

TECHNICAL NOTE

Job Name: Sharpness
Job No: 41745/4004
Note No: TN004
Date: [REDACTED]
Prepared By [REDACTED]
Reviewed By [REDACTED]
Subject: Flood Model Review – updated baseline information

1. Introduction

Stantec UK Ltd. (Stantec) is currently undertaking ongoing flood risk and drainage technical work to support the proposed mixed-use development at Sharpness. A Flood Risk and Drainage Scoping Report was prepared in August 2018 (doc ref 41745-4003-001).

The EA has provided their existing hydraulic models within the vicinity of the site:

- Little Avon/Berkeley Pill fluvial model (2017) and
- North Coast Tidal model (2012).

The existing EA models required updating. The tidal model does not incorporate the latest sea level rises or climate change scenarios. The fluvial model for the Little Avon is more recent and, therefore, does have the current climate change scenarios modelled. Both models are strategic scale models which require site specific refinement to support the planning process. Floodplain extents extracted from the models are also based on the DTM in the models i.e. using LiDAR and not site-specific topographical data. The onsite watercourses have also not been included in either model and, therefore, flow and flooding interactions with these watercourses are not currently represented.

Detailed modelling method statements and Water Framework Directive (WFD) assessment method statements were submitted to the EA in summer 2019 and liaison is ongoing throughout the planning process and progression of technical assessments. Stantec have completed updated hydraulic modelling of all fluvial watercourses within the vicinity of the site (excluding Little Avon as EA model is up to date) and updated the existing EA tidal model with current climate change scenarios. The updated model files and reports will be submitted to the EA over the Summer for review/approval.

This note has been prepared in order to support the ongoing evidence base requested by Stroud District Council to inform the allocation at Sharpness.

DOCUMENT ISSUE RECORD

Technical Note No	Rev	Date	Prepared	Checked	Reviewed (Discipline Lead)	Approved (Project Director)
41745/4004/TN004	-	20.07.21	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

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2. Fluvial Modelling

Little Avon 2017 Fluvial Model

The EA model report states that , ‘There are no formal Environment Agency flood defences along the Little Avon. The only EA maintained defence in the catchment is the coastal embankment along the Severn Estuary at the far downstream extent of the Little Avon. These coastal embankments are not part of this fluvial study, meaning this fluvial study will not feature an undefended scenario.’

Floodplain extents have been extracted from the Little Avon fluvial model and are shown in Figure 1.

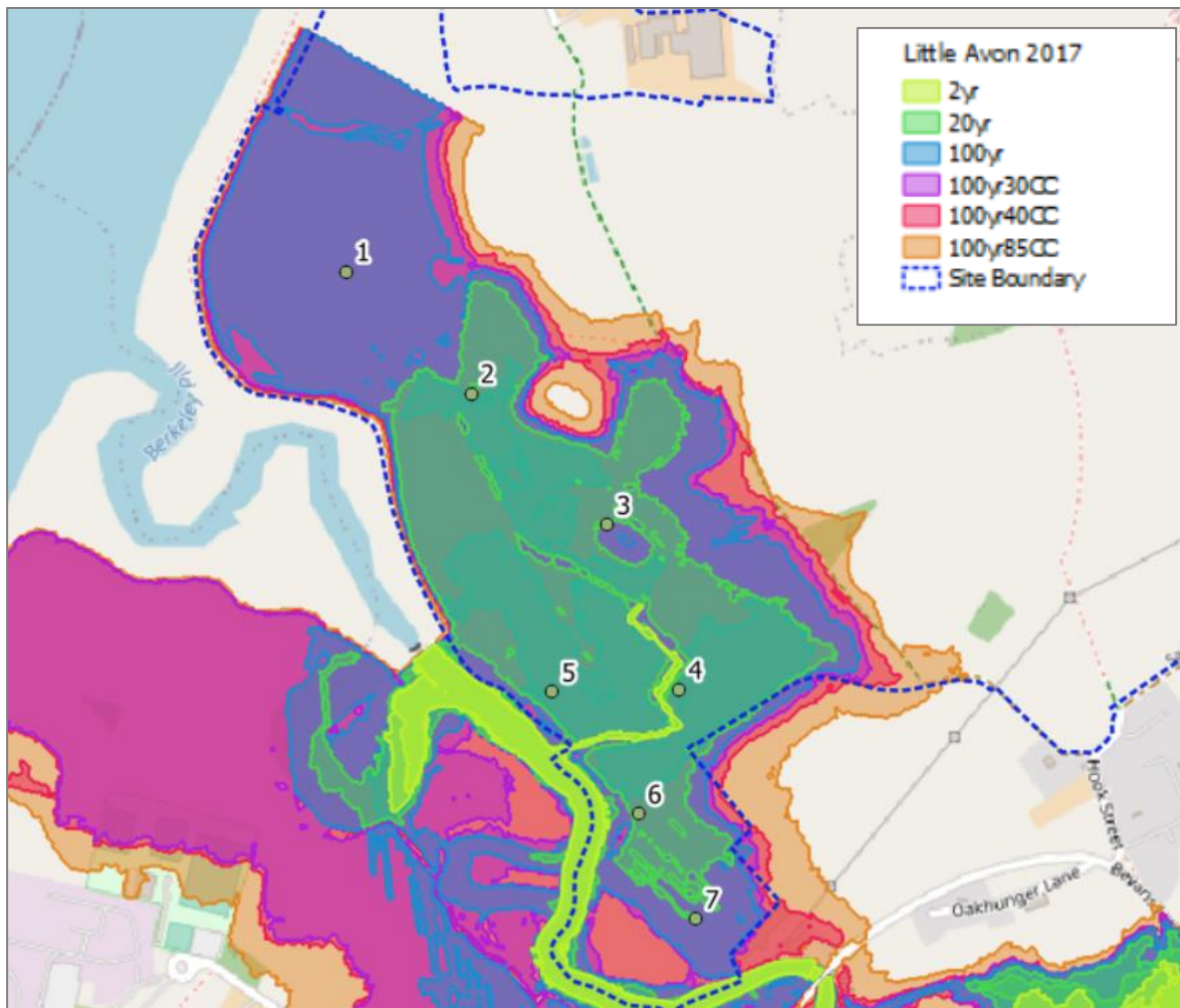


Figure 1 Flood extents - Little Avon 2017 fluvial hydraulic model.

The downstream model boundary is based on a Head-Time boundary based on MHWS tidal curve with the peak of tide coinciding with the long duration fluvial peak. The Little Avon has a flapped outfall at the downstream fluvial model extent and, therefore, the magnitude of the tide is likely to have little impact on fluvial results. Downstream of the outfall is affected by tidal flooding and, therefore, fluvial flood mapped extents stop at this point (see Figure 1).

Data points have been extracted from the 2D domain (based on EA LiDAR data) to give an indication of peak water levels for the various modelled return periods. The locations are shown on Figure 1 and water levels given in Table 1.

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Table 1 Maximum Water levels - Little Avon 2017 fluvial hydraulic model

Point ID	2yr	20yr	100yr	100yr30CC	100yr40CC	100yr85CC
	[m AOD]					
1	-	-	7.66	8.15	8.47	9.29
2	-	7.67	7.96	8.15	9.47	9.29
3	-	7.67	7.96	8.15	9.47	9.29
4	-	7.69	7.96	8.15	9.47	9.29
5	-	7.68	7.96	8.15	9.47	9.29
6	-	7.69	7.96	8.15	9.48	9.29
7	-	-	7.96	8.15	9.48	9.29

All flows remain in bank for the 2 year event but overtop in all events greater than the 2 year. Flood levels are largely identical across the proposed SANG area (based on LiDAR data) due to the flat topography, also resulting in a large expanse of floodplain.

