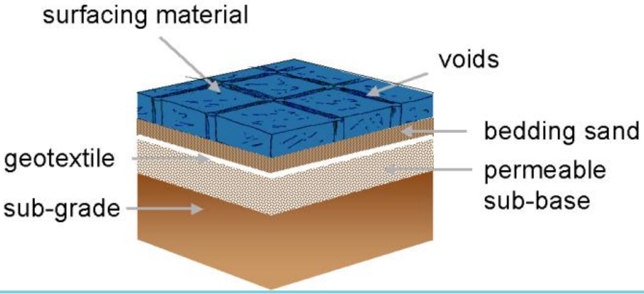
Infiltration Trench - gravel filled trench or chamber allowing soakaway into the ground	

Porous pavements are an alternative to conventional paving in which water permeates through the paved structure rather than draining off it. Porous pavements and permeable surfaces allow a volume of storm runoff to infiltrate the permeable surface and hence be stored below ground rather than immediately runoff to surface waters. The variety of surfaces is wide enough for the selection of a landscape style to suit the nature of the development. This can include, in preference to impermeable surfaces such as tarmac or concrete:

- Grass (if the area will not be trafficked)
- Reinforced grass
- Gravelled areas
- Solid paving blocks with large vertical holes filled with soil or gravel
- Solid paving blocks with gaps between the individual units
- Porous paving blocks with a system of voids within the unit
- Continuous surfaces with an inherent system of voids

The water passes through the surface to a permeable fill below ground or to a filter drain to allow the storage, treatment, transport and infiltration of water. Both the surface and the sub-base of a pavement must allow the passage of water.

The amount of water stored depends on the voids ratio of the permeable fill or sub-base, the plan area and depth. Water can be disposed of by infiltration or a drain. Overflow can be via a high level drain or controlled surface flow. In some situations the water should not be stored for extended periods as it can affect the strength of the surrounding soil. The permeable fill or sub-base traps sediment, thereby cleaning up runoff and recent research shows that they also provide some treatment for other pollutants, such as oil.

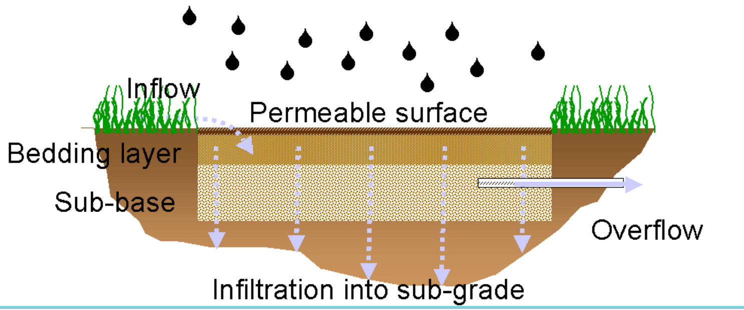
Permeable Pavements	

2.12.5 Permeable Conveyance Systems

Permeable Conveyance Systems move runoff water slowly towards a receiving watercourse, allowing storage, filtering and some loss of runoff water through evaporation and infiltration before the discharge point. There are two main types:

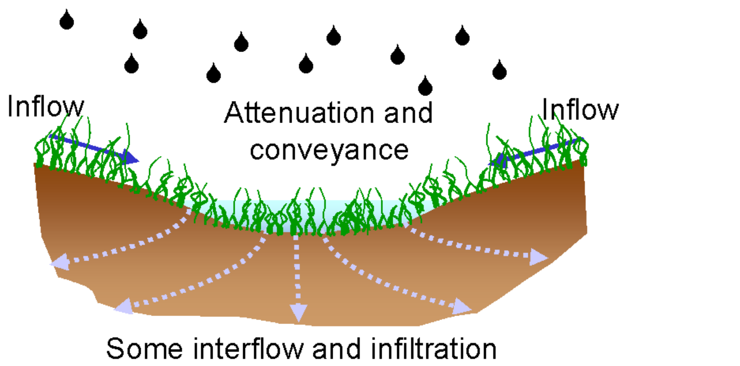
Filter Drains are underground systems comprising a trench filled with gravel wrapped in a geotextile membrane into which runoff is led either directly from the drained surface or via a pipe system. The gravel in the filter drain provides filtering of the runoff trapping organic matter and oil residues which can be broken down by bacterial action through time. Runoff velocity is slowed, and storage of runoff is also provided. Infiltration of stored water through the membrane can also occur and some filter drains need not lead to a watercourse or storm sewer system at all. Filter drain systems have been widely used for roads and a variety of developments, including both residential and industrial sites.

Filter Drain with Infiltration



Swales are shallow and relatively wide grassed depressions which lead surface water overland from the drained surface to a storage or discharge system, typically using the green space of roadside margins. These provide temporary storage for storm water and reduce peak flows and are usually designed as conveyance systems, but can also be designed with check dams to increase attenuation and, where applicable, infiltration. Swales and filter strips are often integrated into the surrounding land use, for example public open space or road verges.

Swales

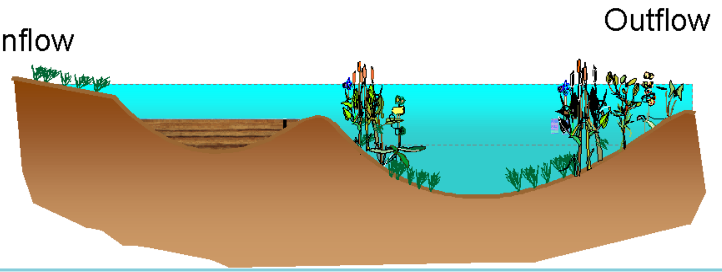


2.12.6 Site control

These include infiltration basins and ponds, which intercept flows not dealt with by source control and conveyance systems. They are designed to provide infiltration if possible and attenuate peak run-off rates and volumes.

Infiltration basins or ponds are areas for storage of surface runoff during storm events and may include floodplains, detention basins, balancing and attenuation ponds, flood storage reservoirs, lagoons, retention ponds or wetlands. These control flow rates by storing floodwater and releasing it slowly once the risk of flooding has passed. The stored water will change the water level, and basins and ponds should be designed to function in both dry and wet weather. Basins and ponds tend to be found towards the downstream end of a surface water system and are used if source control cannot be fully implemented, if extended treatment of the runoff is required or if they are required for wildlife or landscape reasons.

