

AMBIENTAL

ENVIRONMENTAL ASSESSMENT

Flood Risk Assessment

4077

The Nelson, Pier Road,
Littlehampton, West Sussex, BN17
5LP

Ambiental Environmental Assessment
Sussex Innovation Centre,
Science Park Square,
Brighton, BN1 9SB



Document Issue Record

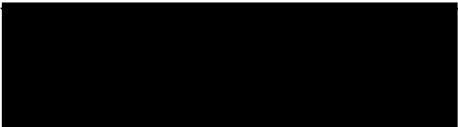
Project: Phase 1 Flood Risk Assessment

Prepared for: Bayside Architectural Design Ltd

Reference: 4077

Site Location: The Nelson, Pier Road, Littlehampton, West Sussex, BN17 5LP

Proposed Development: It is understood that the development is for the demolition of the existing public house and the construction of a hotel, with all guest rooms at the first floor and above.

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1. Summary

- 1.1 Ambiental Environmental Assessment has been appointed by Bayside Architectural Design Ltd to undertake a National Planning Policy Framework (NPPF) compliant Flood Risk Assessment (FRA) for the proposed development at The Nelson, Pier Road, Littlehampton, West Sussex, BN17 5LP.
- 1.2 The site is currently a commercial premises. It is understood that the development is for the demolition of the existing public house and the construction of a four-storey hotel, whereby all guest rooms are to be located at the first floor and above.
- 1.3 The EA Flood Map for Planning indicates that the proposed development site is located in Flood Zone 3.
- 1.4 The existing site is classified as 'More Vulnerable' under the NPPF. Post-development, the site will be considered mixed-use and as such, classified as 'Less and More Vulnerable'. The basement is to be used for storage/ meeting purposes and as such would be classified as 'Less Vulnerable'. On the ground floor and third floor, a restaurant and rooftop terrace bar are proposed respectively. Given the license needed to sell alcohol, both these are classified as 'More Vulnerable' under the NPPF. All guest rooms have been proposed to be located on the first and second floor and are similarly therefore classified as 'More Vulnerable'.
- 1.5 The EA have previously accepted similar schemes on Pier Road, for which it was agreed to set all residential development at 300mm above the 1:200 year (2115) undefended flood level, to be conservative, as the nearby defences could be overtopped.
- 1.6 The EA have stated that *"there are flood defences in the form of a wall. The crest level is 4.8mAOD. The estimated standard of protection is 1 in 300 years (0.3% AEP). The asset is maintained privately"*.
- 1.7 Management of defences in the area is stated in the Beachy Head to Selsey Bill Shoreline Management Plan (2006). The management plan for Angmering-on-Sea to Littlehampton (Policy Unit: 4d18) is 'Hold the Line' (to maintain or upgrade the level of protection provided by defences). This management policy will continue to apply at present day and across the medium (2025 to 2055) to long term (2105). It could therefore be implied that the nearby defences will be maintained and upgraded in the future.
- 1.8 The EA have provided Ambiental with a 2D undefended modelled flood level of 4.94mAOD for the 1:200 year (2115) taken from the Arun to Adur Coastal Model (2012).
- 1.9 A topographic survey has been undertaken on site. Surrounding ground levels have been assessed to slope towards the east and vary between approximately 2.45mAOD and 3.86mAOD. The existing ground floor topographic level has been surveyed to be 4.06mAOD. This level then increases up to the mezzanine (4.82mAOD). The first floor level has been surveyed to be 7.38mAOD.
- 1.10 Proposed ground floor levels are to be set at 3.30mAOD. As previously mentioned, the basement is to be used for storage/meeting rooms and is therefore considered 'Less Vulnerable'. As existing, the ground floor is to continue to be used as a restaurant which features a license to serve alcohol. Subsequently, under the NPPF, this is classified as 'More Vulnerable'. The proposed ground floor levels of 3.30mAOD lie 220mm below the defended 2D flood level that has been provided by the EA for the 1 in 200 year (2115) event. Given that the mechanism of tidal flooding is well understood, it is very likely that an early warning will be issued before such an event would strike. As such, it is very unlikely that the site would be subject to tidal flooding without several hours of early warning.
- 1.11 Subsequently, should this be the case, guests and site users would be made aware and the restaurant and hotel would subsequently close as a safety precaution.

- 1.12 Safe refuge can be provided by internal stairwells to upper floors in the unlikely event that the site would be subject to tidal flooding without several hours of early warning.
- 1.13 All guest rooms are to be located at the first floor and above. The proposed first floor level is to be set at 6.30mAOD, therefore far exceeding the 1:200 year (2115) undefended flood level with the addition of 4.94mAOD, including the 300mm freeboard allowance (5.24mAOD).
- 1.14 As such and given that:
- the proposed development is for the demolition of the existing structures and the construction of a mixed-use scheme to provide commercial use on the basement, ground floor and third floor as well as residential use on the first and second floors;
 - all guest rooms will be set no lower than 5.24mAOD (300mm above the 1:200 year (2115) undefended flood level);
 - the site lies within an area of tidal flood risk and therefore is not required to provide compensatory flood storage;
 - the site lies within an area that is currently protected by defences that have an estimated standard of protection of 1 in 300 years (0.3%). The local Shoreline Management Plan (SMP) suggests nearby defences will be maintained and upgraded in the future, given that the management plan is to 'Hold-the-Line';
 - given the nature of tidal flooding, prior evacuation can be sought;
 - in terms of flood vulnerability, betterment can be achieved through the implementation of a formal flood warnings/alert and prior evacuation, an area of safe refuge can be provided by internal stairwells to the upper floors.

Following the guidelines contained within the NPPF, the proposed development is considered to be suitable assuming appropriate mitigation (including adequate warning procedures) can be maintained for the lifetime of the development.

Development Description	Existing	Proposed
Development Type:	Public house	Four-storey hotel with basement. The basement and ground floor is to be used for a restaurant and other "Less Vulnerable" usages. All guest rooms are to be located on the first floor and above.
Number of Bedrooms:	6	14 guest rooms.
EA Vulnerability Classification:	More Vulnerable	'Less Vulnerable' and 'More Vulnerable'.
Ground Floor Level:	4.06mAOD rising to mezzanine at 4.82mAOD	3.30mAOD.
Level of Sleeping Accommodation:	First and ground floor	First and second floor.
Impermeable Surface Area:	N/A ¹	No change in impermeable surface area post-development.
Surface Water Drainage:	N/A ¹	Negligible change in built footprint and as such it is recommended that the existing Surface Water Drainage System (SWDS) is used.
Site Size:	321m ²	No change.
Risk to Development	Summary	Comment
EA Flood Zone:	3	
Flood Source:	Tidal	River Arun.
1:200 Year Flood Level (0.5%)	3.79mAOD	
1:1000 Year Flood Level (0.1%)	4.05mAOD	Arun to Adur Flood Modelling Study, completed by JBA Consulting Ltd in 2012.
1:200 Year Flood Level (2115 Epoch)	4.94mAOD	
Recorded Flood Events in Area:	Yes	
Recorded Flood Events at Site:	No	
SFRA Available:	Yes	Arun District Council SFRA (2016).
Management Measures	Summary	Comment
Ground floor level above extreme flood levels:	No	Ground floor level is proposed to be set at 3.40mAOD, below the 1:200 year, 1:000 year and the 1:200 year (2115 Epoch) flood levels. The site is protected by flood defences in the form of a wall that have a standard of protection estimated at 1 in 300 years (0.3% AEP).
Safe Access/Egress Route:	Yes	The main flood source is tidal and as such safe access can be provided via timely evacuation. In addition, internal stairwells within the proposed building provide access to upper floors for safe refuge.
Flood Resilient Design:	Yes	Sleeping accommodation located on first floor and above. First floor proposed to be set at 6.30mAOD.
Site Drainage Plan:	N/A ¹	Existing site drainage plan to be carried forward.
Flood Warning & Evacuation Plan:	Yes	EA Flood Warning Service.
Offsite Impacts	Summary	Comment
Displacement of floodwater:	N/A ¹	Site lies in area of tidal flood risk.
Increase in surface run-off generation:	N/A ¹	Increase in built footprint, minor extension.
Impact on hydraulic performance of channels:	None	Does not affect channel.

Table 1 Summary of flood risks, impacts and proposed flood mitigation measures.

N/A¹ not required for this assessment; N/A² data not available.

2. Development Description and Site Area

Proposed Development and Location

- 2.1 The proposed development is located at The Nelson, Pier Road, Littlehampton, West Sussex, BN17 5LP (Figure 1).
- 2.2 The site is currently used as a public house on the ground floor with associated function room and storage in the basement and hotel rooms on the first floor. It is understood that the proposed development is for the demolition of the existing public house and the construction of a hotel, with all guest rooms at the first floor and above. The proposed use of the ground floor and basement is for a restaurant and storage respectively.
- 2.3 The nearest watercourse to the proposed development is the tidal River Arun, located approximately 25m to the west of the site. This is classified by the EA as a Main River. The English Channel is located approximately 320m south of the existing public house and as such, the primary source of flooding to the site is considered to be tidal.
- 2.4 A topographic survey has been undertaken on site. Surrounding ground levels have been assessed to slope towards the east and vary between approximately 2.45mAOD and 3.86mAOD.

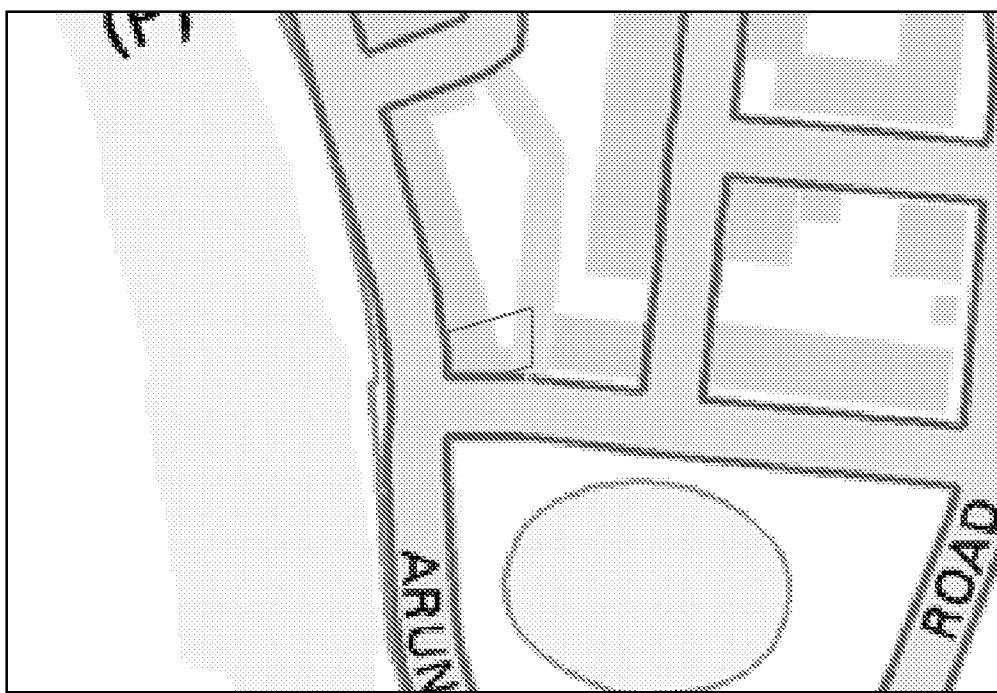


Figure 1 Location Map, identifying the location of the proposed development (Source: OS)



Figure 2 Aerial Map, identifying the location of the proposed development (Source: Google)

Vulnerability Classification

- 2.5 The EA Flood Map for Planning demonstrates that the proposed development lies within tidal Flood Zone 3 with a high probability of greater than 1 in 200 (0.5%) of flooding from seas or tidal estuaries in any year.
- 2.6 According to NPPF guidelines, the existing site is classified as 'More Vulnerable'. Post-development, the site's vulnerability is to be of mixed-use. The basement is to be used for storage purposes and as such would be classified as 'Less Vulnerable'. On the ground floor and third floor, a restaurant and rooftop terrace bar are proposed respectively. Given their licenses to sell alcohol, these are classified as 'More Vulnerable' under the NPPF. All guest rooms have been proposed to be located on the first and second floor and are similarly therefore classified as 'More Vulnerable'. The development is therefore considered a mixture of Less and More vulnerable uses.



Figure 3 EA Flood Map for Planning

Geology

- 2.7 The British Geological Survey (BGS) Geology of Britain Viewer indicates that the bedrock underlying the site is Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation comprising chalk.
- 2.8 The British Geological Survey (BGS) Geology of Britain Viewer indicates that the superficial deposits underlying the site are on the border of Raised Beach Deposits comprising sand and gravel.

3. Sequential Test/Exception Test

- 3.1 Under the NPPF, all new planning applications should undergo a *Sequential Test*. This test should be implemented by local planning authorities with a view to locating particularly vulnerable new developments (e.g. residential, hospitals, mobile homes etc.) outside of the floodplain.
- 3.2 The NPPF *Sequential Test: Flood Risk Vulnerability and Flood Zone 'Compatibility' Table* is reproduced below;

Flood Risk Vulnerability Classification		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test Required	✓	✓
	Zone 3a	Exception Test Required	✓	✗	Exception Test Required	✓
	Zone 3b <i>Functional Floodplain</i>	Exception Test Required	✓	✗	✗	✗

Table 2 The Sequential Test: Flood Risk Vulnerability and Flood Zone 'Compatibility' Table as specified by NPPF.
 Please note: ✓ means development is appropriate; ✗ means the development should not be permitted.

- 3.3 Using the principles of the Sequential Test outlined above, the proposed mixed-use development is 'Less and More Vulnerable' and is located within Flood Zone 3 (as identified by the EA Flood Map for Planning (Figure 3)). As such, the development is required to implement the Exception Test.