The Phase 1 development parcels (southern part of development) are all located outside of the modelled 1 in 100 year + 85%CC floodplain extent associated with the Little Avon/Berkeley Pill. The 1 in 1,000 year scenario has not been included in the existing EA model (i.e. to confirm extent of Flood Zone 2). However the 1 in 100yr + 85%CC can be used as a proxy at this stage and, therefore, all proposed residential development is located in Flood Zone 1 and also outside of the modelled fluvial Upper End climate change allowance floodplain extent.

A review of the potential duration of flood events was also undertaken and is presented in Table 2. The current model run time is 30 hours and, therefore, data is only available for this 30 hour period. Floodwater still remains on site after 30 hours and, therefore, actual duration times will be longer. This will also be affected by the ground conditions at the time the event occurs. No coastal flooding is included in this model.

Table 2 Length of the flooding at the site assessed based on the Little Avon 2017 fluvial hydraulic model.

Event	Description	Length of event on site
2yr	Area is free from flooding.	
20yr	Site is flooded from approx. 18 hours into event until 30 hours.	12 hours
100yr	Site is flooded from approx. 18 hours into event until 30 hours.	12 hours
100yr30CC	Site is flooded from approx. 17.5 hours into event until 30 hours	12.5 hours
100yr40CC	Site is flooded from approx. 17.5 hours into event until 30 hours	12.5 hours
100yr85CC	Site is flooded from approx. 15.5 hours into event until 30 hours	14.5 hours

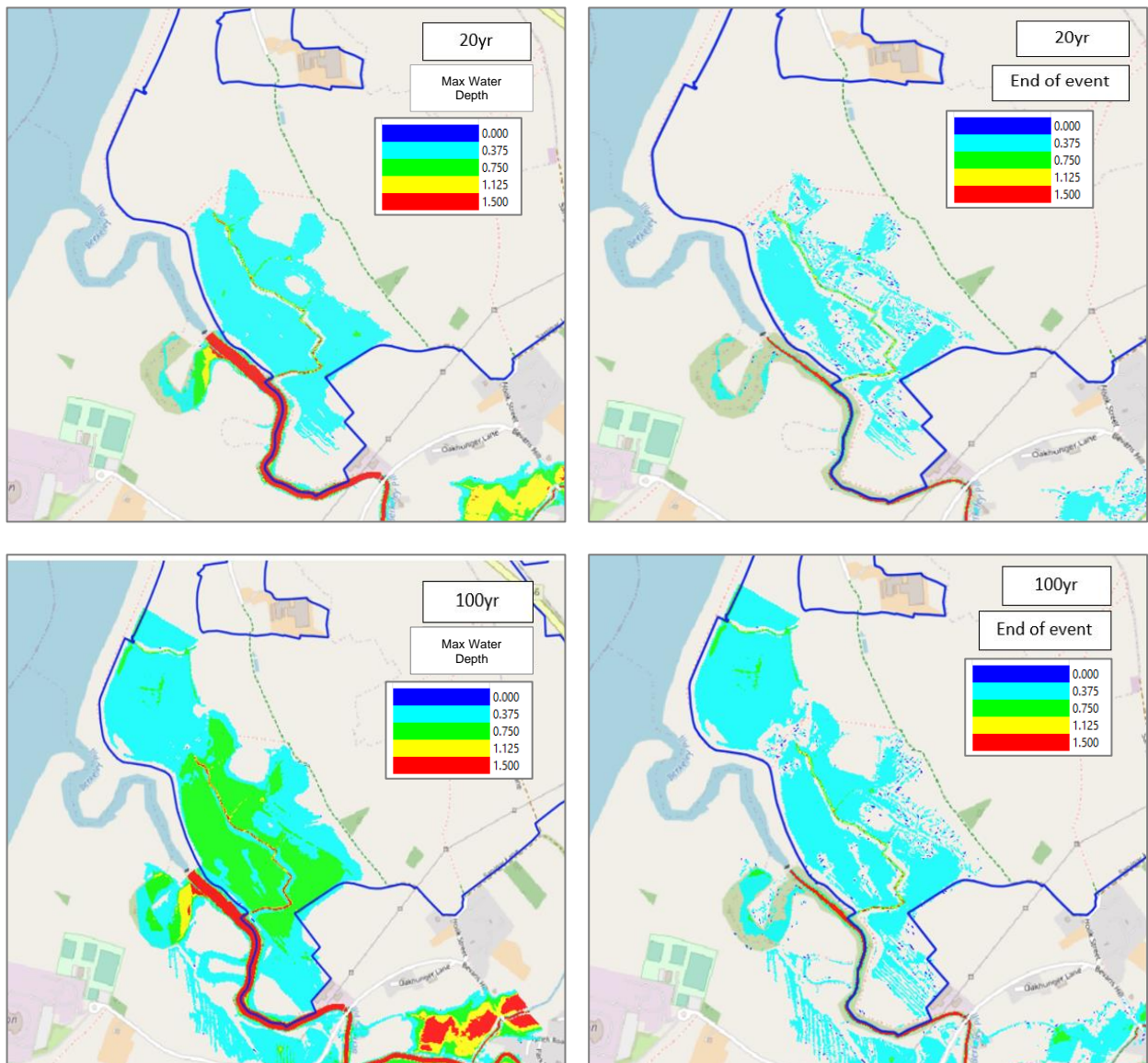
The maps in Figure 2 present the maximum depth of water for all events and depth of water at the site for the end of model run (i.e. after 30 hours). This is again based on LiDAR data for the site and not site-specific topographical data. This high-level review indicates that:

- 1 in 20yr event - maximum flood depth on site is up to 0.375m, with similar depths at the end of model run.
- 1 in 100yr event – maximum flood depth is up to 0.75m and approx. 0.375m depths at the end of model run.

