Shepway District Council

Proposed Leisure Centre and Mixed-Use Development at Princes Parade Hythe

Environmental Statement

Technical Annex 4

Flood Risk

August 2017

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Client: Shepway District Council

Flood Risk Assessment for the Proposed Development at Princes Parade, Hythe, Kent

August 2017

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Flood Risk Assessment for the Proposed Development at Princes Parade, Hythe, Kent

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1 Background and Scope of Appraisal

Flooding is a major issue in the United Kingdom. The impacts can be devastating in terms of the cost of repairs, replacement of damaged property, and loss of business. The objectives of the Flood Risk Assessment are, therefore, to establish the following:

- whether a proposed development is likely to be affected by current or future flooding from any source
- whether the development will increase flood risk elsewhere within the floodplain
- whether the measures proposed to deal with these effects and risks are appropriate
- whether the site will be safe to enable the passing of the Exception Test (where appropriate).

Herrington Consulting has been commissioned by Shepway District Council to prepare a Flood Risk Assessment (FRA) for the proposed development at **Princes Parade, Hythe, Kent, CT21 5QT**.

This appraisal has been undertaken in accordance with the requirements of the National Planning Policy Framework (March 2012) and the accompanying Planning Practice Guidance Suite. To ensure that due account is taken of industry best practice, it has been carried out in line with the CIRIA Report C624 'Development and flood risk - guidance for the construction industry'.

Reference is also made to the National Planning Practice Guidance Suite (March 2014) that has been published by the Department for Communities and Local Government. The *Flood Risk and Coastal Change* planning practice guidance included within the Suite represents the most contemporary technical guidance on preparing FRAs.

2 Development Description and Planning Context

2.1 Site Location and Existing Use

The site is located at OS coordinates 618308, 134771, off Princes Parade in Hythe, Kent. In total the site covers an area of approximately 10 hectares and currently comprises undeveloped brownfield land. The location of the site in relation to the surrounding area, the Royal Military Canal and the coastline is shown in Figure 2.1.

Figure 2.1 – Location map (Contains Ordnance Survey data © Crown copyright and database right 2017).

The site plan included in Appendix A.1 of this report provides more detail in relation to the site location and layout.

2.2 Proposed Development

The proposals for development include the construction of up to 150 new dwellings, a new leisure centre and a small-scale commercial unit, potentially comprising a shop/café on the ground floor with a boutique hotel on the upper floors.

Drawings of the proposed scheme are included in Appendix A.1 of this report.

2.3 The Sequential Test

Local Planning Authorities (LPA) are encouraged to take a risk-based approach to proposals for development in areas at risk of flooding through the application of the Sequential Test. The objectives of this test are to steer new development away from high risk areas towards those areas at lower risk of flooding. However, in some areas where developable land is in short supply there can be an overriding need to build in areas that are at risk of flooding. In such circumstances, the application of the Sequential Test is used to ensure that the lower risk sites are developed before the higher risk ones.

When applying the Sequential Test, it is also necessary to ensure that the subject site is compared to only those sites that are available for development and are similar in size. This requires a comprehensive knowledge of development sites within the district and is generally applied as part of the Local Development Framework (LDF) process. However, when applying the Sequential Test to sites that have not been assessed as part of the LDF it is possible to use the findings of the Flood Risk Assessment to provide additional evidence to better quantify the true risk of flooding, enabling an informed judgement to be made.

The National Planning Policy Framework (NPPF) requires the Sequential Test to be applied at all stages of the planning process and generally the starting point is the Environment Agency's flood zone maps. These maps and the associated information are intended for guidance, and cannot provide details for individual properties. They do not take into account other considerations such as existing flood defences, alternative flooding mechanisms and detailed site based surveys. They do, however, provide high level information on the type and likelihood of flood risk in any particular area of the country. The flood zones are classified as follows:

Zone 1 – *Low probability of flooding* – This zone is assessed as having less than a 1 in 1000 annual probability of river or sea flooding in any one year.

Zone 2 – *Medium probability of flooding* – This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding or between 1 in 200 and 1 in 1000 annual probability of sea flooding in any one year.

Zone 3a – *High probability of flooding* - This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding or 1 in 200 or greater annual probability of sea flooding in any one year.

Zone 3b – *The Functional Floodplain* – This zone comprises land where water has to flow or be stored in times of flood and can be defined as land which would flood during an event having an annual probability of 1 in 20 or greater. This zone can also represent areas that are designed to flood in an extreme event as part of a flood alleviation or flood storage scheme.

The location of the site is shown on the Environment Agency's flood zone map in Figure 2.2 and the information provided by this map has been interrogated and summarised in Table 2.2 below.

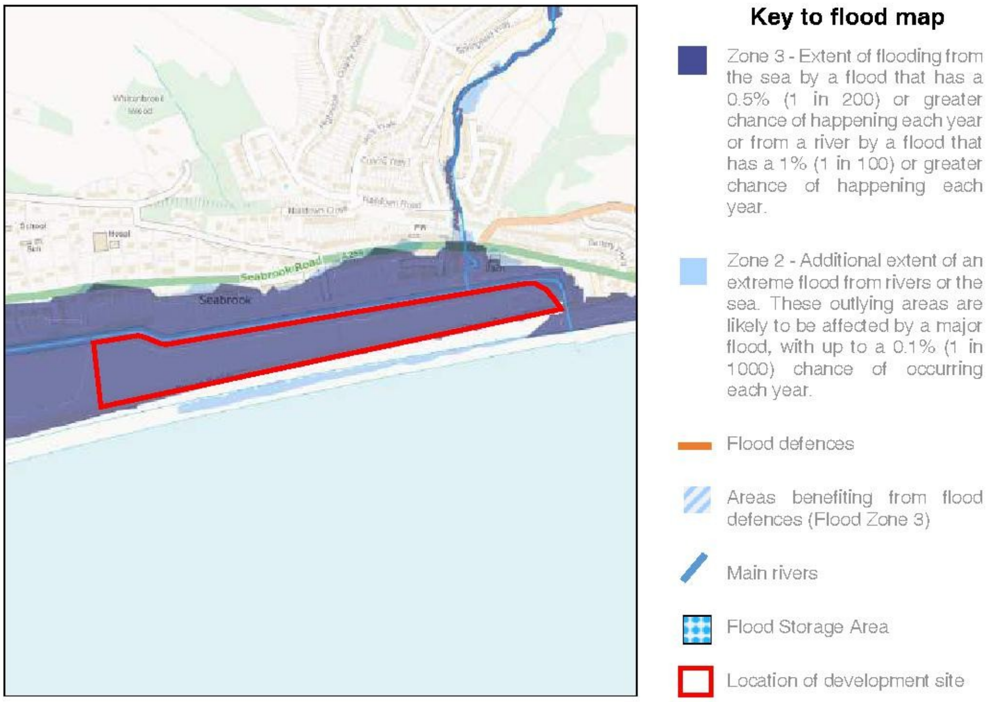

Figure 2.2 – Flood zone map showing the location of the development site (© Environment Agency)

The above mapping shows the development site to be located within Flood Zone 3 and not to be benefiting from existing flood defences that have been constructed in the last 5 years. This mapping does not distinguish between high risk areas and the functional floodplain, i.e. Zones 3a and 3b. This is an important differentiation that needs to be made by the FRA because the NPPF states that no development, other than essential transport and utilities infrastructure, should be located within the functional floodplain.

The functional floodplain is defined by the NPPF as land where water has to flow or be stored in times of flood during events that have a probability of occurrence of 1 in 20 (5%) or greater in any one year. The Planning Practice Guidance goes on to further clarify this by adding the following definition:

> *The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain. Areas which would naturally flood with an annual exceedance probability of 1 in 20 (5%) or greater, but which are prevented from doing so by existing infrastructure or solid buildings will not normally be defined as functional floodplain.*

Based on information provided by the Environment Agency and that derived as part of this appraisal, the following functional floodplain test is applied:

Do predicted flood levels show that the site will be affected by an event having a return period of 1 in 20 years or less?	x
Is the site defended by flood defence infrastructure that prevents flooding for events having a return period of 1 in 20 years or greater?	✓
Does the site provide a flood storage or floodwater conveyance function?	x
Does the site contain areas that are 'intended' to provide transmission and storage of water from other sources?	x
Is site within the functional floodplain (Zone 3b)	**No**

Table 2.1 – Functional floodplain test.

The flood zone mapping and associated information has been summarised in Table 2.2 below.

Flood Zone (percentage of site within zone)		**Source of flooding**	**Benefiting from existing flood defences***
Zone 1	**0%**		
Zone 2	**0%**		
Zone 3a	**100%**	Sea/Estuaries	Yes, the site benefits from a 1 in 200 year standard of protection
Zone 3b	**0%**		
(*) The flood zone maps only recognise defences constructed within the last 5 years			

Table 2.2 – Flood zone classification.

The second level of appraisal is through the application of the more detailed and refined flood risk information contained within the Strategic Flood Risk Assessments (SFRA). Such a document has been prepared for the Shepway District Council (SDC) in 2015 and includes more detailed flood hazard mapping which, unlike the EA's Flood Zone mapping, considers the influence of the defence infrastructure in this location. This mapping provides a more accurate depiction of the variation in the risk of flooding across the district.

An extract of the flood hazard mapping is shown in Figure 2.3 below and represents the maximum impact as a result of either waves overtopping the defence infrastructure or the failure of the defences in a number of locations along the coastline.

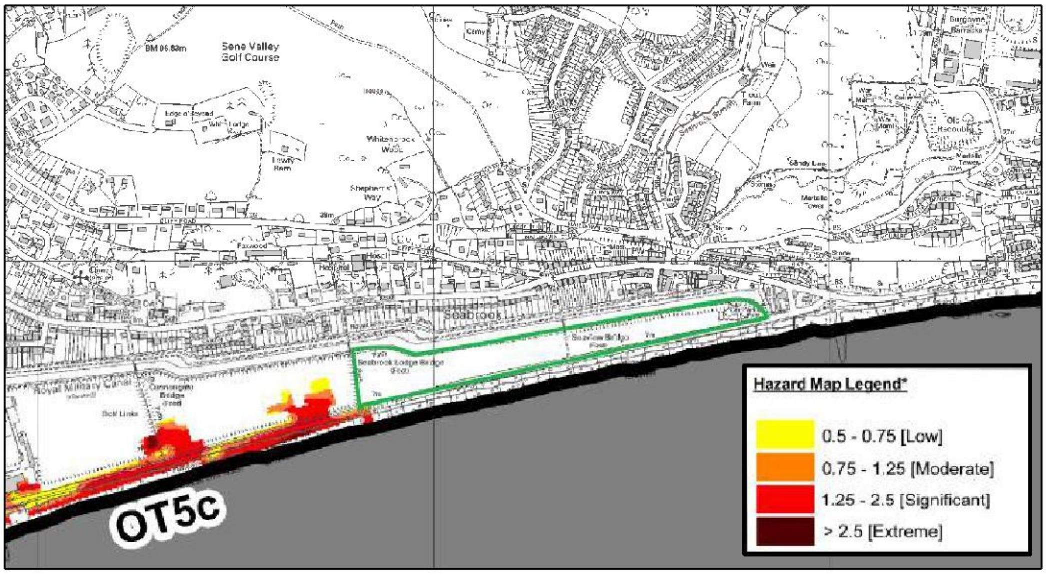

Figure 2.3 – Extract from the Shepway District Council SFRA (2015) Hazard Map for 1 in 200 year (plus 100 years of climate change) return period event. Site outline in green.

From Figure 2.3 above it can be seen that the development site is located outside of any the mapped hazard extents (i.e. it has a very low hazard classification). Consequently, based on the above mapping it is concluded that the Sequential Test will be passed.

The most detailed stage at which the sequential approach can be applied is at a site based level. Careful consideration of the site's topography and development uses can provide opportunities to locate more vulnerable buildings on the higher parts of the site and placing less vulnerable elements such as car parking or recreational use in the areas exposed to higher risk. This approach is examined later on in this FRA.

2.4 The Exception Test

According to the NPPF, if following the application of the Sequential Test it is not possible, consistent with wider sustainability objectives, for the development to be located in zones of lower probability of flooding, the Exception Test can be applied.

As part of this process it is necessary to consider the type and nature of the development. The Planning Practice Guidance: *Flood Risk and Coastal Change* defines the type and nature of different development classifications in the context of their flood risk vulnerability. This has been summarised in Table 2.3 below.

