BANKFIELD LANE, SOUTHPORT

FLOOD RISK ASSESSMENT

Final Report v1.2

October 2015

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1 INTRODUCTION

1.1 PURPOSE OF REPORT

Weetwood Services Ltd ('Weetwood') has been instructed by Wainhomes Developments Ltd to undertake a Flood Risk Assessment (FRA) for land at Bankfield Lane, Southport.

Part of the land under the control of Wainhomes Developments Ltd is identified within the Local Plan for Sefton Draft Publication dated January 2015 as a potential housing allocation (Site Ref: MN2.2). The eastern area of the land is identified as proposed open space.

A Flood Risk Statement (FRS) was prepared by Weetwood in August 2013 in support of the site’s allocation. The Sefton Council Site Selection subsequently concluded that the MN2.2 site area is appropriate for allocation in the Local Plan; however, draft representations submitted by the Environment Agency (EA) indicate that additional information is required in respect of the proposed allocation.

Sefton Council has indicated that the EA are generally in agreement with the FRS; however, the Council wish to fully address any outstanding queries/issues in advance of the Examination later this year.

This FRA has therefore been prepared in order to take account of the comments made by the EA in support of the site’s allocation and has been undertaken in accordance with the requirements of the National Planning Policy Framework (NPPF) and supporting Planning Practice Guidance.

1.2 STRUCTURE OF THE REPORT

The report is structured as follows:

Section 1	Introduction and report structure
Section 2	Presents national and local flood risk and drainage planning policy
Section 3	Provides background information relating to the development site, the development proposals, ground conditions and existing site access arrangements
Section 4	Assesses the potential sources of flooding to the development site
Section 5	Presents flood risk mitigation measures based on the findings of the assessment
Section 6	Addresses the effect of the proposed development on surface water runoff and presents an illustrative surface water drainage scheme to ensure that surface water runoff is sustainably managed and flood risk is not increased elsewhere.
Section 7	Presents a summary of key findings
Section 8	Presents the recommendations

2 PLANNING POLICY AND GUIDANCE

2.1 NATIONAL PLANNING POLICY

The aim of the NPPF is to ensure that flood risk is taken into account at all stages in the planning process and is appropriately addressed.

2.1.1 Sequential Test

Paragraph 100 of the NPPF states that '*inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk but where development is necessary, making it safe without increasing flood risk elsewhere*'.

This policy is implemented through the application of the flood risk Sequential Test which aims to steer new development to areas with the lowest probability of flooding.

2.1.2 Exception Test

If, following application of the Sequential Test, it is not possible for the development to be located in zones with a lower probability of flooding, the Exception Test can be applied, if appropriate.

As detailed in paragraph 102 of the NPPF, for the Exception Test to be passed:

- 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 (SFRA) where one has been prepared; and
- A site-specific FRA 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.

2.2 LOCAL PLANNING POLICY AND GUIDANCE

The Local Plan for Sefton Draft Publication dated January 2015 sets out the spatial vision, objectives, development strategy and policies for Sefton.

This is yet to be adopted; however, the following policies relate to flood risk and surface water drainage:

<u>EQ8; Managing Flood Risk and Surface Water</u>

1. Development must be located in areas at lowest risk of flooding from all sources. Within the site, buildings must be located in the areas at lowest risk of flooding.
2. Development must not increase flood risk from any sources within the site or elsewhere, and where possible should reduce flood risk.
3. Site-specific [FRAs] will be required for all development on sites of 0.5 hectares or more in Critical Drainage Areas as defined in the [SFRA].
4. Development must incorporate sustainable drainage systems to manage surface water flooding run-off within the site so that:
    a. Surface water run-off rates and volumes are reduced by 20% (compared to the pre-existing rates) for sites covered by buildings or impermeable hard surfaces, and for greenfield sites do not exceed greenfield rates.

b. Surface water discharge is targeted using a sequential approach, and proposals to discharge surface water into anything other than the ground must demonstrate why the other sequentially preferable alternatives cannot be implemented:

   i. Into the ground
   ii. Into a watercourse or surface water body,
   iii. Into a surface water sewer, or
   iv. Into a combined sewer.

c. Above ground, natural drainage features rather than engineered or underground systems are used.

5. Sustainable drainage systems and any water storage areas must control pollution and should enhance water quality and existing habitats and create new habitats where practicable.
6. Development on an area which is an adopted Sustainable Drainage System or has a formal flood risk management function is acceptable in principle where the development proposals do not reduce the ability of the area to manage the surface water or flood risk.

2.3 FLOOD DEFENCE CONSENT

Flood defence consent is required before the commencement of any works in, over, or under a main river to ensure that any works do not increase flood risk, damage flood defences, or harm the environment, fisheries, or wildlife (Water Resources Act 1991). Ordinary watercourse consent is required where the watercourse is not a main river (Land Drainage Act 1991).

For main rivers, responsibility for consenting rests with the EA in England and Natural Resources Wales (NRW) in Wales. For ordinary watercourses, responsibility usually rests with the Lead Local Flood Authority or Internal Drainage Board (Flood and Water Management Act 2010).

Undertaking activities controlled by local Byelaws (made under the Water Resources Act 1991) also requires the relevant consent. Byelaws typically include erecting an obstruction with 8 metres of a main river or erecting structures within the floodplain.

2.4 RELEVANT DOCUMENTS

The FRS has been informed by the following documents:

- SFRA, Sefton Council, March 2013
- Preliminary Flood Risk Assessment (PFRA), Sefton Council, May 2011
- Surface Water Management Plan (SWMP), Sefton Council, August 2011

3 SITE DETAILS AND PROPOSED DEVELOPMENT

3.1 SITE LOCATION

The site is located at Ordnance Survey National Grid Reference SD 374 192, as shown in **Figure 1**. The land under the control of Wainhomes Developments Ltd equates to approximately 20.4 hectares (ha) in area, of which Site Ref: MN2.2 (as proposed for allocation) comprises approximately 9.1 ha.

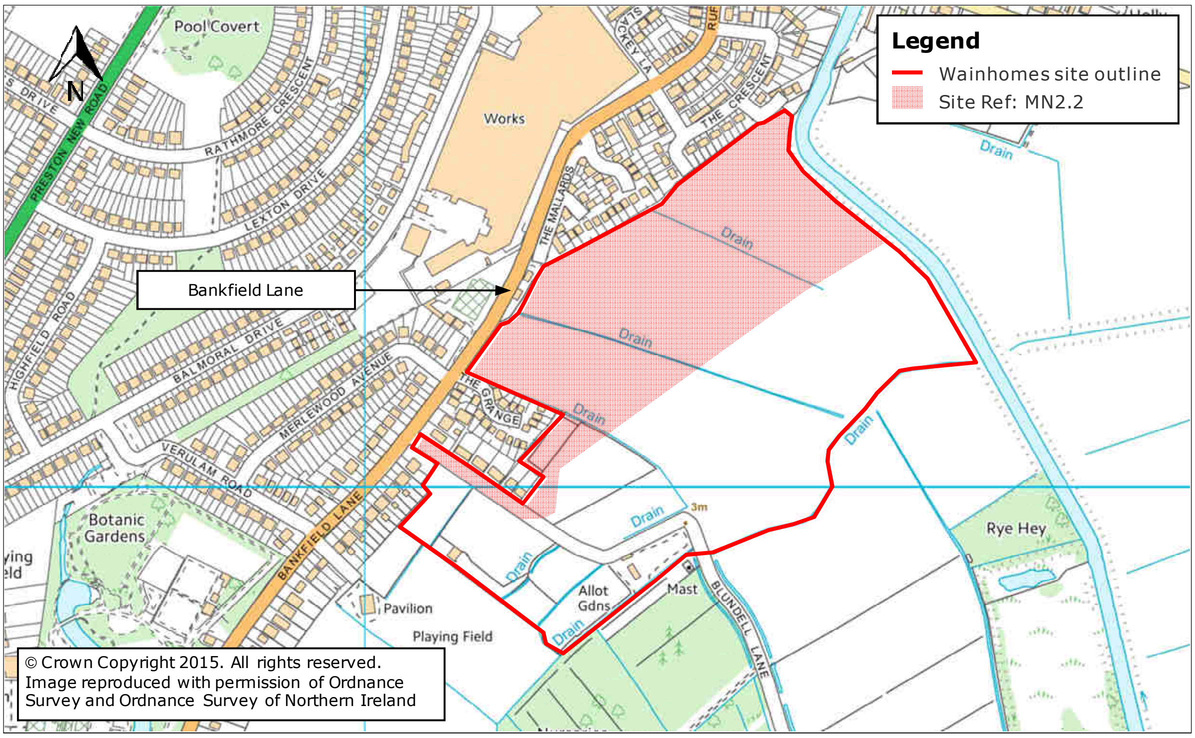


Figure 1: Site Location

3.2 EXISTING AND PROPOSED DEVELOPMENT

The site currently comprises largely greenfield land.

Part of the site is identified within the Local Plan for Sefton Draft Publication dated January 2015 as a potential housing allocation (Site Ref: MN2.2).

The NPPF Planning Practice Guidance classifies residential development as 'more vulnerable' land use.

3.3 GROUND CONDITIONS

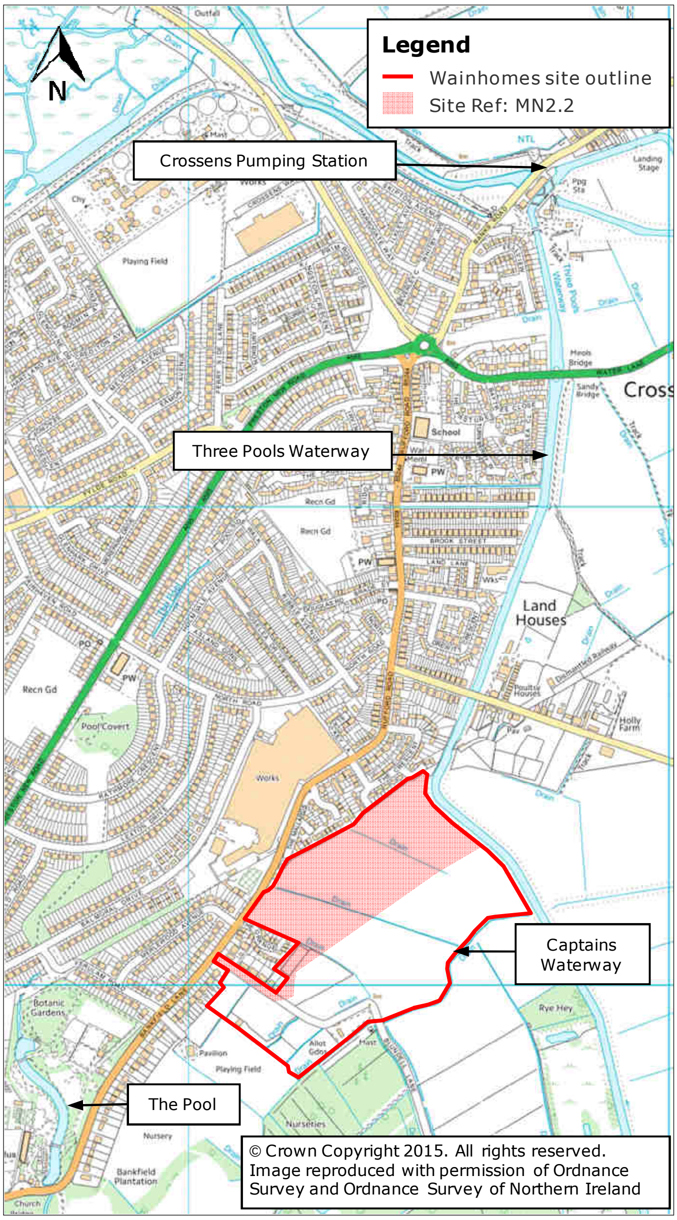
According to the British Geological Survey (BGS) Surface Geology maps[1] the underlying bedrock comprises *Sidmouth Mudstone Formation – Mudstone*. This is overlain by *Tidal Flat Deposits – Clay and Silt* superficial deposits.

