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PLYMOUTH CITY COUNCIL

STRATEGIC FLOOD RISK ASSESSMENT

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GLOSSARY OF TERMS

Term	Meaning / Definition
PCC	Plymouth City Council
PPG25	Planning Policy Guidance Note 25 – Development and Flood Risk
LIDAR	Light Detection and Ranging (Topographic data)
LDF	Local Development Framework
LPA	Local Planning Authority
LDD	Local Development Document
PPS25	Planning Policy Statement 25 – Development and Flood Risk
FRA	Flood Risk Assessment
SFRA	Strategic Flood Risk Assessment
RFRA	Regional Flood Risk Assessment
RPB	Regional Planning Body
RSS	Regional Spatial Study

1. INTRODUCTION

1.1 AIMS OF ASSESSMENT

1.1.1 Study Objectives

The Strategic Flood Risk Assessment sets out to provide a high-level assessment, and data set on flood risk in Plymouth. This assessment and data set are to be used to view the implications of land use planning and change within the catchment areas of Plymouth.

The study focuses on the three main anticipated growth areas of Plymouth as advised by Plymouth City Council:

- Waterfront
- Northern Corridor
- Eastern Corridor

The SFRA has been commissioned by Plymouth City Council with a view to:

- Ensure that Plymouth City Council meet its obligations under current planning guidance
- Provide a reference and policy document to inform local planning policy

1.1.2 Outputs

The principal output from the study is a set of maps which divide Plymouth into Flood Risk Zones in accordance with the definitions given in Planning Policy Guidance Note 25, Development and Flood Risk (PPG 25). These plans should give Plymouth City Council sufficient information so as to have an overall view of flood risk areas for strategic planning purposes. The plans and report will enable consistent and sustainable decisions to be made with respect to flood risk.

1.2 BACKGROUND

Plymouth is located at the centre of the far South West on the border between Devon and Cornwall. It is a geographically compact city, the second largest in the SW Region after Bristol, providing a home for some 240,000 people, as well as high order services for its extensive catchment areas.

The City Council is currently preparing the Local Development Framework (LDF), which will be a portfolio of different policy documents, guiding development in the city up to 2016 and beyond, in the interests of sustainable development and urban regeneration.

The LDF (Core Strategy) proposes to allocate sites for 10,000 new dwellings within the city by 2016. 80% of these will be on previously developed sites, many of which are in key regeneration areas such as Millbay and Devonport. In some cases, allocated development is within identified areas of flood risk, eg Millbay docks.

1.3 FLOOD RISK POLICY

PPG25 recommends that when drawing up or revising development plans local planning authorities should give priority in allocating sites for development in descending order of flood risk.

There is, therefore, a requirement for LPAs to use the Sequential Test, as set out in paragraph 30, table 1 of PPG 25, and explain reasons for any departures when preparing their local plans.

Although PPG 25 does not explicitly require Local Planning Authorities to undertake a Strategic Flood Risk Assessment, paragraph 30 of this guidance advises that as the promoter of allocated sites they must provide an assessment of whether the allocation is:

- Likely to be affected by flooding; and
- Whether it is subject to increased flood risk elsewhere.

Planning Policy Statement 25 (PPS25) is currently in draft status and expected to be published in the near future. This gives Regional Planning Bodies a key target of "preparing Regional or Strategic Flood Risk Assessments as appropriate, either as part of the Sustainability Appraisal of their plans or as a freestanding assessment that contributes to that Appraisal". PPS25 goes on to state "A SFRA should be carried out to inform the preparation of a planning authority's LDDs, having regard to catchment wide flooding issues which affect its area. The SFRA will provide the information needed to apply the sequential approach".

2. METHODS OF ASSESSMENT

A number of methods have been used in order to indicate areas where flood risk issues should be considered in relation to any planned development. The first traditional approach is by observation of Environment Agency floodmaps.

2.1 DATA SOURCES

The quality of the output of this report is reliant on the data provided by the various agencies. The data used in general has been provided by the Environment Agency with supplementary information provided by Plymouth City Council.

Data	Output
Flood Defence Infrastructure	Indicates the location of certain Flood Defence/Control Infrastructure recorded by the Environment Agency
Flood Zone 2	Area at risk from a 1:1000 year tidal or fluvial flood
Flood Zone 3	Area at risk from a 1:200 year tidal flood or a 1:100 year fluvial flood
Critical Drainage Catchments	Areas where development would be subject to specific drainage restrictions
Flood Risk Information Service	Locations where historical flooding incidents have been recorded
LIDAR	Topographic data used to highlight areas at risk from flooding

A floodplain is the area that would naturally be affected by flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas.

There are two different kinds of area shown on the Environment Agency Floodmap. They can be described as follows:

- Areas that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.
- Areas that show the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring each year.

Floodmaps produced by the Environment Agency show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements.

Flood flows follow the natural contours of the ground – therefore the area that may flood could be some distance from a river. The location may be on a route that floodwater will take. Alternatively there may be culverted watercourses under property or nearby, which may transfer floodwaters.

Flooding can occur from other sources such as groundwater and surface water runoff, but flooding from these sources is not shown on these maps.

3. POTENTIAL SOURCES OF FLOODING

Flooding is a natural hazard and can happen at any time in a wide variety of locations. There are a number of forms of flooding which present a range of different risks. The speed of inundation and the duration of different forms of flooding varies greatly. With climate change, the frequency, patterns and severity of flooding are forecast to change and become more damaging.

The limits of flood risk areas cannot be defined precisely because floods with similar probability can arise from different combinations of weather, sources, rainfall patterns, local topography and patterns of development.

Flooding can come from rivers and the sea, directly from rainfall on the ground surface as well as rising groundwater, or overwhelmed sewers and drainage systems. Every flood will have a different impact on people, property and the environment. The consequences of flooding depend greatly on land use. Overtopping of a flood defence in a densely populated urban area could have a serious threat to human life. The same event in a rural area may pose a much lower risk.

3.1 FLOODING FROM RIVERS

Rivers flood when the amount of water in them exceeds the flow capacity of the river channel. Most rivers have a natural floodplain into which the water spills in times of flood. Flooding can either develop gradually or rapidly according to how steeply the ground rises in the catchment and how fast water runs off into surface watercourses. In a large, relatively flat catchment, flood levels will rise slowly and natural floodplains may remain flooded for several days, acting as the natural regulator of the flow. This is a function that the planning system should promote and enhance. In small, steep catchments, local intense rainfall can result in the rapid onset of deep and fast-flowing flooding with little warning. Such “flash” flooding, which may only last a few hours, can cause considerable damage and possible threat to life. Land use, topography and the form of local development can have a strong influence on the velocity and volume of water and its direction of flow at particular points.

3.2 FLOODING FROM THE SEA

Flooding to low-lying land from the sea and tidal estuaries is caused by storm surges and high tides. Where tidal defences exist, they can be overtopped or breached during a severe storm and this is forecast to become increasing likely with climate change. The onset of flooding from the sea can be extremely rapid with little warning. Deep, fast-flowing water can create an extreme hazard. The severity of such flooding will depend on a number of factors, often in combination: the height of tides; weather systems; wind and wave conditions; the effectiveness of drainage systems; and the condition of flood defences.

The potential severity of the consequences of sea flooding is why the designation standard for high risk Flood Zone 3a is set twice as high for sea flooding as for rivers (at the 0.5% annual probability or 1 in 200 year flood rather than the 1% annual probability or 1 in 100 year level).

3.3 FLOODING FROM LAND

Intense rainfall, often of short duration, that is unable to soak into the ground or enter drainage systems can run quickly off land and result in local flooding. In developed areas, this floodwater can be polluted with domestic sewage. Local topography and built form can have a strong influence on the direction and depth of flow. The design of development down to a micro-level can influence or exacerbate this. Overland flow paths should be taken into account in spatial planning for urban developments. Flooding from land can be exacerbated if development increases the percentage of impervious area. Run-off may be polluted with hydrocarbons and other vehicle residues from road surfaces and a potentially wide range of other chemicals from hard surfaces in industrial or agricultural sites.

3.4 FLOODING FROM GROUNDWATER

Groundwater flooding occurs when water levels in the ground rise above surface elevations. It is most likely to occur in low-lying areas underlain by permeable rocks (aquifers). These may be extensive, regional aquifers, such as Chalk or sandstone, or may be localised sands or river gravels in valley bottoms underlain by less-permeable rocks. Water levels below the ground rise during wet winter months, and fall again in the summer as water flows out into rivers. In very wet winters, rising water levels may lead to the flooding of normally dry land, as well as reactivating flow in 'bournes' – streams that only flow for part of the year. The Chalk shows some of the largest seasonal variations in groundwater level, and is the most extensive source of groundwater flooding. Groundwater flooding may take weeks or months to dissipate because it moves much more slowly than surface water and will take time to flow away.

3.5 FLOODING FROM SEWERS

In urban areas, rainwater is frequently drained into surface water sewers or sewers containing both surface and wastewater known as "combined sewers". Flooding can result when the sewer is overwhelmed by heavy rainfall, becomes blocked or is of inadequate capacity, and will continue until the water drains away. When this happens to combined sewers, there is a high risk of internal property flooding with contaminated water.

3.6 FLOODING FROM RESERVOIRS, CANALS AND OTHER ARTIFICIAL SOURCES

Non-natural or artificial sources of flooding can include reservoirs, canals and, lakes where water is retained above natural ground level and also operational and redundant industrial processes e.g. mining, quarrying and gravel extraction. Reservoir or canal flooding may occur either as a result of the facility being overwhelmed or as a result of dam or bank failure. This can happen suddenly resulting in rapidly flowing, deep water that can cause significant threat to life and major property damage. Industrial flooding can also occur when low-level pumping ceases and groundwater returns to its natural level, for example in former mineral workings. Some of this flooding may be contaminated.

4. IMPACT OF CLIMATE CHANGE

Presented below are the current best estimates of the quantitative impact of climate change on sea level, waves, river flows and surface water drainage systems. The impact of these changes has been taken into account in this study when assessing flood risk to specific areas in Section 12.

4.1 ESTIMATED SEA LEVEL RISE (UK CLIMATE IMPACT PROGRAMME)

	Net sea level change (mm)		
Year	**2020s**	**2050s**	**2080s**
Low Greenhouse Gas Emissions Estimate	90	150	200
High Greenhouse Gas Emissions Estimate	190	440	800

Table 1. Net sea-level change for South West Great Britain relative to 1961-1990 for the full range of global sea-level changes estimated by the IPCC, incorporating updated isostatic adjustment data from Shennan and Horton (2002).

4.2 WAVE (UK CLIMATE IMPACT PROGRAMME / PPS 25)

A 10% sensitivity allowance should be added to offshore wind speeds and wave heights by the 2080s. This should be taken into account when carrying out a quantitative assessment of defences needed to protect proposed and existing development from overtopping and wave action. Potential development areas that are vulnerable to wave action are highlighted in the quantitative assessment of flood risk (Table 3, Section 12). For individual development in these areas a detailed investigation into vulnerability from waves should be undertaken as part of a site specific FRA.

4.3 RIVER FLOWS (PLANNING POLICY STATEMENT 25)

In making an assessment of the impacts of climate change on flooding from rivers as part of a flood risk assessment, assuming increases in peak flow allowance of up to 20% for a given return period by 2050 and 30% by 2110 may provide an appropriate precautionary response to the uncertainty about climate change impacts on flood flows.

4.4 SURFACE WATER DRAINAGE (PLANNING POLICY STATEMENT 25)

In making an assessment of the impacts of climate change on flooding from the land as part of a flood risk assessment, assuming increases in rainfall intensities of up to 10% for a given return period by 2050 and 15% by 2110 may provide an appropriate precautionary response to the uncertainty about climate change impacts on rainfall intensities.

5. SOURCES OF FLOODING IN PLYMOUTH

Plymouth is a coastal city, bounded on two sides by water, Plymouth Sound and the River Tamar. In addition, the River Plym runs through the edge of the City. Development in the City runs alongside all of the various waterfront areas and much of this could be at risk from flooding. Flooding is often exacerbated with heavy rainfall, high tide levels, low pressure and southerly winds raising levels in the various water bodies and reducing the effectiveness of various drainage systems.

5.1 FLUVIAL

5.1.1 Main rivers

The principal Main Rivers in Plymouth are the Rivers Tamar and Plym. The risk of flooding from these rivers is identified on the Environment Agency flood risk maps. The Environment Agency's powers to carry out flood defence works apply to main rivers only. Main rivers are designated by the Department for Environment, Food & Rural Affairs in England.

5.1.2 Ordinary watercourse

An ordinary watercourse is every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than public sewer) and passage through which water flows which does not form part of a main river. On ordinary watercourses, the local authority has similar permissive powers as the Agency has on main rivers.

5.2 TIDAL

As a coastal city water levels in Plymouth are influenced by the state of the tide. It is the tide, in combination with other series of events that is most likely to cause flooding to occur. High tides have the potential to cause an increase in general river levels as well as reducing the efficiency of drainage systems.

5.3 DRAINAGE

A significant amount of flooding in Plymouth is caused by ineffective drainage and insufficient sewer capacity. This has in some cases been caused by inappropriate development that has taken place without sufficient consideration of the design capacity of receiving sewers.