Flood Risk Vulnerability Classification	Zone 1	Zone 2	Zone 3a	Zone 3b
Essential infrastructure – Essential transport infrastructure, strategic utility infrastructure, including electricity generating power stations	✓	✓	e	e
High vulnerability – Emergency services, basement dwellings caravans and mobile homes intended for permanent residential use	✓	e	×	×
More vulnerable – Hospitals, residential care homes, buildings used for dwelling houses, halls of residence, pubs, hotels, non-residential uses for health services, nurseries and education	✓	✓	e	×
Less vulnerable – Shops, offices, restaurants, general industry, agriculture, sewerage treatment plants	✓	✓	✓	×
Water compatible development – Flood control infrastructure, sewerage infrastructure, docks, marinas, ship building, water-based recreation etc.	✓	✓	✓	✓

Key :
✓ Development is appropriate
× Development should not be permitted
e Exception Test required
Shaded cell represents the classification of this development

Table 2.3 – Flood risk vulnerability and flood zone compatibility.

From Table 2.3 above it can be seen that the commercial elements of the development are classified as less vulnerable and consequently, the Exception Test is not required to be applied. Notwithstanding this, the residential elements of the development and proposed hotel fall into a classification of 'more vulnerable' and as such, do require the Exception Test to be applied. For the Exception Test to be passed there are two criteria that must be satisfied and these are listed below:

- *it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared; and*
- *a site-specific flood risk assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*

Both elements of the test will have to be passed for development to be allocated or permitted.

Demonstrating that the development provides wider sustainability benefits to the community that outweigh the risk of flooding is outside the scope of this report, nevertheless, given the low level of risk shown by the SFRA mapping it is evident that the level of risk is significantly lower than is depicted by the coarse EA flood zone maps. On this basis, it is assumed that the first element of the Exception Test is likely to be passed. The key focus of this FRA is therefore to establish whether the site is likely to pass the second element of the Exception Test.

3 Definition of Flood Hazard

3.1 Site Specific Information

In addition to the high level flood risk information shown in the Environment Agency (EA) flood zone maps, additional data from detailed studies, topographic site surveys and other information sources is referenced. This section summarises the additional information collected as part of this FRA.

Site specific flood level data contained within the SFRA – The Shepway District Council SFRA (2015) contains detailed mapping of flood extents from a wide range of sources. This document has been referenced as part of this site-specific FRA.

Site specific topographic surveys – A topographic survey has been undertaken for the site and a copy of this is included in Appendix A.1. Inspection of this survey shows that the current levels across the site vary between 4.1m and 8.1m Above Ordnance Datum Newlyn (AODN). Although there are a few isolated low areas, ground levels are relatively flat and are typically around 7.2m AODN,

Geology – A geotechnical report has been undertaken for the site. This shows that the underlying solid geology of the subject site is Weald Clay Formation (clay and mudstone). Overlying this are superficial deposits of Storm Beach Deposits.

Historic flooding – Inspection of information contained within the Shepway SFRA shows that the very eastern edge of the development site has been affected by coastal flooding in the past, before the construction of the latest coast protection scheme in 2004.

3.2 Potential Sources of Flooding

The main categories of flooding have been assessed as part of this appraisal. The specific issues relating to each one and its impact on this particular development are discussed below. Table 3.1 at the end of this section summarises the risks associated with each of the sources of flooding.

Flooding from Rivers (Royal Military Canal) – The site is located directly adjacent to both the Royal Military Canal (RMC) and Seabrook Stream, which discharges into the RMC. Both watercourses are classified as 'main rivers' and the RMC currently discharges into the sea via a tidal outfall located to the east of Princes Parade. The canal outfall is controlled by a penstock and flap gate arrangement at Seabrook and is therefore susceptible to tide-locking during the period of high tide. Whilst the canal is a man-made structure, it does drain a considerable catchment of approximately 90km^2. Consequently, if the peak flows in the canal (that result from extreme rainfall conditions within the catchment) coincide with high tide, there is potential for flooding in the low lying areas of Hythe.

Flooding from the canal has occurred in the past; the most notable being in December 2002 when the low-lying areas of Burmarsh in West Hythe flooded as a result of prolonged and intense rainfall.

However, land levels in this area are over 2m below the lowest point of proposed development. Following the flooding that occurred during December 2002, the Council commissioned a detailed study of the Royal Military Canal to investigate potential improvement measures and also to highlight areas that are at risk of flooding.

This report did not highlight Princes Parade as being at risk of flooding from the canal. The maximum elevation of flooding that occurred in 2002 in Shepard's Walk and Romney Way was approximately 2.7m AODN. Inspection of the topographic data identifies that the site is elevated approximately 3m above the RMC and consequently, any anticipated rise in water level associated with a flood event is unlikely to reach the developed part of the site, even when an allowance for 100 years of climate change is considered. The risk from this source of flooding is therefore considered to be low.

Flooding from the Sea – The site lies within a coastal Flood Zone as shown on the Environment Agency's flood map. The flood zone maps are used as a consultation tool by planners to highlight areas where more detailed investigation of flood risk is required. The fact that the site lies within Flood Zone 3 means that the risk of flooding from this source is examined in more detail in this FRA.

Flooding from Ordinary or Man-made Watercourses – Natural watercourses that have not been enmained and man-made drainage systems such as irrigation drains, sewers or ditches could potentially cause flooding.

Inspection of the site and surrounding area reveals that there are no non-main rivers or artificial watercourses within close proximity of the site and therefore, the risk of flooding from this source is considered to be negligible.

Flooding from Land (overland flow and surface water runoff) – Overland flooding typically occurs in natural valley bottoms as normally dry areas become covered in flowing water and in low spots where water may pond. This flooding mechanism can occur almost anywhere, but is likely to be of particular concern in any topographical low spot, or where the pathway for runoff is restricted by terrain or man-made obstructions.

Figure 3.1 below is an extract of the Environment Agency's 'Risk of Flooding from Surface Water' map. This map has been interrogated to assist in this review, helping to identify whether the site is located in an area at specific risk of surface water flooding.

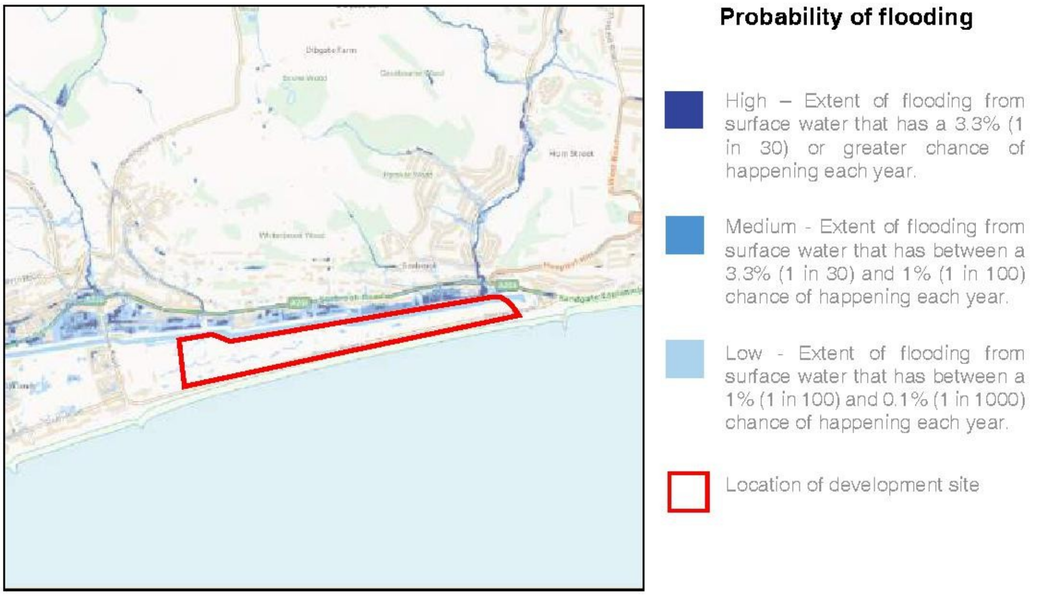

Figure 3.1 – Surface water flooding map showing the location of the development site (© Environment Agency).

Inspection of LiDAR data identifies that there are several low points currently on the site which have the potential to collect surface water, as shown in Figure 3.1. However, the development proposals comprise localised land reprofiling which will remove the localised low points and instead, direct surface water into a sustainable drainage system. Consequently, the risk of flooding to the development and the surrounding area will be significantly reduced when compared to Figure 3.1.

Flooding from Groundwater – 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). Where land that is prone to groundwater flooding has been built on, the effect of a flood can be very costly, and because groundwater responds slowly compared with rivers, floods can last for weeks or months.

The geology in this location is Weald Clay Formation overlain by Storm Beach Deposits and in certain circumstances groundwater flows can occur at the interface with the more impervious clay deposits. However, the elevation of the site has been increased as a result of previous land raising – refer to associated contamination reports (prepared by others) and as such, the groundwater levels are located a considerable distance below the surface. The same site investigation reports confirm there is not direct hydraulic link between the lined RMC and the site and as such, there is limited perceived risk with respect to elevated groundwater levels at this location.

Section 5 of this report discusses the mitigation measures which are proposed to minimise the risk of flooding from the coast and it is recognised that by including these measures within the scheme design, the risk of groundwater flooding will remain low.

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; this will continue until the water drains away. When this happens to combined sewers, there is a high risk of land and property flooding with water contaminated with raw sewage as well as pollution of rivers due to discharge from combined sewer overflows.

Reference to the Shepway SFRA shows that there are no known records of flooding from sewers in this area. The are no surface water sewers at this location, with runoff from the highway currently discharging at an unattenuated rate to the beach. There is a foul sewer located in the existing road (A259), however, the proposals are to relocate this dedicated foul sewer within the new road, which is proposed to be sited to the north of the site. The drainage strategy does not propose to discharge surface water into the foul sewer network and consequently, the risk of the system becoming surcharged will remain low.

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, operational and redundant industrial processes including mining, quarrying and sand and gravel extraction, as they may increase floodwater depths and velocities in adjacent areas. The potential effects of flood risk management infrastructure and other structures also need to be considered. Reservoir or canal flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure.

Inspection of the Ordnance Survey mapping for the area shows that there are no artificial sources of flooding within close proximity to the site. In addition, the Environment Agency's 'Risk of Flooding from Reservoirs' website shows that the site is not within an area considered to be at risk of flooding from reservoirs. Therefore, the risk of flooding from this source is considered to be *low.*

A summary of the overall risk of flooding from each source is provided in Table 3.1 below.

Source of flooding	Initial level of risk	Appraisal method applied at the initial flood risk assessment stage
Rivers	Low	OS mapping and detailed study of the Royal Military Canal
Sea/Estuaries	Low	Environment Agency flood zone map
Ordinary and man-made watercourses	Low	OS mapping
Overland flow	Low	Environment Agency 'Risk of Flooding from Surface Water' flood maps, and aerial height data
Groundwater	Low	BGS Geology mapping, OS mapping and geo-environmental report
Sewers	Low	Historic sewer records contained within the SFRA and topographic survey
Artificial sources	Low	Ordnance Survey mapping and Environment Agency 'Risk of Flooding from Reservoirs' flood map

Table 3.1 – Summary of flood sources and risks.

3.3 Existing Flood Risk Management Measures

The coastline directly to the south of the site is defended by infrastructure constructed as part of the Hythe to Folkestone Harbour Coast Protection Scheme. This comprises rock groynes, wave return walls and capital beach renourishment. In combination with the ongoing beach management works undertaken by Shepway District Council, this scheme provides a standard of protection against flooding of 1 in 200 years to the frontage that extends from the end of St Leonard's Road to Folkestone.

The beaches between Hythe and Folkestone are managed by Shepway District Council to ensure that the volume of shingle required to provide the high standard of protection is maintained and annual beach recycling is undertaken to counter the natural west-east littoral transport process. Currently the study frontage is protected by this shingle beach and a large concrete recovered wall, with a secondary wave return wall sited to the back of the existing promenade. The primary defences are designed to prevent water from reaching the hinterland, whilst the wave return wall is designed to prevent water from being directed onto the highway.

To the west of St Leonard's Road, the defended length of shoreline is referred to as the Hythe Ranges frontage and the defences along this section comprise timber groynes and a rock revetment. There is also a 240m length of shoreline that does not have any formal sea defences. This frontage lies between the seawall at Hythe and the rock revetment of the Hythe Ranges frontage and is formed from a natural shingle beach (Fisherman's Beach). The results of the SFRA numerical flood modelling identifies that due to the elevated land levels at this location the site is not a risk of coastal flooding from water passing over/through the neighbouring defence infrastructure.

