PowerPark and Peto Square, Lowestoft - Flood Risk Appraisal

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Rev No	Comments	Checked by	Approved by	Date
1	Flood Risk Appraisal – Initial Draft	RL	RL	31/03/2010
2	Flood Risk Appraisal – Second Issue	RL	RL	14/04/2010
3	Flood Risk Appraisal – Third Issue	RL	RL	26/04/2010
4	Flood Risk Appraisal – Fourth Issue	RL	RL	21/09/2010
4	Flood Risk Appraisal – Fifth Issue	RL	GK	20/12/2010

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Job No 60151232 Reference LSFT_FRA Date Created March 2010

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1 Introduction

1.1 Introduction to the Report

AECOM has been commissioned by the 1st East Waterfront Regeneration Co. to produce a Flood Risk Appraisal as part of the going Lowestoft Area Action Plan (AAP) work. A Flood Risk Appraisal report is required to inform the delivery planning work in the PowerPark and Peto Square areas of Lowestoft.

AECOM has previously completed the Lowestoft Intervention Sites Site Servicing & Utilities Desk Study Report (AECOM, 2010), Lowestoft and Great Yarmouth Area Action Plans – Stage 1 Gap Analysis and Recommendations Report (AECOM, 2009) and the Lake Lothing and Outer Harbour Area Action Plan (AECOM, 2010). This Flood Risk Appraisal builds on the work already undertaken as part of the going Lowestoft Area Action Plan work, and considers development options for the PowerPark and Peto Square areas in relation to flood risk.

An introduction to the PowerPark and Peto Square areas is provided in Section 2. Section 3 of this report is a document review, and summarises information on flood risk and development in Lowestoft from a number of key documents. Section 4 of this report details the information gathered through consultation, which has been ongoing as part of the Lowestoft (AAP work).

Based on the site information, document review and information gathered through the consultation, Section 5 of this report assesses the flood risk to the PowerPark and Peto Square areas from all types of flooding. The assessment of flood risk is based on the current planning guidance on development and flood risk, Planning Policy Statement 25: Development and Flood Risk (Communities and Local Government, 2006) (PPS25). An introduction to PPS25 and Flood Risk is provided below.

Based on this assessment of flood risk, Section 6 of this report considers the development options for the PowerPark and Peto Square areas. The consideration of development options is based on PPS25, and what type of development is considered appropriate in different Flood Risk Zones.

Section 7 - Masterplan

Section 8 – Mitigation Measures

Based on all the work undertaken as part of this Flood Risk Appraisal, Section 9 of this report provides a conclusion, including recommendations for further work.

1.2 Introduction to PPS25 and Flood Risk

PPS25 is the current guide on development and flood risk. This is also supplemented by 'Development and Flood Risk: A Practice Guide (Communities and Local Government, 2009). Together, these documents guide planners on how to evaluate sites in respect of flood risk. A summary of the requirements of PPS25 is provided below.

This Flood Risk Appraisal has been in written in accordance with PPS25.

1.2.1 Flood Risk

Flood risk takes account of both the probability and the consequences of flooding (i.e. vulnerability of the development, etc.). Flood frequency is usually interpreted in terms of the return period e.g. 1 in 100 and 1 in 200 year event etc. In terms of probability, there is a 1 in 100 (1%) chance of one or more 1 in 100 year floods occurring in a given year. In flood risk terms this is frequently referred to as an Annual Exceedance Probability (AEP).

1.2.2 Sources of Flooding

PPS25 requires a FRA to consider all aspects of flooding, including fluvial (river), tidal (sea), groundwater, sewers, surface water and pluvial (overland flow), land drainage, and artificial sources (i.e. reservoirs, canals, water mains etc.). PPS25 requires this assessment of flood risk to consider the impact on both the proposed development and off site parties and land.

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1.2.3 Flood Zones

There are four classifications of flood zones, as defined in PPS25:

- Zone 1

Low probability (less than 1 in 1,000 annual probability of river or sea flooding in any year).

- Zone 2

Medium probability (between 1 in 100 and 1 in 1,000 annual probability of river flooding or between 1 in 200 and 1 in 1,000 annual probability of sea flooding in any year).

- Zone 3a

High probability (1 in 100 or greater annual probability of river flooding in any year or 1 in 200 or greater annual probability of sea flooding in any given year).

- Zone 3b

High probability (1 in 20 or greater annual probability of flooding in any given year). This is also classified as functional floodplain.

The Practice Guide to PPS25 gives further guidance on the definition of Flood Zone 3b. The Practice Guide states that areas which would naturally flood during a 1 in 20 year flood event, but which are prevented from doing so by existing infrastructure or solid buildings, will not be normally defined as Flood Zone 3b (functional floodplain).

1.2.4 Climate Change

PPS25 makes it a planning requirement to account for climate change. The recommended climate change allowances are summarised in Table 1 below.

Table 1a: Climate Change Allowances (Extract from PPS25, Table B.2)

Parameter / Horizon	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%	

Table 1b: Contingency Allowance for Net Sea Level Rise (Extract from PPS25 Table B.1)

Administrative Region	Net Sea level Rise (mm/yr) Relative to 1990			
	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
East of England, East Midlands, London, SE England	4	8.5	12	15

2 Peto Square and PowerPark Sites

2 Peto Square and PowerPark Sites

This section of the report provides an introduction to Peto Square and PowerPark sites. A site visit was undertaken on the 30th March 2010.

2.1 Peto Square

2.1.1 Existing

Peto Square represents the areas immediately north and south of the Bascule Bridge (North and South Peto Square). The extent of the site contains the following features:

- Lowestoft Rail Station
- Station Square
- Commercial Road Area (including former Aldi site and Association of British Ports (ABP) land extending to Town Quay)
- Belvedere Road/South Quay

Peto Square is at an important location, providing the main south-north link over Lake Lothing in the form of the bascule bridge. It forms the entrance to the Inner Harbour and Lake Lothing.

