Eastleigh Hydrological Sensitivity Study: Flooding at Allbrook railway and road bridge

Final Report

October 2018

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Revision History

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Contract

This report describes work commissioned by Eastleigh Borough Council. Eastleigh Borough Council's representative for the contract was Graham Tuck. Adam Church of JBA Consulting carried out this work.

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Purpose

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Contents

List of Figures

List of Tables

Abbreviations

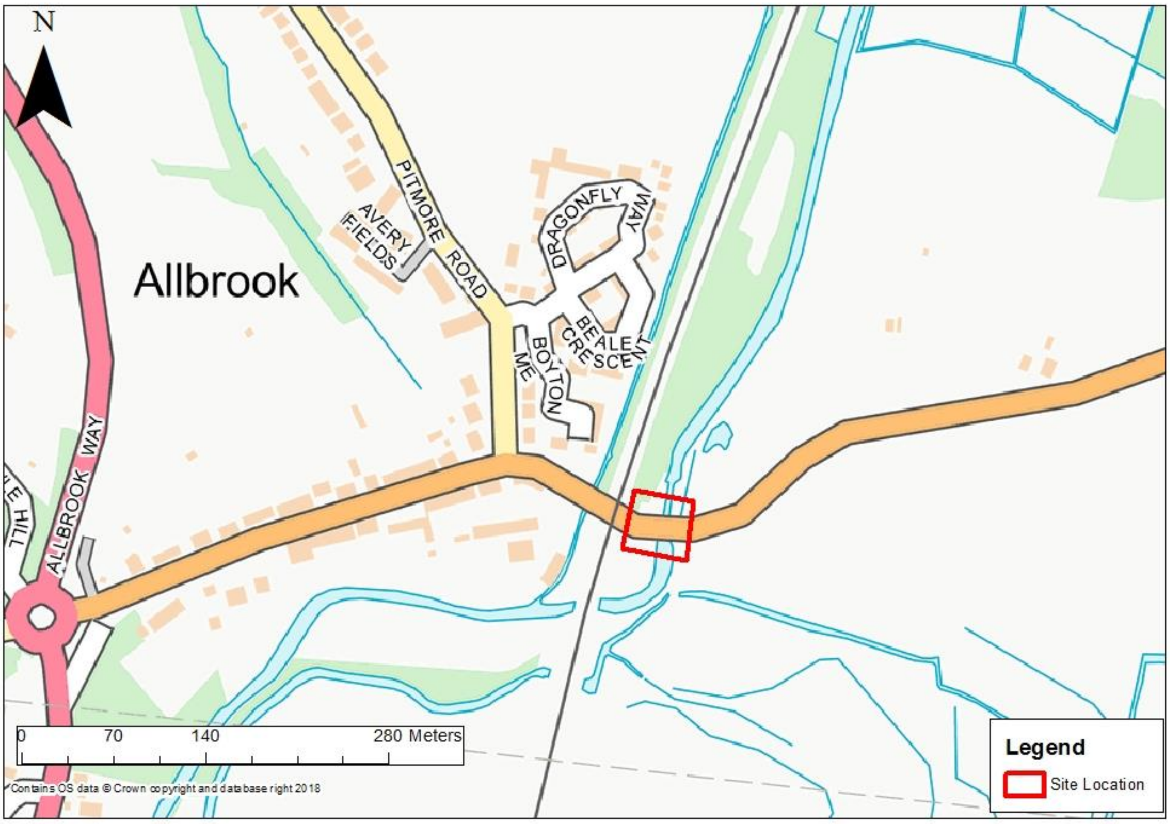
EBC ..... Eastleigh Borough Council
HCC ..... Hampshire County Council
NNR ..... National Nature Reserve
NVC ..... National Vegetation Classification
mAOD ..... metres Above Ordnance Datum
RBMP ..... River Basin Management Plan
RoFSW ..... Risk of Flooding from Surface Water
SAC ..... Special Area of Conservation
SPA ..... Special Protection Area
SSSI ..... Site of Specific Scientific Interest

1 Introduction

1.1 Background

JBA Consulting were commissioned by Eastleigh Borough Council (EBC) to investigate hydrological constraints within one of their boroughs, developed by EBC as part of their Local Plan. An important component of EBC's Local Plan is the improvement of the existing bridge on Allbrook Hill road, to the east of Allbrook, where it bisects the Itchen Navigation. In addition to the improvements to this existing bridge, the road on the approach to the bridge will be realigned to provide a better route for heavy good vehicles (HGV) traffic[1]. This study has investigated the proposed replacement of the road bridge on Allbrook Hill road and road realignment, with regards to flood risk with the vicinity.

Figure 1-1: Site location



1.2 Objectives

The following objectives have been identified for this study:

- Identify the current level of flood risk under the rail bridge from fluvial, surface run off, and groundwater sources.
- Asses the influence that recent property development works located to the north of Allbrook Hill road bridge are likely to have on the risk of flooding to the bridge, if at all.
- Assess the extent to which the proposed road realignment will have on the flood risk to Allbrook Hill road bridge.
- If there remains a flood risk, the mitigation measures that will be implemented to address this.

1 Eastleigh Strategic Transport Study. North Bishopstoke Bypass and Allbrook Hill Relief Road Feasibility Options Report.

2 Proposed works

2.1 Road alignment at Highbridge Road

As part of the wider NBLR alignment project, a section of Highbridge road will be realigned. The new road realignment needed to accommodate the following criteria[2]:

Improve the visibility of the railway bridge to the west of Highbridge Road for traffic travelling from Highbridge to Allbrook.

- To reduce the sharp bends in the current Highbridge Road to improve the route of HGVs.
- To avoid additional use of the floodplain where possible.
- To avoid encroaching into the nearby River Itchen SAC and SSSI.

Out of five concept options explored to meet these criteria for the road alignment, Option H2 was selected at the end of the selection process as it satisfied all of the criteria (Figure 2-1: P). Option H2 provided a compromise between the desire to improve the road as much as possible whilst keeping the costs down, having the least impact on the floodplain and avoiding the nearby River Itchen SAC and SSSI.

Figure 2-1: Proposed realignment of existing B3335 road[3]

2 Eastleigh Strategic Growth Option Allbrook Appraisal. June 2018. The Highwood Group and Galliford Try Partnerships. Prepared on behalf of Paul Basham Associates.

3 Eastleigh Strategic Transport Study, North Bishopstoke Bypass Feasibility Report

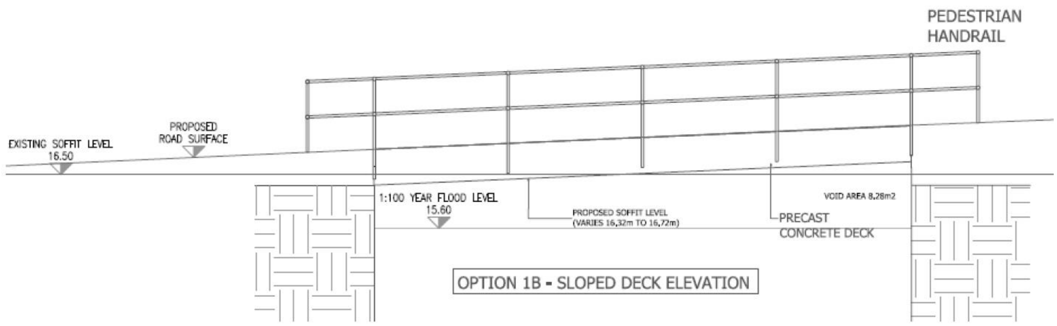
2.2 Allbrook Hill bridge

As part of the road alignment at Highbridge Road, a number of opportunities to relocate and improve the existing bridge as it crosses the Itchen Navigation, to the east of Allbrook, were explored. These are outlined in the 'Highbridge Road / Itchen Navigation Bridge Replacement Options Report'[4]. The new design of the bridge is required to facilitate the realignment of Highbridge Road. The new bridge design needed to accommodate the following criteria:

- To deliver the required road alignment both vertically and horizontally
- To increase the bridge deck width to accommodate a wider carriageway for HGVs and pedestrian crossing.
- To minimise the ecological impact of the new structure and improve the existing ecological situation.

Out of five concept options explored to meet these criteria for the new bridge, Option 1B was selected at the end of the selection process as it satisfied all of the criteria (Figure 2-2).