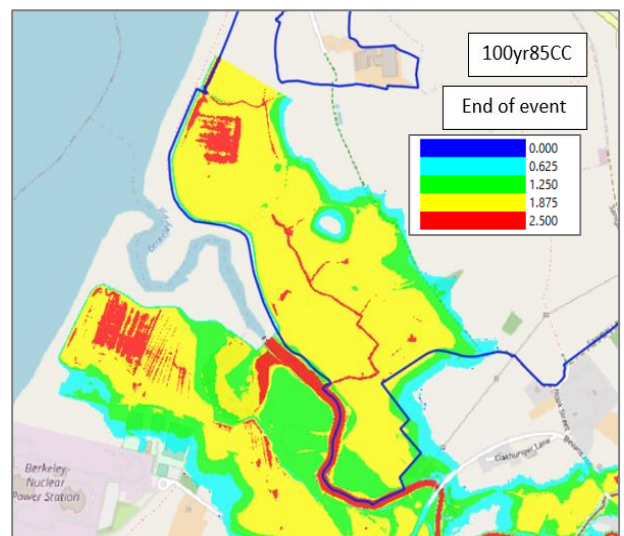
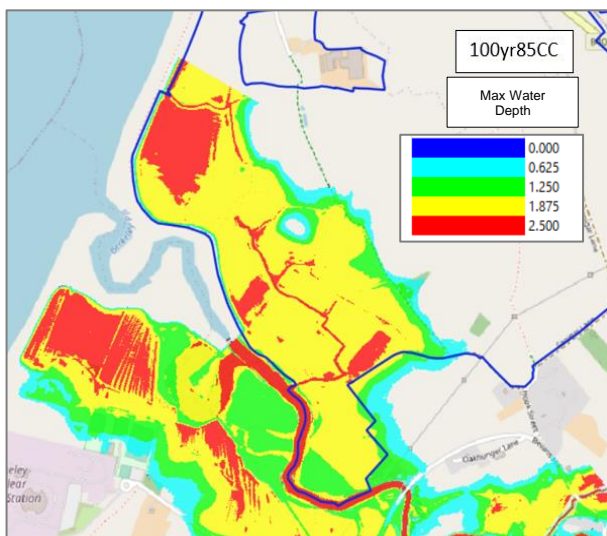
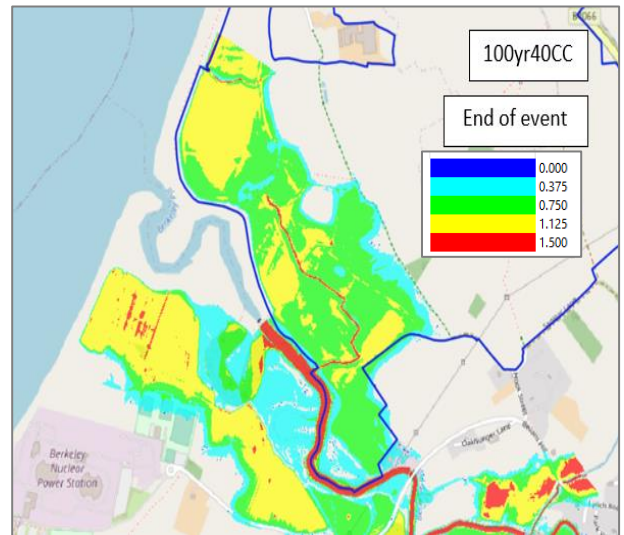
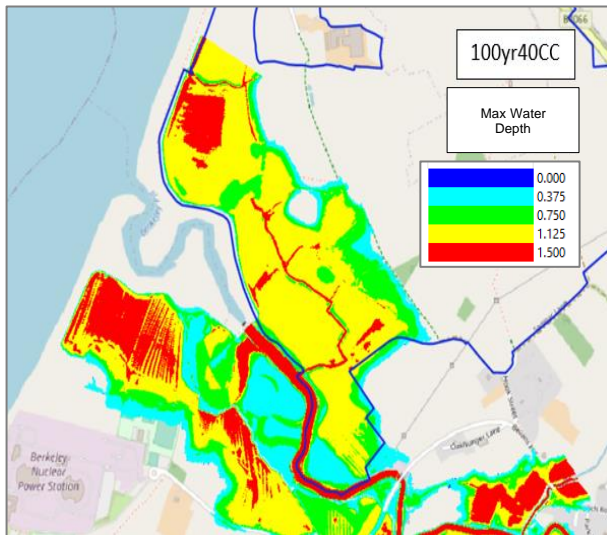
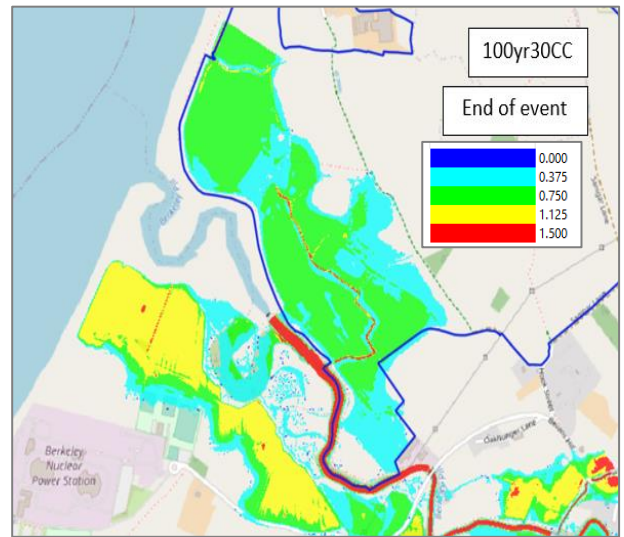
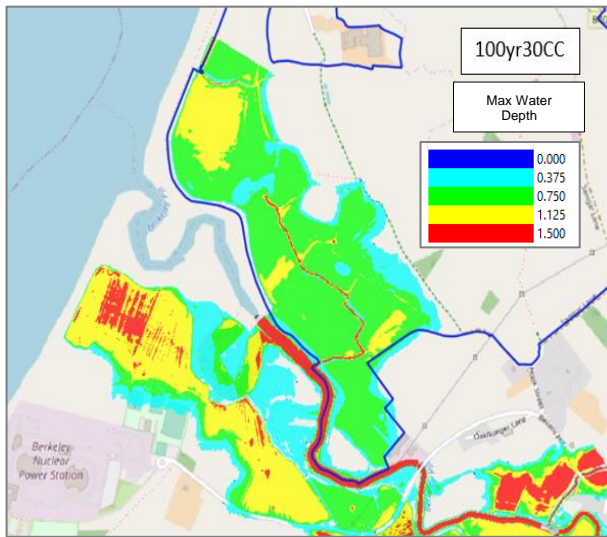
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- 1 in 100 year with 30% climate change event - maximum depth of water at the site is 1.125m with flood depths approximately 0.75m at the end of the model run.
- 1 in 100 year with 40% climate change event - maximum flood depths of water of 1.5m occurs locally with majority of the area covered with a water depth of 1.125m. At the end of the model run flood depths are 1.125m and less.
- 1 in 100 year with 85% climate change event - maximum flood depths of water are approximately 2.5m with majority of the area up to a depth of 1.875m. Similar flood depths also occur at the end of the model run.

Figure 2 Maximum depth of water and depth of water at the end of the model run – fluvial Little Avon 2017