The Environment Agency have identified a number of 'Critical Drainage Catchments' where the drainage system is known to be close to or over its acceptable limit. Continued development and creation of impermeable surfaces in these areas causing an increase in runoff to overloaded drainage paths should be avoided in these areas. Critical Drainage Areas have been designated colours to represent the order of severity of the problem in specific catchments. The Environment Agency have defined general drainage guidelines for new development in each colour zone in order to promote sustainability and to mitigate flood risk. These are outlined below.

5.3.1.1 Red Problem Drainage Areas

The following guidance is recommended by the Environment Agency to be applied by the Local Planning Authority to any development proposals in the above problem drainage area to ensure that local flood risks are not increased. Where appropriate the local authority should consider the use of suitable conditions, or the submission of details in the form of a flood risk assessment, to secure drainage systems designed to these standards. Pre-application consultations with the Agency should be carried out by developers for any development sized 1 hectare or greater.

5.3.1.2 Residential extensions less than $5m^2$

Best practice is recommended utilising infiltration systems wherever practical. This may not need to be a formal drainage system but could involve drainage to a lawn or pervious area. Where infiltration systems cannot be used then the inclusion of, at least, a water butt or equivalent should be considered.

5.3.1.3 Residential extensions greater than $5m^2$

Drain to an infiltration system in accordance with infiltration guidance in BRE 365 or CIRIA 156 using a 10-year return period design standard.

The Planning Authority should consult their Building Control Team to ensure that there is appropriate space and siting for a soakaway to be constructed on the site. Typically, Building Regulations require infiltration systems to be located not less than five metres from any building.

5.3.1.4 Single dwellings and small residential and industrial/business developments

Drain to an infiltration system in accordance with BRE 365 or CIRIA 156 using a 30-year return period design standard. An overflow to a positive system for events greater than 30-year storm may be acceptable where the present drainage is to a surface water sewer or direct to a watercourse.

For redevelopment of existing sites where ground conditions prohibit infiltration (e.g. due to contaminated soils) then positive discharge is to be restricted to greenfield mean annual flood with storage provided on site for up to the 1 in 100-year storm.

5.3.1.5 Medium and large developments

In all cases a Quality Control Procedure for the installation of the drainage system will be required. The drainage system shall then drain either by: -

i) Infiltration according to CIRIA 156 with a capacity based on a 100-year design storm.
ii) Infiltration according to CIRIA 156 with a capacity based on a 30-year design storm but with measures to detain surface water on site for up to the 1 in 100-year storm.

Positive discharge restricted to the mean annual flood greenfield run off, with storage provided for up to the 1 in 100-year storm. Such storage can include above ground storage. The runoff rates must be based on sufficient site permeability tests and local rainfall intensity values

5.3.2 Details of Red Problem Drainage Areas

5.3.2.1 Derriford

Historically the flooding problem was increased by the development of land at the bottom of Forder Valley Road in 1984, which impeded the stream's flow. More recently large-scale development at Derriford has increased the risk. During heavy rainfall water runoff from the urban area upstream rapidly overloaded the watercourse at the point of restricted flow, causing flash flooding of properties and surrounding land.

In 1989 the Council installed a large culvert under Wilbert Road, alleviating to an extent the restriction. The culvert lowered the flood levels but was not enough to prevent it and Leigham Mill Cottages remain at risk of flooding. The watercourse is also subject to significant erosion risks.

5.3.2.2 Long Brook

The Long Brook drains a steep catchment that has been largely urbanised. There is a range of flooding problems along the river particularly in association with inadequate culverts and limited capacity in the surface water and combined sewers. Frequent flooding has occurred at Market Road and Potters Way, as well as locations in Plympton St Maurice.

The large coverage of existing development in the catchment, and notably residential development, does mean that extensions and other minor household alterations are liable have a significant cumulative impact on surface water flows. Drainage from these should be to soakaways wherever feasible.

5.3.3 Yellow Problem drainage Areas

The following guidance is recommended by the Environment Agency to be applied by the Local Planning Authority to any development proposals in the above problem drainage area to ensure that local flood risks are not increased. Where appropriate the local authority should consider the use of suitable conditions, or the submission of details in the form of a flood risk assessment, to secure drainage systems designed to these standards. Pre-application consultations with the Agency should be carried out by developers for any development sized 1 hectare or greater.

5.3.3.1 Residential extensions and single dwellings with no new roads

Best practice is recommended utilising infiltration systems wherever practical. For extensions this may not need to be a formal drainage system but could involve drainage to a lawn or pervious area. Where infiltration systems cannot be used then the inclusion of, at least, a water butt or equivalent should be considered.

5.3.3.2 Small residential and industrial/business developments

Drain to an infiltration system in accordance with BRE 365 or CIRIA 156 using a 10-year return period storm design standard. An overflow to positive system for greater events may be acceptable.

For redevelopment of existing sites where ground conditions prohibit infiltration (e.g. due to contaminated soils) then discharge is to be restricted to the greenfield mean annual flood runoff rate with storage provided on site for up to the 30-year storm.

5.3.3.3 Medium and large developments

In all cases a Quality Control procedure for the installation of the drainage system will be required. The drainage system shall then drain either by: -

i) Infiltration according to CIRIA 156 with a capacity based on a 30-year design storm with measures to retain excess surface waters on the site for up to the 1 in 50 year storm.

Positive discharge restricted to a variable rate depending on the design storm. The allowable discharge rates should vary from the greenfield mean annual flood up to the 1 in 10-year flow. For events in excess of the 10-year storm, storage shall be provided on site for up to the 100-year storm. Such storage can include above ground storage. The assessment of greenfield runoff rates should be based on sufficient site permeability tests.

5.3.4 Details of Yellow Problem Drainage Areas

5.3.4.1 Tamerton Foliot Stream

The culvert at Church Row Bridge has regularly overtopped and the bridge at Milford Lane has been subject to blockage by debris. The dam at Coombe Bottom acts to reduce flood risk to the Tamerton Foliot area, but erosion of the banks is advanced and undercutting of the dam could be an issue. Flooding also occurs as a result of surcharging of the sewers and limited flow capacity in the river channel in places.

5.3.4.2 Ham Brook

There has been a history of flooding at Ham Village, although the culverts downstream of this have been upgraded to reduce this risk. There also remains a concern over the capacity of the Weston Mill culvert particularly for high tides.

5.3.4.3 Colebrook

A watercourse runs under Colebrook; this starts as an open channel from the north downstream of Boringdon Hall but also drains the land from Courtland Terrace and the Mead. There has been a frequent history of flooding from this drainage system, particularly in the Golden Square and Colebrook Road area, but also in Boringdon Hill. The flooding has resulted from a combination of inadequate sewer capacity and intense rainfall on the catchment.

5.3.5 General Drainage Guidance for Plymouth

The following guidance is recommended by the Environment Agency to be applied by the Local Planning Authority to development proposals in general in the Plymouth area (i.e. those outside of identified problem drainage areas) to ensure that local flood risks are not increased. Where appropriate the local authority should consider the use of suitable conditions, or the submission of details in the form of a flood risk assessment, to secure drainage systems designed to these standards. Pre-application consultations with the Agency should be carried out by developers for any development sized 1 hectare or greater.

5.3.5.1 Residential extensions and single dwellings with no new roads

Best practice is recommended utilising infiltration systems wherever practical. For extensions this may not need to be a formal drainage system but could involve drainage to a lawn or pervious area. Where infiltration systems cannot be used then the inclusion of, at least, a water butt or equivalent should be considered.

5.3.5.2 Small residential and industrial/business developments

Best practice is recommended utilising infiltration systems wherever practical. Where the Local Planning Authority is aware of specific local issues then further constraints may be appropriate.

5.3.5.3 Medium and large developments

In all cases a Quality Control procedure for the installation of the drainage system will be required. The drainage system shall then drain either by: -

i) Where ground conditions are suitable, and especially for the redevelopment of sites already draining to soakaways, infiltration methods should be used in accordance with CIRIA 156, using a 30-year design standard storm.

ii) Where infiltration is not possible, positive discharge should be restricted to a variable rate depending on the design storm. The allowable discharge rates should vary from the greenfield mean annual flood up to the 100-year flow depending on the corresponding storm magnitude. The assessment of greenfield runoff rates should be based on sufficient site permeability.

6. HISTORIC FLOODING

Historic flooding incidents are recorded by the Environment Agency by means of the Flood Risk Information System (FRIS).

This is a particularly useful dataset as it highlights areas outside the indicative floodplain which have been subject to flooding. These flooding events may have been caused by high groundwater or ineffective drainage systems that are not incorporated into the Environment Agency floodmap.

7. DEFINING OF FLOOD RISK ZONES

The Environment Agency have traditionally broken down areas into flood risk zones in order to make a fast and high level assessment on whether a site is at risk of flooding. Ideally development should take place in areas at least risk from flooding. When choosing a site for development the sequential test should be applied in relation to flood risk.

7.1 THE SEQUENTIAL TEST

The risk-based Sequential Test should be applied at all stages of planning. Its aim is to steer new development to areas at the lowest probability of flooding (Zone 1).

The Environment Agency's Flood Zones are the starting point for applying the Sequential Test. Zones 2 and 3 are shown on Environment Agency maps with Flood Zone 1 land falling outside Zones 2 and 3. These Flood Zones refer to the probability of sea and river flooding only.

The overall aim of decision-makers should be to steer all new development to Flood Zone 1. The preparation and review of Regional Spatial Strategies (RSSs) and Local Development Documents (LDDs) should be used to review existing and proposed development patterns and allocations and identify opportunities to allocate land in lower flood risk zones suitable for existing uses already in medium and high flood zones.

Where it is not possible to steer all new development to Flood Zone 1, decision-makers allocating land in spatial plans or determining applications for development at any particular location should demonstrate that there are no reasonable options available in a lower risk category and should take into account the flood risk vulnerability of land uses. Section 7.2 explains how development from different classifications of vulnerability may be appropriate in Flood Zones 2 and 3, but only if:

- The requirements relating to flood risk assessments are met
- The residual risks of flooding are assessed and managed
- Where appropriate, the 'Exception Test' is passed

Regional Flood Risk Assessments, Strategic Flood Risk Assessments and site-specific Flood Risk Assessments (FRAs) for development proposals will refine information on the probability of flooding and will determine the probability of flooding from other potential sources.

7.2 INDICATIVE FLOOD RISK ZONES

7.2.1 Zone 1 Low Probability

This zone comprises land assessed as having a less than 1 in 1000 chance of river and sea flooding in any year (<0.1%).

Most uses of land are appropriate in this zone. However, all development proposals should still be considered in relation to:

a) Their vulnerability to flooding from other sources as well as from river and sea flooding
b) Their potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off

For development proposals on sites comprising one hectare or above, these considerations should be incorporated in a FRA. This need only be brief unless the factors at a) and b) above or other local considerations require particular attention.

In this zone, developers and local authorities should seek opportunities to:

i. Reduce the overall level of flood risk in the area through the layout and form of the development
ii. Mitigate the potential to increase flood risk elsewhere through the appropriate application of sustainable drainage techniques

7.2.2 Zone 2 Medium Probability

This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 chance of river flooding (1% – 0.1%) and between a 1 in 200 and 1 in 1000 chance of sea flooding (0.5% – 0.1%) in any year.

All development proposals in this zone should be accompanied by a FRA, which should include:

a) their vulnerability to flooding from other sources as well as from river and sea flooding;
b) their vulnerability to flooding over the lifetime of the development;
c) their potential to increase flood risk elsewhere through the addition of hard surfaces, the effect of the new development on surface water run-off, and the effect of the new development on depth and speed of flooding to adjacent and surrounding property; and
d) a demonstration that residual risks of flooding after existing and proposed flood management and mitigation measures are taken into account, including flood defences, flood resistant and resilient design, escape/evacuation, effective flood warning and emergency planning, are acceptable.

In this zone, developers and local authorities should seek opportunities to:

i. reduce the overall level of flood risk in the area through the layout and form of the development; and
ii. mitigate the potential to increase flood risk elsewhere through the appropriate application of sustainable drainage techniques.

7.2.3 Zone 3a High Probability

This zone comprises land assessed as having a 1 in 100 or greater chance of river flooding (>1%) and a 1 in 200 or greater chance of flooding from the sea (>0.5%) in any year.

Highly vulnerable uses (Section 7.2.5) should not be permitted in this zone. Essential infrastructure uses in should only be permitted in this zone if the Exception Test is passed. All development proposals in this zone should be accompanied by a FRA, which should include:

a) their vulnerability to flooding from other sources as well as from river and sea flooding;
b) their vulnerability to flooding over the lifetime of the development;
c) their potential to increase flood risk elsewhere through the addition of hard surfaces, the effect of the new development on surface water run-off, and the effect of the new development on depth and speed of flooding to adjacent and surrounding property; and
d) a demonstration that residual risks of flooding after existing and proposed flood management and mitigation measures are taken into account, including flood defences, flood resilient and resistant design, escape/evacuation, effective flood warning and emergency planning, are acceptable.

In this zone, developers and local authorities should seek opportunities to:

i. reduce the overall level of flood risk in the area through the layout and form of the development;
ii. mitigate the potential to increase flood risk elsewhere through the appropriate application of sustainable drainage techniques; and
iii. relocate existing development to land in lower flood zones.

7.2.4 Zone 3b The Functional Floodplain

This zone comprises land where water has to flow or be stored in times of flood. Only water-compatible uses and essential infrastructure (Section 7.2.5) that has to be there should be permitted in this zone. Essential infrastructure in this zone should pass the Exception Test and be designed and constructed to:

- remain operational in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows; and
- not increase flood risk elsewhere.