For the Exception Test to be passed, the proposed development must meet the following criteria:

- it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh the flood risk, as informed by a Strategic Flood Risk Assessment;
- a Flood Risk Assessment demonstrates that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

(Source: the NPPF)

- 3.4 It is important to note that several previous applications have been granted permission along Pier Road, provided that all residential development is set at 300mm above the 1:200 year (2115) undefended flood level. In such scenarios, the EA have previously had no objection, whilst furthermore, the EA have not required a Sequential Test.
- 3.5 Further to this, a public house already exists on site and residential use has already been established at this location. The proposed development is a like-for-like replacement to the existing public house, featuring the same site usage "More Vulnerable". There will also be a negligible change to built footprint and no increase in impermeable surface area. As such, Ambiental believe the requirement of a Sequential Test for the proposed development would not be considered pragmatic. The proposed development is a redevelopment of the existing site use and therefore a replacement structure much like a replacement dwelling.

- 3.6 As such, and in order to address these requirements, the planning application submitted by the applicant is required to be accompanied by an FRA which shows that the development can be achieved in a sustainable manner, with an overall reduction of flood risk to the site and surrounding area.

4. Site Flood Hazards

Sources of Flooding

- 4.1 The proposed development is located within Flood Zone 3 (high risk of flooding) and is considered to be 'Less and More Vulnerable' according to NPPF guidelines. Table 3 summarises the potential sources of flooding to the site:

Source	Description
Tidal	River Arun English Channel
Surface	N/A
Groundwater	On Site
Sewer	In Area

Table 3 Summary of flood sources.

Mechanisms of Flooding

- 4.2 According to the EA Flood Map for Planning, the proposed development site is located in Flood Zone 3 of the tidal flood plains of the River Arun and the English Channel (tidal).
- 4.3 The Flood Zones shown in Figure 3 outlines only the potential floodplain; and the mitigating effects of flood defences currently in place are not considered. The EA have stated that "there are flood defences in the form of a wall. The crest level is 4.8mAOD. The estimated standard of protection is 1 in 300 years (0.3% AEP). The asset is maintained privately".

Tidal

- 4.4 The EA Flood Map for Planning (Figure 3) confirms that the site lies within Flood Zone 3 (High Risk), having a 1 in 200 or greater annual probability of flooding from the sea (>0.5%).
- 4.5 The River Arun is located approximately 25m west of the site at its closest proximity. The River Arun has been identified by the EA as a Main River. The English Channel is located approximately 320m to the south.
- 4.6 The proposed development is for the demolition of the existing public house and the construction of a four-storey hotel, whereby all guest rooms are to be located on the first and second floor. The basement is to be used for storage purposes and as a meeting room, whilst the ground floor and third floor are proposed to be a restaurant and rooftop terrace bars respectively. As such, the proposed development is considered 'More and Less Vulnerable' under the NPPF.
- 4.7 The EA provided Ambiental with defended and undefended maximum flood levels and depths at a single 2D node point (NGR: 502778,101601). The data was taken from the Arun to Adur Coastal Model, completed by JBA Consulting. The floodplain node provided has modelled flood levels and depths for the 1:200 year, 1:200 year (2070 and 2115 Epochs) and 1:1000 year annual exceedance probabilities. The undefended levels were provided from simulations ran in 2012. Since then, the model has been updated and defended

results have been produced from simulations undertaken in 2017. The node location map is provided in *Figure 4*.

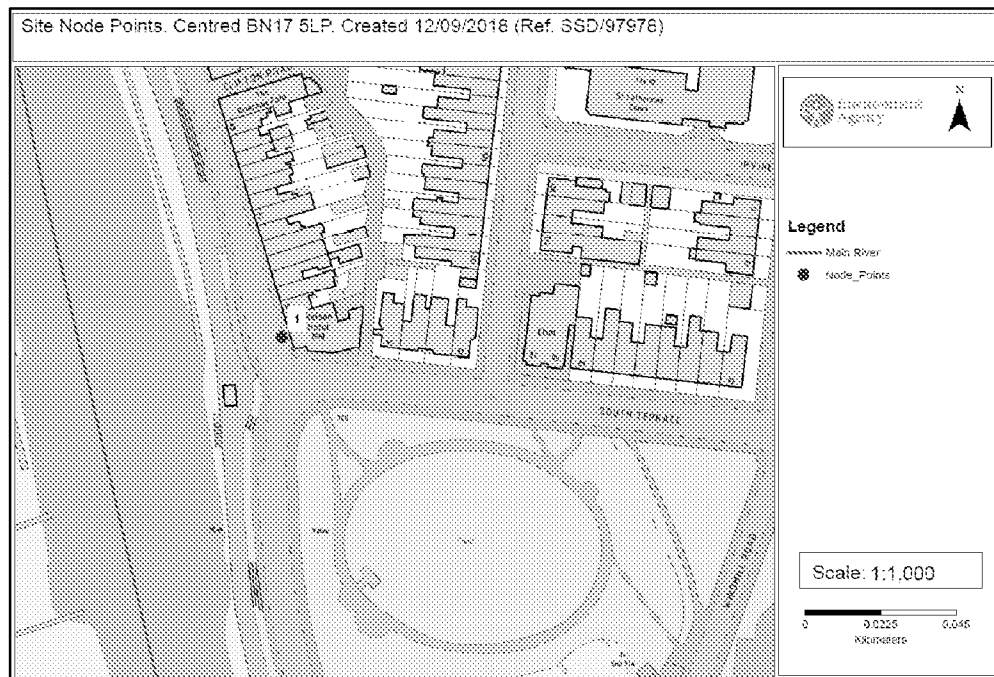


Figure 4 Node Point Location Map (Source: EA)

- 4.8 The provided modelled flood levels for the defended and undefended simulations are presented in *Figure 5*.

Table 1: Water Levels: Tidal Undefended (2012)						
Node Ref	NGR		Modelled Flood Levels in Metres			
	Eastings	Northings	Undefended Annual Exceedance Probability			
			0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	502778	101601	3.79	4.35	4.94	4.05

Table 2: Water Levels: Tidal Defended (2017)						
Node Ref	NGR		Modelled Flood Levels in Metres			
	Eastings	Northings	Defended Annual Exceedance Probability			
			0.5%	0.5% (2065)	0.5% (2115)	0.1%
1	502778	101601	-	-	3.52	-

Figure 5 Undefended and defended flood levels as taken from the Arun to Adur Coastal Model (2012 and 2017) (Source: EA)

- 4.9 The analysis focuses on the undefended 1:200 year (0.5% AEP), 1:200 year (0.5% AEP) 2115 epoch, 1:1000 year (0.1% AEP) flood levels. The EA have also provided the 1:200 year (0.5% AEP) 2070 epoch flood level, however given that the proposed development is for residential usage, it is necessary to ensure that the development is safe for its lifetime which is considered to be 100 years under the NPPF.
- 4.10 Provided that all residential development was set at 300mm above the 1:200 year (2115 epoch) undefended flood level, the EA have previously accepted similar schemes on Pier Road. The undefended level was used to be conservative given that the nearby defences could be overtopped.

- 4.11 The EA have provided Ambiental with a 2D undefended modelled flood level of 4.94mAOD for the 1:200 year (2115) taken from the Arun to Adur Coastal Model (2012).
- 4.12 All guest rooms are to be located at the first floor and above. The proposed first floor level is to be set at 6.30mAOD, therefore far exceeding the 1:200 year (2115) undefended flood level with the addition of the 300mm freeboard (5.24mAOD).
- 4.13 Following a topographic survey, existing ground floor levels have been measured to be set at 4.06mAOD. It is proposed that post-development, ground floor levels will be lowered to 3.30mAOD.
- 4.14 The undefended flood level of 4.94mAOD for the 1:200 year (2115 epoch) flood event subsequently suggests that proposed ground floor levels may experience depths of up to 1.64m.
- 4.15 The EA have stated that *“there are flood defences in the form of a wall. The crest level is 4.8mAOD. The estimated standard of protection is 1 in 300 years (0.3% AEP). The asset is maintained privately”*.
- 4.16 This is further supported by the Arun District Council SFRA (2016) that states *“A Flood Management Scheme for defences along the eastern bank of the River Arun adjacent to Littlehampton has recently been completed. The new defences, which extend from the coastal frontage of Littlehampton to approximately 500m beyond the A259, are reported by the Environment Agency to have been constructed to a 1 in 300 annual exceedance probability standard of protection”*.
- 4.17 Given that the defences have only recently been completed, the condition grade for the embankment defences along the River Arun is ‘Very good’, suggesting that there is at most cosmetic defects that will have no effect on the performance of the assets (Figure 6).

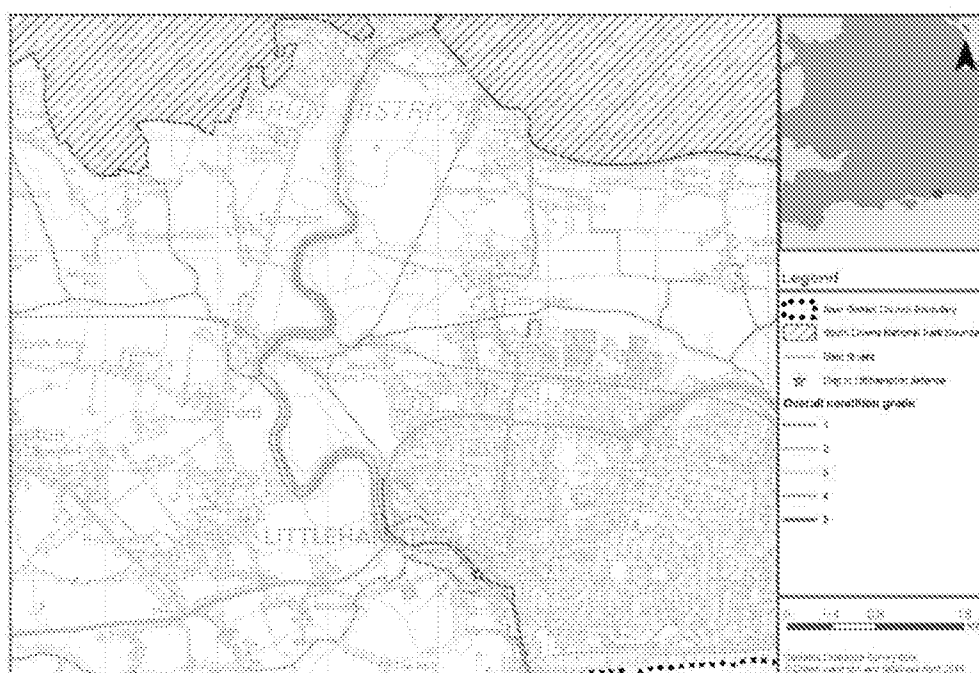


Figure 6 Overall condition grade of the defences in Littlehampton (Source: Arun District Council SFRA ,2016)

- 4.18 The Arun District Council SFRA (2016) also reports that soft engineering methods in the form of a shingle beach provides an estimated design standard of protection for the 1:200 year event.
- 4.19 The scheme to strengthen the defences in the area is stated in the Beachy Head to Selsey Bill Shoreline Management Plan (2006), the management policy for Angmering-on-Sea to Littlehampton (Policy Unit: 4d18) is ‘Hold the Line’ – maintain or upgrade the level of protection provided by defences. The

management policy will continue to apply at present day and across the medium (2025 to 2055) to long term (2105). It can therefore be assumed the improvements in defences will be maintained and upgraded in the future.

- 4.20 It is important to note that tidal flooding is generally caused by low pressure weather systems creating storm-surges (or storm tides), chiefly via high speed winds. These winds (and to a certain extent, the low pressure) create a 'bulge' of water which, if it coincides with high tide, can generate very high, stormy, water levels. However, because this mechanism is well understood, it is very likely that an early warning will be issued before such an event strikes. As such, it is very unlikely that the site would be subject to tidal flooding without several hours of early warning.
- 4.21 Given that the proposed usage of the ground floor is for commercial purposes and that there are defences in the immediate vicinity of the site with a high standard of protection (1 in 300 year), it could be considered unnecessary to set finished ground floor levels in accordance with the undefended flood level. This is particularly the case given that the mechanism of tidal flooding is well understood and, as such, it is very unlikely that the site would be subject to tidal flooding without several hours of prior warning. Internal stairwells to upper floors provide a means of safe refuge in the unlikely event that the site would be subject to such an event.
- 4.22 The EA have also provided a defended climate change flood level for the 1:200 year (0.5% AEP) 2115 epoch flood event which is estimated to be 3.52mAOD. The defended modelling works is an update to the original 2012 undefended data and was completed in 2017.
- 4.23 As such, with reference to the defended modelled flood level, the proposed ground floor is predicted to experience depths of 220mm for the 1:200 year (2115 epoch) event.
- 4.24 Subsequently appropriate flood resilience design and mitigation measures are to be put in place. Following receipt of a flood warning, site users are to be notified and the restaurant and hotel will subsequently close until the event has passed.
- 4.25 The EA have provided details of historic flood incidents in the area of the site. Preceding 1985, flooding of properties, roads and industrial areas have been recorded in the vicinity of the site, caused by overtopping mainly through the harbour masters yard where water gates were reported to be left open. Between 40 and 100 houses were affected by this incident. However, flood defences have been improved in the area which has subsequently reduced the risk of flooding in the vicinity of the site.
- 4.26 Given the quality and standard of defences within the surrounding area, site usage and the mechanism of tidal flooding, the risk of flooding to the site from tidal sources is deemed to be **relatively low**.

Surface Water (Pluvial)

- 4.27 The Environment Agency Flood Risk from Surface Water website shows the proposed development to be within an area of 'Very Low' risk of flooding from surface water. Areas identified to be at 'Very Low' risk have a less than 0.1% annual risk of flooding from this source (*Figure 7*).
- 4.28 The EA Surface Water Flood Depth Map for the High Risk Scenario indicates that the proposed development is not affected in this event.
- 4.29 The EA Surface Water Flood Depth Map for the Medium Risk Scenario indicates that the proposed development is not affected in this event.

