C&V Developments

Residential Development at Sandstell Road, Spittal, Berwick-Upon-Tweed

Flood Risk Assessment

December 2015

Kaya Consulting Limited
Phoenix House, Strathclyde Business Park,
Bellshill, North Lanarkshire, ML4 3NJ, UK
Tel: 01698 464190, Web: www.kayaconsulting.co.uk

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Phoenix House, Strathclyde Business Park,
Bellshill, North Lanarkshire, ML4 3NJ, UK
Tel: 01698 464190, Web: www.kayaconsulting.co.uk

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Author	Callum Anderson

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Kaya Consulting Limited
Phoenix House, Strathclyde Business Park,
Bellshill, North Lanarkshire, ML4 3NJ, UK
Tel: 01698 464190, Web: www.kayaconsulting.co.uk

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1 Introduction

Kaya Consulting Ltd. was commissioned by C&V Developments through Ferguson Planning Ltd. to undertake a flood risk assessment of a proposed development site at Sandstell Road in the Spittal area of Berwick-Upon-Tweed. A general site location plan is shown in Figure 1.

The site is brownfield, comprising an existing warehouse and small scale business storage site. The River Tweed runs close to the northern boundary of the site before meeting the North Sea. There are no other open watercourses near the site. However, there is a local sewer network, with two surface water sewers running close to the northern and south-western boundaries of the site. The flood risk assessment considers the flooding risk from River Tweed, surface water culverts and local drainage infrastructure, surface water runoff and groundwater.

The scope of work as outlined by Kaya Consulting in April 2015 includes the following:

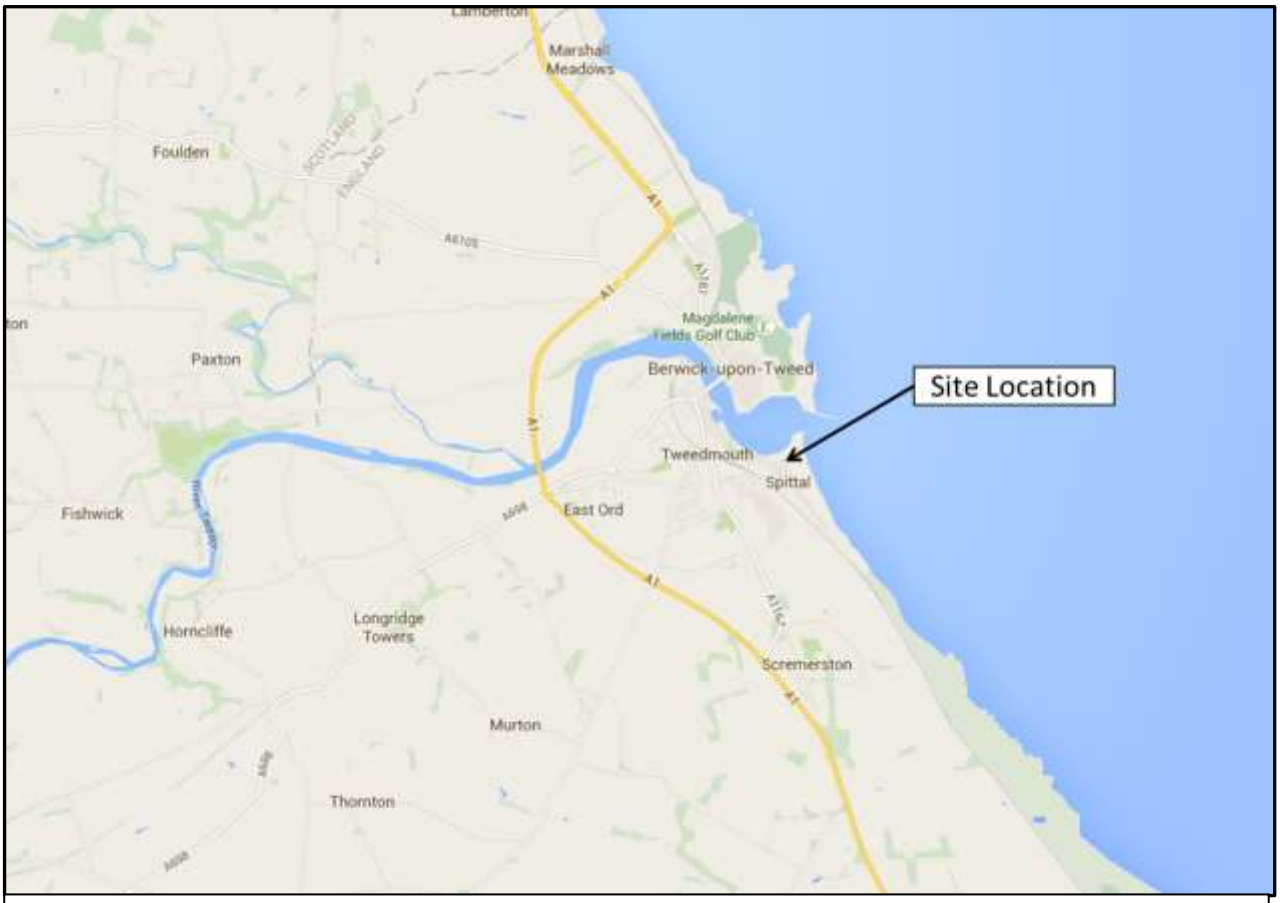
- Site visit and walkover survey;
- Walkover site visit;
- Review of requirements of local council and EA with respect to design levels for coastal development (i.e., freeboard and required return period/climate change);
- Liaison with local council to obtain relevant information with respect to historical flooding and flood levels in the River Tweed;
- Assessment of extreme sea levels (tides and surge) based on standard EA methods;
- Assessment of potential sea level rise due to climate change;
- Initial assessment of risk from waves. It is noted that this does not include detailed wave overtopping calculations. It will be based on a review of available information and simple wave calculations. If a risk from waves is identified and the council and EA require detailed overtopping calculations we would discuss the cost implications with you at the relevant time.
- Assessment of risk from other sources, e.g., River Tweed (assuming flood levels are available and no detailed modelling is required), surface water runoff, existing drainage infrastructure, groundwater. Surface water flooding would be assessed based on a site walkover survey, although we may request LiDAR topographical data (around £150 + VAT) to help undertake a surface water assessment
- Preparation of flood risk assessment report suitable for submission with a planning application.

Information made available to Kaya Consulting Ltd for the study includes the following:

- Location plan and development proposals;
- Northumberland Water service drawings; and
- Previous flood risk assessment for the site by DMJ Associates.