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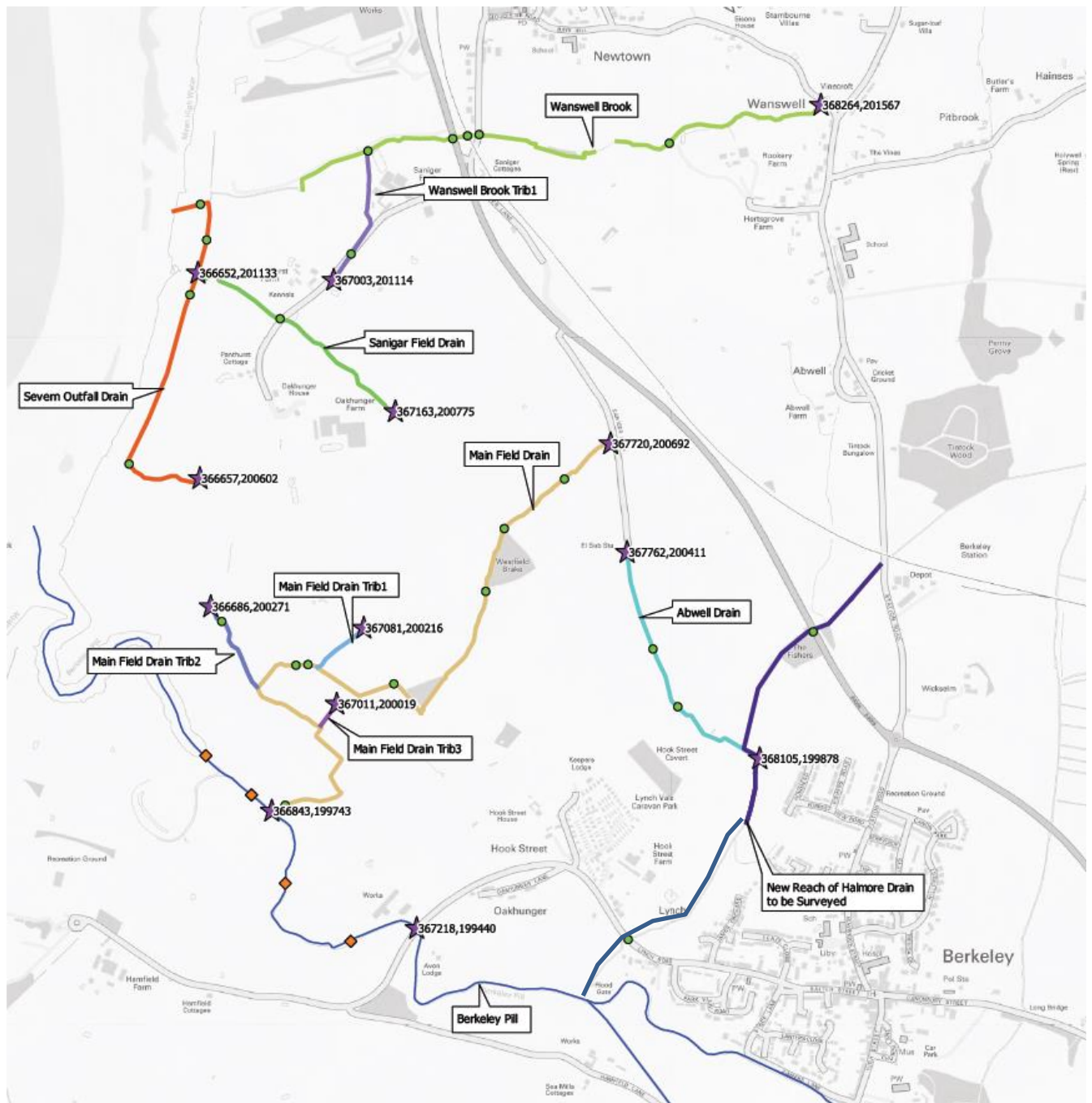
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On-site Watercourses

The onsite watercourses have not been modelled by the EA. Stantec has produced three separate fluvial models to represent all on-site watercourses (Figure 3 shows the location of the watercourses):

- Sanigar and Wanswell Brook system
- The Main Drain system
- Abwell and Halmore Drain system