A review of the Shoreline Management Plan for South Foreland to Beachy Head identifies the management policy for the Hythe to Folkestone frontage as 'Hold the Line'. This policy is supported by the Coastal Defence Strategy Plan. This suggests that capital funding for the ongoing beach management at this location will not be retracted.

The Environment Agency has stated that, as part of the Folkestone to Cliff End Strategy, significant investment in the defence infrastructure on the Romney Marsh is planned "*to improve the sea defences…to provide a 0.5% (1 in 200) standard of protection from a flood event occurring at any point along the coast from 2022*". Given that the proposed scheme has an anticipated lifetime of 100 years, it can be seen that the development will benefit from continued improvements to the defence infrastructure.

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4 Climate Change

When the impact of climate change is considered it is generally accepted that the standard of protection provided by current defences will reduce with time. The global climate is constantly changing, but it is widely recognised that we are now entering a period of accelerating change. Over the last few decades there have been numerous studies into the impact of potential changes in the future and there is now an increasing body of scientific evidence which supports the fact that the global climate is changing as a result of human activity. Past, present and future emissions of greenhouse gases are expected to cause significant global climate change during this century.

The nature of climate change at a regional level will vary: for the UK, projections of future climate change indicate that more frequent short-duration, high-intensity rainfall and more frequent periods of long-duration rainfall of the type responsible for the recent UK flooding could be expected.

These effects will tend to increase the size of flood zones associated with rivers, and the amount of flooding experienced from other inland sources. The rise in sea level will change the frequency of occurrence of high water levels relative to today's sea levels and will also increase the extent of the area at risk should sea defences fail. Changes in wave heights due to increased water depths, as well as possible changes in the frequency, duration and severity of storm events are also predicted.

To ensure that any recommended mitigation measures are sustainable and effective throughout the lifetime of the development, it is necessary to base the appraisal on the extreme flood level that is commensurate with the planning horizon for the proposed development. The NPPF and supporting Planning Practice Guidance Suite state that residential development should be considered for a minimum of 100 years, but that the lifetime of a non-residential development depends on the characteristics of the development. It is recognised that the application includes both commercial and residential elements and considering the residential elements of the development have a longer design life (i.e. 100 years), the appraisal has been undertaken to account for the impacts of climate change over this extended period of time.

4.1 Potential Changes in Climate

Extreme Sea Level

Global sea levels will continue to rise, depending on greenhouse gas emissions and the sensitivity of the climate system. The relative sea level rise in England also depends on the local vertical movement of the land, which is generally falling in the south-east and rising in the north and west. The accompanying Planning Practice Guidance Suite to the NPPF provides allowances for the regional rates of relative sea level rise and these are shown in Table 4.1.

Administrative Region	Net Sea Level Rise (mm/yr) Relative to 1990			
	1990 to 2025	**2026 to 2055**	**2056 to 2085**	**2086 to 2115**
East of England, East Midlands, London, SE England (south of Flamborough Head)	4.0	8.5	12.0	15.0
South West	3.5	8.0	11.5	14.5
NW England, NE England (north of Flamborough Head)	2.5	7.0	10.0	13.0

Table 4.1 – Recommended contingency allowances for net sea level rise.

From these values, it can be seen that the extreme sea level will change with time and that this change is not linear. The 1 in 200 year extreme sea level has been extracted from the EA's Coastal Flood Boundary Conditions database and the impact of climate change has been calculated for a number of time steps between the current day and the year 2115. These values are shown in Table 4.2 below.

Year	1 in 200 year extreme water level (m AODN)
Current day (year 2008)	4.74
2025	4.81
2055	5.06
2075	5.30
2085	5.42
2115	5.87

Table 4.2 – Climate change impacts on extreme flood levels.

Offshore Wind Speed and Extreme Wave Height

As a result of increased water depths resulting from changes in the climate, wave heights have the potential to change. The climate change allowances for offshore wind speed and wave height are shown in Table 4.3 below and where appropriate, have been applied as part of this appraisal. These figures are applicable around the entire English coast and are relative to a 1990 baseline. They also include a sensitivity allowance which should be used to show that the range of impact of climate change is understood.

Parameter	1990 to 2050	2051 to 2115
Offshore wind speed allowance	+5%	+10%
Offshore wind speed sensitivity test	+10%	+10%
Extreme wave height allowance	+5%	+10%
Extreme wave height sensitive test	+10%	+10%

Table 4.3 – Recommended climate change allowance and sensitivity ranges for offshore wind speed and extreme wave height (relative to 1990)

Peak Rainfall Intensity

The recommended allowances for increases in peak rainfall intensity are applicable nationally. There is a range of values provided which correspond with the central and upper end percentiles (the 50^{th} and 90^{th} percentile respectively) over three time epochs. The recommended allowances are shown in Table 4.4 below.

Allowance Category (applicable nationwide)	Total potential change anticipated for each epoch		
	2015 to 2039	2040 to 2069	2070 to 2115
Upper End	+10%	+20%	+40%
Central	+5%	+10%	+20%

Table 4.4 – Recommended peak rainfall intensity allowance for small and urban catchments (1961 to 1990 baseline).

All of the above recommended allowances for climate change should be used as a guideline and can be superseded if local evidence supports the use of other data or allowances. Additionally, in the instance where flood mitigation measures are not considered necessary at present, but will be required in the future (as a result of changes in climate), a "managed adaptive approach" may be adopted whereby development is designed to allow the incorporation of appropriate mitigation measures in the future.

4.2 Impacts of Climate Change on the Development Site

The increase in tidal extremes that results from rising sea levels is significant and therefore needs to be taken into account to ensure that flood risk is appropriately mitigated over the lifetime of the development. The design flood level used to inform the recommendations for mitigation discussed in this report therefore includes an appropriate allowance for climatic changes.

In addition to the impact of tidal flooding at the site, climatic changes will also impact on the way in which the proposed development affects the risk of flooding elsewhere. These impacts are primarily linked to the surface water discharge from the site; therefore, potential increases in future rainfall need to be taken into account when designing surface water drainage systems. An increase of 20% in peak rainfall intensity has been used in the calculations in the outline surface water management strategy (refer to Section 8).

5 Probability and Consequence of Flooding

5.1 The Likelihood of Flooding

When appraising the risk of flooding to new development it is necessary to assess the impact of the 'design flood event' to establish depths, velocities and the rate of rise of floodwater under such conditions. Flood conditions can be predicted for a range of return periods and these are expressed in either years or as a probability, i.e. the probability that the event will occur in any given year, or Annual Exceedance Probability (AEP). The design flood event is taken as the 1 in 200 year (0.5% AEP) event for sea or tidal flooding (including an appropriate allowance for climate change).

The 1 in 200 year extreme still water level at Hythe is 5.87m AODN. This level takes into account 100 years of climate change and sea level rise. When this level is compared to the elevation of the proposed site, it can be seen that the entire development platform is raised above this level.

Nevertheless, the direct application of the open extreme sea level at the subject site is not technically appropriate, because this does not take into account the effects of waves overtopping the defences under an extreme event.

In simple terms, wave overtopping occurs when the surface elevation of the sea is raised above the crest of the seawall or promenade, by the vertical oscillations caused by wave action. In reality, however, the interaction between broken and unbroken random waves with the seawall and underlying beach can result in an extremely violent and unpredictable environment.

There are many variables in the calculation of wave overtopping and apart from the crest elevation of the seawall/beach itself; the most influential are water level and wave height. These extreme values are to a certain degree dependent upon the same weather system to generate them. Thus the combined, or joint, probability of occurrence is often applied in overtopping analysis.

Wave overtopping analysis has been carried out using wave and water levels data from the report - Joint Return Probability for Beach Management, (T Mason, 2014) at the Met Office Hindcast Point MO489. The joint probability data relates to an offshore location and thus needs transforming inshore to the toe of the beach (-4.0m AODN). This has been carried out using the Goda wave transformation formula for a range of wave height and water level combinations.

At the time of analysis, the European Overtopping Manual (EurOtop) online calculation tool was unavailable whilst being upgraded from EurOtop 2007 to EurOtop 2016. Consequently, two methods of calculating wave overtopping have been used, J.W. Van der Meer (1998) and R Wallingford R&D Technical Report W178 (1999). Both analyses assume a diminished beach crest width of 5m (rather than the recommended 10m), which adopts the precautionary approach promoted by the NPPF and thereby reflects the typical beach conditions before the bi-annual beach recycling works have been completed.

Overtopping analyses was undertaken for all 12 wave and water level combinations and the lower water level/high wave condition results in the greatest rate of wave overtopping. The results of both methodologies were similar (less than 100 l/s/m).

The EurOtop Manual (2nd edition, October 2016) suggests that no damage will occur to a seawall/promenade when overtopping rates are <200 l/s/m and therefore the risk is limited to water reaching the proposed properties located to the rear of the promenade. The wave overtopping results suggest that the primary seawall and beach will interrupt the incoming waves during a storm, forcing them to break before they reach the secondary seawall and consequently, reducing their velocity. Nevertheless, water still has the potential to reach the existing promenade as spray, or alternatively as runup. Measures are therefore proposed to be incorporated within the scheme design to ensure surface water is returned towards the beach before it reaches the development.

The existing secondary wave return wall is designed to intercept the runup and prevent the majority of the water from passing onto the A259, with the existing highway drainage currently directing surface water back onto the beach. The scheme proposals include an extended promenade, which replaces the existing double carriageway, and as a precautionary measure relocates the secondary seawall to the rear of this new 11m promenade. In addition, the proposals include increasing the height of the new secondary wave return wall to 1m and reprofiling the new promenade to include a crossfall, which would direct all surface water back towards the beach. Consequently, in the event that water does pass over the primary defence, the secondary defence would prevent water from flooding the study site. These mitigation measures, along with others such as floor raising, are discussed further in Section 6 of this report.

5.2 Residual Risk of Flooding

Despite the presence of the defences, there is always the risk that this infrastructure could fail, for example through structural failure (a breach), or a less predictable mechanism such as ship impact, or an act of terrorism. This is termed the *residual risk* event. Although unlikely to occur, it is still necessary to establish the impact of such a scenario, assuming the existing defences have failed. Consequently, it is necessary to identifying the maximum extent, depth and velocity of flood water at the site following a breach.

In 2015, the whole Romney, Walland and Denge Marsh area was numerically modelled using TUFLOW hydrodynamic numerical modelling software as part of the revised SFRA commissioned by SDC. Within the SFRA, 7 breach were considered in order to ascertain the risks associated with coastal flooding which included an allowance for the defence infrastructure currently in place.

Interrogation of the outputs from the SFRA indicate that the development site is located outside of the predicted extent of flooding from all 7 modelled breach scenarios.

When considering a more localised breach in the defences fronting the development site, the impact on the development will be minimal as land levels will be raised above the extreme still water level, even when considering the impact of climate change over the lifetime of the development. It is therefore concluded that the residual risk of flooding to the development as a result of a failure of the coastal defences is *low*.

6 Flood Mitigation Measures

The key objectives of flood risk mitigation are:

- to reduce the risk of the development being flooded.
- to ensure continued operation and safety during flood events
- to ensure that the flood risk downstream of the site is not increased by increased runoff
- to ensure that the development does not have an adverse impact on flood risk elsewhere

Up to this point in the report the risk of flooding to the site has been appraised and the consequences of flooding to the site from each source has been considered. The following section of this report examines ways in which flood risk can be mitigated.

Mitigation Measure	Appropriate	Comment
Careful location of development within site boundaries (i.e. Sequential Approach)	✓	Refer to Section 6.2
Raising floor levels	✓	Refer to Section 6.3
Land raising	✓	Refer to Section 6.3
Compensatory floodplain storage	x	Not required (Refer to Section 6.4)
Flood resistance & resilience	✓	Refer to Section 6.5
Alterations/ improvements to channels and hydraulic structures	x	Not required
Flood defences	✓	Refer to Section 6.1
Flood warning	✓	Refer to Section 6.6
Management of development runoff	✓	Refer to Section 8

Table 6.1 – Appropriateness of mitigation measures.

