Hartlepool Borough Council

Strategic Flood Risk Assessment Level 1

Volume II- Technical Report

May 2010

Tom Britcliffe
Principal Planning Officer
Department of Regeneration & Planning Services
Bryan Hanson House
Hanson Square
Hartlepool
TS24 7BT

JBA Office

JBA Consulting
The Brew House
Wilderspool Park
Greenall's Avenue
Warrington
WA4 6HL

JBA Project Manager

Sam Wingfield

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Draft report (V.1.0)	Internal review	1 pdf copy to Tom Britcliffe and Cameron Sked.
Final report (V.2.0)	Updated following comments from HBC and the EA.	1 pdf copy to Tom Britcliffe and Cameron Sked.

Contract

This report describes work commissioned by Tom Britcliffe, on behalf of Hartlepool Borough Council, by an email dated 28th August 2009. Hartlepool Borough Council's representative for the contract was Tom Britcliffe. Sam Wingfield of JBA Consulting carried out this work.

Prepared by ..... Samuel Wingfield BSc MRes

Reviewed by ..... Chris Isherwood BSc CertWEM DipWEM
Analyst

Purpose

This document has been prepared as a final report for Hartlepool Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Hartlepool Borough Council.

Copyright

Carbon Footprint

A printed copy of the main text in this document will result in a carbon footprint of 239g if 100% post-consumer recycled paper is used and 304g if primary-source paper is used. These figures assume the report is printed in black and white on A4 paper and in duplex.

JBA is a carbon neutral company and the carbon emissions from our activities are offset.

Executive Summary

Hartlepool Borough Council Level 1 SFRA

This report has been produced as a Level 1 Strategic Flood Risk Assessment (SFRA) for Hartlepool Borough Council, in accordance with PPS25 and its Practice Guide.

Development and Flood Risk

Local Planning Authorities (LPAs) have a raft of issues to consider when planning future development. These are dictated by Government Planning Policy Statements.

Planning Policy Statement 25 (PPS25) relates to development and the constraint of flood risk, with its overarching aim of avoiding development in flood risk areas. This is achieved through PPS25 by the sequential approach to land allocation, meaning that development should be firstly avoided in flood risk areas wherever possible before considering the vulnerability of development planned or possible mitigation measures. The sequential approach is governed by two tests; the Sequential and Exceptions Test. The consideration of flood risk to people and development must be considered by the LPA at the earliest stage of spatial planning decisions and these tests allows this process to be transparent and affective.

In order to carry out these tests a coherent understanding of flood risk is needed at a local level. High level policy and guidance documents such as Catchment Flood Management Plans (CFMPs), Shoreline Management Plans (SMPs) and Regional Flood Risk Appraisals (RFRA) have provided a good introduction in to flood risk; however they do not provide the level of detail required for the LPA to make the right spatial planning decisions.

Strategic Flood Risk Assessments (SFRAs) offer this local level of understanding. SFRAs provide the LPA with a central source of all relevant flood risk information and the evidence base to make tough planning decisions and develop focused local policies required to inform the Local Development Framework (LDF). The SFRA therefore becomes a key planning tool that enables the LPA to select and develop sustainable site allocations.

A **Level 1 SFRA** offers the foundation of this evidence base. It is based purely on the collation of existing flood risk information. The Environment Agency Flood Map is the main source of fluvial and tidal flood information across England and Wales and is the basis of PPS25 Flood Zones used in the Sequential and Exception Tests. The Level 1 SFRA must also consider flooding from all other sources (surface water, sewers, groundwater and artificial sources). This is only achievable through consulting with those stakeholders with specific interest or knowledge in other sources of flooding.

The Level 1 SFRA is assisted greatly by the use of Strategic Flood Risk Maps providing information on flood risk factors needed to be taken into account. The PPS25 Flood Zone Map enables the LPA to carry out the first sweep of Sequential Testing. The additional maps produced as part of the Level 1 SFRA should be used during the Sequential Test 'sieving' process further identify inappropriate development.

Once the LPA has carried out the Sequential Test sieving process, they still may wish to allocate vulnerable development in high risk areas due to the wider need for economic growth and regeneration. In this case the allocations must pass the Exception Test. The evidence provided in the Level 1 SFRA is not detailed enough to justify development through the Exception Test. In order to achieve this Level 2 SFRA must be carried out.

A Level 2 SFRA provides the LPA with a detailed understanding of flood hazard, assessing flood depth, velocity and residual risks such as flood defence breaching or

overtopping. This information provided in the Level 2 SFRA will give the LPA a much more detailed understanding of flood risk at potential development sites. Although it will not provide all the information needed to apply the Exception Test, it will include the appropriateness of the development and the likelihood of it remaining safe if flooded. If the LPA has justified the development by passing parts a) and b) of the Exception Test, it must be supported by a site specific Flood Risk Assessment (FRA) in order to pass part c).

The Three Level 1 SFRA Volumes

The Level 1 SFRA is presented in three volumes, each with their own purpose and intended audience.

VOLUME I: Understanding the SFRA Process

Volume I of the Hartlepool SFRA introduces the SFRA process. It is an excellent reference document for current flood risk management drivers, national regional and local planning policy and introduced Environment Agency policy such as the Tees CFMPs and SMPs.

The report also provides a brief understanding of the mechanisms of flooding and flood risk for those new to the subject. More importantly, it provides a comprehensive discussion on PPS25, the Sequential, Exception Test and links regional and local flood risk assessments.

Volume I holds the main 'Consultation & Data Management' section, identifying key stakeholders and their involvement in the SFRA process.

This Volume should be read by:

- The general public or those new to flood risk
- Those wanting to understanding current flood risk management drivers
- Those wanting to understand the sequential approach to flood risk management
- And generally by those involved in Development Management, Planners and Developers wanting to understand the wider constraints of developing in flood risk areas.

VOLUME II: SFRA Technical Report

Following on from the 'Consultation & Data Management' section in Volume I, Volume II provides the technical information and methods used in the assessment of flood risk across Hartlepool. It assesses six sources of flooding including; fluvial, tidal, surface water, sewers, groundwater and reservoirs and other artificial sources. The Volume also introduces the Environment Agency Flood Warning System and residual risks associated with flood defences.

As discussed, flood risk has many dimensions and as a result has been presented through a suite of maps. These extend the level of detail in the Environment Agency Flood Zone maps.

The SFRA maps include:

SET A:	PPS25 Flood Zones
SET B:	Flood Zone 3 Depths
SET C:	Tidal Climate Change Sensitivity
SET D:	Flood Risk Management Measures
SET E:	Areas Naturally Susceptible to Surface Water Flooding

Volume II along with the suite of SFRA maps, should provide the evidence base of the Hartlepool Level 1 SFRA. It has been arranged in one volume to allow technical information to be easily updated when reviewed. It is only this Volume that can be

updated with new flood risk information when available. Volume I and III would be difficult to update without completely revisiting the SFRA process.

Section 4 provides the results of the first pass of the Sequential Test against Hartlepool Council's proposed development allocations.

This Volume should be read by:

- Spatial Planners
- Development Management
- Planners
- Developers
- Emergency Planners
- Key Stakeholders including the Environment Agency and Northumbrian Water

VOLUME III: SFRA Guidance for Spatial & Development Management

Volume III of the Hartlepool SFRA provides guidance and recommendations to spatial planners, planners, developers and emergency planners, how to use the flood risk information provided in Volume II and further plans which are required to improve the understanding of flood risk in Hartlepool.

Initially the Volume discusses further work required such as Level 2 SFRAs and SWMPs which has been informed by the findings of Volume II. This extra work will provide Hartlepool Council with a strategic and coherent framework for managing flood risk in their area.

This Volume should be read by:

- Spatial Planners
- Development Management
- Planners
- Developers
- Emergency Planners
- Key Stakeholders including the Environment Agency and Northumbrian Water

Contents

Executive Summary ..... **iv**

1 Data Sources **2**

1.1 Flood Zone Map 2
1.2 Flood Defences 3
1.3 Flood Risk Management and Hydraulic Modelling Studies 3
1.4 Topographic Data 7
1.5 Historical Flooding 8

2 Flood Risk in the Borough of Hartlepool **12**

2.1 Introduction 12
2.2 Tidal and coastal flooding 12
2.3 Fluvial flood risk 17
2.4 Surface water flooding 19
2.5 Flooding from sewers 27
2.6 Flooding from groundwater 28
2.7 Flooding from reservoirs and other artificial sources 28
2.8 Effects of Climate Change 28
2.9 Geology and Soils 29
2.10 Flood Defences 30
2.11 Flood Warning 32

3 Strategic Flood Risk Mapping **34**

3.1 Introduction 34
3.2 PPS25 Flood Zone Maps 34
3.3 Flood Zone 3 Depth Map 36
3.4 Climate Change Sensitivity Maps 36
3.5 Flood Risk Management Measures Map 37
3.6 Surface Water Flooding Maps 37

4 Site Specific Allocations **39**

4.1 Introduction 39
4.2 Current Development Site Sequential Test 40
4.3 Summary of sites at risk of fluvial flooding 40
4.4 Flood risk and the 2009 allocations 41
4.5 Level 2 SFRA 45
4.6 Surface water flood risk 46

Appendices ..... **I**

A . Figures ..... **I**

B . Sequential Test Table ..... **II**

List of Figures

Figure 1 - LiDAR Coverage in Hartlepool BC 8
Figure 2: Hartlepool Borough with the rivers the relief map 12
Figure 3 - Seaton Carew flooding in 1922 15
Figure 4 - Breach of Greatham North embankment in 1978 17
Figure 5 - Candidate critical drainage area in the Middle Warren Watercourse area 23
Figure 6 - Candidate critical drainage area in Tunstall Farm Beck area around West Park 24
Figure 7 - Candidate critical drainage area in Tunstall Farm Beck area around Stranton 25
Figure 8 - Flooding in Stranton in 1900 25
Figure 9 - Candidate critical drainage area around The Stell near Seaton 27
Figure 10 - Tees Estuary Flood Zones and proposed allocations 41
Figure 11 - The Stell Flood Zones and proposed allocations 42
Figure 12 - Victoria Harbour Flood Zones and proposed allocations 44
Figure 13 Middle Warren Watercourse Flood Zones and proposed allocations 45

List of Tables

Table 1 - DEM availability 7
Table 2 - Extreme tidal level estimates for the Tees Estuary 13
Table 3 - Extreme tidal level estimates for Hartlepool Bay 13
Table 4 - Functional floodplain and candidate functional floodplain mapping 35
Table 5 - Summary of development sites at risk of fluvial flooding 40
Table 6 - Summary of development sites at risk of surface water flooding 40

1 Data Sources

1.1 Flood Zone Map

The Environment Agency Flood Zone Maps provide an overview of areas considered susceptible to flood risk in the study area as a result of fluvial and tidal flooding. These maps have been prepared in a consistent manner across England and Wales and provide an estimation of the extent of flooding for both the 1% and 0.1% annual probability (a.p.) events.

The Flood Zone maps were prepared using a methodology based on the national digital terrain model (NextMap), derived river flows (Flood Estimation Handbook (FEH)) and two dimensional flood routing.

The derived Flood Zone extents have been adjusted in some locations where the results are inconsistent with historical flooding extents, where more detailed flood mapping studies have been completed, or where there are known errors in the digital terrain model used. In Hartlepool Borough Council, the majority of fluvial and tidal Flood Zones have already been updated with the results of detailed flood mapping studies (see Section 1.3).

The Environment Agency Flood Zone Maps are precautionary in that they do not take account of flood defences and, therefore, represent a worst-case extent of flooding. They do not consider other forms of flooding and do not take account of climate change.

PPS25 divides the country into three basic flood zones, Flood Zones 1, 2 and 3, corresponding to areas of low, medium and high flood risk, respectively.

1.1.1 Delineation on Low Risk Zone 1

PPS25 considers areas within Flood Zone 1 to be at low risk to flooding. The annual probability of flooding within this zone is less than 0.1% or can be easily defined as areas within the Borough Council area located outside either Flood Zone 2 or 3.

1.1.2 Delineation of Medium Risk Zone 2

PPS25 considers areas within Flood Zone 2 to be at medium risk of flooding. The annual probability of fluvial flooding within this zone is between 0.1% and 1% (or between 0.5% and 0.1% for tidal flooding). In general, Flood Zone 2 is considered suitable for most development except highly vulnerable land uses where the Exception Test is required, such as police stations, fire stations and ambulance stations.

1.1.3 Delineation of High Risk Zone 3

PPS25 considers areas within Flood Zone 3 to be at high risk of flooding. PPS25 splits Flood Zone 3 into two sub-zones, 3a and 3b, which correspond to high probability flooding and the functional floodplain.

- Flood Zone 3a: High Probability

In accordance with Table D.1 of PPS25 “This zone comprises land assessed as having a 1% or greater annual probability of flooding or a 0.5% or greater annual probability of sea flooding in any year.”

- Flood Zone 3b: The Functional Floodplain

In accordance with Table D.1 of PPS25 “This zone comprises land where water has to flow or be stored in times of flood”

1.1.4 Delineation of the Functional Floodplain

SFRAs are tasked with the responsibility of defining Flood Zone 3b.

PPS25 suggests the 5% a.p. flood event for the baseline of a functional floodplain. However, a greater event can be used where appropriate, depending on catchment characteristics and on agreement between the LPA and the Environment Agency.

SFRAs can also identify where it might be appropriate to extend the 5% a.p. flood outline to areas within Flood Zone 2 and 3 to restore or expand the functional floodplain. The ability to identify and safeguard large enough areas against redevelopment and development in both urban and rural areas, means that existing open space can potentially be used for flood storage, effectively reducing flood risk downstream. This process assists Flood Zone 3 policy aims, identified in table D.1 in PPS25, which include:

- "Reduce the overall level of flood risk in the area through the layout and form or the development and the appropriate application of sustainable drainage systems,"
- "Create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocation and safeguarding open space for flood storage."

The SFRA should be fully integrated with CFMPs and other strategies that show, at catchment scale, the need to protect the floodplain and avoid inappropriate development in high flood risk areas.

1.2 Flood Defences

As discussed above, the Environment Agency Flood Zone maps do not take account of the presence of flood defences (although defended areas and the location of raised defences are included in the suite of information provided with the maps). PPS25[1] states that defended areas (i.e. those areas that are protected to some degree against flooding by the presence of a formalised flood defence) are still at risk of flooding, and therefore sites within these areas must be assessed with respect to the adequacy of the defences.

The Environment Agency's National Flooding and Coastal Defence Database (NFCDD) has been supplied and provides information existing defences in the area, as well as categorising them by type and providing information on who owns and maintains them. Areas Benefiting from Defences (ABDs) have also been provided. ABDs are those areas which benefit from formal flood defences in the event of flooding from rivers with a 1% a.p. event or from the sea with a 0.5% a.p. event. If the defences were not there, these areas would be subject to increased flood risk.

The River Tyne to Flamborough Head Shoreline Management Plan 2[2] was also used for an overview of the coastal defence and the future coastal defence management policy (see Volume I and the summary below). Hartlepool's engineers were also contacted for information on coastal studies, maintenance practices, conditions assessments and the standard of protection that the defences offer.

1.3 Flood Risk Management and Hydraulic Modelling Studies

Only one of the several 'main' rivers that pass through Hartlepool has been represented using detailed hydraulic models. The Flood Zones for this watercourse give a good representation of reality. However, there is no single comprehensive hydraulic model for each of the river systems. Flood Zones outside of the modelled reaches are still represented with broad scale modelling techniques used to produce the original Flood Zone map (and from a later tidal study) and are known to be prone to error.

[1] Communities and Local Government (2006) *Planning Policy Statement 25: Development and Flood Risk*, *Annex* G para G2.
[2] River Tyne to Flamborough Head Shoreline Management Plan 2, Final Report, North East Coastal Authorities Group, February 2007

The hydraulic models available in the area include:

- North Sea at Hartlepool (March 2008) – Produced from the Hartlepool Tidal Flood Risk Management Study. Uses a 2-D surface water model TUFLOW (two dimensional unsteady flow).
- Hartlepool Becks (Burn Valley Beck, The Slake, March 2008) – Used J Flow modelling but with LiDAR digital terrain model. Produced as part of the above FRM study.
- River Stell Watercourse 1989 – Section 105 Study, hydrodynamic model
- Tunstall Farm Beck Flood Risk Mapping Study (April 2005) – Hydrodynamic model

There is a 2D TUFLOW model of the Tees Estuary was produced by JBA Consulting for the NE RFRA which is not an Environment Agency Model. This will be used in this Level 1 SFRA to give an indication of what detailed tidal modelling of the Tees within Hartlepool would look like.

1.3.1 Tees CFMP

The Tees CFMP will be used to provide some evidence of flood history, flood risk locations and sources. This information will be of a broad scale nature so will need to be supplemented with other detailed information. The proposed flood risk management policy for different areas within the Borough will be noted in order to help assess if future development proposals are likely to be sustainable.

Between June 2007 and January 2008 JBA Consulting undertook strategic catchment modelling work for the Environment Agency, primarily for the Environment Agency's CFMPs in the North East (including the Tees CFMP). The modelling generated 19 new Flood Maps for approximately 10,000 km of watercourse, representing different flood events and assumptions about flood risk management measures.

This catchment modelling was also developed in order to update the parts of the Environment Agency's Flood Map for Flood Zone 3 where no detailed river modelling studies had been completed. This catchment modelling incorporates a number of improvements over the original Flood Maps, including the use of new LiDAR data in place of SAR (NextMap-Britain) data, where available. A number of different scenarios were modelled to represent when flood water would come out of bank e.g. for the 50% a.p. event. Both flood depth and flood hazard maps were included in these outputs.

It was initially thought that the SFRA could utilise these outputs to aid the delineation of Flood Zone 3b and climate change flood outlines where there is no detailed modelling. However, it has not been possible to find a scenario that aligns with the current Environment Agency Flood Zone maps. For example, Flood Zone 3b would be greater than Flood Zone 3a in places. This is because different modelling techniques were used for the different data sources. The Environment Agency have stated that it is critical for the functional floodplain outline to be as accurate as possible. However, the Environment Agency also state that as a precautionary principle, Flood Zone 3 should be used to represent Flood Zone 3b in undeveloped areas (until the functional floodplain can be accurately defined). See Section 3.2.1 for a detailed explanation of how the functional floodplain was derived.

