Lincolnshire County Council

South East Sleaford Regeneration Route

Flood Risk Assessment

Report Ref. B0373000/D00

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Client: Lincolnshire County Council
Project: South East Sleaford Regeneration Route Job No: B0373000
Title: Flood Risk Assessment

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Contents

1 Introduction

1.1 Background

This Flood Risk Assessment (FRA) has been produced to aid the initial design of a new Regeneration Route in Sleaford, Lincolnshire. The road is being designed by Jacobs U.K. Ltd on behalf of Lincolnshire Country Council. The aim of the FRA is to ensure that the proposed Regeneration Route is compliant with Planning Policy Statement 25: Development and Flood Risk (PPS25). PPS25 is described in more detail in Chapter 2.

1.2 Site Description

The site for the proposed Regeneration Route is located east of Sleaford town centre, approximately 350m east from Sleaford Railway Station (Grid Ref TF072453). The road would cover approximately 1.9 hectares, in an area of developed and undeveloped land. A site plan is included in Appendix A (Figure 1), which shows the full extent of the development, including the road and landscaping areas.

The northern part of the site is a recreation ground and is designated as a recreational open space. The southern section includes hardstanding, industrial and warehouse space. The industrial part of the site is bisected by the Sleaford to Lincoln Railway line, which is aligned east-west through the study area. Immediately north and south of the proposed development are residential areas.

1.3 Proposed Development

The route would start from Boston Road in the north, and run south across the Recreation Ground, then through an area of former warehousing, to cross the Sleaford to Lincoln railway line by way of a new bridge. South of the railway line, the route would cross a site currently occupied by a depot, before joining Maltings Way to the west of the Maltings buildings. The route would then follow the line of the existing Maltings Way to join Mareham Lane. Figure 1 shows the location of the proposed scheme.

The proposed development would be constructed on a north-south alignment to link Boston Road in the north with Mareham Lane to the south of Sleaford Station. The Regeneration Route would run through the recreation ground and industrial/ warehousing areas.

The development would involve the construction of a new bridge where the route crosses the Sleaford-Lincoln railway line, and the construction of new signalised junctions at Boston Road, the proposed Retail Access, the access to the Maltings and at Mareham Lane.

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2 Summary of PPS25

PPS25 sets out the national policy for land use planning in relation to flood risk. The policy statement contains the planning and development framework which should be adhered to by Regional Government, Local Planning Authorities and developers. It was produced by the Department for Communities and Local Government in December 2006.

2.1 Policy Aims

PPS 25 states; "The aims of planning policy on development and flood risk are to ensure that flood risk is taken into account at all stages of the planning process to avoid inappropriate development, and to direct development away from areas at highest flood risk. Where new development is, exceptionally, necessary, the policy aims to mitigate the flood risk without increasing the flood risk elsewhere."[1]

2.2 PPS25 Requirements

In order to meet its aim, PPS25 requires that a site-specific FRA is undertaken to assess the *risks of all forms of flooding* to and from development taking climate change into account. This has been done in Section 3 of this document. The FRA is then used to inform the application of the PPS25 Sequential Test.

2.3 PPS25 Sequential Test

The Sequential Test is used to examine the possibility of relocating development in areas found to be at medium and high probability of flooding from rivers and the sea to areas of low probability. The definition of low, medium and high probability flood risk areas is determined in PPS25 and is shown below in Table 2-A.

Flood Zone 1	**Low Probability**	This zone comprises land assessed as having less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1% AEP)[2].
Flood Zone 2	**Medium Probability**	This zone comprises of land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1% AEP) or between a 1 in 200 and a 1 in 1000 annual probability of sea flooding (0.5% - 0.1% AEP) in any year.
Flood Zone 3a	**High Probability**	This zone comprises of land assessed as having a 1 in 100 or greater annual probability of river flooding (>1% AEP) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5% AEP) in any year.
Flood Zone 3b	**The Functional Floodplain**	This zone comprises land where water has to flow or be stored in times of flood. Strategic Flood Risk Assessments (SFRA) should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5% AEP) or greater in any year or is designed to flood in an extreme (0.1% AEP) flood or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes).

Table 2-a Definition of Flood Zones (from PPS25 Table D1)

[1] Planning Policy Statement 25: Development and Flood Risk, page 2, paragraph 5
[2] AEP: Annual Exceedance Probability

If no areas at lower flood risk are available or appropriate then vulnerability of the proposed development to the effects of flooding are considered. Within PPS25, the vulnerability of different types of development is given. These are shown in Table 2-B.

Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Essential transport infrastructure (including mass evacuation routes) that has to cross the area at risk, and strategic utility infrastructure, including electricity generating power stations and grid and primary substations.	Police stations, ambulance stations and fire stations and command centres and telecommunications installations required to be operational during flooding; emergency dispersal points; basement dwellings; caravans, mobile homes and park homes intended for permanent residential use; installations requiring hazardous substances consent.	Hospitals; residential institutions; dwelling houses; pubs, clubs, hotels; health centres, nurseries, schools; landfill and sites for hazardous waste; sites used for holiday, short let caravans and camping.	Retail, offices, warehouses, workshops, leisure; agriculture; non-hazardous waste treatment; mineral working; water treatment plants; sewage treatment plants.	Flood control infrastructure; water transmission infrastructure; docks, marinas, wharves; navigation facilities; MOD defence installations; ship building; water based recreation; lifeguard stations; amenity open spaces and sand and gravel workings.

Table 2-b Development Vulnerability (as defined in PPS25 Table D2)

When the both the ‘Flood Zone’ and ‘flood vulnerability’ of flooding have been identified, the compatibility of the development of the proposed development is confirmed in-line with Table 2-C (Table D3 in PPS25). The requirements of the Exception Test are explained in Section 2.4.

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

✓ Development is appropriate × Development should not be permitted

Table 2-c Flood Risk Vulnerability and Flood Zone ‘Compatibility’ (Table D3 in PPS25).

2.4 PPS25 Exception Test

To pass the Exception Test (described in Appendix D of PPS25):

- *"It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared. If the DPD has reached the 'submission' stage, the benefits of the development should contribute to the Core Strategy's Sustainability Appraisal;*
- *the development should be on developable, previously development land or if it is not on previously developed land, that there are no reasonable alternative sites on previously development land; and*
- *a FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and where possible, will reduce flood risk overall."*

3 Assessment of Flood Risk

In accordance with the requirements of PPS25, an assessment of flood risk to the proposed Regeneration Route and the subsequent risk from the road must be made. This section will outline the possible risks from the various sources of flooding that could affect this development or result from it.

3.1 Fluvial Flooding

Fluvial flooding refers to flooding from rivers, streams and other inland natural watercourses. It is usually caused by prolonged or intense rainfall, generating high rates of runoff which overwhelm the capacity of the river or channel. When this occurs, excess water will spill onto low-lying areas of land adjacent to the channel.

3.1.1 Risk to the Proposed Development

The River Slea is the largest watercourse in close proximity to the site and is located approximately 150m to the north. The River Slea experienced flooding in July 2007 and September 1992, where it burst its banks in multiple locations within Sleaford town centre. According to the Environment Agency, there are no records of the development site being affected.

A review of the Environment Agency's Flood Map for the area[3] shows that the proposed development is located outside of the extreme flood extents (1 in 1000 year flood outline or 0.1% annual probability flood extents). Therefore the site is considered to be situated entirely in Flood Zone 1 and **passes the PPS25 Sequential Test described in Section 2 of this report.** The Exceptions Test is not required for the site.

3.1.2 Risk from the Proposed Development

The outline plan for the proposed Regeneration Route indicates that the area of impermeable surface will increase by 6780m^2 north of the railway line and by 1063m^2 south of the railway following the construction. This is due to the fact that a large proportion of the road will be built on recreational park land and other greenfield areas.

Without mitigation, the proposed Regeneration Route is likely to increase the rate and volume that surface water is discharged into local watercourses. This is because the presently undeveloped land, which lets rainfall soak into the ground, would be replaced by an impermeable surface which channels virtually all water straight into the local watercourse.

This net effect of the loss of greenfield land is likely to be an increase fluvial flood risk in areas downstream of the point of discharge of the surface water. The mitigation measures required to manage this risk are discussed in Section 4.

[3] http://maps.environment-agency.gov.uk/wiyby/ep=map~mapid=mainmap~topic=floodmap~layergroups=1,~layerGroupToQuery=1~lang=_e~mapOfOriginalLocation=false~scale=5~maxx=508351.625~maxy=346640.1875~minx=506256.125~miny=344544.6875.wiyby

3.2 Surface Water

Surface water runoff is defined as water flowing over the ground that has not yet entered a drainage channel or artificial drainage system. It usually occurs as a result of an intense period of rainfall, which exceeds the capacity of the ground to soak up the water.

Typically, runoff occurs on sloping land and where the ground surface is relatively impermeable. The ground can be impermeable, either naturally through the soil type/geology or due to development which places a large area of impervious material over the ground surface (i.e. paving and roads).

The flow path taken by surface water runoff is strongly influenced by the local topography and the built form. Runoff will gravitate towards the lowest areas.

The places at greatest risk from surface water runoff are usually situated in topographical low spots where water will pond or within the flow path for the runoff.

3.2.1 Risk to the Proposed Development

A review of the data available indicates that the risk of surface water runoff affecting the development is very low. This is because:

- An examination of the local topography based upon the OS 1:50,000 map indicates that the land is very flat in the Sleaford area;
- The surrounding developed land is already served by a drainage network and our initial consultation has not identified a known problem with this network;
- The surrounding soil type is highly porous according to Wallingford Winter Rainfall Acceptance Potential (WRAP) maps and unlikely to generate significant volumes of runoff.