Figure 2-2: Option 1B



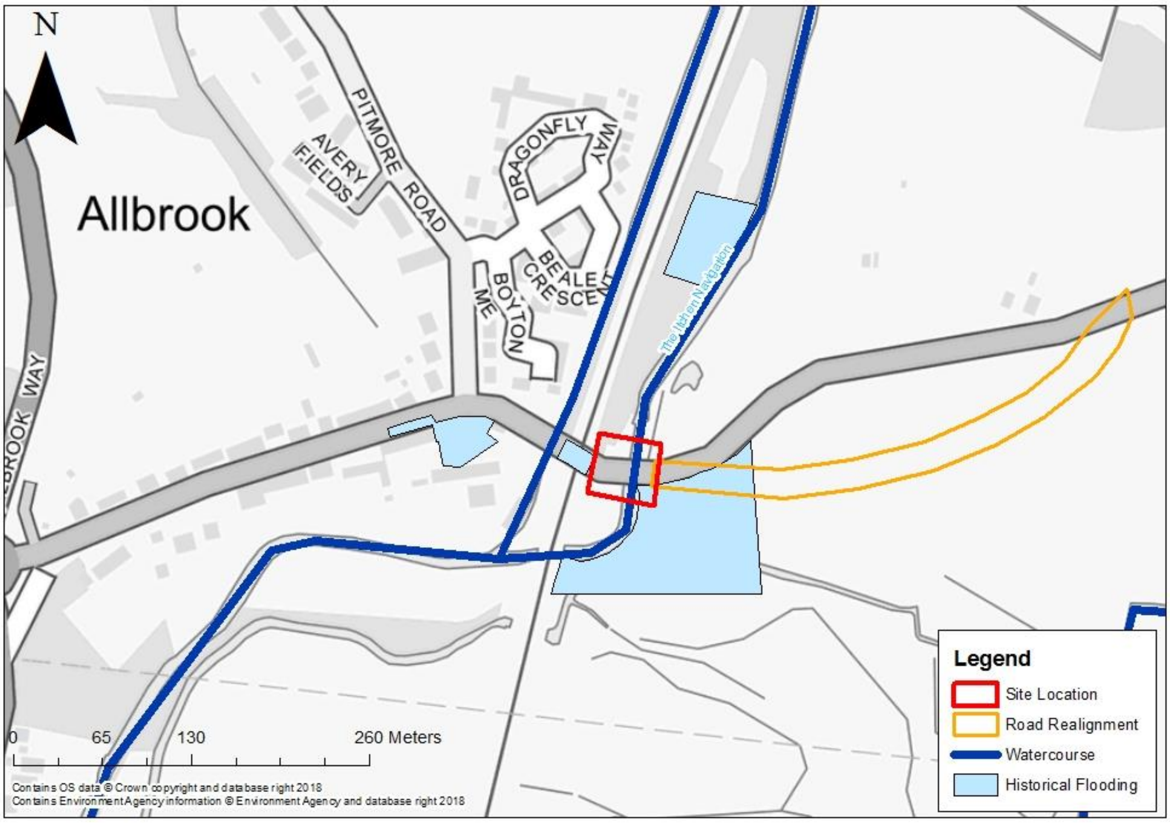
Option 1B provides optimum void space beneath the bridge, whilst also satisfying the parameters set out with regards to the road and flood levels. Moreover, the design incorporates the use of handrails instead of the existing concrete parapets provides ecological benefits to the surrounding area, facilitating the passage of light through the bridge section and minimising shading influences on the local ecology.

4 Highbridge Road/Itchen Navigation Bridge Replacement Options. Bridge Concept Report A-093273. Highwood Group/Galliford Try Partnerships, June 2018. Prepared on behalf of WYG Engineering Limited

3 Historical flooding

An assessment of historical flooding at the proposed development site has been undertaken. The intermediate level Surface Water Management Plan (SWMP) produced by Hampshire County Council included details of a recorded historical flooding incident which happened on Allbrook Hill Road in 2010 (B3335)[5]. This flooding is thought to be due to the river overtopping and flowing down Allbrook Hill road, which also caused flooding to the bridge platform. To alleviate the frequency and severity of flooding incidents to the bridge, it is believed that a grill has been installed on the main river culvert and is continuously maintained. Despite these improvements, there have been several more recent flooding incidents recorded at the bridge and on Allbrook Hill Road between 2010 and present. The recorded historical flood outlines for the area surrounding the site are shown in Figure 3-1.

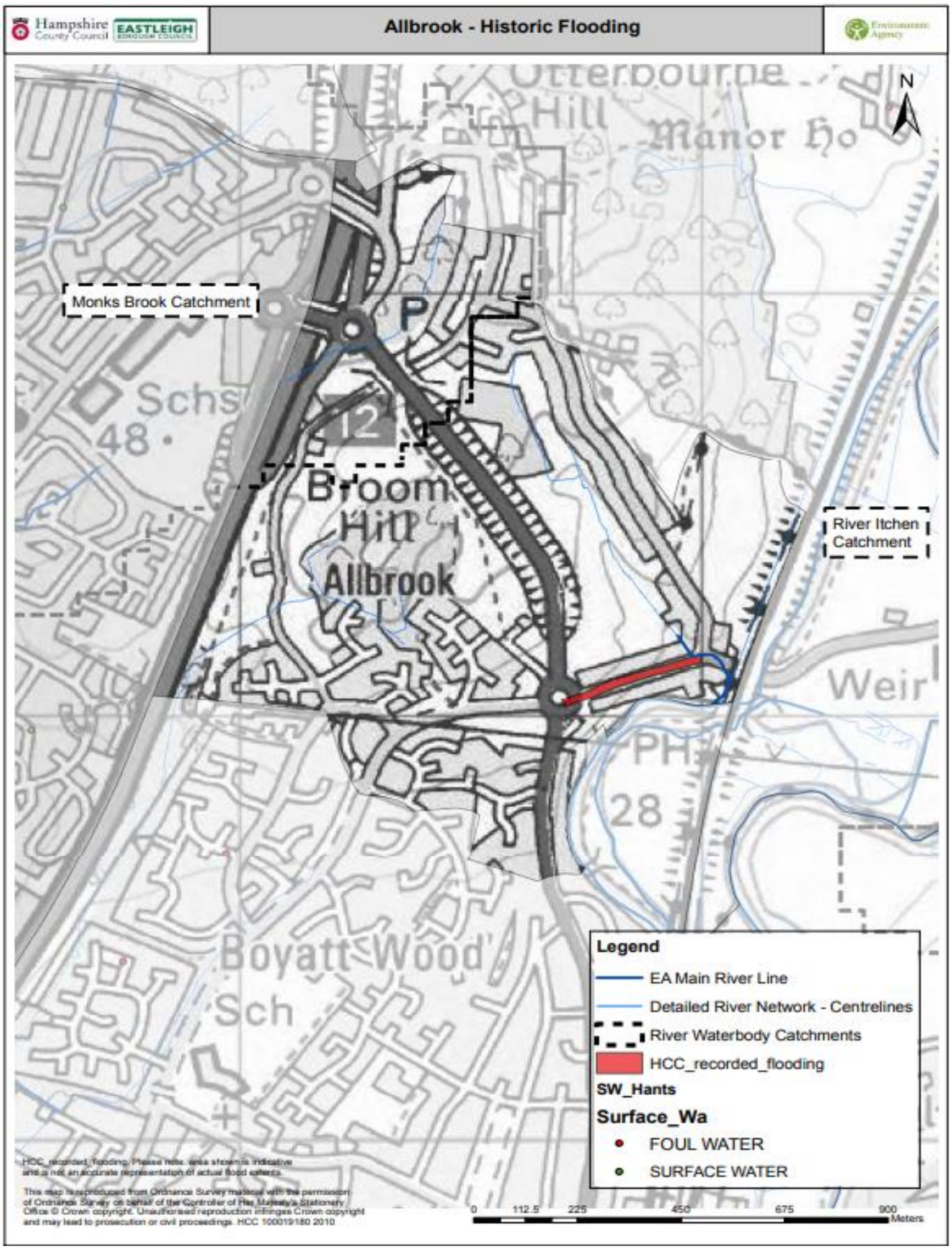
Figure 3-1: Recorded historical flood outlines



5 Eastleigh Surface Water Management Plan, 2011. Hampshire County Council

In addition, data from the Environment Agency's Historic Flood Maps can also be drawn upon, displayed in Figure 3-2. It is clear from the data collected here that there have been four incidents of historical flooding in the area. Flooding has occurred on the bridge platform itself, to the east of the bridge on Allbrook Hill road, to the west of the bridge on Highbridge road, and to the north of the bridge, along western bank of the Itchen Navigation and to the east of the railway bridge.

Figure 3-2: Historic flooding at Allbrook



4 Surface water flood risk

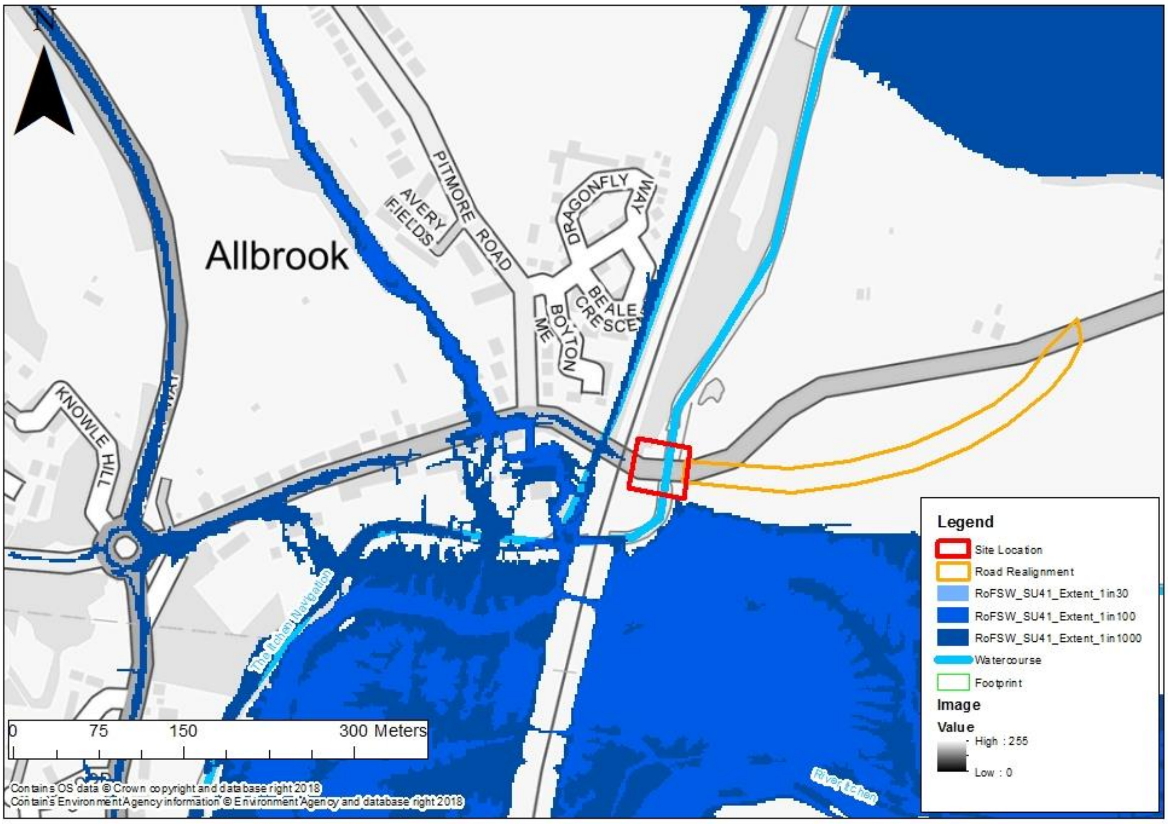
4.1 To the site

Surface water flooding arises when rain falling on saturated ground flows overland, following the local topography. Overland flow can therefore pose a risk to both the development site and land surrounding the development site. Surface water flood risk to the site was assessed using the Government's Risk of Flooding from Surface Water (RoFSW) maps which show the extent of surface water flooding within Allbrook. The recurrence of surface water flooding can be classified into risk, as follows:

- High – an area has a chance of flooding of greater than 1 in 30 each year
- Medium – an area has a chance of flooding of between 1 in 30 and 1 in 100 each year
- Low – an area has a chance of flooding of between 1 in 100 and 1 in 1,000 each year
- Very Low – an area has a chance of flooding of less than 1 in 1,000 each year

The EA RoFSW map shows that the bridge location over the Itchen Navigation is not affected by surface water flooding during any return periods. However, Allbrook Hill road is affected by surface water flooding. The 1 in 1,000-year and 1 in 100-year return period extents for surface water flooding both encroach upon Allbrook Hill road. The surface water risk to the proposed road realignment to the east of the road bridge is believed to be negligible, as the surface water extent does not encroach on the realignment site. However, the details of the road realignment to the west are unknown, and surface water flooding may potentially affect the proposed site of the development.

Figure 4-1:Risk of Flooding from Surface Water at Allbrook



4.1.1 Mitigation options

To mitigate any risk posed by surface water flooding, it is recommended that a SuDS based drainage system is implemented to the west of Pitmore road to deal with surface water runoff from any new road surfaces constructed here, with continuous maintenance and management of the system. In addition, a sufficient number of interceptor drains should be incorporated along low points in the road to minimise the risk of water ponding during storm events. If new drainage systems from the new road to the surrounding watercourses are created, the output of the drain should be positioned above the design water levels in the watercourse to minimise the risk of surcharge outfall scenarios, and the inability of effective drainage from the road surface. In the event that the new road is located on lower topography compared to surrounding land and existing road, cut off drains should be included along the road to prevent surface water runoff from adjacent land entering the new road. Consequently, it is believed that the risk of flooding from surface water sources to the bridge and road realignment is considered low.

4.2 From nearby property development site

A residential development was completed in the recent years at Allbrook Farm, to the north of the bridge on Allbrook Hill road. It is believed to have been developed by Forelle Estates. The development comprised two phases: phase one consisted of seven properties and associated infrastructure on a brownfield site, and phase two consisted of 50 properties and associated infrastructure on a greenfield site. The locations of both phases are outlined in Figure 4-2 as shown in the Flood Risk Assessment[6] (FRA) produced for the Allbrook Farm site.

The development site is located outside of Flood Zones 2 and 3 and is outside of the RoFSW extents for all return periods. It is however adjacent to an unnamed watercourse (tributary of the River Itchen) to the east. This watercourse is understood to be located within Network Rail's land and cross under the Allbrook Hill road in a culvert. It is believed that the site was naturally draining to that watercourse in the pre-development scenario.

The Flood Risk Assessment prepared for the phase 2 of the development by Andrew Malcom Associates Ltd (AMA) in 2014 was reviewed as part of this commission. A key component of the FRA was a surface water drainage strategy aiming to manage the post-development surface water runoff rates and volumes, in order to mitigate any increases in flood risk elsewhere as a result of the development. The adopted drainage strategy for the site comprised a SuDS based drainage system discharging to the existing Southern Water sewage system in Allbrook Hill. It is understood that the public surface water sewer discharges to the stretch of the Itchen Navigation to the south of the Allbrook Hill bridge, potentially meaning that the capacity of the culvert of the unnamed watercourse under the railway bridge is not affected by the sewer flows.

It is understood that AMA considered maintaining the existing drainage arrangements on site and discharging the post-development surface water runoff from the site directly (via a piped outfall) to the unnamed watercourse along its eastern boundary. However, Network Rail have not agreed to the proposal and therefore alternative means of discharge had to be sought.

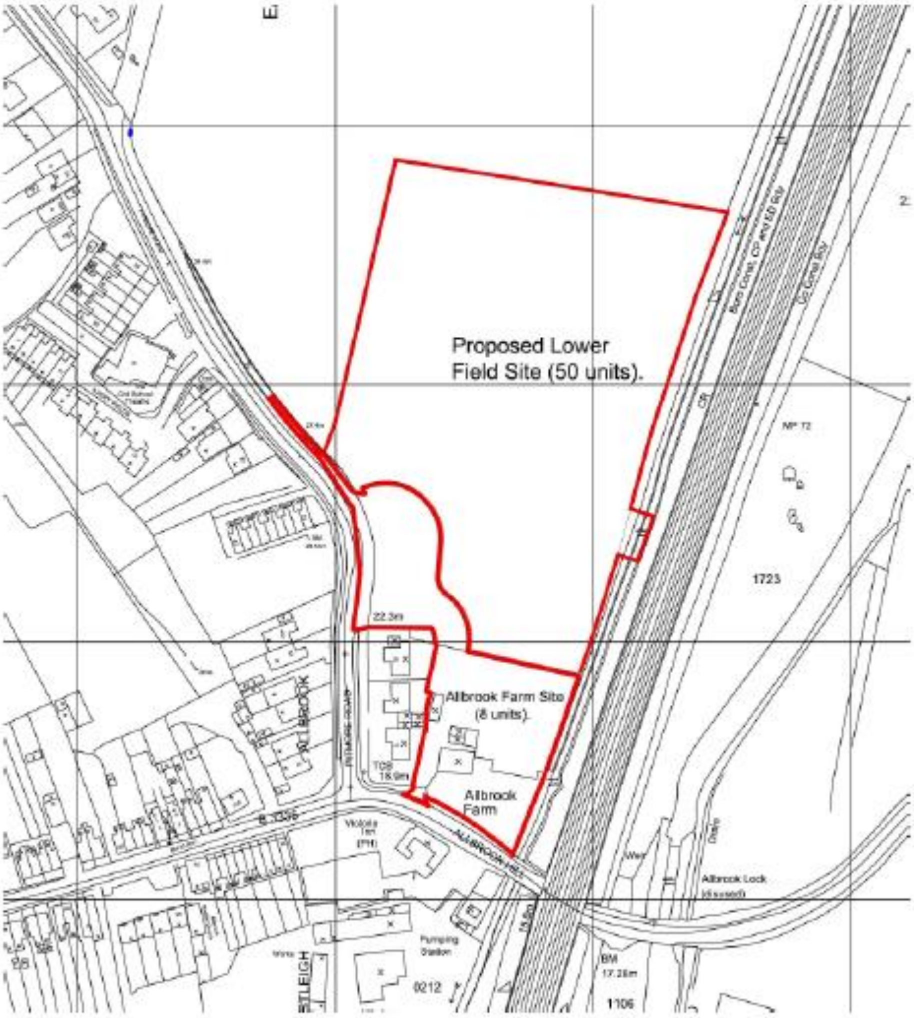
The surface water strategy means that since the development became operational less runoff is draining into the unnamed watercourse adjacent to the site to the east, and therefore the capacity of the channel and the associated culvert should have improved as a result. Consequently, as less flow is now likely contributing to the Itchen unnamed watercourse upstream of the bridge site, the flood risk at that location should have reduced. However, whilst the risk of surface water flooding to the bridge and proposed road realignment has been reduced, the public surface water sewer that the property development site discharges its surface water into poses a risk of flooding to the road and the bridge. Additional sources of water from the property development have been added to the limited sewage system capacity in Allbrook, which may have the potential to reach the capacity of the sewer, or become blocked. However, the risk that the sewage system poses to the bridge and road realignment is unknown; in order to ascertain the risk of flooding from sewage sources, additional studies will have to be conducted.

It should be noted however that no 'as-built' drawings of the drainage scheme discussed have been made available for review and it is uncertain if the drainage strategy proposed at the planning stage has been incorporated on site as initially designed. Additionally, the impact of the proposed development and its drainage scheme on the Itchen Navigation has not been quantified in the

6 Flood Risk Assessment. Proposed residential development, Allbrook Farm, Pitmore road, Eastleigh, Hampshire. Andrew Malcom Associates Ltd. June 2014

original FRA report. Consequently, the above conclusions are based purely on interpretation of the information contained in the reviewed document.