The SFRA will use a flood depth map from this study for a broad scale overview of the potential flood depths in Hartlepool BC. It must be noted that these cannot be directly compared to the current Flood Zone extents, again due to the difference in modelling techniques adopted.

1.3.2 River Tyne to Flamborough Head SMP

A Shoreline Management Plan (SMP) provides a large-scale assessment of the risks associated with coastal evolution and presents a policy framework to address these risks to people and the developed, historic and natural environment in a sustainable manner. In doing so, an SMP is a high-level document that forms an important part of the Department

for Environment, Food and Rural Affairs (Defra) strategy for flood and coastal defence (Defra, 2001). The plan provides both broad scale assessment of these risks but also quite specific advice to operating authorities in their management of defences.

This SMP2 sets out the results of the first revision to the original Shoreline Management Plans for the area of coast extending from the River Tyne south to Flamborough Head.

The document will provide information on the current situation on the coastline, the proposed management policy and specific actions to implement this policy. This information will be used during the production of the Level 1 SFRA.

1.3.3 North East Regional Flood Risk Appraisal

A scoping study for the North East Regional Flood Risk Appraisal (NE RFRA) was completed by JBA Consulting in January 2009. The primary objective of the NE RFRA is to provide an appraisal of strategically significant flood risk issues and guide strategic planning decisions. The findings of this work will form part of the Regional Spatial Strategy evidence base.

1.3.4 2007 Tees Valley SFRA

An SFRA was completed for the Tees Valley local authorities in 2007. This SFRA was a good example of an SFRA produced prior to the publication of the PPS25 Practice Guide, but it needs updating to reflect the new guidance.

The majority of the flood mapping that was used in the 2007 SFRA has now been updated. However, the 2007 SFRA will be used for additional flood history and flood risk location information (where available).

1.3.5 Draft Tees Tidal Flood Management Strategy

The Environment Agency has produced a flood risk management strategy for the Tees Estuary[3]. The aim of this study is to determine a sustainable plan for managing flood risk within the Tidal Tees Estuary for the next 100 years. The first stage of the plan is to identify the key risks and measures to manage them along with further studies to build on our understanding. This draft study will be used to obtain the extreme tide levels for the Tees Estuary. This includes estuarine water levels allowing for predicted sea level rise due to climate change. The Tees Tidal Strategy will also be used to gain a better understanding of the Tees Estuary and the flood risk it poses to the Borough. The proposed flood risk management options will also be considered and how this may affect future development.

1.3.6 Seaton Carew Coastal Strategy

A coastal strategy for Seaton Carew[4] is currently being undertaken, this should eventually lead to a flood defence improvement scheme in line with the SMP2 management policy.

- Stage A has been completed and is a coastal flood defence condition and performance assessment;
- Stage B will provide a technical assessment of the coastline; and
- Stage C will recommend the preferred long-term strategy to be adopted, in which short-term priorities will be highlighted.

1.3.7 Hartlepool Coastal Strategy

A Project Appraisal Report (PAR) was the latest report to be completed as part of the Hartlepool Coastal Protection Strategy[5]. The aim of the strategy was to investigate and recommend a sustainable and justified coast protection strategy for the Hartlepool coastline (from North Sands in the north to Newburn Bridge in the south).

[3] Draft Tees Tidal Flood Risk Management Strategy, Environment Agency, February 2008
[4] Seaton Carew Coastal Strategy, Stage A - Condition and Performance Assessment, Hartlepool BC, August 2009
[5] Project Appraisal Report, Hartlepool Coastal Protection Strategy, Hartlepool BC, January 2006

The information contained in the PAR has been compiled from three report texts produced as part of the strategy:

- Stage A – Site Assessment, 2003;
- Stage B – Technical Assessment, Oct 2005; and
- Stage C – Strategy Report, Oct 2005.

Since the PAR was completed, the SMP2, which includes this part of the coastline has been produced. The SMP2 will have used the information in the strategy to summarise the preferred flood risk management policy for the Hartlepool coastline.

1.3.8 Hartlepool Tidal Mapping Studies

In 2004 a Phase 1 Coastal Flood Risk Study was completed for Hartlepool[6]. This was an initial assessment with a few recommendations. Following this, a tidal flood risk mapping study was completed for Hartlepool[7].

This study produced new tidal Flood Zone 2 and 3 outlines for the Hartlepool coastline (using tidal modelling and wave overtopping analysis). These new flood outlines showed a significant decrease in the overall flood risk compared to the previous Flood Zone maps (see the Hartlepool SFRA Scoping Study for an example). The principal reason for the significant decrease in flood risk area is the use of improved LIDAR rather than NEXTMap data to represent ground levels (see section 1.4). The 2007 SFRA used the superseded, more extensive Flood Zones for the assessment as these were the most up to date at the time.

During this study, simplified fluvial modelling was also undertaken for some of the becks passing through Hartlepool (Burn Valley Beck and The Slake). This is more accurate than previous Fluvial Flood Zones (as LIDAR was used) but the extents should still be viewed with caution.

There is some tidal flood history in these reports which will be used to inform this SFRA.

1.3.9 River Stell Study

A study was completed for the River Stell (between Hartlepool and Seaton Carew) for the Environment Agency in 1998[8]. Hydraulic modelling was completed for this study and the modelled extents have been integrated into the Environment Agency's Flood Zone maps. However, there is no historic flooding information included in this study.

These modelled flood extents are now over 10 years old and will probably need updating in the future due to the availability of new topographical data and the adoption of new hydrology estimation techniques.

1.3.10 Tunstall Farm Beck

Floodplain Mapping Study

Tunstall Farm Beck passes through a small part of west Hartlepool. A floodplain mapping study was completed by the Environment Agency for Tunstall Farm Beck in 2005[9]. This study produced flood risk maps for the watercourse by constructing a 1D hydraulic HEC-RAS model. This included calculating new flood flow estimations. The modelled flood extents have been included in the Flood Zone maps and the flood history information will be included in this SFRA.

[6] North Sea Section 105 Phase 1 Study, Environment Agency, August 2004
[7] Hartlepool Tidal Flood Risk Mapping Study, Environment Agency, March 2008

[8] The River Stell And North Sea Coast At Hartlepool, Volume 1 Main Report, Environment Agency, July 1998

[9] Dales Area Floodplain Mapping, Tunstall Farm Beck, Environment Agency, March 2005

Prefeasibility Study

Following the floodplain mapping study of Tunstall Farm Beck, a prefeasibility study (i.e. assessing the viability of a flood alleviation scheme)[10] was undertaken. The original model produced for the mapping study was used to assess the risk and the possible options for reducing flood risk. The preferred flood risk management options will be used in the defences section of this study along with any additional flood history.

1.3.11 Hartlepool IUD Pilot

Hartlepool was chosen by Defra as one of the pilots of the Integrated Urban Drainage (IUD) pilots. The study was completed in 2008[11].

The study looked to assimilate all available data impacting on urban drainage issues in the Hartlepool catchment. The pilot study has looked at how potential solutions to hydraulic, structural, operational and maintenance issues and prioritised solutions to problems in the catchment could be implemented.

Amongst other things, the final study completed the following:

- Identified and collated a number of sources of drainage data.
- Developed an “interactive visual database” of the data.
- Created an IUD plan which included reports focussed on 3 study areas.

The three areas of focus (due to the nature of flooding and future development pressures) were:

- Middle Warren (Middle Warren Watercourse)
- Valley Drive (Tunstall Farm Beck)
- The Stell

The report contains mostly general information on the methods adopted but there was some specific information on drainage and sewer flooding problems, which included the production of modelled sewer flood extents. However, limited validation of the flood extents has taken place by way of comparison with known issues and historical information.

The baseline historical flooding data from the different stakeholders and the modelled sewer flooding outlines have been requested for this SFRA. Hartlepool BC was able to provide the flooding locations and flow pathways but there is no information on the type and mechanism of flooding. The sewer flooding extents were not provided. The information provided will be of used when attempting to identify critical drainage areas.

1.4 Topographic Data

The essential dataset required for flood modelling, mapping and general elevation information is a Digital Elevation Model (DEM). There are two main types of DEM data for the Borough, as shown in Table 1.

Table 1 - DEM availability

Type	Source	Grid	Filtered	Year
NEXTMap SAR	Environment Agency	5m	Filtered	-
LIDAR	Environment Agency	2m	Filtered and unfiltered	Jan 2000, Oct 2001 and Dec 2003

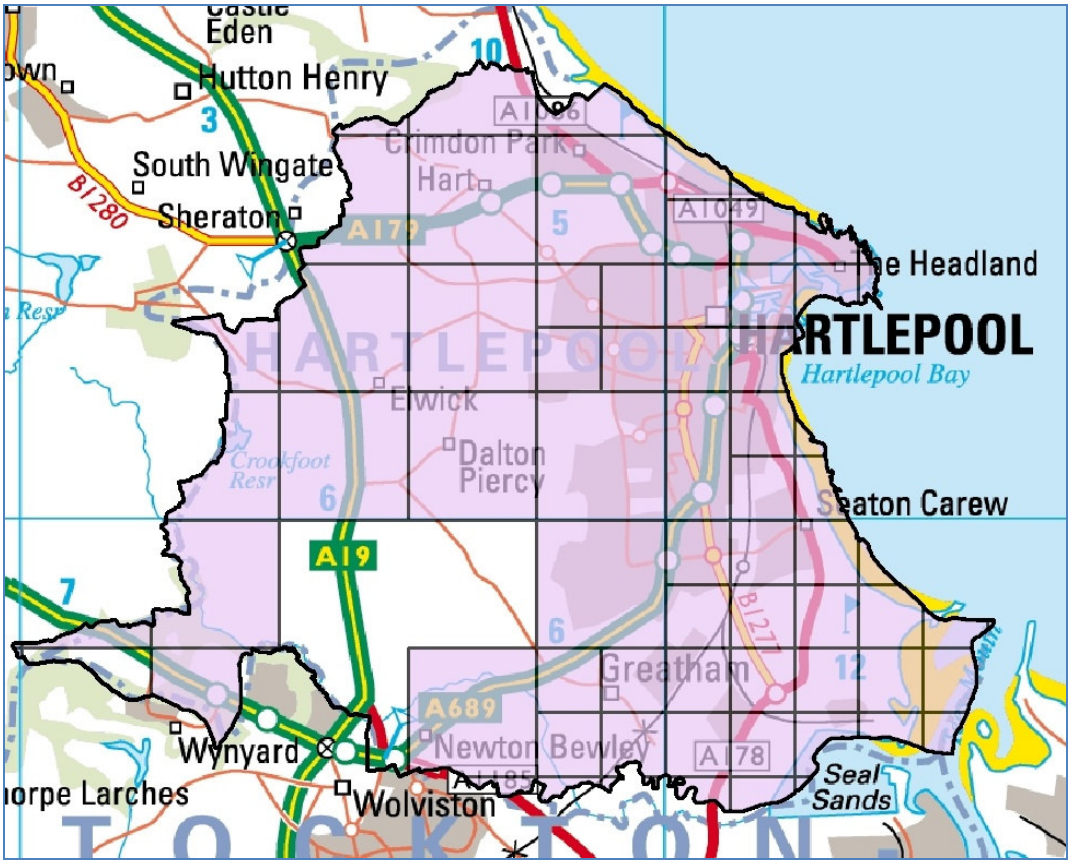
[10] Tunstall Farm Beck, Pre-Feasibility Study, Environment Agency, December 2006

[11] Hartlepool IUD Pilot Study Catchment, Final Report Volume 1, Defra, June 2008

Type	Source	Grid	Filtered	Year
LIDAR	Environment Agency	1m	Filtered and unfiltered	Dec 2008 and May 2009
LIDAR	Environment Agency	0.5m	Filtered and unfiltered	May 2006

LiDAR will be used in preference to NEXTMap SAR data as it has a higher vertical accuracy. The coverage of the LiDAR datasets available is shown in Figure 1. The larger squares show the availability of 1m and 2m resolution LIDAR. The smaller squares show where the higher resolution 0.5m LIDAR is located. The area not in pink within the study area identifies data gaps in the LIDAR coverage.

Figure 1 - LiDAR Coverage in Hartlepool BC



1.5 Historical Flooding

There are a number of sources of historical flood information. The majority of historical data collected was received from key stakeholders during the SFRA consultation process or on review of past flood studies in the area. Studies providing details on flood history include:

- 2007 Tees Valley SFRA
- Tees Catchment Flood Management Plan (CFMP)
- The floodplain mapping and prefeasibility studies described earlier
- Tees Tidal Strategy
- The Hartlepool Coastal Strategies

The British Hydrological Society's Chronology of British Hydrological Events provides some limited descriptive information of past flooding events in the Tees Valley. This goes back many centauries but is more consistent after 1700. The recorded events relevant to Hartlepool are general Tees Estuary flooding incidents. There is no history on the smaller fluvial watercourses that pass through Hartlepool.

Key holders of historical flood data are discussed below. All data collected has been combined to provide a historical flooding GIS based dataset. This has been mapped for the SFRA and can be used by the LPA for future development planning and can be supplied to developers for site specific Flood Risk Assessments. The historic flood risk locations are shown with the PPS25 Flood Zone maps in Appendix A, Figures A1 to A5.

1.5.1 Environment Agency

The Environment Agency is a key source of all flood risk information in England and Wales. As part of the Flood Map, the Environment Agency provides a national historical flood map layer. This should show the location of recorded historical flood events. However, the information provided did not identify any incidents in Hartlepool BC. This was followed up with the Environment Agency, but they were unable to provide any historical flooding information for Hartlepool.

This SFRA will mainly rely on information obtained from other organisations to identify historical flooding hotspots. As flood risk management is not the primary purpose of this organisations (i.e. Fire Brigade) the level of detail, amount of information, quality and accuracy of data can vary. However, this data can prove very useful, especially when considering other sources of flooding than fluvial and tidal e.g. surface water flooding. As stated previously, the Hartlepool IUD Pilot will be an important source of information. These key organisations and data sources are discussed below.

1.5.2 Hartlepool Borough Council

Local Authorities can be an important source of historical flood information but the amount of information varies, depending on whether the local authority has a dedicated team.

Hartlepool Borough Council have a team of engineers which cover flooding, drainage and coastal protection amongst other things. This team were able to provide the coastal strategy studies and CAD drawings for the main flood risk locations in Hartlepool.

This team also had responsibility for the Hartlepool IUD Pilot. This is described in 1.3.11 and some of the information is used in the surface water flooding section. Hartlepool BC's engineers agreed to send the historic flooding locations and the sewer flooding extents for this study. If this arrives in time it will be used for this Level 1 SFRA.

In addition, during the 2007 SFRA, Hartlepool BC provided GIS themes showing problem watercourses and areas flooded. This information had been archived by JBA but was made available for this study. This dataset includes 18 flooded areas and 12 problem watercourses including incidents form surface water and fluvial flooding. This will also be useful data source to compare with the Environment Agency's theoretical surface water flooding maps.

1.5.3 Cleveland Fire Brigade

Cleveland Fire Brigade has provided geo-referenced data in spreadsheet format of all water related call outs since 2003. This has been edited (excluding burst pipes etc) to 31 flooding incidents and converted to GIS. These locations have also been mapped along with all other historical data collected.

1.5.4 Cleveland Emergency Planning Unit

Cleveland Emergency Planning Unit (EPU - a consortium of emergency planners covering the Cleveland local authorities) provided a list of historic flooding locations. This Unit only responds to large scale events, where coordination of different emergency response organisations is required. As a result, none of this data was specific to Hartlepool BC (apart from some general tidal flooding records).

However, the Cleveland EPU did provide addresses of recorded flood incidents from the 17.07.09 surface water flooding event, some of which included Hartlepool BC. This has been converted to GIS and will be used in conjunction with the surface water flooding maps and to assess flood risk across the borough.

Included in the EPU data were flood risk incidents recorded by the policy during the 17.07.09 flooding event.

1.5.5 Other sources

The Highways Agency and Northumbria Water were contacted for flood risk information.

Northumbrian Water (NWL) has not been able to provide any information until recently. After having a meeting with NWL it was agreed that they would send DG5 (sewer flooding data) at drainage area level. The drainage areas have also been highlighted according to the level of risk. The data is at quite a high level but NWL have confirmed they will provide the next level of DG5 information (area and street level) at a Level 2 SFRA stage. A Level 2 SFRA should be able to identify those issues NWL have actually dealt with or those which will definitely need further work. Using this information, more precise recommendations for Surface Water Management Plans (SWMP) can be provided within a Level 2 SFRA. These recommendations should then be use to start SWMP work. The initial DG5 data from NWL will be integrated into the final version of this SFRA.

A-One, the Highways Agency contactor for the A1 and A66, provided a large amount of data for the area. There were no recorded flood incidents in Hartlepool Borough.

2 Flood Risk in the Borough of Hartlepool

2.1 Introduction

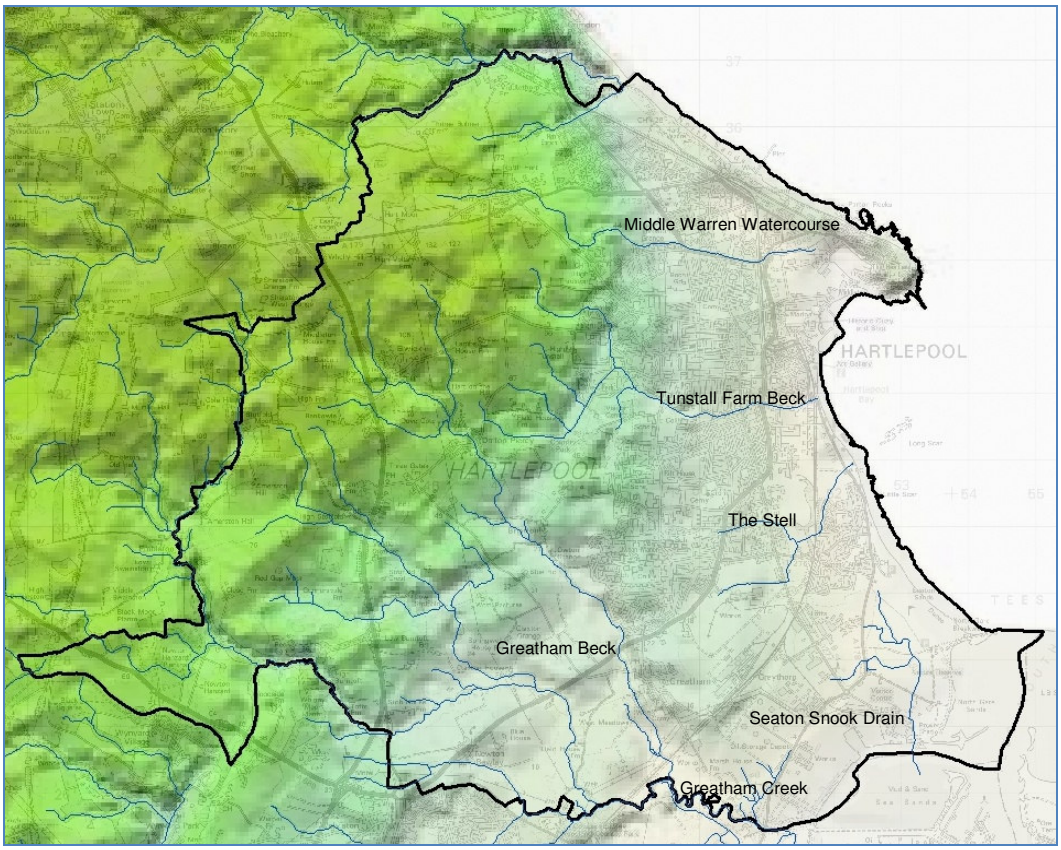
There is a need to understand the risk of flooding from all sources in the Borough, consider where the highest risk locations are, and plan future development and regeneration accordingly.

