**Flood Risk Assessment**

**North East Quadrant, Regents Place**

**British Land Company**

**February 2007**

ENVIRON

## CONTENTS

# 1.0 INTRODUCTION

## 1.1 BACKGROUND

ENVIRON UK Limited was commissioned by British Land to carry out a Flood Risk Assessment (FRA) for the proposed redevelopment of a site on Regents Place in London known as the North East Quadrant (NEQ) at NGR TQ 291 824. The site occupies an area of approximately 1.0 hectare and is shown in Figure 1.

The proposed development will be in the form of three buildings, comprising an office block rising to 8 to 16 storeys in height, a high rise residential block rising to 25 storeys and a lower residential block reaching 9 storeys. The development will provide 47,168 sq m gross external area (GEA) of office accommodation, 35,095 sq m residential accommodation and 3,591 sq m retail and cultural use at ground floor level. Basement level car parking would be provided.

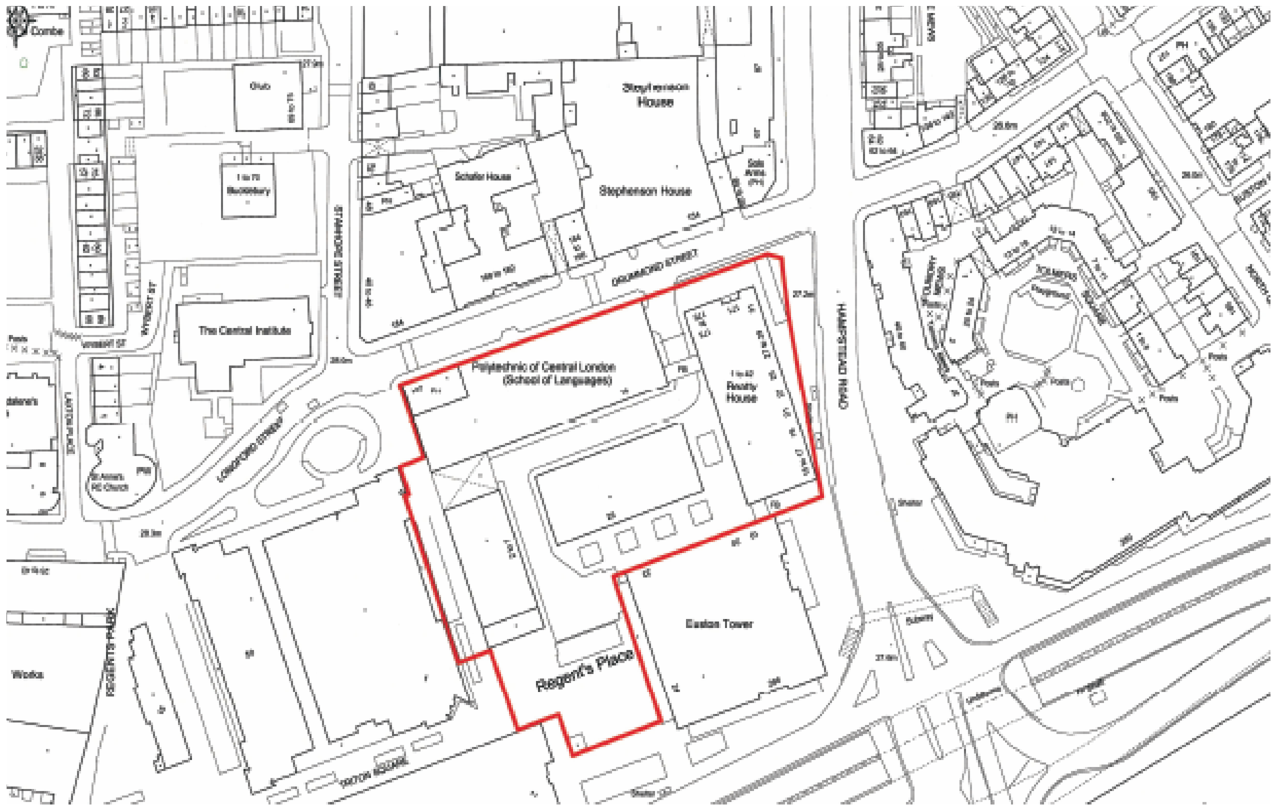


**Figure 1: Site Location Showing Application Site Boundary and Existing Site Layout**

## 1.2 REQUIREMENTS FOR A FLOOD RISK ASSESSMENT

The requirements for FRA are provided in "Planning Policy Statement 25: Development and Flood Risk" (PPS25) which was published in December 2006. This document requires that flood risk should be considered in the planning and development process in order to reduce any future flood damage to property and loss of life. PPS25 emphasises the importance of managing and reducing flood risk in land use planning by taking account of flood risk and the likely impacts of climate change.

Paragraphs E8-E10 of PPS25 require an FRA to be submitted with a planning application to determine the risks of flooding at a development site. As such, an FRA is an essential element in the overall assessment of the economic viability of the development as well as its acceptability in planning terms.

Guidance on the content of FRAs is contained in Annex E of PPS25, which is reproduced in this report as Appendix A. In addition, the EA has produced four Guidance Notes on "Development and Flood Risk Assessments" which aim to simplify the requirements for flood risk assessments according to the nature of the development and the site location in relation to the Zone 3 floodplain.

These Guidance Notes are:

- Minor Development within the Zone 3 Floodplain;
- Non-Minor Development within the Zone 3 Floodplain;
- Minor Development outside the Zone 3 Floodplain; and
- Non-Minor Development outside the Zone 3 Floodplain.