Figure 4-2: Location of residential development in vicinity of the Allbrook railway and road bridge



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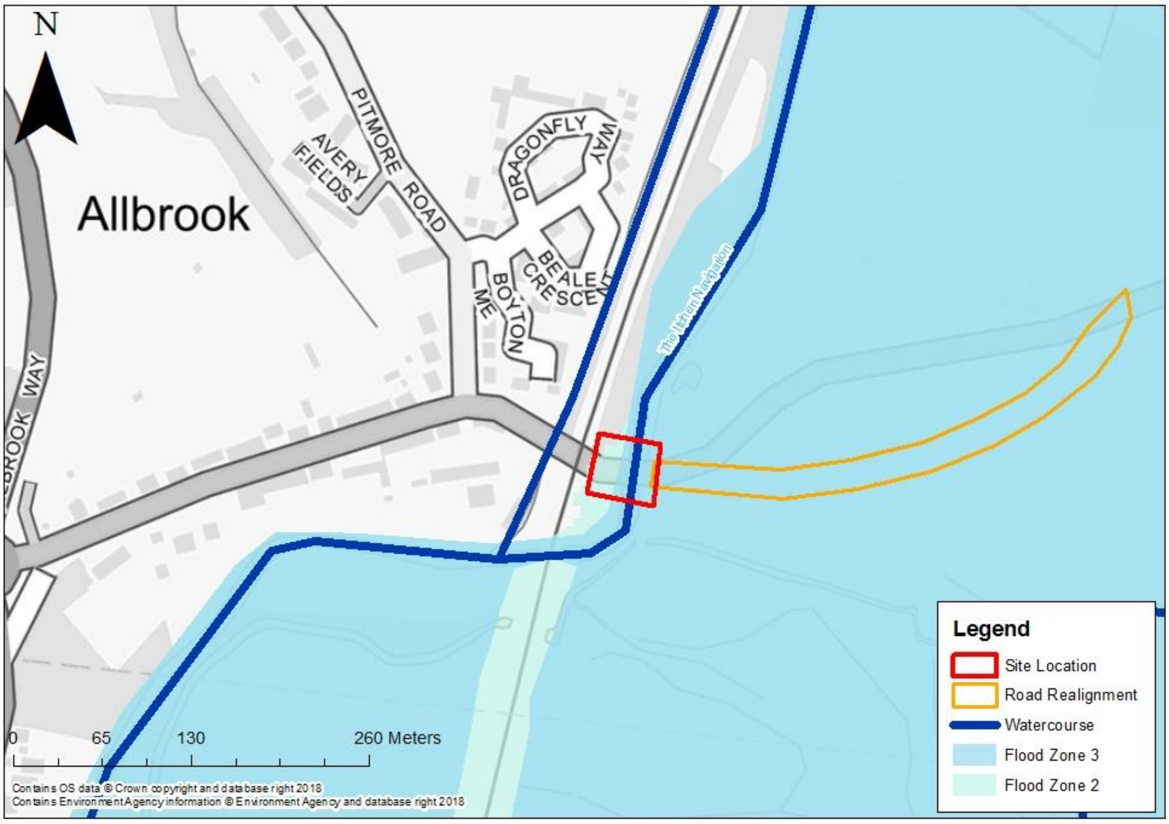
5 Fluvial flood risk

5.1 Environment Agency Flood Zone mapping

The primary watercourse in the vicinity of the proposed development site is the Itchen Navigation, which the bridge bisects. The Itchen Navigation Flows in a South Westerly direction through the site. There is also an unnamed watercourse which is a tributary of the Itchen Navigation, which is situated to the west of this main river. The railway bridge to the west of the bridge development site bisects the unnamed watercourse. The unnamed watercourse joins the Itchen Navigation just to the south of Allbrook Hill road bridge.

The latest EA Flood Zone mapping, Figure 5-1, shows that the bridge is located within Flood Zone 2 (>0.1% AEP) and Flood Zone 3 (>1% AEP). Allbrook Hill road to the west of the bridge location is not within either Flood Zone 2 or 3.

Figure 5-1: Environment Agency Fluvial Flood Zone mapping



There is the possibility of flood risk to the site to increase in the future. An Inquiry launched by the Environment Agency in December of 2017 aimed to investigate the influence that the current levels of water abstraction by Southern Water on the River Itchen have has upon the riverine habitats and organisms. The River Itchen is a Site of Special Scientific Interest (SSSI) and Special Area of Conservation, making the watercourse sensitive to fluctuations in water level. Following the inquiry, it is believed that the Environment Agency served a notice on Southern Water, which required the company to impose an aggregate total monthly abstraction limit during June and September, and to Maintain the flow above 198 Ml/d. Moreover, a time limit was also imposed on Southern Water's abstraction license to the watercourse, which will expire in March 2025.

The subsequent increase in flow through the watercourse may increase the flood risk along the watercourse and increase the frequency and intensity of flooding to the site from a fluvial source.

5.2 Fluvial flood risk modelling and mapping

JBA Consulting are currently preparing new flood risk modelling and mapping for fluvial flood risk across the full River Itchen Catchment for the Environment Agency for the full River Itchen catchment, produced using a 1D-2D Flood Modeller - TUFLOW hydraulic model approach.

Hydrology has been developed to help inform the high-level investigation of bridge works within the Eastleigh model domain. Hydrology for model simulations was adapted from the February 2014 calibration event which has been run on the hydraulic model during the Eastleigh modelling study. At the time of this investigation, design event hydrology had not been finalised and no design event IED files were available. As such, an approximate simplified version of the design event peak flows has been applied to the model to attempt to gain an insight into the approximate peak water levels and flood mechanisms at the area of interest. No attempt has been made to apply hydrograph shapes, factorise the inflows or coincide peak flows of other inflows as the primary aim was to generate an approximation of various flood extents in the area of interest. Given that this approach is only intended on providing an approximation of peak flows to the area of interest, there may be model instabilities apparent which do not appear in the other modelling scenarios run for the Environment Agency as part of the Eastleigh modelling and mapping study. Although intended to be a high-level investigation, instabilities resulting from the simplistic application of the hydrology should still be investigated. It is important to note that these draft results have not yet been calibrated, finalised or approved by the Environment Agency and have only been provided at this stage due to timescale constraints associated with this study. They are therefore considered to be indicative only and will likely be subject to change following formal Environment Agency review.

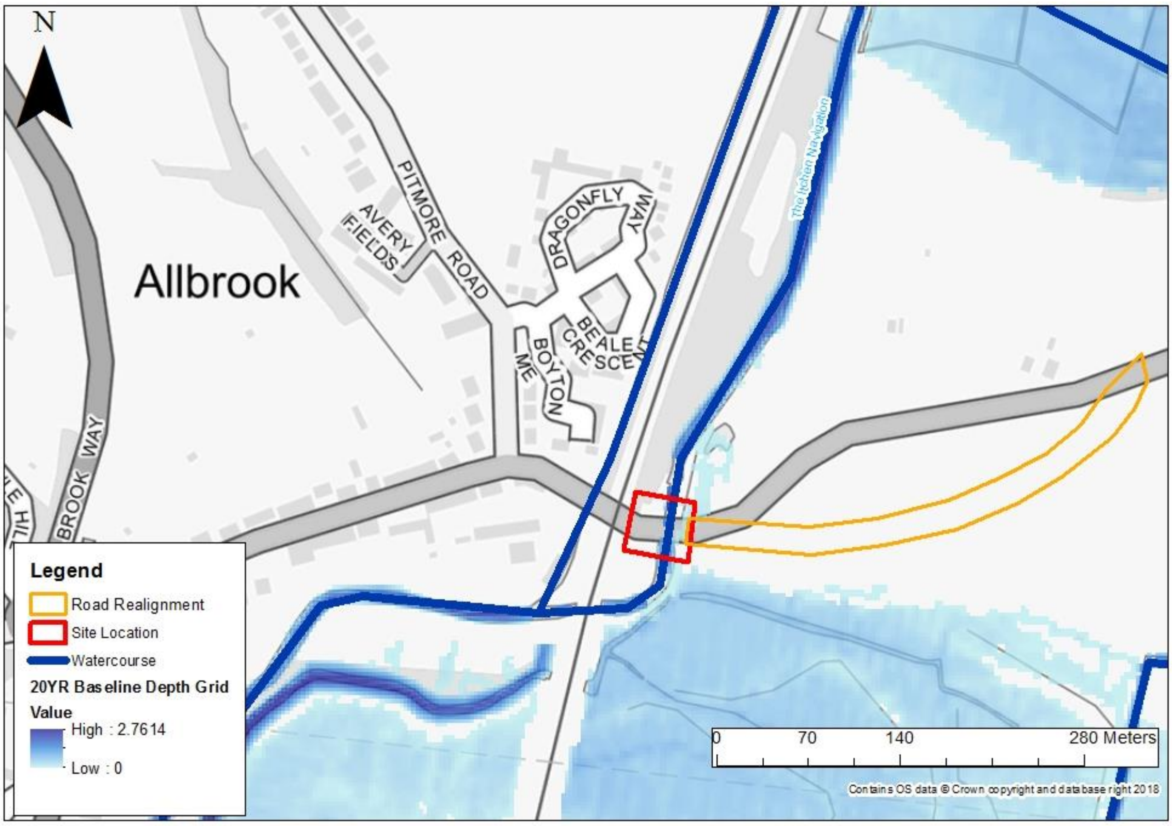
The model was run for the following flood scenarios:

- [Baseline Scenario] 20-year (5% AEP) flood event - existing condition scenario
- [Baseline Scenario] 100-year (1% AEP) flood event - existing condition scenario
- [Option Scenario] 100-year (1% AEP) flood event - bridge and bund scenario

The bridge has been represented as shown in Figure 2-2, however in the modelling software it is not possible to represent a sloping soffit and the bridge has therefore been represented with an average soffit level of 16.52mAOD. The width of the bridge is not indicated in Figure 2-2, and the width of the structure has therefore been kept to the existing width.

The results for the 1 in 20-year baseline scenario are shown in Figure 5-2.