The work carried out to assess the flooding risk of the site and main findings of the study are summarised in the following sections.

Figure 1: General site location



2 Legislative and Policy Aspects

The National Planning Policy Framework (NPPF) and it's associate Technical Guidance, published in March 2012 identifies flood risk as specific material consideration in the planning and consenting process.

2.1 National Planning Policy Framework

The National Planning Policy Framework replaces previous guidance set out in PPS 25: Development and flood risk, however the technical criteria for which development sites are assessed has remained largely unchanged.

The new framework policy sets out how flood risk should be taken into consideration in the planning process in order to deliver appropriate sustainable development. The main aim of the policy is to ensure that flood risk is taken into account at all stages of the planning process to avoid inappropriate development in areas at high risk of flooding. The policy also endeavours to direct development away from flood risk areas whenever possible.

The risk-based sequential approach is used for areas known to be at risk of flooding. An assessment is made whether there are reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use. Subsequently, the Exception Test is applied if it is not possible, consistent with wider sustainability objectives, for the development to be located in zones of lower probability of flooding.

Table 1 of the "Technical Guidance to the National Planning Policy Framework" gives definitions of Flood Zones, which are the starting point for Sequential Approach.

The Flood Zones as specified in the guidance document are summarised below.

Flood Zone 1	Low Probability	This zone comprises of land assessed as having less than 1 in 1000 annual probability of fluvial and coastal flood risk in any year (<0.1% Annual Exceedance Probability (AEP)) All uses of land are appropriate in this zone. For development proposals on sites comprising 1ha or more, the vulnerability to flooding from other sources as well as from fluvial and tidal flooding, and the potential to increase flood risk elsewhere should be incorporated in a brief FRA.
Flood Zone 2	Medium	This zone comprises of land assessed as having between 1 in 100

	Probability	and 1 in 1000 annual probability of fluvial flood risk in any year (1%-0.1% AEP) or between 1 in 200 and 1 in 1000 annual probability of tidal flood risk in any year (0.5%-0.1% AEP) The water-compatible, less vulnerable and more vulnerable uses of land (Table 2) and essential infrastructures are appropriate in this zone. Subject to Sequential Test being applied, the highly vulnerable uses are only appropriate in this zone if the Exception Test is passed. All developments in this zone should be accompanied by a FRA.
Flood Zone 3a	High Probability	This zone comprises of land assessed as having 1 in 100 or greater annual probability of fluvial flood risk in any year (>1% AEP) or 1 in 200 or greater annual probability of tidal flood risk in any year (>0.5% AEP) The water compatible and less vulnerable uses of land are appropriate in this zone. The highly vulnerable uses of land should not be permitted in this zone. The more vulnerable and essential infrastructure uses should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted should be designed and constructed to remain operational and safe in times of flood. All developments in this zone should be accompanied by a FRA.
Flood Zone 3b	Functional Floodplain	This zone comprises of land where water has to flow or be stored in times of flood. Strategic Flood Risk Assessments should identify this zone taking into account local circumstances and not be defined solely on rigid probability parameters. Only the water-compatible uses and essential infrastructures that has to be there should be permitted in this zone providing it remains operational and safe for users in times of flood; result in no net loss of floodplain storage; not impede water flows; and not increase flood risk elsewhere. Essential infrastructure in this zone should pass the Exception Test.

The compatibility of Flood Zones and Flood Risk Vulnerability is summarised in Table 3 of the "Technical Guidance to the National Planning Policy Framework" , an extract of which is given below.

Flood risk vulnerability classification (see table 2)		Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Flood zone (see table 1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	×	Exception Test required	✓
	Zone 3b functional floodplain	Exception Test required	✓	×	×	×

Key: ✓ Development is appropriate.
× Development should not be permitted.

Notes to table 3:
This table does not show:
a. the application of the Sequential Test which guides development to Flood Zone 1 first, then Zone 2, and then Zone 3;
b. flood risk assessment requirements; or
c. the policy aims for each flood zone.

2.2 Return period Vs. Annual Exceedance Probability

The concept of return period is commonly used to describe the severity of a flood event. Return period can be defined as the average number of years between the occurrences of events of a specified magnitude. A 100 year event is likely to be equalled or exceeded once in 100 years when averaged over a long period of time (hundreds of years). However, it can occur more than once or not at all in any given 100 year period.

A better description of flood risk can be expressed in terms of probability. Statistically there is 1% chance of the 100 year event occurring in any one year, 9.6% chance of occurrence in any 10 year period, 39.5% chance of occurrence in any 50 year period, and 63.4% chance of occurrence in any 100 year period.

It is important to note that the concept of return period in flood studies assumes that the conditions associated with flooding (catchment use, river and flood plain characteristics, hydrology, etc.) remain largely unchanged with time. In practice, this is not necessarily the case when considered over long periods of time. Therefore, return period predictions require to be treated with caution, and updated regularly when additional relevant data becomes available, or significant changes take place in the catchment, or when predictive tools are improved.

3 Site Location and Description

The site is located in the Spittal area of Berwick-Upon-Tweed, Figure 1. The site is brownfield, comprising warehousing and commercial storage units. The development proposals are for conversion to residential dwellings.

The site measures approximately 0.4 ha in plan area and is bounded to the north by open ground leading to the banks of the River Tweed. Sandstell Road bounds the site to the south-east and Dock Road bounds the site to the south-west. A detailed location plan is shown in Figure 2.

A site topographical survey was not available at the time of writing. Based on LiDAR data purchased specifically for this assessment the site is generally flat, sloping up from around 3.6 m AOD (Above Ordnance Datum) at the east of the site to around 4.5 m AOD at the south-west of the site. Ground levels fall to a low area to the northern boundary of the site.

Ground levels on Sandstell Road slope north-east away from the site and levels on Dock Road generally fall to the north-west. It should be noted there is a local high point to the south-west of the site at the junction with Sandstell Road and Dock Road where ground levels reach a level of approximately 5 m AOD.

The site is close to Sandstell Point at the boundary between the River Tweed and the North Sea. At this location the River Tweed is tidal as it enters its final meander before discharging into the North Sea. Approximately 300 m to the east of the site, Spittal beach and the foreshore separates the site from the coast.

Local drainage infrastructure drawings show a 300 mm surface water culvert flowing along Dock Road before passing close to the site. In addition, a surface water overflow pipe connects to the combined sewer close to the north-eastern boundary of the site. A network of combined sewers surrounds the site along Dock Road, Sandstell Road and the northern boundary of the site.