Figure 3 Location of onsite watercourses

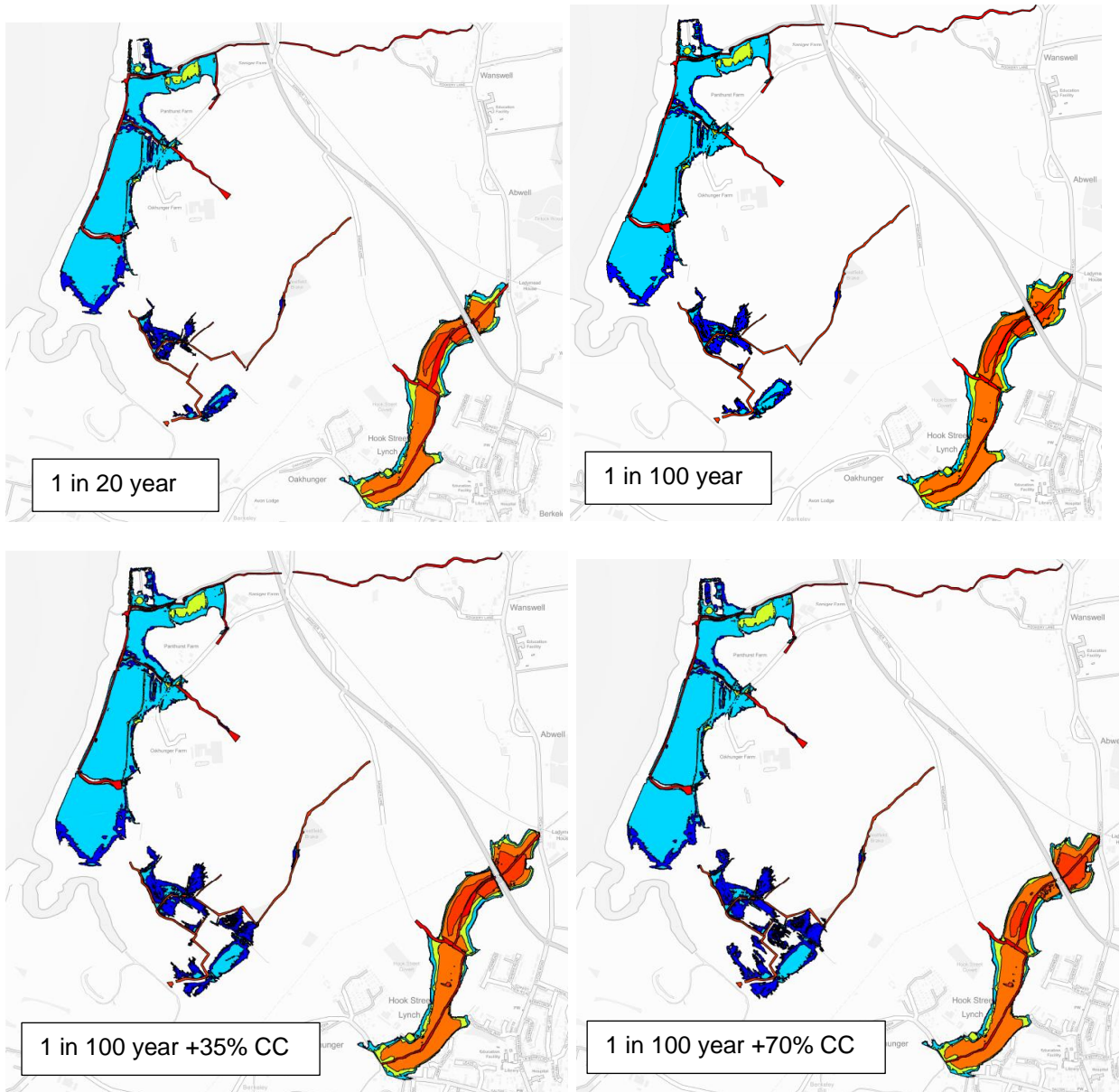


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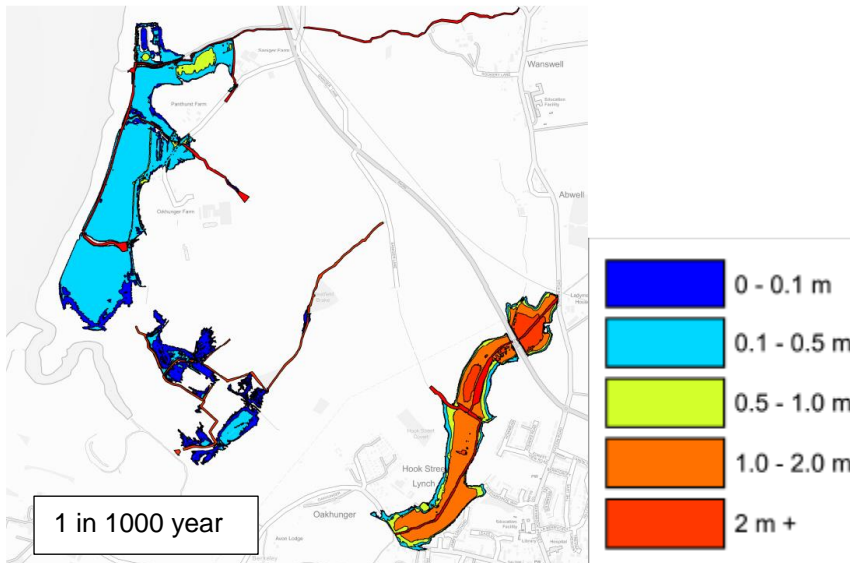
The downstream model boundaries are based on water levels extracted from the EA Little Avon/Berkeley Pill and North Coast Tidal models as appropriate.

Floodplain extents have been extracted from the fluvial models and are shown in Figure 4. Flood depths are also shown.

Figure 4 Fluvial floodplain extents and depths for all modelled onsite watercourses



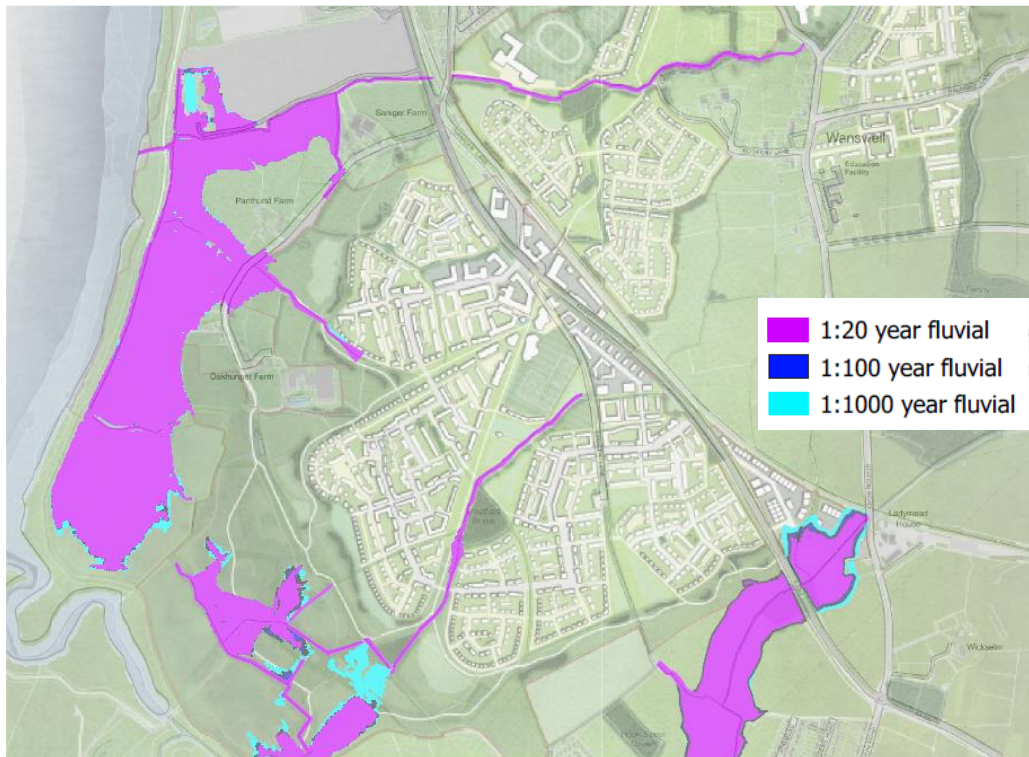
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Floodplain extents are very similar for all modelled return periods due to the topography. Flow is generally contained within the channel throughout the proposed development parcels and affects a wider area of the SANG due to low lying topography. The Abwell Drain flows in a steep incised valley hence flood depths are greater for this watercourse.

The Phase 1 development parcels (southern part of development) are all located outside of the modelled 1 in 100 year + 85%CC floodplains extent and 1 in 1,000 year floodplains extents (Flood Zone 2) associated with the online watercourses except for the proposed employment area between the railway and B4066. If this area is taken forward for employment use, suitable mitigation measures will be put forward. The modelled fluvial flood zones are shown in Figure 5. This does not incorporate the Little Avon/Berkeley Pill floodplains extents.

Figure 5 Fluvial floodplains extents for onsite watercourses overlain on masterplan



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A review of the potential duration of flood events was also undertaken. The current model run time is 20 hours and, therefore, data is only available for this 20 hour period. Floodwater still remains on site after 20 hours and, therefore, actual duration times will be longer. Fluvial flood events largely driven by downstream tidal boundaries being dominant and therefore backing up occurs along the channels/floodplain. This will also be affected by the ground conditions at the time the event occurs. No coastal flooding is included in the fluvial models. Flooding from the Little Avon/Berkeley Pill covers a much greater area than fluvial flooding associated with the onsite watercourses and will be the dominant source of fluvial flooding to the SANG.

3. Tidal Flooding

North Coastal Tidal Model

EA-maintained flood defence embankments are located along the Severn Estuary coast in the vicinity of the site. The EA previously provided defence asset information and the location/type/asset ID for the defences adjacent to the site are shown in Figure 6.