- 4.30 The EA Surface Water Flood Depth Map for the Low Risk Scenario indicates that the proposed development is not affected in this event as displayed in *Figure 8*.
- 4.31 A number of surface water flooding incidents have also been recorded in close proximity to the site along St Catherine's Road and on the junction of Irvine Road and Beach Road. No further information has been provided regarding these incidents, however the SFRA states that the primary source of surface water flooding was attributed to heavy rainfall overloading highway carriageways and paved areas, drains and gullies, as well as blockages and high water levels impeding free discharge from surface water drains and gullies.
- 4.32 As such the risk of flooding to the site from surface water is deemed to be **relatively low**.

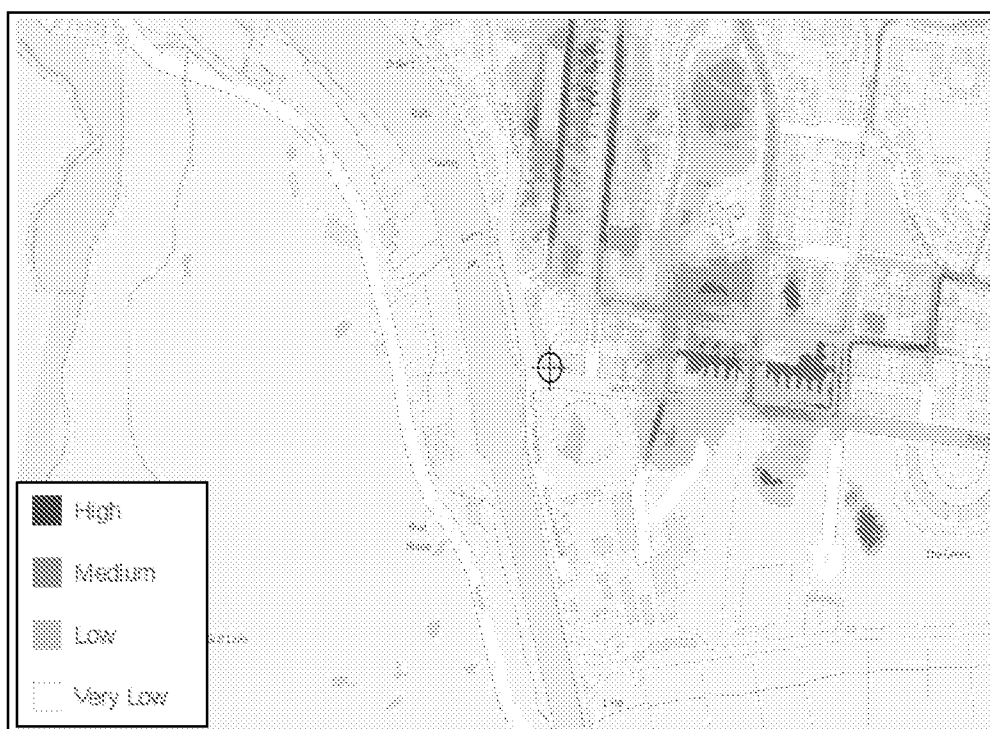


Figure 7 EA Surface Water Flood Risk Map. (Source: EA)

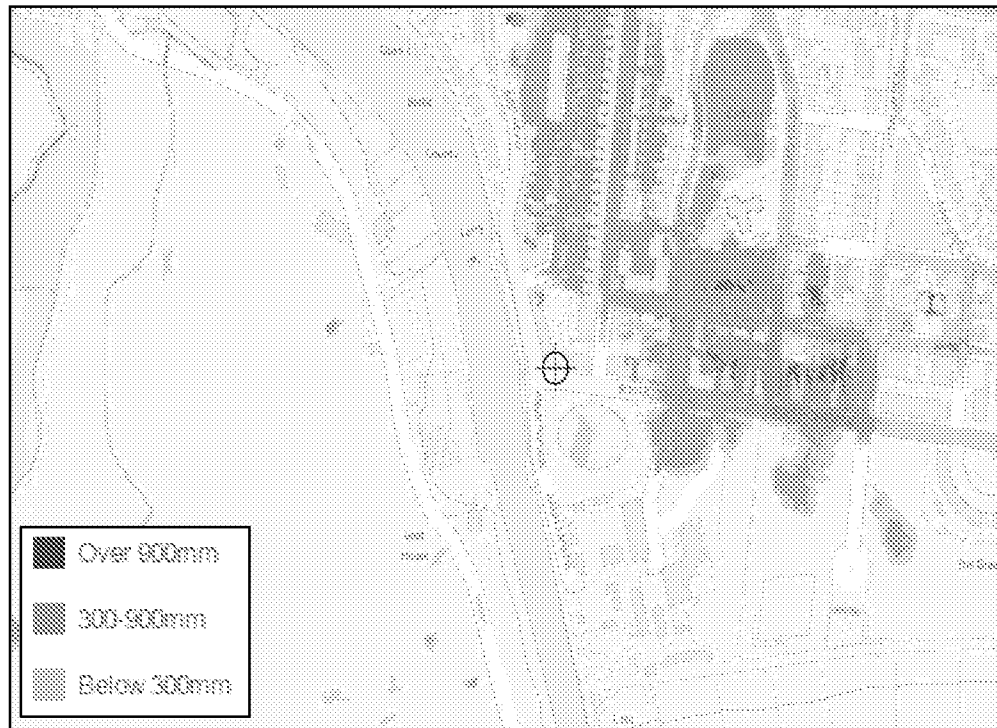


Figure 3 Surface Water Depths for a Low Risk Scenario. (Source: EA)

Groundwater

- 4.33 The British Geological Survey (BGS) Geology of Britain Viewer indicates that the bedrock underlying the site is Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (Source: BGS). This formation is considered to be a Principal aquifer (Source: EA; Magic Map online resource). A Principal aquifer is highly permeable, supporting water supply and/or river base flow on a strategic scale.
- 4.34 The British Geological Survey (BGS) Geology of Britain Viewer indicates that the superficial deposits underlying the site are Raised Beach Deposits comprising sand and Raised Beach Deposits comprising gravel. This formation is a permeable secondary 'A' aquifer which is capable of supporting water supplies at a local scale and may contribute to base flow of rivers (Source: EA; Magic Map online resource).
- 4.35 This aquifer is considered to be a highly vulnerable principal aquifer, meaning that soils have little ability to attenuate pollutants and therefore pollutants can rapidly reach groundwater.
- 4.36 The site is not within an EA groundwater Source Protection Zone (Source: EA; Magic Map online resource). The EA has however identified the site to be located over a major aquifer with high vulnerability (Figure 9).

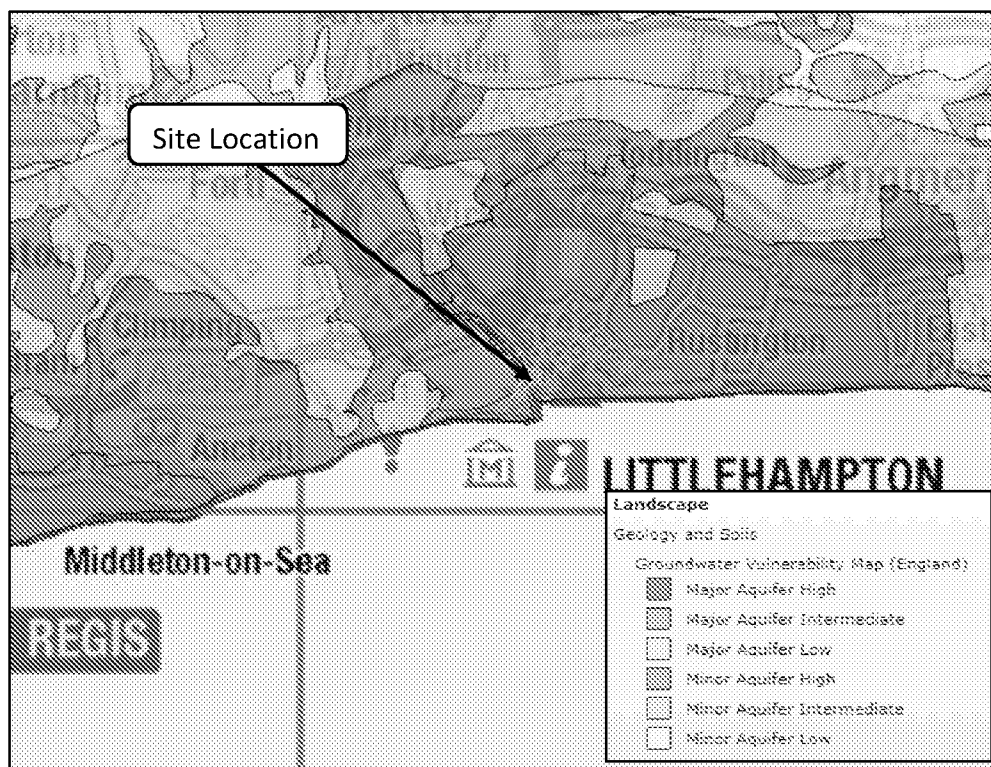


Figure 4 Groundwater Vulnerability Map (Source: EA; Magic Map)

- 4.37 The Arun District Council SFRA (2016) Area Susceptible to Groundwater (Appendix A) shows the site to be located in an area susceptible to groundwater flooding classified as $\geq 75\%$ (Figure 10).
- 4.38 The Arun District Council SFRA (2016) has no records of historical groundwater flooding in the area.
- 4.39 As such, the risk of flooding from this source can be considered to be **moderate**.

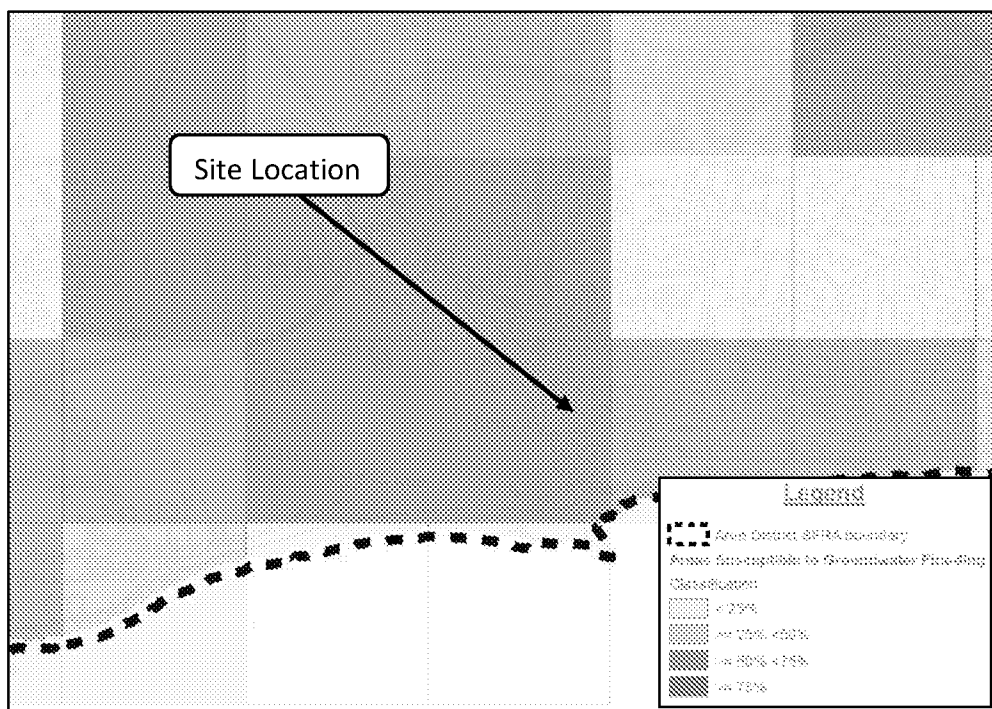


Figure 10 Areas Susceptible to Groundwater Flooding. (Source: Arun District Council SFRA, 2016)

Sewer

4.40 The Arun District Council SFRA (2016 Update) Historic Incidents of Flooding from Sewers Map (Figure 11) shows the area surrounding the site has had 6 recorded historic sewer flooding incidents. However, there have been no recorded historic sewer flood events on site.

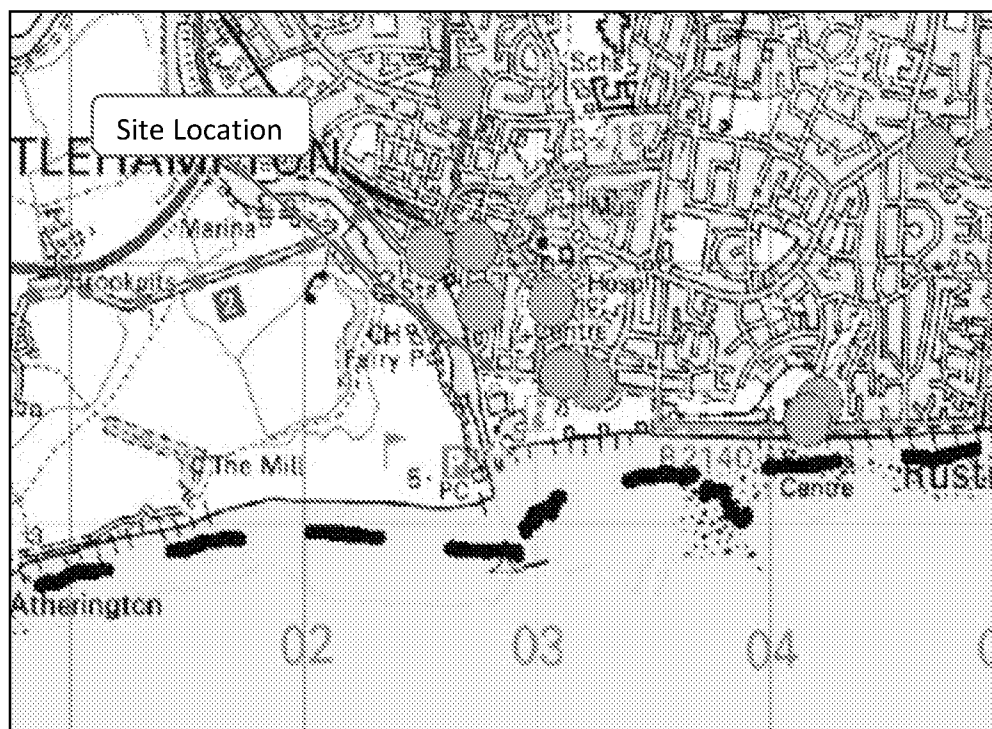


Figure 5 Sewer. (Source: based on DG5 Register)

- 4.41 The Arun District Council SFRA (August 2016 Update) does not provide any further information about when the incidents occurred, severity or cause.
- 4.42 As such, the risk to the site from sewer flood sources can be considered relatively low.