This section assesses flood risk in the Borough from all sources, now and in the future. It makes use of all the data and information described in Chapter 1, including tidal and fluvial Flood Zones and assesses flood risk from other sources. The aim of this is to provide enough information for the Council to perform the Sequential Test.

The historic flood risk information collated during this study shows the distribution of other sources of flooding, the main being surface water flooding (see Figures A1 to A5 in Appendix A).

The Tees Valley CFMP states that the major overall risk of flooding for this policy unit comes from the risk of tidal flooding from the North Sea. Actual and potential flooding sources include the fluvial flooding on Burn Valley Beck, Middle Warren Watercourse, sewerage system (in particular at High Tunstall), highway drainage system, tidal ingress, watercourses, overland flow, and culvert blockages.

Figure 2: Hartlepool Borough with the rivers the relief map



2.2 Tidal and coastal flooding

The Tees Estuary marks the south east boundary of the borough. The boundary then follows Greatham Creek which is also tidal. The eastern boundary of Hartlepool BC is the North Sea. This south east part of Hartlepool BC is vulnerable to high sea levels in the

Tees Estuary and the eastern part is directly at risk of flooding from the sea. This can arise from a combination of high tides, storm surge, the action of waves and, in some cases, the joint impact of fluvial flows and tidal levels.

Greatham Creek and Seaton Snook discharge directly into the Tees Estuary in a very low lying area. This means that these watercourses are predominantly tidal. Several watercourses flow directly into Greatham Creek (including Greatham Beck). These watercourses are also tidal in their lower reaches. There is some industrial development that may be affected by these tidal watercourses, but this area is generally sparsely populated.

The next sections describe the flood risk and flood history directly from the sea (predominantly at Hartlepool) and from the Tees Estuary. Some of the information on the risk to Hartlepool is taken from the tidal mapping studies while flood risk from the Tees Estuary is taken from the Tees Tidal Strategy.

2.2.1 Extreme tidal flood levels

When considering tidal flood risk in allocating and building development in Hartlepool BC, a key data source is the accepted extreme tidal flood levels for the area in question. The Environment Agency accepted levels are described below.

Extreme tide levels for the Tees Estuary, shown in Table 1, have been taken from the Draft Tees Tidal Flood Risk Management Strategy (Environment Agency, February 2008). These levels (and climate change levels) are the current Environment Agency recommended levels for assessing tidal flood risk in the Tees Estuary area.

Table 2 - Extreme tidal level estimates for the Tees Estuary

Return period (years)	Annual probability (%)	Level by Year (m AOD)				
		2007	2025	2055	2085	2017
200	0.5	4.19	4.23	4.44	4.74	5.07
1000	0.1	4.40	4.45	4.66	4.96	5.29

Extreme flood levels from the Hartlepool tidal flood mapping study should be used for the coastline to the north, away from the estuary. During this tidal mapping study, new extreme sea levels were estimated for two points in the Hartlepool region. One is for Hartlepool Bay and one is for Hartlepool Headland. As the Hartlepool Bay point is closest to the main areas of tidal flood risk, this will be quoted for the SFRA.

Table 3 - Extreme tidal level estimates for Hartlepool Bay

Return period (years)	Annual probability (%)	Level by Year (m AOD)				
		2007	2025	2055	2085	2017
200	0.5	4.76	4.81	5.02	5.32	5.60
1000	0.1	4.95	5.00	5.21	5.51	5.79

The tidal Flood Zones should be based on the above levels. However these levels change as new data and guidance are introduced and sometimes the Flood Zone maps have not been updated.

This is the case for the Tees Estuary, the new levels are available (Draft Tees Tidal Strategy), but the Flood Zones have not been updated. Using the new levels and better modelling techniques may give very different flood extents. A draft flood extent has been produced for this SFRA using the new levels and a broad scale TUFLOW tidal model. This is discussed later in Chapter 3.

The tidal Flood Zones around Hartlepool have been updated with detailed modelling and the latest levels.

New UK and Western Europe Extreme Tide Levels

A new database of extreme sea level estimates for the whole of Ireland, the UK and Western Europe (Extreme Sea Level Explorer) is currently developed. This project will produce a spatially consistent and accurate database of extreme sea level estimates for all open coasts, estuaries and tidal rivers. These levels will be based on both model and gauge data and the latest statistical techniques available. The levels will eventually replace all of the existing extreme sea level predictions, including the levels quoted above for Hartlepool and the Tees Estuary.

This data is expected to become available in 2010 and should be incorporated in any future flood risk modelling work.

2.2.2 Hartlepool coastal flood risk

The Tees CFMP states that the main overall risk of flooding for Hartlepool is tidal flood risk from the North Sea.

The Tidal Flood Risk Mapping Study identifies two principal areas of tidal flood risk in Hartlepool. The first area is in the vicinity of the South Marina/Church Street area, where wave overtopping could lead to significant flooding of residential and commercial property, key roads (A178/Corronation Drive, Mainsforth Terrace and Maritime Avenue) and the railway line that passes through this area. The second key area at risk of flooding is the Croft on Heugh area, where wave overtopping from the Town Wall defences and the Victoria Harbour quays could lead to significant flooding of residential property east of Victoria Harbour and the primary road leading into this area (West View Road).

All sources of flood risk identified within the tidal flood mapping study (which formed the new tidal Flood Zones) are associated with wave overtopping. There is no still water flooding expected for Hartlepool (see 0.5% and 1% AEP levels quoted in Table 3), even if all flood defences were removed or breached. However, future flood levels mean still water flooding would occur in Hartlepool if flood defences are not maintained or they breached during an event.

The new tidal Flood Zones (version 3.15, September 2009) produced during the flood mapping study shows a significant decrease in overall flood risk area compared to the old tidal Flood Zones which were used in the 2007 SFRA. The principal reason for the significant decrease in flood risk area is the use of improved LiDAR ground level data. The exception to this is a new area identified as at risk of flooding from the sea in the Old Town area of Hartlepool.

Coastal Flood History

The only flood history that could be found of coastal flooding Hartlepool was from the 2004 Coastal Flood Risk Study. The date of the event is unknown, but 42 properties were reported to have flooded due to overtopping of the Town Wall. There were approximately 600mm deep flood waters for 24 hours. The confidence level in this data is low.

2.2.3 Seaton Carew tidal flooding

An internet search found evidence of flooding at Seaton Carew in 1922 (see the photos in Figure 4). Seaton Carew is at risk of flooding from a number of different sources including surface water, sewer and surcharging culverts. These are discussed later in The Stell fluvial and surface water flood risk sections.

From looking at the extent of flooding in the photos it looks as though the flooding in 1922 was due to tidal flooding. The south east part of Seaton Carew is shown to be at risk of tidal flooding according to the Environment Agency Flood Zones. The most likely flow pathway is from Seaton Sands. The potential flow pathway to Seaton Carew from the Tees Estuary is blocked by the North Gare Breakwater.

There is now coastal defences adjacent to Seaton Carew and a coastal strategy is being undertaken which will eventually lead to an improved defence scheme.

Figure 3 - Seaton Carew flooding in 1922

Source: portcities.hartlepool.gov.uk - accessed October 2009

2.2.4 Tees tidal flood risk

It is recognised that as well as flooding directly from the North Sea, parts of Hartlepool BC are at risk from the Tees Estuary. The risk is not as severe as the neighbouring Stockton BC as the main estuary travels through Stockton rather than Hartlepool BC. In addition, there is less development alongside the estuary and the linked Greatham Creek in Hartlepool BC. Much of the area is used for agricultural grazing and there are two sluices that allow land drainage. However the area at risk includes a nuclear power station and a

large chemical processing plant (Huntsman Tioxide - which contributes 3.3% of the world's production and almost 50% of the UK's production of titanium dioxide). Due to the significant importance of the power station and the Tioxide plant, the Tees Tidal Strategy states that the area may be protected by flooding in the future. Section 2.10.1 provides more details on the future flood risk management strategy here.

Within the Tees Estuary, mean high water springs are 2.7m AOD and the highest astronomical tide is 3.3m AOD. The highest recorded water level of 4.0m on the Tees Estuary was a result of a large tidal surge (1953 event).

According to PPS25 sensitivity ranges, sea levels on the Tees are forecast to rise by 255mm over the next fifty years as a result of climate change. Although stormier conditions can be expected in the future, any impact in terms of increased wave heights within the estuary adjacent to the Borough will probably be of little consequence compared with the impact of sea level rise.

The dominant tidal risk is from the main estuary around Tees Mouth and north of Seal Sands. But tidal flood risk can also occur as a result of concurrent high river flows and tide-locked streams (Greatham Creek, Claxton Beck and Seaton Snook).

The region shown to be at risk from the Environment Agency's Flood Zone maps includes the areas around Seaton Sands, the nuclear power station, the Oil Storage Depot.

Tees Tidal Strategy

The Draft Tees Tidal Strategy has presented preferred options for the future management of tidal flooding in this area. This is focussed on the risk from Greatham Creek. The preferred option is to hold the existing flood defence line in the north east area and realign the embankment in the north-west to the edge of the A178. The existing defences in the western area of Greatham North are to be abandoned as the preferred option involves setting back the defence line. It is recommended that this is implemented within the next 5 years

The Draft Strategy notes that the A178 is very well used and there may be plans to upgrade the road which could present an opportunity to work in partnership with the highways authority when realigning the defences.

The Draft Strategy also proposes to provide compensatory habitat in the part of the tidal risk area, north of Greatham Creek.

It is important to be aware of what future flood risk management is being planned for this area as it may impact on the residual risk associated with future development and whether of not that site will be sustainable. There may also be multiple benefits between the Draft Strategy and the SFRA e.g. developer contributions to any improved flood defences and transport improvements following the proposed realignment of the defences at the A178.

The existing chemical processing plant and nuclear power station may also make this whole area more sustainable as it is unlikely that this area will be abandoned due to the presence of these important industries. If flood risk can be managed safely, further development could be approved around the existing infrastructure. This would be covered in a Level 2 SFRA.

Tees Tidal Flood History

There is a long history of flooding from the Tees Estuary but as explained, the consequences of flooding in Hartlepool appears to be low as the tidal flood risk area has remained predominantly undeveloped. This therefore does not mean that Hartlepool BC is not at risk of flooding from the Tees Estuary. Specifically, the Greatham Creek flood embankments have failed several times relatively recently. Some of the major tidal events recorded may also have affected Hartlepool BC but as no properties were affected flooding in Hartlepool BC may not have been recorded. As this is an area that already has some nationally important industrial development and future development may be

proposed here. It is therefore important to document any tidal flood history that may have impacted this area.

- 1953 - An area of low pressure, in conjunction with north westerly winds and a spring tide, caused a large surge. There were two breaches of the embankments at Greatham Creek. The peak water level was 4.01m AOD at the Tees Estuary. According the current predictions (see 2.8) this event has a 1% a.p.
- There was also a tidal breach of Greatham Creek North Bank and South Bank defences downstream of the A178 bridge in January 1978.
- In February 1983 there was another breach of Greatham South flood defence embankment upstream and downstream of the A178. This event had a peak water level of 3.65m AOD, which is a 10% a.p. event, according to the latest extreme tide levels.

Figure 4 - Breach of Greatham North embankment in 1978

Source: Tees Tidal Strategy. 4% AEP event with a peak water level of 3.77m AOD downstream of the A178

2.3 Fluvial flood risk

Hartlepool BC contains a number of small watercourses including the urban tributary streams of the River Tees. In terms of topography, Hartlepool can generally be spit into two distinct areas. The eastern part is very flat low lying, whilst the western part is generally more undulating and higher (see Figure 2). However, the upland to the west rarely rises above 140m AOD. This also splits the development, with the urban area of Hartlepool in the low lying east and the undeveloped upland to the west.

The majority of Hartlepool's rivers begin in these low hills. This means the river catchments are quite small and would not be subject to large amounts of rainfall or particularly severe rapid rainfall runoff events. However, as the river catchments are small, they are likely to have a relatively quick river response to rainfall. This is confirmed in the Tees Valley CFMP which states that the time of rainfall to peak flood flows for the rivers in Hartlepool are two hours but the flow velocities are moderate.

Flooding problems are likely to occur when the watercourses reach the dense urban area of Hartlepool in the east. This area is heavily developed so there will be many features that are likely to increase flood risk such as blockages at bridges and culverts. This area is

also very flat which means fluvial and surface water flows may struggle to drain into the sea and end up pooling in low lying areas.

The primary watercourses in Hartlepool BC are Tunstall Farm Beck (Burn Valley Beck) and the Middle Warren Watercourse, which drains into Victoria Harbour. This watercourse is culverted for much of its length and in part is denoted as a surface water sewer and part of Northumbrian Water's (NWL) surface water drainage system. Tunstall Farm Beck (south of Middle Warren Watercourse) drains from the east of Dalton Piercy and enters the combined sewer and flows down Burn Road into the pumping station at Mainsforth Terrace. The outfall is utilised as an overflow from the Mainsforth Terrace Pumping Station. Greatham Beck is also a significant watercourse. It is tidal in its lower reaches, but presents a fluvial flood risk further inland.

2.3.1 Middle Warren Watercourse

Middle Warren Watercourse passes through the north part of Hartlepool flowing west to east before discharging into Victoria Harbour. This watercourse is part open and part culverted.

The new fluvial Flood Zones produced during the Hartlepool Tidal Flood Mapping Study included some broad scale modelling of Middle Warren Watercourse (see section 1.3 and 1.3.8 for the modelling description). The modelling indicated that, during an extreme event, flooding from Middle Warren Watercourse could affect residential property, a Hospital and an industrial estate north of the Dyke House area. Flooding from Middle Warren Watercourse could also affect the A179/Easignton Road.

In addition, flooding from an unnamed watercourse to the south of Middle Warren Watercourse could affect a significant number of properties from the B1277 eastward to the pumping station. It should be clarified that that this is what the mapping shows but in reality this watercourse is pumped, allowing water to be removed from the channel during high tides.

Middle Warren Watercourse Flood history

The Tees Valley CFMP shows two historic flooding incidents for this watercourse, one at Throston Grange and one near to the outfall into Victoria Harbour.

2.3.2 Tunstall Farm Beck (Burn Valley Beck)

Tunstall Farm Beck has it source close to Dalton Piercy, 1.75km to the southwest of West Park in Hartlepool. Two tributaries drain into the left bank of the beck. The beck flows northeast alongside Valley Drive in West Park in a concrete channel with gardens and housing on either side. The watercourse is enclosed within culverts beneath houses and roads for large sections further downstream.

The Environment Agency flood mapping study shows that Tunstall Farm Beck has the potential to flood to following locations:

- The upstream end of Valley Drive
- Meadow Drive and Carisbrooke Road area
- Egerton Road and West Park area

Tunstall Farm Beck eventually joins a public sewer which outfalls into the North Sea. The entrance to this sewer is covered by a trash screen which is prone to blockages. This fluvial flood risk area is also recognised as a problem surface water flooding system. This is discussed further in Section 2.4.2.

Tunstall Farm Beck Flood history

Flooding to Valley Drive Road occurs due to overtopping at the confluence with one of the tributaries upstream of Valley Drive. This is reported to happen on numerous occasions every year.

There are several flooding locations recorded by the Fire Brigade and the Tees Valley CFMP, along the watercourse. The two fire brigade incidents occurred in 2003 and 2007, one upstream where the watercourse is open and one further downstream from the public sewer.

2.3.3 The Stell

This heavily modified watercourse passes through Seaton Carew and Hartlepool flowing southwest to northeast. Some sections have been straightened and large sections are culverted. The Stell discharges into the North Sea and is prone to tide locking.

The Stell system is considered to be part of an urban drainage problem area. The surface water flooding issues are discussed in Section 2.4.2.

The Stell Flood history

Historical flood records from the Fire Brigade show that a flood incident occurred on The Stell in August 2004.Other than this, there is little recent flood history associated with this watercourse. However, there are other flood risk locations nearby which may be related to the Stell system (discussed in section 2.4.2).

2.3.4 Greatham Beck

Greatham Beck is one of the longest watercourses in Hartlepool BC. It originates in to the west of the borough and flows southeast towards the Tees Estuary. It passes through Elwick and Dalton Piercy and then alongside the southwest side of Hartlepool town. Greatham Beck eventually flows into Greatham Creek which is fully tidal.

Unlike the other watercourses in Hartlepool, Greatham Beck is predominantly open and any flooding is more likely to be due to capacity issues rather than surcharging and blockages of significant structures.

Greatham Beck Flood history

The CFMP shows a historic flood risk location where Greatham Beck passes Hartlepool near the A689. Other than this, there are no other recorded flood incidents available.

2.4 Surface water flooding

2.4.1 Introduction

The Hartlepool Integrated Urban Drainage (IUD) pilot, completed in 2008, started the process of surface water management in Hartlepool. The IUD looked at three areas in detail and included the use of sewer modelling to produce recommendations for future management of the system.

The government is now encouraging all local authorities to undertake surface water management plans (SWMPs). The SWMP will be the key study for all types of surface water flooding in a local authority area. The majority of SWMPs will start to be developed in 2010.