Therefore surface water runoff does not need to be considered as a significant risk to the development.

3.2.2 Risk from the Proposed Development

As previously stated the increase in impermeable area associated with the construction of the proposed Regeneration Route could increase both the rate and volume of runoff. Furthermore, the construction of the road bridge over the railway line could create a steeply sloping area which could direct runoff to existing development north and south of the proposed Regeneration Route. Mitigation measures required to manage this risk are discussed in Section 4.

3.3 Artificial Drainage Systems

Artificial drainage systems are those which have been installed into an area during development to manage surface water runoff. They include pipes, land drains, sewers and drainage channels.

The main risk from this source of flooding occurs during periods of heavy rain when the capacity of the system is exceeded. Debris and sediment can often get trapped in these systems causing a large reduction in the capacity of the network.

Within the proposed development site there is an open drain to south of the recreational land, north of the railway line (see Appendix A, Figure 1). There is also likely to be an extensive network of piped drainage systems within the industrial area.

3.3.1 Risk to the Proposed Development

Initial discussions with the Environment Agency have not revealed any known problems in this area including the open drain on the north side of the railway. The open drain is believed only to receive runoff from the recreational land.

Therefore, the development is not considered to be at risk from flooding from artificial drainage systems.

3.3.2 Risk from the Proposed Development

As stated in Section 3.3.1, there are no known problems with the existing drainage network. However, the new drainage infrastructure associated with proposed Regeneration Route could change the rate, volume and location where surface water enters the existing network. If this occurs, there is the potential for parts of the existing drainage system receive more flows than they did prior to development.

There is a risk the system outside of the proposed site could become surcharged in places where there have previously been no issues. Mitigation measures required to manage this risk are discussed in Section 4.

The proposed Regeneration Route also has the potential to alter the existing flow regimes in the unnamed drain which crosses the site on the north side of the railway. Furthermore, debris from the construction of the Regeneration Route could enter the watercourse and block culverts downstream. The net result is that local flood risk could be increased by the development (including to the development itself) if not carefully planned and designed. Mitigation measures are required to manage this risk is discussed is Section 4.

3.4 Groundwater

Flooding can occur where the local geology is dominated by permeable rocks, there is a high water table and the land is relatively low-lying. Groundwater flooding occurs where the groundwater levels rise above the ground level.

3.4.1 Risk to the Proposed Development

Land in and surrounding Sleaford is between 10-15m above sea level. The site is located in a relatively flat topography and on the boundary of two distinct hydrological catchments. There are no localised depressions in the area and the site is not situated in a low lying area and therefore groundwater should not be a problem. As part of Lincolnshire the soil and geology are consistent with groundwater in the surrounding area.

No records of groundwater problems in Sleaford have been found. Therefore it is assumed that risk of groundwater flooding is low.

3.4.2 Risk from the Proposed Development

The Regeneration Route is highly unlikely to alter groundwater conditions in the area and consequently should have no impact on the level of this risk elsewhere.

3.5 Public Sewerage

Flooding can result when the public sewerage system becomes overwhelmed with surface runoff from heavy intense rainfall. This typically occurs in combined sewer overflows (CSOs). In a CSO, surface water is allowed to enter the sewerage system. Sewer flooding is common where the sewer system is in poor condition, blocked or requires maintenance. Where flooding from both surface water and foul sewers occurs, floodwaters can be contaminated with sewerage waste that can pollute rivers in addition to creating potential health hazards.

3.5.1 Risk to the Proposed Development

Consultation has not revealed any instances of sewer flooding. Consequently, the proposed Regeneration Route is not considered to be at risk of sewer flooding.

3.5.2 Risk from the Proposed Development

The Regeneration Route would not contain any link to the existing foul water sewerage system. All surface water would be discharged to a separate surface water discharge system. Therefore, there would be no increase sewer flooding risks.

3.6 Climate Change

Climate change will present a *Future Risk* to the site in the form of greater volumes of surface water runoff from the surrounding area and from the site itself.

In making an assessment of the impacts of climate change Table 3-A shows the precautionary allowances that should be considered for the parameters relevant to this site.[4]

Parameter	***1990 to 2025***	***2025 to 2055***	***2055 to 2085***	***2085 to 2115***
Peak rainfall intensity	*+5%*	*+10%*	*+20%*	*+30%*
Peak river flow	*+10%*	*+20%*		

Table 3-a Recommended national precautionary sensitivity range

[4] FCDPAG3 Economic Appraisal, Supplementary Note to Operating Authorities – Climate Change Impacts, October 2006

4 Mitigation Measures

The assessment of flood risks has identified that the key flood risks associated with the proposed development are:

- Increased fluvial flood risk elsewhere;
- Potential increased risk of flooding from artificial drainage systems outside of the development area;
- Increased risk of flooding from surface water runoff.

Clearly surface water management is an important issue that needs to be addressed during the detailed design of the road. This is discussed in more detail in the following section.