Less vulnerable, more vulnerable and highly vulnerable uses (Section 7.2.5) should not be permitted in this zone.

All development proposals in this zone should be accompanied by a FRA, which should include:

a) Their vulnerability to flooding from other sources as well as from river and sea flooding
b) Their vulnerability to flooding over the lifetime of the development
c) Their potential to increase flood risk elsewhere through the addition of hard surfaces, the effect of the new development on surface water run-off, and the effect of the new development on depth and speed of flooding to adjacent and surrounding property
d) A demonstration that residual risks of flooding after existing and proposed flood management and mitigation measures are taken into account, including flood defences, flood resilient and resistant design, escape/evacuation, effective flood warning and emergency planning, are acceptable

In this zone, developers and local authorities should seek opportunities to:

i. Reduce the overall level of flood risk in the area through the layout and form of the development
ii. Mitigate the potential to increase flood risk elsewhere through the appropriate application of sustainable drainage techniques
iii. Relocate existing development to land in lower flood zones

7.2.5 Flood Risk Vulnerability Classification

Described below are examples of types of development grouped into sections relative to their vulnerability to flooding. Measures should be taken to ensure that vulnerable development is sited outside of areas at risk of flooding.

Essential Infrastructure

- Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk, and strategic utility infrastructure.

Highly Vulnerable

- Police stations, Ambulance stations and Fire stations and Command Centres required to be operational during flooding
- Electricity-generating power stations and sub-stations
- Hospitals
- Emergency dispersal points
- Residential institutions such as residential care homes, children's' homes, social services homes and student Halls of Residence and hostels
- Gypsy and traveller sites using caravans or mobile homes
- Mobile or park homes for permanent residential use
- Dwelling houses designed, constructed or adapted for the elderly or other people with impaired mobility

More Vulnerable

- Buildings used for: dwelling houses (except for those in the highly vulnerable classification); drinking establishments; nightclubs; and hotels.
- Non-residential institutions such as health services, nurseries and educational establishments, but excluding hospitals.
- Landfill and hazardous waste facilities

Less Vulnerable

- Buildings used for: shops; financial, professional and other services, restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non-residential institutions; and assembly and leisure.
- Land and buildings used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
- Land and buildings used for agriculture and forestry.
- Waste treatment (except landfill and hazardous waste).
- Minerals working and processing.
- Transport infrastructure.

Water compatible Development

- Flood control infrastructure Water treatment plants and pumping stations.
- Sewage treatment plants and pumping stations.
- Docks, marinas and wharves.
- Navigation facilities.
- Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.
- Water-based recreation and tourism (excluding sleeping accommodation).
- Lifeguard and coastguard stations.
- Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms.
- Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).

7.3 DEFENCES

Flood defences do not completely remove the risk of flooding, but they do reduce it. Defences are built to withstand a flood of a certain magnitude but can be overtopped or fail either in extreme weather conditions or due to poor condition. Defences are built to different design standards according to local needs. Information on the likelihood of flooding takes account of the condition of defences as well as the standard of protection they provide.

8. RESPONSIBILITIES FOR PROTECTION FROM FLOODING

There is no general statutory duty on the Government to protect land or property against flooding. But Government recognises the need for action to be taken to safeguard the wider social and economic wellbeing of the country, including adapting to the impacts of climate change. Operating authorities have permissive powers but not a statutory duty to carry out or maintain flood defence works in the public interest.

8.1 THE OWNER/DEVELOPER

Landowners have the primary responsibility for safeguarding their land and other property against natural hazards such as flooding. Individual property owners and users are also responsible for managing the drainage of their land in such a way as to prevent, as far as is reasonably practicable, adverse impacts on neighbouring land. Those proposing development are responsible for:

- Demonstrating that it is consistent with the policies in PPG25, the emerging PPS25 document and on flood risk in the LDD
- Providing an assessment of:
  - Whether any proposed development is likely to be affected by flooding from any source
  - Whether it will increase flood risk elsewhere
  - The measures proposed to deal with these effects and risks
- Satisfying the LPA that any flood risk to the development or additional risk arising from the proposal will be successfully managed with the minimum environmental effect, and that necessary flood risk management measures are sufficiently funded to ensure that the site can be developed and occupied safely throughout its proposed lifetime
- Designs which reduce flood risk to the development and elsewhere, by incorporating sustainable drainage systems and where necessary, flood resilience measures
- Identifying opportunities to reduce flood risk, enhance biodiversity and amenity and seek collective solutions to managing flood risk

These matters can affect the value of land, the cost of developing it and the cost of its future management and use. They should be considered as early as possible in preparing development proposals.

8.2 THE REGIONAL PLANNING BODY

The Regional Planning Body (RPB) should take flood risk into account in determining strategic planning considerations in the Regional Spatial Study (RSS) for its region including the location of housing provision and transport infrastructure. Its Regional Flood Risk Assessment (RFRA) should identify the risk to its regionally strategic locations. The RPB should consult the Environment Agency on flood risk issues when preparing its RSS.

8.3 LOCAL PLANNING AUTHORITY

LPAs should consult the Environment Agency and other relevant bodies (including adjacent LPAs) when preparing policies in their Local Development Documents (LDD) on flood risk management and in relation to areas potentially identified as at risk of flooding. Their Sustainability Appraisals, land allocations and development control policies should all be informed by a SFRA carried out in liaison with the Environment Agency. Authorities should also consult the Environment Agency on applications for development in flood risk areas. LPAs, advised as necessary by the Environment Agency and other relevant organisations, should determine applications for planning permission taking account of all material considerations, including the issue of flood risk, the FRA prepared by the developer (when required) and proposals for reducing or managing that risk.

Local planning authorities should re-consult the Environment Agency if still minded to approve a planning application after having considered it in the light of initial Environment Agency advice against approval. If minded to approve an application for major development against sustained Environment Agency advice, having notified the Agency of that intention, the planning authority must refer the application to the relevant Government Office to decide whether to call in the application for decision by the First Secretary of State.

A major development is one in which the number of dwellings to be constructed is ten or more, or the site area is equal to or greater than 0.5 Ha. Non-residential developments are defined as major if they involve a floor space equal to or greater than 1000 m^2, or a site area equal to or greater than 1 Ha.

LPAs should notify the Environment Agency of the outcomes of all planning applications to which the Agency has objected on grounds of flood risk. Other organisations which have been consulted, such as Internal Drainage Boards (IDBs), should be notified where conditions attached to planning permissions may affect local drainage.

8.4 THE ENVIRONMENT AGENCY

The Environment Agency has statutory responsibility for flood management and defence in England and will support the planning system by providing planning authorities with timely advice on flooding issues that is fit for purpose. At a strategic level, it provides RPBs and LPAs with advice in the preparation of RFRAs and SFRAs. At the site level, it provides advice to those proposing developments and undertaking FRAs and to planning authorities on planning applications. It is a statutory consultation body for RSSs and Local Development Frameworks, a consultation body for Strategic Environmental Assessment/ Sustainability Appraisal and Environmental Impact Assessment and subject to this consultation, a statutory consultee in flood risk areas.

8.5 OTHER BODIES

A more detailed summary of the roles of other main stakeholder bodies are given in Annex H of PPS25 consultation document.

9. MITIGATION

Included in the table below are a number of methods used to mitigate against flood risk together with a list of objectives that each measure aims to achieve. The following section also gives a brief description of each measure highlighting positive and negative attributes and how each can be used.

Table 2 – Applicability of mitigation measures to meet key sustainability objectives for new developments (Development and Flood Risk – Guidance for the Construction Industry, CIRIA, 2004)

Objective	Site selection	Development zoning	Raising floor levels	Land raising	Flood warning	Flood proofing	Design of channel and hydraulic structures	Flood defences	Developer contributions	Compensatory flood storage	Management of development runoff	Pumping
Reduce flood risk to development	■	■	●	■	●	●[2]	●	●	●	×	■	●
Manage surface water runoff	●	■[1]	×	×	×	×	×	×	●	×	■	●
Avoid increase in upstream flood risk	■	■	×	×	×	×	●	×	●	×[3]	×	●
Avoid increase in downstream flood risk	■	■	●	×	×	×	×	×	●	■	●	×

■ Often Acceptable ● Sometimes Acceptable × Not Applicable

1 Zoning can be used to provide flow paths for extreme events that exceed the capacity of the formal on-site drainage system.
2 Flood proofing is usually only acceptable as a secondary measure e.g. if used in association with raised floor levels, or to provide protection against an extreme flood event.
3 Land regarding as part of compensatory flood storage works may also in some situations improve conveyance within the system.

9.1.1 Development Site Selection

The simplest way to manage the majority of flood risk problems is to select a development site outside the flood risk zone. Some developments are more sensitive to flood risk than others, and national planning policy guidance identifies many of the development types which should be located outside “low

to medium" and "high" flood risk zones. Developments which have potential to be damaged during flood events, and those which could subsequently release pollutants into the water environment, should also be located outside these flood risk zones.

Relocation of the development will not necessarily, in itself, manage runoff from a site, although relocation to a brownfield site – or to a site that drains to a less sensitive watercourse – may reduce the potential impact of runoff from a development.

9.1.2 Development zoning

Careful planning of development layouts may allow flood risk to be managed in a development without the need for the construction of physical mitigation measures. Such solutions are beneficial as they can be very cost effective and can minimise the impact that the development may have on flood risk. A properly zoned development has similar benefits to development constructed on raised land, without the costs associated with land raising and other mitigation measures required to avoid an increase in upstream and downstream flood risk.

9.1.3 Raising floor levels

One method of reducing flood risk to a development is to raise the floor level of buildings to above flood defence level. Car parking and utility areas may be located at lower levels.

Ideally this will be achieved by appropriate zoning or land raising. However, in some cases it may be feasible to design the development so that the ground floor is allowed to flood, provided that the use of the ground floor is such that flooding would be acceptable. Indeed, DTLR (2001) suggests that the use of upper levels of converted structures, such as warehouses, for housing – with appropriate uses at a lower level – may be acceptable. Such a design may also be appropriate for new build developments but, in both cases, a number of factors should be taken into account when deciding on the appropriateness of such a mitigation technique, as discussed below.

The principal benefit of this mitigation technique is the reduction of flood risk to property. To maintain this benefit, ground floors should be designed as open plan public spaces, such as car parks or utility areas. Provision of private garages or other enclosed private spaces should be avoided, both due to the risk of vehicular damage and because this may encourage the future storage of potential pollutants (eg pots of paint, oil etc) and white goods (e.g. washing machines, freezers etc) within flood risk zones.

Special consideration should be given to safety if access to floor levels that are below flood defence level is to be provided by lifts. Lifts should be prevented from operating on such floors during flood events. Adequate flood warning and evacuation procedures should be put in place.

9.1.4 Land Raising

A method which is frequently used to manage flood risk to a development is to raise land levels from existing ground levels to a level above the flood defence level, and to construct the development on this raised ground. Land raising schemes should not produce an area of land that would become an island during a flood event, and safe access to and from the development during the design flood event must be provided.

9.1.5 Flood warning

The majority of new developments should be designed so that flood warning is not a necessary part of the development design. Even so, the use of warning signs highlighting the susceptibility of an area to flood is recommended in areas that are subject to flood risk and where the public has access. Evacuation routes to be used in the event of a flood should also be clearly signed, and marking used to identify such routes should be clearly visible during a flood event.

Flood warning may be a useful mitigation measure for managing flood risk when extreme events which exceed the design flood event occur, and may be needed in conjunction with other mitigation measures. The need for, and feasibility of, flood warning systems for a development should be discussed with the FDA.

9.1.6 Flood proofing

Flood proofing is a technique whereby buildings are designed to withstand the effects of flooding. Flood proofing is unlikely to be suitable as the only mitigation measure for most new residential developments, but may be suitable in certain circumstances outlined below:

- Industrial developments where temporary disruption is acceptable
- Developments which are designed with ground floors that can flood
- Developments where the use of an existing building is to be changed
- Developments which include basements that are at risk of flooding
- Developments which are located on the edge of the flood risk zone, such that flooding depths are likely to be very low and access may be maintained during a flood event
- Developments which will not flood during the design flood event, but which may be flooded by an extreme flood event

Flood proofing methods fall into two main categories:

1 **Dry proofing** methods are designed to keep water out of the building, and can include design of floors and walls to withstand water pressures and prevent seepage (passive measures) and the provision of temporary covers on openings in walls (active measures).

2 **Wet proofing** methods are designed to improve the ability of the property to withstand the effects of flooding once water has entered the building, and can

include construction with appropriate materials, use of flood-resistant fittings and locating vulnerable services above design flood level.