2.1.2 Proposed

It is envisaged that North Peto Square will become a central focus for retail, leisure and commercial activity in Lowestoft, comprising the following key development:

- Retail, leisure, hotel and tourism development in the area between Denmark Road and North Quay.
- Initial phase of development focussed around Commercial Road.
- New railway station facilities.
- New transport interchange adjacent to the railway station
- Development of South Quay for commercial and port related activities.
- Public spaces throughout the site.

The South Peto Square. Residential development is currently being perused as an option of South Peto Square.

2.2 Power Park

2.2.1 Existing

The PowerPark comprises the area south of Ness Point and west of Battery Green Road and includes Hamilton Dock, Waveney Dock, along with parts of Trawl Dock and Outer Harbour. Much of the site is occupied by the Beach Industrial Estate.

The Beach industrial estate currently comprises a mixture of industrial, office and retail wholesale premises. The outer harbour docks area lies to the south of Hamilton Road, much of which is owned by ABP.

2.2.2 Proposed

The PowerPark has been identified as a site with significant potential for a cluster of businesses focussed upon the energy sector. 1st East has commissioned a series of technical studies to help inform the development of the PowerPark, including this Flood Risk Appraisal.

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The PowerPark Demand and Needs Study (BVG associates, 2010) outlines the key energy sectors the PowerPark should target, and what the demands and needs of these key energy sectors are likely to be. This study sets the vision for a centre of excellence in marine engineering focusing on a mix of:

- Offshore wind Operations and Maintenance (O&M).
- Offshore marine Research and Development (R&D) and prototyping.
- Existing traditional marine and underwater engineering facilities on site.
- Blend of other energy activities that do not require significant land or quay space. These include
  - Carbon Capture Storage (CCS.) – potential research and development/operations and maintenance facilities to support carbon capture storage in geological formations under the North Sea.
  - Support to the nuclear industry (in particular the construction of future phases of the Sizewell plant).
  - Gas storage – operations and maintenance for off shore gas storage facilities.
- Training centres to supply the energy sectors.

1st East are building on The PowerPark Demand and Needs Study by co-ordinating studies which will provide a more detailed analysis of the spatial requirements of energy sector companies, the financial implications of relocating companies and the potential delivery mechanisms.

3 Document Review

3 Document Review

As part of the Lowestoft AAP work, a number of documents providing flood risk and development information on the Lowestoft area have been reviewed. The key flood risk and development documents are listed below, and a brief summary of relevant information provided within each document is provided below.

3.1 Suffolk Coastal and Waveney District Strategic Flood Risk Assessment

The Suffolk Coastal and Waveney District Strategic Flood Risk Assessment (Waveney District Council and Suffolk Coastal District Council, 2008) aims to assist the planning process by identifying flood risk areas and outlining the principles and policies for sustainable development. Relevant information from the Strategic Flood Risk Assessment is summarised below.

3.1.1 Flood Warning

The Environment Agency operates a Flood Warning Service in Lowestoft. Waveney District Council supplement flood warning systems provided by the Environment Agency by ensuring its emergency response plans include appropriate arrangements for flooding emergencies. These emergency response plans are reviewed in consultation with the Environment Agency at least every two years.

3.1.2 Tidal Flooding

Lowestoft is one of the areas with the greatest potential risk from a 1 in 200 year tidal flooding in the Waveney and Suffolk coastal area. Lowestoft is at risk from tidal flooding as a result of the flood defences being overtopped or breaching. Overtopping or breaching of the man-made banks around Lake Lothing would cause large parts of Lowestoft to flood. The predicted impact of climate change on sea level rise will increase the frequency and magnitude of tidal flooding from Lake Lothing. Lake Lothing is tidally influenced, and information on flood defences is provided below.

There is also a risk of flooding as a result of surface water outfalls to Lake Lothing becoming tide locked.

3.1.3 Flood Defences

Large sections of the Waveney and Suffolk coastal areas are protected from tidal flooding by embankments and hard defences, including the Lowestoft Harbour area. The overall condition of these defences is good, although the defences were not originally built to provide a high standard of protection. The defences surrounding the Lake Lothing area fall below the 1 in 200 standard of protection, and subsequently considerably below the climate change levels for this stretch of coastline.

3.1.4 Tidal Hazard Mapping

Flood Hazard is a function of both flood depth and flow velocity. For example, wading by able bodied adults becomes difficult and dangerous when the depth of still water exceeds 1.2 m, when the velocity of shallow water exceeds 0.8 m/s; and for various combinations of depth and velocity between these limits. Hence, to assess the hazard risk both flood water depth and flow velocities need to be considered.

The Strategic Flood Risk Assessment provides a number of tidal flooding hazard maps for Lowestoft, which illustrate the hazard associated with of tidal flooding for a range of return periods and a variety of overtopping and breach scenarios. These maps categorise the flood hazard into three categories; low, medium and high.

The Peto Square and PowerPark sites are shown as at risk from a variety of the overtopping and breach scenarios; and the hazard from tidal flooding ranges from high to low. For the majority of overtopping and breach scenarios, parts of the Peto Square and PowerPark sites are located within high hazard areas.

The breach locations used for the hazard mapping were specified by Suffolk and Waveney Councils. The Council based the locations on local knowledge of flood defence condition, future development sites, historical flooding events and the vulnerability of local communities to flooding.

3.1.5 Surface Water Flooding

It is now generally accepted that one of the main effects of climate change in the south east will be a higher intensity of rainfall and winter storms, which will increase the risk of surface water flooding.

In lowland areas such as Suffolk and Waveney, the topography results in the dispersal of any surface water flooding over a large area. Local surface water is often exacerbated by deficiencies in the local surface water drainage system, temporary blockages or saturated ground conditions. Such problems can often be remediated through reactive management once they have been identified in a flooding event.

Lowestoft is particularly sensitive to flooding due to the proximity of Lake Lothing and the surrounding developed areas. Flooding around the margins of the lake occurs when gravity outfalls to the lake become tide locked. Flooding also occurs due limited sewer capacity and tide locking of sewer outfalls, following heavy rainfall. Developments within Lowestoft should therefore mimic greenfield runoff rates, by incorporating SuDS at the detailed design stage. In addition, steps should be taken to improve the tidal outfall systems to limit tide locking.

