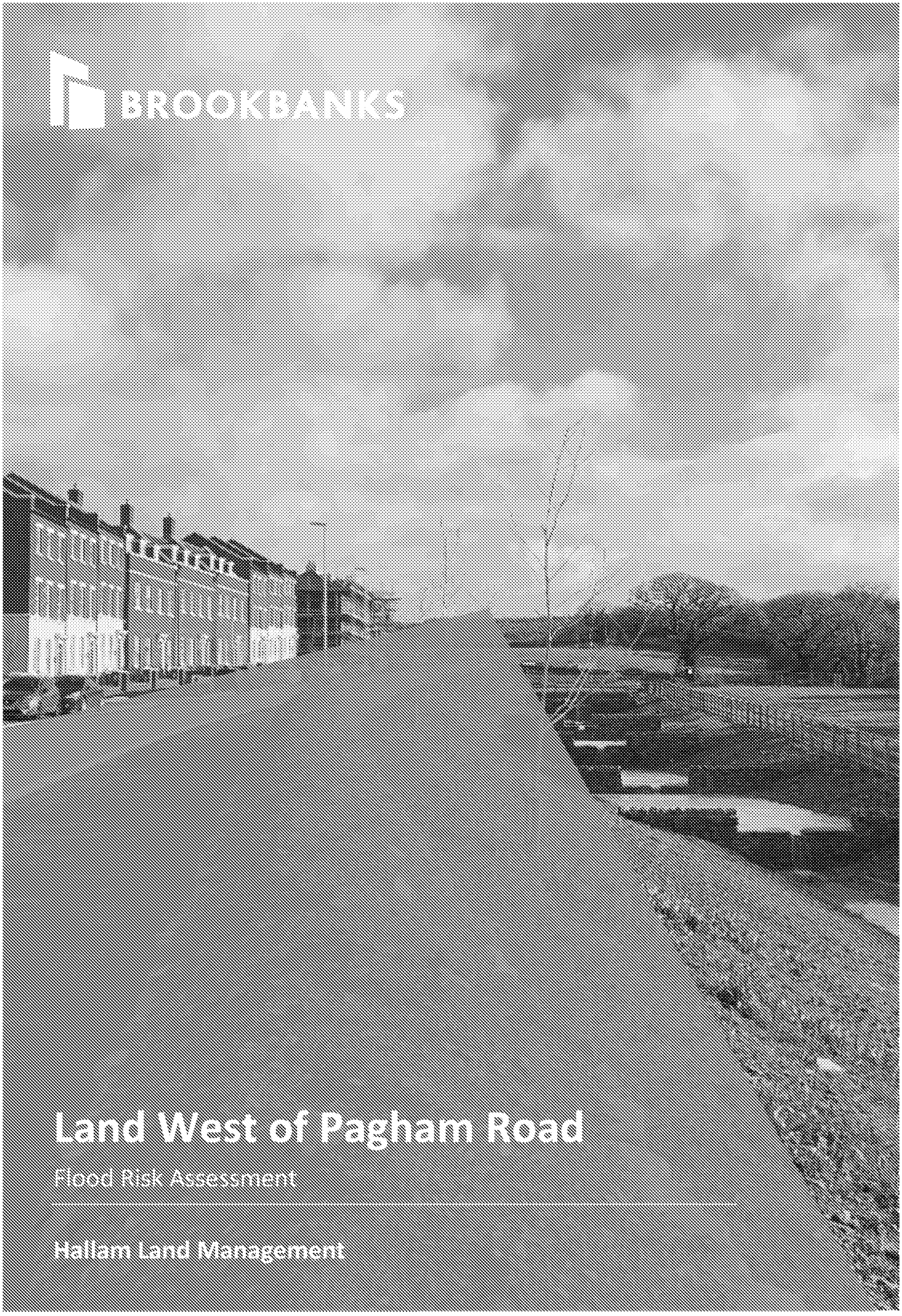
BROOKBANKS



Land West of Pagham Road

Flood Risk Assessment

Hallam Land Management

Document Control Sheet

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Contents

Figures

Tables

Appendices

1 Introduction

1.1 Brookbanks is appointed by Hallam Land Management Ltd to complete a Flood Risk Assessment for a proposed residential development at Pagham.

1.2 The objective of the study is to demonstrate the development proposals are acceptable from a flooding risk and drainage viewpoint.

1.3 This report summarises the findings of the study and specifically addresses the following issues in the context of the current legislative regime:

- Flooding risk
- Surface water drainage
- Foul water drainage

1.4 The illustrative surface water drainage strategy showing the proposed development and drainage strategy is contained within **Appendix A.**

Planning Application

1.5 This Flood Risk Assessment has been produced in order to provide information for an outline planning application.

1.6 Everything designed within this report is to illustrate that the a drainage strategy can be successfully designed and applied for the development site.

1.7 The FRA will then be the subject of a reserved matters application where detailed design layouts and criteria will be provided.

2 Background Information

Location and Details

2.1 The proposed development lies to the north-west of Pagham in West Sussex. The site is bound to the north by open fields and to the west by woodland. To the south, the site is bound by an area of existing residential properties. To the east, the site is bound by Pagham Road, situated adjacent to which is the Pagham North Strategic Site allocation.

2.2 The site is currently undeveloped agricultural land and is not thought to have been historically subject to any significant built development. The historical land uses within 1000m of the site is explored in further detail within Chapter 3 of the Geo-Environmental Phase 1 report submitted alongside this application.