Flood proofing techniques can be applied to a number of permanent features within a building and, if properly designed, can substantially reduce the impact of flooding on the building. A selection of recommendations for flood proofing measures that can be incorporated within the design of buildings are outlined below:

Feature	Considerations to improve flood proofing
External walls	Careful consideration of materials: use low permeability materials to limit water penetration if dry proofing required. Avoid using timber frame and cavity walls. Consider applying a water resistant coating. Provide fittings for flood boards or other temporary barriers across openings in the walls (dry proofing).
Internal walls	Avoid use of gypsum plaster and plasterboard; use more flood resistant linings (eg hydraulic lime, ceramic tiles). Avoid use of stud partition walls.
Floors	Avoid use of chipboard floors. Use concrete floors with integrated and continuous damp proof membrane and damp proof course. Solid concrete floors are preferable; if a suspended floor is to be used, provide facility for drainage of sub-floor void. Use solid insulation materials.
Fitting, fixtures and services	If possible, locate all fittings, fixtures and services above design flood level. Avoid chipboard and MDF. Consider use of removable plastic fittings. Use solid doors treated with waterproof coatings. Avoid using double-glazed window units that may fill with floodwater. Use solid wood staircases. Avoid fitted carpets. Locate electrical, gas and telephone equipment and systems above design flood level. Fit anti-flooding devices to drainage systems

9.1.7 Design of channel and hydraulic structures

The design of channel and hydraulic structures as a mitigation measure can be split into three categories:

- Definition of acceptable development encroachment
- Correct design of bridge/culvert crossings
- Modifications to existing flood channels to offset the impacts of a development

Acceptable development encroachment

The preferred method of avoiding an unacceptable increase in upstream water levels due to a development is to limit the extent of development within the area of flood plain conveying flow. Using hydraulic modelling it is possible to determine the extent to which the development could encroach into the flood plain without water levels rising by more than the amount permitted by the LPA/FDA.

If the development is to encroach into the flood plain to such an extent that it may cause unacceptable increases in upstream water levels then modifications to the channel may be an option to offset this impact.

Design of culvert crossings

Culverting of watercourses should be avoided wherever possible as construction of culverts may affect the ecology of the watercourse and may increase flood risk. Both the Environment Agency and SEPA have general policies against culverting of watercourses. Wherever possible, bridge crossings should be used in preference to culverts.

Channel modifications

The design flood level is a function of the flood flow and the conveyance capacity of the channel/flood plain system. If channel modifications are undertaken to increase the conveyance capacity of the channel, then flood levels at the site – and for some distance upstream – can be reduced, although this will result in a reduction of flood storage. Channel modifications will also be required if a culvert is to be removed and replaced with an open channel, and can be undertaken to improve drainage routes around a development (eg to deal with overland flow or groundwater flooding). Channel enlargements may be undertaken in tidally affected watercourses (on the inland side of tidal gates), or on watercourses which require pumping, to increase the storage capacity within the watercourse.

Key considerations for schemes involving channel improvements and bridge/culvert crossings include:

- Can it be shown that the works do not lead to unacceptable water levels upstream of and next to the works?
- Will the flood velocities following the scheme be such that erosion will not occur or can be managed?
- Can it be shown that the works do not lead to an increase in downstream flood risk?
- Are the works designed such that the risk of disruption due to debris or sedimentation is acceptable?
- Have appropriate maintenance arrangements been made for the life of the development?
- Are the environmental and geomorphological impacts of the proposed works acceptable?
- Would the proposed works be consistent with the strategic flood management policies of the FDA?

- Will the relevant consents be given by the FDA?
- Have the works been designed so as to manage health and safety risks?

The development is unlikely to be acceptable if the answer to any of these questions is "No".

9.1.8 Flood defences

In principle, flood defences can be constructed to protect a development from the design flood. This may involve upgrading or replacing existing flood defences, or the construction of new flood defences in previously undefended areas.

The construction of new flood defences to facilitate development within the flood risk zone should be avoided where possible. As noted in DTLR (2001) "…as part of its strategy for sustainable development, the government wishes to avoid an unnecessary increase in the requirement to provide artificial defence against flooding."

Construction of new structural flood defence measures for developments may not be sustainable in the long-term, as such defences are associated with ongoing maintenance requirements and risk of failure. Flood defences may also disturb aquatic and riparian habitats, have adverse visual impacts, and can restrict access to riverbanks. In addition, drainage of local runoff from behind flood defences can be problematic during flood events. As flood defences must tie into high ground or existing flood defences, it may be necessary to construct flood defences in areas outside the development site itself.

Therefore, flood defences are not a desirable means of managing flood risk to new developments, unless they provide benefit to existing developments currently at risk of flooding.

9.1.9 Developer contributions to strategic flood risk management

In some situations it may be possible for the developer of a site to contribute towards a planned flood alleviation scheme that is part of the long-term plan for strategic flood risk management of an area, rather than provide site-specific mitigation measures.

Such an option is worth consideration where the viability of undertaking site specific mitigation is limited, and where an existing flooding problem exists in the area, for which the FDA has an identified strategy.

9.1.10 Compensatory flood storage

Compensatory flood storage works are required where the proposed development would otherwise reduce the available volume of flood storage.

Compensatory flood storage must become effective at the same point in a flood event as the lost storage would have done. It should therefore provide the same

volume, and be at the same level relative to flood level, as the lost storage. This requirement is often referred to as “level for level” or “direct” compensation.

If the compensatory storage is provided at another level it will already be full (if lower) or still be empty (if higher), when the storage is required, and the characteristics of flood storage at this location will, therefore, be altered.

Ideally, the compensatory storage should be created immediately next to the location of the development. Upstream sites may also be effective, providing that no major inflow occurs between the development and the compensatory flood storage site. For many developments it is likely that suitable land will not be available for the provision of compensatory flood storage within the boundary of the development site, so alternative sites will have to be identified. This may lead to land identification and purchase problems.

9.1.11 Management of development runoff

Careful design of runoff from the development site is required, both to manage the flood risk posed on the site due to runoff and to avoid an increase in flood risk downstream of the site. Long-term operation and maintenance requirements and responsibilities are a key consideration with runoff management techniques and may have a major influence on the choice of methods.

Attenuation of runoff from development sites is required to avoid an increase in runoff rates and volumes in receiving watercourses. Consideration should be given to the means of providing flow attenuation at the development site at an early stage of site planning as this can influence site masterplanning. The feasibility of managing development runoff may constrain the extent of land that may be developed, and runoff management measures may be used as landscaping features.

Where developments discharge directly into watercourses which are subject to Tidelocking it may be more appropriate to provide on-line attenuation through increasing the storage capacity of the receiving watercourse than providing on-site attenuation, as flood risk is influenced by both rainfall and tidal events. In such cases every effort should still be made to encourage infiltration to minimise development runoff at source.

Attenuation of flows from development sites has been undertaken for many years, and there is a wealth of available literature relating to the design of such mitigation measures. Attenuation can be achieved either by Sustainable Drainage Systems (SUDS) or through more traditional means (oversized pipes, tanks etc). SUDS techniques are preferred to traditional measures to control runoff as they attempt to reproduce the natural systems that govern runoff volumes and rates. They are more likely to manage the surface water quality problems which may be associated with development. SUDS techniques can also provide landscape and amenity features, and can increase the ecological diversity of a site.

9.1.12 Pumping

Where a development is to be protected by an existing or a new flood defence, pumping may be required to drain the low-lying area behind the defence, during periods when water levels within the receiving watercourse are higher than the maximum allowable water level within the development.

Typical situations in which pumping may be required include locations where:

- A watercourse drains through a flood defence and has a flap valve on its outfall
- Surface water runoff may be trapped behind a flood defence, and where this may pose a flood risk to the development
- The development is at a lower level than a receiving carrier drain or sewer

Wherever possible, development designs that are reliant on pumping should be avoided, as they have ongoing maintenance and running costs, and the development will be vulnerable should the pumping station fail. For this reason, developments that rely on pumping should be proposed only if the FDA accept that there is no alternative, and that the risks associated with pumping station failure can be managed.

10. USES OF SFRA

The purpose of this study is to give a general overview of flooding in the Plymouth area. Each separate development should be considered on an individual basis with regard to flooding. Applications likely to require particular consideration of flood risk issues include those for development:

- Within a river flood plain or washland shown on the indicative flood plain map prepared by the Environment Agency
- Within a coastal flood plain, including that adjacent to the tidal length of a river, shown on the indicative flood plain map prepared by the Environment Agency
- Within or adjacent to any watercourse, particularly where there might be potential for flash flooding
- Adjacent to or including any flood bank or other flood control structure
- Situated in an area where the Agency have indicated that there may be drainage problems
- Likely to involve the culverting or diverting of any watercourse
- Of such a size or nature relative to the receiving watercourse/drainage system that there could be a significant increase in surface water run-off from the area.

Proposed developments such as those described above are likely to require a separate Flood Risk Assessment following guidance set out in PPG25 and the emerging PPS25 documents.

11. FLOOD RISK TO POTENTIAL DEVELOPMENT AREAS

It can be observed from Appendix 1 that Plymouth, as well as being a coastal city subject to attack from tidal and wave action, is also bisected by two large rivers; the Tamar and the Plym. Appendix 2 gives a general overview of the extent of flooding in Plymouth showing a spread of flooding issues throughout the city boundary.

It can be seen from Appendix 3 that most of the proposed development and redevelopment is concentrated around the waterfront area of the city. This area is already heavily developed meaning that reducing flood risk for new development is likely to be challenging.

From Appendix 3 it can be seen that the city can be broken down into sections in order to inform more specifically on flooding issues relevant to particular locations in the city. There are three general areas that have 'Frameworks for Area Action'; northern corridor, eastern corridor and waterfront. Within these areas a number of more specific potential development areas have been identified, also highlighted on Appendix 3. A quantitative assessment of flood risk to these specific areas has been carried out and is presented in Appendix 18 with each potential development area attaining an overall score of vulnerability to flooding. The process followed to obtain the resultant score for each area is described in Section 12. The resultant scores do not relate to a specific scale but instead are relative to and are meant for comparison with the overall set of resultant scores.

Appendices 4 – 8 illustrate how datasets recorded by the Environment Agency relate to the proposed development areas. This process highlights areas that are likely to be at risk from flooding, and therefore require further study in order to determine the best methods to mitigate the risk, as well as showing areas that are at little or no risk from flooding and do not need further consideration in terms of flood risk.

Appendices 9 – 17 serve a similar purpose highlighting low lying areas that may be subject to flooding during times of high tide and future risk from sea level rise. These appendices predict the extreme tidal level in a number of periods, 2006, 2050, 2080 using LIDAR data from the Environment Agency which highlights bands of ground between specified levels.

Interpretation of the data compiled above can give an indication of the nature of flooding in each development area at risk from flooding. This in turn gives an indication as to which mitigations measures, described in Section 9, would be best suited to reduce risk in the development areas that are currently at risk.

11.1 NATURE OF PREDICTED FLOODING

Table 3 illustrates the quantitative assessment of flood risk and is included in Section 12. This gives a list of the development areas at risk from flooding with a description of the nature of the risk as well as suggested mitigation measures

which may act to reduce the risk, in doing so making the area more suitable for development.

It can be seen from the appendices that there are two main causes of flooding in the city. These are as follows;

- Direct flooding caused by the impact of the tide/waves
- Indirect flooding caused by the tide submerging drainage outlets impeding the flow of surface water drainage systems causing flooding at their inlets

The first can be solved using a quite simplistic approach; either critical development should be moved away from the risk or the development should be protected using flood defences. The simplistic approach does not necessarily imply an easy solution. A large proportion of the potential development area of East End Waterfront (11) is relatively low lying and is likely to be subject to regular inundation by tidal floodwater in the future. Extensive land raising on a relatively large scale is recommended should the necessity arise to develop this area.

The second type of flooding can be more complicated to mitigate and can often involve upgrades to the drainage system. This type of flood risk can be observed in the Union Street area of the city; Appendices 15 – 17 illustrates that much of the area is below the predicted 1 in 1 year tidal still water level for 2006. Measures to reduce the risk to existing and proposed development within this area include raising floor levels so vulnerable infrastructure is taken out of reach of predicted flood levels, maintenance and possible improvements to ensure efficiency of the drainage system as well as measures to store runoff so it can be discharged at low tide or used for other purposes.

The predicted impacts of climate change discussed in Section 4 are likely to cause an overall increase in flood risk. The two main causes of flooding discussed above will be exacerbated by increases in general sea level and high tides causing increased frequency of direct tidal inundation, tide locking of drainage systems and the cumulative effects of more extreme weather events.

Only one of the five proposed waste management facilities, Chelson Meadow Waste Management Centre (Appendix 4), is shown to be at risk from flooding. Special attention should be paid to flooding issues when designing this facility as flooding of sensitive areas of the site may result in the spread of contamination across a large area.

Each separate development should be considered on an individual basis with regard to flooding. Flood risk should always be considered when proposing a new development and if deemed necessary a FRA should be carried out that would highlight on a site specific basis the magnitude and nature of flood risk to the development as well as any increase in flood risk which the development may cause elsewhere.

12. APPRAISAL OF POTENTIAL DEVELOPMENT AREAS

In order to carry out a quantitative assessment of flood risk across the city potential development areas identified from Local Development Frameworks have been defined so that the vulnerability of each area can be compared against the resultant vulnerability of all areas in order to compare and quantify the risk. The quantitative assessment is presented in Table 3 below. The following sheets review in more detail the flood risk at the proposed potential development areas. The discussion for each area only considers the area enclosed within the yellow (mixed use development) or purple (waste management) boundary lines.

It should be noted that where a flood risk has been identified detailed Flood Risk Assessment should be carried out on a site specific basis.

Flood risk to each area is summarised and quantified in the quantitative assessment table (Table 3) included below where the sum of the variables affecting the probability, severity and consequences of a flood in each separate area results in a flood risk score. This score should be used to compare the level of risk between the potential development areas. Scores are discussed in the individual sheets presented below.