Figure 5-2: 1 in 20-year flood event, baseline scenario

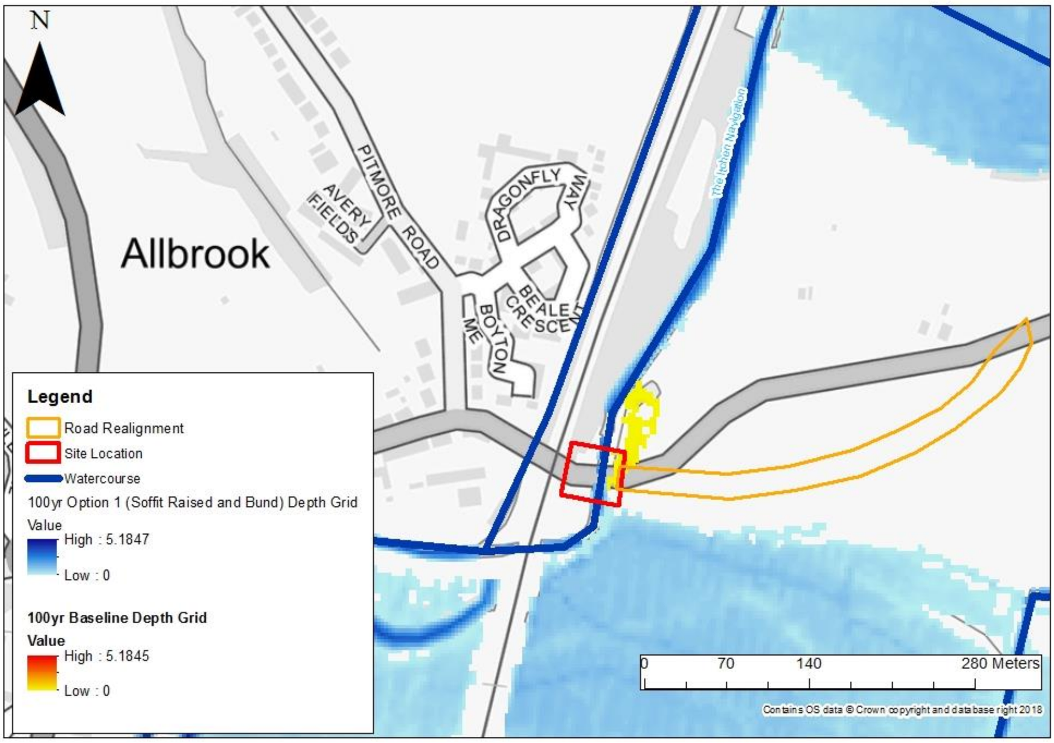


Water gets out of bank on the east bank of the Itchen Navigation directly upstream of Allbrook Hill Road bridge in the 1 in 20-year baseline scenario (Figure 5-2). A low elevation spot along the eastern bank appears to allow water to spill out onto the floodplain. Water overtops the road (as it is currently represented in the model) before returning to the channel downstream of the bridge. Water depths are approximately 80mm on the road surface immediately to the east of the road bridge.

The reason why water is getting out of bank in the model is currently unclear; it could either be due to an actual low spot along the bank, or it could be an artefact of the way the LiDAR is represented at the surface. This should be confirmed with a bank top survey of the bank.

The results for the 1 in 100-year baseline scenario and the 1 in 100-year option scenario are compared in Figure 5-3.

Figure 5-3: 1 in 100-year event, baseline and option scenarios



In the baseline scenario (existing bridge) water gets out of bank on the east bank of the Itchen Navigation directly upstream of Allbrook Hill Road bridge in the 1 in 100-year return period. Water depths are approximately 90mm on the road surface immediately to the east of the road bridge.

A bund was added as a mitigation method at the eastern section of the bank where water is getting out of bank, to reduce the risk of flooding from fluvial sources to the bridge and the road realignment site in the 1 in 100-year option scenario. This is shown to stop water getting out of the left bank of the Itchen Navigation, preventing water from overtopping the road surface.

In terms of in-channel water levels, the existing bridge is not currently surcharging (i.e. water is not reaching the soffit level of the structure: the existing soffit level at the bridge is 16.5mAOD (as shown in Figure 2-2). The 1 in 100-year maximum water level is 15.6mAOD. The soffit level of the proposed bridge varies from 16.32 to 16.72 (i.e. on average it is slightly higher than the existing structure). The proposed structure is therefore likely to have a negligible impact of flood water levels. There is negligible difference between the maximum water elevation levels upstream between the baseline and option scenarios, which indicates that the proposed bridge and bund will not have a significant impact on the fluvial mechanisms of the Itchen Navigation further upstream.

From the model results reviewed here, it can be assumed that the proposed bund mitigation method placed at the low point along the bank is sufficient to reduce the risk of flooding from fluvial sources to the bridge platform and adjacent floodplain, whilst the proposed bridge design is likely to have a negligible impact on the flood risk to the site.

6 Groundwater flood risk

6.1 Overview

This section aims to establish the potential constraints that may occur due to the groundwater conditions at the site, as well as any negative impacts that may occur on the groundwater environment due to the proposed works.

This section presents a desk-based hydrogeological conceptual understanding of the area around the river crossing, using the data sources cited below. The mechanisms for groundwater level variation and emergence within the vicinity are then presented, followed by a review of the potential implications of the proposed river crossing.

6.2 Data sources

The data used in the desk study were obtained from the following sources;

- Topography and general mapping:
  - OS Open Data, Terrain 50 DTM, LiDAR 2m DTM (Environment Agency (EA) Open Data);
  - Aerial photography (Google Earth and Bing Maps);
- Climate:
  - Flood Estimation Handbook (FEH) and CD-ROM (CEH, 2009).
- Geology and Soils:
  - BGS 1:50,000 Geology Map;
  - BGS digital geology mapping;
  - BGS online borehole database (BGS website);
  - BGS online Lexicon (BGS website);
  - 1:250,000 soils mapping (Soil Survey of England and Wales, 1983).
- Hydrogeology:
  - JBA Groundwater Flood Risk Mapping (5m);
  - Aquifer classification (Environment Agency);
  - Groundwater vulnerability (Environment Agency);
  - Source Protection Zones (Environment Agency);
  - Groundwater quality (Environment Agency);
  - Minor Aquifer properties manual (Jones et al., 2000); and,
  - Major Aquifer properties manual (Allen et al., 1997).

6.3 Hydrogeological setting

6.3.1 Geology

The geology beneath the site is detailed within the Eastleigh Hydrological Sensitivity Study (JBA, 2018). A summary of the soils, superficial and bedrock geology found beneath the site is described below.

6.3.1.1 Soil

Soilscape (England) classifies the area of Highbridge-Allbrook as having 'freely draining slightly acid loamy soils', with the main land cover of arable and grassland.

There is a BGS borehole record located 230m north-east shows 0.1m of topsoil.

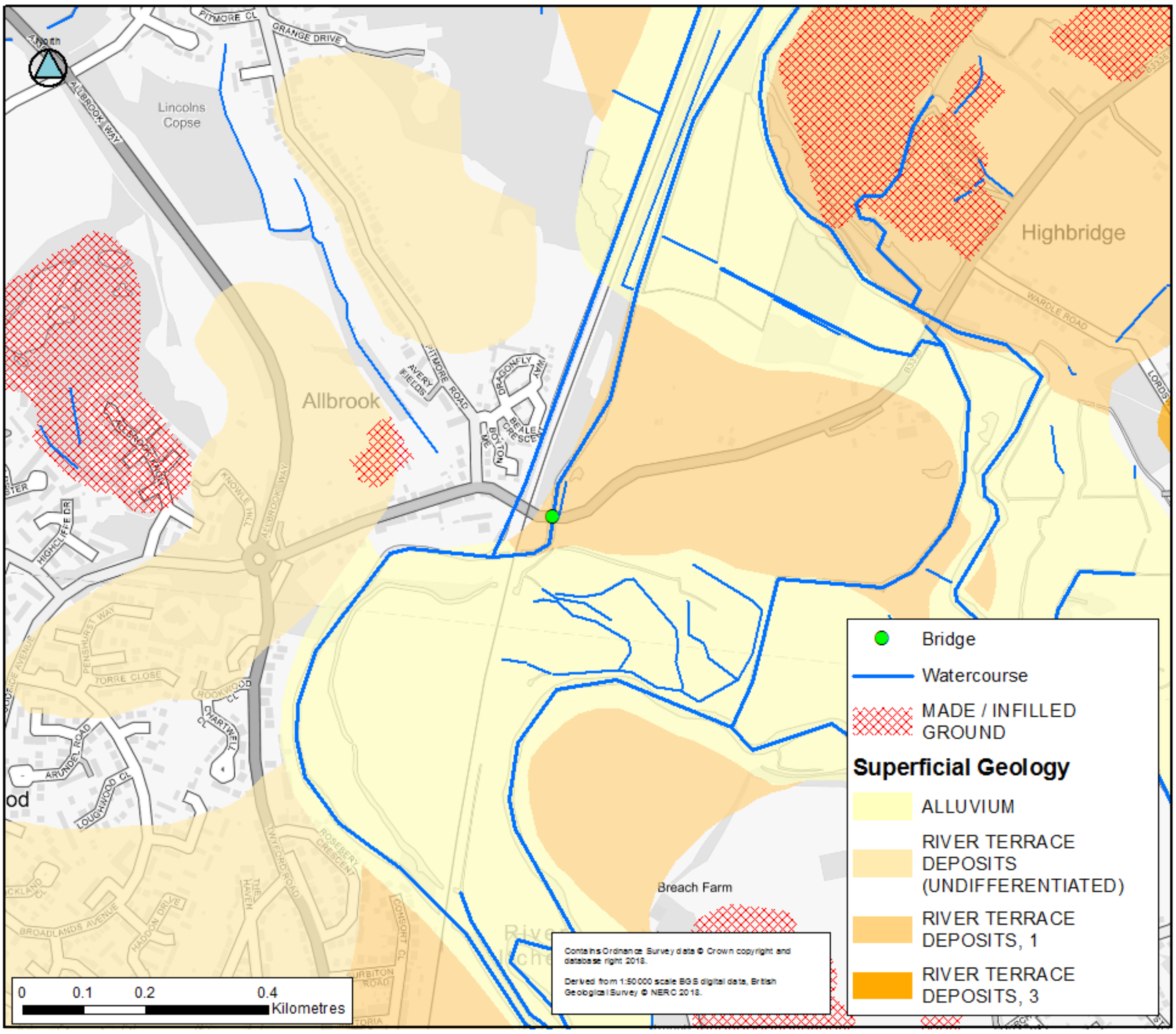
6.3.1.2 Superficial Geology

The superficial deposits mapped beneath the site are river terrace deposits of sand and gravel. To the east, following the course of the main River Itchen, are alluvial deposits of variable clay, silt, sand and gravels.