6.1 Flood Defences

The results of the wave overtopping analysis undertaken in Section 5.1 has identified that the primary seawall and beach will provide a 1 in 200 year standard of protection from coastal flooding and the existing promenade (6.75-6.85m AODN) is located above extreme still water level under the design event, including an allowance for 100 years of sea level rise (5.87m AODN). Notwithstanding this, there is still the opportunity for some water to reach the promenade if waves were to reach the primary seawall and it is therefore proposed to construct a secondary seawall to provide a 'localised defence'. This secondary wall will allow the return flow of water across the promenade and back onto the beach during an extreme event. The defence is proposed to comprise a 1m high wall, set back 11m from the existing primary seawall, and it will replace the existing (lower) wave return wall which serves the same function.

It is generally accepted that wave overtopping rates reduce by approximately one order of magnitude 10 metres inland of the defences, and when applying the W178 method to calculate the wave overtopping at the crest of the secondary seawall, the resulting wave overtopping discharge rate in the area of the proposed development would be reduced to just 0.2 l/s/m. The following sections of this report outline additional mitigation measures which are designed to further reduce the risk associated with this small volume of floodwater.

6.2 Application of the Sequential Approach at a Local Scale

The sequential approach to flood risk management can be adopted on a site based scale and is often be the most effective form of mitigation. For example, on a large scheme this would mean locating the more vulnerable dwellings on the higher parts of the site and placing parking, recreational land or commercial buildings in the lower lying and higher risk areas.

It has been identified that the primary risk of flooding to the development site is from wave overtopping and as such, a Sequential Approach has been adopted to ensure that the proposed buildings are set back from the seawall by a minimum of 12m. By increasing the promenade width and constructing a secondary wave return wall, it will significantly reduce the volume of water reaching the parts of the site on which the buildings are to be located.

6.3 Raising Floor Levels & Land Raising

Internal flooding can result in damage to the property and its contents. Flooded properties are often un-usable for long periods after they are flooded while the property dries and repairs are carried out. By setting the floor levels above the estimated floodwater levels, the risk of internal flooding is reduced and the impacts upon the occupants are minimised. Where this is not feasible, justification must be provided and floor levels set as high as possible. In addition, flood-proofing measures should be considered, up to the design flood level.

It has been demonstrated that existing land levels across the site are typically raised above the extreme sea level for the 1 in 200 year return period event, including an allowance for 100 years of sea level rise. The primary risk of flooding to the proposed development is therefore limited to waves overtopping the primary defences and consequently, by raising the land and the finished floor levels across the developed parts of the site, the risk of internal flooding from this source will be further reduced.

Correspondence with the EA has confirmed that that required finished ground floor level of the proposed dwellings should be set at a minimum of 600mm above the existing promenade level (i.e. 6.85 AODN + 600mm = **7.45m AODN**), refer to Appendix A.2. In this instance, it is recognised that the developed parts of the site will be raised as part of the land remediation works and to facilitate the surface water drainage system. Consequently, the finished floor levels are shown to be located above the minimum level required by the EA (i.e. set above 7.45mAODN).

6.4 Compensatory Floodplain Storage

The construction of a new building within the floodplain has the potential to displace water and to increase the risk elsewhere by raising flood levels. A compensatory flood storage scheme can be used to mitigate this impact, ensuring the volume of water displaced is minimised.

However, where development is proposed in areas at risk of tidal flooding (as is the case in this instance), it is generally accepted by the EA that raising the ground levels, or building within the floodplain is unlikely to impact on maximum tidal levels.

6.5 Flood Resistance and Resilience

During a flood event, floodwater can find its way into properties through a variety of routes including:

- Ingress around closed doorways.
- Ingress through airbricks and up through the ground floor.
- Backflow through overloaded sewers discharging inside the property through ground floor toilets and sinks.
- Seepage through the external walls.
- Seepage through the ground and up through the ground floor.
- Ingress around cable services through external walls.

Since flood management measures only manage the risk of flooding rather than eliminate it completely, flood resilience and resistance measures may need to be incorporated into the design of the buildings. The two possible alternatives are:

Flood Resistance or 'dry proofing', where flood water is prevented from entering the building. For example using flood barriers across doorways and airbricks, or raising floor levels. These measures are considered appropriate for 'more vulnerable' development where recovery from internal flooding is not considered to be practical.

Flood Resilience or 'wet proofing', accepts that flood water will enter the building and allows for this situation through careful internal design for example raising electrical sockets and fitting tiled floors. The finishes and services are such that the building can quickly be returned to use after the flood. Such measures are generally only considered appropriate for some 'less vulnerable' uses (e.g. the leisure centre) and where the use of an existing building is to be changed and it can be demonstrated that no other measure is practicable.

It has been demonstrated that the primary risk of flooding to the development site is from wave overtopping. The construction of a secondary flood wall will significantly reduce the impact of such an event, however, minor wave overtopping could still occur and as such, by incorporating flood resilience into the design of the building it will be possible to increase its resilience to flooding and thereby reduce the impact of such an event.

Flood proofing measures which can be implemented to reduce the damage to buildings and property are becoming more common in areas that are subject to flooding. Typical examples of flood resilience measures which may be appropriate for the development site include (but are not limited to) the following:

- Raising floor slab level further
- Bringing the electrical supply in at first floor
- Placing boilers and meter cupboards on the first floor
- Water-resistant plaster/tiles on the walls of the ground floor
- Solid stone or concrete floors with no voids underneath
- Covers for doors and airbricks
- Non-return valves on new plumbing works
- Avoidance of studwork partitions on the ground floor
- High quality glazing and door/window fittings on the ground floor to ensure that the building will not be impacted by wind blow spray and debris.

Details of flood resilience and flood resistance construction techniques can be found in the document 'Improving the Flood Performance of New Buildings; Flood Resilient Construction', which can be downloaded from the Communities and Local Government website.

6.6 Flood Warning

The Environment Agency operate a flood forecasting and warning service in areas at risk of flooding from rivers or the sea, which relies on direct measurements of rainfall, river levels, tide levels, in-house predictive models, rainfall radar data and information from the Met Office. This service operates 24 hours a day, 365 days a year.

With the sophisticated techniques now employed by the Environment Agency to predict the onset of flood events the opportunity now exists for all residents within the flood risk area to receive early flood warnings.

The nature of the flood mechanism in this location is from a tidal source (wave overtopping). Such an event is dependent on meteorological conditions that can be monitored reliably and therefore it is likely that a minimum of 12 hours warning could be given. This forewarning should be sufficient to allow the users of the site to prepare the buildings for a flood event and to evacuate the site themselves in the event of a flood greater than the design event.

It is therefore recommended that the occupants of the site sign up to the Environment Agency's Flood Warning Service either by calling 0345 988 1188, or by visiting;

https://www.gov.uk/sign-up-for-flood-warnings

7 Offsite Impacts and Other Considerations

7.1 Public Safety and Access

The NPPF states that safe access and escape should be available to/from new developments located within areas at risk of flooding. The Practice Guide goes on to state that access routes should enable occupants to safely access and exit their dwellings during design flood conditions and that vehicular access should be available to allow the emergency services to safely reach the development.

Inspection of the hazard rating outputs from the breach and overtopping modelling undertaken as part of the SFRA identifies that access along the promenade to the south west is shown to be classified as having a 'low' to 'significant' hazard rating. Therefore, under design flood conditions, waves overtopping the sea wall are likely to prevent both pedestrian and vehicular access to/from the site from this direction. Nevertheless, as land levels begin to rise in a north easterly direction, safe access/egress to/from the site to an area outside the predicted flood extents will be possible.

The risk of flooding to the proposed buildings and access road through the site itself will be limited by the construction of a secondary wave return wall and the proposed land raising. It can therefore be seen that safe access/egress to/from the proposed buildings can be achieved to the north of the site. Access to the wider surrounding area will also be available from the north east of the site.

7.2 Proximity to Watercourse and Flood Defence Structures

Under the Water Resources Act 1991 and Land Drainage Byelaws, any proposals for development in close proximity to a 'main river' would need to take into account the Environment Agency's requirement for an 8m buffer zone between the river bank and any permanent construction such as buildings or car parking etc. This buffer zone increases to 16m for tidal waterbodies and sea defence infrastructure.

The development site is located more than 8m from the Royal Military Canal (Main River). The scheme drawings identify that development is proposed to be located 12m from the existing sea wall, however correspondence with the EA has confirmed that this is acceptable. It is therefore considered that the proposed development will not compromise any of the Environment Agency's maintenance or access requirements.

7.3 Impact on Coastal Morphology and Impedance of Flood Flows

In terms of the way in which the development would interact and modify flood flows, its location and size with respect to the flood risk area and the flow path should be considered. It has been demonstrated that the risk of flooding to the proposed development from the Royal Military Canal (main river) is low and as such it is considered that the development will not affect fluvial morphology. The development is also raised above the 1 in 200 year extreme sea level, it is considered that the proposals will not impede or change flood flow regimes.

Whilst the development site is located immediately behind the seawall and is within 30m of the mean high-water line, the proposals will not have any influence over sediment transport or coastal processes and will therefore not directly affect coastal morphology. In addition, this frontage is not shown by the Shoreline Management Plan to have either a 'No Active Intervention' or 'Managed Realignment' policy and therefore, the seawall will remain in its current position and alignment.

8 Surface Water Management Strategy

8.1 Background and Policy

The general requirement for all new development with respect to managing surface water runoff is managed sustainably and the drainage solution for the development does not increase the risk of flooding at the site or within the surrounding area.

Changes relating to The Flood and Water Management Act 2010 National Standards (Schedule 3 – paragraph 5) for design, construction, maintenance, and operation of Sustainable Drainage Systems (SuDS), came into effect from 6 April 2015. These changes provide additional detail and requirements not initially covered by the NPPF, and are (non-statutory) Technical Standards for SuDS.

These National Technical Standards specify criteria to ensure drainage systems incorporated within developments of 10 dwellings or more; or equivalent non-residential, or mixed development (as set out in Article 2(1) of the Town and Country Planning (Development Management Procedure) (England) Order 2010) is sustainable.

In this instance, the proposed development is for more than ten units, on land totalling greater than one hectare. Consequently, the proposals will be classified as 'major development' and the National Technical SuDS Standards will apply. Reference to the Standards has therefore been made throughout the following sections of this report to ensure the principles of sustainable drainage are considered.

8.2 Surface Water Management Overview

The main characteristics of the site that have the potential to influence surface water drainage are summarised in Table 8.1 below.

Site Characteristic	Value
Total area of site	10.07 ha
Impermeable area (existing)	**~ 0 ha**
Impermeable area (proposed – outline application)	Residential roof area = 0.77 ha Sports Centre roof area = 0.24 ha Adoptable highway = 0.94 ha Other hardstanding = 2.00 ha **Total = 3.95 ha**
Current site condition	Undeveloped brownfield site (landfill)
Greenfield runoff rates (based on the ICP SuDS methodology)	QBar = 1.9 l/s/ha Q30 = 4.3 l/s/ha Q100 = 6.0 l/s/ha
Infiltration coefficient	0.0001-0.1 m/hr (assumed based on underlying geology and typical soil conditions)
Current surface water discharge method	No formal drainage - surface water runoff currently discharges directly to the beach and Royal Military Canal.
Is there a watercourse within close proximity to site?	Yes

Table 8.1 – Site characteristics affecting rainfall runoff.

Synthetic rainfall data has been derived using the variables obtained from the Flood Studies Report (FSR) and the routines within the Micro Drainage Source Control software. The peak surface water flows generated on site for the existing and post-development conditions have been calculated by using the Modified Rational Method.

Runoff rates have been calculated for a range of annual return probabilities, including the 100 year return period event with a 20% increase in rainfall intensity to account for future climatic changes. These values are summarised in Table 8.2 for a range of return periods.

Return period (years)	Peak runoff (l/s)	
	Existing site	Developed site
1	Undeveloped	700
30	Undeveloped	1700
100	**Undeveloped**	2300
100 + 20%	Undeveloped	**2700**

Table 8.2 – Summary of peak runoff.

The total volume of water discharged from the site for the 100 year 6 hour event is also summarised in Table 8.3 below, for both the existing and proposed site conditions.

Site condition	Total volume discharged
Existing site (present day)	Undeveloped
Proposed development including a 20% increase in rainfall intensity to account for climate change (prior to any mitigation)	3200 m^3

Table 8.3 – Total volume discharged from the 100 yr+20%cc 6 hour event.

Reference to the tables above show the proposed development will increase the percentage of impermeable area within the boundaries of the site and if unmanaged, this would increase the rate and volume of surface water runoff which is discharged from the site. If discharged informally to a watercourse, or to the public sewer system, this additional water could potentially result in an increased risk of flooding. Consequently, it will be necessary to provide mitigation measures to ensure that the runoff discharged from the site is managed in a sustainable manner and does not increase the risk of flooding at the site, or to the surrounding area.