Where flood risk is identified within a potential development area measures should be taken to ensure that vulnerable development (discussed in section 7.2.5) is sited outside of these areas.

Number Of Area (See Appendix 3)	Development Area	Nature of Existing Risk	Vulnerability to Wave Action	Fast Flowing	Frequency	Depth	Proportion of Area At Risk	Impact of Climate Change	Proposed Mitigation Measure	Scale of Mitigation Cost	Residual Risk	Score	Proposed Development	Discussion - Individual FRAs should be undertaken, for development in all of the below areas identified as being at risk from flooding, Which are suitable to the scale of the proposed development.
1	Southway	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Strengthen the existing centre at Southway which is supported by strong, vibrant and well-connected communities.	This area is not at significant risk from tidal or fluvial flooding.
2	Northern Corridor Mixed Use	Fluvial to low lying undeveloped areas	1	2	1	1	0.1	1	Site selection & Management of development runoff.	1	1	0.2	High density mixed use development including residential areas. Create new and improved infrastructure and establish a new central focal point for the Northern area of Plymouth, providing community focus and safeguard the long-term position of the airport.	New developments should be built outside of the fluvial flood risk areas. Modelling should be undertaken to accurately establish the extents of the fluvial flood zones.
3	Forder Valley	No risk of tidal or fluvial flooding to the area	1	2	1	1	0.1	1	Site selection & Management of development runoff.	1	1	0.2	New link may benefit the accessibility of the area and allow the creation of a more attractive and sustainable urban area.	New developments should be built outside of the fluvial flood risk areas. Modelling should be undertaken to accurately establish the extents of the fluvial flood zones.
4	Coypool (waste site)	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Locate China Clay works site at Coypool. Not all the site is required and it would be appropriate to include other development facilities on this site.	This area is not at significant risk from tidal or fluvial flooding.
5	Chelson Meadow Waste Management Centre	Tidal/Fluvial	2	2	2	1	0.2	3	Site selection & improvement of shoreline defences.	2	2	19.2	Safeguard the use of existing facilities in the south west corner of the site and provide for additional new waste management development.	Ensure infrastructure in flood risk zone is protected to an adequate level. New development should be away from areas at risk from flooding. Improvements to shoreline defences may be necessary to protect the area from the predicted increased risk from tidal flooding due to climate change.
6	High Quality Public Transport Route	Fluvial risk from watercourse that flows alongside the proposed route	1	2	3	2	0.4	1	Ensure route does not reduce capacity of watercourse.	2	2	19.2	New sustainable transport infrastructure to meet the transport needs of existing and future development, as well as promoting sustainable transport modes including walking, cycling and public transport.	Ensure essential new infrastructure in flood risk zone is protected to an adequate level. Modelling should be undertaken to establish the extents of the flood zones. This should be completed prior to the detailed design of the route, especially the stream crossings
7	Sherford	Fluvial	1	2	2	1	0.1	1	Site selection & Management of development runoff.	1	1	0.4	Allocated land within the city boundary for the development of new facilities for the "Sherford New Community". The development will provide for housing, minerals, transport, sports and recreation. A landscape and green buffer area will be safeguarded to create a broad area between the existing area at Elburton and limit development at the Sherford new community.	New developments should be built outside of the fluvial flood risk areas. Modelling should be undertaken to accurately establish the extents of the fluvial flood zones.
8	Moorcroft	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	The quarry which formerly was used for mineral extraction is to be redeveloped as a waste management facility, including recycling and recovery. It will provide a range of employment within the waste industry.	This area is not at significant risk from tidal or fluvial flooding.
9	Plymstock Quarry (mixed use)	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	The quarry is to be redeveloped sustainably and successfully as a new neighbourhood of Plymouth. The development will include 1500 homes (30 homes/ha) without unacceptable impacts on the surrounding area. 25% of the new housing will be affordable and 20% will be to lifetime home standards. The development will also include retail, entertainment, commercial, education, health and recreational facilities and office buildings for type B1 employment which will provide job opportunities. 10% of the energy requirements will come from an on-site renewable energy source.	This area is not at significant risk from tidal or fluvial flooding.
10	Wakehams Quarry	Tidal along shoreline	2	3	2	1	0.1	2	Site selection & improvement of shoreline defences.	2	1	4.8	Poor quality and poor arrangement of developments in this area are to be regenerated by a high quality mixed use re-development.	Ensure infrastructure in flood risk zone is protected to an adequate level. New developments should be outside of areas at risk from flooding.
11	East End Waterfront	Tidal flooding throughout undeveloped area	2	2	2	2	0.4	2	Site Selection, Land Raising, Flood Defences.	3	1	38.4	Create a high quality, sustainable urban district in the Eastern Gateway to the city whilst maintaining and enhancing a thriving commercial port. Reduce the impact of congestion and enable high quality public transport. Mixed use regeneration will produce a high quality waterfront and extend the Prince Rock neighbourhood.	Land raising will create a development area which is not at significant risk from flooding without increasing flood risk elsewhere due to the tidal nature of the local flooding. New development should, where possible be located outside of the flood risk zone.
12	East End Mixed Use	Tidal along shoreline	2	2	1	1	0.1	2	Site selection & improvement of shoreline defences.	2	1	1.6	Create a high quality Eastern Gateway to the city whilst maintaining a thriving commercial port. Mixed use residential use and employment uses whilst improving the established residential areas.	Ensure infrastructure in flood risk zone is protected to an adequate level. Measures should be considered to protect the area from future flood risk from direct inundation due to climate change.
13	Prince Rock Depot (waste Site)	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Waste recycling and other recovering facilities compatible with nearby residential areas.	This area is not at significant risk from tidal or fluvial flooding.
14	Sutton Harbour	Tidal along shoreline as well as reported incidents attributed to insufficient sewer capacity	1	1	2	2	0.3	3	Ensure shoreline defences protect from direct tidal flooding / improve drainage from new development.	2	3	21.6	A sustainable and attractive mixed use development which is appealing to investors and will attract new residents.	Developments should be undertaken in conjunction with enhancements of the drainage system. Defences should be assessed in relation to predicted future flood risk from direct inundation due to climate change.
15	The Hoe Waterfront	Tidal along shoreline	3	1	1	1	0.2	3	Ensure proposed development is compatible with predicted flood risk	2	2	7.2	Improving links to surrounding areas, whilst enhancing the civic focus of The Hoe and promoting tourism, leisure and residential functions.	Ensure infrastructure in flood risk zone is protected to an adequate level. Measures should be considered to protect the area from future flood risk from direct inundation due to climate change.
16	Hoe Mixed Use	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Mixed use regeneration of the area whilst preserving historic townscape and ensure new development is sensitive to its historic setting.	This area is not at significant risk from tidal or fluvial flooding.
17	Millbay Station West	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Attractive buildings and improved streetscape to make the area more attractive and improved public open space.	This area is not at significant risk from tidal or fluvial flooding.
18	Millbay Waterfront (Southern Section)	Tidal along shoreline	3	1	2	1	0.2	3	Site selection / Improve shoreline defences taking into account sea level rise.	2	2	14.4	Sustainable and attractive mixed use development which is appealing to investors and new residents and improve the quality of life of the existing residents.	Ensure infrastructure in flood risk zone is protected to an adequate level. Measures should be considered to protect the area from future flood risk from direct inundation due to climate change.
19	Millbay Waterfront (Northern Section)	Low lying area implying surface water drainage problems during high tides	1	1	1	1	0.2	3	Improvements to drainage system / Ensure protection from direct tidal flooding due to sea level rise.	3	3	5.4	Sustainable and attractive mixed use development which is appealing to investors and new residents and improve the quality of life of the existing residents.	Ensure infrastructure in flood risk zone is protected to an adequate level. Measures should be considered to protect the area from future flood risk from direct inundation due to climate change.
20	Millbay Wyndam Square	No risk from tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Potential new community focus around new square. Attractive buildings and improved streetscape to make the area more attractive and improve public open space and a residential area containing approximately 30 units.	This area is not at significant risk from tidal or fluvial flooding.
21	Millbay Marine Employment	No risk from tidal or fluvial flooding to the area	2	1	2	2	0.8	3	Ensure proposed development is compatible with predicted flood risk	1	2	38.4	High architectural quality building adjacent to the port, for marine sciences and technology. The marine related employment would create new high-income jobs and provide a strong enclosure to the western side of the inner basin.	The section at risk from flooding is however used for marine activity and development in this area is unlikely to suffer significant damage should flooding occur.
22	Union Street Mixed Use	Low lying area implying surface water drainage problems during high tides	1	1	2	1	0.4	3	Improvements to drainage system / Ensure protection from direct tidal flooding due to sea level rise.	2	3	14.4	Improvement of existing facilities and introduction of a new high quality infrastructure. As well as preserving and enhancing the historic environment.	Developments should be undertaken in conjunction with enhancements of the drainage system. Measures should be considered to protect the area from future flood risk from direct inundation due to climate change.
22 West	Union Street (Western Section)	Tidal flooding Under Bridge	1	2	2	2	0.5	3	Land Raising.	2	1	24	Reserved area for a new secondary school, (if needed) which will serve Devonport, Millbay, The City Centre and East End areas.	Ensure infrastructure in flood risk zone is protected to an adequate level. New developments should be outside of areas at risk from flooding.
23	Millfields Mixed Use	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	An attractive and sustainable mixed use development. Providing employment and residential areas situated next to Victoria park.	This area is not at significant risk from tidal or fluvial flooding.
24	Royal William Yard Mixed Use	No risk of tidal or fluvial flooding to the area	2	1	1	1	0.4	2	Ensure proposed development is compatible with predicted flood risk	2	2	6.4	Sensitively restored and reused as part of the Stonehouse Peninsula community. Buildings would be authentically blended to respect the architectural and historic character of the yard. The mixed use development would include residential, commercial, offices and car parking.	Proposed development should be sited where possible outside of the predicted tidal floodplain. Where this is not possible development should be designed so that ground levels are utilised for a non flood sensitive use (e.g. car parking).
25	Devonport Mount Wise	Tidal along shoreline	2	1	1	1	0.1	3	Site Selection, Ensure proposed development is compatible with predicted flood risk	2	2	2.4	High quality development and restoration which interrogates into the wider community.	Development of new areas and redevelopment should take place avoiding areas at risk from fluvial flooding.
26	Devonport Southern (residential)	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Residential area including a mix of accommodation types and sizes and recreational areas. 25% of the new housing will be affordable and 20% will be to lifetime home standards.	This area is not at significant risk from tidal or fluvial flooding.
27	Devonport Storage Enclave (Mixed Use)	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Recreate the heart of the Devonport community by re-using historic buildings and reuniting the two communities. The area will incorporate a number of uses including residential (both affordable and lifetime housing), type B1 and B2 employment, primary school, health centre and relocating the retail stores from Marlborough Street to a shopping centre including a supermarket.	This area is not at significant risk from tidal or fluvial flooding.
28	Devonport Northern Residential	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Demolish and redevelop council flats to create a residential area including a mix of accommodation types and sizes and recreational areas. 25% of the new housing will be affordable and 20% will be to lifetime home standards.	This area is not at significant risk from tidal or fluvial flooding.
29	Ernesettle (reserved Waste Site)	No risk of tidal or fluvial flooding to the area	1	1	1	1	0	1	Area not expected to flood so no mitigation solution required.	1	1	0	Currently a Greenfield site it is proposed to safeguard this area as a reserve site for waste management uses.	This area is not at significant risk from tidal or fluvial flooding.

Flood Risk Scoring Matrix - Key

Nature of Existing Risk	Description of the existing flood risk to the development area
Subject to Wave Action	1 = No effect from wave action 3 = Server effect from wave action
Fast Flowing	1 = No flow 3 = Fast flowing
Frequency	1 = Low frequency 3 = High frequency
Depth	1 = Shallow. 3 = Deep
Proportion of Area At Risk	Proportion of the development area at risk from flooding
Impact of Climate Change	1 = No Significant change in flood risk due to sea level rise 3 = Significant change in flood risk due to sea level rise
Proposed Mitigation Measure	Description of mitigation measures most appropriate to reduce flood risk in each area
Scale of Mitigation Cost	1 = Inexpensive mitigation proposed/No mitigation necessary 3 = Expensive mitigation proposed
Residual Risk	Risk of flooding to development following proposed mitigation 1= Low residual risk. 3 = High residual risk
Score	Low score = Low flood risk to development area High score = High flood risk to development area

Note that resultant scores do not relate to a specific scale but instead are relative to and are meant for comparison with the overall set of resultant scores.

12.1 AREA 1 SOUTHWAY

Nature of Existing Risk:- This area is not at risk from fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 7 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area unless there are problems with the surface water drainage.

Proposed Mitigation Measure:- No mitigation measures necessary as the area is not at risk from flooding.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no significant risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.2 AREA 2 NORTHERN CORRIDOR MIXED USE

Nature of Existing Risk:- Some parts of this area are at risk from fluvial flooding from local watercourses. Flooding is thought to be exacerbated by inefficient surface water drainage systems. This is illustrated in the extract from Appendix 7 below; the area is within a critical drainage catchment and part of the area is within flood zone 3.

Vulnerability to Wave Action:- The area is not subject to wave action.

Fast Flowing:- The nature of the flood risk is fluvial however the streams are quite small and have generally flat catchments. Flood flows are not therefore predicted to be particularly fast flowing.