The EA Guidance Notes and Annex E of PPS25 have been used as guidelines for the content of this FRA.

Similarly, the EA has advised Local Authorities that an FRA should be requested for planning applications for all sites over 1 hectare in area. Such FRAs should consider the risk of flooding of the site (if appropriate) and also set out the proposed methodology for management of surface runoff from the site.

## 1.3 CONSULTATION

In preparing this FRA, a scoping consultation response from the EA regarding their requirements and the extent of available information on flood risk at the proposed development site has been used.

Further consultation has been undertaken with regard to the proposed drainage concepts, the feasibility of using Sustainable Urban Drainage Systems (SUDS) and the associated surface runoff rates.

# 2.0 BASELINE ENVIRONMENTAL CONDITIONS

## 2.1 LOCATION AND TOPOGRAPHY

The proposed development site is located between Hampstead Road and Drummond Street (Figure 1). The northern boundary of the site is formed by Drummond Street and to the east by Hampstead Road. The southern and western site boundaries are formed by Euston Road and development on Triton Square, respectively. Neighbouring sites include a mixture of commercial, hotel, residential, education and hospital uses.

The NEQ site is roughly rectangular in plan, covering an area of approximately 1.0 hectare (Figure 1). The surface topography of the site is broadly level, with ground levels between 27 metres above Ordnance Datum (m AOD) to 28 m AOD. Surrounding areas are at a similar level with no major topographic changes.

A group of buildings, constructed in the 1960s, providing a total of 22,850 sq m of office, retail, residential, cultural and educational floor space, currently occupy the site. The British Land Company PLC owns the freehold of the buildings on the NEQ site, as well as a majority of the rest of the Regent's Place site. Most of the existing buildings are now vacant.

## 2.2 HYDROLOGY AND FLOODING

### 2.2.1 Local Hydraulics and Flood Risk

The EA has provided data that demonstrates that the site lies in Flood Zone 1 (an annual probability of flooding of < 0.1%). The site therefore has "little or no risk of flooding" as set out in Table D.1 of PPS25. On this basis, this FRA has focused on an assessment of the management of surface runoff at the site.

### 2.2.2 Flood Alleviation Measures

The site does not lie within Flood Zone 3 and does not therefore require protection from either fluvial or tidal flood defences.