[1] http://mapapps.bgs.ac.uk/geologyofbritain/home.html

According to the Soilscapes maps produced by the National Soils Research Institute[2], soil conditions within the west of the site are described as '*naturally wet very acid sandy and loamy soils'*, whilst those in the east are described as *'loamy and clayey soils of coastal flats with naturally high groundwater'*.

3.4 WATERBODIES IN THE VICINITY OF THE SITE

There are a number of existing waterbodies within the vicinity of the site as illustrated and detailed within **Figure 2**.



Captains Waterway

Flows in a north-easterly direction along the southern boundary of the site. This ultimately outfalls to Three Pools Waterway.

Captains Way is classified as a main river.

Three Pools Waterway

Flows in a predominately northerly direction along the eastern boundary of the site. This watercourse ultimately outfalls to the Irish Sea via the Crossens pumping station.

There is an existing flood defence located along the left bank of the watercourse in the east of the site, which is maintained by the EA.

Three Pools Waterway is classified as a main river.

The Pool

Flows in a northerly and then north-easterly direction approximately 0.39 km to the west of the site. This ultimately outfalls to Three Pools Waterway approximately 0.65 km to the north of the site.

The Pool is classified as an ordinary watercourse.

Irish Sea

The Irish Sea is located approximately 2.5 km to the west of the site.

A number of existing coastal defences are present within Southport.

Land drains

There are a number of existing land drains within the site and surrounding area.

Groundwater body

The underlying *Sidmouth Mudstone Formation* bedrock is defined as a Secondary B aquifer[3].

The site is not located within a Source Protection Zone.

Figure 2: Location and Description of Waterbodies

2 Soilscapes www.landis.org.uk/soilscapes/

3 Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

3.5 SITE LEVELS

A topographic survey of the site has been undertaken by JLP Surveys Ltd and is provided in **Appendix A**.

Site levels are shown to be in the region of 1.40 to 5.00 metres Above Ordnance Datum (m AOD) falling to the south-east and north-east towards Captains Waterway and Three Pools Waterway.

3.6 ACCESS AND EGRESS

Access and egress to the site is provided via Bankfield Lane to the west. Levels along this route are typically in the region of 5.10 to 5.30 m AOD at the site entrance.

4 REVIEW OF FLOOD RISK

4.1 FLOOD ZONE DESIGNATION

Flood Zones refer to the probability of river and sea flooding, ignoring the presence of defences. The NPPF Planning Practice Guidance defines Flood Zones as follows:

- **Flood Zone 1: Low Probability**. Land having a less than 1 in 1,000 annual probability of river or sea flooding.
- **Flood Zone 2: Medium Probability**. Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or Land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding.
- **Flood Zone 3a: High Probability**. Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding.
- **Flood Zone 3b: The Functional Floodplain**. This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency.

4.1.1 Environment Agency Flood Map for Planning (Rivers and Sea)

According to the EA Flood Map for Planning (Rivers and Sea) (**Figure 3**) the site is located predominately within the defended Flood Zone 3; however, there is an area in the north in Flood Zone 1 and Flood Zone 2.

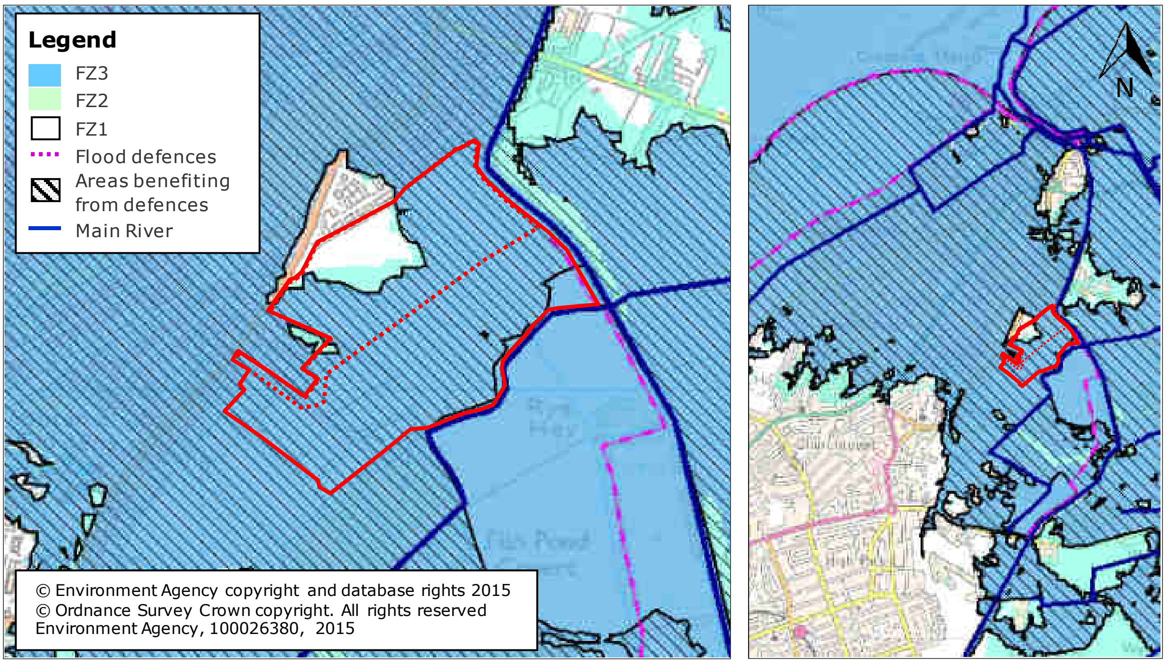


Figure 3: Environment Agency Flood Map for Planning (Rivers & Sea)
(Source: EA website)

4.1.2 Strategic Flood Risk Assessment

Figure 3-1 and Figure 4-1 of the Sefton Council SFRA (**Figure 4**) illustrate the fluvial and tidal flood zones (i.e. ignoring the presence of defences) within Sefton. These differ to the flood outlines as shown on the EA Flood Map for Planning (Rivers and Sea);

however, the EA Flood Map is considered to provide the most up-to-date information as this is based upon modelling completed by the EA in August 2015.

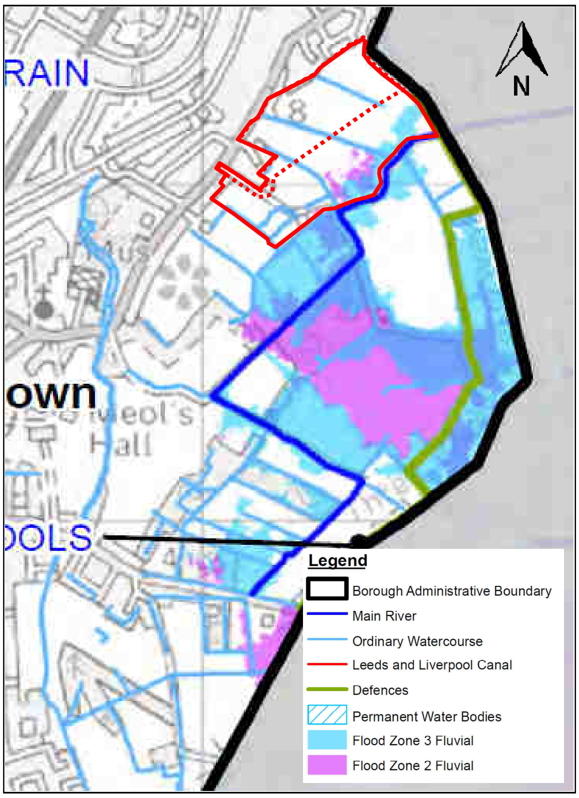


Figure 3-1 EA Fluvial Flood Zones

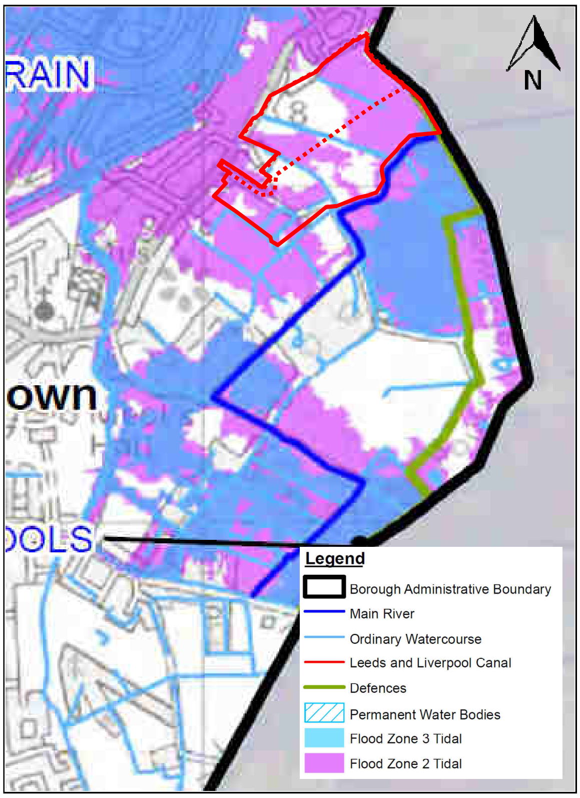


Figure 4-1 EA Tidal Flood Zones

Figure 4: Strategic Flood Risk Assessment - Flood Zones
(Source: Sefton Council SFRA)

4.2 SEQUENTIAL TEST AND EXCEPTION TEST

The Sefton Council Local Plan Site Selection states that *'the site is in Flood Zone 1 once existing flood defences are taken into account, as confirmed by the SFRA'* and that the Sequential Test is subsequently deemed to have been passed.

The Exception Test is required for more vulnerable land use within Flood Zone 3. The first part of the Exception test has been addressed by Wainhomes Developments Ltd.

This report addresses the second part of the Exception Test.

4.3 HISTORICAL RECORDS OF FLOODING

Figure 18 and Table 4-1 of the SFRA do not provide any records of historical fluvial flooding incidents within the vicinity of the site. Table 4-3 provides three records of *'sea walls broken down in Southport'* from January 1839, December 1852 and January 1959; however, it is not known whether these events affected the site.

The EA has advised[4] it does not hold any records of flooding at this location.

[4] EA data request Ref PRE8531

4.4 COASTAL FLOOD RISK - IRISH SEA

As detailed in **Section 3.4** the Irish Sea is located approximately 2.5 km to west of the site.

4.4.1 Flood Defences

Figure 11a-1 and Figure 11b-1 of the SFRA (**Figure 5**) illustrate the manmade and natural flood defences located along the section of the Irish Sea coastline to the west of the site. These are defined as being in *'fair'* condition and are maintained by the EA.

The EA has provided effective crest levels for the coastal defences within the vicinity of the site. These are illustrated in **Figure 6** and indicate a typical crest height of between 7.20 and 7.30 m AOD.

Figure 6 indicates that a section of the coastal defence (Ref: 012KB90060301C12 - approximately 921.7 m in length) is at a level of 6.80 m AOD; however, the secondary defence to the south-east is at a height of 7.00 m AOD and as such would ensure that a continuous level of protection is afforded.