Frequency:- Floodplain areas adjacent to the minor watercourses may flood relatively frequently however no development should take place within these areas. Hence flooding to development areas is not expected to occur frequently.

Depth:- Flooding is not expected to occur to a depth where significant damage would be caused.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area.

Proposed Mitigation Measure:- Development should take place outside of the fluvial floodplain and floodable development should be avoided in this area if possible. Further investigation and hydraulic modelling may be required to better define the extent of the floodplain. Drainage systems should be designed taking into account the impact of surface water runoff.

Scale of Mitigation Cost:- Generally no engineered mitigation solutions are required indicating a relatively cheap cost.

Residual Risk:- If mitigation advice is followed there should be no significant risk from flooding.

Score:- The low score reflects the small proportion of area at risk from flooding and the relatively simple mitigation solution.

12.3 AREA 3 FORDER VALLEY

Nature of Existing Risk:- Some parts of this area may be at risk from fluvial flooding from local watercourses. Flooding is thought to be exacerbated by inefficient surface water drainage systems. This is illustrated in the extract from Appendix 7 below; the area is within a critical drainage catchment and part of the area is close to flood zone 3.

Vulnerability to Wave Action:- The area is not subject to wave action.

Fast Flowing:- The nature of the flood risk is fluvial however the streams are quite small and have generally flat catchments. Flood flows are not therefore predicted to be particularly fast flowing.

Frequency:- Floodplain areas adjacent to the minor watercourses may flood relatively frequently however no development should take place within these areas. Hence flooding to development areas is not expected to occur frequently.

Depth:- Flooding is not expected to occur to a depth where significant damage would be caused.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area.

Proposed Mitigation Measure:- Development should take place outside of the fluvial floodplain and floodable development should be avoid in this area if possible. Further investigation and hydraulic modelling may be required to better define the extent of the floodplain. Drainage systems should be designed taking into account the impact of surface water runoff.

Scale of Mitigation Cost:- Generally no engineered mitigation solutions are required indicating a relatively cheap cost.

Residual Risk:- If mitigation advice is followed there should be no significant risk from flooding.

Score:- The low score reflects the small proportion of area at risk from flooding and the relatively simple mitigation solution.

12.4 AREA 4 COYPOOL, WASTE SITE

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 6 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Fast Flowing:- Flooding to the development area is not expected to occur.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area unless there are problems with the surface water drainage.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measures believed to be required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.5 AREA 5 CHELSON MEADOW SOUTHWEST SECTOR

Nature of Existing Risk:- The Southwest area of Chelson Meadow is at risk from both tidal and fluvial flooding due to high water levels close to the mouth of the River Plym. The extract from Appendix 4 below illustrates the areas within Flood Zone 2 and Flood Zone 3. The extract from Appendix 11 illustrates that by 2080 the south and west sides of the site are expected to flood relatively frequently. Critically the maps illustrate that access to the site is predicted to be affected.

Vulnerability to Wave Action:- When the Plym inner estuary is full and the wind is from the west the site will be subject to a limited amount of wave action.

Fast Flowing:- There is likely to be some flow across the site during flood conditions as the site is bound by a watercourse. The nature of the flood risk is however mainly tidal meaning that water levels are likely to rise gradually.

Frequency:- Parts of the site are expected to flood relatively frequently and this is predicted to increase over time.

Depth:- Depth of predicted flooding is predicted to be relatively shallow. Localised elevated levels should not occur due to the large water body adjacent to the site.

Impact of Climate Change:- As the area is subject to tidal action it is at risk from sea level rise. Appendices 9 – 11 illustrate that the western side of the site is likely to be subject to flooding more frequently over a larger area.

Proposed Mitigation Measure:- Development should take place outside of the area at risk from flooding and floodable development should be avoided if possible. Improvements to shoreline defences may be necessary to protect the area from the predicted increased risk from tidal flooding due to climate change.

Scale of Mitigation Cost:- Larger scale engineering is likely to be required for the shoreline defences.

Residual Risk:- If mitigation advice is followed the significant risk from flooding will be reduced. Any development that is protected by shoreline defences will however still have a relatively high residual risk.

Score:- As a large proportion of the area is a risk from both fluvial and tidal flooding the score is relatively high.

12.6 AREA 6 HIGH QUALITY PUBLIC TRANSPORT ROUTE

Nature of Existing Risk:- The development is at risk from fluvial flooding from Billacombe Brook, a local watercourse that flows alongside the proposed route. The extract form Appendix 4 shows the route running through both Flood Zone 2 and 3. The western extremity of the route is covered in Area 11 – East End Waterfront.

Vulnerability to Wave Action:- The area is not subject to wave action.

Fast Flowing:- The nature of the flood risk is fluvial however the stream is quite small and has a generally flat catchment. Flood flows are not therefore predicted to be particularly fast flowing.

Frequency:- The Environment Agency floodmap indicates that the likelihood of flooding to the proposed route is 0.5 – 1% (1 in 100) or greater probability of happening each year. This should be confirmed through further detailed investigation of local flooding issues.

Depth:- Depth of flooding is unknown however parts of the route are within Floodzone 3 as defined by the Environment Agency and flooding to a major highway could pose a significant risk.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. Any hydraulic modelling or hydrological investigations carried out on the watercourse should take predicted increased flow rates caused by climate change into account.

Proposed Mitigation Measure:- Modelling should be undertaken to gain a better understanding of the flood regime along the proposed route. This is likely to result in constraints being set on the design of the route such as setting the route above predicted extreme flood levels and setting a minimum capacity for any culverts or bridges. These measures will ensure that the proposed route is not at risk from flooding, that its construction does not cause an increase to flood risk elsewhere in the catchment and that the route does not reduce the capacity of the watercourse.

Scale of Mitigation Cost:- Detailed investigation into the local flood regime as well as possible requirement for hydraulic structures to alleviate flood risk implies medium cost.

Residual Risk:- The high number of unknowns is reflected by a medium residual risk.

Score:- The high score reflects the fact that details of the flood regime of the Billacombe Brook are relatively unknown. The watercourse also appears to flood along a significant length of the proposed route.

12.7 AREA 7 SHERFORD

Nature of Existing Risk:- Some parts of this area are at risk from fluvial flooding from local watercourses. The extract from Appendix 5 below illustrates the extent of the area within Flood Zone 3.

Vulnerability to Wave Action:- The area is not subject to wave action.

Fast Flowing:- The nature of the flood risk is fluvial however the streams are quite small and have generally flat catchments. Flood flows are not predicted to be particularly fast flowing.

Frequency:- Floodplain areas adjacent to the minor watercourses may flood relatively frequently however no development should take place within these areas.

Depth:- Flooding is not expected to occur to a depth where significant damage would be caused.

Impact of Climate Change:- The area not subjected to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flooding regime in the area.

Proposed Mitigation Measure:- Development should take place outside of the fluvial floodplain. Modelling should be undertaken to accurately establish the extent of the fluvial floodplain should development in this area be proposed. Drainage systems should be designed taking into account the impact of surface water runoff.

Scale of Mitigation Cost:- No large scale hard engineering should be required.

Residual Risk:- If mitigation advice is followed there should be no significant risk from flooding.

Score:- The low score represents the small proportion of area at risk from fluvial flooding and the low cost, simple mitigation solution.

12.8 AREA 8 MOORCROFT

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 4 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Fast Flowing:- Flooding to the development area is not expected to occur.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area unless there are problems with the surface water drainage.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.9 AREA 9 PLYMSTOCK

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 4 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Fast Flowing:- Flooding to the development area is not expected to occur.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area unless there are problems with the surface water drainage.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.10 AREA 10 WAKEHAMS QUARRY

Nature of Existing Risk:- The area is at risk from tidal flooding along the shoreline, the extract form Appendix 4 below illustrates this.

Vulnerability to Wave Action:- When the Plym inner estuary is full and the wind is from the west the site will be subject to a limited amount of wave action.

Fast Flowing:- High tides combined with high flows in the watercourses adjacent to the site are likely to cause relatively fast flows across the section of the area at risk from flooding.

Frequency:- Sites along the western and eastern extremities of the site are expected to flood relatively often however away from these areas flooding will not occur frequently.

Depth:- Flooding is not expected to occur to a depth where significant damage would be caused.

Impact of Climate Change:- As the area is subject to tidal action it is at risk from sea level rise. Appendices 9 – 11 illustrate that the western side of the site is likely to be subject to flooding more frequently over a larger area.

Proposed Mitigation Measure:- Development should take place outside of the area at risk from flooding and floodable development should be avoided if possible. Improvements to shoreline defences may be necessary to protect the area from the predicted increased risk from tidal flooding due to climate change.

Scale of Mitigation Cost:- Site selection is a relatively cheap mitigation measure however improvements to shoreline defences may be expensive.

Residual Risk:- If mitigation advice is followed there should be no significant risk from flooding.

Score:- The relatively low score reflects a very small proportion of the development area at risk from tidal flooding.

12.11 AREA 11 EAST END WATERFRONT

Nature of Existing Risk:- This area is at risk from tidal flooding throughout the majority of the undeveloped area of the East End. This is illustrated below in the extract from Appendix 8.

Vulnerability to Wave Action:- When the Plym inner estuary is full and the wind is from the east the site will be subject to a limited amount of wave action.

Fast Flowing:- There is likely to be some flow across the area during flood conditions as the site is bound by a watercourse. The nature of the flood risk is however mainly tidal meaning that water levels are likely to rise gradually.

Frequency:- Parts of the site are expected to flood relatively frequently and this is predicted to increase over time, this is illustrated in Appendices 9 – 11.

Depth:- Depth of predicted flooding is predicted to be relatively deep during extreme events as a significant proportion of the area is in the 1 in 1 year tidal floodplain in 2006 (Appendix 9); this is more than 1.5 m lower than the predicted 1 in 200 year level in 2080. However, localised elevated levels should not occur due to the large water body adjacent to the site.

Impact of Climate Change:- As the area is subject to tidal action it is at risk from sea level rise. Appendices 9 – 11 illustrate that the western side of the site is likely to be subject to flooding more frequently over a larger area.

Proposed Mitigation Measure:- Where possible development should take place outside of the area at risk from flooding, to reduce the risk of damage to property and using areas within the floodplain. Land raising will prevent the flood waters from reaching new developments and flood defences will help to protect the area. Detailed study should be undertaken to advise on the most efficient method of reducing the risk to this area.

Scale of Mitigation Cost:- Due to the high proportion of the area at a relatively high risk from direct tidal inundation a large volume of material would be required sufficiently reduce this risk through land raising. The scale of defences that would be needed to sufficiently protect the area would also be very large implying a high mitigation cost.

Residual Risk:- Residual risk to areas outside of flood risk zones and land that has been raised to a low risk elevation is low; there is no chance of flooding occurring due to failure of defences or drainage systems.

Score:- The high score given to the East End Waterfront area reflects the area's current high vulnerability to flooding, the significant proportion of the area at risk from flooding and the scale of mitigation required to reduce the risk.

12.12 AREA 12 EAST END MIXED USE

Nature of Existing Risk:- The East End is at risk from tidal flooding along the shoreline on the west side of the development area as illustrated in the extract from Appendix 8 below.

Vulnerability to Wave Action:- When the Plym inner estuary is full and the wind is from the south the site will be subject to a limited amount of wave action.

Fast Flowing:- There is likely to be some flow across the site during flood conditions as the site is bound by a watercourse. The nature of the flood risk is however mainly tidal meaning that water levels are likely to rise gradually.

Frequency:- Appendices 8 and 10 indicate that flooding to the development area is not expected to occur frequently.

Depth:- Flooding to the developed part of the site is not expected to occur to a depth where significant damage would be caused. This is illustrated in Appendix 10.

Impact of Climate Change:- As the area is subject to tidal action it is at risk from sea level rise. Appendices 9 – 11 illustrate that climate change is likely to cause the eastern side of the area to flood more frequently.

Proposed Mitigation Measure:- Development should take place outside of the area at risk from flooding and floodable development should be avoid in this area if possible. Improvements to shoreline defences may be necessary to help protect the area to an adequate level.

Scale of Mitigation Cost:- Improvements to shoreline defences are expected to be expensive however there is likely to be sufficient space for development to take place outside of areas at risk from flooding.

Residual Risk:- If development does not take place in the flood risk area residual risk will be minimal.

Score:- The low score represents the small proportion of the development area at risk from tidal flooding.

12.13 AREA 13 PRINCES ROCK DEPOT – WASTE SITE

Nature of Existing Risk:- This area is not at risk from fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 8 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area unless there are problems with the surface water drainage.

Proposed Mitigation Measure:- No mitigation measures necessary as the area is not at risk from flooding.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no significant risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.14 AREA 14 SUTTON HARBOUR

Nature of Existing Risk:- Sutton harbour is at risk from tidal flooding along the shoreline on the west side of the development area. However, there have also been reported incidents of flooding attributed to insufficient sewer capacity. The extract from Appendix 4 below illustrates the areas at risk from flooding. The area is protected from direct tidal flooding by tidal gates that keep water levels in the harbour at a safe level during extreme high tides. However the Environment Agency have stated that the existing tidal gate style defences are likely to require upgrading due to their poor condition and increasingly inadequate defence level due to climate change. It is reported that the gates have opened and closed over 5 times the planned rate over the last 10 years.