4.1 Mitigation of Impacts on Fluvial Food Risk

In order to mitigate the impact of the proposed on fluvial flood risk PPS 25 states:

"The surface water drainage arrangements for any development site should be such that the volumes and peak flow rates of surface water leaving a development site are no greater than the rates prior to the proposed development, unless specific off-site arrangements are made and result in the same net effect."[5]

As described in Section 3.1, the loss of greenfield land will lead to an increase in both the rate and volume of water discharged to the receiving watercourse. The estimated volumes the amount of storage and infiltration required to mitigate the loss of greenfield land to satisfy the requirements of PPS25 are given below.

Note that these figures have been obtained using Environment Agency and Defra guidance[6] and include an allowance for climate change. These results are suitable for initial drainage designs only, not for detailed design.

The calculated runoff rate (Q) from the existing greenfield area is shown below in Table 4-A. The rate of runoff is relatively low due to the highly permeable nature of the soil.

Greenfield Discharge Rate	Discharge Rate
Q_{1yr}	0.14 l/s/ha
Q_{30yr}	0.33 l/s/ha
Q_{100yr}	0.49 l/s/ha

Table 4-a Calculated Greenfield Runoff Rate

The amount of attenuation (At Vol) required to ensure that the rates of runoff does not increase are shown below in Table 4-B. These figures are based on the greenfield runoff rate calculations.

[5] Planning Policy Statement 25: Development and Flood Risk, Annex 5, page 34 , paragraph F10.
[6] Preliminary rainfall runoff management for developments, R&D Technical Report W5-074/A/TR/1 Revision C (June 2007)

Attenuation Storage Required	North of Railway	South of Railway	Total
At Vol $_{1yr}$	209 m^3	32 m^3	**241 m^3**
At Vol $_{30yr}$	429 m^3	66 m^3	**495 m^3**
At Vol $_{100yr}$	767 m^3	118 m^3	**885 m^3**

Table 4-b Attenuation Storage

The increased volume of runoff from the site from a 1in 100 year storm of 6 hours duration (L T Vol $_{100yr\ 6hr}$) is shown in Table 4-C.[7] This volume of water should not be discharged into the watercourse if possible, but should be dispersed using infiltration techniques.

However, liaison with Anglian Water and the Environment Agency has indicated that infiltration is not suitable in this area. Surface water runoff from the Regeneration Route is likely to contain pollutants that could contaminate groundwater supplies that are used for drinking water.

Guidance[8] states that where infiltration is not a viable option, the increased volume of surface water originating from the site can be released into the receiving watercourse at very low rates. The low rates are aimed at minimising the risk of exacerbating river flooding. It is suggested than an equivalent rate of less than 2 litres second per hectare should be achieved. The proposed drainage design will meet these discharge constraints.

Long Term Storage (Infiltration) Volume	North of Railway	South of Railway	Total
L T Vol $_{100yr\ 6hr}$	371 m^3	57m^3	**428 m^3**

Table 4-c Long Term Storage Volumes

4.2 Mitigation of Impacts on Artificial Drainage Systems and Surface Water Runoff

To mitigate the impacts of the proposed Regeneration Route on the existing surface water drainage system, PPS25 states that:

"Surface water arising from a developed site should, as far as is practicable, be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development, while reducing the flood risk to the site itself and elsewhere, taking climate change into account." [9]

The drainage for the proposed scheme has been developed in liaison with the Environment Agency and Anglian Water. Water from the northern and southern sections of the scheme would be drained to separate outfalls, with the apex of the bridge dividing the two areas to be drained.

The road to the north of the bridge crest would drain northwards. It is proposed to discharge the road run-off from this northern catchment to an existing surface water discharge system owned by Anglian Water, at the Boston Road junction. This existing surface water sewer discharges into the Old River Slea directly downstream of the Old River Slea sluice.

[7] The 6 hour duration storm is used by designers as this an event which can cause flooding in small catchments.
[8] Preliminary rainfall runoff management for developments, R&D Technical Report W5-074/A/TR/1 Revision C (June 2007) Page 17
[9] Planning Policy Statement 25: Development and Flood Risk, Annex 5, page 33, paragraph F1.

The road to the south of the bridge crest would drain southwards, and would discharge into an existing surface water system also owned by Anglian Water. This is located on Keepers Way which is part of a housing estate to the south of Maltings Way. There is currently a surface water collection system on Maltings Way which is connected directly into an existing foul sewer owned by Anglian Water. This connection would be removed as part of this scheme.

The proposed drainage design will effectively mitigate any direct risk from surface water runoff to the properties north and south of the proposed development site. It will be designed so that no flooding of property should occur as a result of a one in 100 year storm event (including an appropriate allowance for climate change).

The effectiveness of the proposed drainage infrastructure will need to be confirmed through modelling of the system using appropriate drainage modelling software at detailed design stage.

4.2.1 Sustainable Urban Drainage

PPS25 also states that Local Planning Authorities (LPAs) should promote the use of SUDS. The use of several different SUDS measures was investigated for the Regeneration Route.