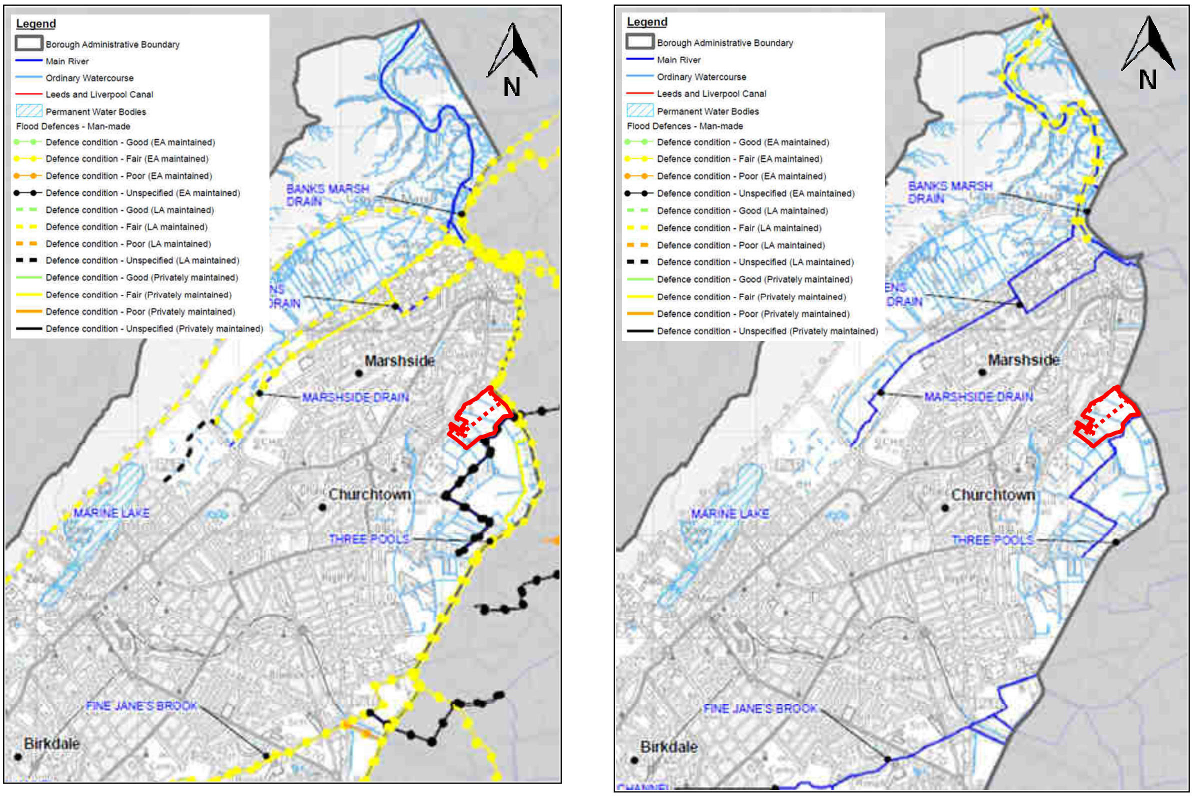


Figure 11a-1 Flood Defences - Manmade *Figure 11b-1 Flood Defences - Natural*

Figure 5: Strategic Flood Risk Assessment - Flood Defences

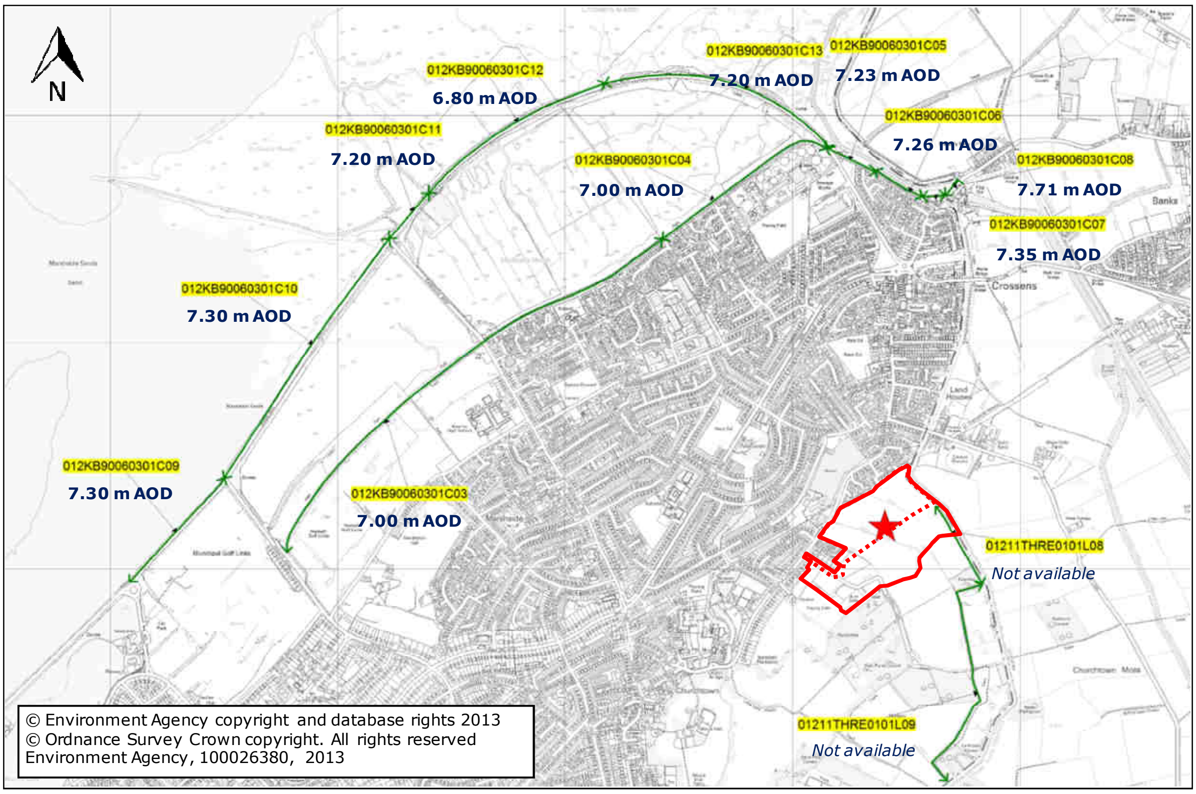


Figure 6: Environment Agency Effective Crest Level of Coastal Defences

4.4.2 Overtopping

The EA has provided a Tidal Flood Level Map for the site[5]. This indicates that no inundation of the site is expected in the defended 1 in 200, 1 in 1,000 and 1 in 200 climate change annual probability events.

4.4.3 Breach

The Sefton Council *Flood Risk Technical Paper* dated September 2015 states that the EA has modelled a breach scenario at the weakest part of the sea defences. The resulting modelled flood extent (**Figure 7**) indicates that no inundation of the site (Site Ref: MN2.2) would be expected.

[5] EA Ref: CL4475

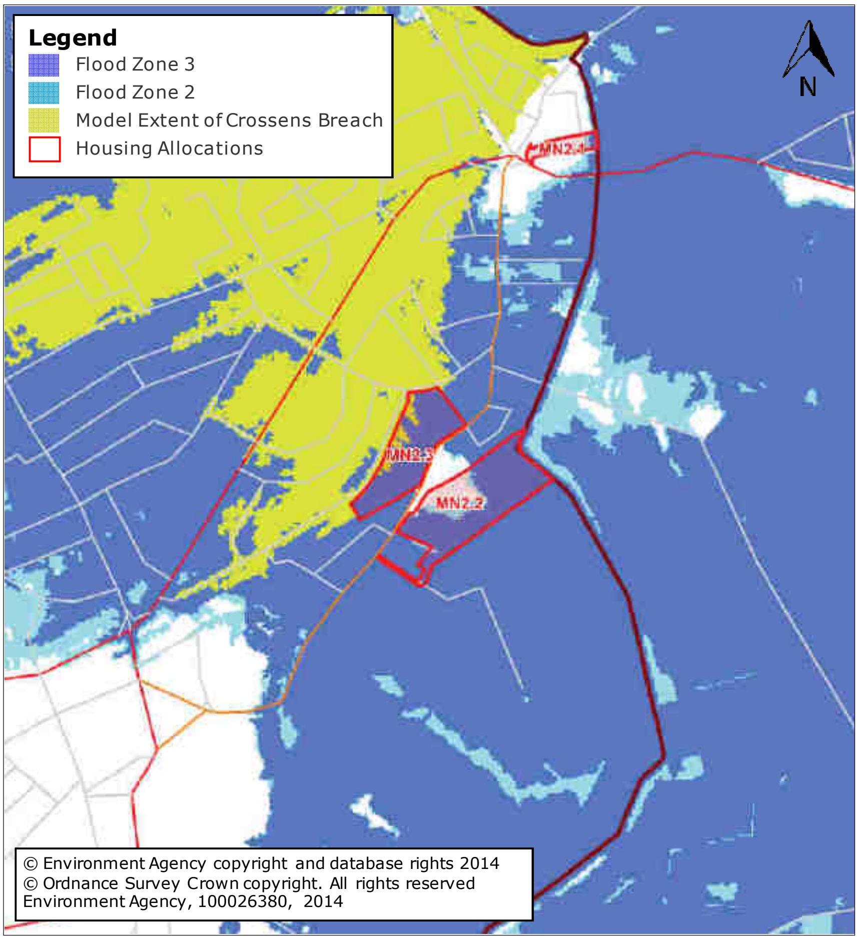


Figure 7: Environment Agency Breach Scenario

4.5 FLUVIAL FLOOD RISK – THREE POOLS WATERWAY & CAPTAINS WATERWAY

As detailed in **Section 3.4**, Captains Waterway is located along the southern boundary of the site and outfalls into Three Pools Waterway, which in turn flows in a northerly direction ultimately outfalling to the Irish Sea.

4.5.1 Flood Defences

The EA Flood Map for Planning (Rivers and Sea) (**Figure 3**) indicates the presence of a defence along the left bank of Three Pools Waterway in the eastern corner of the site. This section of the defence is maintained by the EA; however, no crest level information is available.

The SFRA states that there are *'a large number of structures in the Crossens catchment and along Three Pools Waterway and Captains Waterway that may have an influence on flood risk. The most important structure is obviously Crossens Pumping Station itself, which is the main means by which flooding in the catchment is managed. The current operating regime of the Crossens catchment means that, when operating as intended, there is generally little risk from river or tidal flooding...based on the extent of flood risk seen in the EA's fluvial Flood Zone Map [**Figure 4**], which is understood to be based on an undefended scenario that considers failure of the pumping station...the failure of the Crossens Pumping Station does not seem to result in a significantly greater risk to areas within Sefton'*.

The EA has confirmed[6] that flood levels within the watercourses adjacent to the site are controlled by Crossens Pumping Station.

4.5.2 Modelled Flood Levels

Modelled flood levels for Three Pools Waterway have been provided by the EA for the 1 in 25, 1 in 100, 1 in 100 climate change and 1 in 1,000 annual probability events. No modelled flood levels are available for Captains Waterway; however, these are likely to be largely dictated by those within Three Pools Waterway.

The flood levels derived for the above events for the modelled nodes illustrated on **Figure 8** are provided in **Table 1**.

Table 1: Three Pools Waterway Defended Modelled Flood Levels

Model Node	Annual Probability Flood Level (m AOD)			
	1 in 25	1 in 100	1 in 100 climate change	1 in 1,000
THR01_01201	2.09	2.35	2.40	2.48
THR01_01301	*2.10*	*2.36*	*2.41*	*2.49*
THR01_01397	*2.11*	*2.36*	*2.41*	*2.49*
THR01_01500	*2.11*	*2.37*	*2.41*	*2.50*
THR01_01600	*2.12*	*2.37*	*2.42*	*2.50*
THR01_01700	2.12	2.37	2.42	2.50
THR01_01802	2.12	2.38	2.42	2.51
THR01_01894	2.13	2.38	2.43	2.91

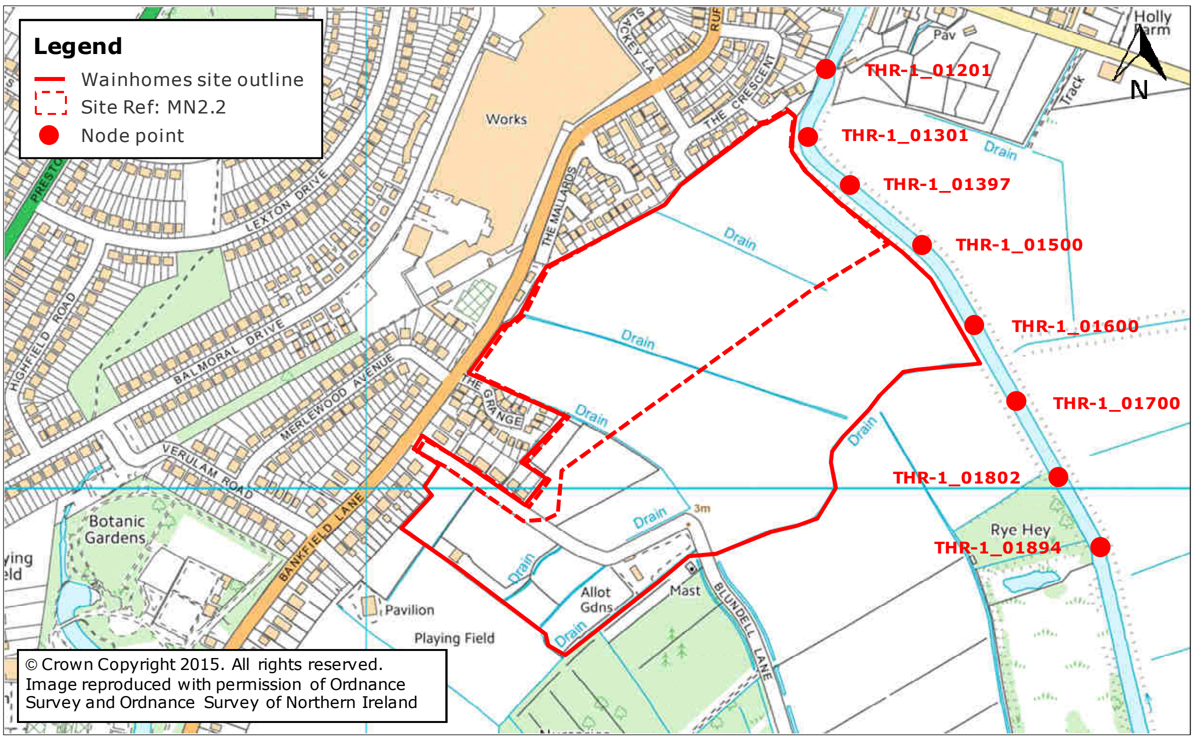


Figure 8: Three Pools Waterway Modelled Node Locations

[6] Footnote 4

4.5.3 Flood Extents

4.5.3.1 Overtopping

Defended fluvial flood extents are provided within Figure 6-1 of the SFRA (**Figure 9**). This indicates that the majority of the site is located outside the 1 in 1,000 annual probability flood outline.