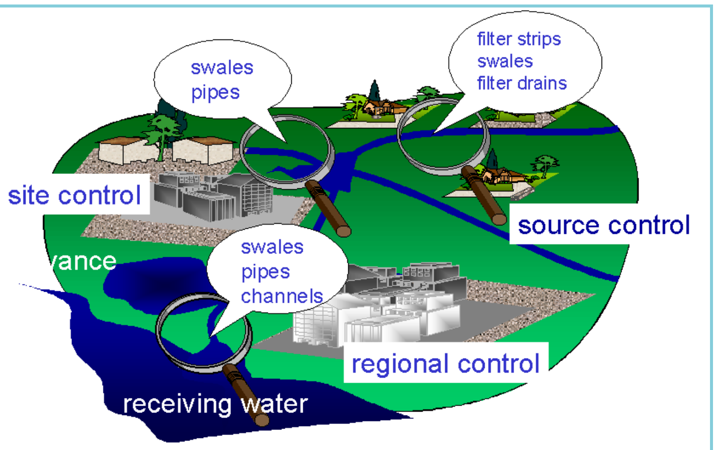
Ponds



2.12.7 Regional controls

Regional controls aim to manage all flows drained from sub-catchments where basically all the above methods could be used alone or in any combination and ideally a site may include more than one method.

Regional Controls



2.12.8 Other Options

Other measures to reduce storm runoff could include the re-use of water from roofed areas to provide grey (non-potable) water. The performance and operation of such a system will be the subject of detailed design considerations but typically the stored water is held in off-line storage tanks. Over the course of a year a water reuse system will reduce the volume of water entering the storm water sewer system but the reduction in peak flows during an extreme storm even will depend on the volume of stored water at the start of each event and cannot be guaranteed.

Green roofs can also be used to reduce the volume and rate of runoff so that other SuDS techniques in the scheme can be significantly reduced in size but often the limited roof area suggests this will only ever provide a small reduction in peak flows.

The choice of flow management facilities within a single site is heavily influenced by constraints including (but not limited to) topography, geology (soil permeability), available area, former site use, proposed site use, groundwater conditions, future adoption and maintenance possibilities. The design, construction and ongoing maintenance regime of such a scheme must be carefully defined, and a clear and comprehensive understanding of the existing catchment hydrological processes and existing drainage arrangements is essential.

Table 2-2: SUDS Techniques

SuDS Technique	Flood Reduction	Pollution Reduction	Landscape and Wildlife Benefit
Living roofs	✓	✓	✓
Basins and ponds Constructed wetlands Balancing ponds Detention basins Retention ponds	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓
Filter strips and swales	✓	✓	✓
Infiltration devices Soakaways Infiltration trenches and basins	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓
Permeable surfaces and filter drains Gravelled areas Solid paving blocks Porous pavements	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	
Tanked systems Over-sized pipes/tanks Storm cells	✓ ✓ ✓		

PPS 25 stresses that Regional Planning Bodies and Local Planning Authorities (LPAs) should:

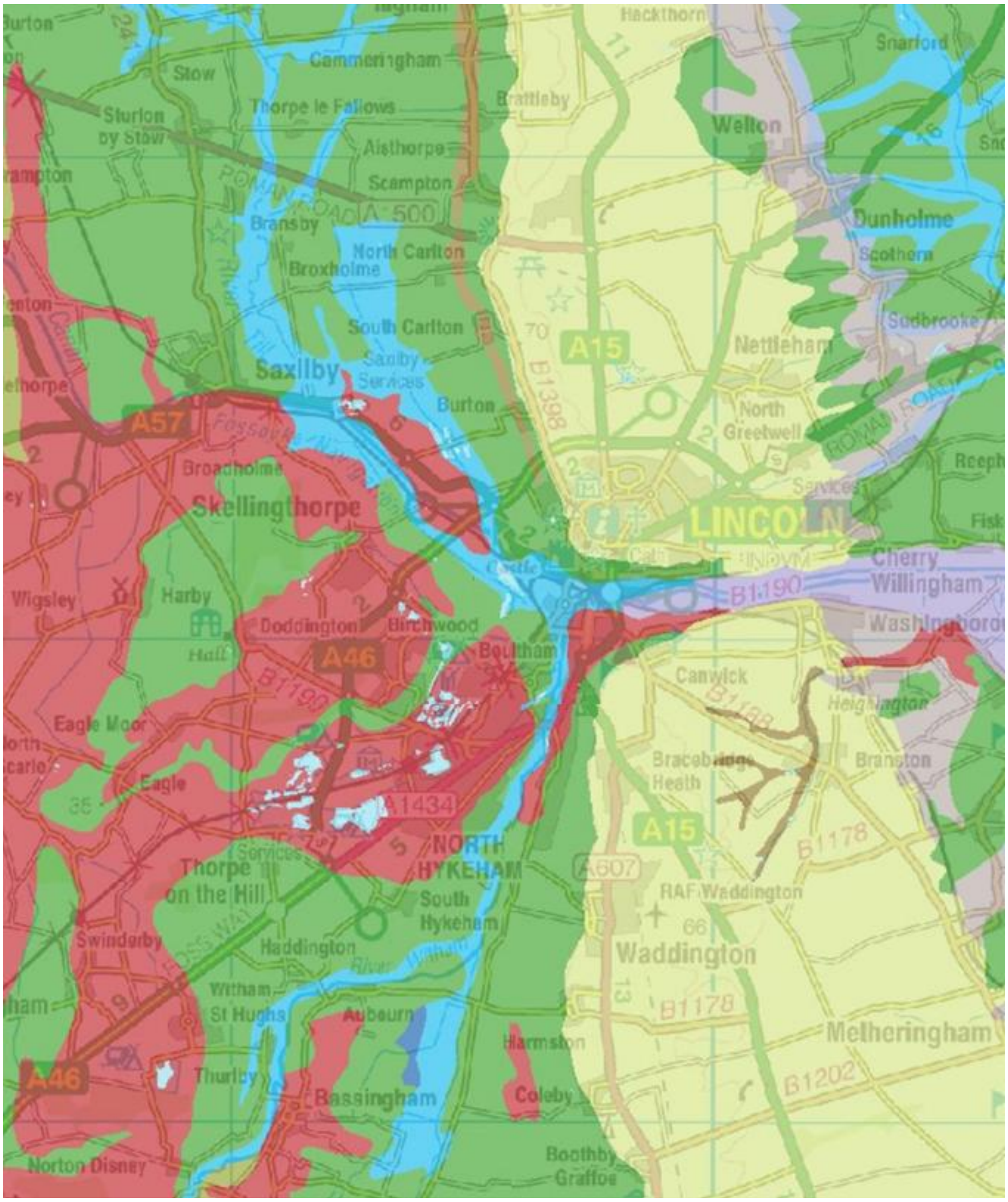
- promote the use of SuDS for the management of run-off.
- ensure their policies and decisions on applications support and complement the Building Regulations on sustainable rainwater drainage, giving priority to infiltration over first watercourses then sewers.
- incorporate favourable policies within Regional Spatial Strategies.
- adopt policies for incorporating SuDS requirements in Local Development Documents
- encourage developers to utilise SuDS wherever practicable, if necessary through the use of appropriate planning conditions
- develop joint strategies with sewerage undertakers and the Environment Agency to further encourage the use of SuDS.