2.3 The site location and boundary is shown indicatively on **Figure 2-1**.

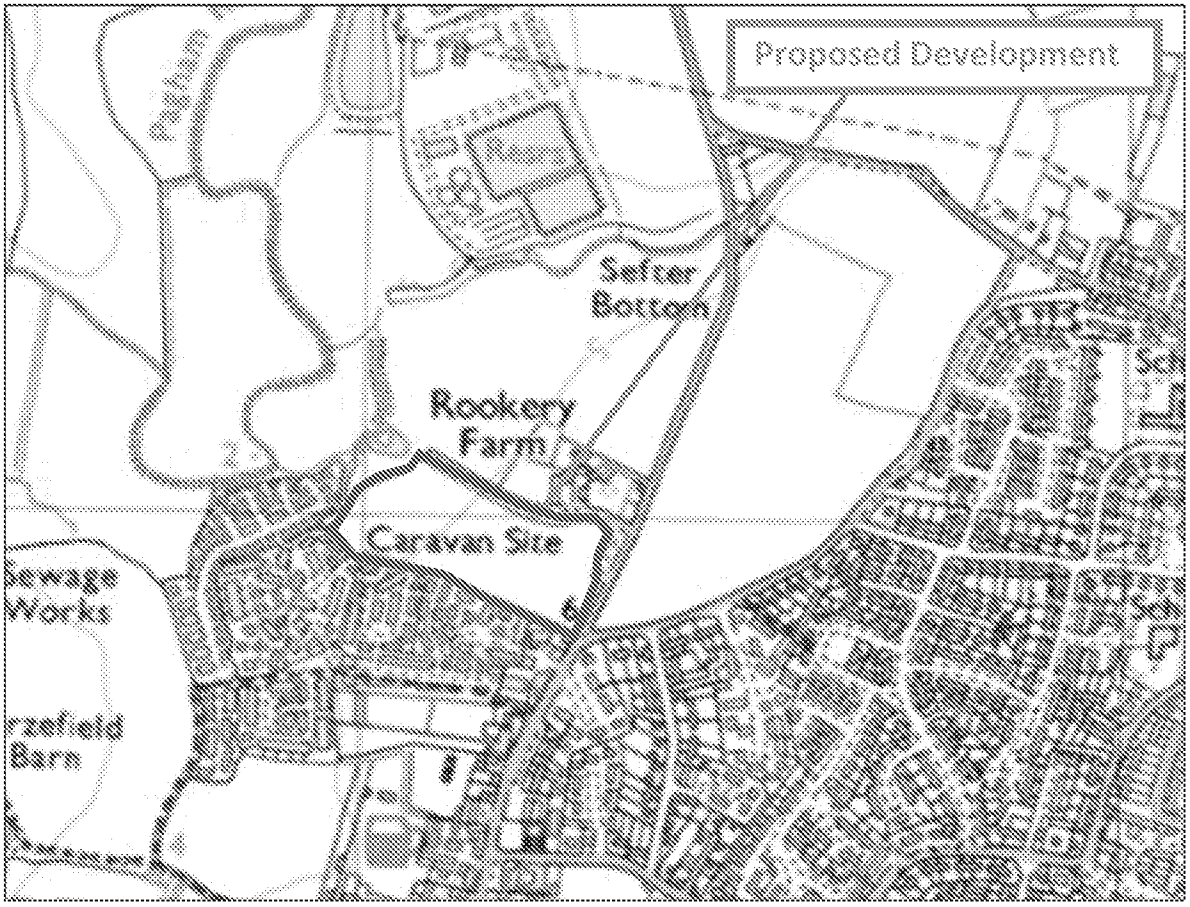

Figure 2-1: Site Location (Bing Maps, 2021)

Development Criteria

2.1 The proposed development is to comprise of:

"The construction of up to 106 new homes, formation of access onto Pagham Road, new pedestrian and cycle links, the laying out of open space, new strategic landscaping, habitat creation, drainage features and associated ground works and infrastructure."

Sources of Information

2.2 The following bodies have been consulted while completing the study:

- Southern Water - Storm & foul water drainage
- Environment Agency - Flood risk and storm drainage
- West Sussex County Council - Flood risk, drainage and associated policy

2.3 The following additional information has been available while completing the study:

- Mastermap Data - Ordnance Survey
- Published Geology - British Geological Survey

3 National Planning Policy

National Planning Policy

3.1 The National Planning Policy Framework (NPPF), updated in July 2021, sets out Governmental Policy on a range of matters, including Development and Flood Risk. The policies were largely carried over from the former PPS25: Development & Flood Risk, albeit with certain simplification. The allocation of development sites and local planning authorities' development control decisions must be considered against a risk-based search sequence, as provided by the document.

3.2 Allocation and planning of development must be considered against a risk-based search sequence, as provided by the NPPF guidance. In terms of fluvial flooding, the guidance categorises flood zones in three principal levels of risk, as follows in **Table 3-1**.

Flood Zone	Annual Probability of Flooding
Zone 1: Low probability	< 0.1 %
Zone 2: Medium probability	0.1 – 1.0 %
Zone 3a / 3b: High probability	> 1.0 %

Table 3-1: NPPF Flood Risk Parameters

3.3 The Guidance states that Planning Authorities should "apply a sequential, risk-based approach to the location of development – taking into account all sources of flood risk and the current and future impacts of climate change".

3.4 According to the NPPF guidance, residential development at the proposed site, being designated as "More Vulnerable" classifications, should lie outside the envelope of the predicted 1 in 100 year (1%) flood, with preference given to sites lying outside the 1 in 1,000 (0.1%) year events and within Flood Zone 1.

3.5 Sites with the potential to flood during a 1 in 100 (1%) year flood event (Flood Zone 3a) are not normally considered appropriate for proposed residential development unless on application of the "Sequential Test", the site is demonstrated to be the most appropriate for development and satisfactory flood mitigation can be provided. Additionally, proposed residential developments within Flood Zone 3a are required to pass the "Exception Test", the test being that:

- The development is to provide wider sustainability benefits
- The development will be safe, not increase flood risk and where possible reduce flood risk.

Regional Policy

3.6 **Regional Flood Risk Assessment**: The South East England Regional Assembly published their Regional Flood Risk Assessment (RFRA) in October 2008. The document is a high level review of flood risk and strategy. In this document, concerns over the effects of flood risk and potential of climate change are identified across the wider South East region.

3.7 As with many RFRA's, this document outlines the broad understanding of flooding risk across areas of potential higher growth however makes no specific reference to the proposed site at Pagham.

3.8 **Catchment Flood Management Plans**: A Catchment Flood Management Plan (CFMP) is a high-level strategic plan through which the Environment Agency seeks to work with other key-decision makers within a river catchment to identify and agree long-term policies for sustainable flood risk management.