Vulnerability to Wave Action:- The area is not subject to wave action as it is enclosed within the harbour area.

Fast Flowing:- There is no significant flow associated with the flood risk as the area is enclosed within the harbour area.

Frequency:- The area is low lying and would be expected to flood relatively frequently if it were not for the flood defences.

Depth:- It is possible that the depth of flooding could cause significant damage should the defences fail.

Impact of Climate Change:- Appendices 15 – 17 illustrate that the predicted increase in frequency and extent of tidal flooding across the area assuming no defences is significant.

Proposed Mitigation Measure:- The Environment Agency have stated that the existing tidal gate style defences are likely to require upgrading due to their poor condition and increasingly inadequate defence level due to climate change. The low lying nature of the area also implies that surface water drainage becomes difficult during times of high water levels. Drainage from the new development should be design taking this into account.

Scale of Mitigation Cost:- Upgrading of tidal defences and improvements to the drainage system in this heavily urbanised area is likely to incur significant cost.

Residual Risk:- High residual risk reflects that failure of the tidal defences during flood conditions could result in significant damage to the area.

Score:- The high score reflects the area's high vulnerability to flooding and the scale of mitigation costs needed to reduce flood risk to the area.

12.15 AREA 15 THE HOE, WATERFRONT

Nature of Existing Risk:- The waterfront area of The Hoe is shown to be at risk from tidal flooding along the shoreline as illustrated in the extract from Appendix 8 below. The majority of this area however consists of rocky cliffs unsuitable for development. Proposed development in low lying sections of the area should be built taking into consideration the predicted food risk.

Vulnerability to Wave Action:- This area will be subject to wave action from the south.

Fast Flowing:- Flood risk to the area is not associated with a watercourse and therefore it is not anticipated that flooding will be fast flowing.

Frequency:- Flooding to the development is not expected to occur frequently.

Depth:- Flooding to development areas is not expected to occur to a depth where significant damage would be caused.

Impact of Climate Change:- The development area is relatively exposed to tidal flooding and wave action, both of which are expected to more severe due to the impact of climate change. Appendices 15 – 17 illustrate the predicted increase in frequency of tidal flooding.

Proposed Mitigation Measure:- Proposed development in flood risk zones should be built taking into consideration the predicted risk. This may involve flood resistant design measures and warning/evacuation procedures. It is possible that shoreline defences may require upgrading to ensure sufficient protection from the predicted increase in flood risk due to climate change.

Scale of Mitigation Cost:- Mitigation measures for new development are likely to be incorporated into the design of proposed buildings and hence mitigation costs are expected to be relatively low. However any improvements to shoreline defences may be relatively expensive in this constrained area.

Residual Risk:- A risk of the area flooding will continue to exist however users should be aware of this risk and be prepared for flooding. Development should also be constructed/adapted in such a way that flooding to a low level does not cause significant damage.

Score:- The low score reflects the small proportion of the development area at risk from tidal flooding.

12.16 AREA 16 THE HOE, MIXED USE

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 8 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.17 AREA 17 MILLBAY STATION WEST

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 8 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area unless there are problems with the surface water drainage.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.18 AREA 18 MILLBAY WATERFRONT, SOUTHERN SECTION

Nature of Existing Risk:- This area is at risk from tidal flooding along the shoreline on the west side of the development area. The extract from Appendix 8 shows that the area at risk is within Flood Zone 2. Appendices 15 – 17 illustrate that the area, currently most of which is above the 1 in 200 year still water tide level, is predicted to have a significant proportion below the 1 in 100 year still water tide level by 2080.

Vulnerability to Wave Action:- This development area will be subject to wave action from the south.

Fast Flowing:- Flood risk to the area is not associated with a watercourse and therefore it is not anticipated that flooding will be fast flowing.

Frequency:- Extreme still water tide levels indicate that the site will not flood frequently however taking into account the exposed nature of the area it is likely that the effect of wind and wave action will increase flooding frequency.

Depth:- Flooding is not expected to occur to a depth where significant damage would be caused.

Impact of Climate Change:- As the area is subject to tidal action it is at risk from sea level rise. Appendices 15 – 17 illustrate that the western side of the site is likely to be subject to flooding more frequently over a larger area.

Proposed Mitigation Measure:- Development should take place outside the area at risk from flooding and floodable development should be avoided in this area if possible. This may include locating less flood sensitive uses such as car parking on the ground level of proposed buildings. Improvements to shoreline defences may be necessary to help protect the area to an adequate level should the proposed development progress.

Scale of Mitigation Cost:- Hard engineering solutions may be required to improve protection of the area from flooding.

Residual Risk:- Failure of shoreline defences implies flooding could still occur to low lying areas, it is however recommended that proposed development should take place outside of these areas.

Score:- The relatively high score reflects the large number of variables affecting flood risk in the area. The section at risk from flooding is however used for marine activity and development in this area is unlikely to suffer significant damage should flooding occur.

12.19 AREA 19 MILLBAY WATERFRONT, NORTHERN SECTION

Nature of Existing Risk:- The low lying nature of this area implies that surface water drainage problems may occur during high tide. Appendices 15 – 17 also illustrate that the area will be at risk from tidal flooding during a 1 in 100 year event by 2080; extracts from these appendices are included below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Fast Flowing:- Flood risk to the area is no associated with a watercourse and therefore it is not anticipated that flooding will be fast flowing.

Frequency:- Predictions indicate that by 2080 the area will be at risk from direct tidal flooding during an event with between a 1 in 1 year and 1 in 100 year chance of occurring. The predictions do not however take into account the effects of wind and surge which are likely to increase frequency.

Depth:- Should flooding of the area occur it is anticipated to be relatively shallow in depth.

Impact of Climate Change:- Appendices 15 – 17 illustrate the predicted impact of climate change on still water tide levels. These appendices show that the area is predicted to become vulnerable to direct tidal flooding during a 1 in 100 year event by 2080. Higher tides may also further reduce the efficiency of the surface water drainage system in the area.

Proposed Mitigation Measure:- Due to the sea level rise the development area should be protected from direct tidal flooding. Existing infrastructure may need to be protected with shoreline defences; proposed development should be built at a level at which it is not at significant risk from flooding. This may be done by means of locating a non flood sensitive use on the ground level (e.g. car parking). Improvements should be made to the drainage systems taking into account the impact of surface water runoff.

Scale of Mitigation Cost:- Larger scale engineering may be required for protecting the area from direct tidal flooding. Improvements to the surface water drainage system may also be necessary. Both of these solutions imply significant cost.

Residual Risk:- Failure of tidal defences during flood conditions could result in significant damage to development.

Score:- The score reflects that, should the area flood, significant damage could result, however the likelihood of the area flooding is low.

12.20 AREA 20 MILLBAY WYNDAM SQUARE

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 4 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Fast Flowing:- No parts of the watercourses will be fast flowing.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area unless there are problems with the surface water drainage.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.21 AREA 21 MILLBAY MARINE EMPLOYMENT

Nature of Existing Risk:- Extracts from Appendices 15 – 17 below illustrate that the area is currently not at high risk from flooding is predicted to be at significant risk from tidal flooding by 2080 due to the impact of climate change.

Vulnerability to Wave Action:- The area is exposed to a limited amount of wave action.

Fast Flowing:- Flooding to the area is not associated with a watercourse and therefore it is not anticipated that flooding will be fast flowing.

Frequency:- Predictions indicate that by 2080 a significant proportion of the area will be below the 1 in 100 year tidal still water level.

Depth:- Flooding is not expected to occur to a depth where significant damage would be caused.

Impact of Climate Change:- As the area is subject to tidal action it is at risk from sea level rise. Appendices 15 – 17 illustrate that the western side of the site is likely to be subject to flooding more frequently over a larger area.

Proposed Mitigation Measure:- Proposed development should be designed and constructed with the predicted flood risk in mind and floodable development should be avoided if possible. This may include locating less flood sensitive uses such as car parking on the ground level of any buildings.

Scale of Mitigation Cost:- Mitigation measures are likely to be incorporated into the design of proposed buildings and hence mitigation costs are expected to be relatively low.

Residual Risk:- A risk of the area flooding will continue to exist however users should be aware of this risk and be prepared for flooding. Development should also be constructed/adapted in such a way that flooding to a low level does not cause significant damage.

Score:- The relatively high score reflects the large number of variables affecting flood risk in the area. The section at risk from flooding is however used for marine activity and development in this area is unlikely to suffer significant damage should flooding occur.

12.22 AREA 22 UNION STREET, MIXED USE

Nature of Existing Risk:- The low lying nature of this area implies that surface water drainage problems may occur during high tide as a significant proportion of the area is below the 1 in 1 year still water tide level. The extract from Appendix 8 below shows the area currently at risk from this problem. A significant proportion of the area is below the current 1 in 1 year high tide level implying that the drainage of surface water is challenging during times of high water. The figures also illustrate that if sea levels rise as predicted a large proportion of the area will be at risk from direct tidal flooding.

Vulnerability to Wave Action:- This area is not subject to wave action.

Fast Flowing:- Flood risk to the area is not associated with a watercourse and therefore it is not anticipated that flooding will be fast flowing.

Frequency:- Predictions indicate that by 2080 the area will be at risk from direct tidal flooding during an event with between a 1 in 1 year and 1 in 100 year chance of occurring. The predictions do not however take into account the effects of wind and surge which are likely to increase frequency.

Depth:- Should flooding of the area occur it is anticipated to be relatively shallow in depth.

Impact of Climate Change:- Appendices 15 – 17 indicate that following the predicted impact of climate change the site will be at risk from direct tidal flooding by 2080. The predicted higher tides will also worsen surface water drainage problems.

Proposed Mitigation Measure:- Due to the sea level rise the development area should be protected from direct tidal flooding. Improvements should be made to the drainage systems taking into account the impact of surface water runoff.

Scale of Mitigation Cost:- Larger scale engineering may be required for protecting the area from direct tidal flooding. Improvements to the surface water drainage system may also be necessary. Both of these solutions imply significant cost.

Residual Risk:- Failure of tidal defences during flood conditions could result in significant damage to development. Wet weather during a particularly high tide could result in an overload of the surface water drainage system causing the area to flood.

Score:- The score reflects the relatively large proportion of the area that is at risk from flooding and the significant damage that could result should flooding occur due to the heavily urbanised nature of the area. However the predicted frequency of the area flooding is low.

12.23 AREA 22 UNION STREET, WESTERN SECTION

Nature of Existing Risk:- The area is at risk from tidal flooding under the bridge. Extracts from Appendices 15 – 17 below illustrate that the area is currently not at high risk from flooding is predicted to be at significant risk from tidal flooding by 2080 due to the impact of climate change.

Vulnerability to Wave Action:- The development area is not subject to wave action.

Fast Flowing:- The site is adjacent to a watercourse so there is likely to be some flow across the area. The nature of the flood risk is however mainly tidal meaning that water levels are likely to rise gradually.

Frequency:- Predictions indicate that by 2080 a significant proportion of the site will be within the 1 in 100 year fluvial floodplain.

Depth:- Flooding to the eastern section of the area may be relatively deep, however land rises to the west and more detail is required regarding the flood mechanism in the area.

Impact of Climate Change:- The impact of sea level rise is likely to have a significant impact on flood risk over a major proportion of the site.

Proposed Mitigation Measure:- Land raising should be considered in order to sufficiently reduce the risk of flooding to the site from tidal inundation. This is significant as the area is earmarked for development of a school, a relatively high risk development type. This measure would also facilitate improved surface water drainage conditions.

Scale of Mitigation Cost:- A significant amount of land raising is likely to be required however the development area is relatively small.

Residual Risk:- Residual risk to areas outside of flood risk zones and land that has been raised to a low risk elevation is low; there is little chance of flooding occurring due to failure of defences or drainage systems.

Score:- The high score reflects the area's current high vulnerability to flooding and the significant proportion of the area at risk from flooding.

12.24 AREA 23 MILLFIELDS MIXED USE

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is below the 1 in 1 year still water tide level as illustrated in the extract from Appendix 17 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.25 AREA 24 ROYAL WILLIAM YARD MIXED USE

Nature of Existing Risk:- Extracts from Appendices 15 – 17 below illustrate that the area is currently not at high risk from flooding is predicted to be at significant risk from tidal flooding by 2080 due to the impact of climate change.

Vulnerability to Wave Action:- The area will be exposed to a limited amount of wave action when the wind is from the west.

Fast Flowing:- Flooding of the site is not associated with a watercourse .

Frequency:- Predictions indicate that by 2080 the area will be at risk of tidal flooding during a 1 in 100 year event based on still water tide levels. This however does not take into account the impact of wind or surge.

Depth:- Should flooding of the area occur it is anticipated to be relatively shallow in depth.

Impact of Climate Change:- At present the area is above the 1 in 200 year still water tide level. The impact of sea level rise is however expected to cause flood risk in the area to increase.

Proposed Mitigation Measure:- Proposed development should be sited where possible outside of the predicted tidal floodplain and floodable development should be avoided if possible. Where this is not possible development should be designed so that ground levels are utilised for a non flood sensitive use (e.g. car parking).

Scale of Mitigation Cost:- Mitigation measures are likely to be incorporated into the design of proposed buildings and hence mitigation costs are expected to be relatively low.

Residual Risk:- A risk of the area flooding will continue to exist however users should be aware of this risk and be prepared for flooding. Development should also be constructed in such a way that flooding to a low level does not cause significant damage.