Land to the south and west of the site rises to a high point of around 80 m AOD. The area between the site and the high ground is urbanised; hence, a portion of the surface water runoff from the urban area is likely to enter into the local drainage network. It is also possible that surface water runoff reaching the site could be intercepted by a railway embankment, which runs perpendicular to the slope approximately 250 m to the south-west of the site.

Figure 2: Detailed Site Location

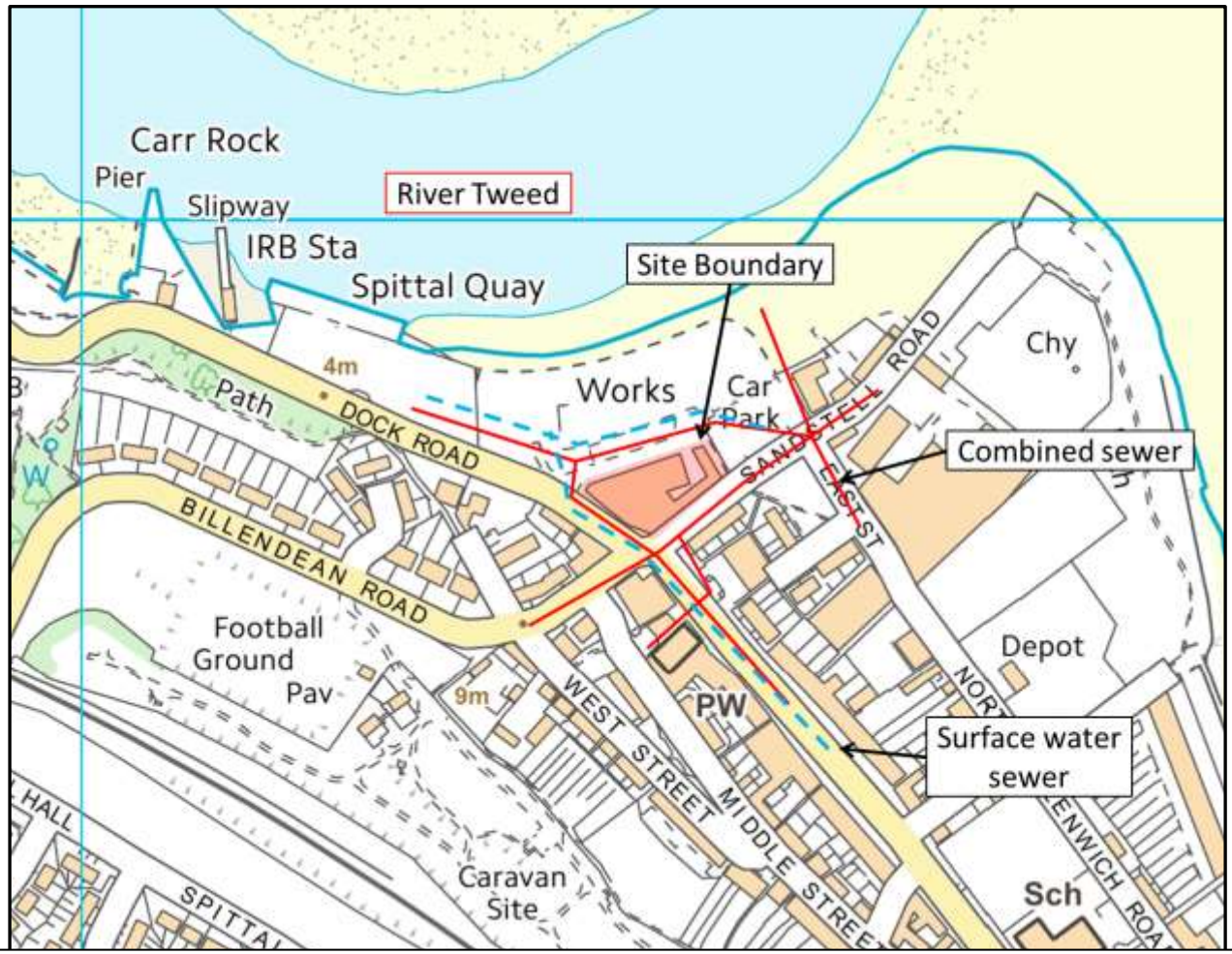
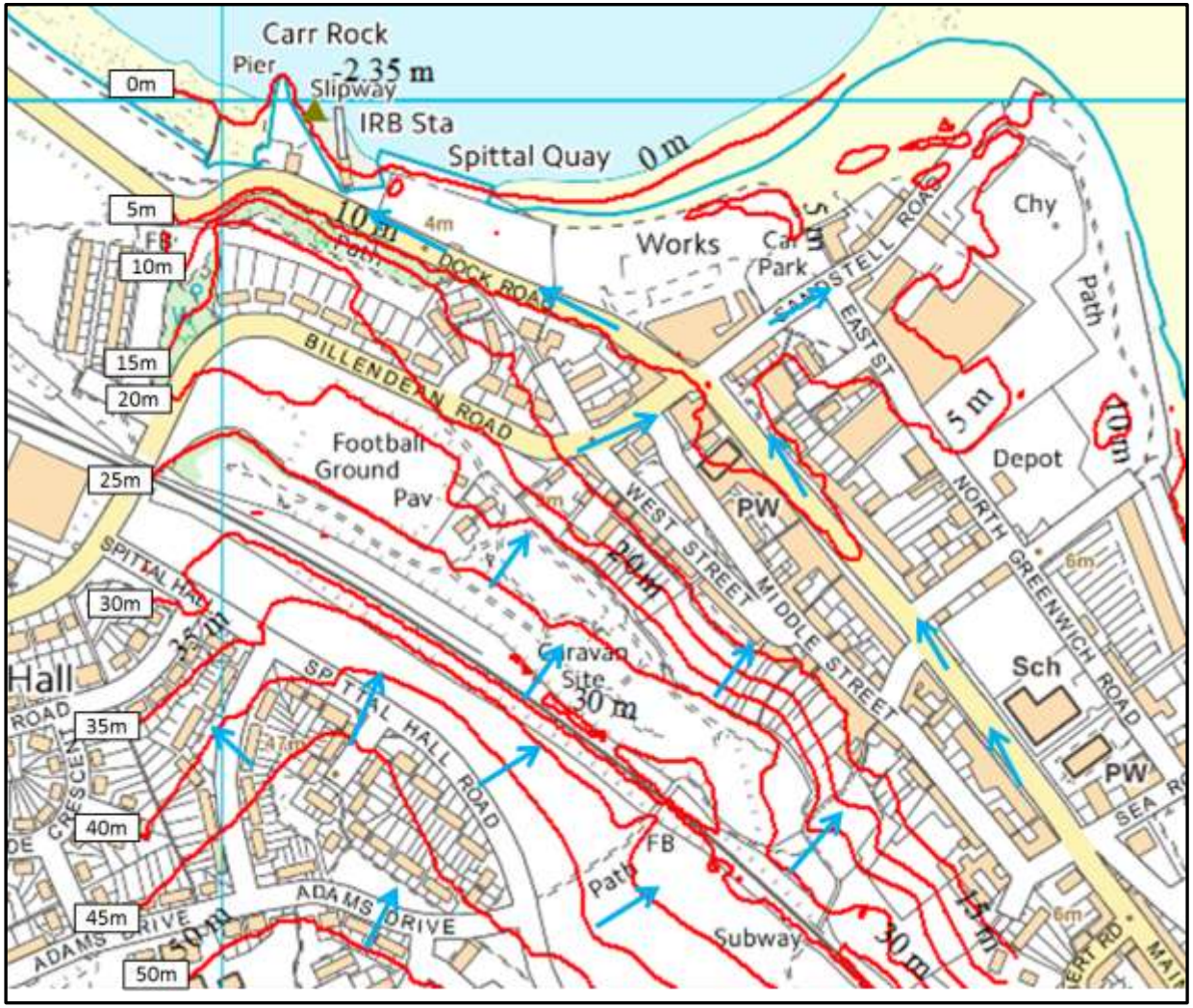