The BGS borehole record located 230 m south shows silts and clays containing sand and gravel. The BGS borehole record located 230 m north-east shows 4.4 m of gravelly clays, becoming more silty at depth.

The superficial geology at the site and local area is shown in Figure 6-1

Figure 6-1: Superficial geology



6.3.1.3 Bedrock geology

The site is underlain by the clay, sand and silt of the London Clay Formation.

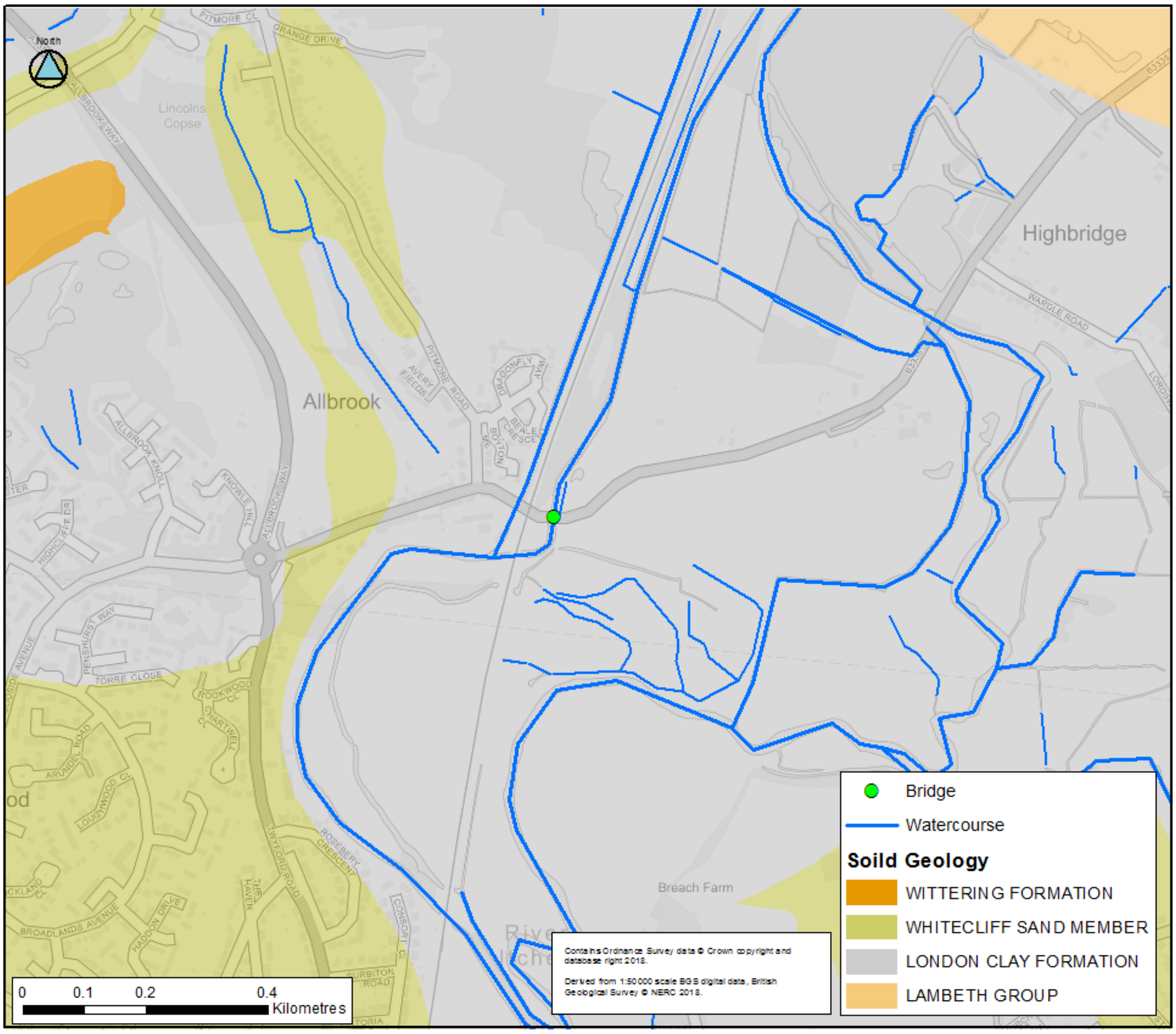
To the south west, the area is underlain by the Whitecliff Sand Member, part of the Thames Group.

Less than 2 km to the north east, the upgradient portion of the River Itchen catchment is underlain by Chalk, which dips southwards under the London Clay.

The BGS borehole record located 230 m south, shows the London Clay is reached at 5.0 m below ground level (mbgl), and is described as stiff grey fissured silty clay. The BGS borehole record located 230 m northeast, shows the London Clay is reached at 4.4 mbgl

The bedrock geology at the site and local area is shown in Figure 6-2.

Figure 6-2: Bedrock geology



6.3.2 Hydrogeology

6.3.2.1 Aquifer properties

An aquifer is a layer of permeable sediment or rock that is able to store and transmit significant quantities of groundwater. The Environment Agency classifies the London Clay as unproductive, whilst the Chalk bedrock underlying the London Clay, which outcrops further north of the site, is classified as a Principal Aquifer, reflecting the regional and strategic importance of the Chalk for public water supply.

Other strata to the north and south of the site are classified as being of Secondary A status i.e. a groundwater supply of local significance, and includes the Tarrant Chalk Member, and the Whitecliff Sand Member.

The superficial head deposits of the area are classified as a Secondary A aquifer.

The regional scale BGS hydrogeology map indicates that the London Clay sequence can be up to 140 m thick, confining the underlying Chalk aquifer.

6.3.2.2 Groundwater levels

Whilst water was encountered in the BGS borehole record 230 m northeast of the bridge, water inflow tests showed that there was no water made after 30 minutes. At the BGS borehole 230 m south of the bridge, water was encountered at 1.5 mbgl.

The nearest BGS mapped water wells, which lie 1.4 and 2 km east of the Allbrook bridge, indicate well depths of 83 and 92 m. Whilst no groundwater level data are available for these boreholes, the Chalk water level is unlikely to be close to ground surface, given the depths required to obtain a groundwater supply from the Chalk aquifer in these locations. It is therefore likely that, at the river crossing site, the bedrock groundwater level is also likely to be much deeper below the surface, and confined by the London Clay

As such, the groundwater inflows above, occurring within the BGS boreholes, is likely to be that occurring within the superficial deposits. Given their limited lateral extent at the location of the river crossing, due to being contained within the River Itchen valley, and absence of water wells on the BGS online mapping, it is unlikely that large flows would be expected within these deposits.

6.3.2.3 Source Protection Zones and EA Position Statement

Source Protection Zones (SPZs) are used to protect areas of vulnerable groundwater that is used for abstraction and where water quality is of high importance (such as drinking water abstractions).

SPZ1 is the inner zone and is defined as the 50-day travel time from any point below the water table to the source. All groundwater abstractions intended for human consumption or food production have an SPZ1 with a minimum radius of 50 m. SPZ2 is the outer zone and is defined by the 400-day travel time from a point below the water table, in some cases depending on the volume abstracted, a default SPZ2 with a minimum radius of 250m applies. SPZ3 is the total catchment zone and is defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source.

The proposed development is not located within any SPZ, with the closest SPZ boundary approximately 650 m north of the site.

The EA Position Statement N8 - Physical disturbance to aquifers in SPZ1 (the EA's approach to groundwater protection, 2018) states: 'Within SPZ 1, the Environment Agency will normally object in principle to any planning application for a development that may physically disturb an aquifer' (EA, 2017). Therefore, it is considered that Position Statement N8 will not apply to the proposed development as no such restriction applies to activities lying outwith SPZs.