A small section of the eastern boundary of the site is shown to be located within the 1 in 100, 1 in 100 climate change and 1 in 1,000 annual probability flood extents; however, this is generally shown to be confined to the lower lying area of land within the immediate vicinity of Captains Waterway at this location.

The residual risk of flooding from this source will be mitigated though the implementation of the measures proposed in **Section 5** of this report.

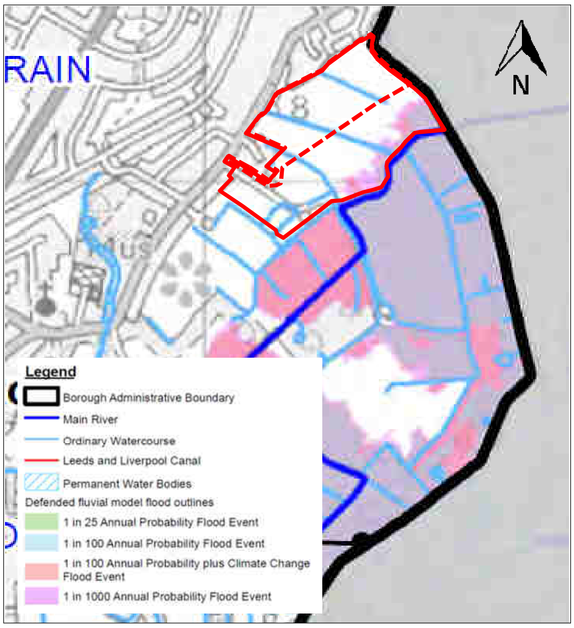


Figure 9: Strategic Flood Risk Assessment - Fluvial Flood Extents with Defences

4.5.3.2 Breach

No analysis of the consequences associated with a breach of the Three Pools Waterway defences has been undertaken at this stage; however, in order to assess the likely extent of flooding from such a scenario Weetwood has utilised defended flood levels provided by the EA for the watercourse (**Table 1**) and projected these across a digital elevation model of the site, which has been created from the topographic survey.

The resulting flood outlines are illustrated in **Figure 10**. It should be noted that this is likely to be a conservative estimate of the flood risk posed to the site during such a scenario as these ignore the presence of all defences and utilise defended (in-channel) flood levels, which in reality would be expected to be lower on the floodplain.

The indicative flood outlines suggest that only a small area in the south-eastern corner of the proposed allocation MN2.2 would be inundated during all scenarios. In a 1 in 100 climate change annual probability event depths are typically below 100 mm.

The flood risk to the site from this source will be mitigated though the implementation of the measures proposed in **Section 5** of this report.

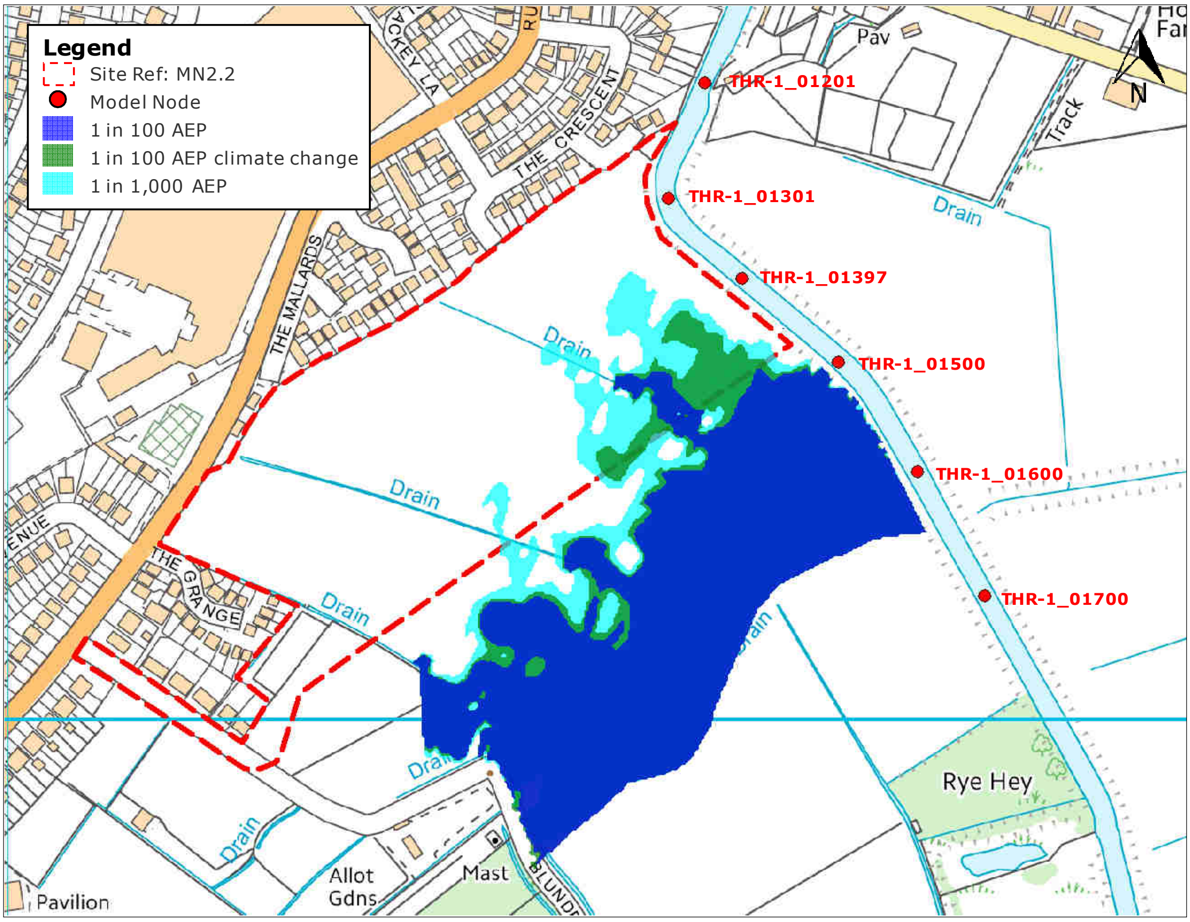


Figure 10: Weetwood Indicative Undefended Flood Extents

4.6 FLOOD RISK FROM RESERVOIRS, CANALS AND OTHER ARTIFICIAL SOURCES

Reservoir or canal flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure.

There are no canals located within the immediate vicinity of the site. The EA Risk of Flooding from Reservoirs map indicates that the site is not at risk of flooding from such sources. The site is therefore not assessed to be at risk of flooding from reservoirs, canals or other artificial sources.

4.7 FLOOD RISK FROM GROUNDWATER

Groundwater flooding generally occurs during intense, long-duration rainfall events, when infiltration of rainwater into the ground raises the level of the water table until it exceeds ground levels. It is most common in low-lying areas overlain by permeable soils and permeable geology, or in areas with a naturally high water table.

As detailed in **Section 3.3** ground conditions at the site are described as naturally wet with high groundwater. However, according to the BGS Groundwater Flooding Hazard map (**Figure 11**) the site is not susceptible to groundwater flooding. Furthermore, as detailed in **Section 3.4** the underlying *Sidmouth Mudstone Formation* bedrock is defined as a Secondary B aquifer, defined as layers which may store limited amounts of groundwater.

Any residual risk of flooding from this source will be mitigated through the implementation of the measures proposed in **Section 5** of this report.

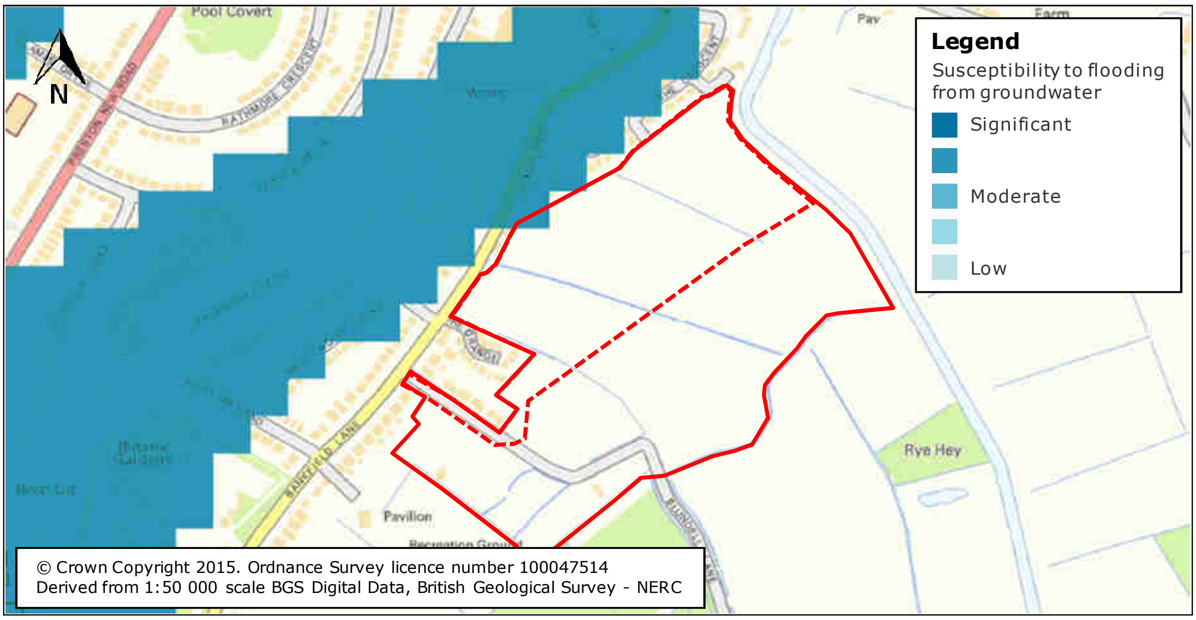


Figure 11: Groundwater Flooding Hazard Map
(Source: Findmaps)

4.8 FLOOD RISK FROM SURFACE WATER

Surface water flooding comprises pluvial flooding and flooding from sewers and highway drains and gullies.

4.8.1 Risk of Pluvial Flooding

Pluvial flooding results from rainfall-generated overland flow, before the runoff enters any watercourse or sewer, or where the sewerage/drainage systems and watercourses are overwhelmed and therefore unable to accept surface water.

Pluvial flooding is usually associated with high intensity rainfall events but may also occur with lower intensity rainfall where the ground is saturated, developed or otherwise has low permeability resulting in overland flow and ponding within depressions in the topography.