Figure 3: Site topographical levels including indicative overland flow pathways (based on LiDAR- site topographical survey not available)



3.1 Historical flooding information

The Environment Agency and Northumberland Council provided data on historical flooding. The information is provided below:

Northumberland Council

The information tabulated below shows historical flooding relevant to the site. The table shows that the main historical source of flooding close to the site has generally related to high levels in the River Tweed with the most recent event being the 2013 high storm surge.

Table 1: Table of historical flooding provided by Northumberland Council

Date	Areas affected by flooding	Source
August 1946	Heavy rainfall fell over the Cheviot Hills extending to the coast between Alnmouth and Berwick-upon-Tweed. Trees were uprooted and water was reported to have been running down from the hills in torrents cutting 3 ft deep channels in several roads	SFRA
February 1831	Exceptional flooding of the River Tweed and all tributaries following a snowstorm and thaw. Flooding at Norham has only occurred once since	SFRA
September 1839	River Tweed Considerable d September 1839 damage between Kirknewton and the River Till confluence.	SFRA
August 1948	Berwick -Tweedmouth - homes along main street flooded, tourists stranded, roads flooded, boathouse flooded - waters almost reach roof level at Boat House, Norham	SFRA / FAP
August 1948	Castle Street in Norham Village flooded to 300mm	FAP
August 1948	Whiteadder Bridge - three bungalows, bridge collapsed	SFRA
1953	Flooding to the properties Berwick Pier Road	FAP
January 1978	2 properties flooded by the Tweed at the Salmon Fisheries, Berwick	FAP
2nd November 1984	Milfield Plain, Kirknewton and Bridge End - flooding of agricultural land.	SFRA
31st March 1992	Norham - road flooded.	SFRA / FAP
February 1997	1 property was flooded in 1997 by the old bridge, North Sea Berwick-upon-Tweed	FAP
October 2002	Flooding to access roads at Boat House, Norham and Norham Village	FAP
October 2005	The estuary broke its banks under the bridge in 2005, however sandbags prevented any damage to Properties. North Sea Berwick-upon-Tweed	FAP
March 2006	Lifeboat Slipway was submerged in tidal flood waters, flooding occurred along low-lying areas along Blakewell Street no properties were damaged - Berwick upon Tweed.	FAP
February 2007	Road at the Quayside, Berwick upon Tweed	FAP

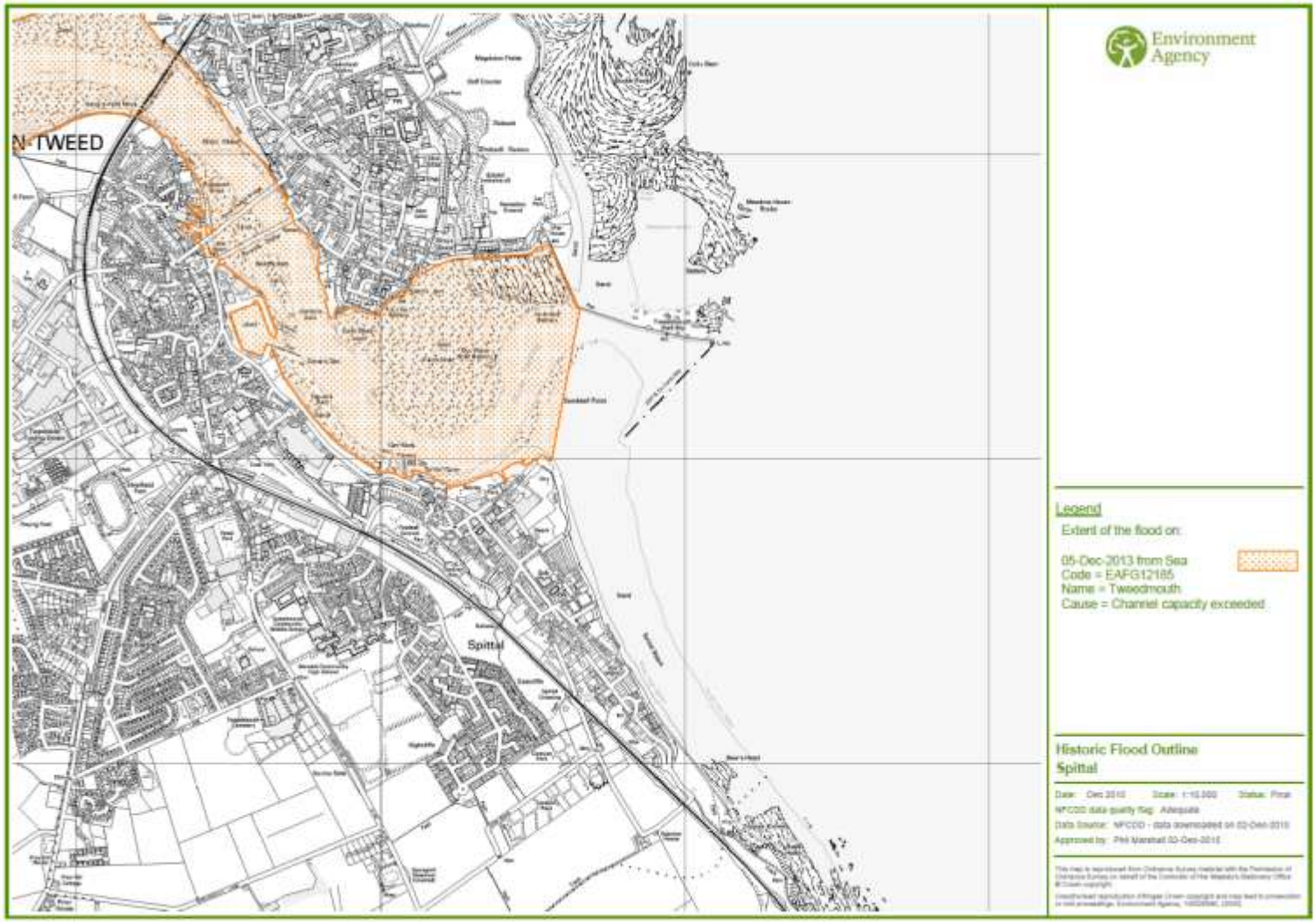
September 2008	Wooler Water / River Breamish / River Tweed / Glen - Agricultural land and properties flooded throughout and Alnwick District	SFRA
December 2013	Tidal surge from North Sea affected areas along the Northumberland Coast, including the Berwick (Tweedmouth) area - A Flood Investigation Report can be found here - http://www.northumberland.gov.uk/Default.aspx?page=16751	NCC FCERM