Surface Water Drainage Strategy

- 4.43 The existing site is developed and is currently used as a public house on the ground floor with associated function room and storage in the basement and hotel rooms on the first floor. It is understood that the proposed development is for the demolition of the existing public house and the construction of a hotel, with all guest rooms at the first floor and above. The proposed use of the ground floor and basement is for a restaurant and storage respectively.
- 4.44 Given that there is to be a negligible increase in built footprint and no change to impermeable surface area on site, it is recommended that the applicant will discharge surface water by means of the existing management infrastructure associated with the existing property.

Records of Historical Flooding

- 4.45 The Arun District Council SFRA (August 2016 Update) Historic Flooding Records Map show one historic flood event approximately 40m north of the development site, however the source of flooding is unknown. One recorded flood outline has been identified in close proximity to the site, approximately 150m north along Pier Road (*Figure 12*).
- 4.46 The EA have provided historic flood incidents in the area of the site. Preceding 1985 flooding of properties, roads and industrial areas have been recorded in the vicinity of the site, caused by overtopping mainly through the harbour masters yard where water gates were reported to be left open. Between 40 and 100 houses were affected by this incident. However, flood defences have been improved in the area which has subsequently reduced the risk of flooding in the vicinity of the site.
- 4.47 A number of surface water flooding incidents have also been recorded in close proximity to the site along St Catherine's Road and on the junction of Irvine Road and Beach Road. No further information has been provided regarding these incidents, however the SFRA states that the primary source of surface water flooding was attributed to heavy rainfall overloading highway carriageways and paved areas, drains and gullies, as well as blockages and high water levels impeding free discharge from surface water drains and gullies.

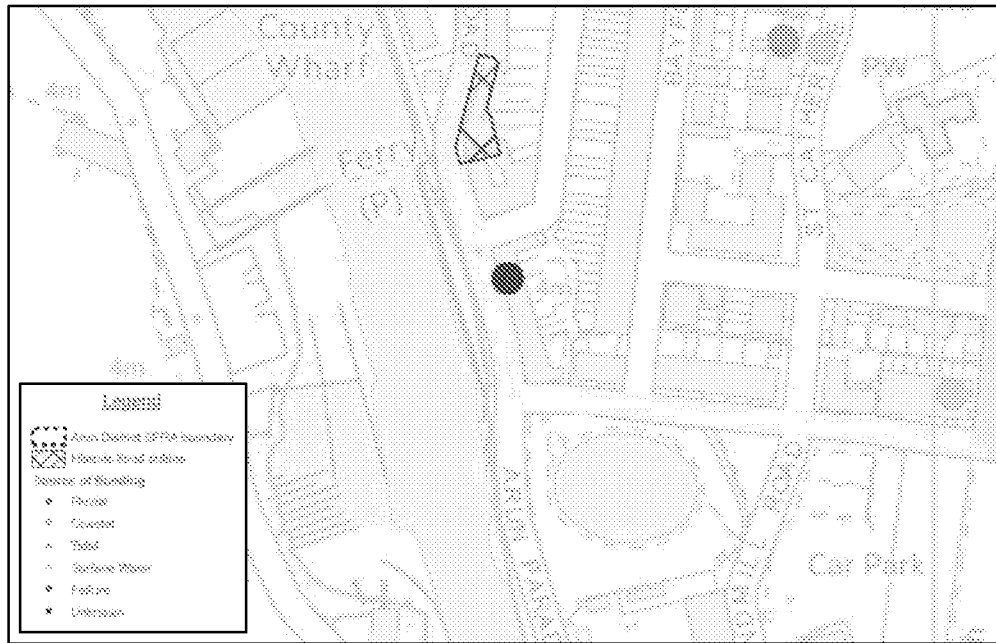


Figure 6 Historical Flooding. (Source: EA)

5. Probability of Flooding

Flood Zones

- 5.1 According to the EA Flood Map for Planning, the site is located within Flood Zone 3 (high risk of flooding).
- 5.2 Tidal flooding is generally caused by low pressure weather systems creating storm-surges (or storm tides), chiefly via high speed winds. These winds (and to a certain extent, the low pressure) create a 'bulge' of water which, if it coincides with high tide, can generate very high, stormy, water levels. However, because this mechanism is well understood, it is very likely that an early warning will be issued before such an event strikes. As such, it is very unlikely that the site would be subject to tidal flooding without several hours of early warning.
- 5.3 The EA Flood Map for Planning has been produced in part using a relatively coarse, national scale flood modelling strategy, and in part by detailed modelling. It is important to note that only the potential floodplain is modelled; **the mitigating effects of any flood defences currently in place are not considered.** For reference, the definition of the NPPF flood risk zones is included below.

Zone	Description
1	Low Probability. This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
2	Medium Probability. This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year.
3a	High Probability. This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
3b	The Functional Floodplain. This zone comprises land where water has to flow or be stored in times of flood. SFRA's should identify this Flood Zone (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, or at another probability to be agreed between the LPA and the EA, including water conveyance routes).

Table 4 Definition of the NPPF Flood Zones. (Source: EA)

Climate Change on Site

- 5.4 Climate change is likely to increase the flow in rivers, and raise sea levels and storm intensity.
- 5.5 The EA have recently updated the peak river flow allowances to use for different types of development. Communication with the EA, Flood and Coastal Risk Management Officer has confirmed that the changes are only focused to river flow and rainfall allowances. Tidal allowances are detailed in Table 3 of the new changes (<https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>). As a result of this dialogue it has been confirmed that the EA detailed data sets provided are relevant for the purposes of this assessment given that the dominant source of flooding is tidal.
- 5.6 The EA has also stated that the climate change will increase the peak rainfall intensity allowance in small and urban catchments.

River basin district	Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
South East	Upper end	25%	50%	105%
	Higher central	15%	30%	45%
	Central	10%	20%	35%

Table 5: Peak river flow allowances for the South East River basin district (Source: EA).

6. Residual Risks

Identification of Residual Risks

6.1 Residual risks are those remaining after applying the sequential approach to the location of development and taking mitigating actions. Examples of residual flood risk include:

- the failure of flood management infrastructure such as a breach of a raised flood defence, blockage of a surface water conveyance system, overtopping of an upstream storage area, or failure of a pumped drainage system;
- failure of a reservoir, or;
- a severe flood event that exceeds a flood management design standard, such as a flood that overtops a raised flood defence, or an intense rainfall event which the drainage system cannot cope with.

6.2 The controlling residual flood risk mechanism on site is tidal. Tidal flooding is generally caused by low pressure weather systems creating storm-surges (or storm tides), chiefly via high speed winds. These winds (and to a certain extent, the low pressure) create a 'bulge' of water which, if it coincides with high tide, can generate very high, stormy, water levels. However, because this mechanism is well understood, it is very likely that an early warning will be issued before a tidal flood event occurs. As such, it is very unlikely that the site would be subject to tidal flooding without several hours of early warning.

6.3 Given the nature of the tidal cycle flood waters on site will likely recede as in-channel water levels fall.

Overtopping

6.4 At the time of writing, the EA and Arun District Council SFRA (August 2016 Update) has not provided data relating to overtopping of defences.

6.5 The Beachy Head to Selsey Bill Shoreline Management Plan (2006) states that the 'hold the line' strategy will cause no loss of property or land behind the existing defences, but properties may become more exposed and subject to overtopping and flood damage (See Table 6).

Location reference: Angmering-on-Sea to Littlehampton						
Policy Unit reference: 4d18						
IMPLICATIONS OF THE PREFERRED PLAN FOR THIS LOCATION						
Time Period	Management Activities	Property, Built Assets & Land Use	Landscape	Nature Conservation	Historic Environment	Amenity & Recreational Use
2005 – 2025	Continue with current management practices.	No loss of property or land behind the existing defences.	No nature conservation gains or losses.	No loss or gains to landscape character of beachfront.	No loss of heritage sites landward of defences.	No loss of continuity of recreational facilities landward of defences. Narrow beach retained.
2025 – 2055	Increased engineering and beach management practices.	No loss of property or land behind the existing defences.	No nature conservation gains or losses.	Landscape character of beachfront may change due to greater defence works, with possible loss of beach habitat.	No loss of heritage sites landward of defences.	No loss of continuity of recreational facilities landward of defences. Some land may need to be sacrificed to establish new defences. Reduction in beach.
2055 – 2105	Increased engineering and beach management practices. New replacement defences required. Espanade may need to be relocated/ set back.	No loss of property or land behind the existing defences. Properties may become more exposed and subject to overtopping and flood damage.	No nature conservation gains or losses.	Landscape character of beachfront may change due to greater defence works.	No loss of heritage sites landward of defences. Some potential loss of conservation areas.	No loss of continuity of recreational facilities landward of defences. Blue Flag status may be lost due to reduced beach width.

Table 6: Implications of the Preferred Strategy for this Location (Source: Beachy Head to Selsey Bill SMP, 2006)

Defence Breach

- 6.6 The EA have stated that *“there are flood defences in the form of a wall. The crest level is 4.8mAOD. The estimated standard of protection is 1 in 300 years (0.3% AEP). The asset is maintained privately”*.
- 6.7 This is further supported by the Arun District Council SFRA (2016) that states *“A Flood Management Scheme for defences along the eastern bank of the River Arun adjacent to Littlehampton has recently been completed. The new defences, which extend from the coastal frontage of Littlehampton to approximately 500m beyond the A259, are reported by the Environment Agency to have been constructed to a 1 in 300 annual exceedance probability standard of protection”*.
- 6.8 Given that the defences have only recently been completed, the condition grade for the embankment defences along the River Arun is ‘Very good’, suggesting that there is at most cosmetic defects that will have no effect on the performance of the assets.
- 6.9 The Arun District Council SFRA (2016) also reports that soft engineering methods in the form of a shingle beach provides an estimated design standard of protection for the 1:200 year event.
- 6.10 The scheme to strengthen the defences in the area is stated in the Beachy Head to Selsey Bill Shoreline Management Plan (2006), the management policy for Angmering-on-Sea to Littlehampton (Policy Unit: 4d18) is ‘Hold the Line’ – maintain or upgrade the level of protection provided by defences. The management policy will continue to apply at present day and across the medium (2025 to 2055) to long term (2105). It can therefore be assumed the improvements in defences will be maintained and upgraded in the future.
- 6.11 The Arun District Council SFRA (2016) outlines that there is a 17m gap in the new defences west of the site, close to ‘Riverside Autos’ (NGR: 502397,102097) which is currently not to the 1 in 300-year standard of protection. This is represented by the yellow star in *Figure 7*. The Environment Agency have arrangements in place to deploy temporary barriers at this gap in the defence should it be necessary, until the defence line has been completed.

Reservoir Failure

- 6.12 The EA Risk from Reservoir Map demonstrates that the site is outside flood extents in the event of reservoir flooding.

7. Flood Risk Management Measures

Flood Risks

- 7.1 The site is located in Flood Zone 3 (High Risk of flooding as defined in the NPPF) according to the EA Floodmap, as such the proposed development will require flood mitigation measures.
- 7.2 The controlling residual flood risk mechanism on site is tidal. Tidal flooding is generally caused by low pressure weather systems creating storm-surges (or storm tides), chiefly via high speed winds. These winds (and to a certain extent, the low pressure) create a 'bulge' of water which, if it coincides with high tide, can generate very high, stormy, water levels. However, because this mechanism is well understood, it is very likely that an early warning will be issued before such an event strikes. As such, it is very unlikely that the site would be subject to tidal flooding without several hours of early warning.
- 7.3 Given the nature of the tidal cycle and fluvial channel setting, flood waters on site will likely recede as the in-channel water levels fall.
- 7.4 The existing site is developed and is currently used as a public house on the ground floor with associated function room and storage in the basement and hotel rooms on the first floor. It is understood that the proposed development is for the demolition of the existing public house and the construction of a new hotel, with all guest rooms at the first floor and above. The proposed use of the ground floor and basement is for a restaurant and storage respectively. Given this, all sleeping accommodation will be located on the first and second floor.
- 7.5 Following comparing modelled flood levels with the proposed ground floor levels, it can be confirmed that post-development the site would reside within the extreme tidal flood extent. The site is subsequently estimated to experience depths of 220mm for the 1:200 year (0.5% AEP) 2115 epoch. Given that the nature and mechanism of tidal flooding is well understood, it is very unlikely that the site would be subject to tidal flooding without several hours of prior warning, as such, it is recommended that 600mm demountable flood barriers are installed on site.
- 7.6 As such the following mitigation measures are proposed:
 - the instalment of 600mm demountable flood barriers;
 - bringing down electrical services from ceilings, where possible;
 - all plumbing insulation to be of closed-cell design;
 - locate all sleeping accommodation on the first floor and above;
 - any kitchen units to be of solid, water resistant material;
 - subscribe to the EA Flood Warning Service and ensure that this service is made available to all site users, future owners and residents, and;
 - formulate an evacuation plan to be implemented in the event of severe flood or weather warnings.
- 7.7 The first floor level of the existing development is proposed to be set 3.00m above the ground floor level (*Figure 13*) at 6.30mAOD. This proposed level is approximately 1.36m higher than the undefended 1:200 year (2115 epoch) flood level of 4.94mAOD and 1.06m higher than 5.24mAOD (with the 300mm freeboard allowance previously agreed by the EA for other developments along Pier Road). Furthermore, the proposed first floor level is 2.78m higher than the defended 1:200 year (2115 epoch) flood level of 3.52mAOD.