## 2.3 GEOLOGY AND HYDROGEOLOGY

**TABLE 2.1: SUMMARY OF THE STRATIGRAPHY OF THE DEVELOPMENT SITE**

| Stratum | Thickness (m) | Top of Stratum (AOD) |
|---|---|---|
| Made Ground | 1.2 - 3.35 | + 26.0 to + 29.0 |
| River Terrace Deposits | 3.05 – 4.8 | + 23.5 to +27.8 |
| London Clay | 15 – 18.35 | + 18.5 to +22.5 |
| Lambeth Group | 9.75 | 0 to + 6.5 |
| Thanet Sand | 9.15 | |

Source: Regents Place - Geotechnical Desk Study Report, Yolles Partnership (June, 2005)

With regard to infiltration-based SUDs, the 1:10,560 scale geological map of London (Sheet TQ28SE, 1982) indicates that the site is underlain by River Terrace Deposits (Lynch Hill Gravel), overlying the London Clay Formation. The Environment Agency's Groundwater Vulnerability Map of the area (Sheet No.39, West London, 1: 100,000 scale) indicates that the site is situated above a minor aquifer (the River Terrace Deposits) of intermediate to high vulnerability. The underlying London Clay Formation is classified as a non-aquifer.

Table 2.1 provides a summary of the stratigraphy of the site which is taken from BGS borehole data for locations close to the site. Made ground is shown to overly the River Terrace deposits and is likely to comprise variable ground of brick, clay and gravel varying in thickness from 1.0 to 3.0 metres.

In 2000, borehole surveys undertaken as part of a ground investigation on the adjacent site found that there was a thinner layer of 1 m of Terrace Gravels, compared to the expected 4 m from the stratigraphy presented in Table 2.1. In addition, basement excavations at 350 Euston Road found that the terrace gravels were waterlogged due to the presence of a perched water table and that the London Clay was exposed within the excavation depth.

# 3.0 FLOOD RISK ASSESSMENT

## 3.1 FLOODING MECHANISMS

### 3.1.1 Comparison of EA Flood Levels and Proposed Site Levels

The site has been shown to lie within Flood Zone and therefore has little or no risk of flooding as set out in Table D.1 of PPS25.

### 3.1.2 Climate Change Impact on Fluvial Flows

As a consequence of the site lying within Flood Zone 1, the impacts of climate change on the site are negligible (i.e. the application site will remain in Flood Zone 1 for its operational lifetime).

### 3.1.3 Impact of Potential Failure of Local Flood Defences

There are no flood defences that afford protection for the site and therefore no consideration of the impact of their failure is required.

### 3.1.4 Fluvial Morphology

There is considered to be no potential impact of the development on fluvial morphology or on the likely longer-term stability and sustainability of any watercourses, as no works or discharges to watercourses are anticipated.

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### 3.1.5 Residual Risks

The residual risks are assessed after the construction of any necessary defences. As new or modified flood defence arrangements are not provided, the consideration of their behaviour under extreme events is not required.

### 3.1.6 Conclusions (Flood Risk)

The site has been shown to lie above the predicted 100 year floodplain and therefore lies within Flood Zone 1. PPS25 states that "all uses of land are appropriate in this zone".

# 4.0 RUNOFF GENERATION

## 4.1 INTRODUCTION

The surface runoff likely to be generated from the proposed development has been calculated using the Flood Estimation Handbook (FEH) rainfall data. These runoff rates and volumes can be compared with those from the existing use of the site.

The feasibility of the site for the use of Sustainable Urban Drainage Systems (SUDS) has also been considered, within the constraints of available site area, ground conditions and site permeability to establish the potential for reducing the overall rates of runoff from the site.

### 4.1.1 Summary of PPS 25: Guidance on Surface Runoff Management

Flooding results from sources external to the development site and rain falling onto and around the site. The sustainable management of this rainfall, described as surface water, is an essential element in reducing future flood risk to both the site and its surroundings.