Environment Agency:

The Environment Agency was also contacted regarding historical flooding to the site and they have provided a flood extent map delineating the 2013 flood event, see Figure 4. Model results indicated that low lying areas of land upstream of the site could have been inundated; however the site was unaffected during the 2013 event.

Additional modelling results have also been provided which are discussed in the Sections below.

Figure 4: December 2013 flood outline



4 Flood Risk Assessment

The flood risk assessment considers risk from:

- River Tweed/Tweed Estuary;
- Wave overtopping;
- Surface water runoff from adjacent land;
- Sewers and water mains;
- Groundwater; and
- Site access.

In accordance with NPPF, the assessment also details the sequential/exception test.

4.1 River Tweed/Tweed Estuary

The River Tweed drains a very large upstream catchment before meeting the North Sea close to the site. Due to the proximity of the North Sea, water levels within the Tweed close to the site are affected by a combination of fluvial flows and tide levels.

Due to the hydraulic interactions of the Tweed adjacent to the site, a comprehensive hydraulic model would be required to undertake a detailed assessment of the effect of water levels at the mouth of the river. Such a modelling study is out with the scope of this assessment; however, correspondence with the Environment Agency has indicated that a detailed modelling study has already been undertaken and results are now publically available.

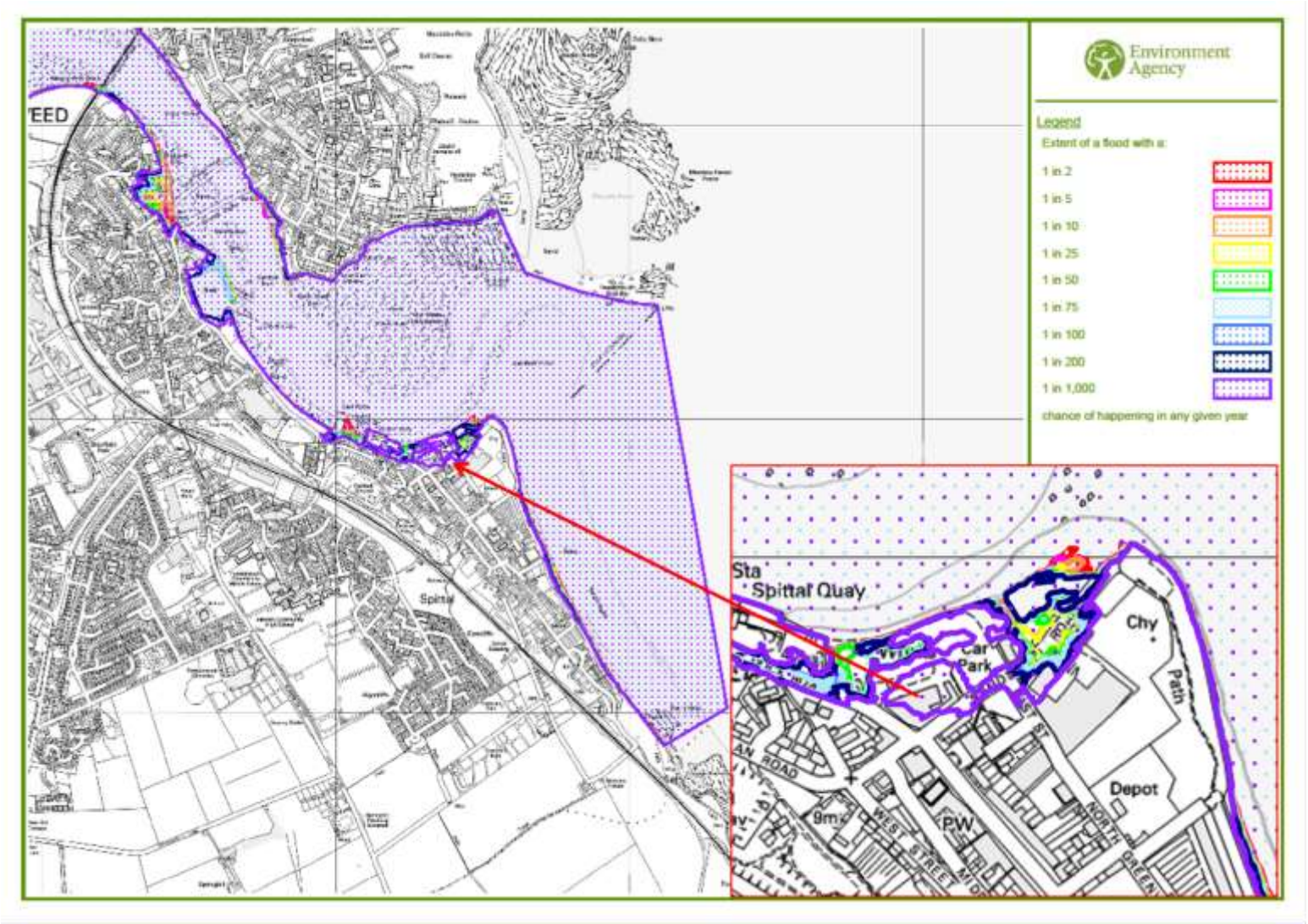
A flood map showing the results of the modelling study was provided by the Environment Agency and is shown in Figure 5.