This Level 1 SFRA aims, to some extent, to continue with the work already completed in the IUD and set Hartlepool up for any future SWMP. This can be done be collecting and using the surface water flooding data that has already be collected during the IUD pilot and by contributing to the conclusions already made to the three areas studied.

Ultimately, the Level 1 and Level 2 SFRA (if required), will identify Critical Drainage Areas (CDAs), through consultation with Northumbrian Water (NWL). Section 2.4.2 provides more details on this process.

2.4.2 Surface Water Flooding in Hartlepool

As Hartlepool is urban in nature, there are a significant number of obstructions which stop or slow down rainwater naturally entering neighbouring watercourses or the local drainage system. The volume of runoff can also cause significant flood risk in urban areas as the drainage system can become surcharged producing local overland flow routes and/or areas of stagnant water around naturally lower areas of land.

The Environment Agency's national Areas Susceptible to Surface Water Flooding maps can strategically identify these flow pathways and pooling locations. Validating this data with historic surface water flooding locations collected can give a more accurate picture of the actual risk and help identify key surface water flooding systems. This information can be used to identify Critical Drainage Areas (CDAs) and are discussed in section 2.4.2.

The distribution of these surface water flooding locations can be seen in Figure A, Appendix A1 to A8.

In addition, Hartlepool has a system of surface water and foul sewers. This is primarily a pumped system as the drainage infrastructure is affected by tide levels. The topography of the urban area (where the majority of the sewerage infrastructure is) is relatively flat and located near the coast. Due to the shallow gradient within the Hartlepool area, 28 pumping stations are utilised to direct the sewer flows. The sewerage system is predominantly a gravity/pumped system and drains to Seaton Carew sewage treatment works (STW).

Information from the Hartlepool IUD Pilot, the historic flooding locations and the surface water susceptibility maps have been combined to assess surface water flood risk in Hartlepool BC.

2.4.3 Specific locations at risk

Middle Warren Watercourse and Middle Warren

The 2007 SFRA noted that the Oakesway Industrial Estate has drainage issues. This location is adjacent to the culvert that carries Middle Warren Watercourse. The problem is related to a box culvert overflow (relief storm overflow which goes to the beach) being blocked with sand, resulting in flooding. This is noted as a major problem area related to NWL.

The 2007 SFRA also identified drainage problems at Victoria Harbour (which Middle Warren Watercourse flows into). There is a surface water pipe here which is believed to be damaged/blocked and causes ponding on the highway. The pipe is also prone to overloading due to the volume of runoff from a nearby site.

The Hartlepool IUD Pilot identified Middle Warren as one of their three study areas. Middle Warren is just to the north of Middle Warren Watercourse which flows as an open watercourse, before flowing into a culvert shortly after. The surface water sewerage system is likely to be linked by some degree to Middle Warren Watercourse. However, the sewerage is linked to the treatment works which is further up the coast at Victoria Harbour than the Slake outfall. Issues with the Middle Warren area, as identified by the IUD Pilot, include:

- The treatment works outfall on the beach and the interface with marine environment
- Proposed new development and changes to existing development plans including the potential redevelopment of a strategic site (hospital)
- Flooding to properties and highways
- Ownership of large diameter surface water culvert / sewer known as the Northern Area Main Drain

Valley Drive and Tunstall Farm Beck

Valley Drive was one of the three areas looked at in the IUD Pilot. This system is related to Tunstall Farm Beck which is described in section 2.3.2 and is a combined fluvial and surface water flooding issue.

Issues in this area include flooding from multiple sources, to properties and highways. One of the main reasons for this is overtopping of Tunstall Farm Beck at the upstream end of Valley Drive (in West Park) and surcharging of the culvert at locations downstream (Valley Drive, Carisbrooke Road). A secondary flooding mechanism issue is the gradient of the system. Some works have been undertaken to improve capacity of this culvert.

In addition to surface water flooding from this watercourse, there is a risk of flooding from backing up of the public sewer culvert here due to blockages at the trash screen. It is likely that any flood water from the sewerage system runs off into Tunstall Farm Beck. The last major flood from this system was in 2003 but some properties in West Park and Park Drive are flooded regularly from backing up of the sewer. The IUD Pilot noted that the gullies in West Park are drained to a combined sewer and not the beck.

The Stell

The 2007 SFRA notes that at a location called Golden Flatts in Hartlepool has a highway drain which is prone to blockages. This is located by The Stell culvert.

Just to the north of this, at Sovereign Park there is another drainage issue affecting a number of properties. This is located close to a minor watercourse which flows into The Stell, but the 2007 SFRA noted that it is a NWL issue.

The 2007 SFRA also makes note of an NWL drainage problem relating to the headworks located at Seaton Carew. When the headworks fail, water continues to be pumped there causing water and raw sewerage to back up and eventually to come up through the ground. Several existing locations in the area are affected including The Front, Seaton and South End.

The Stell was one of the three problem areas considered in the Hartlepool IUD Pilot. This area was chosen because of the proposed new development and flooding from multiple sources to properties and highways. NWL have undertaken major works in recent years (2006-2007) to resolve issues at Honiton Way and Boston Close with further schemes currently being prioritised. The issues identified in this area includes:

- Sewer network issues (e.g. blockages)
- Surface water drainage issues
- Changes in land use and uncertain re-development plans
- The potential for managed retreat of the coastal defences

2.4.4 Candidate Critical Drainage Areas

SFRAs provide the opportunity for local authorities to assess, at a strategic level, the risk from multiple sources of flooding, which can then feed into more detailed assessments where appropriate by both themselves and other operating authorities. This includes the identification of Critical Drainage Areas (CDAs). CDAs are those areas identified from historical flood events and/or modelled data as having a significant risk from surface water flooding. Recommendations can then be made for the future provision of Surface Water Management Plans (SWMPs) in high risk locations or areas of significant development for which an integrated drainage solution is possible that can reduce flood risk to both the current community and new development (SWMPs guidance is discussed in Volume III).

This Level 1 SFRA will identify candidate CDAs using the surface water vulnerability maps, the high level data provided by NWL and historic flooding locations (many of which are from surface water flooding). This Level 1 SFRA will then recommend that these sites/communities are investigated further within the Level 2 SFRA (modelling and further consultation). At this level, only brief recommendations/introductions could be made for SWMPs and and/or Drainage Impact Assessments (DIA) and FRAs.

A level 2 SFRA should investigate these sites further, initially through a meeting with NWL and other relevant stakeholders. NWL have confirmed they will provide the next level of DG5 information as this stage (area and street level). The Level 2 SFRA should be able to 'whittle the sites down' between those issues NWL have actually sorted (or plan to) or those which will definitely need further work/investigation. On the back of this, more precise recommendations for SWMPs can be provided. These recommendations should then be use to start the SWMP/DIA work.

Screening for the candidate CDAs within the Hartlepool BC area was undertaken using data from the following sources:

- Cleveland Emergency Planning Unit flood risk locations
- Fire Brigade flood incident locations
- Local authority flood risk locations
- Flooding records from previous studies
- The Environment Agency's national Areas Susceptible to Surface Water Flooding maps

The Hartlepool BC area was assessed to try and identify any potential CDAs. The candidate CDAs are shown below. These were identified by finding any clusters of historical flooding locations. If incident clusters and mapped surface water flow pathways overlap, this would be an indication that there is a CDA. The high level data from NWL was also used to see if this is a problem drainage area for them.

It will be important to get feedback from NWL (and the HBC drainage contacts) on whether the locations identified:

- are actual problems
- were existing problems but a scheme has been completed to deal with the problem.
- are existing problems but a scheme will be completed in the future

The following candidate CDAs include figures showing all the surface water flooding information available. This includes flooding areas and flow pathways from the Hartlepool IUD Pilot and historic surface water flooding incidents collected for this SFRA. The colours correspond to the following data:

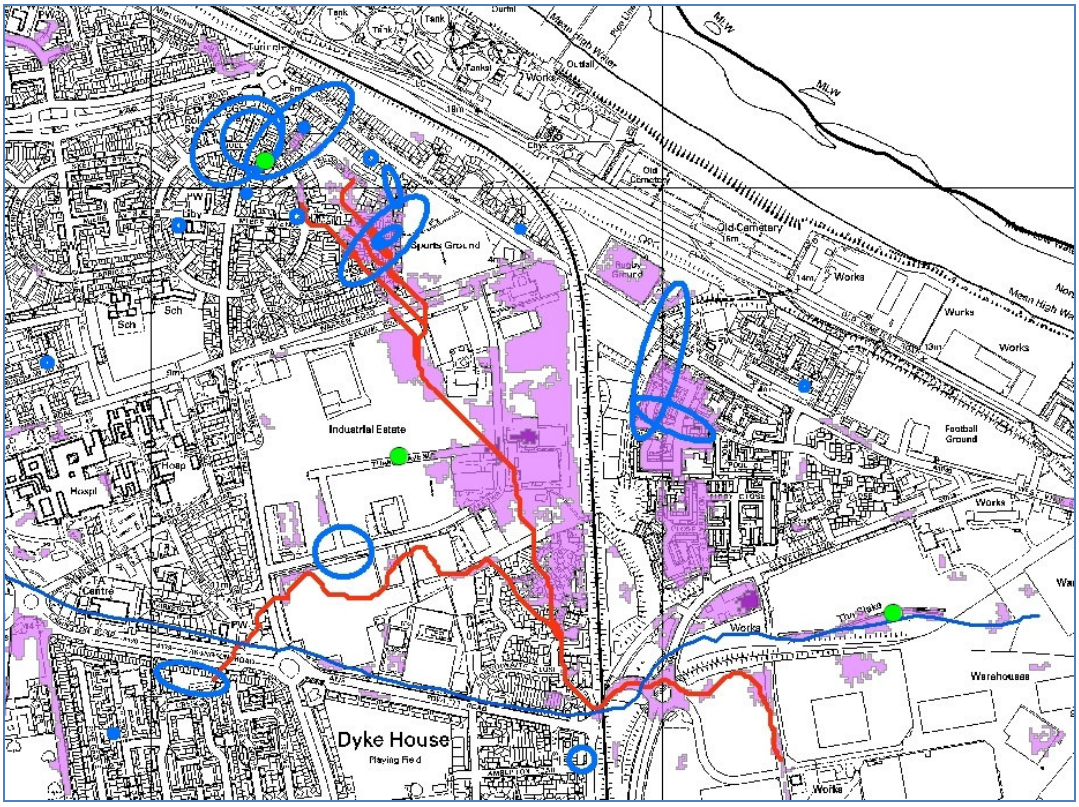
- Dark purple extents are high susceptibility to surface water flooding
- Medium purple extents are intermediate susceptibility to surface water flooding
- Blue circles are IUD flooding areas
- Red lines are the IUD surface water flow pathways
- Blue lines are watercourses
- Green dots are historic surface water flooding incidents.

Candidate CDA in the Middle Warren Watercourse area

The first candidate critical drainage area (cCDA) is based around the Middle Warren Watercourse system and to the north of Middle Warren Watercourse, which ties in with Middle Warren Watercourse flooding information described in section 2.4.3.

As can be seen in Figure 5, there is a surface water flow path (red line) extending north from Middle Warren Watercourse (blue line). This follows, to some extent, the surface water flood map (purple). To the north, near the sewage treatment works, there are many different surface water flooding areas, from the IUD and the information collected for this SFRA. It is therefore proposed that this area is considered as a cCDA.

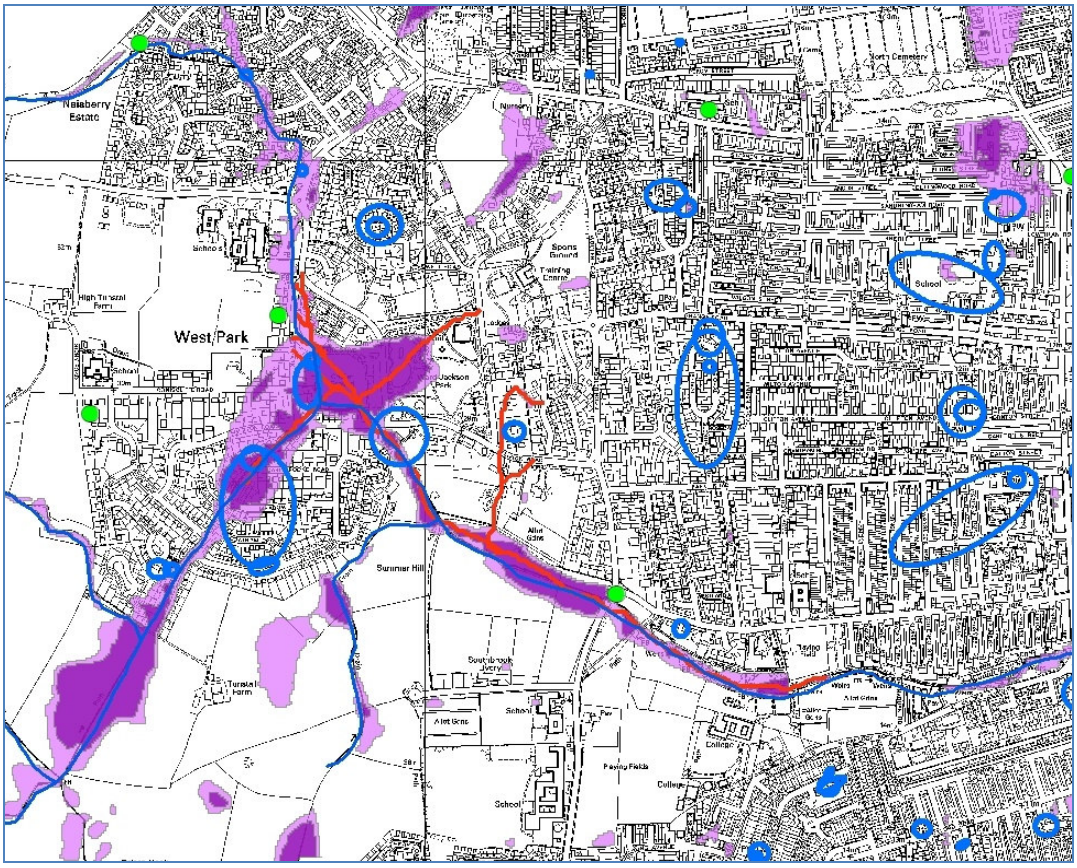
Figure 5 - Candidate critical drainage area in the Middle Warren Watercourse area



Candidate CDA in Tunstall Farm Beck area West Park

Surface water flooding from the Tunstall Farm Beck system, around West Park is described in section 2.4.3. As can be seen from Figure 6 there are some large areas highly susceptible to surface water flooding. This follows the line of the open and culverted watercourses around West Park. The surface water flow pathways (red line) also align with the surface water flood map in some areas as do the IUD surface water flooding locations (blue circles). It is therefore proposed that this area should be considered as a CDA.

Figure 6 - Candidate critical drainage area in Tunstall Farm Beck area around West Park



Candidate CDA in Tunstall Farm Beck area around Stranton

Tunstall Farm Beck continues in culvert (classed as a combined public sewer) through Stranton and flows down Burn Road into the pumping station at Mainsforth Terrace. Although there is not a concentration of historic surface water flooding incidents, there is an extensive area susceptible to surface water flooding shown on the Environment Agency national Areas Susceptible to Surface Water Flooding maps (see Figure 7). This could originate from the Tunstall Farm Beck culvert surcharging and spreading north to south across the low lying area at Stranton.

From an internet search, two photos were found showing flooding in Stranton in 1900. This area is outside of the tidal flood risk area so it is thought that this flooding could have come from fluvial / surface water flooding via Tunstall Farm Beck. It is proposed that this area is included as a CDA. This could be combined with the West Park cCDA as this issue may just be down to the capacity of the culvert at Stranton.

Figure 7 - Candidate critical drainage area in Tunstall Farm Beck area around Stranton