2.12.9 Infiltration Potential

For infiltration SuDS techniques it is imperative that the water table is low enough and a site-specific infiltration test is undertaken in accordance with BRE365 or CIRIA 156. Where sites lie within or close to groundwater source protection zones or aquifers further restrictions may be applicable. A large part of the Lincoln Policy Area is covered by a Source Protection Zone. A Source Protection Zone is an area over which recharge is captured by an extraction borehole. They are designed by the Environment Agency and are delineated to protect potable water suppliesagaist the polluting effects of human activity. More information and guidance should be sought from the Environment Agency regarding developments within these zones.

The Geological Maps below provide an indication of likely soil types within Lincoln Policy Area. These are broadscale and there will be variations in ground conditions within these areas, therefore a detailed site investigation will be required.

Figure 2-3: Geological Map



Key

- Red - Naturally wet very acid sandy and loamy soils
- Green - Slow permeable, seasonally wet, basic loams and clays
- Light Blue - Water
- Mid Blue - Loamy and clayey floodplain soils with naturally high groundwater
- Dark Blue - Loamy and sandy soils with naturally high groundwater and a peaty surface
- Yellow - Shallow. Lime rish soils over chalk or limestone
- Brown - Freely draining slightly acid but base rich soils
- Purple - Freely draining lime rich loamy soils

2.12.10 Adoption and Maintenance

Adoption and future maintenance of above ground SuDS facilities by the local authorities within the Lincoln Policy Area as public open space requires early discussion between the developer, local authority (LA) and Anglian Water. Above ground attenuation can be adopted by the LA as public open space, with the provision of a payment to the LA via a Section 106 Agreement under the Town and Country Planning Act. This must, however, be agreed at an early stage and ideally discussed in advance of the planning application to allow the contribution to be ring fenced specifically for the facility.

If future maintenance arrangements are to be assigned to a Management Company, this should be discussed at an early stage with Anglian Water. This can have implications on the adoption of the remaining site drainage and consequently adoption of any highways on the development.

Allowance should be made by whomever is to take future responsibility for the SuDS facilities, for checking the SuDS designs and for inspection during construction, if necessary employing competent individuals to perform this task.

Information should be provided to make the end-users of the development aware of SuDS and in particular their responsibilities to maintain and not to remove any privately owned SuDS facilities. If deemed necessary the removal of permitted development rights or the inclusion of covenants in the deeds of properties could be considered.

The Lincoln Drainage Group (which contains members from all interested parties) should be consulted to discuss large development proposals.

2.12.11 Examples of SuDS Techniques

Living (Green) Roofs and Walls

Living Roofs and walls can vary in type from Roof Gardens, Roof Terraces, Green Roofs and Green Walls.

This approach utilises plants and their substrate to provide temporary storage of rainfall. The water retained by the substrate and lost through evaporation and evapotranspiration minimises runoff from the roof. Even when saturated, the run-off rate is slowed by the roughness of the vegetation and so mimics more closely the run-off prior to development.

Commonly perceived problems are largely unwarranted. These include a lack of British Standards associated with green roofs. However, the German FLL, the Landscape Research, Development & Construction Society, covers all aspects of green roofs from waterproofing, soils, vegetation, installation methods and maintenance and members include major UK suppliers.

Photos courtesy of livingroofs.org/greenroofconsultancy.com

There is also a perception that dry vegetation during the summer months could lead to fires being started on green roofs, however, the FLL have strict guidelines on this issue.

Maintenance requirements will depend on the type of roof system. An amenity space will require similar maintenance to a garden; otherwise a one to two year inspection is likely to suffice, to weed out unwanted plants.

Basins, Ponds and Wetlands

Dry basins, ponds and wetlands can be designed to provide temporary storage for storm water through the regrading of site ground levels to form a contained storage area, in conjunction with a flow control to force water into the storage facility and allow it to drain down slowly at a controlled rate.

They can often be a key part of landscape strategies, providing amenity space and opportunities for the creation of wildlife habitats.

The permanent pool volume and pond planting can be designed to provide a cleaning function, diluting and removing pollutants from the storm water. Basins, ponds and wetlands can be fed by swales, filter drains or piped systems.

Safety should be carefully considered when designing the side slope gradients and water depths and, if required, fencing and barrier planting should be incorporated.

The future adoption and maintenance arrangements need to be agreed with the LA and Anglian Water prior to designing the attenuation basin or pond, as this can potentially affect the adoption of site sewers and highways.

Photos courtesy of Greenbelt Group

In areas susceptible to fluvial flooding, surface water attenuation facilities should be designed not to conflict with floodplains or flood mitigation measures. The basin or pond base level should be set above the peak 1 in 100 year fluvial flood level with climate change.

Filter Strips, Swales and Infiltration Devices

Swales provide temporary storage for storm water to help reduce peak flow runoff. While providing an alternative to traditional piped conveyance systems, the flow across vegetation provides a filtering function at low velocities. Check dams and flow controls can be introduced to further reduce flows and utilise the storage potential.

Filter Strips are vegetated areas that are intended to treat sheet flow from adjacent impervious areas. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice.


Photos courtesy of Greenbelt Group

Infiltration devices drain water directly into the ground. They may be used at source or the runoff can be conveyed in a pipe or swale to the infiltration area. They include soakaways, infiltration trenches and infiltration basins as well as swales, filter drains and ponds. Infiltration devices can be integrated into and form part of the landscaped areas.

Filter Drains are gravel filled trenches which trap sediments from run-off and provide attenuation. Flow is directed to a perforated pipe which conveys run-off back into the sewerage network or into a water body. Filter drains are used mainly to drain road and car park surfaces.

Rainwater Harvesting

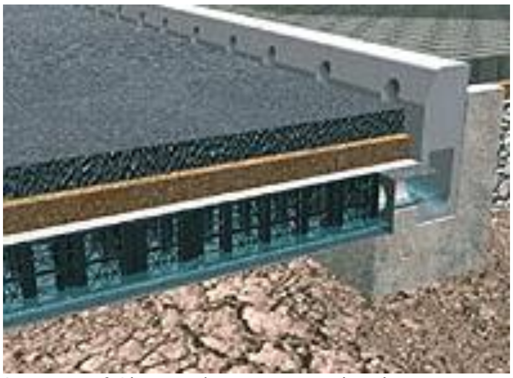
Rainwater harvesting techniques can aid in increasing the attenuation of rainfall and contribute to the onsite recycling of water. Water butts are a common rainwater harvesting technique, however they are easily bypassed or full when a rainfall event occurs. If used on a strategic basis and it can be demonstrated that their use will make available volume for storage, the Environment Agency may consider whether they can count towards surface water attenuation.

Permeable Surfaces

Pervious pavements such as permeable concrete blocks, reinforced grass, crushed stone or gravel and permeable asphalt will allow water to infiltrate directly into the subsoil before soaking into the ground.