8.3 Opportunities to Discharge Surface Water Runoff

The various opportunities for managing the surface water runoff discharged from the development site are listed, below, in order of preference:

Discharge to a Surface Water Body – The National Technical SuDS Standards states that, if a system can directly discharge to a surface water body which can accommodate an uncontrolled discharge without any impact on flood risk from that source (e.g. the sea or large estuary), then it will not be necessary to provide the required storage and attenuation for storm water discharged from the site (detailed within S2 and S3). Given the proximity of the site to the adjacent coastline, there is potential for a direct outfall from the development to the sea.

Infiltration – Geotechnical investigations, undertaken by others, identify made ground deposits present beneath parts of the site. As a result, it is unlikely infiltration SuDS will be suitable for use at this site. The opportunity for discharging via infiltration is subsequently discounted from further analysis.

Discharge to Watercourses – Given the proximity of the site to the Royal Military Canal, there is some opportunity to discharge surface water runoff into this watercourse. To ensure the risk of flooding is not increased, it would be necessary to store storm water onsite and attenuate the discharge into the Royal Military Canal to greenfield discharge rates as detailed with S2 and S3 of the National Technical Standards for SuDS. Nonetheless, a more preferable solution for draining the site is available and consultation with the EA has confirmed that discharging any additional surface water runoff to the Royal Military Canal will not be considered acceptable. Consequently, this option has been discounted at this stage.

Discharge to Public Sewer System – It is considered unlikely that there will be sufficient capacity within the public sewer system to accommodate surface water runoff discharged from the proposed development. Notwithstanding this, a new surface water sewer could be requisitioned from the sewerage undertaker as a last resort. It is acknowledged that the costs for implementing this new sewer would most likely be charged to the developer. Notwithstanding this, as a more preferable solution for draining the site is available it is considered unlikely that Southern Water will permit any surface water runoff to be discharged to the public sewer system until the other options have been exhausted.

Based on the opportunities outlined above, the most sustainable solution for managing surface water runoff discharged from the proposed development is via a direct connection to the sea. Kent County Council (KCC - acting in their role as the Lead Local Flood Authority), Shepway District Council's Engineering Department and the EA have all been consulted over the possibility of draining the proposed development via a new direct connection to the sea. An agreement has been made in principle that this solution will present the most sustainable solution and will minimise the risk of flooding to both the site and the surrounding area.

8.4 Proposed Surface Water Management Strategy (SWMS)

To simplify the maintenance of the proposed drainage system two outfalls into the sea will be constructed. One of these outfalls will drain all of the surface water runoff from the proposed residential development and associated hardstanding. The second outfall will discharge all surface water runoff from the leisure centre and associated car park.

The invert level of both proposed outfall structures is proposed to be located above the extreme sea level for a 1:30 year return period, to minimise the risk of the system becoming tide-locked, which is aligned with the recently constructed tidal outfalls at Sandgate, which were installed as part of the Hythe to Folkestone Harbour Coast Protection Scheme.

To reduce the risk of pollutants being entrained to the sea, additional pollution control measures such as sediment traps, oil interception devices and SuDS will be incorporated within the detailed drainage design for the development.

The proposed drainage strategy is set out below and describes each of the different elements of the proposed scheme and demonstrates how the overall objectives can be achieved. This does not represent a detailed surface water drainage design and is simply an assessment to demonstrate that the objectives and requirements of the NPPF can be met at the planning stage.

Sports Centre and Car Park

Surface water runoff from the roof of the leisure centre will be drained via a piped drainage network to a new outfall structure located on the beach. The surface of the car parking and hardstanding areas servicing the leisure centre will be made permeable, to filter rain landing on these areas. The associated sub-base will provide a filtering layer to remove any pollutants and improve the quality of water discharged from the site into the sea. The base of this paving system will tanked to prevent water from infiltrating into the made ground and instead will be connected to the piped drainage network that will discharge to the new outfall structure. Figure 8.1 is an indicative drainage layout plan showing the proposed drainage system for the leisure centre and associated car park.

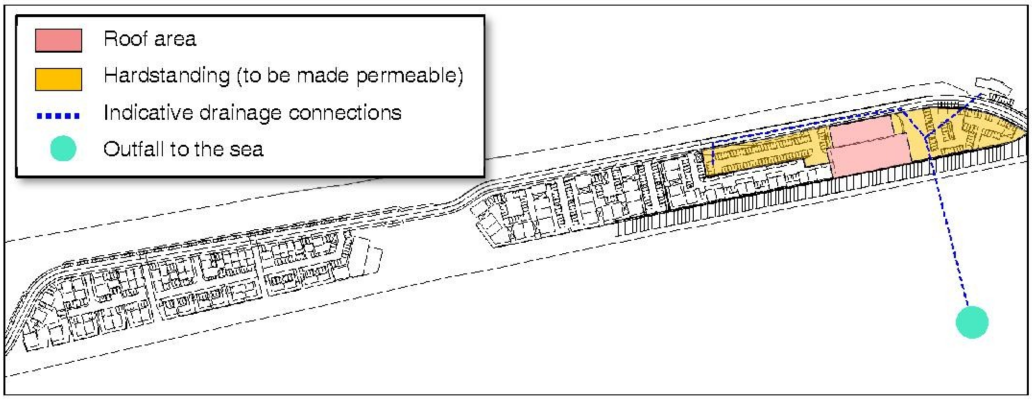


Figure 8.1 – Indicative drainage layout for the leisure centre and car park.

Residential and Other Development (excluding the leisure centre)

Surface water runoff from the roofs of the remaining proposed buildings will be drained directly into a piped drainage network. These drains will connect with a new outfall structure located on the adjacent beach. Permeable paving will be incorporated across the hardstanding and car parking areas to provide a level of treatment to the surface water runoff filtering through the sub-base. The sub-base will be tanked to prevent any infiltration into the made ground, before it is drained into the piped drainage network which will be connected to a new sea outfall structure. Figure 8.2 is an indicative drainage layout plan showing the proposed drainage system for the parts of the development which exclude the leisure centre.

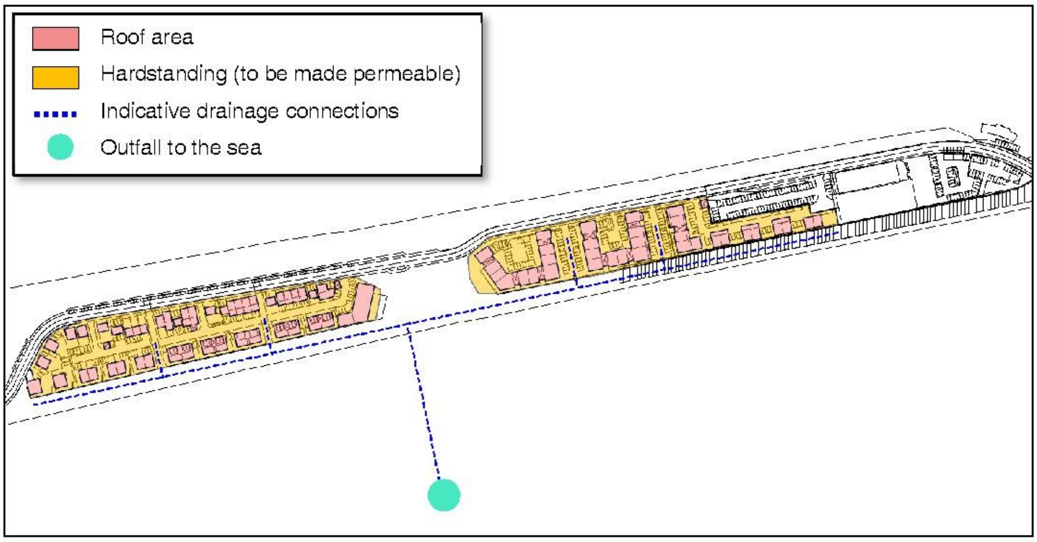


Figure 8.2 – Indicative drainage layout for the residential development.

Adoptable Highway

It is envisaged that the proposed highway drainage will be constructed to an adoptable standard. The highway drainage system will subsequently discharge at an unattenuated rate to the piped drainage network which will be used to drain the rest of the development. Consequently, runoff from the highway will ultimately be discharged into the sea at an unattenuated rate.

To reduce the risk of pollutants reaching the sea, the highway drainage system will contain a series of sediment traps and oil interceptors where required.

8.5 Indicative Drainage Layout Plan

Figure 8.3 below is an indicative drainage layout plan delineating how the entire proposed drainage system can be incorporated into the scheme proposals.

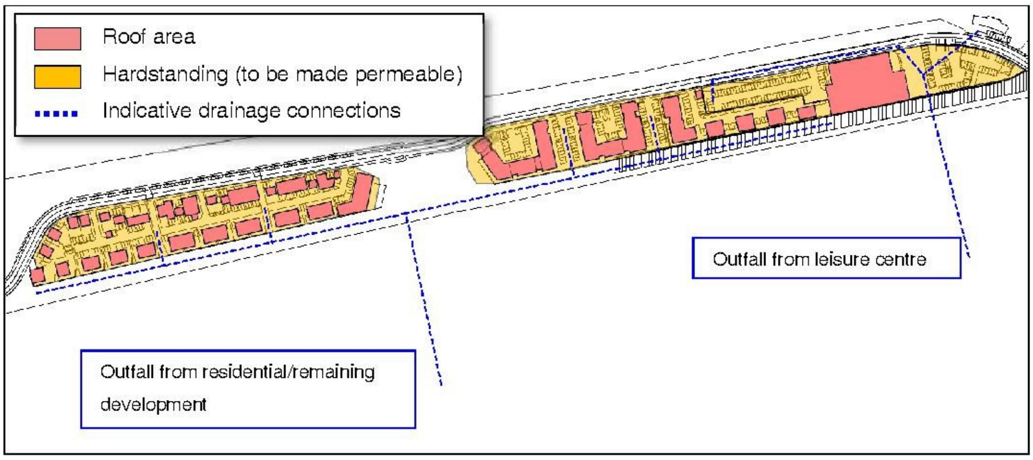


Figure 8.3 – Indicative drainage layout plan showing the possible location of both new outfall structures.

8.6 Management and Maintenance

For any surface water drainage system to operate as originally designed, it is necessary to ensure that it is adequately maintained throughout its lifetime.

The key requirements of any management regime are routine inspection and maintenance, when the development is taken forward to the detailed design stage an 'owner's manual' will need to be prepared. This should include:

- A description of the drainage scheme,
- A location plan showing all of the SuDS features and equipment such as flow control devices etc.
- Maintenance requirements for each element, including any manufacturer specific requirements
- An explanation of the consequences of not carrying out the specified maintenance
- Details of who will be responsible for the ongoing maintenance of the drainage system.

For the SuDS and drainage features recommended by this assessment, the most obvious maintenance tasks will be the cleaning of the permeable paving and regular de-silting of sediment traps and the piped drainage network.

In addition, for developments such as this that rely to some extent on the ongoing inspection and maintenance of the drainage system, it will be necessary to ensure that measures are in place to maintain the system for the lifetime of the development. In this case it is considered likely that the ongoing maintenance for different elements of the scheme will be adopted by different parties as outlined in Table 8.4.

Element of Drainage System	Responsibility for Maintenance
Adoptable highways	Highway Authority (KCC)
Leisure centre and associated car parking (including permeable paving and new outfall structure)	Local Authority (SDC)
Residential/remaining development (including permeable paving and new outfall structure)	A management company will be created and tasked with the inspection and maintenance of the permeable paving and rest of the piped drainage system

Table 8.4 – Maintenance responsibilities.

8.7 Residual Risk

When considering residual risk, it is necessary to consider the impact of a flood event that exceeds the design event, or the implications if the proposed drainage system was to become blocked.

Inspection of the topographic survey and the proposed landscaping plan identifies that the land levels across the site generally fall towards the coastline. Therefore, if the drainage system was to block, or become overwhelmed following an extreme rainfall event, water would exit the system and would flow overland. Figure 8.4 shows the most likely path water would take as it flows across the site.