Figure 15-1 of the Sefton Council SFRA indicates that the vast majority of the site is not located within an area susceptible to surface water flooding, with the exception of some isolated areas which are defined as being 'less susceptible'.

The EA Risk of Flooding from Surface Water map (**Figure 12**) indicates that the site is typically at a very low[7] risk, with the exception of the land within the immediate vicinity of the lands drains through the site which, along with some isolated areas, is shown to be at a low[8] to medium[9] risk. Only a very small area in the west of the site is shown to be at a high[10] risk; however, this is within the vicinity of an existing land drain.

[7] Very Low Risk; Chance of flooding of less than 1 in 1,000 in each year
[8] Low Risk; Chance of flooding of between 1 in 1,000 and 1 in 100 in each year
[9] Medium Risk; Chance of flooding of between 1 in 100 and 1 in 30 in each year
[10] High Risk (Chance of flooding is greater than 1 in 30 in each year)

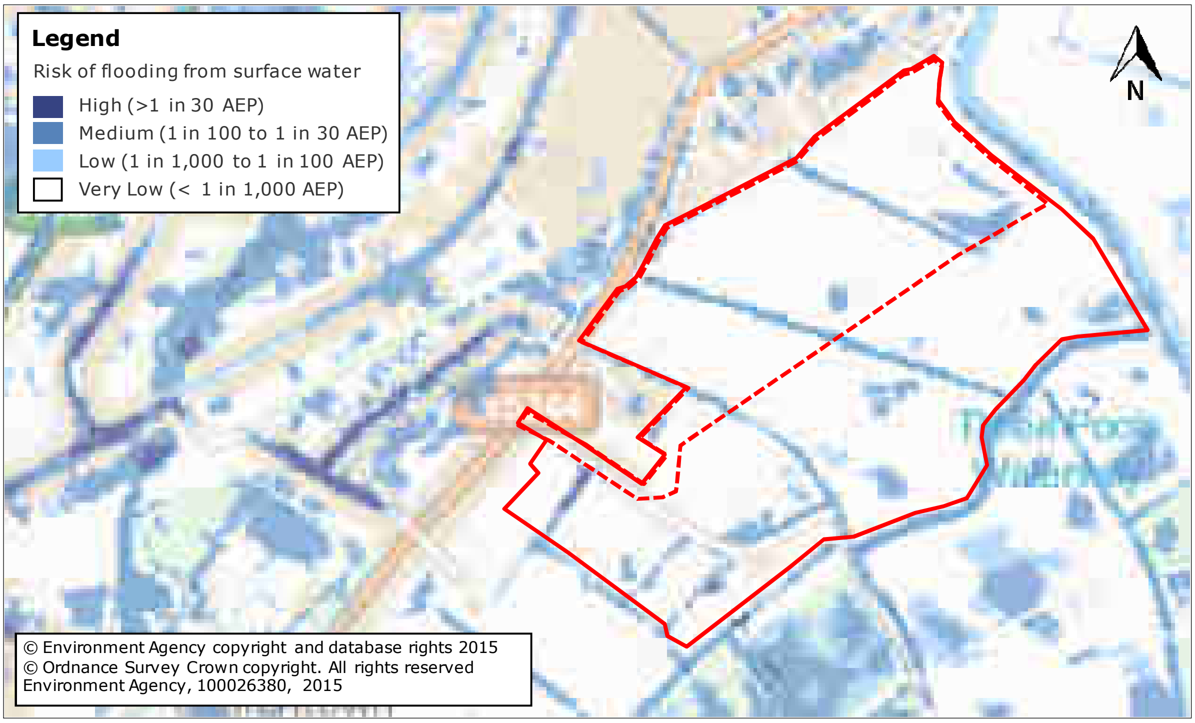


Figure 12: Environment Agency Risk of Flooding from Surface Water
(Source: EA website)

Potential depths and velocities for the low, medium and high risk surface water flooding events are provided in **Figure 13** and **Figure 14**.

These indicate that flood depths would typically be expected to be below 300 mm in the medium and low occurrence events, with the exception of the land drains where depths are shown to be between 300 and 900 mm (although over 900 mm in some sections).

During both the medium and low occurrence events velocities are typically expected to be below 0.25m/s, with some isolated areas of over 0.25 m/s.

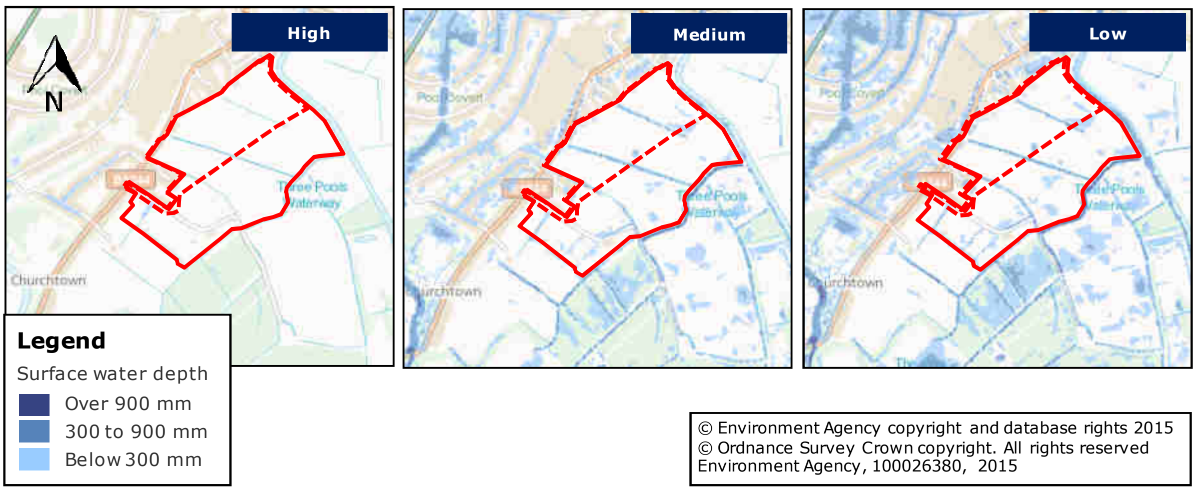


Figure 13: Environment Agency Surface Water Depth Map

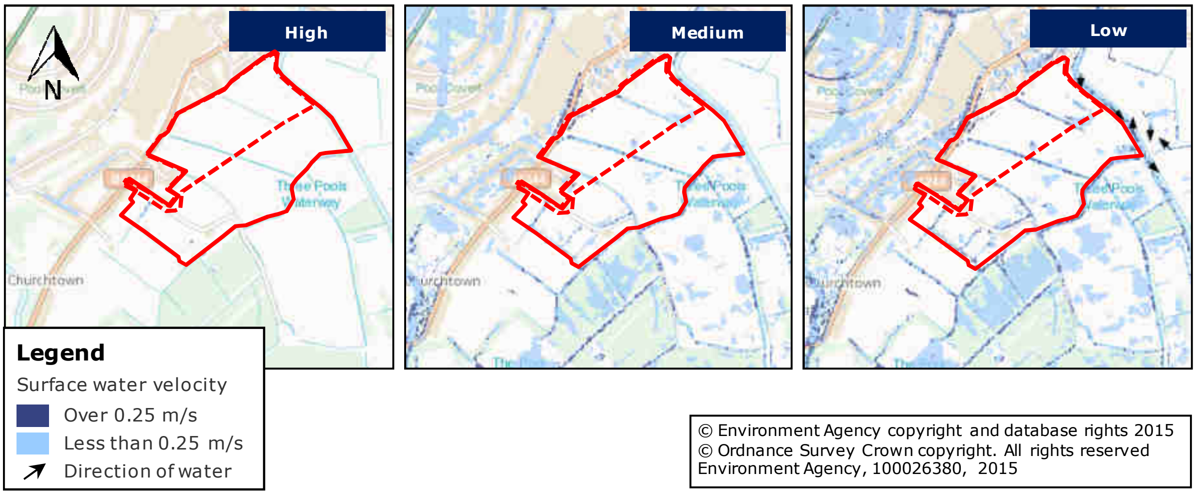


Figure 14: Environment Agency Surface Water Velocity Map

In light of the above the site is anticipated to have a very low to medium risk of surface water flooding. This will be mitigated though the implementation of the measures proposed in **Section 5** of this report and the surface water drainage strategy in **Section 6**.

4.8.2 Risk of Flooding from Sewers and Highway Drains and Gullies

Flooding of land and/or property can occur when the capacity of the sewer/drainage system is overwhelmed by heavy rainfall, becomes blocked or is of inadequate capacity or where the normal discharge of sewers and drains through outfalls is impeded by high water levels in receiving waters.

United Utilities has been consulted to ascertain whether it holds any records of sewer flooding at the site. It has confirmed[11] that there are no recorded historical sewer flooding issues within the vicinity of the site; however, there is a record of flooding incidents in the surrounding area. Figure 16-1 of the SFRA indicates that United Utilities has advised of 2 to 3 reported incidents of sewer flooding to the south-west of the site and 1 to 2 to the north-west.

Sefton Council has been consulted to ascertain whether it holds any records of highways flooding at or within the vicinity of the site. At the time of writing a response is awaited. Figure 16-1 of the SFRA indicates that the Sefton Drainage Report data includes 2 surface water flooding incidents to the north-east of the site.

[11] Email from United Utilities to Weetwood dated 2 July 2015

5 FLOOD RISK MITIGATION MEASURES

5.1 FLOOD MITIGATION

The flood risk to the site from fluvial sources and surface water, and any residual risk associated with groundwater will be mitigated though the implementation of the measures proposed within the following section of this report.

5.1.1 Finished Floor Levels

Finished floor levels should be set at a minimum of 2.72 m AOD. This provides a freeboard of 300 mm above the Three Pools Waterway 1 in 100 climate change annual probability flood level adjacent to the site.

Finished floor levels should be set at a minimum of 0.15 m above adjacent ground levels following any reprofiling of the site. This will enable any potential overland flows to be conveyed safely across the site without affecting property in accordance with the approach promoted by government policy[12].

5.2 FLOOD RISK ELSEWHERE

Any proposal to modify ground levels should demonstrate that there is no increase in flood risk to the development itself, or to any existing buildings which are known to, or are likely to flood.

Developers must ensure there will be no loss of flood flow or flood storage capacity for floods up to the severity of the 1 in 100 annual probability fluvial event. Whilst not specified by the NPPF, the EA generally recommend that this should be the case over the lifetime of development (i.e. should take into account climate change).

Compensatory storage is generally not required for the loss of floodplain storage or conveyance during a tidally dominated event. However, in such instances where overtopping of defences is expected by tidal floodwaters, and the predicted water level is not an extension of the water level within the estuary then the developer should demonstrate no increase in flood risk elsewhere in a 1 in 200 annual probability tidal overtopping event over the lifetime of the development.

No built development is proposed within the 1 in 100 climate change annual probability fluvial flood outline as indicated on *Figure 6-1: Fluvial Flood Extents with Defences* of the SFRA (**Figure 9**). The proposed development would therefore not be expected to increase fluvial flood risk elsewhere.

As detailed in **Section 4.4.2** no inundation of the site would be expected in a 1 in 200 climate change annual probability event. As such development would be expected to have a negligible (if any) impact on tidal flood risk.

Reprofiling of the area of the site shown to be within the defended 1 in 100 climate change annual probability flood outline indicated on *Figure 6-1: Fluvial Flood Extents with Defences* of the SFRA (**Figure 9**) will be restricted in order to ensure that flood flow routes are retained within this area and that flood risk is not increased elsewhere.

12 Making Space for Water, Taking forward a new Government strategy for flood and coastal erosion risk management in England, March 2005, Dept for Environment, Food and Rural Affairs

In the event that works are proposed/deemed necessary within this area then the necessary consultation will be undertaken with the EA and mitigation provided as appropriate.

5.3 FLOOD DEFENCE CONSENT

An 8 m undeveloped buffer strip should be provided from either the top of bank or toe of any flood defence on Captains Waterway and Three Pools Waterway. This will allow for future maintenance and also ensure that any works do not increase flood risk, damage flood defences, or harm the environment, fisheries, or wildlife. Any development in, over or under or within 8 m of a main river would require Flood Defence Consent from the EA.