Undeveloped sites generally rely on natural drainage to convey or absorb rainfall, the water either soaking into the ground or flowing across the surface into watercourses, providing a natural flow which is of environmental and ecological benefit. Sites currently or previously used for agricultural purposes may additionally have systems of underground drainage pipes as well as open ditches and watercourses.
To satisfactorily manage flood risk in new developments, appropriate surface water drainage arrangements are required, to manage surface water and the impact of the natural water cycle on people and property.

SUDS aim to reduce the volume of runoff arising from a site at source and/or attenuate those flows that do arise such that the runoff rates being released into the wider environment are reduced. SUDS can rely on infiltration of runoff into the ground (using soakaways, swales, infiltration trenches and permeable pavements) or attenuation of flow at the surface (using filter strips or swales and attenuation basins / ponds). Infiltration-based SUDS require favourable ground conditions (i.e. uncontaminated and highly permeable ground) and surface SUDS require sufficient land to be available for the siting of SUDS structures.

SUDS cover the whole range of sustainable approaches to surface water drainage management including:

- source control measures including rainwater recycling and drainage;
- infiltration devices allow water to soak into the ground, that can include individual soakaways and communal facilities;
- filter strips and swales, which are vegetated features that hold and drain water downhill mimicking natural drainage patterns;
- filter drains and porous pavements to allow rainwater and runoff to infiltrate into permeable material below ground and provide storage if needed; and
- basins and ponds to hold excess water after rain and allow controlled discharge that avoids flooding.

The use of SUDS, where they are feasible, provides a significant contribution towards more sustainable development since they:

- manage environmental impacts at source, rather than downstream;
- manage surface water runoff rates, reducing the impact of urbanisation on flooding;
- protect or enhance water quality;
- are sympathetic to the environmental setting and the needs of the local community; and
- provide opportunities to create habitats for wildlife in urban watercourses; and can encourage natural groundwater recharge.

### 4.1.2 Methodology

The feasibility of the proposed development site for the use SUDS has also been considered, within the constraints of available site area, ground conditions and site permeability to establish the potential for reducing the overall rate of runoff from the site (Section 4.3.3).

FEH modelling software has been used for assessing the surface water runoff on the site. FEH modelling software generates statistical data on rainfall events and river flows and provides an estimation of these parameters for any specified return period.

Results were obtained using:

- the FEH method to establish rainfall depths for a range of return periods;
- FEH to determine catchment descriptors, such as annual average rainfall;
- the Wallingford Procedure to determine values for soil index (SOIL) and urban catchment wetness index (UCWI);
- the Modified Rational Method to calculate storm runoff volumes for each return period. The percentage impermeable surface was taken as 98% for the existing site which, using the Wallingford Procedure, equates to a percentage runoff (PR) value of 73%; and
- peak discharges for the 30 minute storm were determined from storm volumes using the standard hydrograph approach.

## 4.2 SURFACE RUNOFF MANAGEMENT

### 4.2.1 Comparison of Pre- and Post-Development Runoff Rates

The proposed development would have the same percentage area of impermeable surface as that of the existing site, which is estimated at 98%. As a result, the 100 year storm would generate the same surface runoff as the existing land use.

**TABLE 4.1: EXISTING / PROPOSED RUNOFF RATES**

| Return Period yrs | Runoff Rates: 30 min FEH Storm (mm) | Storm Volume V ($m^3$) | Peak Flow Q (l/s) |
|---|---|---|---|
| 2 | 11.2 | 81.89 | 45.53 |
| 5 | 16.6 | 121.37 | 67.48 |
| 10 | 21.5 | 157.19 | 87.40 |
| 25 | 29.9 | 218.60 | 121.54 |
| 50 | 38.2 | 279.29 | 155.28 |
| 100 | 48.7 | 356.06 | 197.97 |

The peak runoff rate for the 100 year return period storm is 197.97 l/s for the existing site; this would remain the same (prior to mitigation) for the proposed development. In order to account for the likely effects of climate change, it is generally accepted that rainfall intensities are likely to increase by 20% by 2060 and therefore runoff rates need to be reduced from current levels to account for this.