It is also possible to incorporate attenuation into the sub base of porous paving construction if the infiltration potential of the ground is not ideal.

On brownfield sites where contaminated ground is an issue, a lined attenuation system can be built into the sub-base. The porous paving provides a filtering action and improves water quality. Additional products are available that provide a specific filtering function within the attenuation system.



Courtesy of Charcon / Aggregate Industries

The shallow excavation required to install such facilities in comparison to traditional over-sized pipes can have the added benefit of reducing surplus material and costly off-site disposal.

- Bettess R. (1996). Infiltration Drainage - Manual of Good Practice. CIRIA Report 156.
- CIRIA. (2000). Sustainable Urban Drainage Systems – Design Manual for England and Wales. CIRIA Report C522.
- CIRIA. (2001). Sustainable Urban Drainage Systems – Best Practice Manual. CIRIA Report C523.

There are many different SuDS techniques which can be implemented. Further information can also be found in the Environment Agency's Standing Advice. The suitability of the techniques discussed in this chapter, which is by no means exhaustive, will be dictated in part by the development proposals and site conditions. Advice on best practice is available from the Environment Agency and the Construction Industry Research and Information Association (CIRIA).

The inclusion of SuDS within developments should be seen as an opportunity to enhance ecological and amenity value, incorporating above ground facilities into the development landscape strategy. SuDS must be considered at the outset, during preparation of the initial site conceptual layout to ensure that enough land is given to design spaces that will be an asset to the development rather than an after-thought.

2.13 Making Space for Water

2.13.1 Opportunities for River Restoration and Enhancement

All new development close to rivers should consider the opportunity presented to improve and enhance the river environment. Developments should look at opportunities for river restoration and enhancement as part of the development. Options include backwater creation, de-silting, in-channel habitat enhancement and removal of structures. When designed properly, such measures can have benefits such as reducing the costs of maintaining hard engineering structures, reducing flood risk, improving water quality and increasing biodiversity. Social benefits are also gained by increasing green space and access to the river.

2.13.2 Buffer Strips

Developers should set back development from the landward toe of fluvial defences (or top of bank where defences do not exist) and this distance should be agreed with the EA. This provides a buffer strip to 'make space for water', allow additional capacity to accommodate climate change and ensure access to defences is maintained for maintenance purposes. Flood defence consent will also be required for developments within 9 metres of the landward toe.

2.14 Environment Agency Objection to Planning Authority

The SFRA should be used to test that the requirements of the Sequential Test are met. If the development meets with the recommendations of the SFRA strategically, then the specifics of an objection should be addressed in a detailed FRA undertaken to PPS25 requirements. Developers are advised to check with the LA and the Environment Agency before presuming a site can be developed.

A precautionary approach to development and flood risk is required. At each site, applicants for all development proposals need to carry out an assessment of flood risk from all sources and they also need to consider the potential impact the development could have on others. Guidance on sustainable development and the detail required in this assessment for different types of development is provided in PPS25 and by the Environment Agency through their standing advice on development and flood risk.

2.15 Summary for Planners

- Consider flood risk to the development from fluvial sources
- Apply The Sequential Test
- Apply The Exception Test
- Refer Applications to the Environment Agency
- Consider Flood Risk From Other Sources
- Consider flood risk as a result of the development
- Request Flood Risk Assessment
- Refer Applications and FRA to local authority Drainage Engineers

Table 2-3: Flood Risk Vulnerability and Flood Zone Compatibility

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

Key:

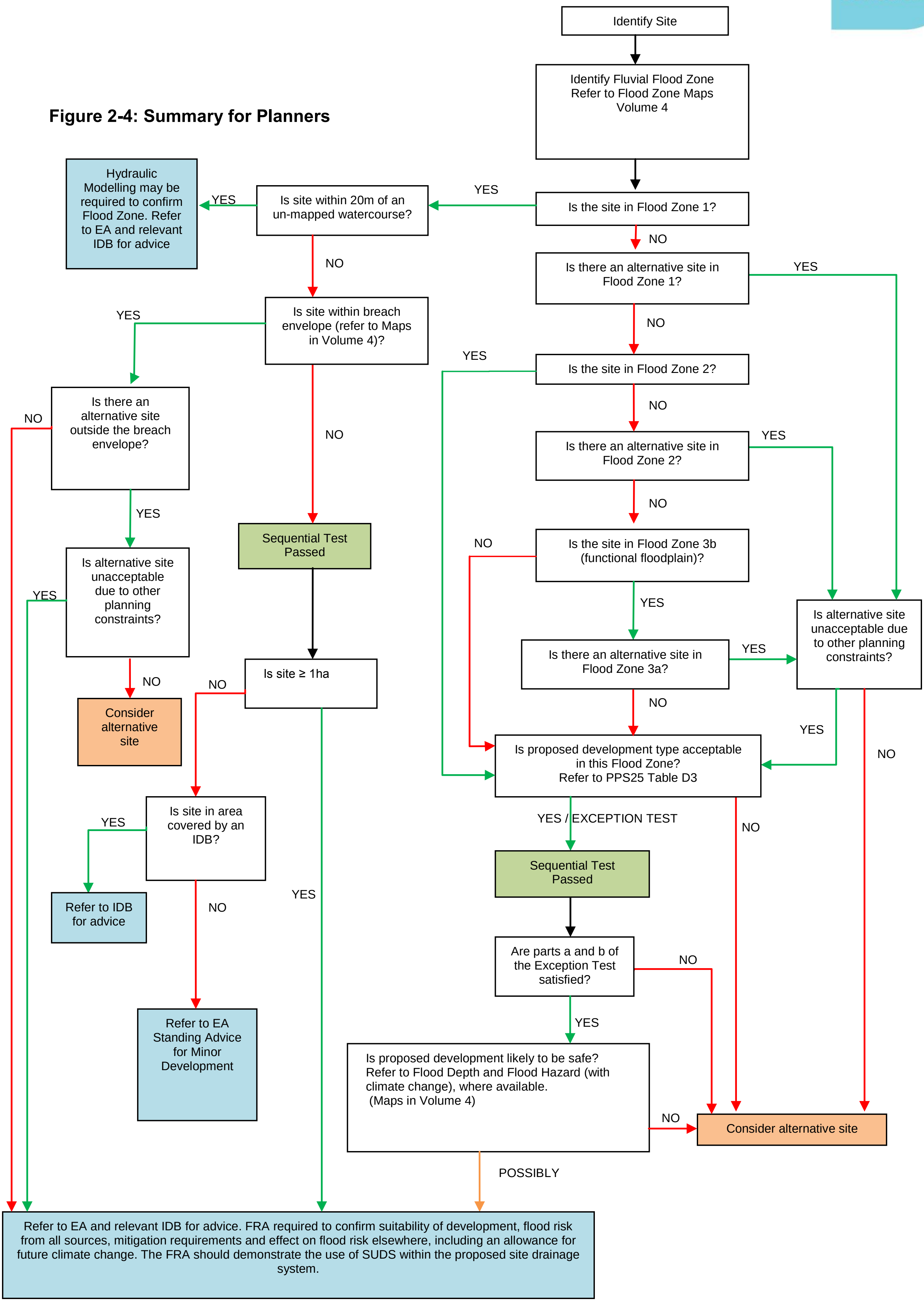
Source: PPS25 Table D3

✓ Development is appropriate

× Development should not be permitted

The following flow chart guides the consideration of development applications, making recommendations for the provision of FRAs.