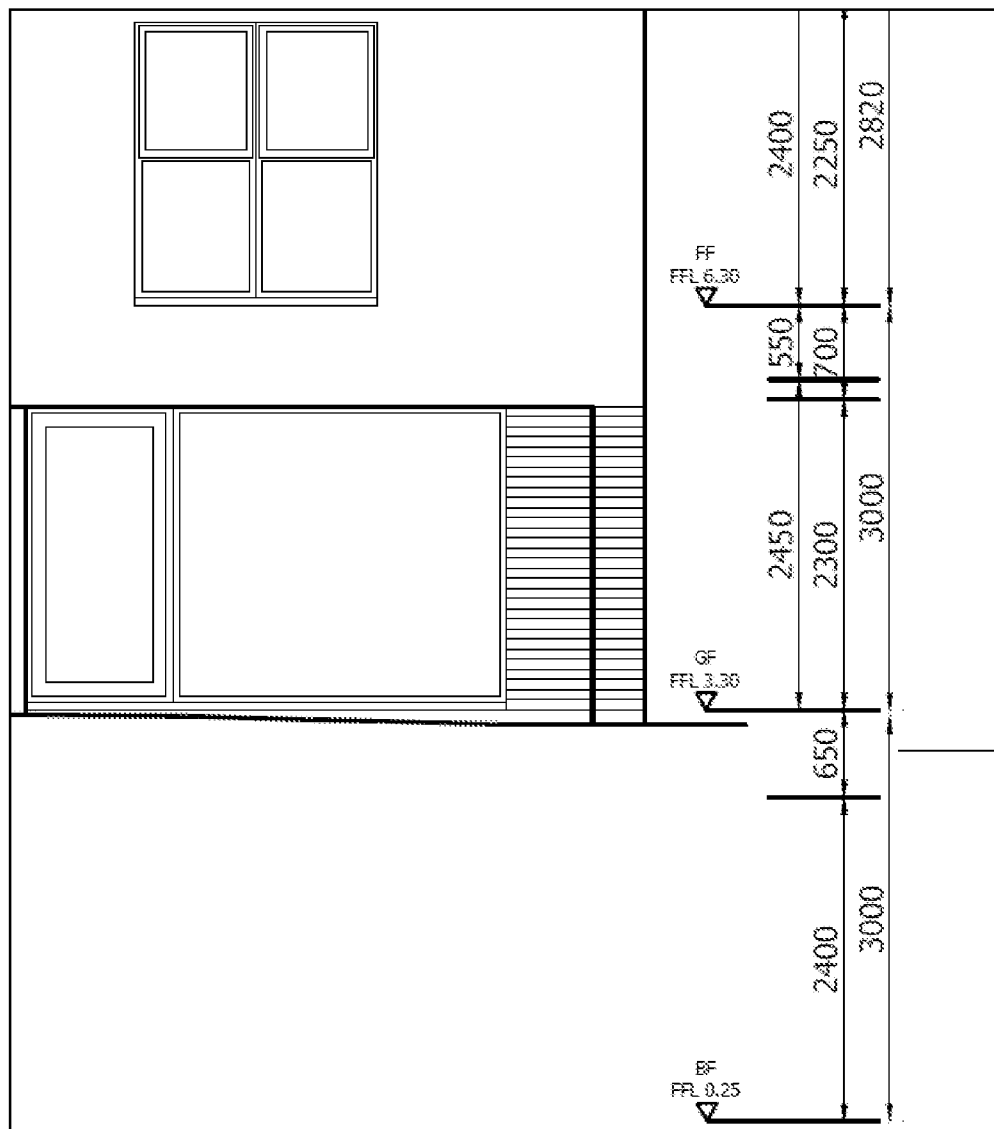


Figure 13 Extract of Finished Floor Levels

Flood Warning Service

- 7.8 The site resides within Flood Zone 3 (tidal) and is located within an EA Flood Warning Service Area (Figure 14).
- 7.9 It is recommended the site owner and site staff sign up to the EA flood warning service if they have not done so already in order to provide betterment to the site. It is recommended that all new site owners and new site staff are made aware of the potential flood risk to the site and that they sign up to the EA flood warning service. It is recommended that all site users are also made aware of the potential flood risk posed to the site.
- 7.10 The EA operates a 24-hour telephone service on 0345 988 1188 that provides frequently updated flood warnings and associated floodplain information. Further information can be found on www.environment-agency.gov.uk/floodline. Floodline Warnings Direct is a free service operated by the EA that provides flood warnings direct to occupants by telephone, mobile phone, fax or pager.

- 7.11 Upon receipt of a Flood Warning, site users are advised to evacuate the site to a designated place of safe refuge within Flood Zone 1.

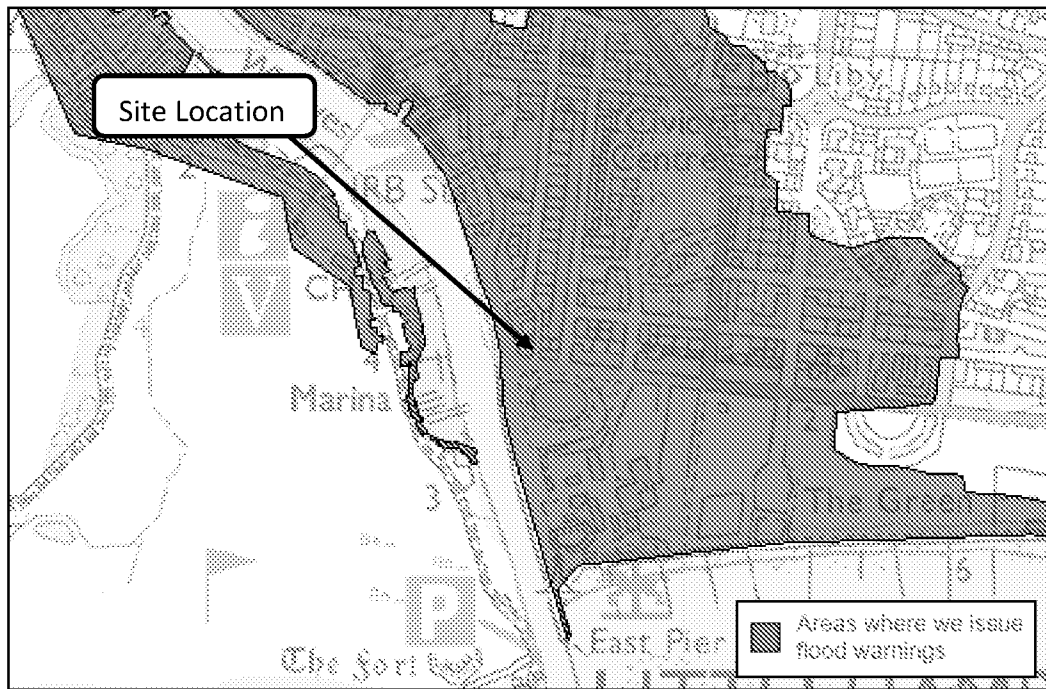


Figure 74 EA Flood Warning Area (Source: EA Online).

- 7.12 If flooding has already occurred prior to evacuation, it is advised to remain on the upper floors of the property and await instruction from the emergency services or until it is deemed safe to evacuate. Residents should move via internal stairwells to the upper floors of the property so as to be located within an area of safe refuge. No evacuation should be sought if flood depths exceed 25cm, evacuation should only be sought with the assistance of the emergency services in these circumstances.
- 7.13 The maximum and minimum sea level (tidal peak and trough) are approximately 6 hours apart. As such, it is expected that tidal waters will drain away well within 6 hours. In practicality, the peak of the surge would last for a much shorter period of time and as such, it would be likely that water would recede much faster. However, due to the potential hazard of overtopping via wave-action, it is not recommended that occupants leave the building until low tide (or until the emergency services instruct them to do so).
- 7.14 Tidal flooding is generally caused by low pressure weather systems creating storm-surges (or storm tides), chiefly via high speed winds. These winds (and to a certain extent, the low pressure) create a 'bulge' of water which, if it coincides with high tide, can generate very high, stormy, water levels. However, because this mechanism is well understood, it is very likely that early warning will be issued before such an event strikes.
- 7.15 **As such, it is very unlikely that the site would be subject to flooding without several hours of early warning.**

8. Off Site Impacts

Impact to Flood Risk Elsewhere

- 8.1 The site is located in Flood Zone 3, (tidal flood risk) and under the NPPF:

“unless the development is located in an area which is subject to tidal flooding and which serves no conveyance function, land raising must be accompanied by compensatory provision of flood storage either on- or off-site”

As such there is no requirement for compensatory flood storage.

Generation of Runoff

- 8.2 The existing site is developed and is currently used as a public house on the ground floor with associated function room and storage in the basement and hotel rooms on the first floor. It is understood that the proposed development is for the demolition of the existing public house and the construction of a hotel, with all guest rooms at the first floor and above. The proposed use of the ground floor and basement is for a restaurant and storage respectively. Given this, all sleeping accommodation will be located on the first and second floor.
- 8.3 Given that there is to be a negligible increase in built footprint and no change to impermeable surface area on site, it is recommended that the applicant will discharge surface water by means of the existing management infrastructure associated with the existing property.

9. Conclusion

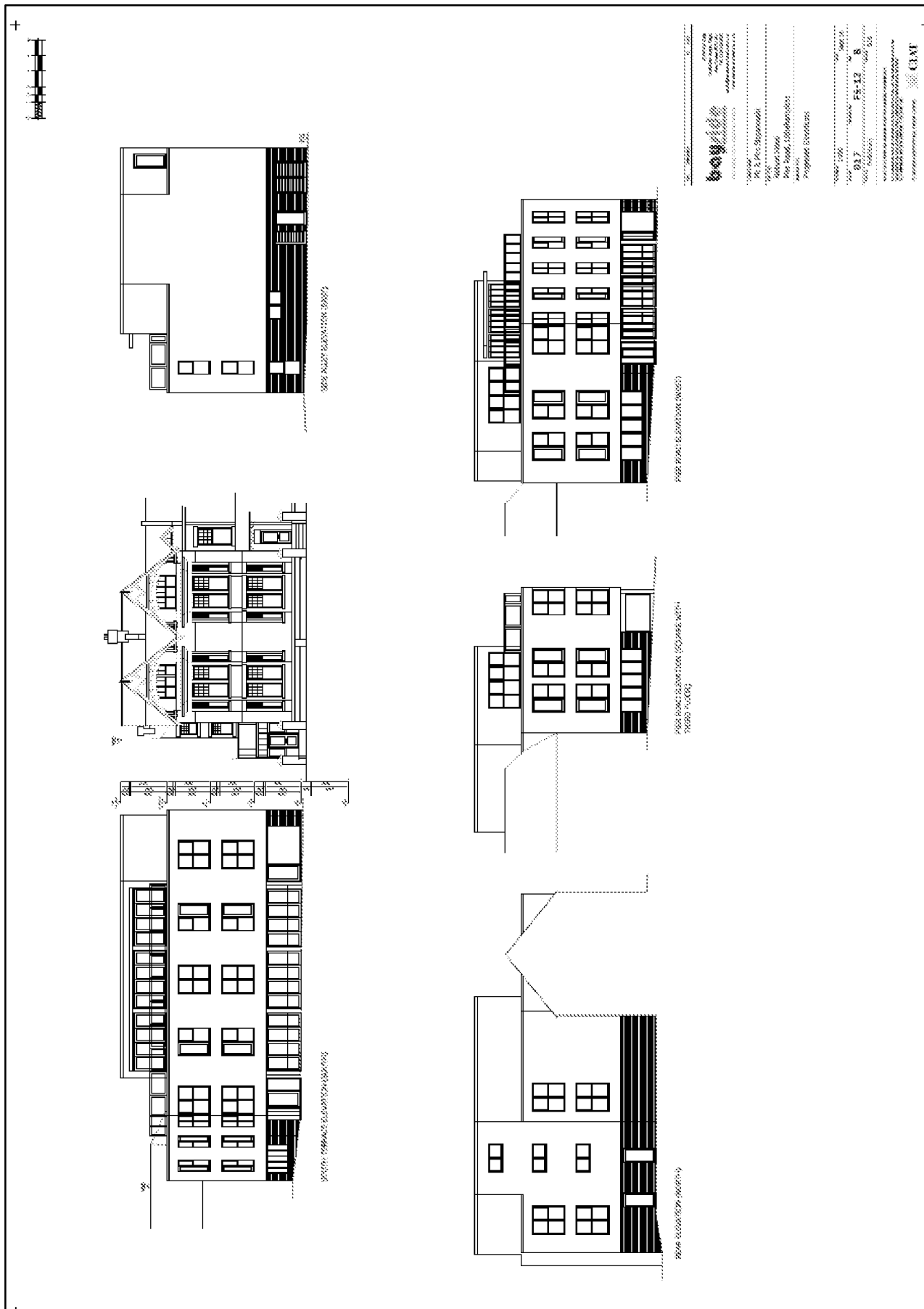
- 9.1 Ambiental Environmental Assessment has been appointed by Bayside Architectural Design Ltd to undertake a National Planning Policy Framework (NPPF) compliant Flood Risk Assessment (FRA) for the proposed development at The Nelson, Pier Road, Littlehampton, West Sussex, BN17 5LP.
- 9.2 The site is currently a commercial premises. It is understood that the development is for the demolition of the existing public house and the construction of a four-storey hotel, whereby all guest rooms are to be located at the first floor and above.
- 9.3 The EA Flood Map for Planning indicates that the proposed development site is located in Flood Zone 3.
- 9.4 The existing site is classified as 'More Vulnerable' under the NPPF. Post-development, the site will be considered mixed-use and as such, classified as 'Less and More Vulnerable'. The basement is to be used for storage purposes and as such would be classified as 'Less Vulnerable'. On the first floor and third floor, a restaurant and rooftop terrace bar are proposed respectively. Given their license to sell alcohol, these are classified as 'More Vulnerable' under the NPPF. All guest rooms have been proposed to be located on the first and second floor and are similarly therefore classified as 'More Vulnerable'.
- 9.5 The EA have previously accepted similar schemes on Pier Road, for which it was agreed to set all residential development at 300mm above the 1:200 year (2115) undefended flood level, to be conservative, as the nearby defences could be overtopped.
- 9.6 The EA have stated that *"there are flood defences in the form of a wall. The crest level is 4.8mAOD. The estimated standard of protection is 1 in 300 years (0.3% AEP). The asset is maintained privately"*.
- 9.7 Management of defences in the area is stated in the Beachy Head to Selsey Bill Shoreline Management Plan (2006). The management plan for Angmering-on-Sea to Littlehampton (Policy Unit: 4d18) is 'Hold the Line' (to maintain or upgrade the level of protection provided by defences). This management policy will continue to apply at present day and across the medium (2025 to 2055) to long term (2105). It could therefore be implied that the nearby defences will be maintained and upgraded in the future.
- 9.8 The EA have provided Ambiental with a 2D undefended modelled flood level of 4.94mAOD for the 1:200 year (2115) taken from the Arun to Adur Coastal Model (2012).
- 9.9 A topographic survey has been undertaken on site. Surrounding ground levels have been assessed to slope towards the east and vary between approximately 2.45mAOD and 3.86mAOD. The existing ground floor topographic level has been surveyed to be 4.06mAOD. This level then increases up to the mezzanine (4.82mAOD). The first floor level has been surveyed to be 7.38mAOD.
- 9.10 Proposed ground floor levels are to be set at 3.30mAOD. As previously mentioned, the basement is to be used for storage/meeting rooms and is therefore considered 'Less Vulnerable'. As existing, the ground floor is to continue to be used as a restaurant which features a license to serve alcohol. Subsequently, under the NPPF, this is classified as 'More Vulnerable'. The proposed ground floor levels of 3.30mAOD lie 220mm below the defended 2D flood level that has been provided by the EA for the 1 in 200 year (2115) event. Given that the mechanism of tidal flooding is well understood, it is very likely that an early warning will be issued before such an event would strike. As such, it is very unlikely that the site would be subject to tidal flooding without several hours of early warning.
- 9.11 Subsequently, should this be the case, guests and site users would be made aware and the restaurant and hotel would subsequently close as a safety precaution.