3.1.6 Groundwater Flooding

There is a risk of groundwater flooding in the Waveney and Suffolk region. Although there are no records of significant groundwater flooding in the region, it is still a possibility.

The future risk from groundwater flooding is uncertain. Current climate change predications indicate that will sea levels rise, thus possibly raising groundwater levels. Climate change predications also indicate that summer rainfall may decrease, which could possibly have the long term effect on lowering the groundwater levels. However, long periods of wet weather are expected to increase with climate change. These are the type of weather patterns that can cause groundwater flooding to occur.

3.1.7 Drainage

Sustainable Drainage Systems (SuDS) are the preferred method of dealing with surface water flows, due to difficulties associated with updating sewer systems. Where possible a SuDS technique should seek to:

- Reduce flood risk (to the site and neighbouring area).
- Reduce pollution.
- Provide landscape and wildlife benefit.

Underlying ground conditions will determine the type of SuDS appropriate for a development. Permeability in Lowestoft is variable, with the Lowestoft Till Formation, Peat and Tidal Flat Deposits (amongst other drift deposits) dominating the geology. These deposits include muds, silts, sands and clays, indicating that attenuation systems are the most appropriate SuDS technique. Where permeable sands are encountered, infiltration methods could be used.

3.1.8 Managing Flood Risk

The Strategic Flood Risk Assessment considers various methods for managing flood risk. These include:

- Recreation, Amenity and Ecology
- Secondary Defences
- Land Raising
- Finished Floor Levels
- Flood Resilience
- Flood Warning and Emergency Procedures

Methods for managing flood risk on the Peto Square and the PowerPark sites are considered in Section 7 and 8.

3.2 Cumulative Land Raising Study

The Cumulative Land Raising Study (1st East Waterfront Regeneration Co., 2008) investigated the potential impacts of the proposed strategic regeneration of the Lake Lothing area in Lowestoft on tidal flooding. The proposed strategic regeneration incorporated land raising at strategic sites in Lowestoft. The land raising scheme was proposed to mitigate potential flood risks and facilitate the regeneration of the Lake Lothing waterfront area.

Information from the Cumulative Land Raising Study is summarised below.

3.2.1 Peak Tide Levels for Lowestoft

As part of the land raising study, extreme water levels for calculated were calculated for Lowestoft that allowed for an increase in sea levels as a result of climate change. The increase in sea level was calculated in accordance with PPS25 (Table 1), and Table 2 details the peak tide levels of Lowestoft in 2107.

Table 2: Peak Tide Levels for Lowestoft (2107)

Return Period (years)	1 in 20	1 in 200	1 in 1000
Flood Level (mAOD)	3.77	4.31	4.69

3.2.2 Land Raising Scenarios

Three land raising scenarios were modelled as part of the Cumulative Land Raising Study. Scenario one considered the potential impacts of raising four key sites on tidal flooding. One of these key sites is South Peto Square. Scenario two considered the potential impacts of scenario one plus raising an additional four sites. These additional four sites include North Peto Square and the PowerPark. Scenario three considers the potential impacts of the scenario two without one of the additional four sites (Horn Hill).

3.2.3 Modelling Results

The overall analysis of three land raising scenarios showed that land raising sites in the Lake Lothing tidal flood cell has very little effect (1 – 2cm) on flood levels. Land raising of the Horn Hill site was assessed to have the most significant impact on flood levels, increasing levels by up to 5cm in some parts of the tidal flood cell (scenario 2 compared to scenario 3). While this increase in flood levels is only marginal, the study recommended that the Horn Hill site should be treated in isolation.

The removal of the remaining seven sites (scenario 3) from the tidal floodplain, through land raising, has very little impact on the remaining flood cell. It can therefore be summarised that these seven sites do not have a conveyance function for tidal flows. Whilst some of these seven sites may be at risk of tidal flooding during a 1 in 20 year flood event, due to insufficient defences, this study suggests these sites do not operate as functional floodplain. The sites should therefore be classified as Flood Zone 3a, as opposed to Flood Zone 3b – Functional Floodplain.

3.3 Waveney and Great Yarmouth Water Cycle Strategy – Scoping Study

The Waveney and Great Yarmouth Water Cycle Strategy – Scoping Study (Waveney District Council and Great Yarmouth Borough Council, 2009) provides information on development constraints in the regions. The development constraints identified for Lowestoft are detailed below.

3.3.1 Development Constraints

The Water Cycle Strategy uses a traffic light system to summarise potential development constraints. A green light indicates no known development constraint, an amber light indicates further investigation required, and a red light indicates a significant existing constraint to development.

Table 3: Flood Risk Development Constraints in Lowestoft (Extract from Waveney and Great Yarmouth Water Cycle Strategy – Scoping Study)

Flood Risk Development Constraint	**Category**
Groundwater Flooding	No Known Development Constraint
Condition of Flood Defence Infrastructure	Further Investigation Required
Fluvial Flooding (within fluvial floodplain)	Further Investigation Required
Tidal Flooding (within tidal floodplain)	Significant Development Constraint
Pluvial Flooding (land drainage, surface water etc.)	Significant Development Constraint
Recorded Flood Events	Significant Development Constraint
Sites Defended from Flooding	Significant Development Constraint

Based on Table 3, significant development constraints in Lowestoft are posed by tidal flooding, land drainage flooding, flood defences and historic flood events.

3.4 The Sequential Approach to Flood Risk in Lowestoft

The Sequential Approach to Flood Risk in Lowestoft (Waveney District Council, 2008) explains that the comprehensive redevelopment of the Lake Lothing and Outer Harbour Area of central Lowestoft would contribute positively towards the sustainable development of Waveney. The need for regeneration at the heart of Lowestoft has been endorsed by

the Government through the establishment of 1st East Urban Regeneration Company as a local delivery vehicle. The Regional policy context also supports this approach.

The Sequential Approach to Flood Risk in Lowestoft explains that there are no sequentially better sites that would be appropriate for the proposed mixed use development at the Petro Square and PowerPark site areas full range of uses proposed, nor deliver the synergistic benefits offered by allocating this brownfield and largely vacant, central, area for mixed-use development.