In order to comply with the requirements of current planning policy and associated guidance, the drainage system for the proposed development should ideally be designed to reduce peak runoff rates from 197.97 l/sec to greenfield runoff rates (5 litres per second per hectare – equivalent to 7.5 l/sec in total) through the introduction of SUDS, where feasible.

However, in many circumstances it is not possible to attenuate to this level, particularly in heavily urbanised areas, such as London. The Mayor of London has therefore released a document – Sustainable Design and Construction; The London Plan Supplementary Planning Guidance.

From this, the preferred attenuation would be to greenfield runoff rates but, essentially, the requirement is for a 50% reduction. The extent of attenuation that is possible using SUDs would depend implicitly on the site location and conditions.

The objective of this FRA is to investigate the feasibility of using SUDS measures in order to demonstrate the feasibility of achieving an overall 50% reduction in runoff rates for the development.

A conceptual drainage strategy for the proposals has been prepared and an attenuation rate has been discussed and agreed with the EA (as the key consultee regarding flood risk for sites over one hectare in area). The runoff rate for the proposed development that has been agreed with the Environment Agency is 83 l/sec compared to 197.97 l/sec for the existing site.

This reduction in runoff rates should be achieved as far as is practical by the use of SUDs. Where there is a requirement for further attenuation beyond that achievable using SUDs, then traditional engineering measures would have to be utilised (e.g. the adoption of oversized pipes, holding tanks or underground storage). These options are discussed in more detail in the following subsection.

### 4.2.2 Feasibility of the Use of Sustainable Urban Drainage Systems (SUDs)

This subsection provides an overview, in the form of a matrix, of the feasibility of a range of SUDS techniques in order to identify which measures are feasible at the NEQ site (refer to Table 4.2).

**TABLE 4.2: SUDS FEASIBILITY MATRIX**

| Technique | Physical Constraints | Feasibility |
|---|---|---|
| Permeable pavement / surface car parking | Requires a level site and sufficient surface area of pavements and parking areas | Due to poor ground conditions, infiltration not recommended at this site; paved areas are also limited in area |
| Green roofs | Generally not suitable for pitched roofs; flat roofs are preferred | Feasible |
| Bioretention – shallow landscaped infiltration areas | Primarily used to remove pollutants from runoff and due to their shallow nature are not as effective at runoff attenuation as other SUDS techniques; sufficient land needs to be available | Space limited within the proposed landscaped areas |
| Soakaways and infiltration trenches | Ideally require infiltration rates of $1 \times 10^{-6}$ m/s or greater, uncontaminated ground and sufficient unsaturated zone depth above the water table. | Gravel is too thin and water table is too shallow |
| Grassed filter strips – wide gently sloping areas of grass or other vegetation | Normally used to treat polluted runoff from car parks or roads. Not as effective at runoff attenuation as other SUDS techniques | Not enough space |
| Infiltration basins / swales | Are widely applicable for attenuation and treatment of surface runoff by infiltration into the ground. Require slope of no more than 4-10% and can act as a substitute for soakaways where groundwater is shallow – need to consider the impact these techniques have on local groundwater levels | Gravel is too thin and water table is too shallow |
| Filter drains | These are normally used adjacent to areas of car parking or roads and convey runoff via flow through an engineered substrate (normally gravel). | Not considered ideal due to poor ground conditions (i.e. shallow water table) |
| Rainwater Recycling System | Rainwater harvesting is a technique used to collect and re-use roof water. The water is filtered then used again for laundry, WC flushing. Landscape irrigation etc. A technique that should prove useful in areas with decreasing water supply and increasing floods. | Could be used for irrigation of landscape areas |

The proposed basement beneath the site, as well as the geological conditions, limit the potential for the adoption of infiltration methods, even for the public areas.

Therefore, on the basis of the SUDS feasibility study, there are very few techniques that would be appropriate for use at NEQ, Regents Place (i.e. only the green roof areas). Further details are provided below.