- 9.12 Safe refuge can be provided by internal stairwells to upper floors in the unlikely event that the site would be subject to tidal flooding without several hours of early warning.
- 9.13 All guest rooms are to be located at the first floor and above. The proposed first floor level is to be set at 6.30m AOD, therefore far exceeding the 1:200 year (2115) undefended flood level with the addition of 4.94m AOD, including the 300mm freeboard allowance (5.24m AOD).
- 9.14 As such and given that:
- the proposed development is for the demolition of the existing structures and the construction of a mixed-use scheme to provide commercial use on the basement, ground floor and third floor as well as residential use on the first and second floors;
 - all guest rooms will be set no lower than 5.24m AOD (300mm above the 1:200 year (2115) undefended flood level);
 - the site lies within an area of tidal flood risk and therefore is not required to provide compensatory flood storage;
 - the site lies within an area that is currently protected by defences that have an estimated standard of protection of 1 in 300 years (0.3%). The local Shoreline Management Plan (SMP) suggests nearby defences will be maintained and upgraded in the future, given that the management plan is to 'Hold-the-Line';
 - given the nature of tidal flooding, prior evacuation can be sought;
 - in terms of flood vulnerability, betterment can be achieved through the implementation of a formal flood warnings/alert and prior evacuation, an area of safe refuge can be provided by internal stairwells to the upper floors.

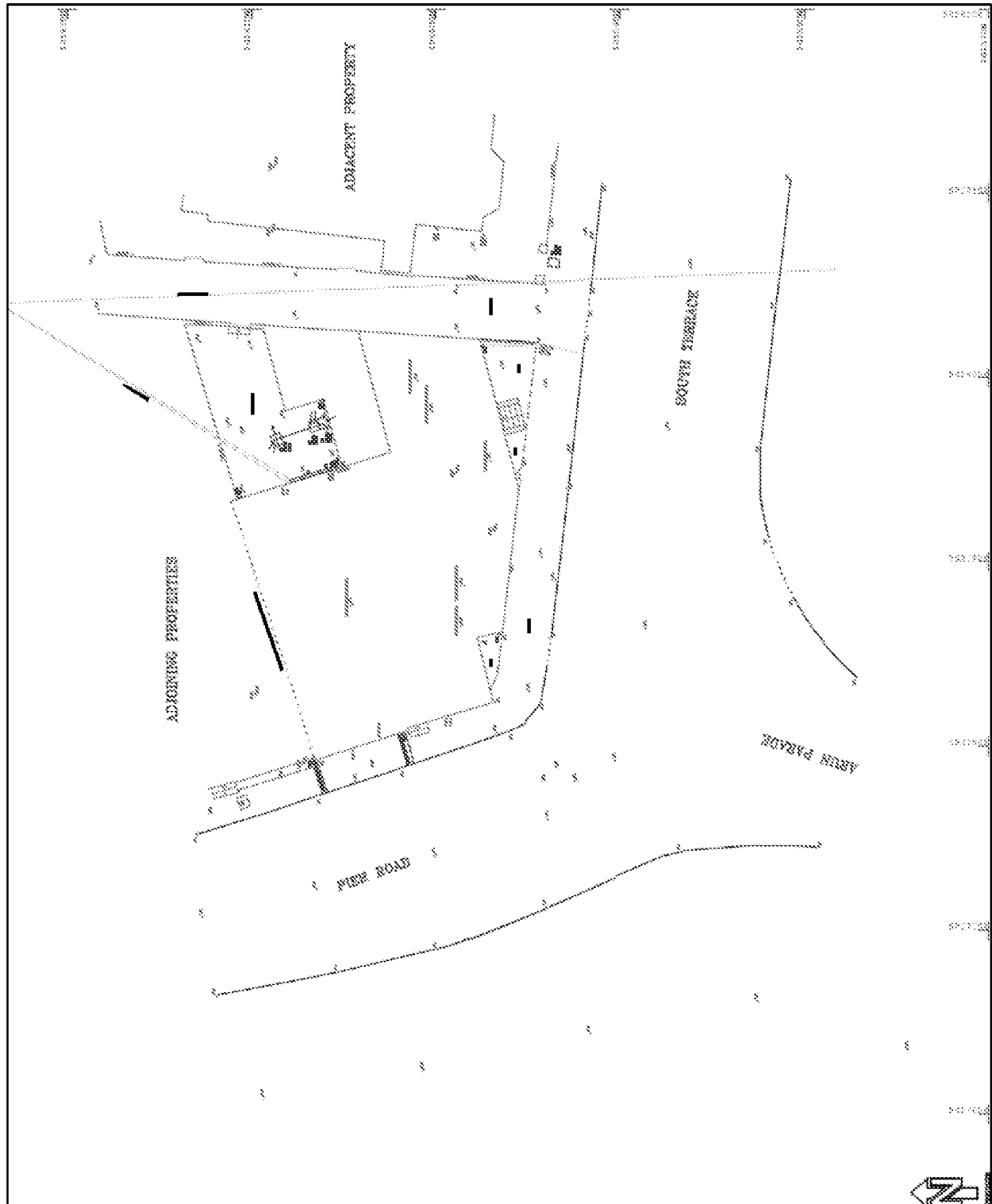
Following the guidelines contained within the NPPF, the proposed development is considered to be suitable assuming appropriate mitigation (including adequate warning procedures) can be maintained for the lifetime of the development.

Appendix I - Site Plans



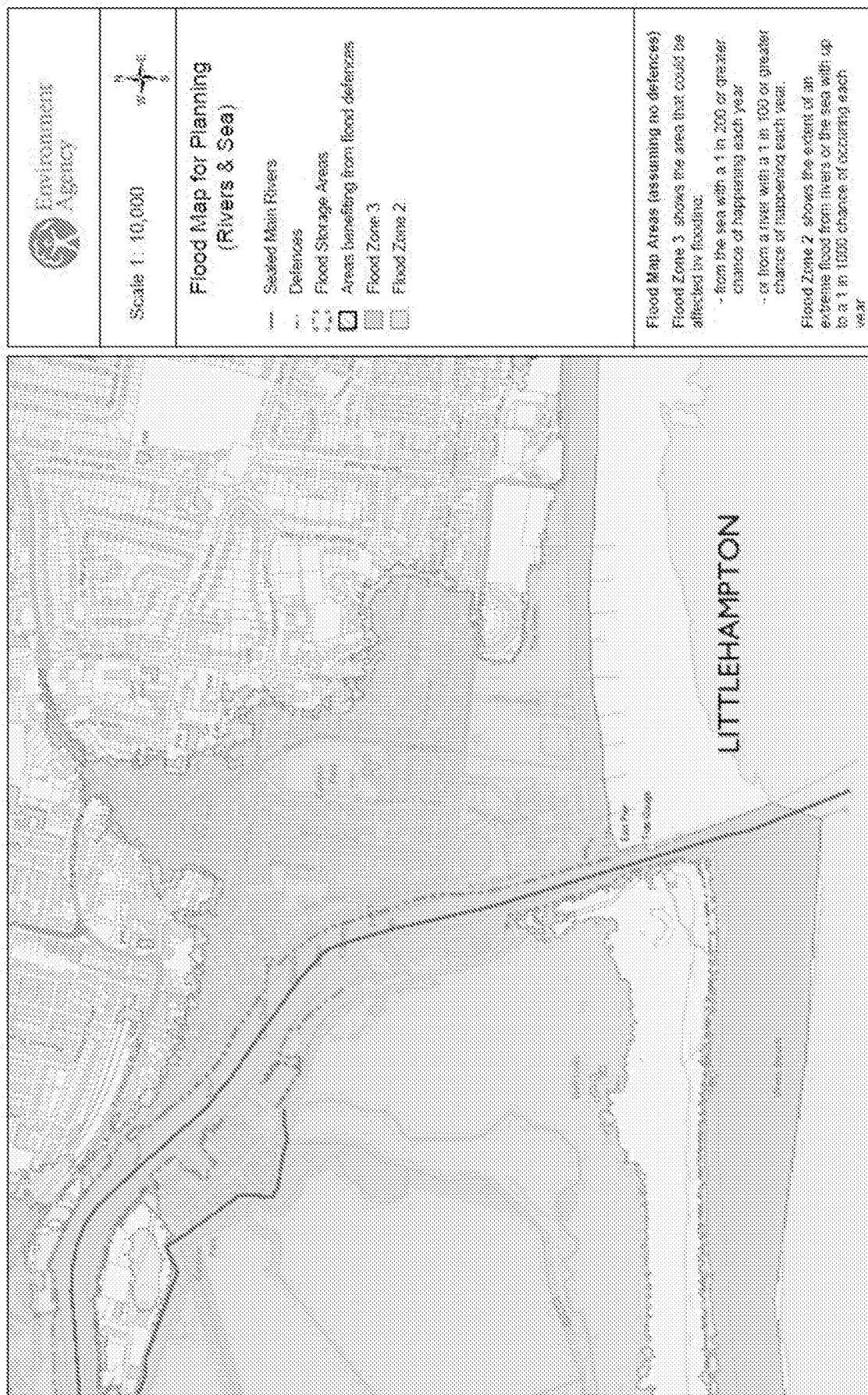






Appendix II - EA Data

Flood Map for Planning (Rivers and Sea) centred BN17 5LP. Created 12/09/2018



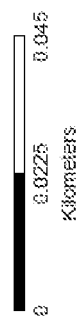
Site Node Points. Centred BN17 5LP. Created 12/09/2018 (Ref: SSD/97978)



Legend

- Main River
- Node Points

Scale: 1:1,000





Product 4 Flood Risk Data Requested by: Ambiental

Site: The Nelson, Pier Road, Littlehampton, BN17 5LP

Table 1: Water Levels: Tidal Undefended (2012)

Node Ref	NGR		Modelled Flood Levels in Metres			
	Eastings	Northings	Undefended Annual Exceedance Probability			
			0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	502778	101601	3.79	4.35	4.94	4.05

Table 2: Water Levels: Tidal Defended (2017)

Node Ref	NGR		Modelled Flood Levels in Metres			
	Eastings	Northings	Defended Annual Exceedance Probability			
			0.5%	0.5% (2065)	0.5% (2115)	0.1%
1	502778	101601	-	-	3.52	-

Table 3: Water Depth: Tidal Undefended (2012)

Node Ref	NGR		Modelled Flood Depths in Metres			
	Eastings	Northings	Undefended Annual Exceedance Probability			
			0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	502778	101601	0.31	0.87	1.46	0.57

Table 4: Water Depth: Tidal Defended (2017)