The map indicates that the site is located out with the joint 100 year flood map for the River Tweed. The only flooding, which is predicted at the site, is from the 1000 year event. A table of modelled water levels have also been provided and are show in Table 2 below.

Table 2: Spittal modelled water levels

Return Period (years)	Water Level (m AOD)
5	3.48
10	3.56
25	3.71
50	3.79
75	3.87
100	3.92
1000	4.19

Figure 5: Environment Agency Modelled flood map



Based on the information provided above, the site is not predicted to be at risk of flooding from the River Tweed during a 100 year flood event.

4.2 Wave Overtopping

The site is located close to Sandstell Point, a small outlying area of land which is located between the mouth of the River Tweed and the North Sea coast. Based on this an assessment of the risk of flooding from wave overtopping has been undertaken.

Waves from north

Due to the location of Sandstell Point, waves arriving at the site from the River Tweed would be generated by wind only and originate from a northerly direction. The fetch length has been measured to be approximately 900 m. The site is located approximately 100 m to the south of the banks of the Tweed, land between the site and the river is comprised of open land and coastal sand dunes. Ground levels in this are rise up to approximately 5 m AOD. In the event of high water levels in the Tweed, it is possible that wind waves arriving from the north could cause overtopping of the banks to the north of the site. However, the effect of the overtopping is predicted to be dissipated before reaching the site. As a result, the site is not expected to be at significant risk from wave overtopping from the north.

Waves from east

The coastline to the east of the site is comprised of an embankment reinforced with rock armour. The defences cover a reach of approximately 290m in length and protect a small car park and footpath between the site and the defence. No raised walled defence is present at this location hence there is a risk from wave action during a storm.

A detailed hydraulic modelling study was commissioned by Northumberland Council to assess the coastal processes within the Tweed Estuary. The report, produced by Martin Wright Associated, Sep 2011, undertook detailed hydrodynamic modelling as well as overtopping calculations based on the EurOtop methodology. Model results indicated that for the present day scenario, the rate of overtopping expected during a 1:200-year event is very small at 0.03 l/s/m. This is below the EurOtop target tolerance for "unaware pedestrians". Whilst climate change is expected to increase wave overtopping at this defence, the maximum overtopping limit after 100 years for both DEFRA and UKCP09 projections is expected to remain below 0.4 l/s/m. Based on this modelling the site is not predicted to be at risk of flooding from wave overtopping

4.3 Flooding risk from surface water runoff

Flood Modeller Prop (FMP) 2D mathematical modelling software was used to assess the risk to the site from pluvial flooding. Catchment descriptors were extracted for the site based on a surrounding FEH CD-Rom v3 catchment, which were then used to generate rainfall hyetographs using FEH methods for various design storm events to be used as inputs to the 2D model.

The standard percentage runoff was altered to represent the adjacent urban area, which was estimate to have a runoff percentage of 70%. An allowance for the local drainage of up to 20 year return period

capacity has been taken and the resultant inflows into the 2D model are based on the net rainfall totals.

Based on the LiDAR data, model results for a 7 hour rainstorm indicated that Dock Road falls north-west close to the southern boundary of the site; hence, any significant flooding of the road would result in flood waters flowing towards the site and entering the southern boundary of the site. In addition, Billendean Road falls towards the junction with Dock Road, so there is a significant risk of surface water entering the site from south and west.

A flood map showing the predicted 100 year flood map based on surface water runoff is provided in Figure 6. Flood levels at the site are predicted to reach approximately 4.1 m AOD and flood a low lying area of land within the site.

As shown in the modelling results above, any flood waters entering the site would flow north through the site before ponding on the site, flood waters are also predicted to flow around the south-eastern boundary.

An additional model run was undertaken to simulate the effect on water levels adjacent to the site if the site was raised above the pluvial water level. The results are presented in Figure 7. These indicate flood waters ponding to the north of the site would increase in level to 4.2 m AOD. Water levels could increase in land to the north of the site, on Sandstell Road, as well as along the edge of the car park to the east of the site. It should be noted that these runs are conservative and do not include any flooding within the site, although ponding could be possible on the road network and the runs do not consider the impact of existing buildings on the site.

Based on the modelling there is a risk to the site from surface water flooding. It is recommended that Finished Floor Levels of properties are raised at least 600 mm above the post-development predicted flood levels in Figure 7, i.e., above 4.8 m AOD. There is also a risk of development increasing flood risk to neighbouring land. Land to the north is undeveloped, so it may be that the site can be designed to route surface water through the site to the north, without flooding properties or the car park to the east and increasing flood depths on Sandstell Road. These issues should be discussed with the local council and the Environment Agency.

It should be noted the modelling is based on LiDAR data (with interpolation under existing buildings) and a detailed land survey of the area may show different levels and flow pathways.