3.9 The Arun and Western Streams Catchment Flood Management Plan (December 2009), outlines that the catchment has been divided into 9 sub-catchments. The Site is shown to be situated within the Chichester and Lower Chalk Streams catchment which is covered by the following policy:

"Policy 4: Areas of low, moderate or high flood risk where we are already managing the flood risk effectively but where we may need to take further actions to keep pace with climate change.

This policy will tend to be applied where the risks are currently deemed to be appropriately-managed, but where the risk of flooding is expected to significantly rise in the future. In this case we would need to do more in the future to contain what would otherwise be increasing risk. Taking further action to reduce risk will require further appraisal to assess whether there are socially and environmentally sustainable, technically viable and economically justified options."

4 Local Planning Policy Compliance

4.1 Pagham lies within West Sussex County Council (WSCC) which is the Lead Local Flood Authority (LLFA). A **Preliminary Flood Risk Assessment** (PFRA) was produced in 2011 by WSCC according to the guidance and information provided by DEFRA. The PFRA identifies flood risk from local flood sources and extreme events occurrence.

4.2 Indicative Flood Risk Areas consist of an area where flood risk is most concentrated, and over 30,000 people are predicted to be at risk of flooding.

4.3 **Strategic Flood Risk Assessment**: To support local planning policy, NPPF guidance recommends that local planning authorities produce a Strategic Flood Risk Assessment (SFRA). The SFRA should be used to help define the Local Plan and associated policies; considering potential development zones in the context of the sequential test defined in the guidance.

4.4 Arun District Council published their Level 1 and Level 2 Strategic Flood Risk Assessment in September 2016. The document generally underpins national guidance and provides recommendations to developers with regards to SuDS and design which will be explored further in this report under the Storm Drainage section.

4.5 This report undertakes the NPPF "Sequential Test" on the three sites identified within the Level 1 SFRA which do not meet the required standard for flood risk vulnerability classification.

4.6 The site design has had full regard to the recommendations set out within the SFRA.

4.7 West Sussex County Council published the **Surface Water Management Strategy** in October 2016. The document offers Guiding Principals in managing flood risk and a structure of managing strategy, in addition to that provided in the SFRA.

4.8 The objectives of the document are to:

- Obtain an understanding of the current surface water catchments and their associated issues.
- Determine the required storage volume at six potential strategic development locations to mitigate surface water flood risk, up to the 1 in 100 year event plus climate change allowance, as a result of an assumed level of potential development.
- Develop options for on-site and / or off-site surface water management schemes to provide the required storage, considering potential constraints and opportunities for the creation of multifunctional assets and biodiversity enhancements.
- Report on findings and produce technical drawings and costings for a preferred surface water management strategy.

4.9 This study has identified that all surface water generated from the development can be attenuated within the space available on site, and within the topographical and geographical constraints.

4.10 The objectives detailed above will be delivered through a series of local measures and actions. Site level Specific Management Actions are introduced so they could be implemented within locally important flood risk areas in order to translate the aims of the overall strategic actions onto a local scale.

4.11 **Development Flood Risk Assessment**: At a local site by site level, the NPPF and guidance and supporting documents advocate the preparation of a Flood Risk Assessment (FRA). The NPPF requires that developments covering an area of greater than one hectare prepare a FRA in accordance with the guidance. The FRA is required to be proportionate to the risk and appropriate to the scale, nature and location of the development.

4.12 This document forms a Flood Risk Assessment (FRA), to accord with current guidance and addresses national, regional and local policy requirements in demonstrating that the proposed development lies within the acceptable flood risk parameters.

Local Plan Policies

4.13 The proposed drainage strategy will be designed in full compliance with the Arun District Councils Local Plan policies. The relevant policies are outlined below with Brookbanks response to how these requirements have been met in blue.

Policy W DM2 Flood Risk

Development in areas at risk from flooding, identified on the latest Environment Agency flood risk maps and the Council's Strategic Flood Risk Assessment (SFRA) , will only be permitted where all of the following criteria have been satisfied:

a. The sequential test in accordance with the National Planning Policy Guidance has been met.

A sequential test is not required for this development as the site is located within flood zone 1. Flood Risk vulnerability is covered in Chapter 7 of this report.

b. A site specific Flood Risk Assessment demonstrates that the development will be safe, including access and egress, without increasing flood risk elsewhere and reduce flood risk overall.

This document is the FRA for this development.

c. The sustainability benefits to the wider community are clearly identified.

The proposed SuDS will discharge to QBAR, reducing the flood risk further downstream. Once at the detailed design stage, should the need arise, the basin could be designed to retain an area of permanent water.

d. The scheme identifies adaptation and mitigation measures.

This will be provided at the appropriate stage once at reserved matters.

e. Appropriate flood warning and evacuation plans are in place; and

As the site lies outside of any flood risk, no warning or evacuation plans will need to be provided.

f. New site drainage systems are designed to take account of events which exceed the normal design standard i.e. consideration of flood flow routing and utilising temporary storage areas.

SuDS (illustrated on drainage strategy 10821-DR-01 A) have been designed to the 1 in 100 year + 40% storm events. A full exceedance plan will be produced at the appropriate time.

The reports prepared as part of the criteria above must take into account contingency allowances, taking climate change into account as set out in Flood Risk Assessments: climate change allowances section of the NPPG.

The SuDS have been designed to accommodate the 1 in 100 year + 40% climate change allowance storm event, with a 300mm freeboard.

In locations where strategic flood defence or resilient and resistant construction measures are necessary within the site itself, proposals will be required to demonstrate how measures have been incorporated as an intrinsic part of the scheme in a manner which is compatible with the latest Strategic Flood Risk Assessment.

All development proposals must take account of relevant Surface Water Management Plans, Catchment Flood Management Plans and related Flood Defence Plans and strategies such as the Lower Tidal River Arun Strategy. The council may require financial contributions from development on sites where measures to address flood risk or to improve the environmental quality of watercourses have been identified by these Plans and Strategies.

Policy W DM3 Sustainable Urban Drainage Systems

To increase the levels of water capture and storage and improve water quality, all development must identify opportunities to incorporate a range of Sustainable Urban Drainage Systems (SUDS), appropriate to the size of development, at an early stage of the design process.