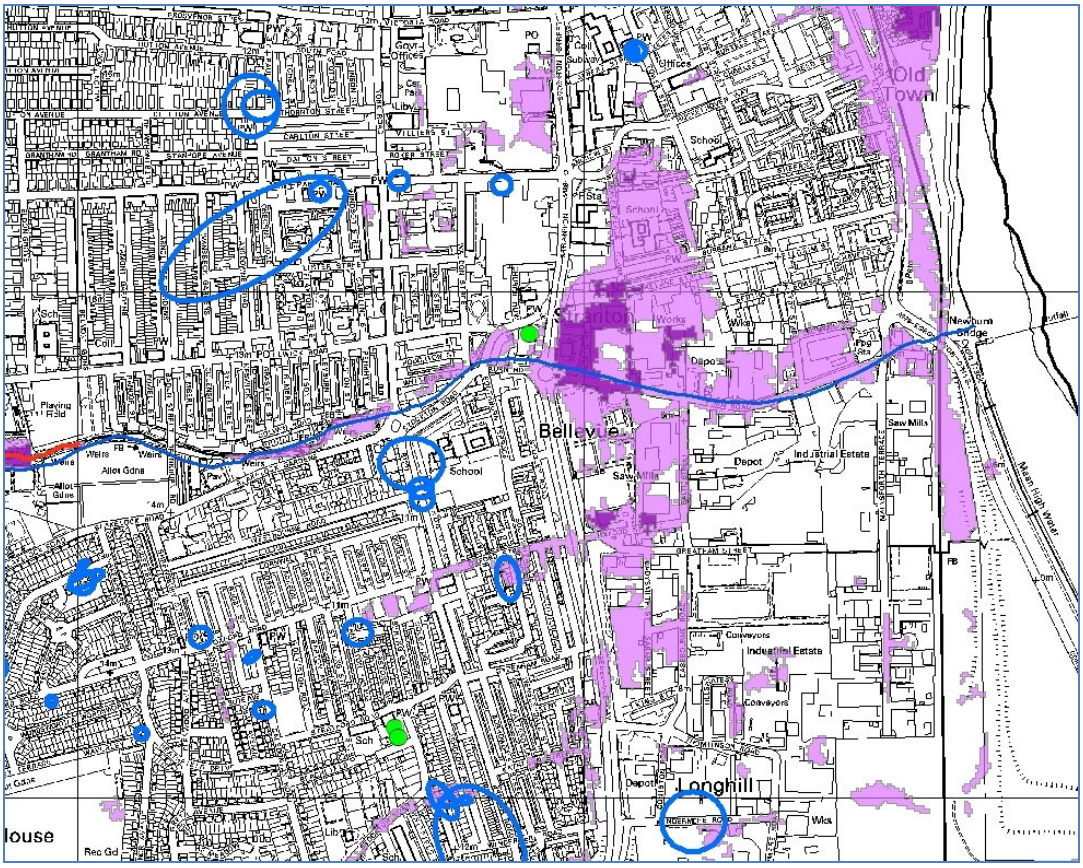


Figure 8 - Flooding in Stranton in 1900

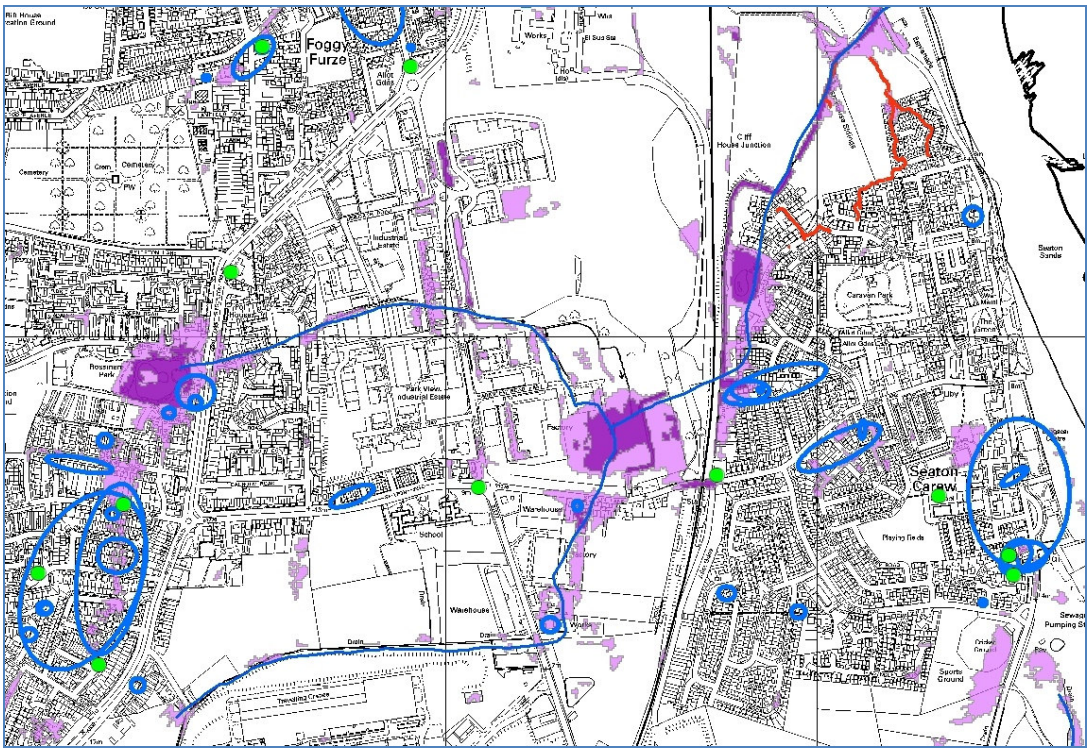
Source: www.thisishartlepool.co.uk. Accessed October 2009.

Source: www.thisishartlepool.co.uk. Accessed October 2009.

Candidate CDA from The Stell near Seaton

Surface water flooding problems associated with The Stell are described in section 2.4.3. Figure 9 shows several areas highly susceptible to surface water flooding. These link in with the IUD surface water flooding locations and the culverted watercourses. Surface water flooding is likely to arise from surcharging of these culverts and associated sewers. As a result, this area has been identified as a cCDA.

Figure 9 - Candidate critical drainage area around The Stell near Seaton



2.5 Flooding from sewers

During the completion of the Pilot IUD for Hartlepool, NWL provided information on sewer flooding locations. This information has been provided for this SFRA. However, the information does not include details on the type and mechanism of sewer flooding and as a result it is therefore not possible to establish where the flooding is down to foul or surface water sewers.

Sewer flooding problems are often linked to surface water flooding issues (i.e. the surface water and foul water systems are both overwhelmed at times due to the volume of rainfall). Surface water flooding is discussed in section 2.4.2. As explained in section 2.4.4, NWL have agreed to provide the next levels of sewer flooding information, after consultation on the Level 1 SFRA.

Below is a review of sewer flooding information available on NWL's website.

2.5.1 Northumbrian Water improvement schemes

A search of NWL's website has highlighted some upcoming sewer improvement schemes. This identifies sewer flooding problem locations but also summarises works to reduce the risk.

Glentower Grove

200 metres of sewer pipe is to be upgraded and a 220 cubic metre storage tank is to be installed in the Glentower Grove and Stanmore Grove areas of Hartlepool. This scheme should be completed in 2009.

In times of extremely heavy rainfall the sewerage network has struggled to cope with the volume of water, which has resulted in external and internal flooding in Glentower Grove.

With the scheme in place, when heavy rainfall occurs, water will be stored in the tank, which will be returned to the sewerage network afterwards.

The Fens

In 2006 a scheme was undertaken to upgrade and increase the capacity of the sewerage network in the The Fens area of Hartlepool. This scheme reduces the risk of flooding to properties in Boston Close and Stamford Walk in times of heavy rainfall by increasing the capacity of the network in the area.

The work, involved installing 100 metres of new sewer pipe and construction of a new storage tank. The new underground storage tank holds up to 250 cubic metres of wastewater.

In 2007 a scheme was completed to reduce the risk of property flooding in the Honiton Way area of Hartlepool.

2.6 Flooding from groundwater

The Draft Tees CFMP states that there is little documented evidence of groundwater flooding in the Tees catchment. In addition, none of the historical flood incidents recorded relate to groundwater flooding.

2.7 Flooding from reservoirs and other artificial sources

The Environment Agency was contacted for the location of major reservoirs in Hartlepool Borough. The information provided gave three entries for Hartlepool BC; Crookfoot, Hart Lower and Hart Upper.

Crookfoot is located on the far west border of Hartlepool BC. The reservoir flows into Amerston Beck which eventually becomes Close Beck then North Burn. There is no existing or proposed development directly below the reservoir dam. In addition, the watercourse that flows from the reservoir does not pass any significant development. It is therefore suggested that no further flood risk assessment will be required for this reservoir other than those currently being carried out by the Environment Agency and reservoir undertakers.

The Lower and Upper Hart reservoirs are situated next to each other, below Hart and above Throston Grange in the north of Hartlepool. This reservoir flows into the recently remodelled beck in Middle Warren (this watercourse is unnamed so will be referred to as Middle Warren Watercourse). This watercourse then drops into the Northern Area Main Drain at the Easington Road roundabout. There is proposed and existing development below (to the east) of the reservoir dam. The risk from this reservoir should be considered further by the Environment Agency and reservoir undertakers.

There are no other artificial sources such as canals in Hartlepool BC.

2.8 Effects of Climate Change

UKCIP02 climate change scenarios suggest that winters will become wetter over the whole of England, by as much as 20% by the 2050s. A shift in the seasonal pattern of rainfall is also expected, with summers and autumn becoming much drier than at present. Snowfall amounts will decrease significantly throughout the UK, by the number of rain-days and the average intensity of rainfall are expected to increase. Rainfall intensity and the increase in the number of rain-days could have significant implications for surface water flooding and should be considered when designing drainage systems for new developments. Peak flow increase by around 20% over the next 50 years will translate into higher water levels in rivers. In addition, sea level rise due to climate change will increase the risk of tidal flooding. In this part of the UK, sea levels are currently rising by 2.5mm/year. However, by 2085, levels will be increasing by 13mm/year. This will increase sea levels by around 900mm over the next 100 years.

Figure C1 in Appendix A shows the only location where there is a modelled climate change flood extent in Hartlepool BC. This shows a small increase in flood extent around West Park due to flooding from Tunstall Farm Beck.

The draft TUFLOW tidal model has also used to produce a climate change extent on the Tees Estuary (see Figure G2 in Appendix A). This shows a significant increase in flood extent. 0.5% a.p. tidal flood with 100 years climate change is expected to be greater than the current 0.1% a.p. flood. The 0.5 % a.p. flood level for the Tees Estuary is currently 4.19m AOD. In 100 years time it is predicted that this will be 5.07m AOD. The current 0.1% AEP flood level is 4.4m AOD. If the tidal climate change flood extent is mapped along the full length of Hartlepool BC's coastline, it may show a similarly significant increase in extent.

Where there are no modelled climate change flood extents, Flood Zone 2 can be used as an indication of what Flood Zone 3 will look like in 100 years time. Across Hartlepool BC, this indicates that Middle Warren Watercourse and Tunstall Farm Beck will have a greater flood extent in Hartlepool. However, this increase in extent is not reflected in The Stell watercourse.

Table B.2 Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights.

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%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

Extracted from PPS25

This climate change summary does not take account of other sources of flooding e.g. surface water flooding but just looks at the current Flood Zones. The frequency and extent of surface water flooding could increase significantly in the future and rain storms become heavier and more frequent due to climate change.

2.9 Geology and Soils

The geology and soils of the Borough were investigated using a strategic scale (1:250,000) map available from the National Soil Research Institute and can be viewed at: http://www.landis.org.uk/soilscapes/

According to the soils map the majority of the Borough is covered by grass, arable land and some woodland. This is slowly permeable seasonally wet loam and clay soils. This will impede natural drainage which means that winter waterlogging of the land can occur. The area around the River Tees is composed of grassland and some arable land. This loamy soil is freely draining which means that the soils absorb rainfall readily and allow it to drain through to underlying layers. This could conclude, that although there are no records of groundwater flooding, the soil and geology of Hartlepool indicates that some areas could be vulnerable to groundwater flooding (after heavy rainfall) due to poor drainage.

Unfortunately the scale of this data makes it not particularly relevant at a local level, therefore it should be used only as an indication of the potential for groundwater and surface water flooding and a generalised dataset for the implementation of source control and infiltration sustainable drainage techniques (SUDS).

Geology and soils can only really be investigated at a site level during a FRA. Their characteristics are not the only considerations when designing SUDS. It is recommended (refer to Volume III of this SFRA) that the application of SUDS should be explored at an early stage of new development projects and design requirements documented within any FRA produced. More detail on the application of SUDS and the SUDS "Management Train" is also provided in Volume III.

2.10 Flood Defences

Figure D in Appendix A shows the location of the flood defences in Hartlepool BC. The Flood defences are predominantly confined to sections the coastline and the Tees Estuary.

2.10.1 Tees Estuary

Existing formal defences

The Tees Tidal Strategy provides some details on the flood defences on the Tees Estuary. There is a section of tidal defences that protects the power station and the Tioxide plant from flooding. This is known as the Greenabella Sea Wall. These defences tie into the north bank of Greatham Creek.

The embankment at Greatham Creek has breached several times in the past. Remedial works were carried out on the Greenabella Sea Wall in the mid 1990s when the space between the inner and the outer banks was filled. A recent survey indicates that the crest level ranges from 5.16m to 5.32m AOD. The defence on the north bank of Greatham Creek was reconstructed in the mid 1990s to a level of 4.6m AOD. A recent survey indicates that the crest level ranges from 4.18 to 4.36m AOD.

The defence that extends to the west of the A178 on Greatham Creek ties into an area of raised ground. This section was reconstructed in the mid 1990s to a level of 4.6m AOD. A recent survey indicates that the crest level ranges from 4.17 to 4.50m AOD. The LIDAR data indicates that the existing defences adjacent to Marsh House Farm could be outflanked, due to a low area of land at 3.60m AOD, placing the Tioxide plant at risk of flooding.

The existing defences to the east of the A178 on Greatham Creek are of substantial construction, following the works to the embankments in the 1990s. A survey indicates that the crest levels are not consistent and are between 230 and 370mm below the original level of 4.6m AOD. Recent construction works by Industry Nature Conservation Association (INCA) indicate that the embankments are founded on very soft silky clay and they appear to be permeable, which may lead to an increased risk of breach failure.

There is a fluvial flood embankment following Greatham Creek north as it becomes Greatham Beck. Parts of this defence are redundant and protect arable and pasture land.

Tees Tidal proposed Flood Management Strategy

The Tees Tidal Strategy's preferred flood risk management option for this part of the Tees Estuary is to raise the defences east of A178 and re-align the defences to the west of A178. This will involve realigning the Greatham Creek embankment along eastern edge of the A178, following the line of emergency access track and tie in with the Greenabella Seawall. Realigning the defence to western edge of the A178 will tie in with petroleum bunds. This option would also include the creation area of a new inter-tidal habitat.

The Tees Tidal Strategy recommends that the defences are built and maintained to a 4% a.p. standard of protection.

2.10.2 Hartlepool Coast

Details of the flood defences along the Hartlepool BC coastline have been summarised from the SMP2. A coastal protection strategy was completed for the Hartlepool BC

coastline in January 2006. This predates the SMP2 but the recommendations align with the management policies of the SMP2. A coastal strategy would normally come after the SMP by providing more detail and appraising the benefits of a flood defence scheme.

Hartlepool north

The northern section of Hartlepool BC's coastline comprises a wide expanse of sandy beach backed by dunes. This then runs to the bare rock outcrop foreshore of the Hartlepool Headland. There is continuous coast protection works extending nearly 2km along and around the headland. This protection comprises large seawalls and revetments protecting the raised platform of northern Hartlepool.

The SMP2 policy for this stretch of coastline is to provide coastal protection along key parts of North Sands to allow future development. This ties in with one of the SHLAA sites provided for this SFRA. However, there may be managed retreat to some areas on North Sands including the golf club. For Hartlepool Headland, the policy is to 'hold the line'. This will include maintaining the coastal defences on the urban area of Hartlepool Headland.

Hartlepool south

Between the Heugh breakwater and the entrance to the Victoria docks there is a promenade area (Block Sands) backed by sea walls and a raised road, giving on to the core residential development of the Headland. The foreshore is rock outcrop with a narrow, but in places dry, sand beach.

Within the docks are generally vertical quay walls associated with the current port activities. The south western side of the docks, together with defences further south, provide a flood defence function extending back through both industrial and residential areas some 3.5km from the coastline.

The southern side of the docks entrance is trained by the Middleton Pier, with Middleton beach enclosed between here and the North Pier, covering the inner entrance to the main Hartlepool Marina. The back of the beach is fully defended, providing both a flood defence and erosion protection role.

With the railway running close to the shore, the coastal road, intermittent areas of development and a developed area extending inland, there has been a need to protect the natural curve of the coast with a rock revetment and seawall. This defence retains an area of open recreational land between the sea wall and the road behind.

The SMP2 policy for this stretch of coastline is to 'hold the line'. This means that the coastline will be protected from increased flooding in the future making it sustainable for current and future development. Included in this policy will be the development of flood defences at Middleton Beach which will tie in with redevelopment plans (i.e. the Victoria Harbour SHLAA site). The SMP states that improvements may also be made to the Heugh Breakwater. There are currently no plans for this and it is not known when or if this will take place.

Seaton Carew to the Tees Estuary mouth

To the south of Little Scar is the town of Seaton Carew, and beyond it, the open dune system of Seaton Sands. The northern section of the Seaton Carew town is relatively close to the defence line, with only the road between houses and the sea defence. The main part of the town sea front is set back and the defence line is fronted by a relatively wide, typically dry sand beach. While still exposed under more severe storm conditions, the defences are afforded considerable protection by the beach.

According to the SMP, the potential flood risk area includes the nuclear power station and extends in land to the Cowpen Marshes and significant areas of north bank to Teesport. This means that this area can be flooded directly from the sea via the coast and by the Tees Estuary. There are, however, other defences set back from the shore line which

defend this larger area. The Power Station is constructed at a slightly higher level than the land to the north.

The SMP2 policy for this stretch of coastline is to 'hold the line'. This means that the flood defences at Seaton Carew will be maintained and improved to take account of climate change so that flood risk does not increase in then future. The first step in this process is to produce a coastal strategy and this is one of the actions in the SMP2.

A coastal strategy for Seaton Carew is currently being undertaken, this should eventually lead to a flood defence improvement scheme in line with the SMP2 management policy.

- Stage A has been completed and is a coastal flood defence condition and performance assessment.
- Stage B will provide a technical assessment of the coastline.
- Stage C will recommend the preferred long-term strategy to be adopted, in which short-term priorities will be highlighted.

The SMP policy and the strategy confirm that works to reduce the future risk of flooding are likely to be undertaken. This means that in the long term, coastal flood risk to existing and proposed development in this area should be sustainable.

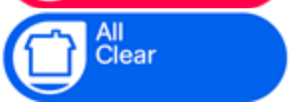
2.11 Flood Warning

The Environment Agency has the lead role in providing flood warnings service in England and Wales. The aim of the flood warning service is to reduce risk to like, distress to people and damage to property caused by flooding by providing accurate, timely flood warnings to residents within the floodplain of rivers, estuaries and coasts; to the media and partner organisations.

It is crucial that people at risk receive appropriate flood warnings and take action to protect themselves and their property. Within the Environment Agency corporate plan "Creating a Better Place[12]" the Agency has highlight three main targets:

- To have 80% of properties at risk in the floodplain in England and Wales receiving and appropriate flood warning service,
- 75% of people who live in flood risk areas take appropriate action by 2011,
- To have major incident plans in place for high flood risk areas.

Currently the Environment Agency operates a flood warning service in specific locations known as "Flood Warning Areas" where "Flood Warning Codes" are assigned based on the overall impact of flooding within an area. These codes include:

Flood Watch		"flooding of low-lying land and roads is expected"
Flood Warning		" flooding of homes and businesses is expected"
Severe Flood Warning		"severe flooding is expected"
All Clear		"all clear or receding floodwaters"

The Environment Agency's Floodline Warnings Direct service provides flood warnings direct to people by telephone, mobile, email, SMS text message, fax or pager.

[12] Environment Agency (2006) Creating a Better Place: Corporate Strategy 2006-2011

There are some tidal and coastal Flood Warning and Flood Watch areas that cover the Borough, some of which cross over administrative boundaries. Figure D in Appendix A show the Flood Warning Areas. They include:

- **Hartlepool to Cowbar** - North Sea coastline including Hartlepool, Seaton Carew and Cowbar
- **Tidal River Tees** - Tees Estuary at Greatham Creek (The heavy engineering basin in the north west corner which includes the Tioxide plant and the power station)

Hartlepool Borough Council Flood Warning Plan

A flood warning plan has been prepared by Hartlepool BC. The flood warning plan covers the following areas:

- **Middleton** - there are two industrial premises in this area.
- **The West Harbour** - there are three properties in this area.
- **Greatham Creek** - there are five properties in this area.