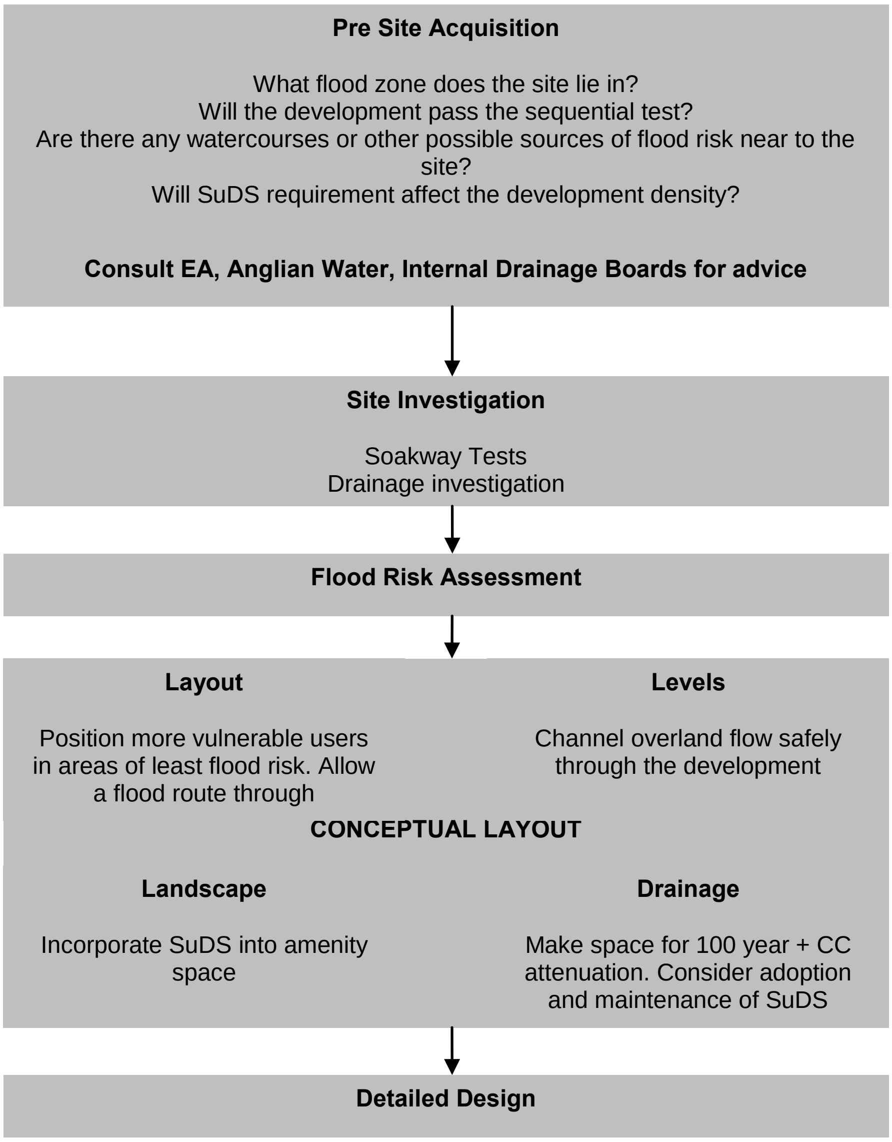
Figure 2-4: Summary for Planners



2.16 Summary for Developers

The flow chart below guides developers thorough the SFRA process from gaining an understanding of the sites location in relation to the EA flood zones to the flood risk Assessment and further works which may be undertaken in relation the design of a development.

Figure 2-5: Summary for Developers



JBA consulting

3 Guidance for Emergency Planning

3.1 Introduction

An understanding of the flood mechanisms and processes occurring within the Lincoln Policy Area has been developed for this SFRA. As a result of the detailed analysis guidance has been produced to aid future emergency planning within the policy area.

Key Points:

- The location of emergency Services, evacuation centres and other emergency **infrastructure should be considered in relation to flood risk areas;**
- The outcomes of this SFRA should be incorporated into Local Emergency Plans, which should:

  (i) identify the responsibilities of key partners
  (ii) identify an appropriate response to flood warnings
  (iii) identify appropriate recovery actions
  (iv)identify clear lines of communication between key partners

- Information provided in this SFRA can be used to identify:

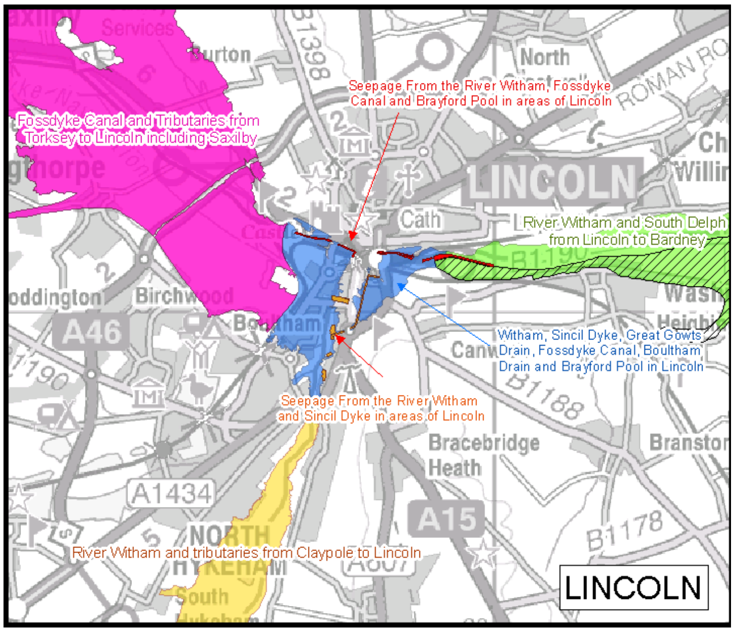
  (i) risk to residential areas
  (ii) risk to major transport routes
  (iii) risk to vulnerable industry

3.2 Current Emergency Planning Procedures

Each local authority has Emergency Planning teams and policies for flooding scenarios.

Flood warnings supplied by the Environment Agency's Floodline Warnings Direct service covers the River Trent, Fossdyke Canal and tributaries and the River Witham and tributaries. Further information and contact details are available through the Environment Agency's website, (**www.environment-agency.gov.uk/subjects/flood/**) and the Floodline telephone number is 0845 988 1188.