4 Consultation

4 Consultation

As part of the ongoing Lowestoft AAP work, the Environment Agency, Suffolk County Council and Waveney District Council have been consulted. The information gathered from these parties, which is relevant to this flood risk appraisal and informing potential development options, is detailed below.

4.1 Environment Agency

AECOM contacted the Environment Agency to complete the Lowestoft Intervention Sites Site Servicing & Utilities Desk Study Report (AECOM, 2010). AECOM also met with the Environment Agency on the 30th March 2010 to discuss development options for Peto Square and the Power Park, and confirm the Environment Agency's requirements.

The information provided by the Environment Agency is summarised below.

4.1.1 Flood Risk

The Environment Agency confirmed that Peto Square and the PowerPark are located within Flood Zone 3a, which comprises land assessed as having a 0.5% (1 in 200 year) or greater annual probability of flooding from the sea. The Environment Agency provided a more detailed Flood Map.

4.1.2 Flood Defences

The Environment Agency does not have any formal defences within the Lake Lothing/Inner Harbour area of Lowestoft. The only Environment Agency defences are on the inland side of Mutford Lock around Oulton Broad (West of the four sites). There is a sea wall running from south from Ness Point to the harbour, however this is not the responsibility of the Environment Agency.

4.1.3 Historic Flooding

Environment Agency records show Peto Square and the PowerPark flooded in 1925, 1938 and 1953. Historic flood levels are not available. Lowestoft was not affected by the 2007 summer floods.

The Environment Agency explained that the pattern of flooding has changed since these historic flood events, and that the Peto Square and the PowerPark would now flood under different circumstances.

4.1.4 Flood Levels

The Environment Agency provided modelled flood levels for Bascule Bridge, which intersects Peto Square and Fishers' Wharf. These flood levels are detailed in Table 4 below.

Table 4: Flood Levels at Bascule Bridge

Return Period	1	5	10	20	50	100	200	500	1000
Flood Level (mAOD)	2.04	2.42	2.58	2.75	2.96	3.13	3.29	3.51	3.67

The Environment Agency explained that the outfall level from any proposed sewerage system would be a key consideration in relation to the modelled flood level data.

4.1.5 Flood Risk Assessment Requirement

The Environment Agency stated that under PPS25, a formal Flood Risk Assessment is needed to support Planning Applications for developments in Flood Zone 2 and 3, and for those in Flood Zone 1 over one hectare in area.

A formal Flood Risk Assessment will therefore need to be submitted as part of the planning process for developing Peto Square and the PowerPark. Any Flood Risk Assessment will need to recalculate the impact of sea level rise on the above flood levels.

4.1.6 Development of Peto Square and PowerPark

The Cumulative Land Raising Study provides the most useful information on the tidal flood risks to Peto Square and the PowerPark. This Study also provides information on how mitigate the risk of tidal flooding, through land raising, to facilitate the development of these two sites as follows:

- If a flood defence or a strip of raised land is provided as a mitigation measure, this should be set at a minimum level of 4.7m AOD.
- Finished floor levels could be set at different levels, depending on the vulnerability of the different developments to flooding. PPS25 classifies the vulnerability of developments to flooding into five categories. These categories are detailed in Section 6 (Table 5). The Environment Agency's finished floor level requirements are as follows:
  - 'Less Vulnerable' development finished floor levels should be located 300mm above the 1 in 20 year flood level, including climate change.
  - 'More Vulnerable' development finished floor levels should be located at least 300mm above the 1 in 200 year flood level, including climate change. Where 'More Vulnerable' development is provided as a single storey development, finished floor levels should be located 300mm above the 1 in 1000 year flood level, including climate change. Where 'More Vulnerable' development is provided as a multi-storey development finished floor levels only need to be located 300mm above the 1 in 200 year flood level, including climate change.
- Safe access and egress is not required for 'Less Vulnerable' development, providing a suitable flood evacuation plan is agreed with the emergency planning unit of the Local Authority. Safe access and egress is required for the 'More Vulnerable' development.

4.2 Suffolk County Council and Waveney District Council

AECOM contacted Suffolk County Council and Waveney District Council in completing the Lowestoft Intervention Sites Site Servicing & Utilities Desk Study Report. The information gathered from these Councils, which is relevant to this flood risk appraisal, is summarised below.

4.2.1 Drainage

Waveney District Council explained that Anglian Water and Suffolk County Council manage the majority of drainage systems in Lowestoft. Waveney District Council has no responsibility for unadopted drains in this area.

Suffolk County Council (Lowestoft Highways) confirmed that highway surface water drains in the Peto Square and PowerPark areas discharge directly to Anglian Water sewers. They are not aware of any surface water outfalls which discharge directly into the sea, not adopted by Anglian Water.

4.2.2 Historic Flooding

The Lake Lothing area is low lying, and central Lowestoft area around Lake Lothing has ground levels of approximately 2.1mAOD. The storm water discharge networks therefore tend to discharge within the tidal range and so outfalls are within the intertidal zone and are prone to tide locking. Instances of tide locking in the past, have contributed to rainfall-induced flooding in the central Lowestoft are in the vicinity of North and South Peto Square.

High tides have caused flooding by overtopping of harbour quays (North and South Peto Square), by wave spray over seawalls (PowerPark) and by backing up of drains (North and South Peto Square). Instances of heavy rainfall were also cited as causing limited flooding of highways in the North central part of town. Historically, there has been regular flooding of premises in the Bevan Street, Station Square, Belvedere Road and St Johns Road areas. It is believed that recent remediation works by Anglian Water however, have resolved this.

Leathes' Ham is a small lake west of North Peto Square and drains into Lake Lothing. Drainage problems had arisen in the past, posing a flood risk to the adjacent railway and buildings. Waveney District Council have mitigated the problem

by installing a pumping station, which directs flows underneath the railway and discharges to Lake Lothing through a pipe, shared with Bannatyne's Health Club.