<u>Green Roofs</u>

There is no potential for green roofs on the main commercial building. The total green roof to be installed represents an area of 139.5 $m^2$, which appears upon the roof (9th floor) of the affordable block parallel to Hampster Road.

Green roofs are effective at attenuating rainfall up to and including the 2-year rainfall event. Storms above this return period tend to run off the roofs and therefore these techniques have limited, if any, hydraulic benefits above the 2-year event.

Based on attenuation of the 2-year storm within the green roof area, it is possible to calculate the level of attenuation achieved using the Modified Rational Method (set out in Table 4.1 for the whole development area). The area of green roof represents 1.4% of the total site area (139.5 $m^2$ within a site area of 1 ha). Therefore, the green roof areas will reduce the runoff rate by an estimated 1.4% of the runoff rate generated by the 2-year storm. This is equivalent to approximately 0.65 l/sec or 0.35% of the 100-yr storm runoff rate.

This is a small reduction but green roofs are also important in relation to visual and biodiversity benefits and are therefore desirable at this site.

Other Attenuation Solutions

As no other SUDs measures are feasible, the principal practical option would be to utilise oversized pipework in building drainage systems, to increase the period over which flow concentrates and so decrease the peak runoff hydrograph or the use of a balancing tank or tanks to accommodate and attenuate a large volume of water.

The balancing tanks will be weir type and located in the basement of each of the two buildings. A connection will need to be made to the local stormwater sewer where the surface water can be discharged at the rate agreed by the Environment Agency. The scheme may also allow the rainwater to be harvested and diverted to the irrigation tanks during drier periods to provide water for the public landscape areas. Another amenity feature will also be included at this site, in the form of a water wall; surface water will be collected from the courtyard and reciprocated round with a pump, creating a waterfall.

The exact nature of these mitigation measures will be defined at the detailed drainage design stage in consultation with the Environment Agency and the Local Authority.

### 4.2.3 Summary

Reductions in runoff rates are not realistically achievable using measures such as infiltration techniques. However, the adoption of 139.5 m$^2$ of green roof will provide a small reduction in runoff rates.

The most practical solution to achieve the necessary reduction in runoff rates is to attenuate as much surface runoff as possible, in the space provided, using a balancing tank. The architects and drainage engineers have agreed that it would be feasible to attenuate the peak storage volume of 430 m$^3$ (280 m$^3$) within balancing tanks.

Through a combination of green roof and storm balancing tanks with rainwater recycling capabilities (irrigation tanks), it is possible to reduce the peak runoff during a 100-yr rainfall event from 197.97 l/s to the agreed rate of 83 l/s; equivalent to a 58% reduction.

### 4.2.4 Conclusions (Runoff Generation)

The site, once developed, will generate essentially the same peak volume of surface water runoff as the site in its current developed condition, but this will be balanced prior to discharge. Existing drainage discharge arrangements will be adequate for the volumes generated from the proposed development.

The applicability of SUDS based on infiltration techniques is limited by the extensive basement that underlies the site and the underlying geology. The only SUDs technique that is considered feasible is the adoption of a green roof, which provides some attenuation as well as visual and biodiversity benefits. However, the required reduction in runoff rates is best achieved (in this instance) through the use of over-sized pipe work and balancing tank(s) within the development.

The surface water management assessment has established that it is possible to reduce the overall runoff rate for the 100 year storm by as much as 58%, through the use of these combined techniques. In order to achieve a reduction of 58% in peak runoff rates compared to the existing scenario, holding tanks at basement level in each of the two buildings with a combined capacity of 280 m$^3$ would be required.

The peak flow runoff rate will therefore be reduced from 197.97 l/sec for the existing site to 83 l/s. A connection will be made to the local stormwater sewer where the surface water can be discharged at this reduced rate, as agreed by the Environment Agency.

## 5.0 SUMMARY AND CONCLUSIONS

The requirements for a Flood Risk Assessment are provided in Planning Policy Statement 25: Development and Flood Risk together with the Environment Agency's Guidance Notes.