All of these properties are categorised under the Environment Agency's flood matrix as HLL (High probability, Low impact, Low risk).

3 Strategic Flood Risk Mapping

3.1 Introduction

The investigation and identification of the extent and level of flood risk to an area is assessed primarily geographically. Whilst the Environment Agency's Flood Maps are very useful in this respect in showing indicative land use planning zones as required by PPS25, they are only a starting point in the consideration of flood risk in a particular area.

PPS25 Flood Zone Maps should be used primarily to enable the Sequential Test to be carried out, firstly in avoiding inappropriate development and then secondly, to seek compatibility between flood risk vulnerability and Flood Zones as required in Table D3 of PPS25.However, more detailed analysis is often needed to gain a greater understanding of the varying degree of flood risk at a district level.

At this SFRA level, it is not appropriate to look at flood risks in detail for individual proposed development sites, as this is a requirement of the site-specific FRA and will be undertaken by developers in respect of specific development proposal and prior to submitting a planning application. However, there is a need to undertake a broad assessment of flood risk issues to assist the LPA in making the spatial planning decisions required. This will enable a degree of certainty that the proposed development sites allocated in the LDD, allow compliance with the Sequential and Exception Tests in PPS25 and importantly provide information to test whether the developments should be safe for occupants and users.

This broad assessment is assisted greatly a suite of council scale flood risk information and include the PPS25 Flood Zone Maps. No one map should be considered in isolation without reference to the others. The set of Strategic Flood Risk Maps provided in the Hartlepool BC Level 1 SFRA can be found in Appendix A and include:

Map	Description
SET A:	PPS25 Flood Zones
SET B:	Flood Zone 3 Depths
SET C:	Climate Change Sensitivity
SET D:	Flood Risk Management Measures
SET E:	Areas Naturally Susceptible to Surface Water Flooding

After the PPS25 Flood Zone Map has been used to carry out the first sweep or Sequential Testing for various proposed development locations, all sets of maps need to be interpreted consistently in order to complete the second or third pass of the sequential approach sieving process. They can also be used "outside" of the development planning process to gain an understanding of various flood risk factors in other areas of interest across the Borough.

The detail provided in the Strategic Flood Risk Maps may also facilitate the application of the Exceptions Test where applicable. These maps should be used in sequence as shown in the Sequential Test sieving process as shown in Volume I of the SFRA.

3.2 PPS25 Flood Zone Maps

The PPS25 Flood Zones have been produced on a set of eight maps covering the Borough (see Appendix A Figures A1 to A8). The fluvial Flood Zone maps are based on information provided in the Environment Agency Flood Map. Version 3.14 of the Environment Agency Flood Zones issued in June 2009 has been used as the latest flood zones in this area. Flood Zones 2 and 3 were checked against all the most recent

modelling outputs to see if they had all been integrated. Both Flood Zones 2 and 3 appear to have been updated with all the currently available hydraulic models.

As stated in PPS25, a normal aim of SFRAs is to define Flood Zone 3b: the functional floodplain. In this SFRA, this has been delineated using the method outlined in section 3.2.2.

These key maps should be used for the facilitating the undertaking of the Sequential Test by planners and developers according to PPS25, as discussed previously in Volume I and illustrated within stage 1 of the Sequential Test sieving process.

3.2.1 Functional Floodplain

The Environment Agency recommend that the Functional Floodplain (Flood Zone 3b) should be defined using modelled 4% a.p. outlines where available. The modelled outlines should then be edited using the following methodology:

- Inclusion of land which provides a function for flood conveyance or flood storage (e.g. washlands)
- Removal of areas benefitting from defences (ABDs)
- Removal of developed land. However opportunities to reinstate functional floodplain on brownfield (derelict) sites will be sought.
- Removal of major transport infrastructure (e.g. motorways and railways)
- Removal of 'dry islands' defined using the 'size standards' within the Environment Agency SFRM Specification for Flood Risk Mapping13

However, there was only modelled data for Tunstall Beck. For those watercourses that have not been modelled or where a 4% a.p. outline is available, "Candidate Flood Zone 3b" areas have been identified based on the Environment Agency Flood Zone 3 outlines. Greenfield areas within Flood Zone 3 have been identified which should be safeguarded from future development. Storing flood water in these areas during an event could potential reduce risk downstream at urban areas in the future.

However, as these areas have not been explicitly modelled (or have used a 1% a.p. modelled outline) and are partly based on profession judgement, it is important that they are assessed in more detail at a site-specific FRA level if development is planned in the future. Nevertheless it is recommended in this SFRA that they are left as open greenfield for future flood storage or as flood compensation needed to allow other development.

Previously developed brownfield land, adjacent to watercourses may provide opportunities to incorporate space for flood water to reduce flood risk to new and existing developments. Opportunities to reinstate the functional floodplain on brownfield sites will therefore be identified.

The data used to define the functional floodplain and "Candidate Flood Zone 3b" for each watercourse is summarised in Table 4.

Table 4 - Functional floodplain and candidate functional floodplain mapping

Watercourse	Extent	Data source
Tunstall Beck	4% AEP	EA floodplain mapping March 2005
Remaining watercourses	1% AEP candidate Flood Zone 3b	Flood Zone 3 Version 3.14

[13] Environment Agency (2006) *Strategic Flood Risk Management Specification for Flood Risk Mapping* release 1.2

3.2.2 Draft Tidal TUFLOW extents

As mentioned earlier in the report, a 2D TUFLOW model of the Tees Estuary was produced by JBA Consulting for the NE RFRA (which is not an Environment Agency Model). This has been used to produce draft tidal extents for this SFRA. These extents are likely to be more accurate than the current Tees Estuary Flood Zones as they have been produced using more detailed modelling techniques and they are based on the latest extreme flood levels.

A comparison of Flood Zone 3 and the modelled 1% a.p. flood extent can be seen in Figure G1. This shows that the modelled extent is significantly smaller than the current Flood Zone 3.

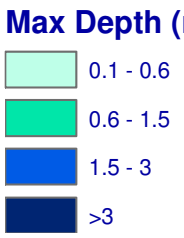
3.3 Flood Zone 3 Depth Map

An indicative depth map of the 1% a.p. fluvial event has been provided for Hartlepool BC (see Figure B1 in Appendix A). This fluvial depth grid was obtained from the Environment Agency North East broad scale modelling work for CFMPs undertaken by JBA Consulting in 2008. The methodology is based on the original methodology used in creating the original Environment Agency Flood Map using an overland routing model JFLOW. However, the map was improved by:

- Updating the hydrology of inflows into the model, and
- Updating the topographical data from NEXTMAP to LiDAR data. Flow paths under structures were also included to provide a more realistic result.

Whilst the extent of the depth grid cannot be directly compared to the current Flood Zones (as Flood Zones are based on detailed hydraulic models in some locations and NEXTMAP extents in others) they do provide a useful indication of potential scale of flood inundation during a 1% a.p. event.

The depth map has been categorised in depth ranges using the scaling below:



3.4 Climate Change Sensitivity Maps

Where there is modelling available, climate change sensitivity maps have been provided (see Figures C2 to C8 in Appendix A). These maps show fluvial flood extents for an undefended floodplain with a 1% AEP flood flow plus a 20% increase in flood flows. This is representative of a plus 100 years climate change extent. For un-modelled watercourses the presumption is to take Flood Zone 2 as a precautionary extent of Flood Zone 3a in the future.

The sequential approach requires early consideration of the effects climate change on flood risk and these maps help greatly in this respect.

PPS25 requires the consideration of the sensitivity of new developments to climate change to be considered as part of an appropriate FRA and these maps provide an indication of this sensitivity. In addition, emergency evacuation routes can be identified and planning put in place to ensure they are outside of the flood extent.

The sensitivity of a particular location and land use to climate change can be factored into decisions regarding floor levels, building uses and safe access and egress etc. Greater changes in depth or extents can be associated with greater increases in flood risk and in these areas, where this risk cannot be avoided, or substituted, mitigation measures are

likely to be extensive. For some developments, the FRA may not be able to demonstrate continued safety for occupants as required by the Exception Test in PPS25.

The potential impact of climate change in Hartlepool BC is summarised in section 2.8.

3.5 Flood Risk Management Measures Map

Residual risks are the risks that remain after all risk avoidance, substitution and mitigation measures have been taken. The residual risks in the Borough are therefore related to the occurrence of events of low probability, such as extreme flood events greater than the design capacity of the constrained river/coastal system or where the design standard of flood defences is exceeded.

A map of flood risk management measures has been produced (see Figure D in Appendix A). The map includes the:

- location of Environment Agency river flood defences
- coverage of Environment Agency Flood Warning Areas

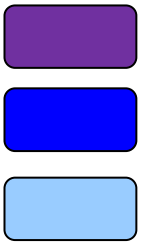
This map is very important when considering the residual risks associated with flood. These residual risks must be investigated within any Level 2 SFRA or site specific FRA as relevant.

3.6 Surface Water Flooding Maps

The Areas Susceptible to Surface Water Flooding Maps show actual surface water flood extent and variation in depths for particular geographical areas of interest, assuming a 0.5% rainfall event and a “hard surface” ground model.

The areas susceptible to surface water flooding zones have been provided on a set of eight maps, and are largely based on information provided in the Environment Agency national Surface Water Map (see Figures E1 to E8 in Appendix A).

The Areas Susceptible to Surface Water Flooding are split between three zones relating to risk highlighted below:



More Susceptible

Susceptible

Less Susceptible

These maps are extremely helpful in supplementing the PPS25 Flood Zone Maps as they show where localised, flash flooding can cause problems, even if the Main Rivers are not overflowing.

More information on surface water flooding and the surface water flood maps can be found in section 3.2.3 of Volume I.

4 Site Specific Allocations

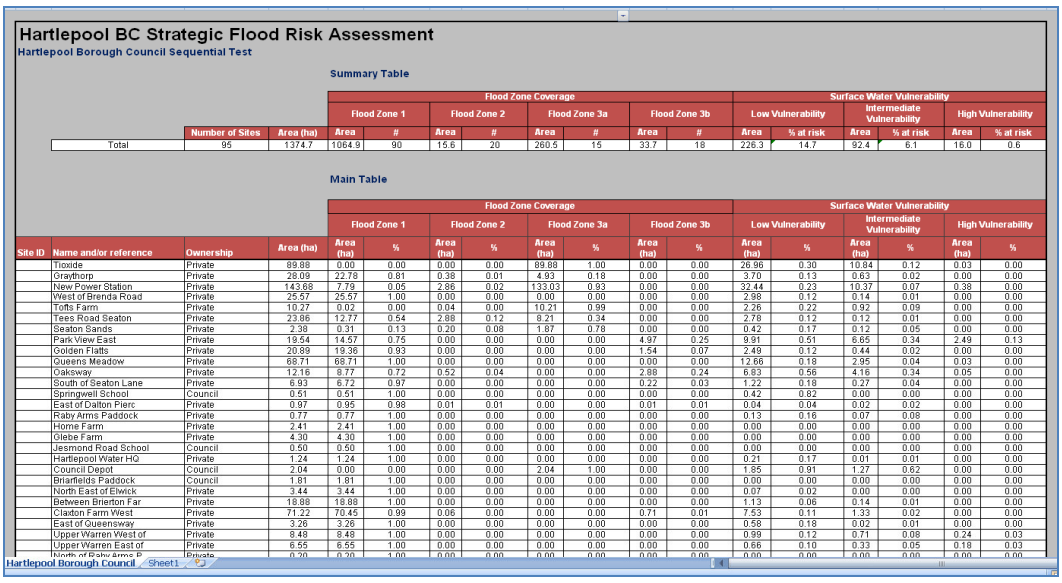
4.1 Introduction

A Level 1 SFRA should enable Hartlepool BC to carry out the Sequential Test as outlined in Annex D of PPS25. This is required for when the allocations go through examination to show that the LPA has considered other sites before allocating them in areas at risk of flooding.

This Level 1 SFRA has provided Hartlepool BC with PPS25 Flood Zone classifications for all locations identified for development provided within this assessment. The Council will be required to prioritise the allocation of land for development in ascending order from Flood Risk Zone 1 to 3, including the subdivisions of Flood Risk Zone 3, if necessary.

The Environment Agency has statutory responsibility and must be consulted on all development applications allocated with medium and high risk zones, including those in areas with critical drainage problems and for any development on land exceeding 1 hectare outside flood risk areas. In these circumstances, the Environment Agency will require the Council to demonstrate that there are no reasonable alternatives, in lower flood risk categories, available for development. Where appropriate, the Exception Test is to be applied.

A Sequential Test spreadsheet has been produced showing the results of all allocations provided by Hartlepool BC against PPS25 Flood Zones and as an extra layer of information against the surface water susceptibility zones. Area (ha) and percentage cover of each Flood Zone is provided. In addition, two columns have been provided, one indicating whether the site is affected by the climate change extent (Flood Zone 3 in 2100) and the other saying whether the site is at risk from any other sources of flooding. A screenshot of the spreadsheet is provided below. The full spreadsheet is included in Appendix B.



Hartlepool BC Strategic Flood Risk Assessment

Hartlepool Borough Council Sequential Test

Summary Table

			Flood Zone Coverage								Surface Water Vulnerability					
			Flood Zone 1		Flood Zone 2		Flood Zone 3a		Flood Zone 3b		Low Vulnerability		Intermediate Vulnerability		High Vulnerability	
	Number of Sites	Area (ha)	Area	#	Area	#	Area	#	Area	#	Area	% at risk	Area	% at risk	Area	% at risk
Total	95	1374.7	1064.9	90	15.6	20	260.5	15	33.7	18	226.3	14.7	92.4	6.1	16.0	0.6

Main Table

				Flood Zone Coverage								Surface Water Vulnerability					
				Flood Zone 1		Flood Zone 2		Flood Zone 3a		Flood Zone 3b		Low Vulnerability		Intermediate Vulnerability		High Vulnerability	
Site ID	Name and/or reference	Ownership	Area (ha)	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
	Tioxide	Private	89.88	0.00	0.00	0.00	0.00	89.88	1.00	0.00	0.00	26.96	0.30	10.84	0.12	0.03	0.00
	Graythorp	Private	28.09	22.78	0.81	0.38	0.01	4.93	0.18	0.00	0.00	3.70	0.13	0.63	0.02	0.00	0.00
	New Power Station	Private	143.68	7.79	0.05	2.86	0.02	133.03	0.93	0.00	0.00	32.44	0.23	10.37	0.07	0.38	0.00
	West of Brenda Road	Private	25.57	25.57	1.00	0.00	0.00	0.00	0.00	0.00	0.00	2.98	0.12	0.14	0.01	0.00	0.00
	Tofts Farm	Private	10.27	0.02	0.00	0.04	0.00	10.21	0.99	0.00	0.00	2.26	0.22	0.92	0.09	0.00	0.00
	Tees Road Seaton	Private	23.86	12.77	0.54	2.88	0.12	8.21	0.34	0.00	0.00	2.78	0.12	0.12	0.01	0.00	0.00
	Seaton Sands	Private	2.38	0.31	0.13	0.20	0.08	1.87	0.78	0.00	0.00	0.42	0.17	0.12	0.05	0.00	0.00
	Park View East	Private	19.54	14.57	0.75	0.00	0.00	0.00	0.00	4.97	0.25	9.91	0.51	6.65	0.34	2.49	0.13
	Golden Flatts	Private	20.89	19.36	0.93	0.00	0.00	0.00	0.00	1.54	0.07	2.49	0.12	0.44	0.02	0.00	0.00
	Queens Meadow	Private	68.71	68.71	1.00	0.00	0.00	0.00	0.00	0.00	0.00	12.66	0.18	2.95	0.04	0.03	0.00
	Oakesway	Private	12.16	8.77	0.72	0.52	0.04	0.00	0.00	2.88	0.24	6.83	0.56	4.16	0.34	0.05	0.00
	South of Seaton Lane	Private	6.93	6.72	0.97	0.00	0.00	0.00	0.00	0.22	0.03	1.22	0.18	0.27	0.04	0.00	0.00
	Springwell School	Council	0.51	0.51	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.82	0.00	0.00	0.00	0.00
	East of Dalton Piercy	Private	0.97	0.95	0.98	0.01	0.01	0.00	0.00	0.01	0.01	0.04	0.04	0.02	0.02	0.00	0.00
	Raby Arms Paddock	Private	0.77	0.77	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.16	0.07	0.08	0.00	0.00
	Home Farm	Private	2.41	2.41	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Glebe Farm	Private	4.30	4.30	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Jesmond Road School	Council	0.50	0.50	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hartlepool Water HQ	Private	1.24	1.24	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.17	0.01	0.01	0.00	0.00
	Council Depot	Council	2.04	0.00	0.00	0.00	0.00	2.04	1.00	0.00	0.00	1.85	0.91	1.27	0.62	0.00	0.00
	Briarfields Paddock	Council	1.81	1.81	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	North East of Elwick	Private	3.44	3.44	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.02	0.00	0.00	0.00	0.00
	Between Brierton Far	Private	18.88	18.88	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.06	0.14	0.01	0.00	0.00
	Claxton Farm West	Private	71.22	70.45	0.99	0.06	0.00	0.00	0.00	0.71	0.01	7.53	0.11	1.33	0.02	0.00	0.00
	East of Queensway	Private	3.26	3.26	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.18	0.02	0.01	0.00	0.00
	Upper Warren West of	Private	8.48	8.48	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.12	0.71	0.08	0.24	0.03
	Upper Warren East of	Private	6.55	6.55	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.10	0.33	0.05	0.18	0.03
	North of Raby Arms P	Private	0.20	0.20	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Hartlepool Borough Council | Sheet1

Hartlepool BC should use this information to carry out the first sieve of the Sequential Test, by identifying and removing those sites at greatest risk. Once a decision has been made by Hartlepool BC on whether to remove or keep (due to wider social/economic reasons) those sites at higher risk, they should then carry out a second or third pass of the Sequential Test against the wider suite of flood risk maps produced within this SFRA. This should ensure that there is an evidence base for replacing sites at a high risk of flooding with those that are at a lower risk. Or for keeping the sites and bringing them forward for the Exception Test.

Once the sequential sieving process has been carried out, the Environment Agency will require the Council to demonstrate that there are no reasonable alternatives in lower flood risk categories available for development. The vulnerability of the remaining sites at risk should be considered and substituted with lower risk development (if possible) before any mitigation measures are considered.