Proposals for both major and minor development proposals must incorporate SUDS within the private areas of the development in order to provide source control features to the overall SUDS design. These features include:

- *Green roofs*
- *Permeable driveways and parking*
- *Soakaways*
- *Water harvesting and storage features including water butts.*

The use of additional SuDS apart from basins will be looked at in further detail once a layout has been fixed. This is detailed more in Chapter 8.

Proposals for major development must also integrate SUDS within public open spaces and roads, reflecting discussion with the appropriate bodies. SUDS must therefore be integrated into the overall design of a development and must:

a. Contribute positively to the appearance of the area, integrating access to allow maintenance of existing watercourses and the system.

A 5m earthworks and maintenance strip around the top of the basin has been included within the design.

b. Effectively manage water (including its quality)

Water management and quality is detailed in Chapter 10.

c. Accommodate and enhance biodiversity by making connections to existing Green Infrastructure assets and

d. Provide amenity for local residents (ensuring a safe environment)

For points c and d, permanent water could be incorporated into the design should the need arise to enhance biodiversity and amenity across the site. This would be explored at reserved matters.

e. Retain the existing drainage network of the site and the wider area,

The site will not remove or change the existing drainage network.

f. Be maintained in perpetuity, supported through a Maintenance and Management Plan/Regime, including its financing, agreed with the Local Planning Authority.

A maintenance schedule has been provided in Chapter 10 of this document. All other information will be provided at the appropriate stage.

In order to ensure that SUDS discharge water from the development at the same or lesser rate, as prior to construction, developers must:

g. Follow the hierarchy of preference for different types of surface water drainage disposal systems as set out in Approved Document H of the Building Regulations and the SUDS manual produced by CIRIA.

The drainage hierarchy is outlined in paragraph 8.9 and 8.10.

h. Undertake up to six months groundwater monitoring within the winter period.

3 months of groundwater monitoring have already been completed however a full SI works including 6 months monitoring will be completed at reserved matters.

i. Undertake winter percolation testing in accordance with BRE365.

Full SI works including infiltration testing will be completed at reserved matters. Due to high groundwater levels across the site the use of infiltration features in not a viable option. Therefore, current designs utilises detention features.

i. The proposed drainage system must be designed to ensure that there is no flooding on a 1 in 30 year storm event.

Calculations showing the SuDS design for the 1 in 30 year storm event is provided in Appendix C.

j. The design must also take account of the 1 in 100 year storm event plus 30% allowance for climate change, on stored volumes, to ensure that there is no flooding of properties or the public highway or inundation of the foul sewerage system. Any excess flows must be contained within the site boundary, and within designated storage areas.

Basins have been designed to a 1 in 100 year + 40% climate change allowance with an additional 300mm freeboard. Calculation shave been provided in Appendix C.

SuDS Design Guidance

4.14 The SuDS guidance for Arun District Council is outlined on its website within the supplementary requirements for surface water drainage proposals. The requirements by the council are outlined in italics below with Brookbanks response to how these requirements have been met in blue.

***Restricted discharge**: Discharge to a watercourse or surface water sewer must be restricted to the estimated mean greenfield runoff rate (Qbar) for all design storm events, using the impermeable area (and including other permeable areas that are positively drained) of the site to be developed as the basis for the calculations, rather than the entire greenfield site area.*

The proposed SuDS basin has been designed to discharge at QBAR using a 55% impermeable area for the site with 10% urban creep added on.

***Flow exceedance routes:** The drainage design should show flow routes through the proposed development, demonstrating where surface water will be conveyed for three types of flow:*

1. Low flow routes

Regular flow from source control features such as permeable pavements should travel in low flow channels through the development in a controlled way contributing to landscape quality.

Through detailed design at reserved matters stage, urban SuDS, such as roadside swales, will be considered as a design inclusion to support low flow routes. Any urban SuDS provision is subject to detailed design and agreement outside of this outline planning application.

2. Overflows

In the event of local blockages or surcharge a simple overflow arrangement should allow water to bypass the obstruction and return to the management train sequence until conditions return to normal.

An overflow arrangement will be finalised at the detailed design stage.

3. Exceedance routes

When SuDS are overwhelmed by exceptional rainfall, then exceedance routes are required to protect people and property. These provide unobstructed overland flow routes from the development and should be considered for all drainage schemes. Exceedance routes should also be protected from future changes in land use.

The proposed SuDS are located adjacent to the existing watercourses so any exceedance from the basin will flow downhill directly into the watercourse.

***Maintenance and management**: Ditches and watercourses (including culverts) should retain a three metre easement with access that allows for its future maintenance. Details of the maintenance and management of the SuDS system are to be set out in writing in a site specific maintenance manual. This manual shall include details of the financial management and arrangements for the replacement of components at the end of the manufacturers recommended design life. This document is then to be submitted as part of the planning process*

No development of SuDS feature will be constructed within 3m of the existing drainage ditch that forms the northern boundary of the development site. A maintenance regime for the SuDS is outlined in paragraph 10.17.

5 Baseline Conditions

Present Day

5.1 As identified above the site is currently undeveloped agricultural land therefore, is not subject to any existing site drainage.

5.2 **Figure 5-1** below illustrates the site at present.

Figure 5-1: Existing Site Conditions (Google Maps, 2021)

Topography & Site Survey

5.3 A detailed topographical survey of the site was completed in October 2021 by Interlocks Surveys. A review of the survey indicates that the topography across the site is characterised by moderate gradients falling generally in a north easterly direction. Levels fall from a high point of circa 6.13mAOD in the southern corner of the site, to a low point of circa 3.34mAOD along the western boundary.

5.4 The topographical survey can be seen in **Appendix X**.

Geology & Hydrogeology

5.5 With reference to the British Geological Survey map, the Site is shown to be underlain by clay, silt, and sand of the London Clay Formation.

5.6 Full details of the existing geology can be seen in the Geo-Environmental report submitted with this application.

5.7 The majority of the Site highlights Superficial sand, silt and clay Deposits of the River Terrace Deposits (Undifferentiated). Ares to the north-west are shown to be overlain by sand and gravel River Beach Deposits, with the furthest west overlain by superficial clay, silt, sand and gravel Raised Marine Deposits.