4.2.3 Flood Defences

Waveney District Council explained that responsibility for the seawall at the boundary of PowerPark is shared. Waveney District Council is responsible for the section from Ness Point in the North to Hamilton Road. The latter section, from Hamilton Road (which covers both Hamilton and Waveney dock) is the responsibility of the Association of British Ports. Waveney District Council indicated that maintenance of the wall by the Association of British Ports in the future is questionable, unless there is financial incentive.

Capabilities on project:
Water

5 Flood Risk Assessment

5 Flood Risk Assessment

In accordance with PPS25, flood risk must be assessed for all sources of flooding. This section identifies all possible sources of flooding and assesses the flood risk associated with each source.

5.1 Flood Risk Assessment

Flood risk from the following sources has been considered:

5.1.1 Tidal Flooding (Sea)

The Peto Square and PowerPark sites are located adjacent to Lowestoft Harbour, the North Sea and the tidally influenced Lake Lothing. Both sites are located in Flood Zone 3a, and the probability of probability of tidal flooding occurring on these sites is greater than 0.5% per year and is considered high. The hazard associated with tidal flooding on the Peto Square and PowerPark is also high, as the Strategic Flood Risk Assessment Lowestoft Hazard Maps illustrate.

The risk to the Peto Square and PowerPark areas from tidal flooding is therefore considered to be high and unacceptable without mitigation.

5.1.2 Fluvial Flooding (River)

The Peto Square and PowerPark sites are located adjacent to Lake Lothing, a tidally influenced watercourse. Peto Square and the PowerPark are not considered to be at risk from fluvial flooding from Lake Lothing. There are no other known watercourses located within close proximity of the two sites.

The risk to the Peto Square and PowerPark areas from fluvial flooding is therefore considered to be low and acceptable.

5.1.3 Groundwater Flooding

The Waveney and Great Yarmouth Water Cycle Strategy – Scoping Study explains that there are no known instances of groundwater flooding in Lowestoft., and that groundwater flooding should not be a constraint to development. However, the Suffolk Coastal and Waveney District Strategic Flood Risk Assessment explains that climate change could potentially increase the risk of groundwater flooding occurring in Lowestoft in the future.

It is therefore recommended that the risk to the Peto Square and PowerPark areas from groundwater flooding is investigated further at a later stage. Further investigations would involve site investigation work.

5.1.4 Pluvial Flooding (Land Drainage, Surface Water and Overland Flow etc)

The Waveney and Great Yarmouth Water Cycle Strategy – Scoping Study explains that there pluvial flooding is a significant constraint to development in Lowestoft. The Suffolk Coastal and Waveney District Strategic Flood Risk Assessment explains that pluvial flooding in the area occurs as a result of severe, localised storm events that cause excessive runoff. Pluvial flooding is often exacerbated by deficiencies in the local surface water drainage system, temporary blockages or saturated ground conditions.

In South Peto Square, there is a known overland flow route to Lake Lothing. This flow route is currently used as a cycle route, and acts a flow route to Lake Lothing during high flows. This flow path would need to be maintained.

The risk to the Peto Square and PowerPark areas from pluvial flooding is therefore considered to be high and unacceptable without mitigation.

5.1.5 Flooding from Sewers and Water Mains

Anglian Water have not provided any information on flooding from sewers or water mains in Lowesfoft area as part of the ongoing AAP work. There is the potential for the PowerPark and Peto Square areas to flood as the result of a burst water main or a blockage in the sewer system.

However, while there is potentially a risk of flooding from sewers and water mains, Anglian Water are responsible for maintaining their assets. The risk of the PowerPark and Peto Square areas from sites flooding from sewers or water mains is therefore considered to be low and acceptable.

5.1.6 Flooding from Other Artificial Sources

There are no significant artificial sources of water (i.e canals, lakes or large ponds but excluding sewers and water mains) located within close proximity of Peto Square or the PowerPark (within 1km). None of the documents reviewed in Section 3 detailed any risk to the Lowestoft area from artificial water bodies, and artificial water bodies were not described to present any constraints to development.

The risk of Peto Square and the PowerPark flooding from other artificial sources is therefore considered to be low and acceptable.

5.2 Flood Risk Assessment Summary

Table 5 below summaries the risk of flooding on the Peto Square and PowerPark areas. Based on the flood risks to Peto Square and the PowerPark identified above, and summarised in Table 6, a Flood Risk Assessment would need to be submitted as part of the planning process for developing the both Peto Square and the PowerPark.

Table 5: Summary of Flood Risk at Peto Square and the PowerPark

Site	Risk of Flooding						Flood Risk Assessment Required
	Tidal	Fluvial	Groundwater	Pluvial	Sewers and Water Mains	Artificial Sources	
Peto Square	✓ Flood Zone 3a	×	Further Investigation Required	✓	×	×	✓
Power Park	✓ Flood Zone 3a	×	Further Investigation Required	✓	×	×	✓

6 Development Options

6 Development Options

Based on this assessment of flood risk, this section of the report considers the development options for Peto Square and the PowerPark based on PPS25.

6.1 Flood Risk Implications

Based on the Flood Risk Assessment (Section 5), there is a high risk of tidal and pluvial flooding occurring on the Peto Square and PowerPark sites. The risk to both these sites from groundwater flooding requires further investigation.

While PPS25 requires a Flood Risk Assessment to consider all sources of flooding, PPS25 only considers the vulnerability of developments to fluvial and tidal flooding. PPS25 does not consider the vulnerability of developments to other flood risks (i.e. pluvial, groundwater and artificial sources). However, PPS25 does require a Flood Risk Assessment to demonstrate that the risk of flooding to a proposed development site, from all sources of flooding, can be mitigated to an acceptable level.

If the Peto Square and PowerPark sites are developed, appropriate mitigation strategies will need to be implemented on each site to mitigate the risk of from sources of flooding to an acceptable level. Mitigation measures are considered in Section 7.

How PPS25 considers the vulnerability of developments to fluvial and tidal flooding is detailed below.

6.2 PPS25 Development Guidelines

PPS25 classifies the vulnerability of developments to flooding into five categories. These categories are detailed in Table 6 below.