Figure 3-1: Flood Warning Areas

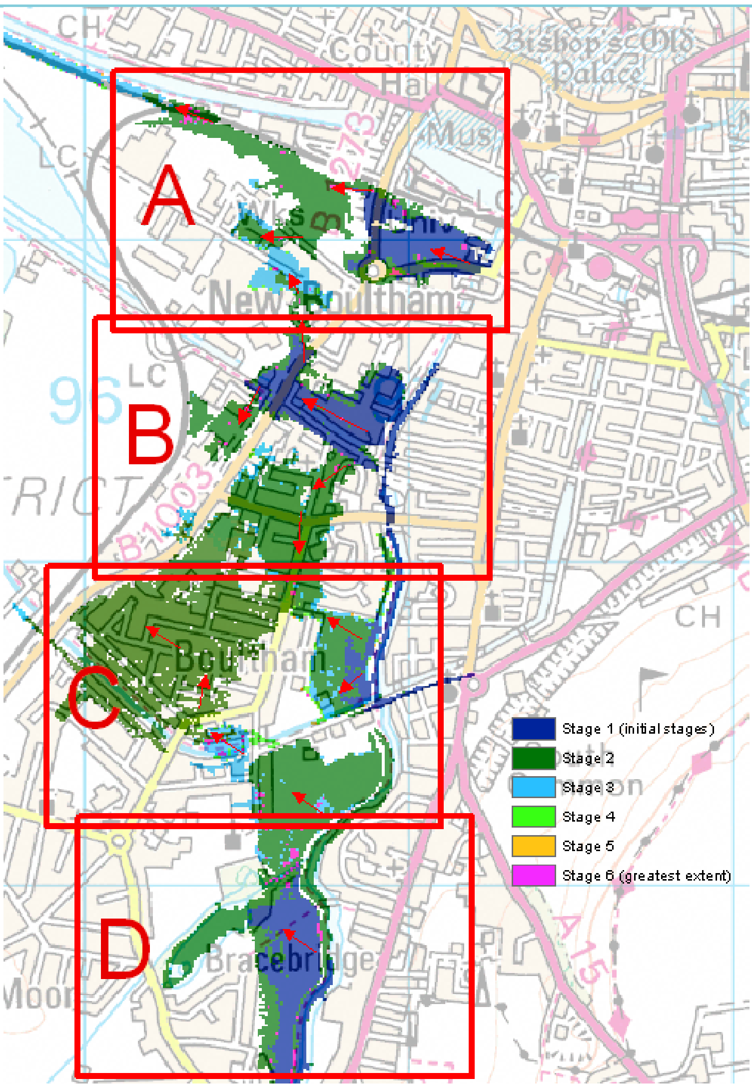


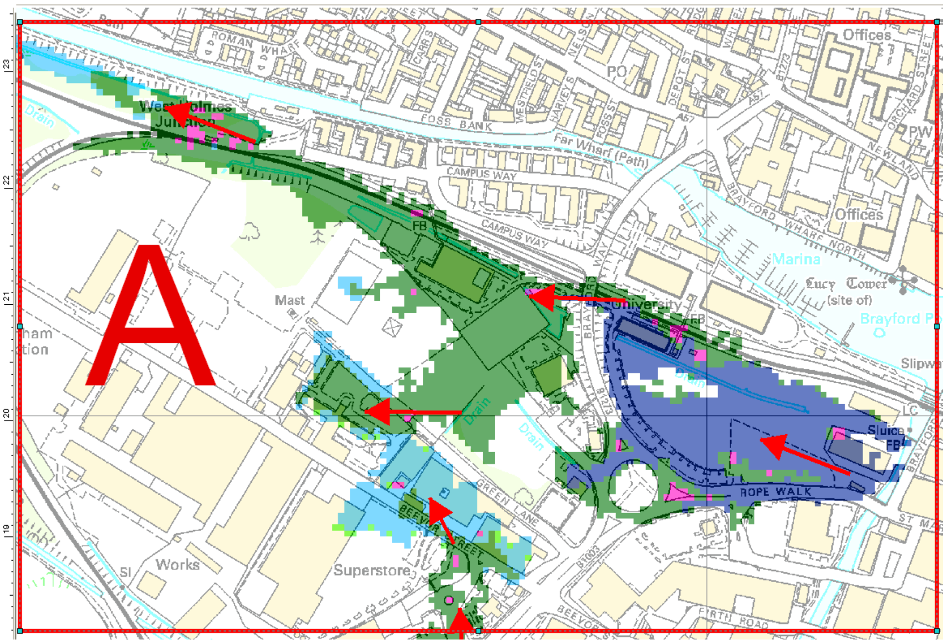
3.3 Flood Inundation Mapping from Flood Defence Overtopping

The following sections provide an overview of the sequence of flood inundation along with flood depth within the City of Lincoln. The flood maps shown have been created through detailed 2D hydraulic modelling and show the result of river banks and flood defences being overtopped in a 1 in 100 annual chance flood with Climate Change for the River Witham, Fossdyke and the Boultham Catchwater.

The following map combines modelled overtopping outlines from the River Witham, Fossdyke and Boultham Catchwater. Individual outlines can be found in Volume 4.

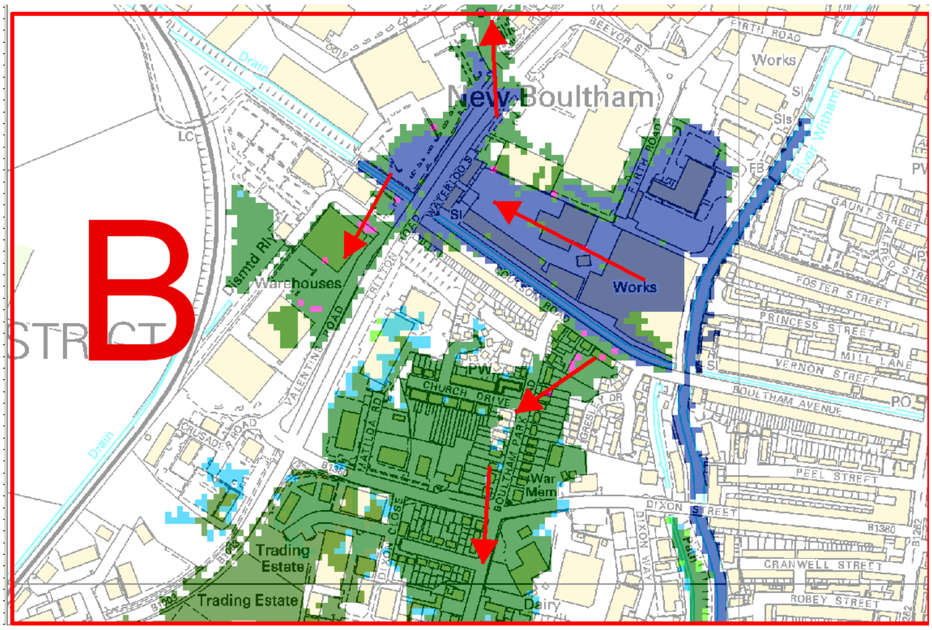
Figure 3-2: Progression of flooding due to overtopping during the 100 year with climate change scenario