SUDS measures that rely on infiltration were ruled out due to the potential impacts on groundwater quality (see Section 4.1).

Other SUDS measures would involve the loss of open space in the park. The park is an important local community facility, and consultation with the Local Authority has revealed that they wish to minimise land take in this park. Consequently, surface water attenuation will be provided by more traditional methods, such as oversized pipes.

5 Conclusion

This FRA has been produced in line with PPS25 to aid the initial design of the new Regeneration Route in Sleaford, Lincolnshire.

The FRA has shown that the proposed location of the Regeneration Route is located entirely in Flood Zone 1 and is therefore considered to be at low risk from fluvial flooding. The development therefore **passes the Sequential Test** as required in PPS25.

However, the replacement of permeable areas of open space with the impermeable surfaces of the road, without mitigation, could increase the risk of fluvial flooding to areas outside of the Regeneration Route. This is because both volume and rate of surface water runoff into the receiving watercourse will increase.

The impact on fluvial flood risk will be mitigated in the following ways:

- **Attenuation** of the surface water runoff to limit rates of discharge to that of the existing site. The volume of storage required for a 1% annual probability (1 in 100 year flood event) plus climate change is 885m$^{3.}$

- **Long term storage** of surface water runoff so that the increased volume leaving the site does not exacerbate flood risk. The estimated long term storage volume required for a 1% annual probability (1 in 100 year flood event) plus climate change is 428m$^{3.}$

The proposed Regeneration Route, without mitigation, could also increase the risk of flooding from existing surface water drainage network in areas outside of the site. This is because the points of discharge from the site could be significantly altered during design of the road.

There is also a risk that following development of the site that surface water runoff could, without mitigation, directly affect properties north and south of the Regeneration Route. The slope of the proposed road may guide flows towards these areas.

Both of these risks will need to be mitigated by a drainage system which will intercept surface water and direct flows into Anglian Water surface water sewers. Anglian Water has indicated that there is sufficient capacity in the receiving system. Appropriate discharge points need to be agreed with Anglian Water at detailed design stage.

In summary, the proposed development is not considered to be at significant risk of flooding, but it could have impacts on various types of flood risk in the surrounding area. However, all of these impacts will be mitigated in line with relevant guidance such that the proposed Regeneration Route will be compliant with the requirements of PPS25.