Table 6: Flood Risk Vulnerability Classification (Adapted from PPS25, Table D.2)

Flood Risk Vulnerability Classification	Examples of Development Types
Essential Infrastructure	- Essential Transport Infrastructure - Utility Infrastructure (e.g. power stations)
Water Compatible	- Flood Control Infrastructure - Water and Sewerage Infrastructure - Navigation Facilities
Highly Vulnerable	- Emergency Services - Basement Dwellings - Mobile home parks
More Vulnerable	- Hospitals and other health services - Residential Establishments - Educational Establishments
Less Vulnerable	- Commercial Establishments (e.g. shops, restaurants and offices)

Based on the vulnerability of a development, PPS25 states what Flood Zone(s) the development is appropriate within. The flood risk vulnerability and Flood Zone ‘compatibility’ of developments is summarised in Table 7.

Table 7: Flood Risk Vulnerability and Flood Zone Compatibility (Extract from PPS25, Table D.3)

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

6.3 Site Development Options

Based on PPS25, and the tidal flood risk to the Peto Square and the PowerPark, the development options for both sites are summarised in Table 8. Table 8 is based on both sites being entirely located within Flood Zone 3a.

Table 8: Flood Risk Vulnerability and Flood Zone Compatibility (Extract from PPS25, Table D.3)

Site	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Peto Square	Exception Test required	✓	×	Exception Test required	✓
PowerPark	Exception Test required	✓	×	Exception Test required	✓

6.4 The Exception Test

As detailed above, PPS25 requires the Exception Test to be applied to certain forms of new development in Flood Zone 2 and 3. The Exception Test considers the vulnerability of the new development to flood risk and, to be passed, must demonstrate that:

- There are sustainability benefits that outweigh the flood risk;
- It is on previously developed land or there are no other suitable previously developed sites in lower flood risk zones; and
- The new development is safe and does not increase flood risk elsewhere.

Based on the Peto Square and PowerPark sites being located in Flood Zone 3a, the Exception Test may be required for both sites. The Exception Test would be required if 'More Vulnerable' development or 'Essential Infrastructure' development is proposed on either site.

Waveney District Council prepared The Sequential Approach to Flood Risk in Lowestoft. This document explains that the comprehensive redevelopment of the Lake Lothing and Outer Harbour areas of Lowestoft would contribute positively towards the sustainable development of Waveney. The document also explains that there are no sequentially better sites that would be appropriate for a large proposed mixed use development scheme, nor deliver the synergistic benefits offered by the brownfield, largely vacant, central Lake Lothing and Outer Harbour areas.

As previously identified, a formal Flood Risk Assessment will need to be submitted as part of the planning process for development of the Peto Square and PowerPark sites. Assuming an appropriate Flood Risk Assessment is prepared, this Flood Risk Assessment should demonstrate the proposed development at the Peto Square and PowerPark sites will be safe and will not increase flood risk elsewhere.

Subject to a Flood Risk Assessment being completed, the Exception Test could be passed for the Peto Square and PowerPark sites.

6.5 The Sequential Test

The Sequential Test is a risk-based test that should be applied at all stages of development, and aims to steer all new development to areas with the lowest probability of flooding (Flood Zone 1). The Sequential Test will therefore need to be passed in order to develop the Peto Square and PowerPark sites.

As explained above, the Sequential Approach to Flood Risk in Lowestoft explains that there are no sequentially better sites that would be appropriate for a large proposed mixed use development scheme, nor deliver the synergistic benefits offered by the brownfield, largely vacant, central Lake Lothing and Outer Harbour areas.

6.6 The Sequential Approach

The Sequential Approach is also a risk based approach to development. In a development site located in several flood zones or with other flood risks, the sequential approach directs the most vulnerable types of development towards the areas of least risk within the site.

The Peto Square and the PowerPark sites are located entirely within Flood Zone 3a. However, the Sequential Approach can still be applied to the development of both sites, and is considered further in Section 7.

Capabilities on project:
Water

7 Mitigation Options

7 Mitigation Options

As outlined in Sections 5 and 6, if the Peto Square and PowerPark sites are developed appropriate mitigation strategies will need to be implemented on both sites to mitigate the risk of flooding (from all sources) to an acceptable level. While both sites have been identified to be at risk from tidal and pluvial flooding, and also potentially groundwater flooding, the mitigation strategies outlined below only consider the risk from tidal flooding. Mitigation strategies to address the risk from pluvial flooding, and potentially groundwater, will need to be considered at a later stage. Potential mitigation strategies to address the risk of tidal flooding have been considered initially as tidal flooding poses the most significant constraint to development. If it is not possible to mitigate the risk of tidal flooding to an acceptable level, it would not be possible to develop Peto Square or the PowerPark sites.

This Flood Risk Appraisal is based on the Cumulative Land Raising Study which included the climate change allowance from 2007 onwards. Therefore the flood levels quoted in this appraisal have a baseline date of 2007 and any subsequent site specific Flood Risk Assessment will need to be based on the lifetime of the development from the date of the assessment and the climate change allowance will need to be recalculated.

Potential mitigation measures to address the risk of tidal flooding are considered below.

7.1 Flood Defence

A flood defence could be provided to protect Peto Square and the PowerPark from tidal flooding and would have to have a minimum crest level of 4.7m AOD.

The Environment Agency is unlikely to adopt any new flood defences. Any flood defences constructed would therefore to be maintained by the site developers or a private company, and an appropriate maintenance programme would need to be installed.

A budget cost of building a floodwall would be approximately £1,000/m, (£1,000,000/km).

To provide the required standard of protection any floodwall would need to be completed prior to development and would require a significant amount of co-ordination and investment.

7.2 Land Raising

As detailed in Section 3, land raising has been identified as an appropriate strategy in Lake Lothing waterfront area of Lowestoft. Land raising could be used to mitigate the tidal flood risks to an acceptable level, and facilitate the regeneration of the Lake Lothing area. Land raising of several key strategic sites (including Peto Square and PowerPark) was found to have very little impact on the remaining tidal flood cell.

Ground levels within the Peto Square and PowerPark could be raised to 4.7mAOD. This would protect both sites from tidal flooding up to and including the 1 in 1000 year tidal flood event. The 1 in 1000 year tidal flood level plus climate change is 4.69mAOD in Lowestoft (Table 2).