5.8 The published site geology is illustrated on **Figure 5-2** and **5-3.**

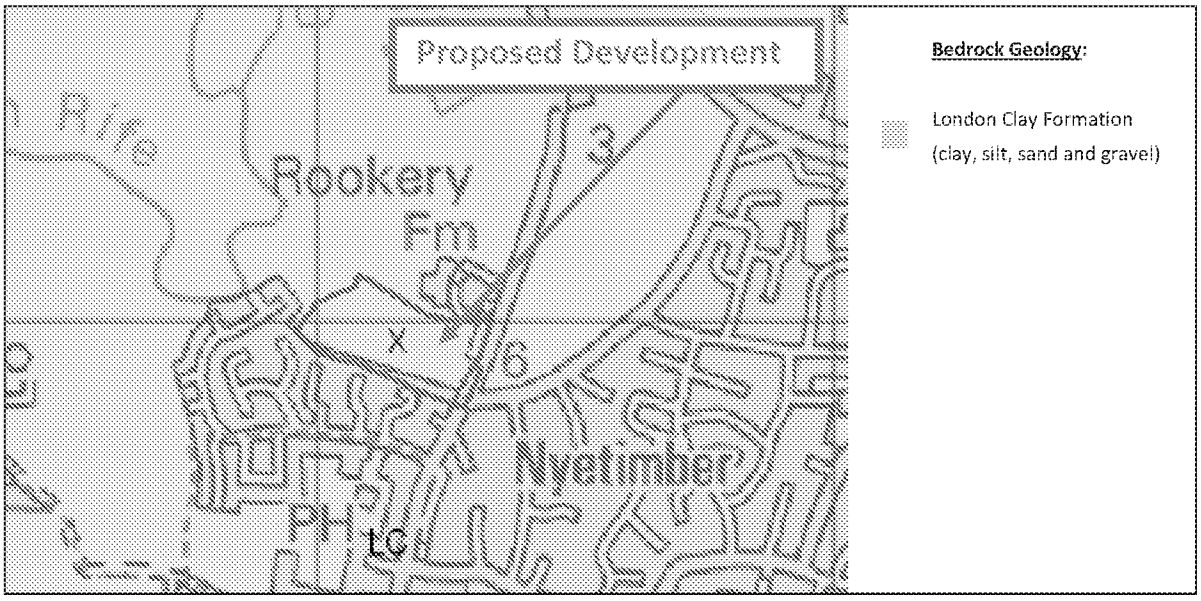

Figure 5-2: BGS Published Bedrock Geology

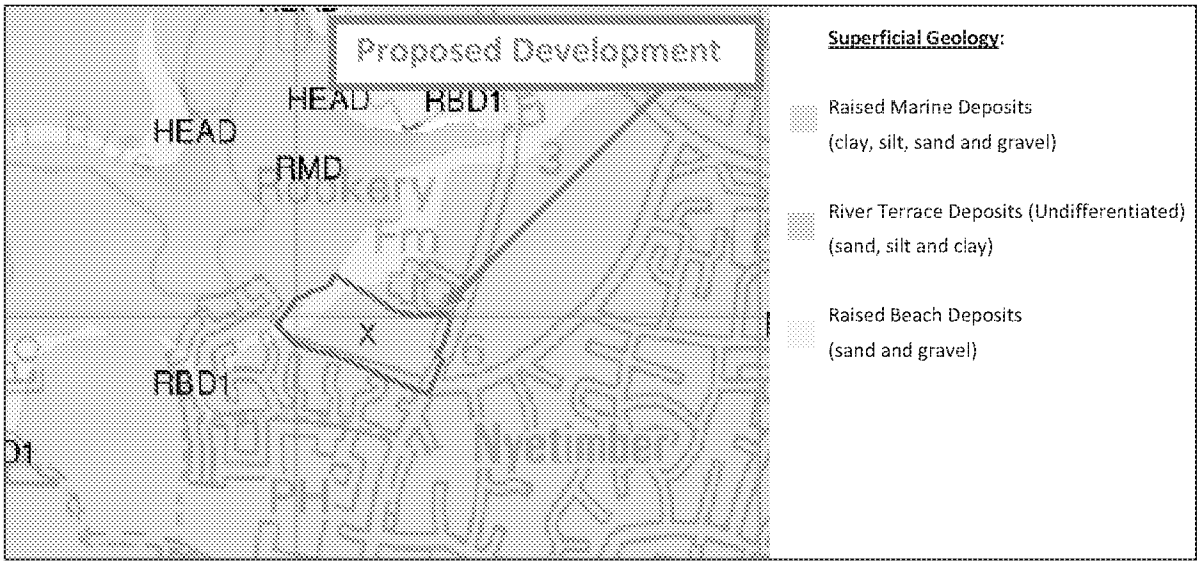

Figure 5-3: BGS Published Superficial Deposits

5.9 The underlying sand of the London Clay Formation, forming Unproductive Strata across the whole site and the superficial deposits form a secondary A Aquifer (**5-4**).

5.10 The EA provides the following definitions for Aquifers:

Secondary Aquifers *- These include a wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into two types:*

Secondary A *- permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.*

Unproductive Strata *- These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.*

5.11 The EA Groundwater Vulnerability Zones (GVZ) Mapping summarises the overall risk to groundwater, taking into account groundwater vulnerability, the types of aquifer present (superficial and/or bedrock) and their designation status, as discussed previously.