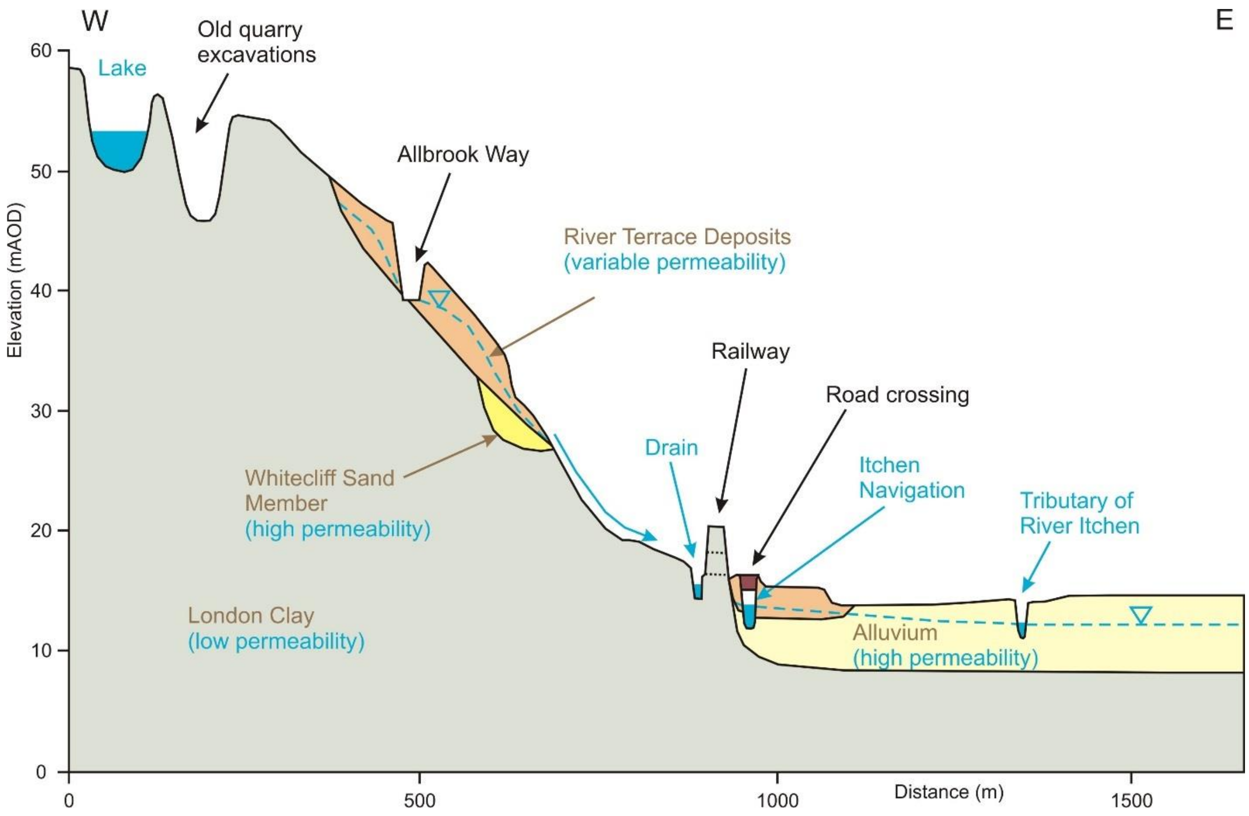
The EA Position Statement N11 (EA, 2018) - Protection of resources and the environment from changes to aquifer conditions states: "For any proposal that would physically disturb aquifers, lower groundwater levels, or impede or intercept groundwater flow, the Environment Agency will seek to achieve equivalent protection for water resources and the related groundwater-dependent environment as if the effect were caused by a licensable abstraction."

6.3.3 Hydrogeological conceptual model

The EA defines a conceptual model as "a description of how a hydrogeological system is believed to behave" and its development as "an iterative or cyclical process of development and testing in which new observations are used to evaluate and improve the model." (EA, 2002, p.4.1-2).

A preliminary hydrogeological conceptual model for the site and surrounding environment has been developed based on the information available and is shown in Figure 6-3.

Figure 6-3: Hydrogeological conceptual model



The main features of the conceptual model are as follows:

- The bedrock underlying the site of the road crossing is the London Clay, which is a low-permeability stratum unlikely to support groundwater flow. The depth to the Clay is approximately 4.5-5 mbgl where superficial deposits are present, with bedrock outcropping to the west. A band of the Whitecliff Sand Member extends north to south, to the west of the site;
- Superficial deposits consist of alluvial deposits associated with the Itchen River, with river terrace deposits located around the site and at higher elevation to the west;
- Groundwater levels have been observed historically to be around 1.5 - 2.5 mbgl in the local area, where superficial deposits are present;
- There is an old quarry excavation in Allbrook, to the west of the site. The voids have been left unfilled, with a lake formed in one of them (this is likely to be a lined lake above the water table although details are not available). These voids may increase infiltration and recharge of the groundwater body; and
- The London Clay is sufficiently thick (45+ mbgl in the local area), that the underlying Chalk aquifer will be completely confined and unlikely to impact the site in terms of groundwater.

6.4 Conceptual understanding of groundwater flooding

6.4.1 Introduction

The BGS define groundwater flooding as the emergence of groundwater at the ground surface away from perennial river channels or the rising of groundwater into man-made ground, under conditions where the 'normal' ranges of groundwater level and groundwater flow are exceeded (MacDonald *et al*., 2008;2010).

A number of events, most notably the flooding in England and Wales during the winters of 2000/2001 and 2002/2003 and the summer of 2007 (Cobby et al., 2009), have illustrated the potential impact of groundwater flooding in the UK. As such, it is important to consider the potential combined effects of flooding from groundwater and from other sources, as well as considering flooding from groundwater alone.

Unlike fluvial flooding i.e. flooding from surface water courses, which represents the short-term response of a catchment to rainfall, groundwater flooding is often dependent on the longer-term water balance and the amount of water stored in the aquifer. For example, groundwater flooding is often more likely following a wet winter when groundwater levels are unusually high and little additional rainfall is required to bring the water table to the ground surface. However, if an aquifer has a very low storage capacity, or if additional sources of water are present (such as a river or a leaking water main), then a wet winter may not be necessary in order for groundwater flooding to occur.

6.4.2 Groundwater flood risk at Allbrook

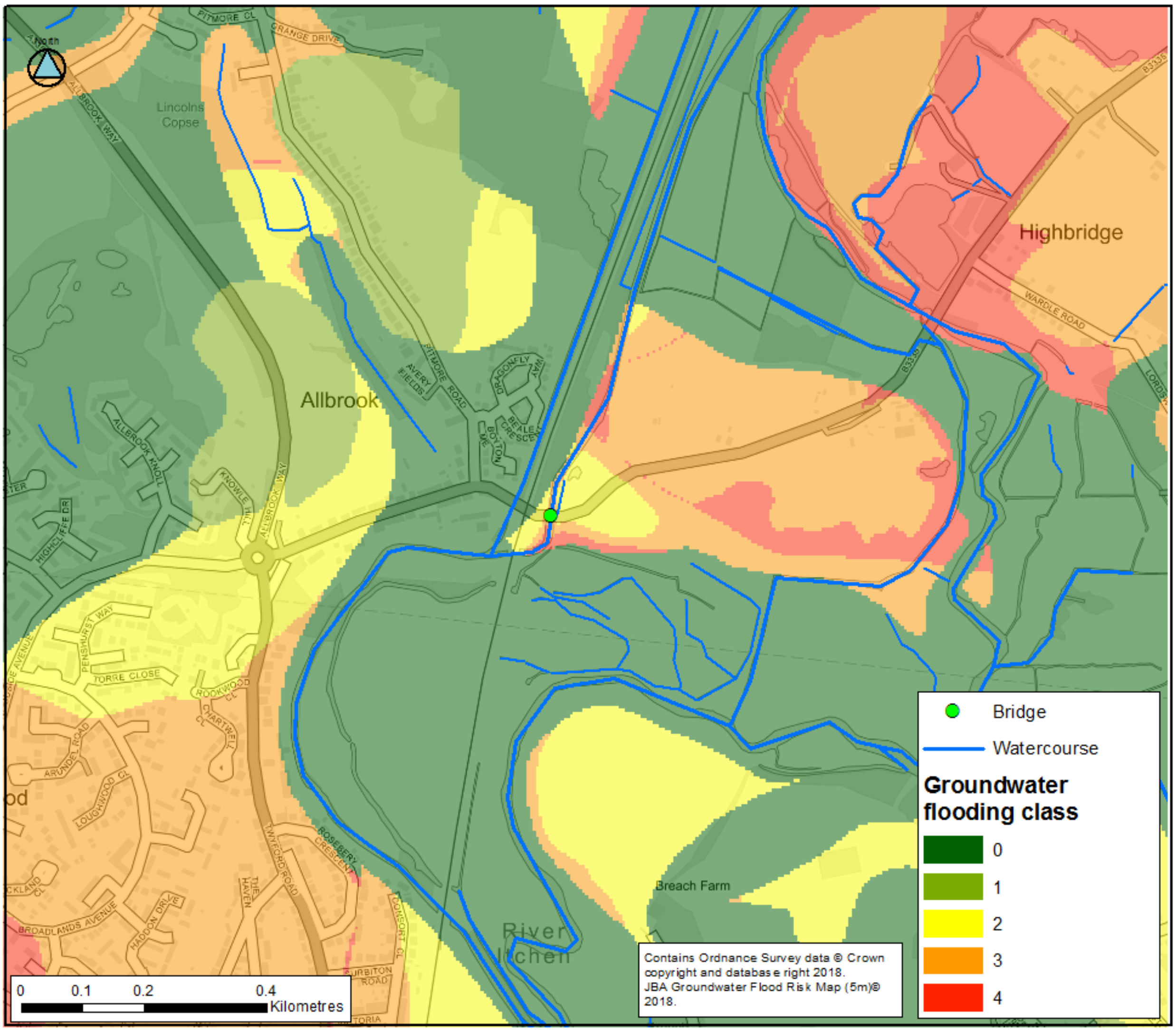
For the purposes of this report, the Groundwater Flood Map 5 m Resolution V2.3 (JBA licenced product) has been utilised to provide a detailed assessment of the groundwater flood hazard across the site. The modelling used to generate the groundwater flood map involves simulating groundwater levels for a range of return periods (including 75, 100 and 200-years). Groundwater levels are then compared to ground surface levels to determine the head difference (in m), where a zero head suggests artesian discharge at the ground surface. The head difference is defined on a 5 m grid.

The V2.3 model categorises the head difference (in m) into five different feature classes (0-4). A detailed description of each individual class is given in Table 6-1. The groundwater flood map generated by the V2.3 model for the site is presented in Figure 6-4.