As a result of both sites being raised to 4.7mAOD, the sites would no longer be classified as being located within Flood 3, but would be re-classified as being located within Flood Zone 1. This would provide greater development options for both sites, as based on PPS25 there are no development restrictions in Flood Zone 1. Tables 5 and 6 (in Section 6) shows the development options for Flood Zone 1 and 3.

However, the land raising for both sites, as described above, would require a significant amount of co-ordination and investment

Alternatively, site levels could be raised to a lower level. Based on consultation with the Environment Agency, it would be acceptable for ‘Less Vulnerable’ development types (i.e. commercial and office use) to flood during high return periods. Protecting ‘Less Vulnerable’ development from flooding up to and including a 1 in 20 year tidal event (including climate change) is considered an appropriate level of protection. The 1 in 20 year tidal flood level plus climate change is

3.77mAOD in Lowestoft (Table 2). Site levels would therefore need to be raised by to 3.8mAOD to provide protection from a 1 in 20 year tidal flood event.

This land raising could be achieved on a site by site basis.

It would not be acceptable for 'More Vulnerable' development uses (i.e Training Centres on the Power Park, Hotel Accommodation on North Peto Square and Residential Housing on South Peto Square) to flood during a 1 in 20 year event. 'More Vulnerable' development should be protected from at least a 1 in 200 year tidal flood event. The 1 in 200 year tidal flood level plus climate change is 4.31mAOD in Lowestoft (Table 2). Site levels would therefore need to be raised by to at least 4.31mAOD to provide protection 'More Vulnerable' development from a 1 in 200 year tidal flood event (Table 2).

However, where 'More Vulnerable' development is provided as a single storey development, the development should be protected from the 1 in 1000 year flood event, including climate change. Where 'More Vulnerable' development is provided as a multi-storey development, the development should be protected from the 1 in 200 year flood event, including climate change. The level of land raising could therefore vary for different development types.

A budget cost of land raising would be approximately £20/m^3.

Based on the above:

- 300mm of land raising would cost £60,000/ha.
- 800mm of land raising would cost £160,000/ha.
- 1300mm of land raising would cost £260,000/ha.

In order to provide the 'More Vulnerable' Training Academy, Hotel Accommodation and Residential Housing with a 1 in 200 year standard of protection it could also be possible to construct a strip of land raised to 4.7mAOD. This strip of raised land could provide protection from a 1 in 200 year tidal event. However, the tidal flooding mechanisms would need to be considered in greater detail to assess where strips of raised land should be located to provide protection.

- 1700mm of land raising would cost £340,000/ha.

The Sequential Approach could be followed in raising site levels on the Peto Square and the PowerPark sites. The 'More Vulnerable' development could be located on the higher parts of the existing sites, which in turn would reduce the amount of land raising required in both Peto Square and the PowerPark.

7.3 Finished Floor Levels

Based on discussions with the Environment Agency, finished floor levels would need to set at different levels for different vulnerability classifications of the proposed developments.

Finished floor levels on 'Less Vulnerable' development should be located at least 300mm above the 1 in 20 year flood level, including climate change. This equates to a finished floor level of at least 4.1mAOD.

Finished floor levels on 'More Vulnerable' development should be located at least 300mm above the 1 in 200 year flood level, including climate change. This equates to a finished floor level of at least 4.61mAOD. However, where 'More Vulnerable' development is provided as a single storey development, finished floor levels should be located 300mm above the 1 in 1000 year flood level, including climate change. This equates to a finished floor level of at least 5.0mAOD. A finished floor level of at least 4.61mAOD is appropriate when 'More Vulnerable' development is provided as a multi-storey development.

7.4 Safe Access and Egress

Based on discussions with the Environment Agency, safe access and egress is not required for 'Less Vulnerable' development. However, this is subject to a suitable flood evacuation plan being agreed with the emergency planning unit of the Local Authority. A suitable flood evacuation plan would form part of a flood management, which should be prepared for the PowerPark and Peto Square sites. The aspects of a flood management plan are considered below, in Section 7.8.

Safe access and egress is required for the 'More Vulnerable' development. It must be ensured that it is possible to safely access and egress 'More Vulnerable' development during a 1 in 200 year tidal flood event, including climate change, and that users of these developments do not become trapped as a result of the surrounding areas flooding. Raised access and egress will therefore need to be provided from the 'More Vulnerable' development to surrounding areas located at or above 4.31mAOD. This could potentially be provided by a raised walkway and/or access road.

7.5 Building Usage

As an alternative to land raising to 4.7mAOD, or in addition to land raising to a lower level, the layout of each proposed building could be designed to ensure that no 'More Vulnerable' development uses are provided on the ground floor of buildings. All residential accommodation and training facilities could be located on the 1st floor or above, with 'Less Vulnerable' commercial development on the ground floor.

Car parking could be provided at ground level provided that the design of the buildings did not allow for cars to float away from the parking areas.

It is also recommended that no basement levels (i.e. below ground level) are provided on the Peto Sqaure or PowerPark sites.

7.6 Water Resistant and Resilient Construction

If not all buildings (and all levels of buildings) are protected from a 1 in 200 year tidal flood, including climate change, water resistant and resilient construction techniques could be utilised within the buildings. Ideally these techniques should be used up to the future 1:1000 year flood level where this has been modelled

A flood resistant building is one which prevents flood water entering the building or damaging its fabric. Typical techniques include flood gates, temporary flood boards or locating finished floor levels above the flood level. Land raising, which would facilitate finished floor levels being located above the 1 in 200 year tidal flood level including climate change, has already been considered. Providing individual buildings with flood gates and temporary flood boards that provide a 1 in 200 year standard of protection, including climate change, is also a possibility.

A flood resilient building is one which is built in such a way that if flood water enters the building, the impact of this flooding is reduced. No structural damage should occur within flood resilient building. Flood resilient construction techniques include hard finishes, tiling, breathable plaster finishes, and water resistant materials. These types of finishes all facilitate the drying and cleaning of buildings and ensure that buildings are re-usable as soon as possible after flood events. Flood resilient construction techniques could also be utilised up to the 1 in 200 year tidal flood level including climate change.