5.12 The site is shown (**Figure 5-4**) to be situated within a 'high risk', in terms of groundwater vulnerability.

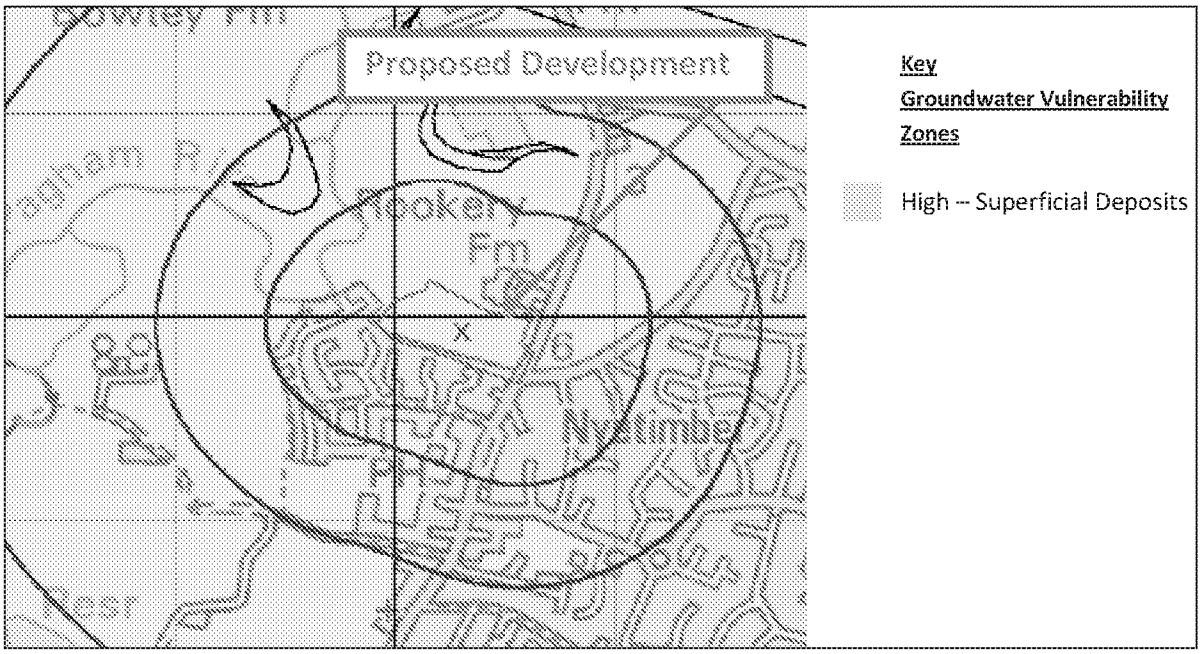

Figure 5-4: EA Groundwater Vulnerability Zones Map (Magic Maps, 2021)

5.13 The EA provides the following definition for the underlying GVZ:

High *– These are high priority groundwater resources that have very limited natural protection. This results in a high overall pollution risk to groundwater from surface activities. Operations or activities in these areas are likely to require additional measures over and above good practice pollution prevention requirements to ensure that groundwater isn't impacted.*

Drainage Network and FEH Catchment Data

5.14 Reference to the online Flood Estimation Handbook shows the Site to lie adjacent to a drainage network associated with the Pagham Rife.

5.15 The Site lies within Pagham Rife catchment, lying within a catchment area of 16.94km^2. The catchment has an average annual rainfall value of 769mm.

5.16 The FEH catchment information will be used in determining the size of the SuDS required for the proposed development.

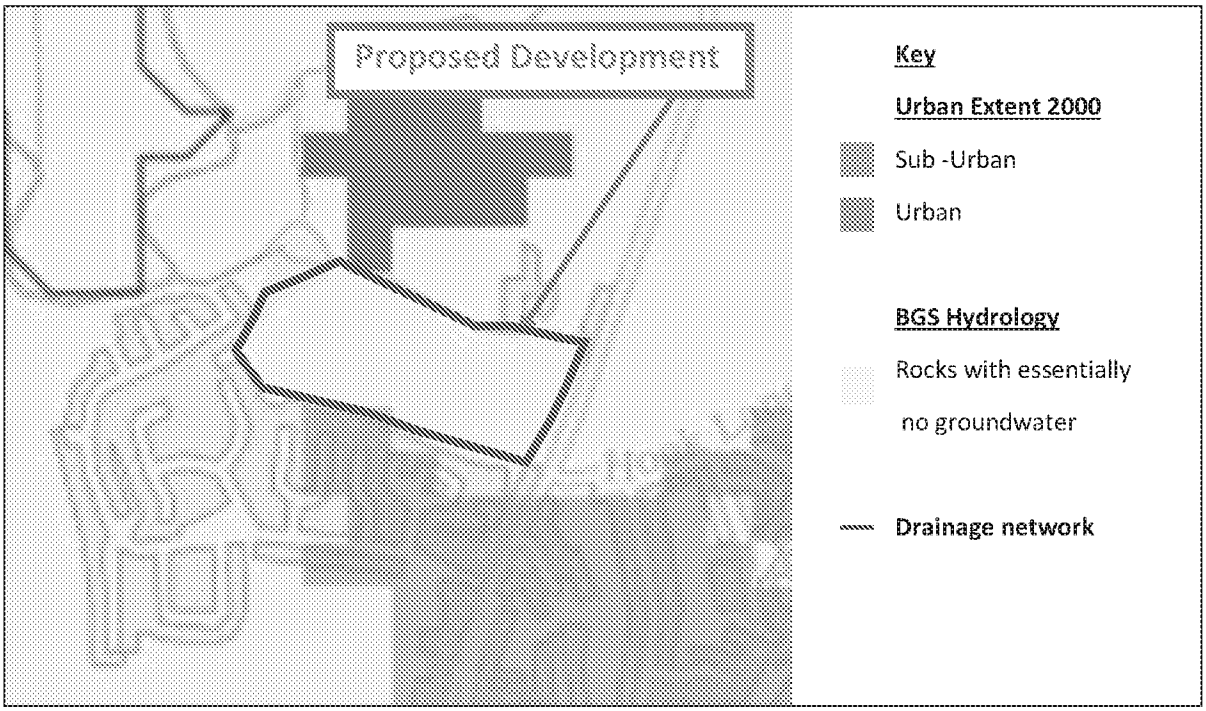

Figure 5-5: FEH web service – Urban Extent 2000 and BGS Hydrology and Drainage Network

6 Flood Risk

Flood Mechanisms

6.1 Having completed a site hydrological desk study and walk over inspection, the possible flooding mechanisms at the site are identified as follows in **Table 6-1**.