The next part of this chapter summarises flood risk to the proposed development sites that Hartlepool BC have provided for this study. This includes recommendations for changing the proposed allocations (before the Sequential Test is undertaken) and whether certain sites are likely to pass the Exception Test.

4.2 Current Development Site Sequential Test

Development sites identified by Hartlepool BC include:

- Strategic Housing Land Availability Assessment (SHLAA) sites over 1ha
- Employment sites

Including the above sites, the total developable area is around 1375 ha. Tables 5 and 6 provide a summary of sites at risk of fluvial and surface water flooding that are included in the Sequential Test spreadsheet.

4.3 Summary of sites at risk of fluvial flooding

Table 5 - Summary of development sites at risk of fluvial flooding

		Flood Zone Coverage					
		Flood Zone 2		Flood Zone 3a		Flood Zone 3b	
No. Sites	Total Area (ha)	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.
95	1375	15.6	20	260.5	15	33.7	18

- 294 ha out of 1375 ha of the sites are within Flood Zone 3 (Flood Zone 3a+3b in Table 5). This is 33 out of the 95 sites assessed although some of the areas at risk are small.
- 310 ha of sites are within Flood Zone 2 (Flood Zone 2+3a+3b in Table 5). This is 53 out of the 95 sites assessed although some of the areas at risk are small.
- 17 employment / housing sites are situated in the functional floodplain and under PPS25 these will not be permitted. However, 12 of the areas considered functional floodplain are relatively small. It should be possible to redefine some of these site boundaries to make development acceptable.

Table 6 - Summary of development sites at risk of surface water flooding

		Surface Water Flood Zone Coverage					
		Low Susceptibility		Susceptible		High Susceptibility	
No. Sites	Total Area (ha)	Area (ha)	%	Area (ha)	%	Area (ha)	%
95	1375	226.3	15.5	92.4	6.4	16.0	0.6
		74 sites		65 sites		19 sites	

The risk of surface water flooding to Hartlepool BC's allocations is shown to be more widespread than fluvial flooding.

- The majority of the sites are at some level of risk from surface water flooding. 16% of the proposed development area is at risk of surface water flooding. Much of this is low and intermediate susceptibility of surface water flooding which can be managed during development.

- 19 sites have a high susceptibility of surface water flooding which should be considered within the Sequential Test sieving process (depending on the extent of surface water flooding). Managing surface water flooding to sites which have a high susceptibility, may be more problematic. If these sites go forward and are developed, a FRA must consider surface water mitigation techniques such as Sustainable Urban Drainage or a more open site layout

4.4 Flood risk and the 2009 allocations

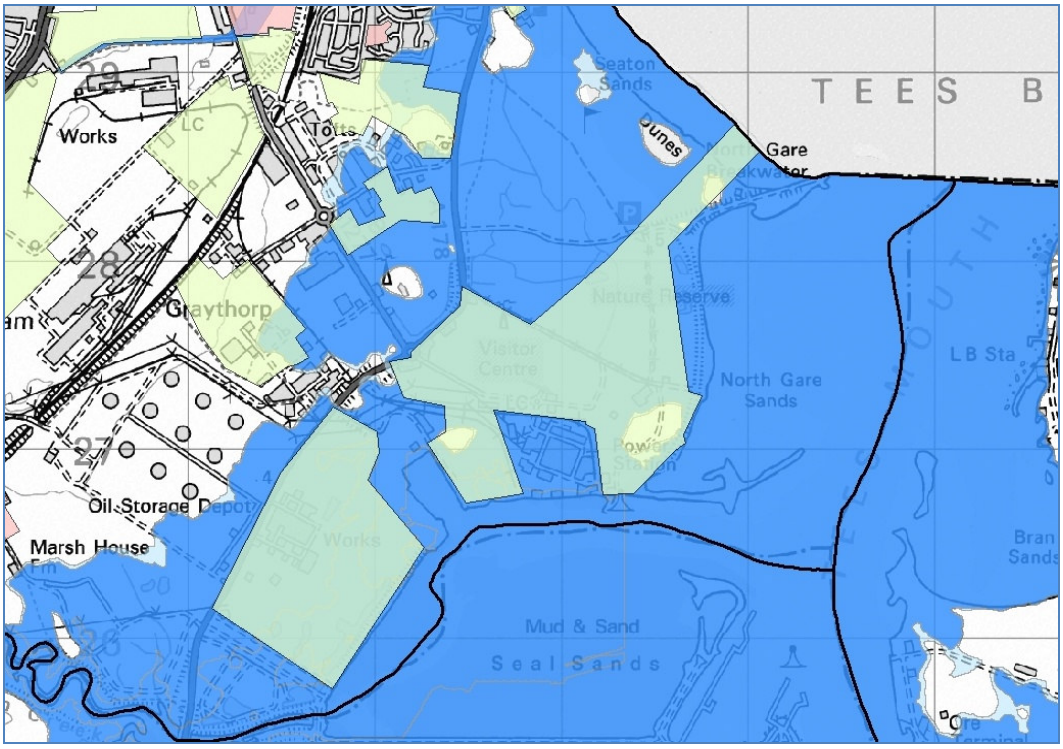
4.4.1 Introduction

The previous section combines Flood Zone and surface water map information with the proposed future development sites to allow the application of the Sequential Test. This section summarises where specific, generally larger, sites are at flood risk and includes recommendations for development planning. This assessment includes sites that may require a Level 2 SFRA. However, the specified requirements for a Level 2 SFRA are included in the next section.

4.4.2 Proposed industrial sites at tidal flood risk

There are a number of (mainly) industrial proposed development sites at risk of tidal flooding from the Tees Estuary. The sites to the east may also be at risk directly from the North Sea. The sites at risk include the proposed Tioxide site extension, the new nuclear power station site, Graythorp, Tofts Farm, Tees Road and Seaton Sands.

Figure 10 - Tees Estuary Flood Zones and proposed allocations



Green are employment sites, red are SHLAA sites. Dark blue is Flood Zone 3; light blue is Flood Zone 2.

The sites closest to the Tees Estuary (Tioxide and nuclear power station) are shown to be within Flood Zone 3. The Tioxide plant is classed as less vulnerable in PPS25 (as it is not a COMAH site) and should therefore be acceptable in Flood Zone 3, following a Flood Risk Assessment (FRA). The nuclear power station is classed as essential infrastructure (more vulnerable) and would therefore need to pass the Exception Test before being approved.

But before this, a first pass of the Sequential Test should attempt to move these sites to areas of lower flood risk. However, it is likely that these sites could not be located elsewhere due to their type and size (large chemical and nuclear industrial sites). In addition, it is essential that some of these sites have a coastal location in order to operate. It is therefore difficult to apply the Sequential Test to these sites apart from spatial planning within the site boundary. These sites should therefore go straight through to a Level 2 SFRA in order to assess whether the sites will be safe once developed and would not increase flood risk elsewhere.

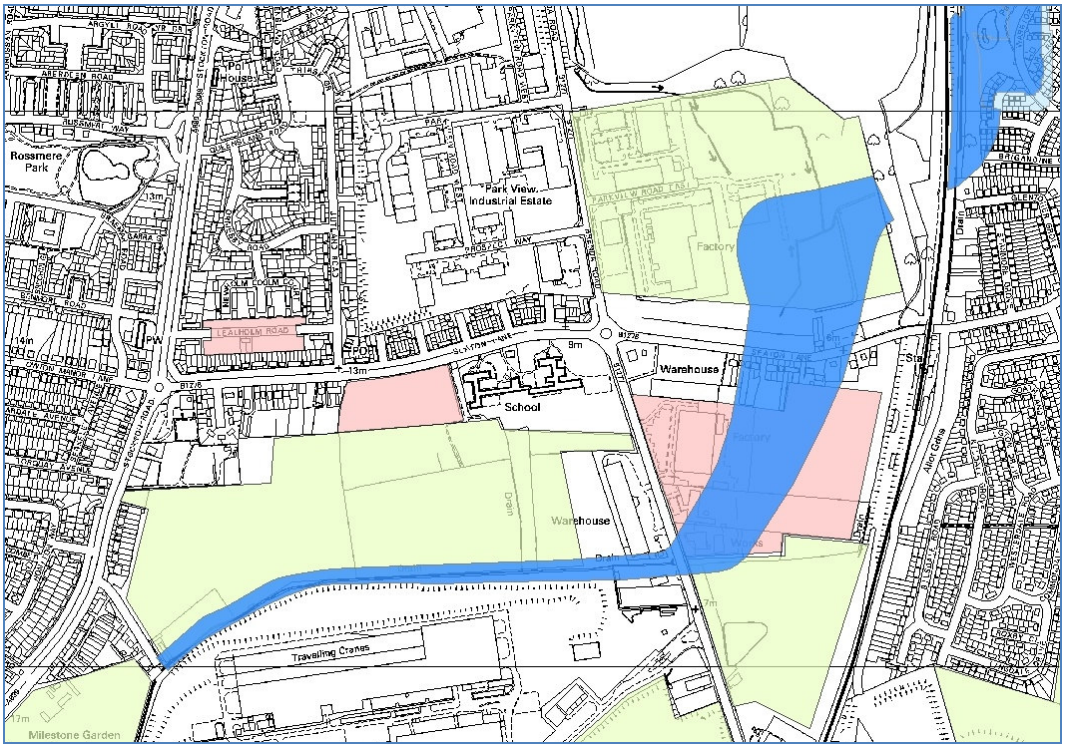
As discussed previously, the draft tidal modelling outlines show a significantly reduced flood extent compared to the current Environment Agency Flood Zones (Version 3.15, September 2009). This draft extent shows that the proposed employment allocations are either no longer at risk of flooding or at a reduced risk (i.e. at risk from the 0.1% AEP event not the 1% AEP event). More detailed tidal modelling in a Level 2 SFRA could confirm and more accurately define these draft extents by producing risk maps, taking into account flood defences. These could then be reviewed by the Environment Agency and they could provide approval to the allocations, subject to a detailed flood risk assessment (FRA).

4.4.3 Proposed allocations on The Stell

The Brenda Road SHLAA and Park View East industrial sites are at risk of flooding from The Stell. The Stell and another associated watercourse pass through these sites. Large parts of the sites are within Flood Zone 3 (the Flood Zone here is modelled which normally means it is reasonably accurate).

In addition, there is another proposed industrial development immediately upstream (Golden Flatts). Only a narrow corridor adjacent to the watercourse is shown to be within Flood Zone 3. However, this proposed development is important as it may increase runoff into The Stell, potentially increasing flood risk downstream. In addition, the OS mapping shows a smaller drain passing through this site and into The Stell, which could be another source of flood risk.

Figure 11 - The Stell Flood Zones and proposed allocations



Green are employment sites, red are SHLAA sites. Dark blue is Flood Zone 3.

The Stell system is considered to be part of an urban drainage problem area and was one of the three areas considered in the Hartlepool IUD Pilot. The area was chosen because of the proposed new development and flooding from multiple sources to properties and highways. Flooding issues in this area include:

- Sewer network issues (e.g. blockages)
- Surface water drainage issues
- Changes in land use and uncertain re-development plans

The proposed development in this area could increase runoff into The Stell and exacerbate the flooding issues.

The Sequential Test should attempt to move development to areas at a lower risk of flooding. The LPA should provide evidence that the Sequential Test has been passed. If (after the test has been applied) there are no other available sites, they will need to go through the Exception Test (e.g. residential development in Flood Zone 3) before being allocated. In this case, industrial sites will not be required to pass the Exception Test if the Sequential Test has already been applied. The site is also located on greenfield land which may be an obstacle in the site passing the Exception Test.

In addition to the planning issues, there may be further problems at the detailed design stage. The drainage infrastructure will have to be carefully designed so as not to increase the current problematic surface water flooding issues. Floodplain compensation will be required if any development is to go ahead in Flood Zone 3. Compensational storage should first be placed directly within or adjacent to the area lost before looking at the surrounding area, however there does not appear to be many options available for floodplain storage. Finally, it is likely that a developer will want to culvert the drains and watercourses that pass through these sites. The Environment Agency is unlikely to approve these requests, so the watercourses would need to be kept open with access and potential floodplain to store any flood water, further reducing the proposed development area.

Taking into account the above issues, the recommendations for these sites are:

- Use the Sequential Test to see if there are any alternative sites that could be developed. This applies to the Brenda Road SHLAA and Park View East industrial sites. The Golden Flatts site should be acceptable for development following a detailed FRA.
- If the above is not possible, keep the area within Flood Zone 3 free from development and retain as a green area. Development should be sequentially placed away from high risk areas (this could potentially reduce the developable area, impacting on yield values and profitability of the site).
- Proceed with a Level 2 SFRA, which would require modelling or requesting the model for The Stell. At best, less vulnerable development (e.g. employment use) would need to be within the Flood Zone 3 area and floodplain storage will need to be found. It does not look likely that a floodplain storage area is available.

As this system has many existing problems, developing in an area already at risk of flooding would increase flood risk and it will be difficult to mitigate the impacts. It is likely that the area at risk of flooding is naturally used to reduce the strain on the rest of the system.

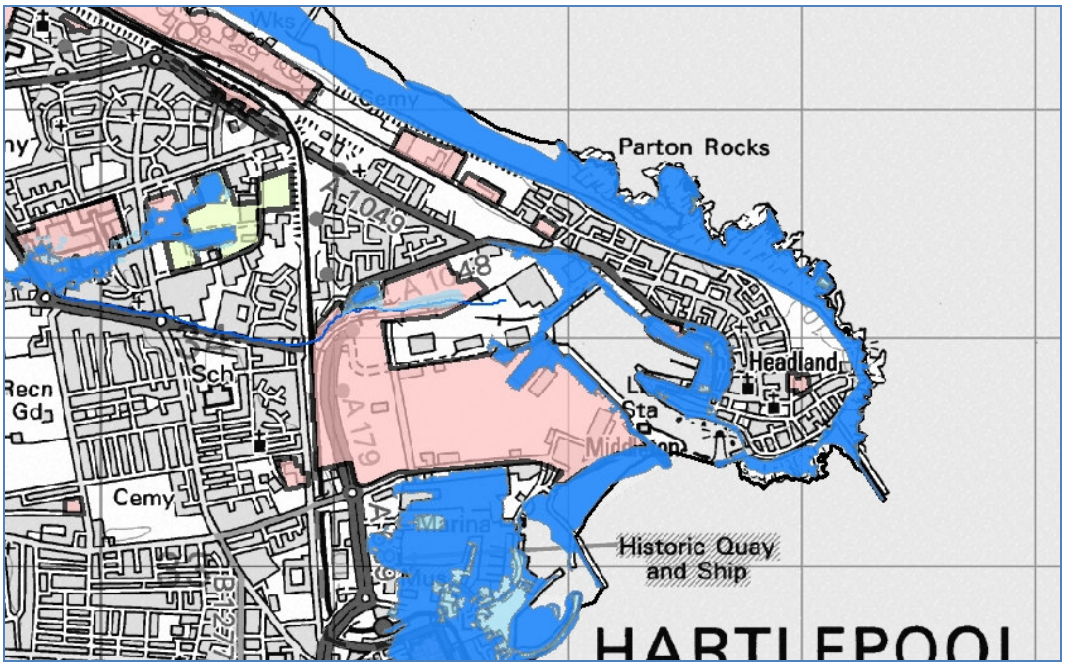
4.4.4 Victoria Harbour development area

Until recently, the Victoria Harbour SHLAA sites were shown to be at risk of flooding from the sea. The previous Flood Zones showed that almost the entire site was within Flood Zone 3. This would have meant that the site would require a Level 2 SFRA. However, recent modelling results have been able to better define the flood risk around Victoria Harbour. As Figure 12 shows, hardly any of the SHLAA site is within Flood Zone 2 or 3.

At the detailed design stage, a Flood Risk Assessment should be completed for this site. This should include assessing flood risk from Middle Warren Watercourse which passes

through the north part of the site (see Figure 12). It is unlikely that flood risk will be a major constraint to development.

Figure 12 - Victoria Harbour Flood Zones and proposed allocations



Green are employment sites, red are SHLAA sites. Dark blue is Flood Zone 3, light blue Flood Zone 2.

4.4.5 Hartlepool Hospital development area

Middle Warren Watercourse puts the Hartlepool Hospital and Oaksway Hospital SHLAA sites along with the Oaksway industrial site within Flood Zone 3 (see Figure 13 below). Before the watercourse reaches the sites, it passes through a culvert and flows to the south of the sites. The Flood Zone here appears to have been derived by modelling the approximate flow route if the culvert surcharged. This outline is crude and a more detailed assessment will provide a better representation of the flood extent.

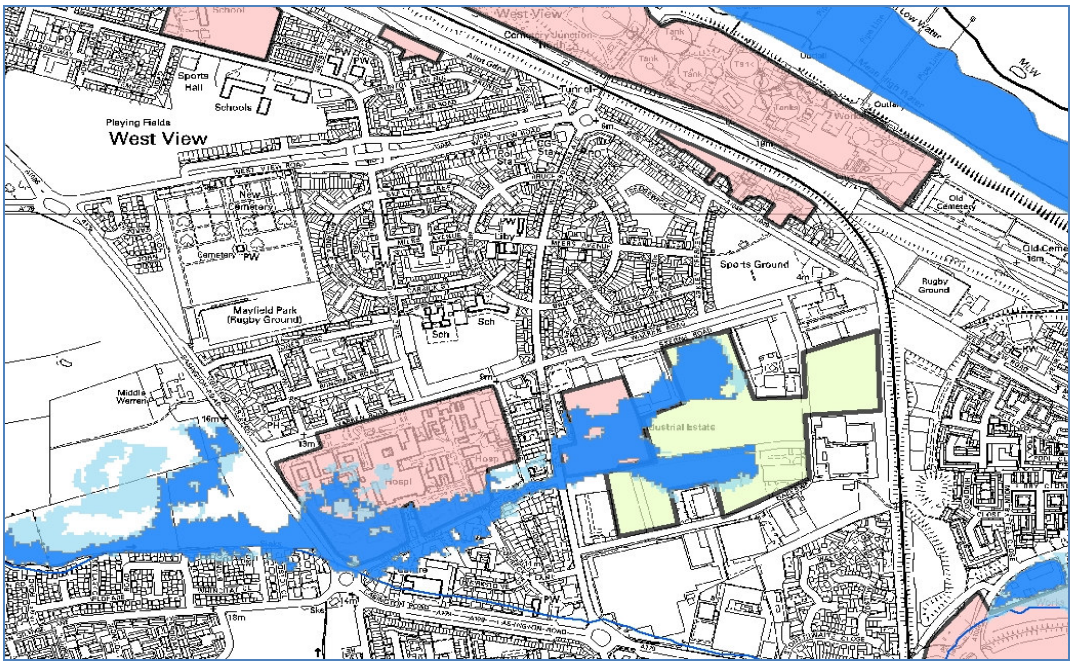
Flood risk from Middle Warren Watercourse could be a combined tidal and fluvial issue (i.e. the combined issue of high tides backing up the culvert during high fluvial flows).