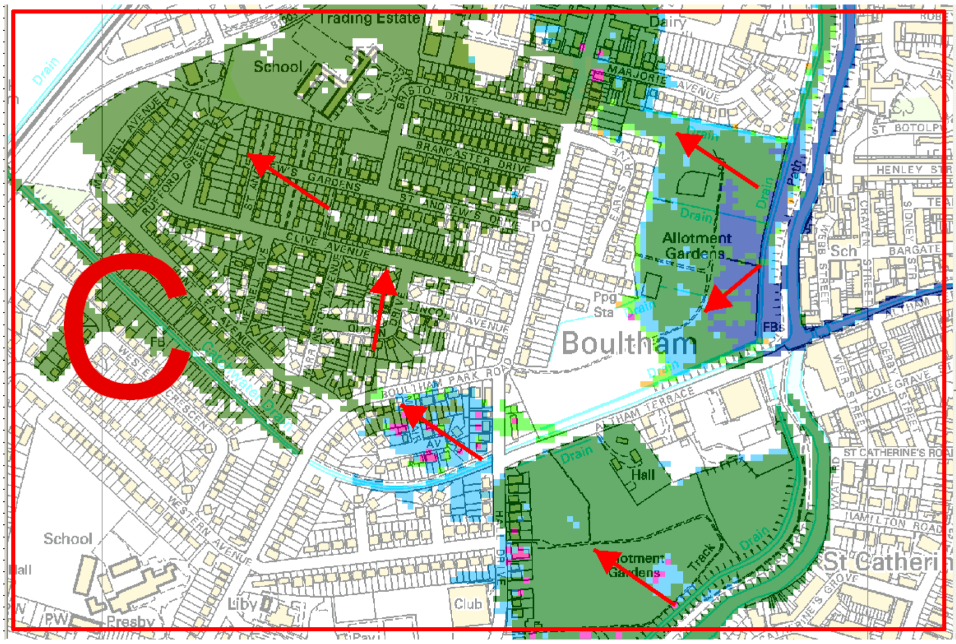




Vicinity of:

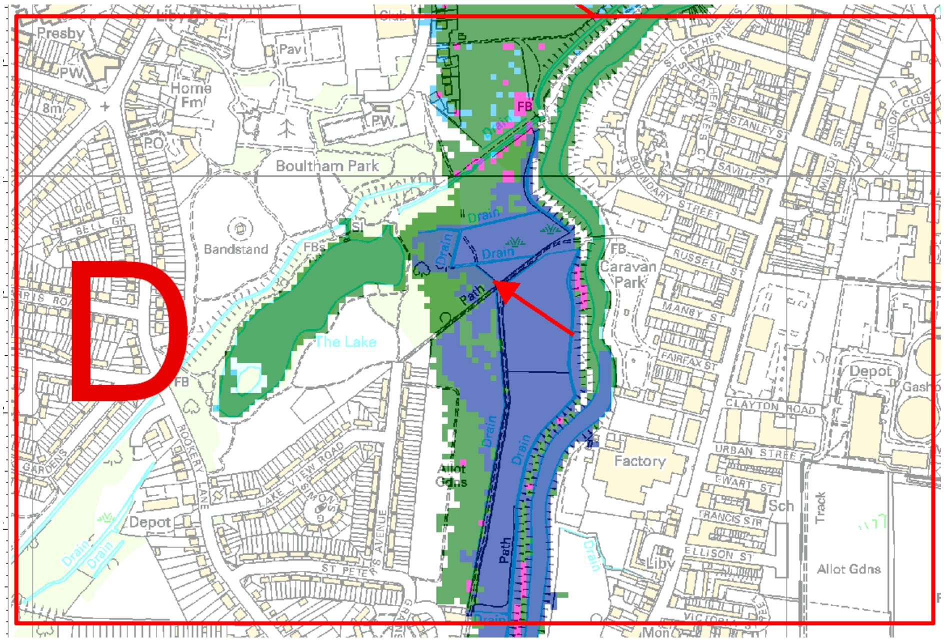
University, Rope Walk and Brayford Way: Overtopping adjacent to Rope Walk results in flows across Brayford Way and along side Campus Way and the university area.





Vicinity of:

Boultham, Altham Terrace, Earls Drive: Overtopping of the Witham will result in the flooding of Allotment gardens adjacent to Earls Drive. Earls Drive itself is raised above the flood risk area, however a flow route exists to the north towards Marjorie Avenue conveying flows towards Bristol Drive. A further flow route exists across Hall Road conveying flows towards Hunt Lea Avenue. Flooding will impact upon residential areas here.



Vicinity of:

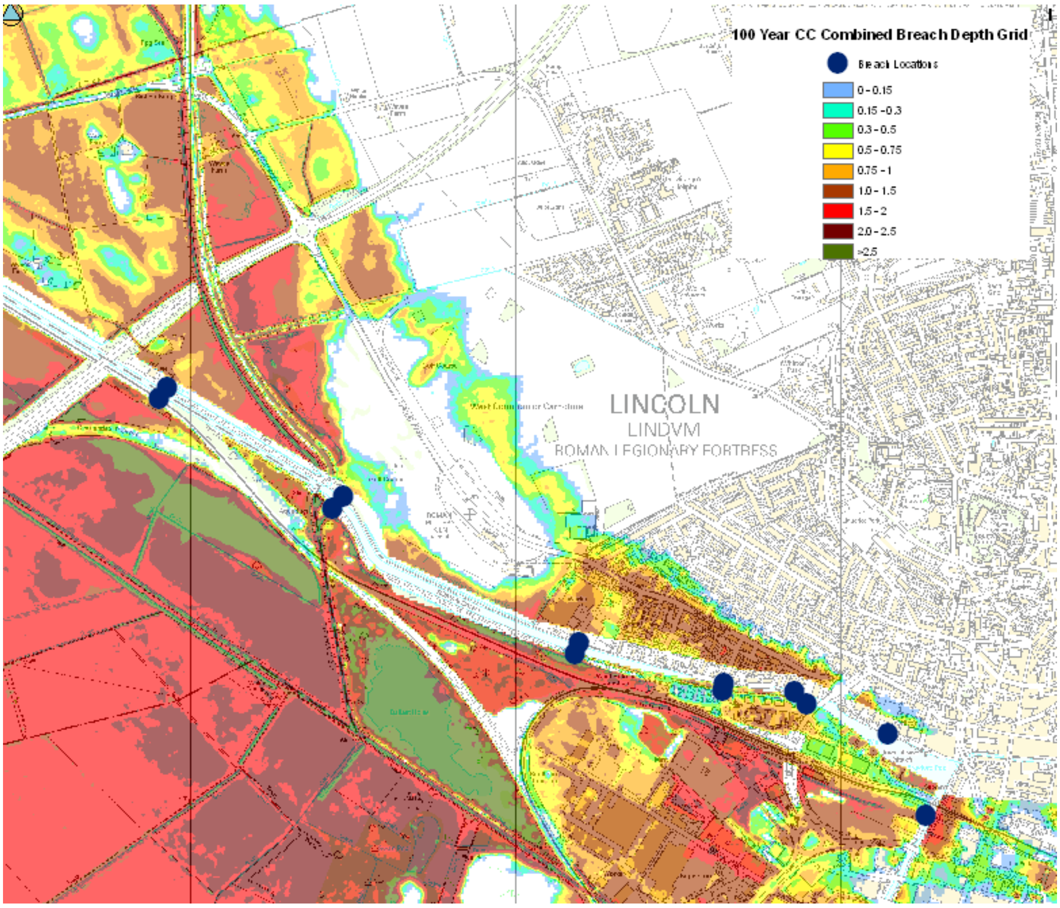
Boultham Park: Overtopping of the West Bank results in the flooding of parkland area.