Node Ref	NGR		Modelled Flood Depths in Metres			
	Eastings	Northings	Defended Annual Exceedance Probability			
			0.5%	0.5% (2065)	0.5% (2115)	0.1%
1	502778	101601	-	-	0.04	-

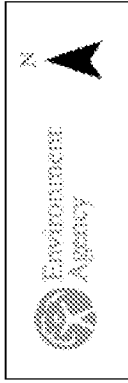
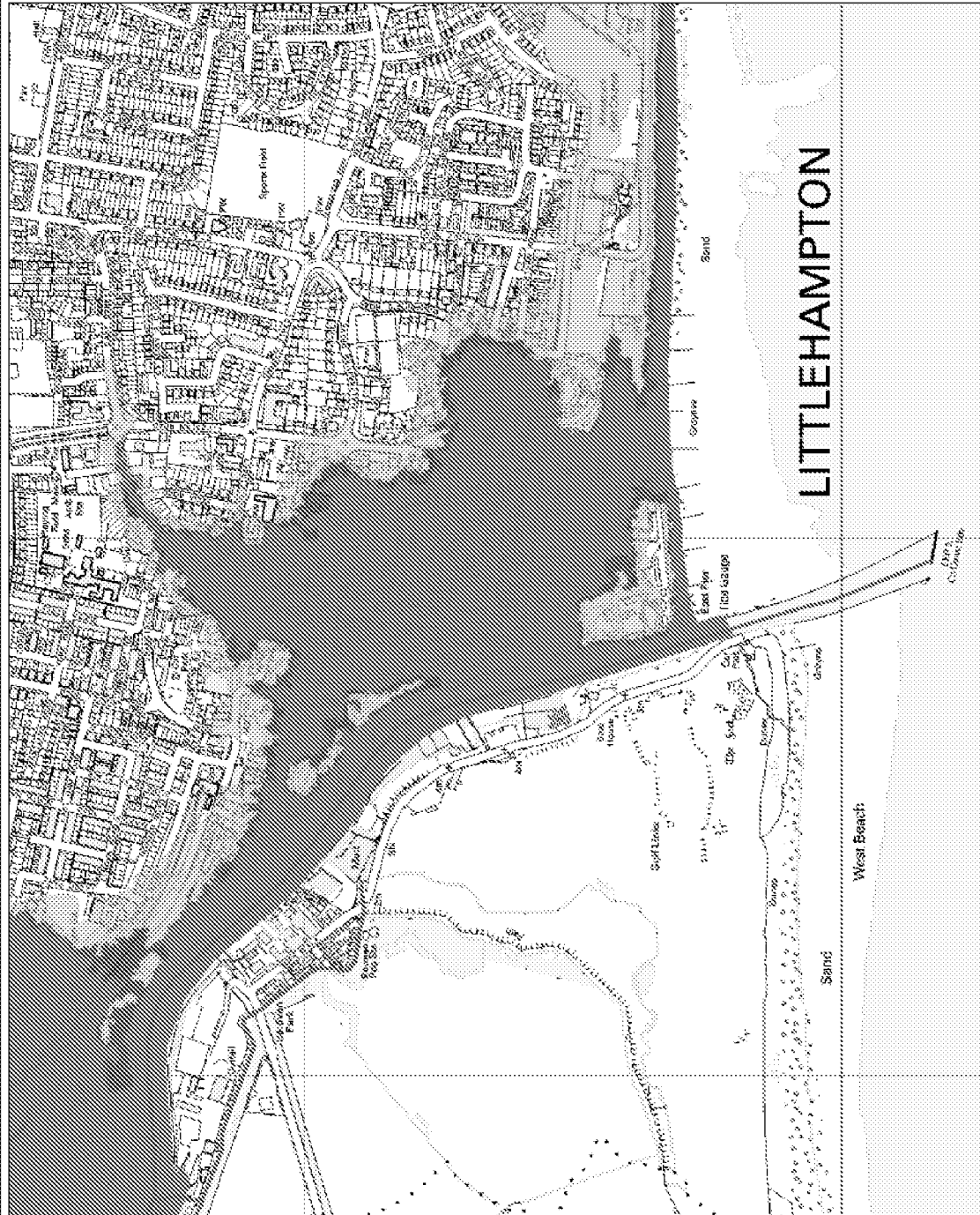
All levels taken from: Arun to Adur Coastal Model. A model update was run in 2017 to take into account the new flood defences.

Produced on: 12/09/2018

Office Address: Guildbourne House, Chatsworth Road, Worthing BN11 1LD.



Modelled Flood Outlines. Centred BN17 5LP. Created 12/09/2018 (Ref: SSD/97978)



Legend

- Main River
- 0.5% AEP (2012) (Undefended)
- 0.1% AEP (2012) (Undefended)
- 0.5% AEP (2070) (Undefended)
- 0.5% AEP (2115) (Undefended)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

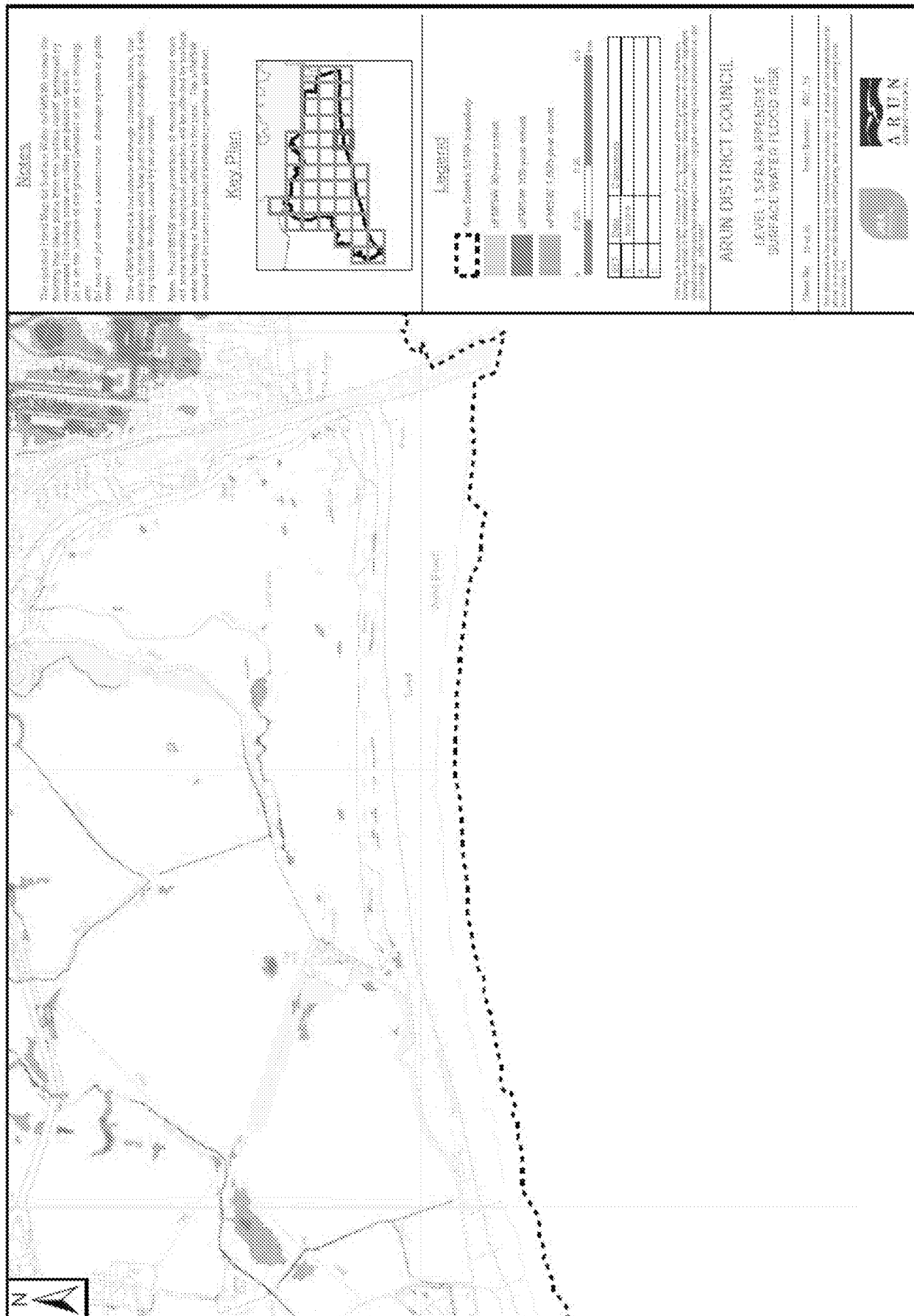
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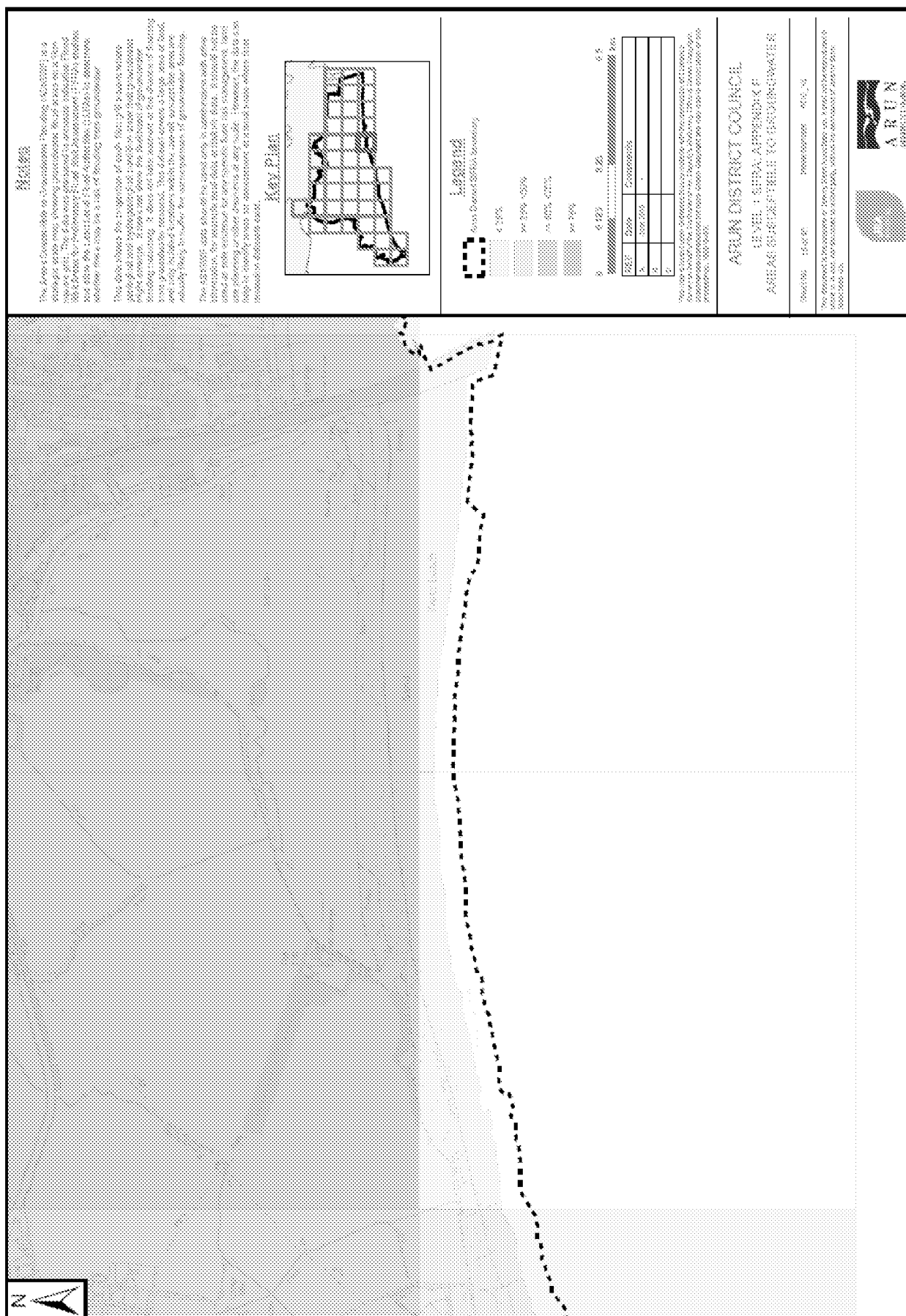