Figure 6: 1 in 100 year pluvial flood map

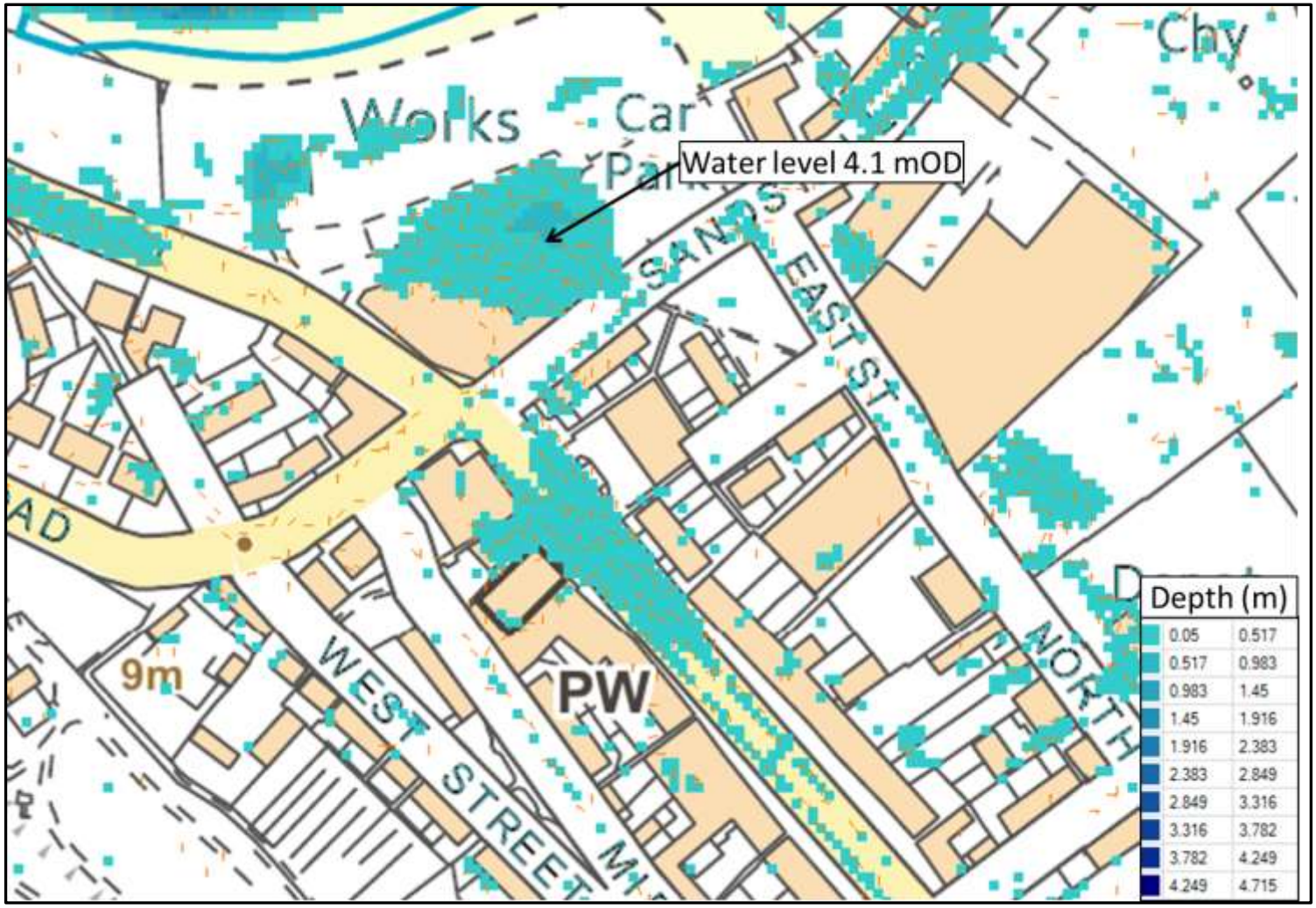
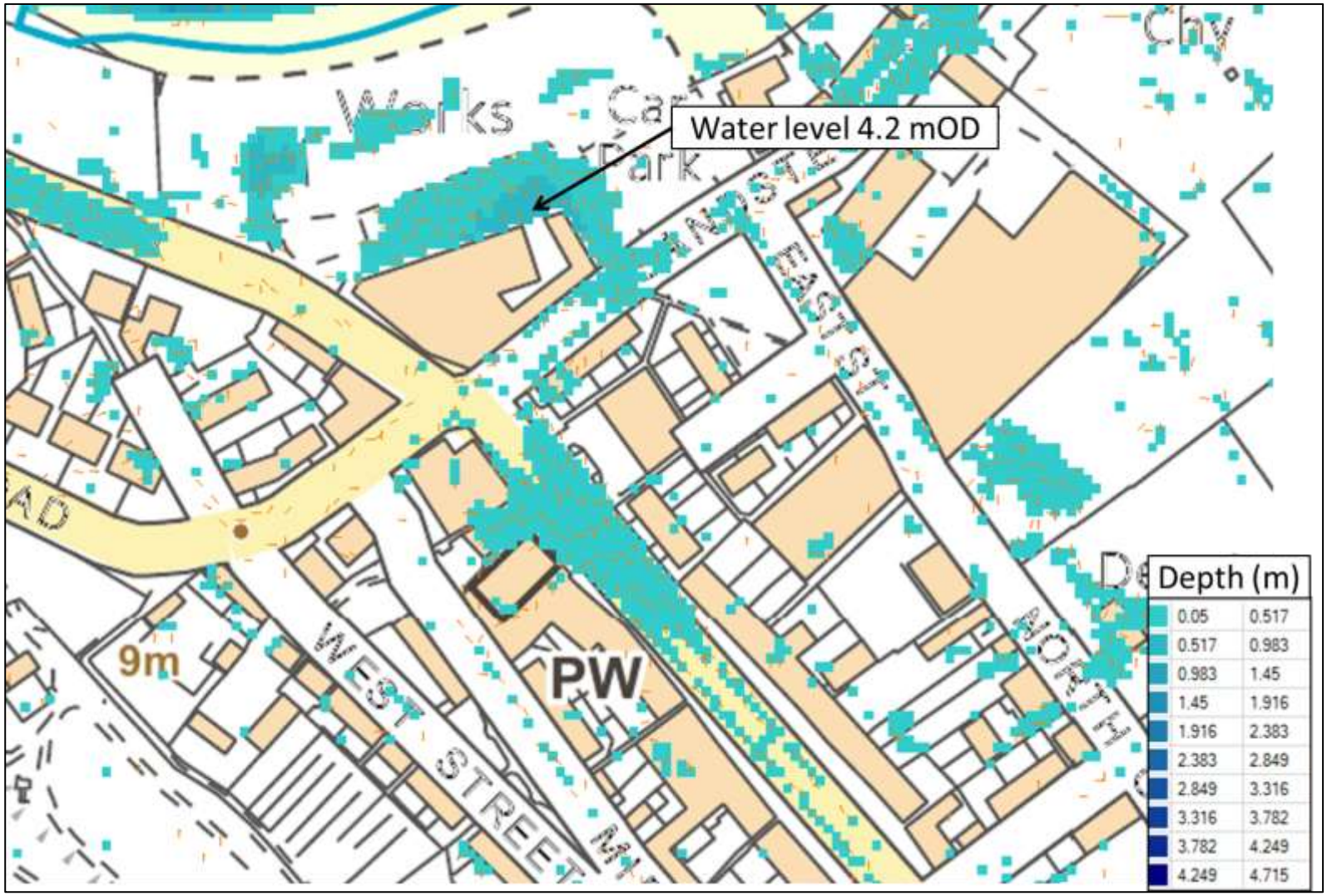


Figure 7: 1 in 100 year pluvial flood map (site raised)



4.4 Groundwater

There is no information on groundwater levels in the area, without detailed information it is hard to provide a detailed assessment regarding groundwater. Based on observations there was no evidence of high groundwater levels on the site.