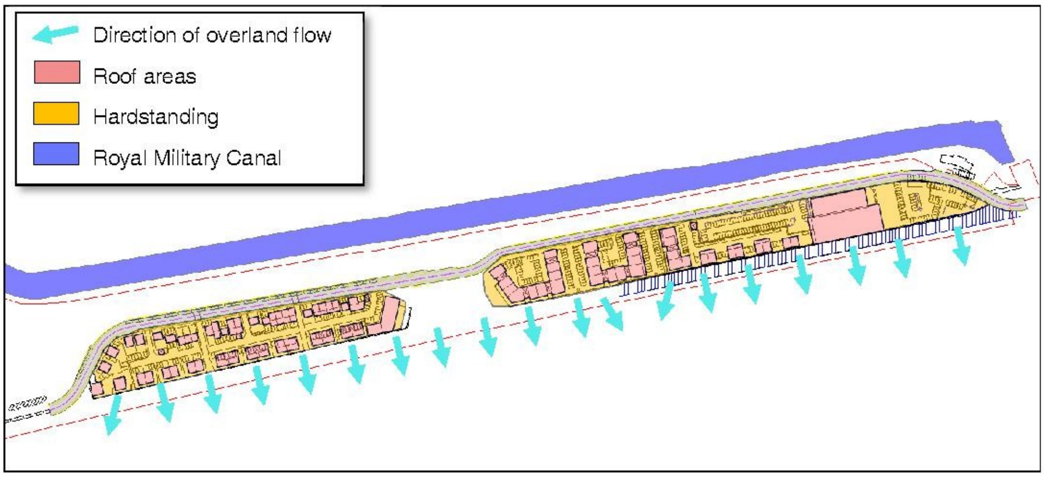


Figure 8.4 - Anticipated flow routes during an exceedance or blockage event.

From Figure 8.4, it is evident that most water would be discharged safely towards the coastline and would not pose any risk to the development or surrounding buildings. Furthermore, by incorporating permeable paving and providing storage within the piped drainage network beneath the site, the drainage proposals will provide additional storage for storm water when compared with the existing site which currently discharges to the Royal Military Canal. This additional storage will help to reduce the volume of water discharged from the site, even if the proposed drainage system were to fail under an extreme rainfall event and will provide a significant betterment when compared to the existing situation.

9 Conclusions

The key aims and objectives for a development that is to be sustainable in terms of flood risk are summarised in the following bullet points:

- the development should not be at a significant risk of flooding, and should not be susceptible to damage due to flooding.
- the development should not be exposed to flood risk such that the health, safety and welfare of the users of the development, or the population elsewhere, is threatened
- normal operation of the development should not be susceptible to disruption as a result of flooding and safe access to and from the development should be possible during flood events
- the development should not increase flood risk elsewhere
- the development should not prevent safe maintenance of watercourses or maintenance and operation of flood defences by the Environment Agency
- the development should not be associated with an onerous or difficult operation and maintenance regime to manage flood risk; the responsibility for any operation and maintenance required should be clearly defined
- the development should not lead to degradation of the environment
- the development should meet all of the above criteria for its entire lifetime, including consideration of the potential effects of climate change

In determining whether the proposals for development at Princes Parade, Hythe are sustainable in terms of flood risk and are compliant with the NPPF and its Planning Practice Guidance, all of the above have been taken into consideration as part of this FRA.

Section 2.3 of this report depicts the risk of flooding from the Environment Agency's coarse flood zone maps, which is used as the starting point to establish whether further analysis is required. With reference to both the SDC SFRA (2015) and the findings of this report, it is evident that the risk of flooding is significantly lower than is depicted by this coarse flood zone mapping and consequently, if the Sequential Test is applied, it is assumed that the development will meet the requirements. Without having a comprehensive knowledge of the land that is available for development in the district it is not possible for this FRA to comment in detail on the Test, nevertheless, the evidence provided within this report can be used to support the application of the Sequential Test if required.

In addition to the Sequential Test it is also necessary to consider the type and nature of the development and whether the Exception Test is applicable. From Table 2.3 it can be seen that the proposed development is situated within Flood Zone 3a and is a development type that is classified as being both 'less vulnerable' and 'more vulnerable'. Consequently, it has been necessary to apply the Exception Test to determine whether suitable and appropriate mitigation can be incorporated into the design of the scheme to ensure that it is sustainable in terms of flood risk.

The risk of flooding has therefore been considered across a wide range of sources and it is only the risk of flooding from wave overtopping that has been shown to have any bearing on the development. However, when this risk is examined in detail, it has been demonstrated that with appropriate mitigation, the occupants of the proposed development will be safe and remain so throughout the lifetime of the development.

The mitigation measures to be incorporated into this development include the following:

- An increased promenade (increased width from 6m to 12m), with a crossfall towards the beach.
- The construction of a secondary wave return wall, located 11m landward of the existing sea wall and 1m in height. This wall is not contiguous, but is designed to deflect water from the more vulnerable elements of the development.
- All development will be located a total of 12m (minimum) landward of the existing sea wall.
- Land levels across the site will be raised and will sloped towards the coast.
- Finished floor levels should also be raised a minimum of 600mm above the promenade level and set to a minimum of 6.45m AODN.
- Flood resistant and resilient construction techniques should be used where possible as a precautionary measure.
- 2 tidal outfalls will be constructed to reduce the volume of water entering the Royal Military Canal.

This FRA also demonstrates that the development will not increase the risk of flooding at the site and furthermore, by restricting the volume of surface water discharged into the Royal Military Canal, the proposed development will help to reduce the risk of flooding elsewhere. The surface water drainage strategy that has been identified at this early stage achieves the requirements of the National Technical Standards for SuDS by discharging the entire site directly into the sea via two proposed outfall structures.

In consideration of the above, it has been shown that the development will be safe, will meet the requirements of the NPPF and is therefore appropriate for its location within a flood risk area.

10 Recommendations

The findings of this report conclude that the development will not increase the risk of flooding at the site, or elsewhere. However, in order to achieve this a number of recommendations are listed below. These comprise the following.

- The finished floor level for all proposed buildings shall be set at least 600mm above the level of the promenade – a minimum of 6.45m AODN.

- Flood resilience measures (discussed in Section 6.5 of this report) are to be incorporated into the design of the building where possible. These measures should include high quality glazing and door/window fittings, to ensure that the building will not be impacted by wind blow spray and debris.

- The owner and occupants of the proposed dwelling should sign up to the Environment Agency's floodline warnings. The flood warnings provide residents with the opportunity to evacuate in the unlikely event than an exceedance event should occur.

- The surface water management strategy for the development will need to be developed to a detailed design stage and this will need to take into account the requirements set out in Section 8.1 and 8.2.

With the above mitigation measures incorporated into the design of the development the proposals will meet the requirements of the NPPF and its Planning Practice Guidance and will therefore be acceptable and sustainable in terms of flood risk.

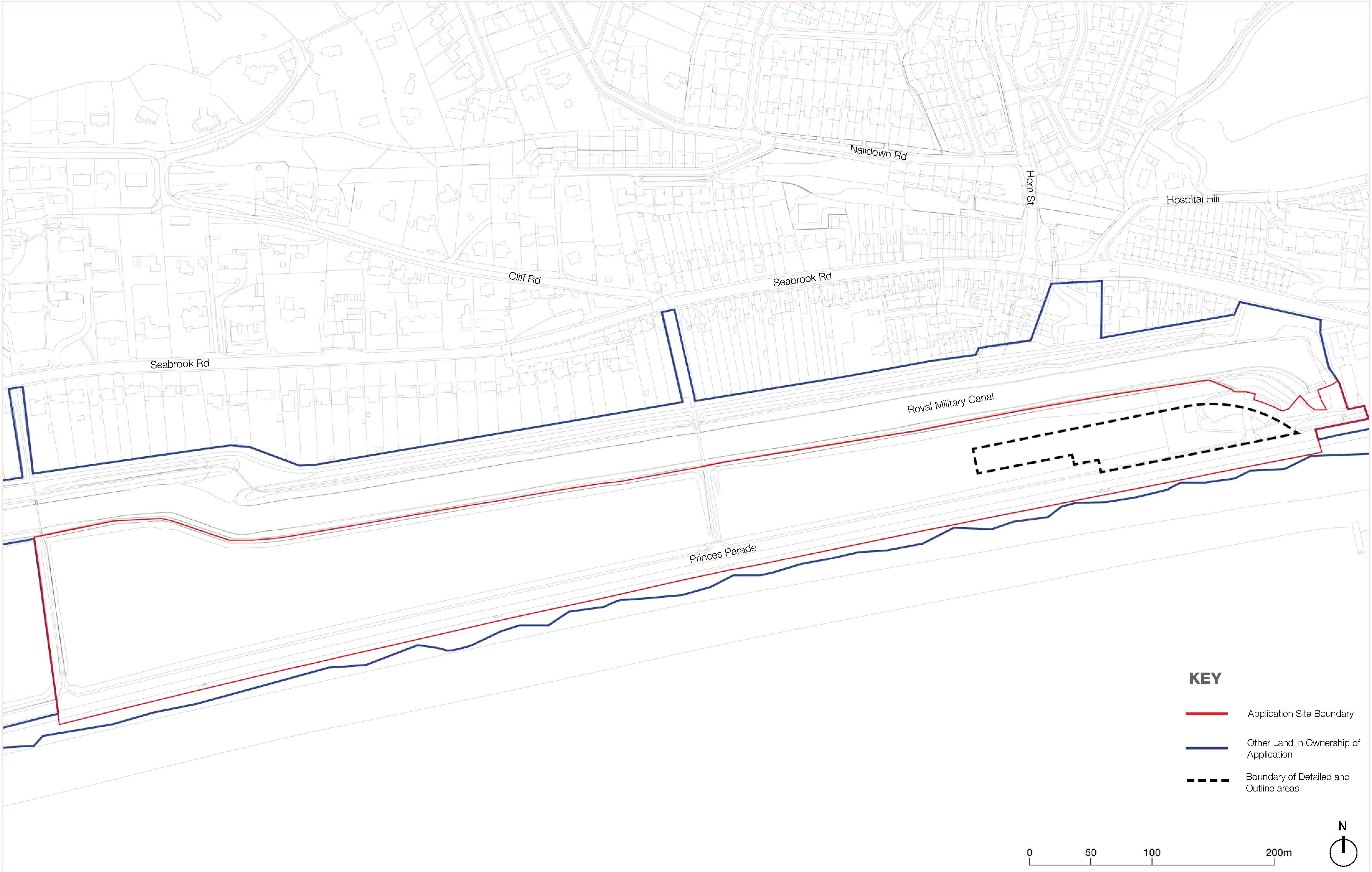
11 Appendices

Appendix A.1 – Drawings

Appendix A.2 – Environment Agency Correspondence

Appendix A.3 – Surface Water Management Calculations

Appendix A.1 – Drawings



Princes Parade

Site Location Plan

drawing no. LP 001a

scale 1: 2,000 @ A2

date 19-06-2017

Tibbalds

Princes Parade

Illustrative Masterplan

drawing no. IM 007

scale 1: 2,000 @ A2

date 08-08-2017

Tibbalds

Appendix A.2 – Environment Agency Correspondence

From: KSLPlanning [mailto:KSLPlanning@environment-agency.gov.uk]
Sent: 03 August 2017 14:54
To: Kirsty Thomas <[redacted]
Cc: Crates, Andrew [redacted]; Mortimer, Meriel <[redacted] Simon Maiden-Brooks <[redacted]
Subject: Confirmation of proposed mitigation for Princes Parade, Hythe

Dear Kirsty

Further to a pre-application meeting on the 2nd March 2017, it has now been agreed that the proposed development will be required to include the following mitigation measures;

1) 8 metre buffer zones are required for the Royal Military Canal and the Seapoint Outfall for maintenance access. Our Asset and Performance Team access the Seapoint Outfall from the car park (west);
2) Construction of a secondary wave return wall situated 11m inland of the existing sea wall. Proposed buildings to be located an additional 1m inland of secondary wall to provide an overall distance of 12m between the existing sea wall and proposed dwellings (a total of 12m from the sea wall);
3) Finished floor levels for the proposed dwellings to be set a minimum of 7.45m ODN; and
4) The Flood Risk Assessment to be submitted with the application needs to demonstrate that the building will not be impacted by windblown spray and debris.