A summary of the key conclusions of this FRA is provided below:

- **Flood Risk –** the site lies within Flood Zone 1 (annual probability of flooding of < 0.1%) and therefore has "little or no risk of flooding" in accordance with PPS25; and

- **Runoff Generation –** the proposed development would have the same impermeable surface area as the existing development and therefore runoff rates and volumes generated by the proposed development would be equal (prior to any mitigation). However, the proposed development would include the use of a green roof and holding tanks for attenuation of runoff and potential use in rainwater harvesting. These measures would reduce peak flows by 58% from 197.97 l/sec to 83 l/sec, i.e. to the runoff rate agreed with the Environment Agency.

The site is located within an area with little or no flood risk (Flood Zone 1). Table D.1 of PPS25 indicates that Flood Zone 1 areas are suitable for all types of development. In addition, as the proposed drainage strategy would result in a reduction in runoff rates of 58%, the criteria for development as set out in PPS25 have been satisfied and therefore development on this site should be permitted.

# APPENDIX A: GUIDANCE ON REQUIREMENTS FOR UNDERTAKING A FLOOD RISK ASSESSMENT, PPG25 (APPENDIX F).

## ANNEX B: THE ASSESSMENT OF FLOOD RISK, PPS25 (ANNEX E)

### GENERAL PRINCIPLES

E1. Properly prepared assessments of flood risk will inform the decision making process at all stages of development planning. There should be iteration between the different levels of flood risk assessment.

E2. Any organisation or person proposing a development must consider whether that development will not add to and should where practicable reduce flood risk. The future users of the development must not be placed in any danger from flood hazards and should remain safe throughout the lifetime of the plan or proposed development or land use.

E3. At all stages of the planning process, the minimum requirements for flood risk assessments are that they should

- be proportionate to the risk and appropriate to the scale, nature and location of the development;
- consider the risk of flooding arising from the development in addition to the risk of flooding to the development;
- take the impacts of climate change into account;
- be taken by competent people, as early as possible in the particular planning process, to avoid misplaced effort and raising landowner expectations where land is unsuitable for development
- consider both the potential adverse and beneficial effects of flood risk management infrastructure including raised defences, flow channels, flood storage areas and other artificial features together with the consequences of their failure;
- consider the vulnerability of those that could occupy and use the development, taking account of the sequential and exception tests and the vulnerability classification including arrangements for safe access;
- consider and quantify the different types of flooding (whether from natural and human sources and including joint and cumulative) and identify flood risk reduction measures, so that assessment are fit for the purpose of the decisions being made;
- consider the effects of a range of flooding events including extreme events on people, property, the natural and historic environment and river and coastal processes;
- include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular development or land use;
- consider how the ability of water to soak into the ground may change with development, along with how the proposed layout of development may affect drainage systems; and
- be supported by appropriate data and information, including historical information on previous events.

### SITE SPECIFIC FLOOD RISK ASSESSMENTS (FRAS)

E8. At the planning application stage, an appropriate FRA will be required to demonstrate how flood risk from all sources of flooding to the development itself and flood risk to others will be managed now and taking climate change into account. Policies in LDD's should require FRA's to be submitted with planning applications in areas of flood risk identified in the plan.

E9. Planning applications for development proposals of 1 hectare or greater in Flood Zone 1 and all proposals for new development located in Flood Zone 2 and 3 should be accompanied by a FRA. This should identify and assess the risks of forms of flooding to and from the development and demonstrate how these flood risks will be managed, taking climate change into account. For major new developments in Flood Zone 1, the FRA should identify opportunities to reduce the probability and consequences of flooding. A FRA will also be required where the proposed development or change of use to a more vulnerable class may be subject to other sources of flooding, or where the Environment Agency, Internal Drainage Board and/or other bodies have indicated that there may be drainage problems.

E10. The FRA should be prepared by the developer in consultation with the LPA. The FRA should form part of an environmental statement when one is required by the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 as amended.