Modifications to the land drains through the site are likely to be required to facilitate the development. Consent will be required from Sefton Council for any works to those that may be designated as ordinary watercourses.

6 SURFACE WATER MANAGEMENT

6.1 REQUIREMENTS FOR SUSTAINABLE DRAINAGE SYSTEMS

Planning applications for major developments[13] are required[14] to provide Sustainable Drainage Systems (SuDS) for the management of surface water runoff, unless demonstrated to be inappropriate[15] or disproportionately expensive.

SuDS aim to mimic natural drainage and can achieve multiple objectives such as removing pollutants from urban runoff at source, controlling surface water runoff from developments, and ensuring that flood risk is not increased downstream. Combining water management with green space can provide amenity and biodiversity enhancement.

In considering a development that includes a sustainable drainage system, the local planning authority will want to be satisfied that the proposed minimum standards of operation are appropriate and that there are clear arrangements in place for ongoing maintenance. Technical standards have been published by Defra in relation to the design, construction and operation of sustainable drainage systems.

6.2 DISPOSAL OF SURFACE WATER

In accordance with the NPPF Planning Practice Guidance[16], surface water runoff should be disposed of according to the following hierarchy:

1. Into the ground (infiltration)
2. To a surface water body
3. To a surface water sewer, highway drain, or another drainage system
4. To a combined sewer

As the site is underlain by naturally wet soils with naturally high groundwater it is unlikely to be suitable for infiltration. In light of this it is proposed to direct all runoff from the developed site to Captains Waterway, which ultimately outfalls to Three Pools waterway.

6.3 PEAK FLOW CONTROL

For the purposes of this report the small area of impermeable surface at the existing site has been ignored. For greenfield sites, the peak runoff rate from the proposed development to any highway drain, sewer or surface water body for the 1 in 1 annual probability rainfall event and the 1 in 100 annual probability rainfall event should not exceed the peak greenfield runoff rate for the same event.

The land under the control of Wainhomes Developments Ltd has a total area of 20.4 ha, of which Site Ref: MN2.2 (as proposed for allocation) comprises 9.1 ha. The latter has

[13] 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)

[14] Written Statement (HCWS161) made by the Secretary of State for Communities and Local Government (Mr Eric Pickles) on 18 December 2014

[15] Paragraph 082 (Reference ID: 7-082-20150323) of the Planning Practice Guidance outlines how a sustainable drainage system might be judged to be inappropriate

[16] Paragraph 080, Reference ID: 7-080-20150323

been assumed as the development platform in the following calculations. The remaining 11.3 ha would continue to runoff independently of the proposed drainage system.

The greenfield surface water runoff rate has been calculated using the ICP SUDS method within MicroDrainage (**Appendix B** and **Table 2**).

Table 2: Greenfield Runoff Rate

Annual probability of rainfall event	Greenfield Runoff (l/s/ha)	Greenfield Runoff Rate for 9.1 ha Site (l/s)
1 in 1	2.0	18.2
1 in 30	4.0	36.4
1 in 100	4.8	43.7

6.4 VOLUME CONTROL

Where reasonably practicable, for greenfield sites, the runoff volume from the proposed development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event should not exceed the greenfield runoff volume for the same event.

The formula[17] used to calculate the runoff volume following development is described as follows:

$$Vol = RD.A.10\left[\frac{PIMP}{100}(0.8) - SPR\right]$$

$Vol \;=\; additional\ runoff\ volume\ (m^3)$
$RD \;=\; 100\ year\ 6\ hour\ rainfall\ depth\ (mm);$
$A \;=\; site\ area\ (ha);$
$PIMP \;=\; percentage\ impermeable\ area$
$SPR \;=\; standard\ percentage\ runoff\ index\ for\ the\ soil\ type$

Assuming that 60% of the site was to comprise impermeable surfaces following development, the additional volume of surface water would be calculated as follows:

$$Vol = 54.5 \times 9.1 \times 10\left[\frac{60}{100}(0.8) - 0.3\right]$$

Based upon the above, an additional 893 m³ of surface water runoff would be expected from the developed site.

This additional volume of surface water runoff may be accounted for within the drainage strategy by providing a 'long term storage' facility. This should be designed to either slowly infiltrate the additional volume of surface water into the ground or discharge at a maximum rate of 2 l/s/ha in accordance with DEFRA/EA guidance[18]. Recognising the existing ground conditions, the latter is proposed in this instance.

[17] Box 4.11 - Long-term storage formula, The SuDS manual, p 4-23
[18] Rainfall runoff management for developments – Report SC030219, Defra/EA

6.5 MANAGING SURFACE WATER WITHIN THE DEVELOPMENT

The surface water drainage system must be designed so that:

- Flooding does not occur on any part of the site for a 1 in 30 annual probability rainfall event, unless an area is designed to hold and/or convey water as part of the design;
- Flooding does not occur in any part of a building during a 1 in 100 annual probability event; and
- Flows resulting from rainfall in excess of a 1 in 100 annual probability rainfall event are managed in exceedance routes that minimise the risks to people and property, so far as is reasonably practicable.

The proposed impermeable areas within the development have been estimated to be 5.5 ha, assuming a percentage impermeable area of 60%.

The Detailed Design module of MicroDrainage Source Control has been utilised to determine the required storage volume, which has been sized to store the 1 in 100 annual probability rainfall event including a 30% increase in rainfall intensity in order to allow for climate change in accordance with EA guidance[19] (**Appendix C**).

A complex control has been utilised in order to ensure that the peak runoff from the developed site does not exceed the peak greenfield runoff rate for each event as outlined in **Table 2**.

Based upon the above a total storage volume of 2,741 m^3 would be required (which equates to 498 m^3 of surface water storage required per hectare of new impermeable surfaces). This comprises 1,848 m^3 of attenuation storage and 893 m^3 accommodated within online or offline long term storage. It should be noted that these volumes are indicative and will be subject to change as the site proposals are developed.

6.5.1 Sustainable Drainage Systems

One of the philosophies behind the use of SuDS is the “management train” concept. A management train provides different SuDS components in sequence to control flows and volumes through the system. Some components may also remove or reduce pollutants from runoff thereby improving water quality.

A decision on the types of surface water storage to be provided at the site will be made at the detailed drainage design stage; however, potential SuDS components which may be considered at the site include green roofs, rainwater harvesting, permeable paving, bioretention areas, filter strips, swales or filter drains and detention basins or retention ponds.

6.6 MAINTENANCE OF SUDS

The pipe network, designed to Sewers for Adoption (7th edition) standard, may be adopted by the sewerage undertaker.

SuDS in open spaces may be adopted by the local authority or water company and may be maintained by a management company.

[19] Climate Change Allowances for Planners – Guidance to Support the National Planning Policy Framework, September 2013, EA ref: LIT 8496 NA/EAD/Sept 2013/V12

6.7 SUMMARY

The purpose of this FRA is to demonstrate that a surface water drainage strategy is feasible for the site given the development proposals and the land available. The proposals provide the opportunity for the inclusion of SuDS elements, ensuring that there will be no increase in surface water runoff from the proposed development. The storage calculations will be refined as the proposals are developed, with a final decision on the types of storage to be provided made at the detailed design stage.

7 SUMMARY

This FRA has been prepared on behalf of Wainhomes Developments Ltd and relates to the proposed development of land at Bankfield Lane, Southport.

Part of the site is identified within the Local Plan for Sefton Draft Publication dated January 2015 as a potential housing allocation (Site Ref: MN2.2). The eastern area of the site is identified as proposed open space.

According to the EA Flood Map for Planning (Rivers and Sea) the site is located predominately within the defended Flood Zone 3; however, there is an area in the north in Flood Zone 1 and Flood Zone 2.

The Sefton Council Local Plan Site Selection states that the Sequential Test for the site is passed. The first part of the Exception test has been addressed by Wainhomes Developments Ltd. This report addresses the second part of the Exception Test.

There are a number of existing waterbodies within the vicinity of the site; however, there are no historical records of flooding.

The Irish Sea is located approximately 2.5 km to the west of the site, which is afforded protection from a series of coastal defences. Data provided by the EA indicates that no inundation of the site is expected in the defended 1 in 200, 1 in 1,000 and 1 in 200 climate change annual probability events. The EA has modelled a breach scenario at the weakest part of the sea defences. The resulting modelled flood extent indicates that no inundation of the site would be expected.

Captains Waterway is located along the southern boundary of the site and outfalls into Three Pools Waterway, which in turn flows in a northerly direction along the eastern boundary of the site. The SFRA defended fluvial flood extents indicate that the majority of the site is located outside the 1 in 1,000 annual probability flood outline. A small section of the eastern boundary of the site is shown to be located within the 1 in 100, 1 in 100 plus climate change and 1 in 1,000 annual probability flood extents; however, this is confined to the lower lying area of land within the immediate vicinity of Captains Waterway at this location.

No breach analysis has been undertaken for Three Pools Waterway at this stage; however, in order to assess the likely extent of flooding from such a scenario Weetwood has utilised defended flood levels provided by the EA for the watercourse and projected these across a digital elevation model of the site. The indicative flood outlines suggest that only a small area in the south-eastern corner of the proposed allocation would be inundated.

The site is not at risk of flooding from reservoirs, canals or other artificial sources. According to the BGS Groundwater Flooding Hazard map the site is not susceptible to groundwater flooding. The site is anticipated to have a very low to medium risk of surface water flooding.

In order to mitigate the flood risk to the site it is proposed to set finished floor levels at a minimum of 2.72 m AOD. This provides a freeboard of 300 mm above the Three Pools Waterway flood level expected adjacent to the site in a 1 in 100 climate change annual probability event.

Finished floor levels should also be set at a minimum of 0.15 m above adjacent ground levels following any reprofiling of the site to enable any potential overland flows to be conveyed safely across the site without affecting property.

The proposed development is not expected to increase flood risk elsewhere. In the event that any reprofiling works are proposed/deemed necessary within the defended 1 in 100 climate change annual probability flood outline indicated on *Figure 6-1: Fluvial Flood Extents with Defences* of the SFRA then the necessary consultation will be undertaken with the EA and mitigation provided as appropriate.

An 8 m undeveloped buffer strip should be provided from either the top of bank or toe of any flood defence on Captains Waterway and Three Pools Waterway. Flood Defence Consent will be required from the EA for any development in, over or under or within 8 m of a main river and from Sefton Council for any modifications to the land drains through the site which are considered to be classified as ordinary watercourses.

Surface water runoff from the developed site may be sustainably managed in accordance with the NPPF and local policy.