If the Sequential Test is applied and it proves that no alternative sites are available at a lower level of flood risk, then these sites would need to pass the Exception Test before being allocated. This should be undertaken in a Level 2 SFRA.

In order to pass the Exception Test, the sites will need to pass all three criteria including part c, which states that the development should be safe if flooding occurs and would not increase flood risk elsewhere.

The Level 2 SFRA would require more detailed modelling of Middle Warren Watercourse. If the detailed modelling shows that the sites are still at risk of flooding, then compensatory flood storage would need to be found if the whole of the sites are to be developed. Alternatively, the development area could be reduced to exclude the areas within Flood Zone 3.

Figure 13 Middle Warren Watercourse Flood Zones and proposed allocations



Green are employment sites, red are SHLAA sites. Dark blue is Flood Zone 3, light blue Flood Zone 2.

4.5 Level 2 SFRA

Proposed development sites within Flood Zones 2 or 3 should undergo the Sequential Test, which aims to move allocations to areas of lower flood risk. The information presented in the Level 1 SFRA should be used to complete the Sequential Test. If it is not possible to avoid sites in high flood risk areas, a more thorough study is required to truly understand the mechanisms of flood risk around the sites in question, before the Exception Test is applied and sites are allocated. This should be undertaken in a Level 2 SFRA.

Sections 4.4.2 to 4.4.4 above provide details on the locations where a Level 2 SFRA may be required. This states that the following site areas would require a Level 2 assessment:

- The industrial sites around the Tees Estuary (Tioxide and the power station area)
- Allocations at risk of flooding from The Stell (Brenda Road area)
- The Hartlepool Hospital area at risk of flooding from Middle Warren Watercourse.

A key objective of a Level 2 SFRA is to assist the LPA in establishing whether the requirements of the Exception Test can be met as outlined below:

a) It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared. If the LDD has reached the 'submission' stage (see Figure 4.1 of PPS12: Local Development Frameworks) the benefits of the development should contribute to the Core Strategy's Sustainability Appraisal (SA);

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

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

Whilst the Exception Test process makes it possible to identify areas where developments can be built safely, it must not been seen as an opportunity to place inappropriate development in flood risk areas. It is a useful planning tool that can justify the acceptability of the residual risks remaining after the mitigation measures have been applied.

In order to establish whether applying the Exception Test is justified or can then be satisfied, namely part c), the Level 2 SFRA considers the detailed nature of flood hazard, taking account of the presence of flood risk management measures such as flood defences. The detail nature of the flood hazard within a flood zones includes:

- Flood probability;
- Flood depth;
- Flood Velocity; and
- Rate of onset of flooding.

These factors can be significantly affected by the presence of flood defences or any other infrastructure which acts as a flood defences. Flooding behind such infrastructure can occur either as a result of:

- Constructional or operation failure of the defence, either in whole or in part (breach); or
- Water levels rising to exceed the level of the defence (overtopping);

By facilitating the application of the Exception Test, the Level 2 SFRA technical work will also provide supporting evidence to the possible mitigation measures that would enable the development to proceed.

4.6 Surface water flood risk

The surface water flood maps show that a number of proposed development sites at risk from surface water flooding. These maps show three different scales of surface water flooding (low, intermediate and high susceptibility). For all developments, surface water management will be an issue that will have to be dealt with. Large dense development could have significant implications on current risk in the area and further downstream if runoff is not controlled.

The intermediate and low surface water flooding areas can, in general, be managed relatively easily. However, sites that are at risk from high susceptibility surface water flooding may have to keep the surface water flow pathways open and undeveloped.

4.6.1 Surface Water Management Plan Recommendations

Critical Drainage Areas (cCDAs) are those areas identified from historical flood events and/or modelled data as having a significant risk from surface water flooding. cCDAs have been identified in this Level 1 SFRA using the available data (historic flooding incidents and the surface water vulnerability maps).

The cCDAs are summarised in Section 2.4.2 and are:

- The area around and north of Middle Warren Watercourse
- Tunstall Farm Beck at West Park
- Tunstall Farm Beck at Stranton
- The Stell system near Seaton

This Level 1 SFRA recommends that these sites/communities are investigated further within the Level 2 SFRA (modelling and further consultation). These sites have been sent to NWL for consultation.

A level 2 SFRA should investigate these sites further, initially through a meeting with NWL, the Environment Agency, Hartlepool BC and other relevant stakeholders. NWL have confirmed they will provide the next level of DG5 information as this stage (area and street level). The Level 2 SFRA should be able to 'whittle the sites down' between those issues NWL have actually sorted (or plan to) or those which will definitely need further

work/investigation. On the back of this, more precise recommendations for SWMPs can be provided. In these high risk locations or areas of significant development, an integrated drainage solution should be possible that can reduce flood risk to both the current community and new development (SWMPs guidance is discussed in Volume III).

Appendices

A . Figures

(Provided separately)

B . Sequential Test Table

Hartlepool BC Strategic Flood Risk Assessment

Hartlepool Borough Council Sequential Test

Summary Table

			Flood Zone Coverage								Surface Water Vulnerability					
			Flood Zone 1		Flood Zone 2		Flood Zone 3a		Flood Zone 3b		Low Vulnerability		Intermediate Vulnerability		High Vulnerability	
	Number of	Area (ha)	Area	#	Area	#	Area	#	Area	#	Area	% at risk	Area	% at risk	Area	% at risk
Total	95	1374.7	1064.9	90	15.6	20	260.5	15	33.7	18	226.3	15.5	92.4	6.4	16.0	0.6

Main Table

				Flood Zone Coverage								Surface Water Vulnerability					
				Flood Zone 1		Flood Zone 2		Flood Zone 3a		Flood Zone 3b		Low Vulnerability		Intermediate Vulnerability		High Vulnerability	
Site ID	Name and/or reference	Ownership	Area (ha)	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
	Tioxide	Private	89.88	0.00	0.00	0.00	0.00	89.88	100.00	0.00	0.00	26.96	30.00	10.84	12.07	0.03	0.03
	Graythorp	Private	28.09	22.78	81.10	0.38	1.34	4.93	17.56	0.00	0.00	3.70	13.17	0.63	2.25	0.00	0.00
	New Power Station	Private	143.68	7.79	5.42	2.86	1.99	133.03	92.59	0.00	0.00	32.44	22.58	10.37	7.21	0.38	0.26
	West of Brenda Road	Private	25.57	25.57	100.00	0.00	0.00	0.00	0.00	0.00	0.00	2.98	11.64	0.14	0.55	0.00	0.00
	Tofts Farm	Private	10.27	0.02	0.18	0.04	0.43	10.21	99.39	0.00	0.00	2.26	22.03	0.92	8.92	0.00	0.00
	Tees Road Seaton	Private	23.86	12.77	53.53	2.88	12.07	8.21	34.40	0.00	0.00	2.78	11.66	0.12	0.51	0.00	0.00
	Seaton Sands	Private	2.38	0.31	13.12	0.20	8.39	1.87	78.48	0.00	0.00	0.42	17.47	0.12	5.15	0.00	0.00
	Park View East	Private	19.54	14.57	74.55	0.00	0.00	0.00	0.00	4.97	25.45	9.91	50.72	6.65	34.05	2.49	12.73
	Golden Flatts	Private	20.89	19.36	92.65	0.00	0.00	0.00	0.00	1.54	7.35	2.49	11.92	0.44	2.10	0.00	0.00
	Queens Meadow	Private	68.71	68.71	100.00	0.00	0.00	0.00	0.00	0.00	0.00	12.66	18.43	2.95	4.29	0.03	0.04
	Oaksway	Private	12.16	8.77	72.12	0.52	4.24	0.00	0.00	2.88	23.65	6.83	56.20	4.16	34.19	0.05	0.37
	South of Seaton Lane	Private	6.93	6.72	96.90	0.00	0.00	0.00	0.00	0.22	3.10	1.22	17.63	0.27	3.93	0.00	0.00
	Springwell School	Council	0.51	0.51	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	81.67	0.00	0.00	0.00	0.00
	East of Dalton Pierc	Private	0.97	0.95	97.88	0.01	1.13	0.00	0.45	0.01	0.54	0.04	4.26	0.02	1.70	0.00	0.00
	Raby Arms Paddock	Private	0.77	0.77	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	16.29	0.07	8.42	0.00	0.00
	Home Farm	Private	2.41	2.41	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Glebe Farm	Private	4.30	4.30	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Jesmond Road School	Council	0.50	0.50	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hartlepool Water HQ	Private	1.24	1.24	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	16.70	0.01	0.93	0.00	0.00
	Council Depot	Council	2.04	0.00	0.00	0.00	0.00	2.04	100.00	0.00	0.00	1.85	90.51	1.27	62.44	0.00	0.00
	Briarfields Paddock	Council	1.81	1.81	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.01	0.00	0.00
	North East of Elwick	Private	3.44	3.44	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	1.96	0.00	0.00	0.00	0.00
	Between Brierton Far	Private	18.88	18.88	100.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	6.00	0.14	0.73	0.00	0.00
	Claxton Farm West	Private	71.22	70.45	98.92	0.06	0.08	0.00	0.00	0.71	1.00	7.53	10.57	1.33	1.86	0.00	0.00
	East of Queensway	Private	3.26	3.26	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	17.74	0.02	0.57	0.00	0.00
	Upper Warren West of	Private	8.48	8.48	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	11.64	0.71	8.39	0.24	2.87
	Upper Warren East of	Private	6.55	6.55	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	10.05	0.33	5.10	0.18	2.80
	North of Raby Arms P	Private	0.20	0.20	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wynyard North	Private	140.54	133.27	94.83	0.69	0.49	0.00	0.00	6.58	4.68	12.81	9.11	5.84	4.16	1.95	1.39
	Wynyard West	Private	10.77	10.77	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	5.25	0.22	2.03	0.00	0.01
	High Tunstall Farm	Private	62.75	62.75	100.00	0.00	0.00	0.00	0.00	0.00	0.00	3.66	5.84	0.91	1.45	0.00	0.00
	Hart Station	Private	2.22	2.22	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	11.46	0.12	5.45	0.00	0.00
	Oxford Road	Private	0.78	0.78	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	99.15	0.30	38.64	0.00	0.00
	Three Gates Farm Sou	Private	0.95	0.95	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Three Gates Farm Nor	Private	1.78	1.78	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dalton Piercy South	Private	2.94	2.94	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.44	0.00	0.15	0.00	0.00
	Dalton Piercy North	Private	5.12	5.12	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.15	0.00	0.00	0.00	0.00
	Dalton Piercy Dalton	Private	0.11	0.11	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Claxton Farm East	Private	29.84	26.09	87.45	0.87	2.92	0.00	0.00	2.87	9.63	7.95	26.64	5.42	18.16	2.74	9.20
	Brewery Farm	Private	22.34	22.34	100.00	0.00	0.00	0.00	0.00	0.00	0.00	1.84	8.22	0.17	0.76	0.00	0.00
	Middlethorpe Farm	Private	9.39	9.39	100.00	0.00	0.00	0.00	0.00	0.00	0.00	1.77	18.83	1.34	14.32	0.59	6.28
	Greatham Station Roa	Private	1.01	1.01	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	14.17	0.10	10.19	0.00	0.00
	Valley Drive	Private	35.24	33.76	95.79	0.74	2.11	0.26	0.72	0.48	1.37	12.33	35.00	9.94	28.20	5.20	14.74

	Egerton Terrace	Private	0.10	0.10	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Greatham Station Ave	Private	0.38	0.38	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00
	Greatham Stockton Ro	Private	10.47	9.27	88.51	0.09	0.88	0.00	0.00	1.11	10.60	1.19	11.35	0.81	7.72	0.00	0.00
	Greatham West of The	Private	0.28	0.28	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Greatham Allotments	Private	1.13	1.13	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	48.73	0.23	20.21	0.00	0.00
	Greatham Allotments	Private	1.65	1.53	92.45	0.02	1.12	0.00	0.00	0.11	6.43	0.31	18.47	0.23	13.92	0.00	0.00
	Brierton Quarry	Private	2.76	2.76	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	17.63	0.40	14.56	0.00	0.00
	North Hart Farm	Private	8.81	8.81	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	5.32	0.09	1.04	0.00	0.01
	Butts Lane	Private	1.36	1.36	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hartlepool Hospital	Private	10.87	7.43	68.34	0.78	7.22	0.00	0.00	2.66	24.44	1.94	17.81	0.31	2.88	0.00	0.00
	North of Voltigeur D	Private	0.48	0.48	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	East of Millbank Clo	Private	0.84	0.84	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	37.69	0.07	8.67	0.00	0.00
	Potters Farm	Private	11.54	11.54	100.00	0.00	0.00	0.00	0.00	0.00	0.00	1.18	10.18	0.89	7.71	0.00	0.00
	Quarry Farm West	Private	19.32	19.32	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	3.53	0.26	1.33	0.00	0.00
	Quarry Farm East	Private	22.72	22.72	100.00	0.00	0.00	0.00	0.00	0.00	0.00	1.61	7.09	0.94	4.15	0.71	3.11
	Brenda Road	Private	10.12	5.70	56.31	0.00	0.00	0.00	0.00	4.42	43.69	3.39	33.48	1.34	13.25	0.00	0.00
	Owton Grange Farm We	Private	18.39	16.72	90.96	0.20	1.11	0.00	0.00	1.46	7.93	2.08	11.29	1.65	8.99	0.72	3.91
	Owton Grange Farm So	Private	14.09	13.28	94.25	0.21	1.46	0.00	0.00	0.60	4.29	4.16	29.53	1.32	9.38	0.00	0.00
	Owton Grange Farm Ea	Private	9.93	9.93	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	6.64	0.16	1.63	0.00	0.00
	Owton Grange Farm No	Private	17.69	17.69	100.00	0.00	0.00	0.00	0.00	0.00	0.00	2.81	15.90	0.99	5.59	0.00	0.00
	Victoria Harbour Eas	Private	4.51	0.40	8.75	0.20	4.39	3.92	86.85	0.00	0.00	0.14	3.21	0.02	0.46	0.00	0.00
	Victoria Harbour Wes	Private	77.67	70.71	91.04	2.14	2.75	4.82	6.21	0.00	0.00	16.77	21.60	4.23	5.45	0.05	0.07
	West of Guliver Road	Private	21.15	21.15	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	1.27	0.01	0.03	0.00	0.00
	Nelson Farm East	Private	5.44	5.44	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	9.43	0.06	1.06	0.00	0.00
	Nelson Farm West	Private	13.44	13.44	100.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66	12.35	0.42	3.09	0.00	0.00
	Manor House Farm Eas	Private	95.10	91.61	96.34	2.24	2.36	0.09	0.09	1.15	1.21	13.43	14.12	8.56	9.00	0.62	0.65
	Manor House Farm Wes	Private	17.85	17.85	100.00	0.00	0.00	0.00	0.00	0.00	0.00	1.48	8.28	0.38	2.12	0.00	0.00
	Southbrook Farm	Private	0.65	0.65	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Rear of Bruntoft Ave	Council	0.41	0.41	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	14.20	0.02	4.26	0.01	2.74
	Hill View	Private	0.42	0.42	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Golden Flatts	Council	1.98	1.98	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	14.36	0.00	0.00	0.00	0.00
	East Central Area (W	Council	0.67	0.63	94.10	0.00	0.00	0.04	5.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Britmag Main	Private	21.48	21.48	100.00	0.00	0.00	0.00	0.00	0.00	0.00	2.28	10.64	0.82	3.82	0.00	0.00
	Britmag Middle	Private	3.61	3.61	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	14.75	0.00	0.00	0.00	0.00
	Britmag Small	Private	1.19	1.19	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	6.38	0.00	0.00	0.00	0.00
	Oaksway Industrial E	Private	2.78	0.84	30.20	0.05	1.89	0.00	0.00	1.89	67.92	0.91	32.70	0.04	1.26	0.00	0.00
	Former Niromax Site	Private	0.77	0.00	0.00	0.16	20.56	0.62	79.44	0.00	0.00	0.77	100.00	0.63	81.19	0.00	0.00
	Eaglefield Road	Private	3.38	3.38	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	1.18	0.00	0.00	0.00	0.00
	Clarkston Court	Private	0.44	0.44	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	39.27	0.04	9.71	0.00	0.00
	East Central Area (E	Council	0.50	0.00	0.00	0.00	0.00	0.50	100.00	0.00	0.00	0.05	9.66	0.00	0.00	0.00	0.00
	Behind 224-246 West	Council	1.50	1.50	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	4.52	0.03	2.00	0.00	0.00
	Friarage Manor	Private	0.68	0.68	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Coronation Drive	Council	1.79	1.53	85.21	0.23	12.90	0.03	1.89	0.00	0.00	0.49	27.49	0.14	7.70	0.00	0.00
	Kipling Road	Council	0.55	0.55	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Claremont Flats	Private	0.63	0.61	96.37	0.02	2.93	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00
	Lealhom Road	Private	1.06	1.06	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Eskdale Road	Council	0.46	0.46	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Elizabeth Way	Council	1.21	1.21	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Former St Hilds Scho	Council	3.81	3.81	100.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79	47.04	0.78	20.58	0.00	0.00
	Old Cemetery Road	Private	0.59	0.59	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	West of Eaglesfield	Private	9.60	9.60	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	2.37	0.11	1.14	0.00	0.00
	Century Park	Private	12.14	12.02	0.00	0.03	0.21	0.09	0.70	0.00	0.00	2.04	16.83	0.49	4.06	0.02	0.19

Offices at

Atherstone
Doncaster
Edinburgh
Haywards Heath
Limerick
Newcastle upon Tyne
Northallerton
Northampton
Saltaire
Skipton
Tadcaster
Wallingford
Warrington

Registered Office
South Barn
Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE

t:+44(0)1756 799919
e:info@jbaconsulting.co.uk

Jeremy Benn Associates Ltd
Registered in England 3246693