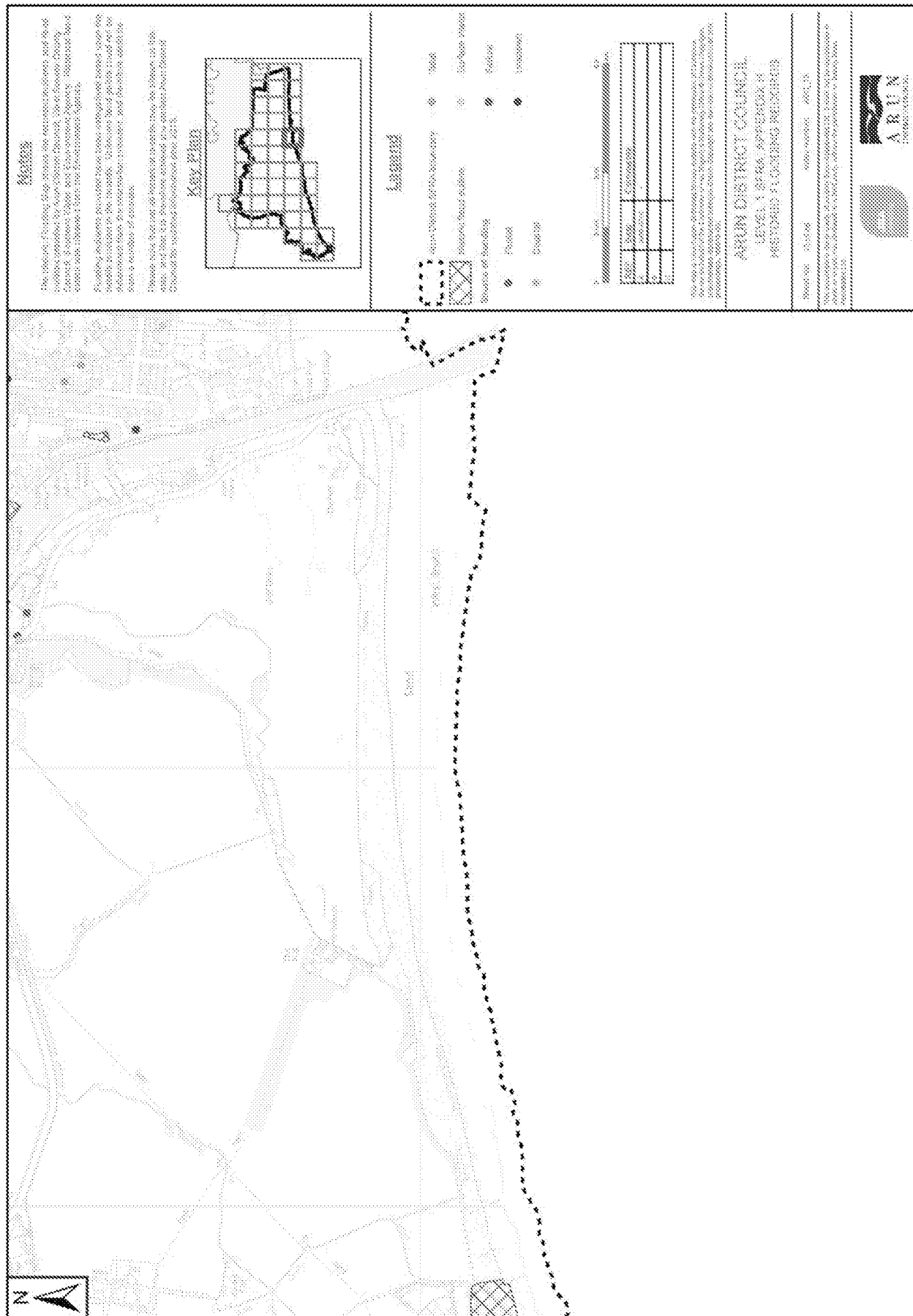
Modelled Flood Outlines. Centred BN17 5LP. Created 12/09/2018 (Ref: SSD/97978)

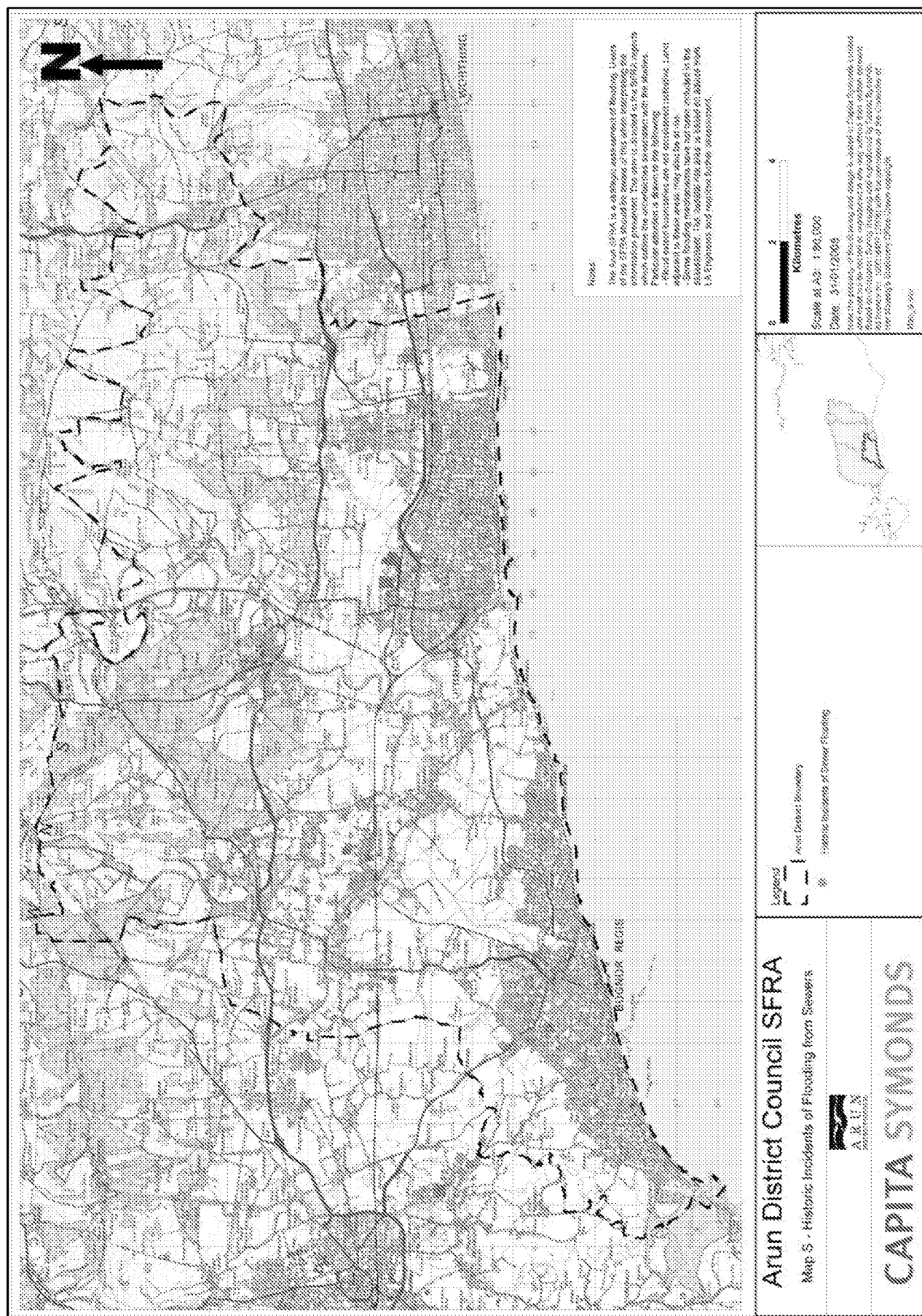


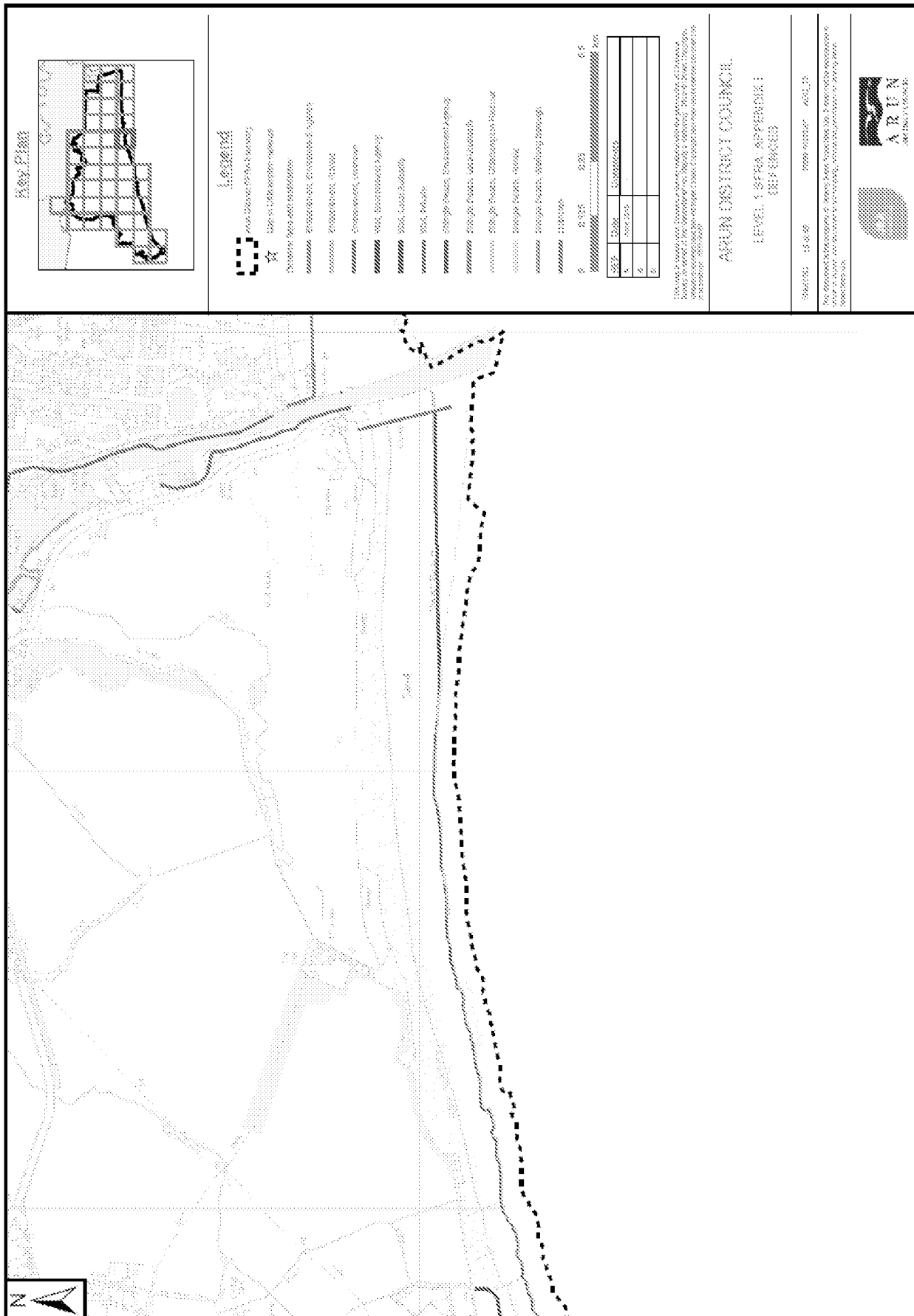
Appendix III - Supplementary Information











Appendix IV – Information Relating To JFLOW

JFLOW and flood outlines (Source: EA)

Flood Zones have been produced using JFLOW, a nationally consistent model. JFLOW has been used to produce the 1% (1 in 100 year) and 0.1% (1 in 1000 year) flood outlines.

The flood outlines have been developed by applying flow and tide models to a 3D ground level map of England and Wales, known as a Digital Terrain Model (DTM). This is created by flying an aircraft over the whole of the country using radar to record and create a contoured model of the land. This DTM is used as the basis of a grid of cells which is used to estimate the extent of flooding in a flood of a given return period or probability.

The size of the flood event (1 in 100 or 1 in 1000 year) is determined by the inflows to the JFLOW model, which are calculated using statistical techniques from the Flood Estimation Handbook. The technique used is based upon catchment descriptors and data transfer, the details of these can be found in the Flood Estimation Handbook volume 3. The Flood Estimation Handbook provides a consistent technique for estimating inflows to the national model and its methods are widely accepted.

The methodology is a raster-based approach, driven by an underlying Digital Elevation Model (DEM).

- Each cell has a ground level and water depth
- Water can move to any of surrounding 8 cells where the water level is lower
- Water will pond in low spots until the water level is high enough to spill
- The velocity of movement depends on water surface slope and surface roughness

The above points describe the basic principles of the model. The two underlying principles are:

- Mass conservation within each cell
- Calculation of the fluxes between the cells

Each grid cell is treated as a small storage area. Mass conservation is applied to each grid cell. The flux between cells is calculated using a form of the generalised weir equation.

Efficient coding is achieved by keeping a list of all currently wet cells and a list of newly wet cells. This avoids having to search through each cell in the ground grid.

For whole catchment modelling, the hydrographs used as inflow boundary conditions represent the whole hydrograph at that inflow location and a simple conceptual method has been derived to account for the amount of flow within the channel banks. A simple solution was therefore sought which would approximately account for the proportion of flow contained within the channel without requiring further information about the channel.

The simple conceptual method used involves two assumptions:

1. That bankfull flow (Q_b) is equal to QMED as calculated by the Flood Estimation Handbook (FEH) methods. QMED has a return period of 2 years. This assumption derives from the concept of dominant discharge in fluvial geomorphology (Wolman and Leopold, 1957; Wolman and Miller,

1960) where the cross-section shape is assumed to be formed by a discharge with a recurrence interval of 1-2years.

2. That the additional channel flow (Q_c) scales with both Q_b and depth above bankfull (d).

The basis of the current model is that each grid cell acts as a small flood cell and the links to each of the surrounding cells are automatically calculated. It is therefore capable of simulating the inundation extent at a level of detail equal to the underlying DEM. It is fundamentally volume conservative and so, in a given time period, will simulate the peak water levels across the floodplain depending on the volume of water that has entered the floodplain. This approach is a half-way house between the common 1D hydrodynamic models and a 2D hydrodynamic model.

Limitations

JFLOW was used to produce flood maps for the whole of England and Wales for all catchments greater than 3 sq-km in a consistent manner. The method is therefore very generalised and therefore cannot take account of information that may be very significant locally. This might include:

1. Effects of bridges and other structures including flood defences are not taken into account.
2. Errors in the DTM, caused by trees and buildings for example.
3. The effect of reservoirs and urban drainage and other man made influences on the flow regime can only be taken into account in a very general sense in JFLOW.
4. The channel is assumed to be able to take the 2 year flow. This may not be true especially in those modified by man.
5. Hydraulic roughness is assumed to be the same everywhere in JFLOW, but of course it is not.

For these and many other reasons, the flood outlines produced by JFLOW can only be taken as a rough guide, showing where more detailed flood risk assessments are essential. Flood risk assessments should also be undertaken near small watercourses whose catchments are too small to have been included in the JFLOW modelling.