Appendix A – Site Plan

Figure 1 – Site Plan

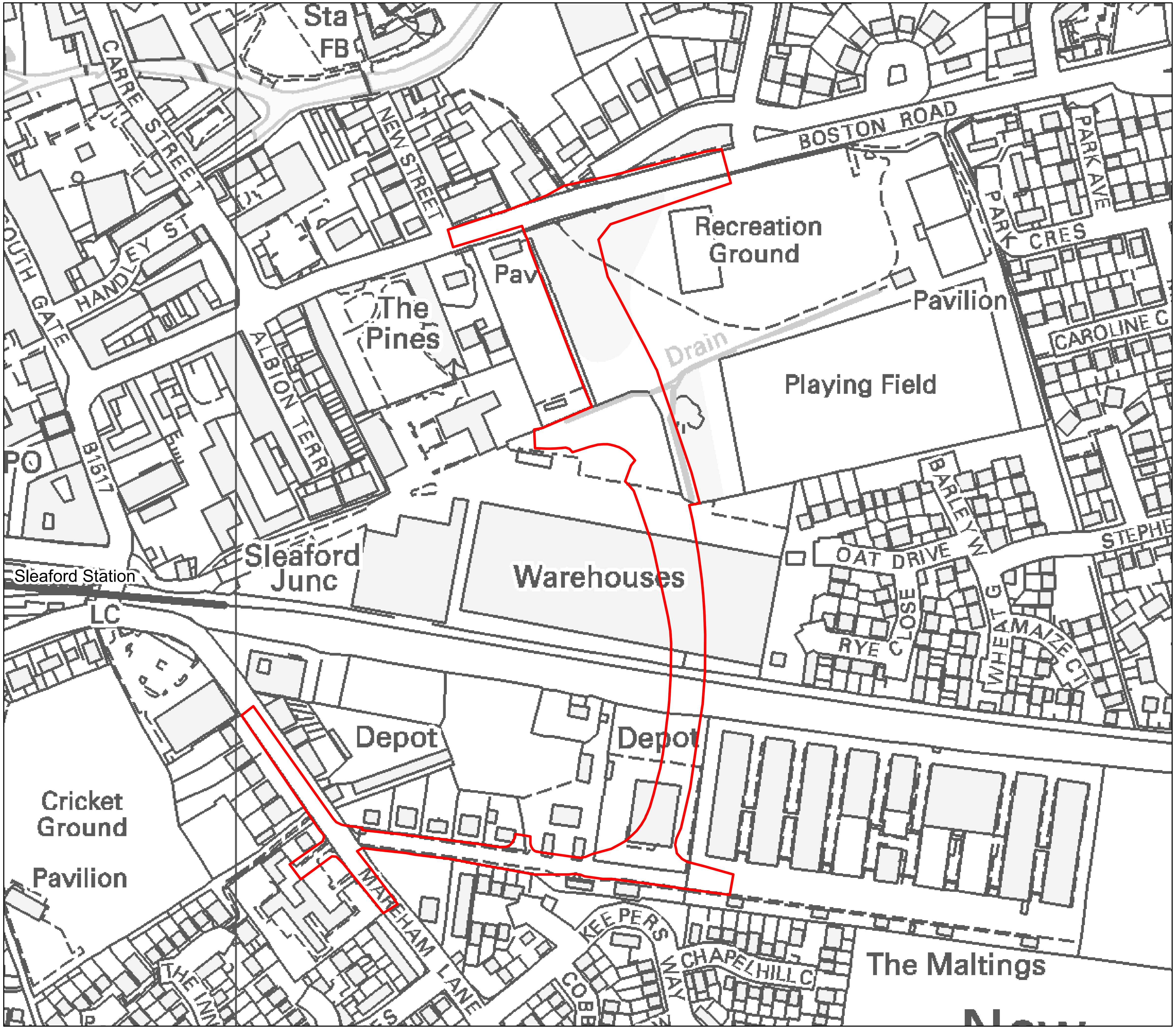

FIGURE 1

Legend

Site Boundary

N
W E
S

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Project

South East Sleaford Regeneration Route

Title

Site Location Plan

Scale 1:2500 (A3)	Date Dec 2008	Ref. B0373000_FR_1
Drawn AD	Checked SW	Approved VL

Appendix B - Assessment of Rainfall Rates and Calculations

Preliminary Assessment of Rainfall Runoff Storage Volumes

Project Name:	Sleaford Maltings Link Road FRA	**Calculation by:**	S Round
Project Number:	B0373000	**Checked by:**	P Roberts
Client:	Lincolnshire County Council	**Signed off by:**	D Dickson

Notes:

1 The methodology used to calculate runoff has been obtained from 'The SUDS Manual' (CIRIA, 2007).

2 The methodology used to calculate runoff volume and storage required has been obtained from 'Preliminary Rainfall Runoff Management for Developments' (R&D Technical Report W5-07/A/TR/1 Revision C).

Site Details

Source of Data

Location: North of Railway Line

Grid Reference: 507424, 345441 — *OS Data*

Area of Development: 6,920 m^2 | 0.692 ha | 0.00692 km^2 — *Client Supplied*

Hydrological Region: 5 — *The SUDS Manual*

SAAR: 594 mm — *R&D Technical Report W5-07/A/TR/1 Rev C*

Soil Type: — *Wallingford Maps*
Winter Rainfall Acceptance Potential

% of Site	Soil Type	SPR	Total SPR
100%	SOIL1	0.1	0.1
0%	SOIL2	0.3	0
0%	SOIL3	0.37	0
0%	SOIL4	0.47	0
0%	SOIL5	0.53	0
		TOTAL =	**0.1**

Greenfield Runoff Rate Calculation

This calculation described in The SUDS Manual (CIRIA, 2007) is as follows:

$$QBAR_{rural} = 0.00108 AREA^{0.89}.SAAR^{1.17}.SOIL^{2.17}$$

Where:

$QBAR_{rural}$ = Catchment mean annual peak flow (approximately 43% annual probability or 2.3 year return period) (m^3/s)
AREA = Catchment area (km^2)
SAAR = Standard average annual rainfall for the period 1941 to 1970 (mm)
SOIL = Soil index (from Flood Studies or Wallingford Procedure WRAP maps). It is a weighted sum of individual soil class fractions, where:

$$SOIL = 0.1\ SOIL_1 + 0.3\ SOIL_2 + 0.37\ SOIL_3 + 0.47\ SOIL_4 + 0.53\ SOIL_5$$

Note that The SUDS Manual states that where the development is less than 50ha, the analysis for using greenfied discharge rate should use 50ha in the formula but linearly interpolate the flow rate based upon the ratio of the development to 50ha.

Results

QBAR *Whole Development*: **0.00010** m^3/s | **0.10** l/s

QBAR *Per Hectare*: **0.00014** $m^3/s/ha$ | **0.14** l/s/ha

Using growth curves (for hydrological area 5), the following flow rates have been determined for different return periods:

	Return Period					
	1	5	10	30	100	1000
Growth Factor	0.85	1.29	1.65	2.40	3.56	5.75
Whole dev (l/s)	0.08	0.12	0.16	0.23	0.34	0.55
Whole dev (m^3/s)	0.000082	0.000124	0.000158	0.000230	0.000342	0.000552
Per ha (l/s)	0.12	0.18	0.23	0.33	0.49	0.80
Per ha (m^3/s)	0.000	0.000	0.000	0.000	0.000	0.001