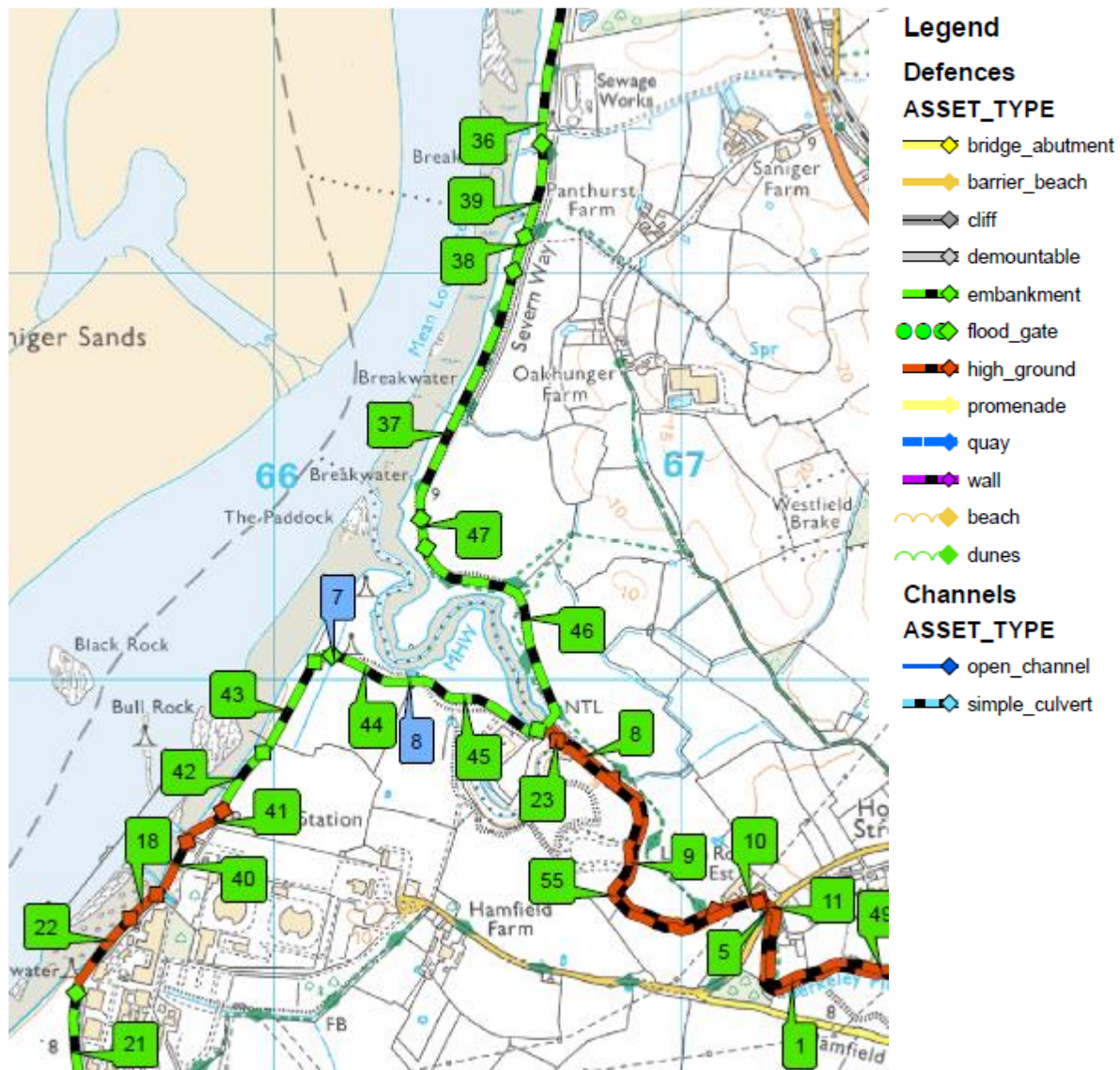


Figure 6 Current Flood Defences at Berkeley Pill Outfall, inland to Berkeley and along Coast (supplied by EA dated 27/07/18)

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Corresponding asset data for each section of embankment confirms that the defence crest height in the vicinity of the site at each point is as follows:

- Asset 36 – 9.58mAOD
- Asset 39 – 9.85mAOD
- Asset 38 – 9.84mAOD
- Asset 37 – 9.74mAOD
- Asset 47 – 9.80mAOD
- Asset 46 - 9.38mAOD

There is a clear lower point in the tidal defences to the north of Little Avon at embankment asset 46. As stated above, upstream of Berkeley Pill/Little Avon tidal outfall, there are no formal defences, just areas of high ground which only offer a standard of protection of approximately 1 in 2 years.

Tidal flood levels within the Severn Estuary, at the coastline (just upstream of Little Avon outfall), were extracted from the Coastal Design Sea Levels – Coastal Flood Boundary Extreme Sea Levels database (last updated 2018 and, therefore, provide more up to date sea levels than the EA 2012 model):

- NFCDD 2 yr tidal level – 9.09mAOD
- NFCDD 20 yr tidal level – 9.50mAOD
- NFCDD 100 yr tidal level – 9.79mAOD
- NFCDD 200 yr tidal level – 9.95mAOD

This indicates that the defences to the west of the site largely have a minimum standard of protection of only 20 years, except for the low spot in the Little Avon tidal reach where the standard of protection is less than 20 years.

Sharpness Docks and industrial estate to the south of the docks (north west of the site) appear to be protected in the 1 in 200 year event (based on online flood mapping showing areas benefitting from defences) – i.e. there should be no overtopping in this location in lower return periods.

The North Coast tidal model (2012) flood extents provided by the EA are based on wave overtopping extents (incorporating combination of an extreme tidal event with an extreme wind event, i.e. not simply base extreme water levels). Climate change scenarios, latest coastal flood estimates and up to date sea level rises are not included in the EA North Tidal model and, therefore, the existing model was updated (including consideration of H++ scenario).

Updated wave overtopping analysis has been undertaken to incorporate updated sea level rise in line with latest climate change guidance. The tidal model has been re-run to define the 200 year plus climate change allowance floodplain extents and depths.

The modelled combination tidal flood extents have been extracted from the results files provided by the EA from the North Coast Tidal model and are shown in Figure 7. Maximum flood depths are also shown on Figure 7. These indicate that the defences are overtopped in all modelled return periods.

This mapping indicates that:

- 1 in 10 year event - floodplain limited to land adjacent to the defences in the western part of the site. Maximum flood depth on site is less than 0.5m.
- 1 in 25 year event – maximum flood depth is up to 1m for the western SANG area and 0.5m for the affected southern SANG area.
- 1 in 100 year event - maximum flood depths of water of approximately up to 1m with very localised areas in the western part of the site up to 1.5m.

Figure 7 Maximum water levels on site – North Coastal Tidal 2012 hydraulic model



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1:25 AP, wind direction 270, Force 10, Tidal Depths