Kind Regards,

Jennifer Wilson
Planning Specialist
Sustainable Places – Kent and South London

kslplanning@environment-agency.gov.uk
External: [redacted]

Appendix A.3 – Surface Water Management Calculations

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	9.225	1.225	2261.4	14.0	O K
30 min Summer	9.122	1.122	2028.2	10.8	O K
60 min Summer	8.859	0.859	1472.9	5.5	O K
120 min Summer	8.677	0.677	970.3	3.3	O K
180 min Summer	8.593	0.593	737.0	2.5	O K
240 min Summer	8.527	0.527	598.1	2.0	O K
360 min Summer	8.452	0.452	441.4	1.4	O K
480 min Summer	8.405	0.405	352.7	1.2	O K
600 min Summer	8.369	0.369	298.2	1.0	O K
720 min Summer	8.343	0.343	258.9	0.9	O K
960 min Summer	8.309	0.309	207.4	0.7	O K
1440 min Summer	8.251	0.251	150.7	0.5	O K
2160 min Summer	8.206	0.206	109.6	0.4	O K
2880 min Summer	8.184	0.184	89.1	0.3	O K
4320 min Summer	8.156	0.156	63.6	0.3	O K
5760 min Summer	8.142	0.142	50.8	0.3	O K
7200 min Summer	8.133	0.133	43.1	0.2	O K
8640 min Summer	8.126	0.126	36.7	0.2	O K
10080 min Summer	8.123	0.123	33.5	0.2	O K
15 min Winter	9.391	1.391	2692.6	14.1	O K
30 min Winter	9.149	1.149	2106.8	11.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	118.957	0.0	881.1	10
30 min Summer	79.711	0.0	1180.9	17
60 min Summer	50.847	0.0	1506.4	32
120 min Summer	31.206	0.0	1849.1	62
180 min Summer	23.054	0.0	2049.0	92
240 min Summer	18.539	0.0	2197.0	122
360 min Summer	13.627	0.0	2422.2	180
480 min Summer	10.934	0.0	2591.4	240
600 min Summer	9.210	0.0	2728.3	306
720 min Summer	8.000	0.0	2844.0	360
960 min Summer	6.400	0.0	3033.8	480
1440 min Summer	4.664	0.0	3316.4	714
2160 min Summer	3.392	0.0	3617.5	1064
2880 min Summer	2.702	0.0	3842.5	1460
4320 min Summer	1.958	0.0	4176.1	2156
5760 min Summer	1.557	0.0	4426.7	2936
7200 min Summer	1.304	0.0	4636.8	3672
8640 min Summer	1.129	0.0	4816.0	4240
10080 min Summer	0.999	0.0	4973.1	5144
15 min Winter	118.957	0.0	1174.8	9
30 min Winter	79.711	0.0	1574.4	17

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	8.819	0.819	1390.8	4.9	O K
120 min Winter	8.639	0.639	858.1	3.0	O K
180 min Winter	8.545	0.545	637.1	2.1	O K
240 min Winter	8.487	0.487	515.0	1.7	O K
360 min Winter	8.423	0.423	380.0	1.3	O K
480 min Winter	8.373	0.373	304.3	1.0	O K
600 min Winter	8.341	0.341	255.8	0.8	O K
720 min Winter	8.319	0.319	222.5	0.8	O K
960 min Winter	8.282	0.282	178.5	0.6	O K
1440 min Winter	8.229	0.229	130.2	0.4	O K
2160 min Winter	8.190	0.190	95.1	0.3	O K
2880 min Winter	8.171	0.171	77.3	0.3	O K
4320 min Winter	8.147	0.147	55.8	0.2	O K
5760 min Winter	8.135	0.135	44.4	0.2	O K
7200 min Winter	8.127	0.127	37.1	0.2	O K
8640 min Winter	8.121	0.121	31.7	0.2	O K
10080 min Winter	8.113	0.113	28.2	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	50.847	0.0	2009.0	34
120 min Winter	31.206	0.0	2465.3	62
180 min Winter	23.054	0.0	2732.0	92
240 min Winter	18.539	0.0	2929.2	120
360 min Winter	13.627	0.0	3229.5	182
480 min Winter	10.934	0.0	3455.2	242
600 min Winter	9.210	0.0	3637.8	312
720 min Winter	8.000	0.0	3792.0	356
960 min Winter	6.400	0.0	4045.0	480
1440 min Winter	4.664	0.0	4421.9	728
2160 min Winter	3.392	0.0	4823.4	1092
2880 min Winter	2.702	0.0	5123.5	1496
4320 min Winter	1.958	0.0	5568.2	2108
5760 min Winter	1.557	0.0	5902.4	2848
7200 min Winter	1.304	0.0	6182.8	3584
8640 min Winter	1.129	0.0	6421.9	4368
10080 min Winter	0.999	0.0	6631.5	48

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	20.900	Shortest Storm (mins)	15
Ratio R	0.353	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 3.950

Time From:	**(mins) To:**	**Area (ha)**
0	4	3.950

Model Details

Storage is Online Cover Level (m) 10.000

Pipe Structure

Diameter (m) 2.000 Length (m) 10.000
Slope (1:X) 10.000 Invert Level (m) 8.000

Pipe Outflow Control

Diameter (m) 2.000 Entry Loss Coefficient 0.500
Slope (1:X) 10.0 Coefficient of Contraction 0.600
Length (m) 1.000 Upstream Invert Level (m) 8.000
Manning's n 0.015

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	8.453	0.453	442.4	1.4	O K
30 min Summer	8.430	0.430	395.1	1.3	O K
60 min Summer	8.362	0.362	287.6	1.0	O K
120 min Summer	8.294	0.294	189.4	0.6	O K
180 min Summer	8.244	0.244	143.8	0.5	O K
240 min Summer	8.214	0.214	116.9	0.4	O K
360 min Summer	8.180	0.180	85.5	0.3	O K
480 min Summer	8.162	0.162	69.1	0.2	O K
600 min Summer	8.150	0.150	58.1	0.2	O K
720 min Summer	8.142	0.142	50.8	0.2	O K
960 min Summer	8.131	0.131	40.8	0.2	O K
1440 min Summer	8.117	0.117	29.8	0.2	O K
2160 min Summer	8.096	0.096	21.8	0.1	O K
2880 min Summer	8.084	0.084	17.4	0.1	O K
4320 min Summer	8.073	0.073	13.0	0.1	O K
5760 min Summer	8.069	0.069	11.5	0.2	O K
7200 min Summer	8.069	0.069	11.7	0.2	O K
8640 min Summer	8.060	0.060	8.2	0.2	O K
10080 min Summer	8.064	0.064	9.6	0.2	O K
15 min Winter	8.492	0.492	525.5	1.7	O K
30 min Winter	8.435	0.435	405.6	1.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	118.957	0.0	171.7	9
30 min Summer	79.711	0.0	230.2	17
60 min Summer	50.847	0.0	293.6	32
120 min Summer	31.206	0.0	360.4	62
180 min Summer	23.054	0.0	399.4	92
240 min Summer	18.539	0.0	428.3	122
360 min Summer	13.627	0.0	472.2	184
480 min Summer	10.934	0.0	505.2	242
600 min Summer	9.210	0.0	531.9	302
720 min Summer	8.000	0.0	554.4	364
960 min Summer	6.400	0.0	591.4	486
1440 min Summer	4.664	0.0	646.5	722
2160 min Summer	3.392	0.0	705.3	1096
2880 min Summer	2.702	0.0	749.3	1468
4320 min Summer	1.958	0.0	814.2	2176
5760 min Summer	1.557	0.0	884.4	4752
7200 min Summer	1.304	0.0	915.8	7144
8640 min Summer	1.129	0.0	957.7	1600
10080 min Summer	0.999	0.0	981.1	2144
15 min Winter	118.957	0.0	229.0	9
30 min Winter	79.711	0.0	306.9	17

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	8.350	0.350	269.5	0.9	O K
120 min Winter	8.270	0.270	167.6	0.6	O K
180 min Winter	8.224	0.224	125.6	0.4	O K
240 min Winter	8.196	0.196	100.1	0.3	O K
360 min Winter	8.167	0.167	74.1	0.3	O K
480 min Winter	8.151	0.151	59.5	0.2	O K
600 min Winter	8.142	0.142	50.8	0.2	O K
720 min Winter	8.135	0.135	44.4	0.2	O K
960 min Winter	8.125	0.125	35.3	0.2	O K
1440 min Winter	8.105	0.105	25.4	0.1	O K
2160 min Winter	8.087	0.087	18.6	0.1	O K
2880 min Winter	8.078	0.078	15.1	0.1	O K
4320 min Winter	8.067	0.067	11.0	0.1	O K
5760 min Winter	8.071	0.071	12.3	0.2	O K
7200 min Winter	8.067	0.067	11.0	0.2	O K
8640 min Winter	8.070	0.070	12.1	0.2	O K
10080 min Winter	8.067	0.067	10.8	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	50.847	0.0	391.5	32
120 min Winter	31.206	0.0	480.6	64
180 min Winter	23.054	0.0	532.6	94
240 min Winter	18.539	0.0	571.0	120
360 min Winter	13.627	0.0	629.6	188
480 min Winter	10.934	0.0	673.5	238
600 min Winter	9.210	0.0	709.2	306
720 min Winter	8.000	0.0	739.2	348
960 min Winter	6.400	0.0	788.5	476
1440 min Winter	4.664	0.0	862.0	732
2160 min Winter	3.392	0.0	940.4	1088
2880 min Winter	2.702	0.0	998.9	1460
4320 min Winter	1.958	0.0	1085.5	2112
5760 min Winter	1.557	0.0	1151.7	2200
7200 min Winter	1.304	0.0	1208.0	7072
8640 min Winter	1.129	0.0	1257.9	4408
10080 min Winter	0.999	0.0	1310.1	672

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	20.900	Shortest Storm (mins)	15
Ratio R	0.353	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.770

Time (mins) From:	To:	Area (ha)
0	4	0.770

Model Details

Storage is Online Cover Level (m) 10.000

Pipe Structure

Diameter (m)	2.000	Length (m)	10.000
Slope (1:X)	10.000	Invert Level (m)	8.000

Pipe Outflow Control

Diameter (m)	2.000	Entry Loss Coefficient	0.500
Slope (1:X)	10.0	Coefficient of Contraction	0.600
Length (m)	1.000	Upstream Invert Level (m)	8.000
Manning's n	0.015		

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	8.237	0.237	137.5	0.4	O K
30 min Summer	8.221	0.221	122.9	0.4	O K
60 min Summer	8.184	0.184	89.6	0.3	O K
120 min Summer	8.150	0.150	58.6	0.2	O K
180 min Summer	8.135	0.135	44.9	0.2	O K
240 min Summer	8.125	0.125	35.8	0.2	O K
360 min Summer	8.109	0.109	26.7	0.1	O K
480 min Summer	8.095	0.095	21.6	0.1	O K
600 min Summer	8.087	0.087	18.4	0.1	O K
720 min Summer	8.080	0.080	15.9	0.1	O K
960 min Summer	8.072	0.072	12.9	0.1	O K
1440 min Summer	8.063	0.063	9.4	0.1	O K
2160 min Summer	8.050	0.050	6.8	0.1	O K
2880 min Summer	8.048	0.048	6.6	0.1	O K
4320 min Summer	8.051	0.051	6.9	0.1	O K
5760 min Summer	8.043	0.043	5.9	0.2	O K
7200 min Summer	8.036	0.036	4.9	0.2	O K
8640 min Summer	8.030	0.030	4.1	0.2	O K
10080 min Summer	8.029	0.029	3.9	0.2	O K
15 min Winter	8.266	0.266	163.9	0.5	O K
30 min Winter	8.224	0.224	125.6	0.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	118.957	0.0	53.5	10
30 min Summer	79.711	0.0	71.7	17
60 min Summer	50.847	0.0	91.5	32
120 min Summer	31.206	0.0	112.3	62
180 min Summer	23.054	0.0	124.5	90
240 min Summer	18.539	0.0	133.5	122
360 min Summer	13.627	0.0	147.2	180
480 min Summer	10.934	0.0	157.5	244
600 min Summer	9.210	0.0	165.8	306
720 min Summer	8.000	0.0	172.8	358
960 min Summer	6.400	0.0	184.4	478
1440 min Summer	4.664	0.0	201.5	728
2160 min Summer	3.392	0.0	220.3	1828
2880 min Summer	2.702	0.0	235.2	2440
4320 min Summer	1.958	0.0	258.7	1048
5760 min Summer	1.557	0.0	275.4	3896
7200 min Summer	1.304	0.0	288.0	5152
8640 min Summer	1.129	0.0	299.3	5312
10080 min Summer	0.999	0.0	312.6	3680
15 min Winter	118.957	0.0	71.4	10
30 min Winter	79.711	0.0	95.7	17