Table 6-1: Groundwater flood map class description

Groundwater head difference (m)	Feature class	Description
N/A	0	No Risk. This zone is deemed as having a negligible risk from groundwater flooding due to the nature of the local geological deposits.
>5	1	Groundwater levels are at least 5m below the ground surface in the 100-year return period for a flood event.
0.5 - 5	2	Groundwater levels are between 0.5m and 5m below the ground surface in the 100-year return period for a flood event. There is a risk of flooding to subsurface assets, but the surface manifestation of groundwater is unlikely.
0.025 - 0.5	3	Groundwater levels are between 0.025m and 0.5m below the ground surface in the 100-year return period flood event. Within this zone there is a risk of groundwater flooding to surface and subsurface assets. There is the possibility of groundwater emerging at the surface locally.
0 - 0.025	4	Groundwater levels are either at very near (within 0.025m of) the ground surface in the 100-year return period flood event. Within this zone there is a risk of groundwater flooding to both surface and subsurface assets. Groundwater may emerge at significant rates and has the capacity to flow overland and/or pond within any topographic low spots.

Figure 6-4: Map of groundwater flooding potential



It is evident from the groundwater flood map in shown in Figure 6-4, that the site is located within an area with a groundwater flood hazard classification of 2 to 4. This indicates that groundwater levels in the area may have large variability, with a range of 0 - 5 m below the ground surface during a 100-year return flood event. This is due to the variable topography and permeability of the river terrace and alluvial superficial deposits in the area.

6.5 Implications of the proposed river crossing at Allbrook

6.5.1 Overview

The proposed river crossing at Allbrook may be at risk of groundwater flooding due to its topographical setting and underlying geology. Groundwater levels within the superficial deposits have been recorded to be within 1.5 m of the ground surface, with the potential for levels to reach near-surface during flood events.

6.5.2 Source Protection Zones (SPZs) and EA's Position Statements

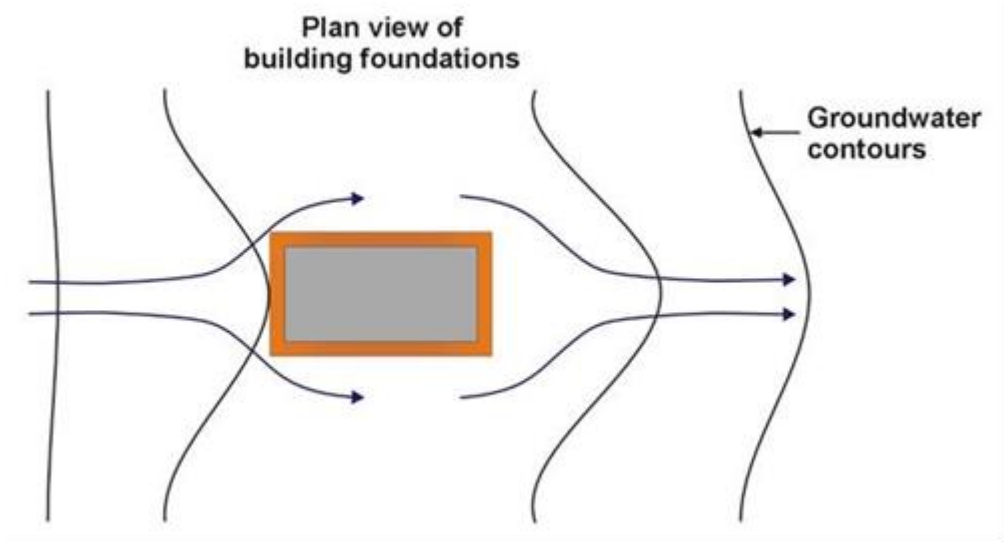
The EA Position Statement N8 - Physical disturbance to aquifers in SPZ1 (the Environment Agency's approach to groundwater protection, 2018) states: "Within SPZ 1, the Environment Agency will normally object in principle to any planning application for a development that may physically disturb an aquifer" (Environment Agency, 2017). Therefore, it is considered that Position Statement N8 will not apply to the proposed development, as no such restriction applies to activities within SPZ2 or SPZ3.

The EA Position Statement N11 (EA, 2018) - Protection of resources and the environment from changes to aquifer conditions states: "For any proposal that would physically disturb aquifers, lower groundwater levels, or impede or intercept groundwater flow, the Environment Agency will seek to achieve equivalent protection for water resources and the related groundwater-dependent environment as if the effect were caused by a licensable abstraction." The proposed development would be located on a Secondary Undifferentiated Aquifer (relating to the river terrace superficial deposits). Therefore, works such as excavations and construction of foundations within these superficial deposits have the potential disturb and impede groundwater flow.

6.5.3 Impact of the proposed development on aquifers

Where building foundations or other sub-floor structures provide an impermeable barrier to groundwater flow within an aquifer there is potential for the 'damming' of groundwater with an associated rise of groundwater levels up-gradient of the obstruction. They may also be a diversion of groundwater around the obstruction. This is illustrated in Figure 6-5.

Figure 6-5: Impact of the proposed development on groundwater conditions



The foundation design for the proposed development has not been made available for this study, but the potential impact of the foundations on local groundwater levels must be considered, particularly when groundwater levels may be higher than planned excavation and construction depths. Subsurface structures can also reduce the volume of groundwater storage in an aquifer.

6.5.3.1 Mitigation options

The following mitigation options can be recommended based on findings of this report:

- Any foundations and structures below the high groundwater level would need to be lined and engineered in such a way as to prevent the ingress of groundwater (detailed engineering advice and design is beyond the scope of this report);
- Groundwater ingress would need to be managed during any excavation and construction works;
- Seasonality of groundwater levels should be considered, such as completing the works during summer, when levels are likely to reach their lowest; and
- Where any structure is acting as a groundwater barrier, drainage should be considered around the development, to increase groundwater flow around the structure and prevent an increase in groundwater levels upgradient. This could be in the form of high permeability gravels installed around the bridge support foundations.

6.6 Conclusions and Recommendations

The following conclusions can be made based on the findings of this report:

- The proposed development is located on an area of river terrace superficial deposits, which are classed as a Secondary Undifferentiated Aquifer. This indicates that the permeability of the strata is variable, and may not be significant in the area of the site;
- Local historical borehole records show groundwater levels to be up to 1.5 mbgl, with flood levels potentially reaching close to ground level (based on the 100-year event flood map);
- Should there be an intersection of the construction with groundwater, this will form an impermeable barrier which would cause some divergence and impediment during periods of high groundwater levels;
- During periods of naturally high groundwater levels there is the possibility of causing new or increased quantities of groundwater upgradient of any foundation works, where the natural groundwater flow direction is restricted; and
- There would be a minor loss to the storage capacity of the aquifer due to any excavation works and impermeable nature foundations.

7 Conclusions and recommendations

7.1 Conclusions

JBA Consulting were commissioned by Eastleigh Borough Council (EBC) to review the flood risk at the proposed replacement Allbrook/Highbridge road bridge crossing of the Itchen Navigation, immediately east of the railway, as well as flooding under the railway bridge.

The Environment Agency historic flood maps reveal a number of historical flooding events in the area, including flooding on the existing road bridge platform, to Allbrook Hill road, a section of flood plain to the west of the bridge and on the western bank of the Itchen Navigation, and the eastern bank of the Itchen Navigation to the north of the bridge and to the east of the railway line. The source of these flooding incidents is believed to be due to the river overtopping, and from surface water flowing down Allbrook Hill road.

The EA RoFSW map shows that the road bridge over the Itchen Navigation is not affected by surface water flooding during any return periods. However, Allbrook Hill road is affected by surface water flooding. The 1 in 1,000-year and 1 in 100-year return period extents for surface water flooding both encroach upon Allbrook Hill road and under the railway bridge. The surface water risk to the proposed road realignment to the east of the road bridge is believed to be negligible, as the surface water extent does not encroach on the realignment site.

Based on available data, it is also believed that the property development site to the north of the bridge did not increase the flood risk to the bridge.

JBA are currently preparing flood risk modelling and mapping for fluvial flood risk across the River Itchen catchment for the Environment Agency, which was used in this report to attempt to gain an insight into the fluvial flooding mechanisms at the bridge site. A low elevation spot along the eastern bank of the Itchen Navigation immediately upstream of the road bridge results in water getting out of bank and overtopping the road surface in the 1 in 20-year and 1 in 100-year flood events. An option scenario was tested with the new bridge and a bund on the left bank in place: there is negligible difference in the maximum water levels in the 1 in 100-year flood event. The new bridge (as shown in Figure 2-2) and proposed bund are therefore unlikely to result in an increase to flood risk at the site.

The proposed river crossing at Allbrook may be at risk of groundwater flooding due to its topographical setting and underlying geology. Groundwater levels within the superficial deposits have been recorded to be within 1.5 m of the ground surface, with the potential for levels to reach near-surface during flood events.

7.2 Recommendations

Whilst the risk of flooding from surface water to the road bridge and known section of the road realignment to the east of the bridge, any road realignment developments to the west of the bridge are likely to be at medium risk of surface water flooding. It is recommended that a SuDS based drainage system is implemented at this section of the road realignment, with continuous maintenance and management of the system conduced.

Based on the outputs from the draft version of the hydraulic model for the Itchen Catchment, it is believed that adding a bund defence to the eastern bank of the Itchen Navigation would be a sufficient strategy to reduce fluvial flood risk to the road to the east of the bridge. However, the representation of the bank levels on the left bank in the model should be confirmed with bank top survey as part of the detailed design.

Once detailed design of the bridge has been carried out, further hydraulic modelling should be conducted to confirm that the structure will not impact on flood risk at the site.

Based on the review of the BGS geology and soil data, any excavation procedures for any foundations or structures for the bridge should be engineered in such a way as to prevent the entrance of groundwater, and should be continuously managed for the duration of the excavation works. Moreover, the seasonality of the groundwater levels in the area should be considered when excavating, such as completing the works during the summer when groundwater levels are lowest, and alternative drainage systems for groundwater should be considered to direct groundwater flow around any structures or foundations implemented.

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