The inundation maps above are presented to allow future emergency planning to be targeted at areas most at risk. They provide guidance on the likely sequence of flooding within urban areas.

3.4 Flood Defence Breaching Depth Maps

These maps have been produced by 2D modelling for both the 100yr with climate change and the 1000yr with climate change flooding scenarios. These maps demonstrate the effects of failure of the flood defences. It has been decided to display a maximum possible breach outline for Lincoln – **the "Worst Case Breach Envelope".** Although it is unlikely that all defences would breach simultaneously the outline shows the worst case depth as a result of any breach occurring.

Figure 3-3: breaching Depth Maps



3.5 Hazard Mapping

Hazard maps have been produced from the flood depth and velocity data derived from 2D modelling. Hazard maps have been produced for flood defence breaching and river bank / defence overtopping. The flood hazard maps have been produced in accordance to the methodology given in the Defra report FD2320.

The maps have been created for (i) 100 year (with climate change) flood scenario with climate change and (ii) 1000 year (with climate change) flood scenario with climate change. Three hazard categories are displayed – **danger for some** (includes children, elderly and infirm), **danger for most** (includes the general public) and **danger for all** (includes the emergency services). The full maps are included in Volume 4 and examples are shown below:

Figure 3-4: Overtopping Flood Hazard

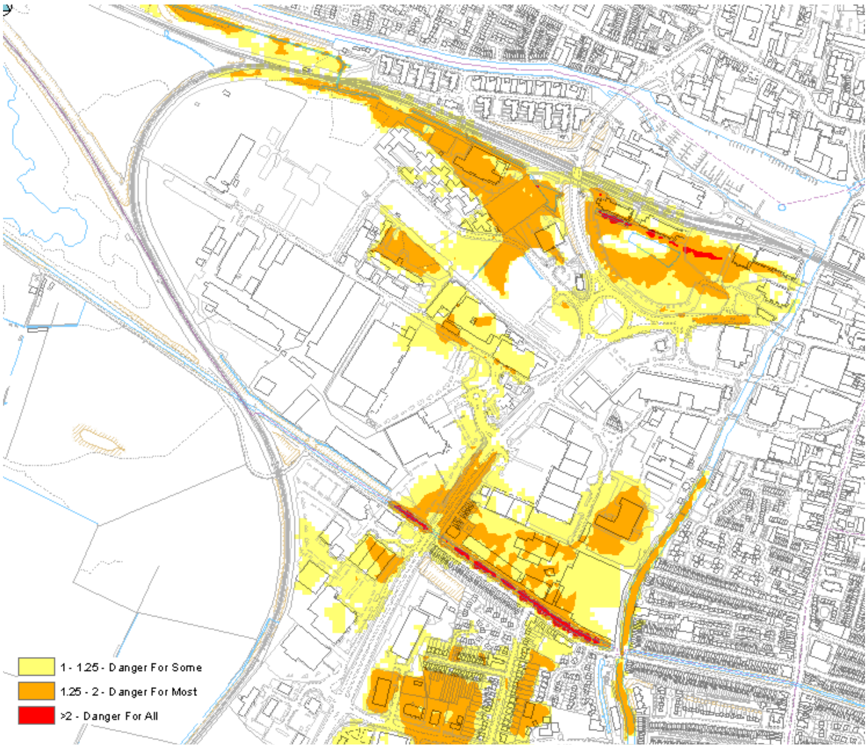
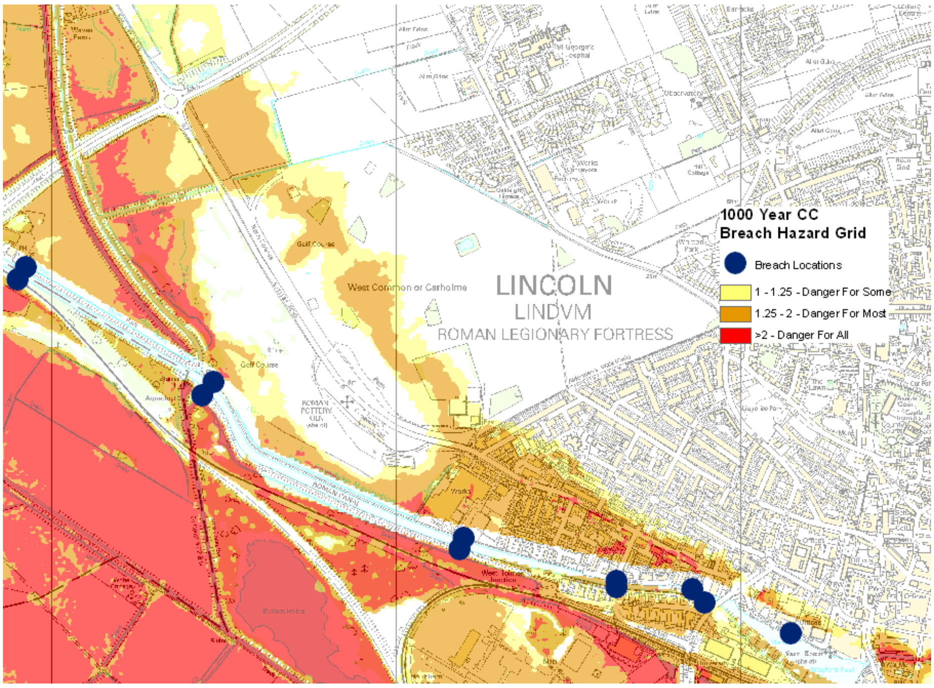


Figure 3-5: Breaching Flood Hazard



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