- <= 0
- 0.5 m
- 1 m
- 1.5 m
- 2 m +

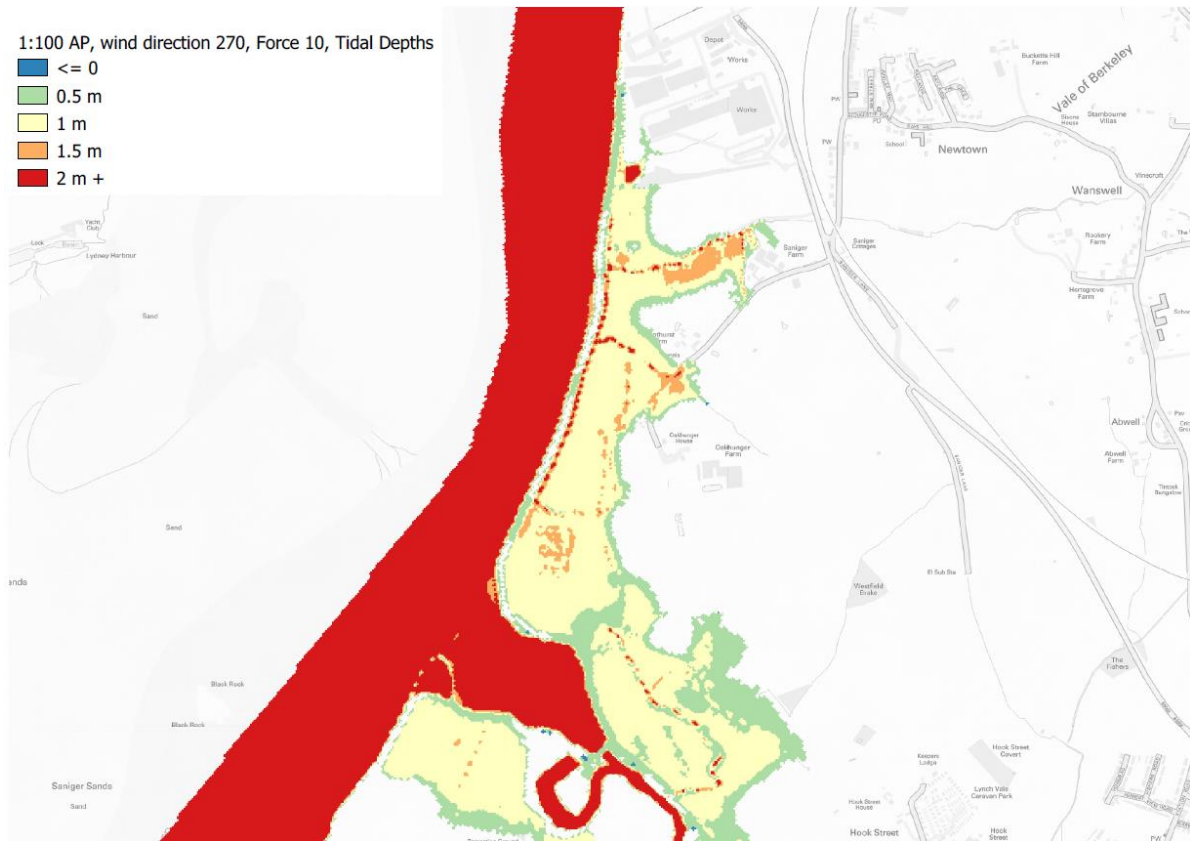


1:75 AP, wind direction 270, Force 10, Tidal Depths

- <= 0
- 0.5 m
- 1 m
- 1.5 m
- 2 m +



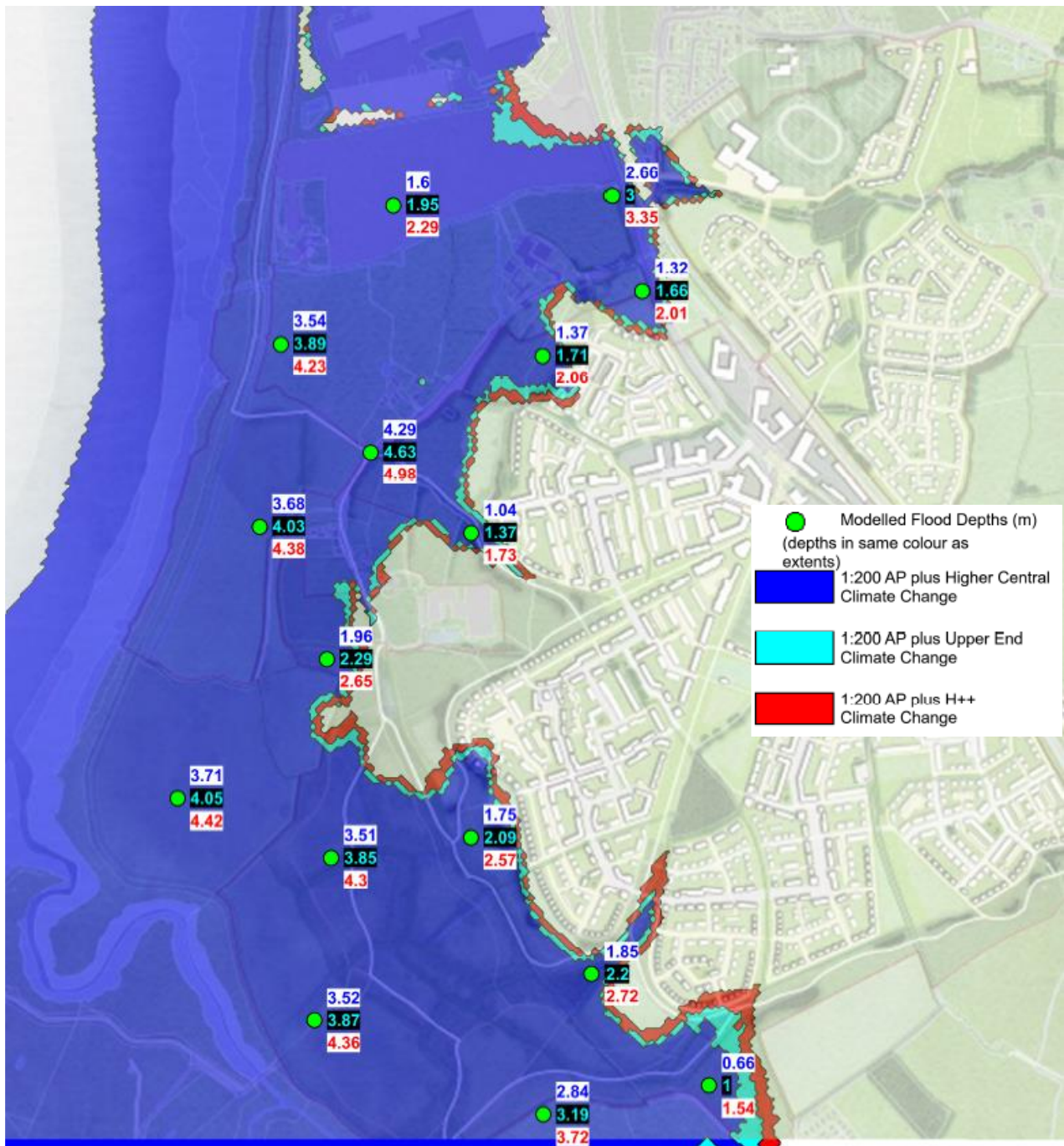
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The modelled combination 200 year plus climate change allowance floodplain extents and depths are shown in Figure 8. This is based on our updated hydrological assessment and updated model runs.

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Figure 8 Maximum water levels on site –200yr + CC events (updated North Coastal Tidal 2012 hydraulic model)



Once the defence is overtopped, the relatively flat topography will result in widespread, extensive flooding as per the fluvial floodplain extents. Floodwater will remain on site for the duration of the tidal cycle before draining back to the Severn via the watercourses as water levels recede in the Severn.

The updated tidal 200year plus climate change allowance floodplain extents infringe into the proposed development parcels in a couple of locations. Liaison is currently ongoing with the masterplanning team to revise the masterplan so all built development is located outside of the 1 in 200 year plus climate change allowance floodplain extents and sufficient freeboard provided between flood levels and finished floor levels. All surface water attenuation features are also to be located outside of these floodplain extents as per LLFA requirements.

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There is sufficient space within the SANG area (that is not affected by tidal or fluvial flooding) to provide mitigation if required.

In low order events (1 in 20 year or less), a review of tidal and fluvial flood extents for all watercourses indicates that flooding is largely limited to the southern area of the SANG and the nature reserve to the west. An area of SANG surrounding the Phase 1 development is dry in these events.

The future planning application will be supported by a Flood Risk Assessment outlining all required mitigation measures to ensure the development is safe and has no detrimental impact on flood risk on and off-site. The hydraulic modelling is due to be submitted to the EA for review and approval in Summer 2021.

4. EA Coastal Defences

As stated above, the defences to the west of the site largely have a minimum standard of protection of less than 20 years. Sharpness Docks and industrial estate to the south of the docks (north west of the site) appear to be protected in the 1 in 200 year event.