Growth curves obtained from The SUDS Manual

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Attenuation Storage Volumes (ASV) Calculation

		Symbol	Answer	Unit	Notes
1	Hydrological region	R	5		
2	Hydrological rainfall zone	$M_5$60, r	20, 0.4		
3.1	Development size	A	0.69	ha	
3.2	Public open space	$A_{public\ open\ space}$	0.00	ha	
4.1	Impermeable area served by direct drainage	$A_{impermeable\ area}$	0.69	ha	
4.2	Proportion of impervious area requiring Attenuation storage	$\propto$	1.00		
5	Greenfield flow rate per unit area	Q_{BAR}	0.14	l/s/ha	
6	Estimate of development percentage impermeable area	PIMP	100	%	
7.1	1yr attenuation storage volume per unit area	$Uvol_{1yr}$	275	m^3/ha	*Qbar/A is < 2l/s/ha, so an estimate of Uvol has been made on the assumption of 1l/s/ha value in line with EA guidance.*
7.2	30yr attenuation storage volume per unit area	$Uvol_{30yr}$	500	m^3/ha	
7.3	100yr attenuation storage volume per unit area	$Uvol_{100yr}$	630	m^3/ha	
8.1	1yr basic storage volume	BSV_{1yr}	190	m^3	
8.2	30yr basic storage volume	BSV_{30yr}	346	m^3	
8.3	100yr basic storage volume	BSV_{100yr}	436	m^3	
9	Climate change factor	CC	1.1		*Defra guidance on climate change is to apply a factor of 1.2* ***on river flows****. As there is a non-linear realationship between rainfall and runoff a factor of 1.1 is applied during this procedure in line with EA guidance.*
10.1	1yr FEH rainfall factor	FF_{1yr}	1		
10.2	30yr FEH rainfall factor	FF_{30yr}	0.9		
10.3	100yr FEH rainfall factor	FF_{100yr}	0.7		
11.1	1yr storage volume ratio	SVR_{1yr}	1.1		
11.2	30yr storage volume ratio	SVR_{30yr}	1.2		
11.3	100yr storage volume ratio	SVR_{100yr}	1.8		
12.1	1yr adjusted storage volume	ASV_{1yr}	209	m^3	
12.2	30yr adjusted storage volume	ASV_{30yr}	429	m^3	
12.3	100yr adjusted storage volume	ASV_{100yr}	767	m^3	
13.1	1yr Hydrological Region volume storage ratio	HR_{1yr}	1.00		
13.2	30yr Hydrological Region volume storage ratio	HR_{30yr}	1.00		
13.3	100yr Hydrological Region volume storage ratio	HR_{100yr}	1.00		
14.1	**1yr Attenuated Storage Volume**	At. Vol_{1yr}	209	m^3	
14.2	**30yr Attenuated Storage Volume**	At. Vol_{30yr}	429	m^3	
14.3	**100yr Attenuated Storage Volume**	At. Vol_{100yr}	767	m^3	

Estimation of Long Term Storage Volume

		Symbol	Answer	Unit
1	Development area	A	0.69	ha
2	Estimate of PIMP	PIMP	100	%
3	Impermeable area	AP	0.692	ha
4	Long term Storage Factor	LTF	8.50	m^3/ha/mm
5	Rainfall Depth	RD	63	mm

6	Long term storage volume	L T Vol $_{100yr\ 6\ hr}$	371	m^3

JACOBS

Preliminary Assessment of Rainfall Runoff Storage Volumes

Project Name:	Sleaford Maltings Link Road FRA	**Calculation by:**	S Round
Project Number:	B0373000	**Checked by:**	P Roberts
Client:	Lincolnshire County Council	**Signed off by:**	D Dickson

Notes:

1 The methodology used to calculate runoff has been obtained from 'The SUDS Manual' (CIRIA, 2007).

2 The methodology used to calculate runoff volume and storage required has been obtained from 'Preliminary Rainfall Runoff Management for Developments' (R&D Technical Report W5-07/A/TR/1 Revision C).

Site Details

Source of Data

Location:	**South of Railway Line**					
Grid Reference:	507424, 345441					*OS Data*
Area of Development:	1,063	m^2	0.1063 ha	0.00106	km^2	*Client Supplied*
Hydrological Region:	5					*The SUDS Manual*
SAAR:	594	mm				*R&D Technical Report W5-07/A/TR/1 Rev C*

Soil Type:

% of Site	Soil Type	SPR	Total SPR
100%	SOIL1	0.1	0.1
0%	SOIL2	0.3	0
0%	SOIL3	0.37	0
0%	SOIL4	0.47	0
0%	SOIL5	0.53	0
		TOTAL =	**0.1**

Wallingford Maps
Winter Rainfall Acceptance Potential

Greenfield Runoff Rate Calculation

This calculation described in The SUDS Manual (CIRIA, 2007) is as follows:

$$QBAR_{rural} = 0.00108 AREA^{0.89} . SAAR^{1.17} . SOIL^{2.17}$$

Where:

$QBAR_{rural}$ = Catchment mean annual peak flow (approximately 43% annual probability or 2.3 year return period) (m^3/s)
AREA = Catchment area (km^2)
SAAR = Standard average annual rainfall for the period 1941 to 1970 (mm)
SOIL = Soil index (from Flood Studies or Wallingford Procedure WRAP maps). It is a weighted sum of individual soil class fractions, where:

$$SOIL = 0.1\,SOIL_1 + 0.3\,SOIL_2 + 0.37\,SOIL_3 + 0.47\,SOIL_4 + 0.53\,SOIL_5$$

Note that The SUDS Manual states that where the development is less than 50ha, the analysis for using greenfied discharge rate should use 50ha in the formula but linearly interpolate the flow rate based upon the ratio of the development to 50ha.

Results

QBAR *Whole Development*	**0.00001**	m^3/s	**0.01**	l/s
QBAR *Per Hectare*	**0.00014**	$m^3/s/ha$	**0.14**	l/s/ha

Using growth curves (for hydrological area 5), the following flow rates have been determined for different return periods:

	Return Period					
	1	5	10	30	100	1000
Growth Factor	0.85	1.29	1.65	2.40	3.56	5.75
Whole dev (l/s)	0.01	0.02	0.02	0.04	0.05	0.08
Whole dev (m^3/s)	0.000013	0.000019	0.000024	0.000035	0.000052	0.000085
Per ha (l/s)	0.12	0.18	0.23	0.33	0.49	0.80
Per ha (m^3/s)	0.000	0.000	0.000	0.000	0.000	0.001

Growth curves obtained from The SUDS Manual

Attenuation Storage Volumes (ASV) Calculation		Symbol	Answer	Unit	Notes
1	Hydrological region	R	5		
2	Hydrological rainfall zone	$M_5 60$, r	20, 0.4		
3.1	Development size	A	0.11	ha	
3.2	Public open space	$A_{public\ open\ space}$	0.00	ha	
4.1	Impermeable area served by direct drainage	$A_{impermeable\ area}$	0.11	ha	
4.2	Proportion of impervious area requiring Attenuation storage	$\propto$	1.00		
5	Greenfield flow rate per unit area	Q_{BAR}	0.14	l/s/ha	
6	Estimate of development percentage impermeable area	PIMP	100	%	
7.1	1yr attenuation storage volume per unit area	$Uvol_{1yr}$	275	m^3/ha	*Qbar/A is < 2l/s/ha, so an estimate of Uvol has been made on the assumption of 1l/s/ha value in line with EA guidance.*
7.2	30yr attenuation storage volume per unit area	$Uvol_{30yr}$	500	m^3/ha	
7.3	100yr attenuation storage volume per unit area	$Uvol_{100yr}$	630	m^3/ha	
8.1	1yr basic storage volume	BSV_{1yr}	29	m^3	
8.2	30yr basic storage volume	BSV_{30yr}	53	m^3	
8.3	100yr basic storage volume	BSV_{100yr}	67	m^3	
9	Climate change factor	CC	1.1		*Defra guidance on climate change is to apply a factor of 1.2* ***on river flows****. As there is a non-linear realationship between rainfall and runoff a factor of 1.1 is applied during this procedure in line with EA guidance.*
10.1	1yr FEH rainfall factor	FF_{1yr}	1		
10.2	30yr FEH rainfall factor	FF_{30yr}	0.9		
10.3	100yr FEH rainfall factor	FF_{100yr}	0.7		
11.1	1yr storage volume ratio	SVR_{1yr}	1.1		
11.2	30yr storage volume ratio	SVR_{30yr}	1.2		
11.3	100yr storage volume ratio	SVR_{100yr}	1.8		
12.1	1yr adjusted storage volume	ASV_{1yr}	32	m^3	
12.2	30yr adjusted storage volume	ASV_{30yr}	66	m^3	
12.3	100yr adjusted storage volume	ASV_{100yr}	118	m^3	
13.1	1yr Hydrological Region volume storage ratio	HR_{1yr}	1.00		
13.2	30yr Hydrological Region volume storage ratio	HR_{30yr}	1.00		
13.3	100yr Hydrological Region volume storage ratio	HR_{100yr}	1.00		
14.1	1yr Attenuated Storage Volume	At. Vol_{1yr}	32	m^3	
14.2	30yr Attenuated Storage Volume	At. Vol_{30yr}	66	m^3	
14.3	100yr Attenuated Storage Volume	At. Vol_{100yr}	118	m^3	

Estimation of Long Term Storage Volume				
1	Development area	A	0.11	ha
2	Estimate of PIMP	PIMP	100	%
3	Impermeable area	AP	0.1063	ha
4	Long term Storage Factor	LTF	8.50	m^3/ha/mm
5	Rainfall Depth	RD	63	mm
6	Long term storage volume	L T Vol $_{100yr\ 6\ hr}$	57	m^3