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	8.179	0.179	84.6	0.3	O K
120 min Winter	8.143	0.143	52.2	0.2	O K
180 min Winter	8.129	0.129	39.4	0.2	O K
240 min Winter	8.120	0.120	31.2	0.2	O K
360 min Winter	8.099	0.099	23.1	0.1	O K
480 min Winter	8.087	0.087	18.6	0.1	O K
600 min Winter	8.080	0.080	15.9	0.1	O K
720 min Winter	8.075	0.075	13.8	0.1	O K
960 min Winter	8.068	0.068	11.1	0.1	O K
1440 min Winter	8.058	0.058	7.9	0.1	O K
2160 min Winter	8.057	0.057	7.8	0.1	O K
2880 min Winter	8.060	0.060	8.2	0.1	O K
4320 min Winter	8.046	0.046	6.3	0.1	O K
5760 min Winter	8.039	0.039	5.3	0.2	O K
7200 min Winter	8.033	0.033	4.5	0.2	O K
8640 min Winter	8.028	0.028	3.9	0.2	O K
10080 min Winter	8.025	0.025	3.4	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	50.847	0.0	122.0	34
120 min Winter	31.206	0.0	149.8	60
180 min Winter	23.054	0.0	166.0	88
240 min Winter	18.539	0.0	178.0	120
360 min Winter	13.627	0.0	196.2	182
480 min Winter	10.934	0.0	209.9	236
600 min Winter	9.210	0.0	221.0	310
720 min Winter	8.000	0.0	230.4	368
960 min Winter	6.400	0.0	245.8	480
1440 min Winter	4.664	0.0	268.7	714
2160 min Winter	3.392	0.0	293.8	68
2880 min Winter	2.702	0.0	314.7	2524
4320 min Winter	1.958	0.0	339.8	972
5760 min Winter	1.557	0.0	369.0	1160
7200 min Winter	1.304	0.0	388.3	6160
8640 min Winter	1.129	0.0	401.8	6416
10080 min Winter	0.999	0.0	413.4	3792

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	20.900	Shortest Storm (mins)	15
Ratio R	0.353	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.240

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.240

Model Details

Storage is Online Cover Level (m) 10.000

Pipe Structure

Diameter (m)	2.000	Length (m)	10.000
Slope (1:X)	10.000	Invert Level (m)	8.000

Pipe Outflow Control

Diameter (m)	2.000	Entry Loss Coefficient	0.500
Slope (1:X)	10.0	Coefficient of Contraction	0.600
Length (m)	1.000	Upstream Invert Level (m)	8.000
Manning's n	0.015		

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	8.498	0.498	538.2	1.8	O K
30 min Summer	8.470	0.470	478.2	1.6	O K
60 min Summer	8.405	0.405	353.5	1.1	O K
120 min Summer	8.325	0.325	231.6	0.7	O K
180 min Summer	8.278	0.278	175.3	0.6	O K
240 min Summer	8.243	0.243	142.9	0.5	O K
360 min Summer	8.200	0.200	104.2	0.3	O K
480 min Summer	8.178	0.178	84.1	0.3	O K
600 min Summer	8.164	0.164	70.9	0.3	O K
720 min Summer	8.155	0.155	62.7	0.2	O K
960 min Summer	8.141	0.141	50.4	0.2	O K
1440 min Summer	8.126	0.126	36.2	0.2	O K
2160 min Summer	8.108	0.108	26.3	0.1	O K
2880 min Summer	8.093	0.093	20.8	0.1	O K
4320 min Summer	8.078	0.078	15.1	0.1	O K
5760 min Summer	8.071	0.071	12.5	0.2	O K
7200 min Summer	8.066	0.066	10.4	0.2	O K
8640 min Summer	8.063	0.063	9.2	0.2	O K
10080 min Summer	8.062	0.062	8.9	0.2	O K
15 min Winter	8.549	0.549	644.4	2.1	O K
30 min Winter	8.478	0.478	496.1	1.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	118.957	0.0	209.7	9
30 min Summer	79.711	0.0	281.0	17
60 min Summer	50.847	0.0	358.6	32
120 min Summer	31.206	0.0	440.0	62
180 min Summer	23.054	0.0	487.6	92
240 min Summer	18.539	0.0	522.8	122
360 min Summer	13.627	0.0	576.4	178
480 min Summer	10.934	0.0	616.7	238
600 min Summer	9.210	0.0	649.3	300
720 min Summer	8.000	0.0	676.8	358
960 min Summer	6.400	0.0	722.0	490
1440 min Summer	4.664	0.0	789.2	716
2160 min Summer	3.392	0.0	860.9	1080
2880 min Summer	2.702	0.0	914.6	1464
4320 min Summer	1.958	0.0	993.9	2144
5760 min Summer	1.557	0.0	1057.9	5768
7200 min Summer	1.304	0.0	1122.8	1112
8640 min Summer	1.129	0.0	1168.5	6832
10080 min Summer	0.999	0.0	1200.6	9384
15 min Winter	118.957	0.0	279.6	10
30 min Winter	79.711	0.0	374.7	17

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	8.388	0.388	327.7	1.1	O K
120 min Winter	8.307	0.307	204.3	0.7	O K
180 min Winter	8.252	0.252	151.6	0.5	O K
240 min Winter	8.221	0.221	122.9	0.4	O K
360 min Winter	8.186	0.186	91.0	0.3	O K
480 min Winter	8.166	0.166	72.7	0.3	O K
600 min Winter	8.153	0.153	61.3	0.2	O K
720 min Winter	8.145	0.145	54.0	0.2	O K
960 min Winter	8.134	0.134	43.5	0.2	O K
1440 min Winter	8.120	0.120	30.9	0.2	O K
2160 min Winter	8.098	0.098	22.7	0.1	O K
2880 min Winter	8.087	0.087	18.4	0.1	O K
4320 min Winter	8.073	0.073	13.2	0.1	O K
5760 min Winter	8.068	0.068	11.1	0.2	O K
7200 min Winter	8.070	0.070	12.1	0.2	O K
8640 min Winter	8.062	0.062	9.1	0.2	O K
10080 min Winter	8.068	0.068	11.3	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	50.847	0.0	478.0	32
120 min Winter	31.206	0.0	586.7	60
180 min Winter	23.054	0.0	650.1	94
240 min Winter	18.539	0.0	697.1	120
360 min Winter	13.627	0.0	768.5	178
480 min Winter	10.934	0.0	822.2	248
600 min Winter	9.210	0.0	865.7	304
720 min Winter	8.000	0.0	902.4	374
960 min Winter	6.400	0.0	962.6	482
1440 min Winter	4.664	0.0	1052.4	738
2160 min Winter	3.392	0.0	1147.8	1084
2880 min Winter	2.702	0.0	1219.4	1476
4320 min Winter	1.958	0.0	1325.8	2224
5760 min Winter	1.557	0.0	1406.9	5592
7200 min Winter	1.304	0.0	1473.1	2784
8640 min Winter	1.129	0.0	1530.8	232
10080 min Winter	0.999	0.0	1583.6	9656

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	20.900	Shortest Storm (mins)	15
Ratio R	0.353	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.940

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.940

Model Details

Storage is Online Cover Level (m) 10.000

Pipe Structure

Diameter (m)	2.000	Length (m)	10.000
Slope (1:X)	10.000	Invert Level (m)	8.000

Pipe Outflow Control

Diameter (m)	2.000	Entry Loss Coefficient	0.500
Slope (1:X)	10.0	Coefficient of Contraction	0.600
Length (m)	1.000	Upstream Invert Level (m)	8.000
Manning's n	0.015		

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	8.736	0.736	1145.9	4.0	O K
30 min Summer	8.694	0.694	1020.4	3.5	O K
60 min Summer	8.598	0.598	748.6	2.5	O K
120 min Summer	8.475	0.475	489.8	1.6	O K
180 min Summer	8.419	0.419	374.7	1.2	O K
240 min Summer	8.371	0.371	302.0	1.0	O K
360 min Summer	8.319	0.319	222.5	0.8	O K
480 min Summer	8.282	0.282	179.0	0.6	O K
600 min Summer	8.251	0.251	150.7	0.5	O K
720 min Summer	8.229	0.229	130.6	0.4	O K
960 min Summer	8.201	0.201	105.1	0.3	O K
1440 min Summer	8.170	0.170	76.8	0.3	O K
2160 min Summer	8.147	0.147	55.8	0.2	O K
2880 min Summer	8.136	0.136	45.4	0.2	O K
4320 min Summer	8.122	0.122	32.6	0.2	O K
5760 min Summer	8.106	0.106	25.8	0.2	O K
7200 min Summer	8.098	0.098	22.5	0.2	O K
8640 min Summer	8.088	0.088	18.9	0.2	O K
10080 min Summer	8.084	0.084	17.4	0.2	O K
15 min Winter	8.809	0.809	1361.3	4.5	O K
30 min Winter	8.705	0.705	1054.4	3.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	118.957	0.0	446.1	9
30 min Summer	79.711	0.0	597.9	17
60 min Summer	50.847	0.0	762.8	32
120 min Summer	31.206	0.0	936.2	62
180 min Summer	23.054	0.0	1037.4	92
240 min Summer	18.539	0.0	1112.4	122
360 min Summer	13.627	0.0	1226.4	180
480 min Summer	10.934	0.0	1312.1	240
600 min Summer	9.210	0.0	1381.4	300
720 min Summer	8.000	0.0	1440.0	366
960 min Summer	6.400	0.0	1536.1	482
1440 min Summer	4.664	0.0	1679.2	728
2160 min Summer	3.392	0.0	1831.7	1084
2880 min Summer	2.702	0.0	1945.6	1456
4320 min Summer	1.958	0.0	2114.5	2120
5760 min Summer	1.557	0.0	2241.4	2864
7200 min Summer	1.304	0.0	2348.2	2312
8640 min Summer	1.129	0.0	2439.1	7272
10080 min Summer	0.999	0.0	2529.6	304
15 min Winter	118.957	0.0	594.9	10
30 min Winter	79.711	0.0	797.1	17

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	8.576	0.576	701.2	2.3	O K
120 min Winter	8.450	0.450	436.1	1.4	O K
180 min Winter	8.386	0.386	324.0	1.1	O K
240 min Winter	8.344	0.344	260.4	0.9	O K
360 min Winter	8.296	0.296	191.3	0.7	O K
480 min Winter	8.255	0.255	153.9	0.5	O K
600 min Winter	8.228	0.228	129.7	0.4	O K
720 min Winter	8.209	0.209	112.4	0.4	O K
960 min Winter	8.186	0.186	91.0	0.3	O K
1440 min Winter	8.159	0.159	66.8	0.2	O K
2160 min Winter	8.139	0.139	48.1	0.2	O K
2880 min Winter	8.129	0.129	39.0	0.2	O K
4320 min Winter	8.111	0.111	27.7	0.2	O K
5760 min Winter	8.097	0.097	22.4	0.2	O K
7200 min Winter	8.088	0.088	18.7	0.2	O K
8640 min Winter	8.081	0.081	16.3	0.2	O K
10080 min Winter	8.077	0.077	14.6	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	50.847	0.0	1016.9	32
120 min Winter	31.206	0.0	1248.3	64
180 min Winter	23.054	0.0	1383.3	90
240 min Winter	18.539	0.0	1483.2	122
360 min Winter	13.627	0.0	1635.2	184
480 min Winter	10.934	0.0	1749.5	240
600 min Winter	9.210	0.0	1841.9	304
720 min Winter	8.000	0.0	1920.0	354
960 min Winter	6.400	0.0	2048.1	494
1440 min Winter	4.664	0.0	2239.0	756
2160 min Winter	3.392	0.0	2442.2	1068
2880 min Winter	2.702	0.0	2594.1	1356
4320 min Winter	1.958	0.0	2819.8	2224
5760 min Winter	1.557	0.0	2989.7	5704
7200 min Winter	1.304	0.0	3132.3	1928
8640 min Winter	1.129	0.0	3252.9	2512
10080 min Winter	0.999	0.0	3360.4	408

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	20.900	Shortest Storm (mins)	15
Ratio R	0.353	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 2.000

Time From:	**(mins) To:**	**Area (ha)**
0	4	2.000

Model Details

Storage is Online Cover Level (m) 10.000

Pipe Structure

Diameter (m)	2.000	Length (m)	10.000
Slope (1:X)	10.000	Invert Level (m)	8.000

Pipe Outflow Control

Diameter (m)	2.000	Entry Loss Coefficient	0.500
Slope (1:X)	10.0	Coefficient of Contraction	0.600
Length (m)	1.000	Upstream Invert Level (m)	8.000
Manning's n	0.015		