More information on groundwater levels should be obtained during site investigations as part of detailed design. Appropriate types of foundations will need to be used in the design of the site. SuDS measures will need to take account of groundwater conditions, if elevated groundwater levels are identified.

4.5 Site drainage and sewer system

As shown in Figure 2, there is a significant drainage network surrounding the site. Sewer networks are usually designed to accommodate the 30 year return event; hence, it is possible that flood water could enter the site during larger return periods. This has been considered through modelling flood conditions in Section 4.2.

Design of the site drainage system is not part of this commission. The standard practice is to attenuate surface water runoff to greenfield runoff rates before being discharged to any watercourse. However, due to the close proximity of the tidal reach of River Tweed, it is possible that water will be able to be discharged without attenuation, but this will need to be discussed and agreed with regulators.

It is noted that during periods with high water levels in the Tweed, the ability of site runoff to be discharged from the site may be impacted. This should be considered during the site drainage design, with additional storage either provided on site until water levels in the Tweed have decreased allowing site runoff to be discharged, or assessments made to show that any site runoff would be able to flow from the site to the sea without increasing flood risk to others..

Design of the site drainage system (including SuDS) was not part of this commission. However, any new drainage system and SuDS (if required) should be designed by a suitably qualified professional.

It is good practice to provide, within the development site, an appropriate overland flow route through which flood waters could escape in the event of the site being flooded during floods exceeding the design flows or following blockage of the site drainage system.

4.6 Flood risk to site access

There are numerous pedestrian access points designated along the south-east and south-western boundary of the site, of Sandstell Road and Dock Road respectively. In addition, vehicular access to the site is proposed from the northern boundary of the site, via a local access road. Ponding of water on the road is not predicted that would prevent access along the southern boundary; however, there is a risk that the internal access road could be blocked at the north-eastern corner of site. As a result, it is recommended that ground levels on the access road are raised above 4.1 m OD so that the site

access does not act as a flow pathway, directing water from the north into the site. Flooding of the minor road along the northern boundary of the site is predicted, with modelled flood depths to exceed 0.3 m which is the threshold for vehicular access.

4.7 Sequential test

As discussed above, the Environment Agency has provided results of a fluvial modelling study of the River Tweed, to the north of the site. The detailed maps indicate that the site is outside the 100 year flood extent, but would be affected by flooding during a 1000 year fluvial event.

The site is therefore located within flood zone 2 and the following applies,

"This zone comprises of land assessed as having between 1 in 100 and 1 in 1000 annual probability of fluvial flood risk in any year (1%-0.1% AEP) or between 1 in 200 and 1 in 1000 annual probability of tidal flood risk in any year (0.5%-0.1% AEP)

The water-compatible, less vulnerable and more vulnerable uses of land (Table 2) and essential infrastructures are appropriate in this zone. Subject to Sequential Test being applied, the highly vulnerable uses are only appropriate in this zone if the Exception Test is passed.

All developments in this zone should be accompanied by a FRA."

The development will comprise of residential dwellings and would be classed as more vulnerable. Based on the Flood Risk Table 3 shown in Section 2.1 above, it is determined that the development is classed as "appropriate".

5 Summary, Conclusions and Recommendations

This report describes a flood risk assessment for a proposed development at site at Sandstell Road in the Spittal area of Berwick-Upon-Tweed. The site is brownfield comprised of an existing building and car parking.

The River Tweed enters the North Sea approximately 130 m to the north of the site. The Environment Agency was consulted regarding the site and have provided flood maps based on a detailed modelling study of the Tweed. The maps indicate that the site is located out with the 100 year flood map of the river which has a predicted water level of 3.92 m OD.

The risk of flooding from wave overtopping was also assessed and was found to be low.

As ground levels rise to the south-west of the site, mathematical modelling software was used to assess the risk to the site from pluvial flooding. Model results indicated that flood waters could flow flowing towards the site and entering the southern boundary of the site. In addition, Billendean Road falls towards the junction with Dock Road, so there is a significant risk of surface water entering the site from south and west.

A flood map showing the predicted 100 year flood map based on surface water runoff is provided in Figure 6. Flood levels at the site are predicted to reach approximately 4.1 m AOD. Modelling of the post-development case with the site raised indicated that local flood levels around the site could be increased by development. It is recommended that Finished Floor Levels of properties are raised at least 600 mm above the post-development predicted flood levels in Figure 7, i.e., above 4.8 m AOD. There is also a risk of development increasing flood risk to neighbouring land. Land to the north is undeveloped, so it may be that the site can be designed to route surface water through the site to the north, without flooding properties or the car park to the east and increasing flood depths on Sandstell Road. These issues should be discussed with the local council and the Environment Agency.

We would recommend a land survey of the site and surrounding areas as the analysis is based on LiDAR data.

Adjacent drainage networks surround the site. In the event of a blockage or surcharging from the network, flood waters could flow towards the site following similar flow pathways indicated by the surface water runoff modelling.

The site is not considered to be at significant risk of flooding from other sources; however, further information on groundwater levels will need to be obtained during ground investigations at later stages of the project and taken into account in the design of the site.

Finished Floor Levels at the site should therefore be raised to at least 4.8 m OD, which is approximately 600 mm above the 1 in 100 year surface water flood level with the site being raised. In addition, we would recommend that ground levels at the north-eastern corner of the site should be raised so to displace flood waters away from the site and to provide safe access to the site especially in the north-eastern corner where the vehicular access will be enter the site.

Design of the site drainage system is not part of this commission. We would recommend that existing connections and flow pathways are maintained, with site runoff attenuated to the greenfield rate, with appropriate SuDS measures.

In addition to the above, it is good practice to design finished floor levels an appropriate height above surrounding ground levels and arrange finished ground levels sloping away from buildings. General ground levels should be finished in a way not to allow ponding of surface water within the site where it could increase the risk of flooding of properties.

It should be noted that risk of flooding can be reduced but not totally eliminated, given the potential for events exceeding design conditions and the inherent uncertainty associated with estimating hydrological parameters for any given site.