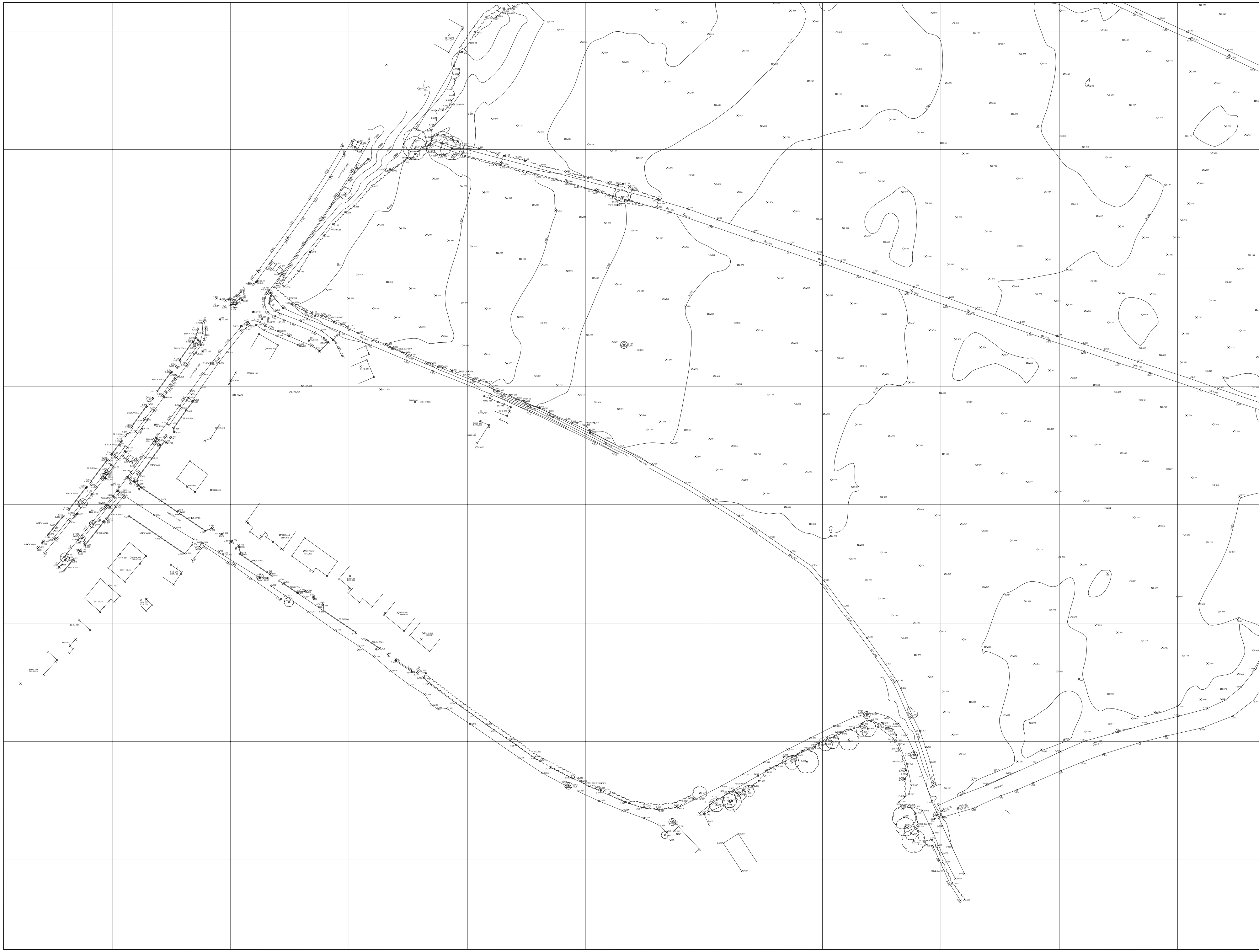
8 RECOMMENDATIONS

From a flood risk perspective, the majority of the land under the control of Wainhomes Developments Ltd is developable.

This FRA has demonstrated that the site may be developed without conflicting with the requirements of the NPPF and may therefore be allocated for housing subject to the following:

- Finished floor levels to be set at a minimum of 2.72 m AOD
- Finished floor levels to be set 0.15 m above adjacent ground levels
- The detailed drainage design, developed in accordance with the principles set down in this FRA, should be submitted to and approved by the local planning authority prior to the commencement of development

APPENDIX A:	Topographic Survey



SURVEY ORIENTATED TO REAL TIME GPS

NOTES AND AMENDMENTS

ONLY MANHOLES AND SERVICES VISIBLE AT TIME OF SURVEY SHOWN

DRAINAGE INFORMATION MUST BE CHECKED AND VERIFIED WITH LOCAL AUTHORITY RECORDS PRIOR TO WORK COMMENCING

Levels defining edge of carriageway are observed at channel (bottom of kerb). Unless otherwise stated.

TREE SPREADS ARE SYMBOLIC ONLY AND ARE REPRESENTATIVE OF THE THE AVERAGE SPREAD. THE DRIP LINE LAYER DENOTES THE TREES EXTREMITY

REVISIONS

REV.	DESCRIPTION	DRAWN	CHKD.	DATE

Topographical Survey Legend

Bol	Bollard	Hyd	Hydrant
Bin	Litter bin	IC	Inspection cover
BS	Bus stop	JB	Junction box
BT	British telecom ic	KO	Kerb outlet
CPS	Concrete paving slabs	LB	Letter box
DR	Drain	LP	Lamp post
Elec	Electrical ic	Mkr	Utility marker
EP	Elec. pole	MP	Mile post
ER	Earth rod	NP	Name plate
FP	Flagpole	P	Post
FT	Floodlight	PM	Parking meter
G	Gully	RE	Rodding eye
GP	Gate post	RS	Road sign
GV	Gas valve	TV	Cable television cover

Fence annotation

B/W	Barbed wire
C/B	Closed boarded
C/I	Corrugated iron
C/L	Chain link
C/P	Concrete panel
H/R	Hand rail
I/R	Iron railings
O/B	Open boarded
P/C	Post & chain
P/R	Post & rail
P/W	Post & wire
W/M	Wire mesh
rwp	Rain water pipe
SP	Sign post
ST	Stop tap
Stay	Cable stay
SV	Stop valve
TCB	Telephone call box
TL	Tie line
TP	Telegraph pole
TPS	Tactile paving slabs
TS	Traffic signal light
TV	Television cover
VP	Vent pipe
WM	Water meter
UTL	Unable to lift

Level prefix descriptions

AL	Arch level
BL	Bed level
CL	Cover level
EH	Eaves level
FL	Floor level
IL	Invert level
PL	Parapet level
RH	Roof/ridge level
SL	Soffit level
Spr	Arch springing level
Top	Top of pipe/culvert
WH	Wall height
WL	Water level

BENCH MARK INFORMATION

All levels relate to OSBM Newlyn

Datum Generated by VRS GPS

SURVEY STATIONS

STN1	337046.331	419061.766	5.250
STN1A	337068.284	419076.671	5.331
STN1B	337037.151	419035.780	5.284
STN1A1	337101.178	419135.258	5.211
STN2	337112.486	419019.346	4.592
STN3	337242.747	418931.313	3.176
STN4	337286.565	418916.007	3.033
STN5	337368.685	418961.172	2.915
STN6	337388.646	418944.233	2.744
STN7	337398.299	418918.826	2.741
STNA	337266.158	419117.437	3.280
STNB	337359.146	419273.879	3.591
STNC	337472.085	419415.590	3.521

JLP Surveys Limited

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Rodney House,
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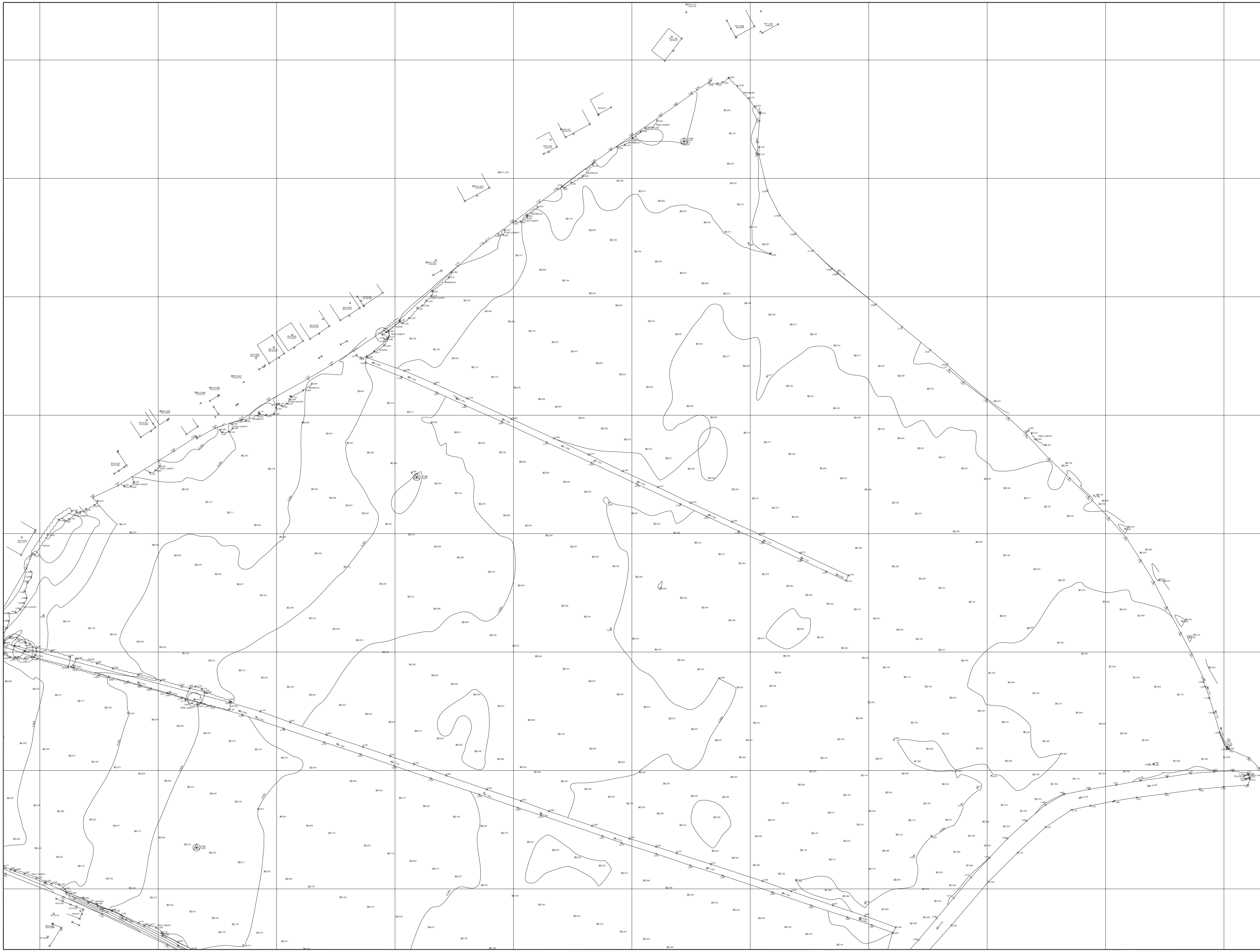
PROJECT
Bankfield Lane
Southport

DRAWING TITLE
Topographical Land Survey

SCALE	SHEET SIZE	No. of SHEETS	DATE	REVISION
1:500	A0	2	18.08.13	

DRAWING NUMBER
S13/423



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1:500	A0	2	18.08.13	

DRAWING NUMBER
S13/423

APPENDIX B:	Greenfield Runoff Calculations

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.300
Area (ha)	1.000	Urban	0.000
SAAR (mm)	864	Region Number	Region 10

Results	**l/s**
QBAR Rural	2.3
QBAR Urban	2.3
Q100 years	4.8
Q1 year	2.0
Q30 years	4.0
Q100 years	4.8

APPENDIX C:	Surface Water Attenuation - Storage Volume Calculation

Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.131	0.131	7.1	265.0	O K
30 min Summer	0.168	0.168	10.2	339.2	O K
60 min Summer	0.205	0.205	12.3	416.2	O K
120 min Summer	0.241	0.241	13.8	492.4	O K
180 min Summer	0.260	0.260	14.5	531.5	O K
240 min Summer	0.270	0.270	14.9	553.7	O K
360 min Summer	0.282	0.282	15.3	579.7	O K
480 min Summer	0.291	0.291	15.6	597.2	O K
600 min Summer	0.296	0.296	15.8	607.5	O K
720 min Summer	0.298	0.298	15.8	612.6	O K
960 min Summer	0.299	0.299	15.9	614.9	O K
1440 min Summer	0.294	0.294	15.7	603.4	O K
2160 min Summer	0.278	0.278	15.1	571.1	O K
2880 min Summer	0.262	0.262	14.6	535.5	O K
4320 min Summer	0.231	0.231	13.4	472.2	O K
5760 min Summer	0.207	0.207	12.4	422.0	O K
7200 min Summer	0.189	0.189	11.6	383.7	O K
8640 min Summer	0.176	0.176	10.9	356.4	O K
10080 min Summer	0.166	0.166	10.0	335.5	O K
15 min Winter	0.147	0.147	8.4	296.6	O K
30 min Winter	0.187	0.187	11.5	379.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	26.180	0.0	201.1	26
30 min Summer	16.984	0.0	274.8	40
60 min Summer	10.676	0.0	398.5	68
120 min Summer	6.602	0.0	500.3	124
180 min Summer	4.959	0.0	567.6	182
240 min Summer	4.043	0.0	619.5	240
360 min Summer	3.030	0.0	699.6	298
480 min Summer	2.469	0.0	761.8	360
600 min Summer	2.101	0.0	811.4	426
720 min Summer	1.838	0.0	852.1	496
960 min Summer	1.489	0.0	919.2	632
1440 min Summer	1.106	0.0	1018.8	904
2160 min Summer	0.822	0.0	1190.6	1300
2880 min Summer	0.666	0.0	1284.2	1680
4320 min Summer	0.496	0.0	1419.8	2428
5760 min Summer	0.402	0.0	1574.9	3168
7200 min Summer	0.341	0.0	1668.7	3888
8640 min Summer	0.299	0.0	1745.8	4584
10080 min Summer	0.267	0.0	1806.4	5336
15 min Winter	26.180	0.0	230.8	26
30 min Winter	16.984	0.0	314.0	39

Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.229	0.229	13.3	467.1	O K
120 min Winter	0.270	0.270	14.9	554.4	O K
180 min Winter	0.292	0.292	15.6	599.9	O K
240 min Winter	0.305	0.305	16.1	626.7	O K
360 min Winter	0.317	0.317	16.4	652.9	O K
480 min Winter	0.324	0.324	16.7	668.5	O K
600 min Winter	0.328	0.328	16.8	676.1	O K
720 min Winter	0.328	0.328	16.8	677.0	O K
960 min Winter	0.325	0.325	16.7	669.5	O K
1440 min Winter	0.310	0.310	16.2	637.8	O K
2160 min Winter	0.282	0.282	15.3	579.8	O K
2880 min Winter	0.256	0.256	14.4	524.7	O K
4320 min Winter	0.214	0.214	12.7	436.5	O K
5760 min Winter	0.185	0.185	11.4	375.0	O K
7200 min Winter	0.167	0.167	10.1	338.7	O K
8640 min Winter	0.155	0.155	9.1	312.7	O K
10080 min Winter	0.145	0.145	8.2	292.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	10.676	0.0	450.3	66
120 min Winter	6.602	0.0	564.5	124
180 min Winter	4.959	0.0	639.9	180
240 min Winter	4.043	0.0	698.2	234
360 min Winter	3.030	0.0	788.0	336
480 min Winter	2.469	0.0	857.8	380
600 min Winter	2.101	0.0	913.4	456
720 min Winter	1.838	0.0	959.0	534
960 min Winter	1.489	0.0	1034.4	684
1440 min Winter	1.106	0.0	1146.4	972
2160 min Winter	0.822	0.0	1336.6	1388
2880 min Winter	0.666	0.0	1442.0	1784
4320 min Winter	0.496	0.0	1595.7	2516
5760 min Winter	0.402	0.0	1765.9	3232
7200 min Winter	0.341	0.0	1871.6	3960
8640 min Winter	0.299	0.0	1959.0	4672
10080 min Winter	0.267	0.0	2029.2	5352

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.314	0.314	16.3	646.6	O K
30 min Summer	0.402	0.402	19.0	835.9	O K
60 min Summer	0.487	0.487	23.4	1024.9	O K
120 min Summer	0.565	0.565	26.8	1199.3	O K
180 min Summer	0.602	0.602	28.1	1283.5	O K
240 min Summer	0.622	0.622	28.8	1328.2	O K
360 min Summer	0.636	0.636	29.3	1360.7	O K
480 min Summer	0.641	0.641	29.5	1372.8	O K
600 min Summer	0.644	0.644	29.5	1378.0	O K
720 min Summer	0.644	0.644	29.5	1379.1	O K
960 min Summer	0.640	0.640	29.4	1369.3	O K
1440 min Summer	0.620	0.620	28.8	1324.9	O K
2160 min Summer	0.583	0.583	27.5	1239.0	O K
2880 min Summer	0.545	0.545	26.1	1154.4	O K
4320 min Summer	0.483	0.483	23.1	1014.8	O K
5760 min Summer	0.433	0.433	20.2	904.1	O K
7200 min Summer	0.387	0.387	18.6	804.0	O K
8640 min Summer	0.348	0.348	17.4	720.3	O K
10080 min Summer	0.316	0.316	16.4	651.3	O K
15 min Winter	0.350	0.350	17.5	724.7	O K
30 min Winter	0.448	0.448	21.1	937.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	64.005	0.0	563.3	26
30 min Summer	41.724	0.0	747.4	40
60 min Summer	26.061	0.0	1022.2	68
120 min Summer	15.842	0.0	1249.9	126
180 min Summer	11.734	0.0	1391.9	184
240 min Summer	9.450	0.0	1496.4	242
360 min Summer	6.932	0.0	1648.3	330
480 min Summer	5.545	0.0	1757.9	386
600 min Summer	4.661	0.0	1846.3	448
720 min Summer	4.045	0.0	1921.6	514
960 min Summer	3.233	0.0	2042.9	652
1440 min Summer	2.355	0.0	2213.4	926
2160 min Summer	1.714	0.0	2509.3	1328
2880 min Summer	1.367	0.0	2664.8	1732
4320 min Summer	0.993	0.0	2883.9	2508
5760 min Summer	0.791	0.0	3114.6	3288
7200 min Summer	0.663	0.0	3258.3	4032
8640 min Summer	0.574	0.0	3374.9	4760
10080 min Summer	0.507	0.0	3465.7	5456
15 min Winter	64.005	0.0	636.5	26
30 min Winter	41.724	0.0	841.8	40

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.543	0.543	26.0	1149.3	O K
120 min Winter	0.631	0.631	29.1	1348.5	O K
180 min Winter	0.673	0.673	30.5	1446.8	O K
240 min Winter	0.697	0.697	31.2	1501.0	O K
360 min Winter	0.715	0.715	31.8	1544.4	O K
480 min Winter	0.716	0.716	31.8	1545.9	O K
600 min Winter	0.717	0.717	31.8	1547.7	O K
720 min Winter	0.714	0.714	31.7	1542.6	O K
960 min Winter	0.703	0.703	31.4	1516.1	O K
1440 min Winter	0.668	0.668	30.3	1434.2	O K
2160 min Winter	0.609	0.609	28.4	1298.6	O K
2880 min Winter	0.555	0.555	26.4	1176.2	O K
4320 min Winter	0.472	0.472	22.5	990.5	O K
5760 min Winter	0.404	0.404	19.1	842.3	O K
7200 min Winter	0.345	0.345	17.3	713.6	O K
8640 min Winter	0.299	0.299	15.9	614.6	O K
10080 min Winter	0.263	0.263	14.6	538.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	26.061	0.0	1149.3	68
120 min Winter	15.842	0.0	1404.3	124
180 min Winter	11.734	0.0	1563.3	180
240 min Winter	9.450	0.0	1680.4	238
360 min Winter	6.932	0.0	1850.5	346
480 min Winter	5.545	0.0	1973.4	408
600 min Winter	4.661	0.0	2072.2	472
720 min Winter	4.045	0.0	2156.4	548
960 min Winter	3.233	0.0	2292.0	702
1440 min Winter	2.355	0.0	2481.6	998
2160 min Winter	1.714	0.0	2813.7	1424
2880 min Winter	1.367	0.0	2988.1	1824
4320 min Winter	0.993	0.0	3235.6	2636
5760 min Winter	0.791	0.0	3490.5	3416
7200 min Winter	0.663	0.0	3652.1	4176
8640 min Winter	0.574	0.0	3784.3	4920
10080 min Winter	0.507	0.0	3889.8	5640

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.515	0.515	24.8	1086.2	O K
30 min Summer	0.661	0.661	30.1	1417.4	O K
60 min Summer	0.804	0.804	34.3	1753.5	O K
120 min Summer	0.936	0.936	37.7	2072.9	O K
180 min Summer	1.001	1.001	39.3	2233.3	O K
240 min Summer	1.037	1.037	40.1	2323.8	O K
360 min Summer	1.067	1.067	40.8	2398.7	O K
480 min Summer	1.070	1.070	40.9	2406.9	O K
600 min Summer	1.071	1.071	40.9	2408.1	O K
720 min Summer	1.070	1.070	40.9	2405.5	O K
960 min Summer	1.062	1.062	40.7	2386.6	O K
1440 min Summer	1.032	1.032	40.0	2311.5	O K
2160 min Summer	0.974	0.974	38.6	2165.8	O K
2880 min Summer	0.913	0.913	37.2	2017.0	O K
4320 min Summer	0.804	0.804	34.3	1754.3	O K
5760 min Summer	0.716	0.716	31.8	1545.7	O K
7200 min Summer	0.645	0.645	29.6	1381.2	O K
8640 min Summer	0.587	0.587	27.6	1249.7	O K
10080 min Summer	0.540	0.540	25.8	1142.3	O K
15 min Winter	0.573	0.573	27.1	1217.1	O K
30 min Winter	0.735	0.735	32.3	1589.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	107.328	0.0	972.7	26
30 min Summer	70.622	0.0	1283.4	40
60 min Summer	44.405	0.0	1767.3	70
120 min Summer	27.084	0.0	2162.3	126
180 min Summer	20.061	0.0	2404.6	186
240 min Summer	16.138	0.0	2580.0	244
360 min Summer	11.797	0.0	2827.8	360
480 min Summer	9.396	0.0	3000.2	428
600 min Summer	7.872	0.0	3137.5	486
720 min Summer	6.816	0.0	3254.6	548
960 min Summer	5.426	0.0	3438.1	678
1440 min Summer	3.929	0.0	3673.3	954
2160 min Summer	2.841	0.0	4176.8	1364
2880 min Summer	2.255	0.0	4414.6	1764
4320 min Summer	1.626	0.0	4746.9	2552
5760 min Summer	1.288	0.0	5082.1	3288
7200 min Summer	1.075	0.0	5294.7	4040
8640 min Summer	0.926	0.0	5467.6	4760
10080 min Summer	0.817	0.0	5604.2	5456
15 min Winter	107.328	0.0	1092.2	26
30 min Winter	70.622	0.0	1436.3	40

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.893	0.893	36.7	1969.1	O K
120 min Winter	1.041	1.041	40.2	2332.6	O K
180 min Winter	1.114	1.114	41.9	2518.9	O K
240 min Winter	1.156	1.156	42.8	2626.5	O K
360 min Winter	1.194	1.194	43.6	2724.6	O K
480 min Winter	1.201	1.201	43.7	2741.1	O K
600 min Winter	1.195	1.195	43.6	2725.3	O K
720 min Winter	1.190	1.190	43.5	2714.3	O K
960 min Winter	1.176	1.176	43.2	2677.2	O K
1440 min Winter	1.127	1.127	42.2	2550.3	O K
2160 min Winter	1.037	1.037	40.1	2323.8	O K
2880 min Winter	0.949	0.949	38.0	2105.5	O K
4320 min Winter	0.798	0.798	34.1	1740.7	O K
5760 min Winter	0.682	0.682	30.8	1467.8	O K
7200 min Winter	0.595	0.595	27.9	1266.4	O K
8640 min Winter	0.529	0.529	25.4	1116.9	O K
10080 min Winter	0.481	0.481	23.0	1010.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	44.405	0.0	1983.5	68
120 min Winter	27.084	0.0	2425.6	124
180 min Winter	20.061	0.0	2696.6	182
240 min Winter	16.138	0.0	2892.5	240
360 min Winter	11.797	0.0	3169.2	352
480 min Winter	9.396	0.0	3361.5	458
600 min Winter	7.872	0.0	3514.3	552
720 min Winter	6.816	0.0	3643.3	574
960 min Winter	5.426	0.0	3843.4	728
1440 min Winter	3.929	0.0	4092.4	1030
2160 min Winter	2.841	0.0	4681.1	1472
2880 min Winter	2.255	0.0	4947.7	1880
4320 min Winter	1.626	0.0	5319.8	2684
5760 min Winter	1.288	0.0	5693.9	3456
7200 min Winter	1.075	0.0	5933.2	4184
8640 min Winter	0.926	0.0	6128.5	4928
10080 min Winter	0.817	0.0	6285.6	5648

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	17.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 5.500

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	2.000	4	8	2.000	8	12	1.500

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1985.0	1.500	2759.3

Complex Outflow Control

Orifice

Diameter (m) 0.125 Discharge Coefficient 0.600 Invert Level (m) 0.000

Orifice

Diameter (m) 0.070 Discharge Coefficient 0.600 Invert Level (m) 0.400

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