Score:- The relatively low score reflects that even though a relatively large proportion of the site is at risk from flooding the predicted flood frequency remains low.

12.26 AREA 25 DEVONPORT MOUNT WISE

Nature of Existing Risk:- This area is at risk from tidal flooding along the shoreline in the south east of the development site. The extracts form Appendices 15 and 17 show the extent of areas risk from tidal flooding at present and the predicted increase in risk due to climate change in 2080. The area at risk is almost exclusively utilised for marine based activities and as such development in the area should be relatively resilient to flooding.

Vulnerability to Wave Action:- The development will be subject to a limited amount of wave action during stormy conditions.

Fast Flowing:- Flood risk to the area is not associated with a watercourse and therefore it is not anticipated that flooding will be fast flowing.

Frequency:- Flooding to the development is not expected to occur frequently.

Depth:- Flooding to the development is not expected to occur to a depth where significant damage would be caused.

Impact of Climate Change:- Appendices 15 to 17 illustrate the predicted impact of climate change on flood risk to the development area; the extent of the area at risk is expected to increase slightly and areas that are currently at risk from a 1 in 100 -1 in 200 year flood are predicted to incur an increase in risk to a 1 in 1 year flood.

Proposed Mitigation Measure:- proposed development should be sited outside of areas at risk from flooding. Any development taking place in the flood risk zone should be designed so that it continues to function during flood conditions and does not incur significant damage from flooding. It is possible that shoreline defences may require upgrading to ensure sufficient protection from the predicted increase in flood risk.

Scale of Mitigation Cost:- Mitigation measures for new development are likely to be incorporated into the design of proposed buildings and hence mitigation costs are expected to be relatively low. However any improvements to shoreline defences may be relatively expensive in this constrained area.

Residual Risk:- A risk of the area flooding will continue to exist however users should be aware of this risk and be prepared for flooding. Development should also be constructed/adapted in such a way that flooding to a low level does not cause significant damage.

Score:- The low score reflects the small proportion of the development area at risk from tidal flooding.

12.27 AREA 26 DEVONPORT SOUTHERN, RESIDENTIAL

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 8 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.28 AREA 27 DEVONPORT STORAGE ENCLAVE, MIXED USE

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 8 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.29 AREA 28 DEVONPORT NORTHERN RESIDENTIAL

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 8 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

12.30 AREA 29 ERNESETTLE

Nature of Existing Risk:- This area is not at risk from tidal flooding or fluvial flooding from local watercourses. The area is not within the critical drainage catchment area and no part of the site is within Flood Zone 3 as illustrated in the extract from Appendix 7 below.

Vulnerability to Wave Action:- The area is not subject to wave action.

Frequency:- Flooding to the development area is not expected to occur.

Depth:- Flooding to the development area is not expected to occur.

Impact of Climate Change:- Area not subject to tidal action therefore not at risk from sea level rise. It is not anticipated that increased storminess due to climate change will have a significant impact on the flood regime in the area.

Proposed Mitigation Measure:- Flooding to the development area is not expected to occur, therefore no mitigation measure is required.

Scale of Mitigation Cost:- No mitigation measure required.

Residual Risk:- No mitigation measures required. No risk from flooding.

Score:- The very low score reflects the area being at no risk from flooding and no mitigation solution necessary.

Surface Water:- Although the above assessment has identified no specific flood risk to the area, surface water runoff should always be considered when planning a new development. Increasing the impermeable area of a site is likely to increase runoff from the site which may have an impact on the flood regime on or downstream of the site. Sustainable drainage systems (SuDS) should be considered to mitigate this impact.

13. APPENDIX EXPLANATION

Please refer to the separate booklet containing the appendices.

13.1 APPENDIX 1 EXTENT OF STUDY

The attached plan shows the study area, Plymouth City boundary, and the main water bodies which influence flooding in the city.

13.2 APPENDIX 2 GENERAL FLOOD RISK IN PLYMOUTH

The attached plan indicates the current Environment Agency Flood Zones 2 and 3 within the study area.

Flood Zone 3 (Dark blue ■) shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- From the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year
- From a river by a flood that has a 1% (1 in 100) or greater chance of happening each year

Flood Zone 2 (Light blue ■) shows the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring each year.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements.

Sites of historical flooding incidents are recorded by the Environment Agency's Flood Risk Information System. It can be observed that these incidents are spread quite evenly around the city with a concentration around Plympton and Sutton Harbour. The cause of flooding recorded at each of these points is almost exclusively attributed to inadequate sewer capacity.

Critical drainage catchments area areas whose drainage systems are sensitive to flooding and any development proposal should consider this when deciding on the drainage method; details are given in Section 5.3

These data sets are invaluable as they are not based on just topographic data as the Environment Agency floodmaps and LIDAR data mainly are.

13.3 APPENDIX 3 KEY STUDY AREAS

The attached drawing highlights the three key study areas as below:

- Eastern Corridor
- Northern Corridor
- Waterfront

These are described in the Local Development Framework as areas having Frameworks for Area Action.

Potential development areas are numbered and can be identified in the table below. These areas have been considered in the quantitative assessment of flood risk included in Section 12.

1	Southway (Residential / Mixed Use Regeneration)
2	Northern Corridor Mixed Use
3	Forder Valley
4	Coypool (Waste Site)
5	Chelson Meadow Southwest Sector
6	High Quality Public Transport Route
7	Sherford (Northern Elburton Section)
8	Moorcroft Quarry (Waste, Employment)
9	Plymstock Quarry (Mixed Use)
10	Wakeham's Quarry (Mixed Use)
11	East End Waterfront
12	East End Mixed Use Regeneration
13	Prince Rock Depot (Waste Site)
14	Sutton Harbour
15	The Hoe Waterfront
16	Hoe Mixed Use
17	Millbay Station West
18	Millbay Waterfront Southern
19	Millbay Waterfront Northern
20	Millbay Wyndam Square
21	Millbay Marine Employment
22	Union Street
23	Millfields Mixed Use
24	Royal William Yard
25	Devonport Mount Wise Mixed Use
26	Devonport Southern (Residential)
27	Devonport Storage Enclave (Mixed Use)
28	Devonport Northern Residential
29	Ernesettle (Reserved Waste Site)

13.4 APPENDIX 4 EASTERN CORRIDOR CONSTRAINTS

The attached drawing indicates the Eastern Corridor of Plymouth Study area in more detail. Shown on this plan are the details as below:

- Environment Agency Flood Zone 3
- Environment Agency Flood Zone 2
- Sites of Historic Flooding Incidents
- Critical Drainage Areas

These are described in Appendix 2 above.

13.5 APPENDIX 5 SHERFORD FLOODING CONSTRAINTS

The attached drawing illustrates the Sherford area in more detail. The majority of this area is outside of the Plymouth City Boundary but the proposed development here is directly linked with the Plymouth regeneration program and has therefore been included in this study. Shown on this plan are the details as below:

- Environment Agency Flood Zone 3
- Environment Agency Flood Zone 2
- Sites of Historic Flooding Incidents
- Critical Drainage Areas

These are described in Appendix 2 above.

13.6 APPENDIX 6 PLYMPTON FLOODING CONSTRAINTS

The attached drawing illustrates the Plympton area in more detail. Shown on this plan are the details as below:

- Environment Agency Flood Zone 3
- Environment Agency Flood Zone 2
- Sites of Historic Flooding Incidents
- Critical Drainage Areas

These are described in Appendix 2 above.

13.7 APPENDIX 7 NORTHERN CORRIDOR CONSTRAINTS

The attached drawing indicates the Northern Corridor Framework area of the Plymouth Study area in more detail. Shown on this plan are the details as below:

- Environment Agency Flood Zone 3
- Environment Agency Flood Zone 2
- Sites of Historic Flooding Incidents
- Critical Drainage Areas

These are described in Appendix 2 above.

13.8 APPENDIX 8 WATERFRONT CONSTRAINTS

The attached drawing indicates the Waterfront Framework area of the Plymouth Study area in more detail. Shown on this plan are the details as below:

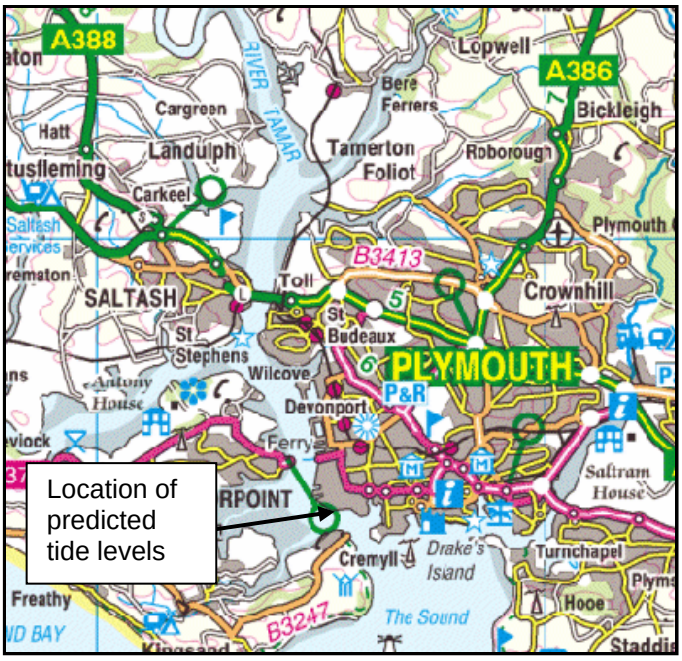
- Environment Agency Flood Zone 3
- Environment Agency Flood Zone 2
- Sites of Historic Flooding Incidents
- Critical Drainage Areas

These are described in Appendix 2 above.

13.9 APPENDIX 9 EASTERN DEVELOPMENT AREA – EXTREME TIDAL STILL WATER LEVEL (2006)

The following Appendices use LIDAR data to illustrate areas at risk from tidal flooding by highlighting the areas below the predicted extreme tidal still water level for a range of return periods. The LIDAR data can be used to illustrate bands of ground which is situated between specified levels. The following appendices use LIDAR data to show the change in tidal flood risk associated with the predicted sea level rise for the period 2006, 2050 and 2080.

These levels as below were provided by the EA and relate to the Devonport area of the city. Variations may therefore exist due to the action of rivers and small tidal differences within the study area. The location of the point for which the tides are predicted is highlighted on the plan below.



The attached plan indicates the areas below the predicted extreme tidal still water levels for the Eastern Corridor Framework area in 2006.

The table below indicates the predicted changes to sea level due to the impact of climate change.

Devonport SX 455 540	
Return Period	Level mm AOD
1 year (2006)	2970
1 year (2050)	3410
1 year (2080)	3770
100 year (2006)	3610
100 year (2050)	4050
100 year (2080)	4410
200 year (2006)	3700
200 year (2050)	4140
200 year (2080)	4500
Assumptions: High Greenhouse Gas Emissions Estimate	

13.10 APPENDIX 10 EASTERN DEVELOPMENT AREA – EXTREME TIDAL STILL WATER LEVEL (2050)

The attached plan indicates the areas below the predicted extreme tidal still water levels for the Eastern Corridor Framework area in 2050.

13.11 APPENDIX 11 EASTERN DEVELOPMENT AREA – EXTREME TIDAL STILL WATER LEVEL (2080)

The attached plan indicates the areas below the predicted extreme tidal still water levels for the Eastern Corridor Framework area in 2080.

13.12 APPENDIX 12 NORTHERN DEVELOPMENT AREA – EXTREME TIDAL STILL WATER LEVEL (2006)

The attached plan indicates the areas below the predicted extreme tidal still water levels for the Northern Corridor Framework area in 2006.

13.13 APPENDIX 13 NORTHERN DEVELOPMENT AREA – EXTREME TIDAL STILL WATER LEVEL (2050)

The attached plan indicates the areas below the predicted extreme tidal still water levels for the Northern Corridor Framework area in 2050.

13.14 APPENDIX 14 NORTHERN DEVELOPMENT AREA – EXTREME TIDAL STILL WATER LEVEL (2080)

The attached plan indicates the areas below the predicted extreme tidal still water levels for the Northern Corridor Framework area in 2080.

13.15 APPENDIX 15 WESTERN DEVELOPMENT AREA – EXTREME TIDAL STILL WATER LEVEL (2006)

The attached plan indicates the areas below the predicted extreme tidal still water levels for the Western Corridor Framework area in 2006.

13.16 APPENDIX 16 WESTERN DEVELOPMENT AREA – EXTREME TIDAL STILL WATER LEVEL (2050)

The attached plan indicates the areas below the predicted extreme tidal still water levels for the Western Corridor Framework area in 2050.

13.17 APPENDIX 17 WESTERN DEVELOPMENT AREA – EXTREME TIDAL STILL WATER LEVEL (2080)

The attached plan indicates the areas below the predicted extreme tidal still water levels for the Western Corridor Framework area in 2080.

13.18 APPENDIX 18 REFERENCES

The following documents have been used as guidance in the preparation of this Strategic Flood Risk Assessment;

- Planning Policy Statement 25: Development & Flood Risk (Draft for Consultation), Environment Agency, 2005
- Planning Policy Guidance 25: Development & Flood Risk, Environment Agency, 2001
- Plymouth City Council Local Development Framework, Core Strategy Preferred Options, Plymouth City Council, 2005
- Development & Flood Risk (Guidance for the Construction Industry), CIRIA, 2004.