The Shoreline Management Plan indicates that the coastline between Sharpness Docks and Purton is stable, with very little change observed. North of Purton there is some observed sediment movement but the High Water Mark has historically been stable. South of Sharpness Docks there has been some observed erosion and accretion of the bank, which is reflected in the Hold the Line policy. An extract of the Coastal Change mapping/Shoreline Management Plan is shown in Figure 5.

The management policy to the north and south of the site is to 'Hold the Line'. There is no specified policy adjacent to the Sharpness site.

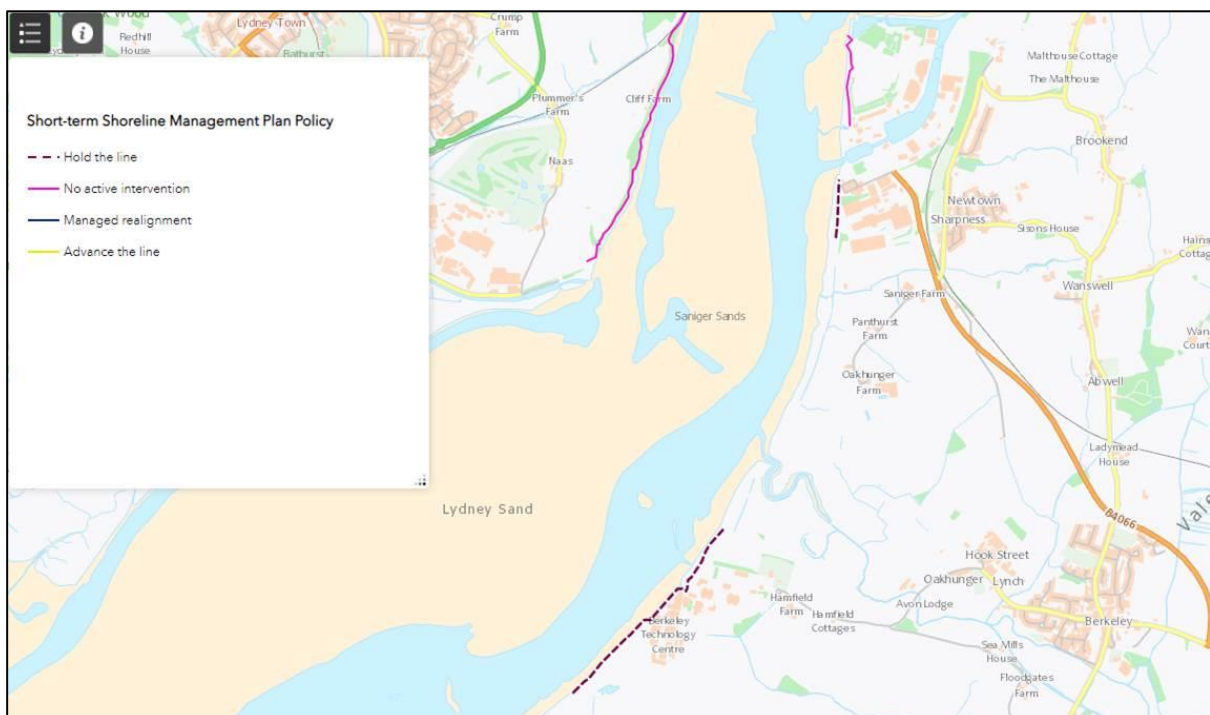


Figure 5 Extract of Shoreline Management Policy/Coastal Change Mapping

The EA and SDC have previously raised the issue of realigning the defences in this location. Liaison with the EA in November/December 2020 confirmed there is no driver from the EA to pursue this due to the

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relatively small scale of the area, the fact there is a reasonable amount of saltmarsh habitat already in the area and there is not an urgent need for more. As such, unless there is a compelling/legislative need for the developer to investigate this option, it is not something the EA are pushing for in the development.

Realigning the defences is not required to deliver the development site as coastal erosion is not a significant risk to the site. A review of fluvial and tidal modelling indicates that the proposed SANG and areas of open space can be delivered within the floodplain. The development is proposed entirely on the landward side of the defences and, therefore, will not be affected by coastal squeeze on the seaward side of the defences.

Natural England have raised concerns in relation to the loss of SAC intertidal habitats. There are no proposed future works in relation to the defences as a result of this development which would result in a loss of designated sites. The EA flood defence policy of 'Hold The Line' may mean that defences are raised in the future. This is outside the scope of our development and any assessment required would lie with the body responsible for carrying out these works. The tidal modelling has confirmed that even in the future 1 in 200 year H++ climate change scenario, the development is not affected by flooding based on current defence standard.

Further technical assessment looking at sediment movement and change to the estuary could be completed at a later stage this year if required by stakeholders.

5. Water Quality and Drainage

Stantec is currently undertaking ongoing drainage technical work to support the proposed allocation of a mixed-use development at Sharpness. A Water Quality and Drainage Statement (doc ref 41475-4004-YN003) was prepared in January 2021. This sets out initial consideration of the baseline water quality and nutrient neutrality issues and demonstrates how the allocation can be brought forward without risk of likely significant effects on water quality. The Stroud District Local Plan (November 2015) includes Delivery Policy ES4 (Water resources, quality and flood risk) and Core Policy CP14 (High Quality Sustainable Development), which seek the use of Sustainable Drainage Measures (SuDS) to both enhance biodiversity and improve water quality.

The key objectives of the Water Framework Directive (WFD) are to prevent deterioration in the status of water bodies and to achieve good ecological and chemical status/potential (including quantitative status in groundwater bodies) by 2021. Action must also be taken to reverse any identified sustained upward trend in pollution concentrations in groundwater bodies.

WFD assessment method statements were submitted to the EA in summer 2019 and discussions held in winter 2020 with EA, LLFA and Stroud District Council. Liaison will be ongoing throughout the planning process.

The drainage strategy will continue to evolve throughout the masterplanning process. The future planning application will be supported by a WFD Compliance Report and a Flood Risk Assessment which will include the proposed Surface Water Drainage Strategy.

6. Summary

Stantec has reviewed the tidal and fluvial floodplain extents provided by the Environment Agency in relation to the Berkeley Pill and the Severn Estuary. In the absence of any existing model data, Stantec has completed baseline fluvial modelling to confirm floodplain extents associated with the on-site ordinary watercourses. Updated wave overtopping analysis has also been undertaken to incorporate updated sea level rise in line with current climate change guidance. The existing EA North Coast tidal model has been re-run to define the 200 year plus climate change allowance floodplain extents and depths.

The results confirm that the majority of the proposed development is located in Flood Zone 1 and also not affected by the climate change scenario (including H++ scenario). Liaison with the masterplanning team is ongoing and there is sufficient space in the masterplan to ensure that all built development is located

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outside of the 1 in 200 year plus climate change allowance floodplain extents and sufficient freeboard provided between flood levels and finished floor levels.

In low order events (1 in 20 year or less), a review of tidal and fluvial flood extents for all watercourses indicates that flooding is largely limited to the southern area of the SANG and the nature reserve to the west. An area of SANG surrounding the Phase 1 development is dry in these events and therefore access to SANG can be provided.

The future planning application will be supported by a Flood Risk Assessment outlining all required mitigation measures to ensure the development is safe and has no detrimental impact on flood risk on and off-site. The hydraulic modelling is due to be submitted to the EA for review and approval in Summer 2021.