7.7 Mechanical and Electrical Protection

If not all buildings (and all levels of buildings) are not protected from a 1 in 200 year tidal flood event, including climate change, mechanical and electrical protection will need to be provided.

All mechanical and electrical equipment should be placed above the 1 in 200 year tidal flood level, including climate change, including the boiler, generator, transformers and motors. Separate electric circuits should be installed below and above the flood level, so that the ground floor of any buildings located below the 1 in 200 year flood level will have a

separate circuit to the rest of the building. The circuits placed below the flood level will be sacrificial, and their controls should be installed above the flood level.

Where possible service entries to the buildings and switches and sockets should be located above the 1 in 200 year flood level, including climate change, or sealed to prevent water ingress. Services located below flood levels should be designed to resist water ingress as far as practicable, and floatation and impact.

To warn of a flood or impending flooding, an audible and visible alarm should be installed on each floor of the proposed buildings to warn building users. This will be linked to the Flood Management Plan and should be inspected, maintained and tested regularly.

7.8 Flood Management Plan

A flood management plan should be prepared for the PowerPark and Peto Square. This plan should cover all aspects of mitigating the flood risk to people and property including maintaining and testing flood defences, a flood warning procedure, a designated flood safety officer and having an emergency response plan.

There is a formal flood warning service provided by the Environment Agency in Lowestoft. All the proposed buildings within the PowerPark and Peto Square sites should register to receive this service. Refuge Areas

If not all buildings are not protected from a 1 in 200 year tidal flood event, including climate change, refuge areas will need to be provided above the 1 in 1000 year flood level, including climate change, so that building users have a safe place to go during a flood. Given that all buildings will all have levels above the ground level, there will be plenty of space available to provide safe refuge areas.

7.9 De-Watering

If not all buildings are not protected from a 1 in 200 year tidal flood event, de-watering will be required in the event of flooding.

A sump and pumping regime should be constructed at the lowest points on site, with a discharge point to be agreed above the flood level, but where it will not adversely affect off site or on site users. Any permanent discharge points should prevent the flow of water from outside into the buildings (non return valve/device).

8 Masterplanning Parameters

8 Masterplanning Parameters

As detailed in Section 3 and 7, land raising has been identified as an appropriate strategy for both the PowerPark and Peto Square. Approximate ground levels on the PowerPark and Peto Square sites have been taken from the manhole cover levels on the Anglian Water sewer plans. These approximate ground levels are shown on the two plans on the following pages.

Based on the approximate ground levels, which are shown on the two plans, the land raising mitigation option has been considered in greater detail. The existing ground levels have been used to develop the following masterplanning parameters. The parameters outlined below will inform further refinement of the Masterplan.

8.1 Land at 2.0mAOD

In these areas limited land raising is recommended. It is recommended that any development is restricted to 'Water Compatible' uses as detailed Table 6. 'Water Compatible' uses include public open spaces, recreational areas and landscaped areas.

8.2 Land at 3.0mAOD

In these areas 'Less Vulnerable' development would need to be located on land or above at 3.8mAOD. Raising ground levels to 3.8mAOD would require 800mm of land raising at £160,000/ha. Alternatively, car parking could be provided at ground level with 'Less Vulnerable' development provided above 3.8mAOD (i.e. 1st floor and above).

'More Vulnerable' development would need to be located on land above 4.3mAOD. Raising ground levels to 4.3m AOD would require 1700mm of land raising at £260,000/ha. If the proposed Training Academy was located within this area, locating 'Less Vulnerable' development on the ground floor of the Training Academy building would be the preferred option. The 'Less Vulnerable' development would be located at 3.8mAOD, with the 'More Vulnerable' Training Academy located on the 1st floor above 4.3m AOD.

In North Peto Square there is higher land to the east and west of the site. It may therefore be possible in North Peto Square to provide a strip of raised land or defence to provide the required standard of protection. Further detailed topographical analysis would be required to consider this further.

8.3 Land at 3.5mAOD

In these areas 'Less Vulnerable' development would need to be located on land or above at 3.8mAOD. Raising ground levels to 3.8mAOD would require 300mm of land raising at £60,000/ha. This level of land raising (300mm) is considered minimal.

'More Vulnerable' development would need to be located on land above 4.3mAOD. Raising ground levels to 4.3m AOD would require 800mm of land raising at £160,000/ha. If the 'More Vulnerable' Training Academy was to be located at ground floor level this land raising would be required.

8.4 Land at 4.0mAOD

'Less Vulnerable' development would be appropriate in these areas without any land raising.

'More Vulnerable' development would need to be located on land above 4.3mAOD. Raising ground levels to 4.3m AOD would require 300mm of land raising at £60,000/ha these areas. This level of land raising (300mm) is considered minimal.

8.5 Land at 5.0mAOD

'Less Vulnerable' and 'More Vulnerable' development would be appropriate in these areas without any land raising.

8.6 Timing and Cost of Mitigation

The raising of land will need to be defined at the detailed site planning stage and will be subject to detailed flood risk assessment for each development.

Land raising to provide the above mitigation can be restricted to the area under the ground floor of the buildings and that required to provide a safe access and egress. It is not necessary to raise the land in general areas for flood risk purposes.

It is suggested that the land raising operation will be undertaken by each developer as part of the initial construction works for their site. This will avoid the need for up front enabling works to be provided by public bodies.

The indicative cost of land raising for each development, based on the ground floor area of the development, is £2/m2 for every 100mm of land raising.

For example, the indicative cost to raise the land by 300mm for a building with a ground floor of 1980m2 =

£2 x 1980 x 3 = £11,880

8.7 Additional Mitigation Measures Required

Depending on where certain types of development (i.e Less Vulnerable and More Vulnerable) are located in the masterplanning process and the level of land raising that will be provided, additional mitigation measures may be required. Mitigation measures that may be required were outlined in Section 7, and include raised finished floor levels, safe access and egress and a flood management plan. The mitigation strategy should be finalised as part of the masterplanning process.