Mechanisms	Potential	Comment
Fluvial	Y	The Pagham Rife lies to the west of the site and has the potential to impact upon the proposed development.
Coastal & Tidal	N	The site is not affected by tidal flooding.
Overland Flow (Pluvial)	Y	Surface water flood mapping shows as such the risk relating to overland flow is considered low.
Groundwater	Y	The SFRA identifies a high risk of groundwater flooding.
Sewers	N	No foul or surface water sewers lies within the site.
Reservoirs, Canals etc	N	There is no risk of flooding from reservoirs.

Table 6-1: Flooding Mechanisms

6.2 Where potential risks are identified in **Table 6-1**, above, more detailed assessments have been completed and are outlined and discussed further within the following sections.

Fluvial Flooding

6.3 The Environment Agency's (EA) National Generalised Modelling (NGM) Flood Zones Plan indicates predicted flood envelopes of Main Rivers across the UK. In many circumstances, the NGM is based on basic catchment characteristic data and modelling techniques. Where appropriate, more accurate Section 105 / SFRM models are produced using more robust analysis techniques.

6.4 The mapping below on **Figure 6-1** shows that majority of the site to lie within Flood Zone 1; being an area of Low Probability of flooding and outside both the 1 in 100 (1% AEP) and 1 in 1,000 (0.1% AEP) year flood events.

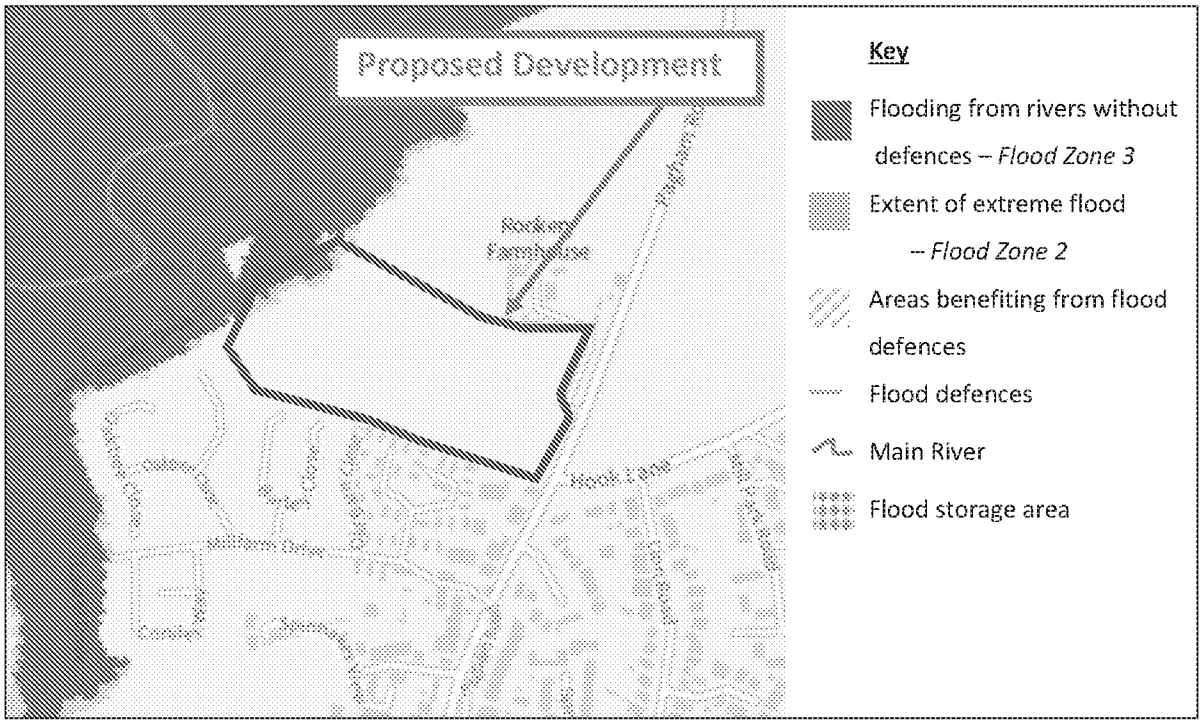

Figure 6-1: EA Flood Zone Plan showing 1 in 100 & 1 in 1,000 year floodplains

Surface Water Modelling

6.5 Surface water modelling is based on high level fluvial assessment models and terrain data. It is not based on observed or recorded flooding but is an extremely broad brush tool for seeing where water could collect given the topography.

6.6 In the design however the EA's surface water mapping has been acknowledged and the basins for the water management of the SuDS are placed in the these low areas of flooding as shown the surface water mapping. SuDS are obviously water compatible development and have the effect of keeping the built environment to the edge of the surface water flooding shown the mapping.

Coastal Flooding

6.7 The EA's flood mapping does not show any risk tidal flood risk within the site boundary.

Overland Flow (Pluvial)

6.8 Overland flow mechanisms result from the inability of unpaved ground to infiltrate rainfall or due to inadequacies of drainage systems in paved areas to accommodate flow directed to gullies, drainage downpipes or similar. In minor cases, local ponding may occur. In more extreme events, flows accumulate and may be conveyed across land following the topography.

6.9 The Environment Agency, in partnership with lead local flood authorities, produced a series of surface water flood maps for many parts of the UK.

6.10 **Figure 6-2,** illustrates areas of low to high risk from surface water flooding:

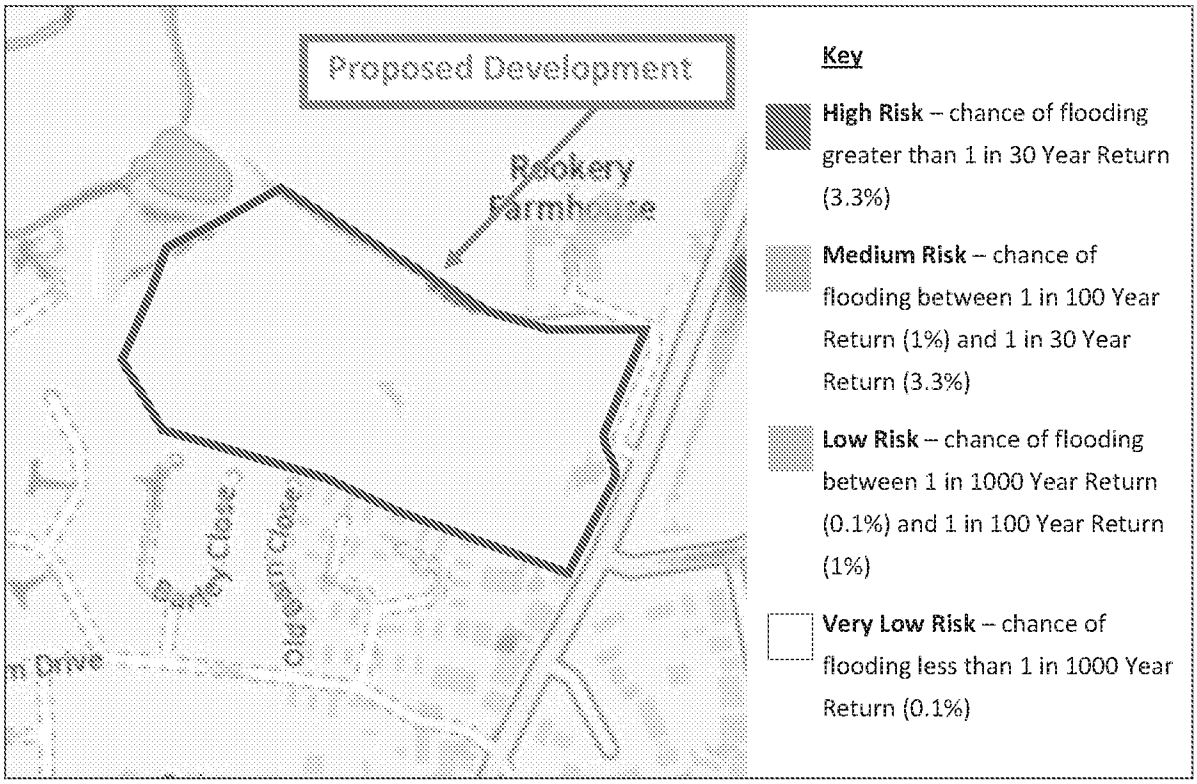

Figure 6-2: EA Long Term Flood Risk Maps – Flood risk from Surface Water (Gov.Uk website)

6.11 The mapping above identifies that most of the site has a very low risk of surface water flooding. However, a small area in the centre of the site is shown to have a low risk from surface water flooding.

6.12 Initial investigations suggest that the risk of overland flow relates primarily to the topography of the site; low areas of the site naturally store water limiting the surface runoff in concentrated areas. As part of the development, the topography will be altered, providing a rationalised surface for water runoff.

6.13 Recognising the risk of overland flow mechanisms, published guidance in the form of the Design and Construction Guidance for Foul and Surface Water Sewers and the Environment Agency document Improving the Flood Performance of New Buildings: Flood Resilient Construction et al advocate the design of developments that implement infrastructure routes through the development that will safely convey flood waters resulting from sewer flooding or overland flows away from buildings and along defined corridors. Further to protect the Proposed Development, current good practice measures defined by guidance will be incorporated. However, given the nature of the development this is unlikely to be onerous or to have any material effect on layout.

6.14 Given the baseline site characteristics and further mitigating measures to be implemented residual flood risk from an overland flow mechanism is considered of a low probability.

Groundwater

6.15 Groundwater flooding is characterised by low-lying areas often associated with shallow unconsolidated sedimentary aquifers which overly non-aquifers. These aquifers are reported to be susceptible to flooding, especially during the winter months, due to limited storage capacity.

6.16 Groundwater related flooding is fortunately quite rare, although where flooding is present, persistent issues can arise that are problematic to resolve. Such mechanisms often develop due to construction activities that may have an unforeseen effect on the local geology or hydrogeology.

6.17 The Environment Agency's national dataset, Areas Susceptible to Groundwater Flooding (AStGWF), provides the main dataset used to assess the future risk of groundwater flooding. The AStGWF map uses four susceptibility categories to show the proportion of each 1 km grid square where geological and hydrogeological conditions show that groundwater might emerge.

6.18 This mapping (**Figure 6-3**) identifies that the area lies within a >=75% susceptibility to groundwater flooding.

Figure 6-3: Groundwater Flooding Susceptible

6.19 Within the SFRA it is reported that, "Significant groundwater flood events have been recorded across the district."

6.20 Positive drainage systems incorporated into the Proposed Development will further reduce the risk as a result of permeable pipe bedding materials and filter drains incorporated within elements of the built development.

6.21 Given the baseline site characteristics and further mitigating measures to be implemented, residual flood risk from a ground water mechanism is considered to be of a low probability.

Sewerage Systems

6.22 Flooding related to sewerage systems is a result of there being insufficient capacity within an existing sewerage system (combined and surface water sewers) or from there being a blockage within the system.

6.23 The SFRA collected data from Southern Water and determined that there have been 315 recorded flood incidents in the Arun district.

6.24 Positive drainage measures incorporated on site, coupled with sustainable drainage systems (SuDS) will ensure that no increase in surface water will result from the site. Flood risk associated with sewer flooding is therefore considered to be a low probability.

Artificial Water Bodies - Reservoirs & Canals

6.25 Non-natural or artificial sources of flooding comprises of reservoirs, canals and lakes where water is retained above the natural ground level. However unlikely, reservoirs, canals and other artificial sources have a potential to cause flooding due to the release of large volumes of water, resulting from a dam or bank failure.

6.26 The Environment Agency has produced mapping to indicate a worst case scenario of flooding that would be caused, as a result of unlikely structural failure or damage of a reservoir. The site is shown to lie a considerable distance from the potential maximum extent of flooding.

Summary

6.27 In terms of fluvial flood risk, the site lies primarily within Flood Zone 1 and hence has a low probability of flooding from this mechanism. Assessment of other potential flooding mechanisms shows the land to have a low probability of flooding from overland flow, ground water and sewer flooding.

6.28 Accordingly, the Proposed Development land is in a preferable location for development when appraised in accordance with the NPPF Sequential Test and local policy.

Objectives

6.29 The key development objectives that are recommended in relation to flooding are:

- Work collaboratively with the Environment Agency to identify potential flooding.
- Compliance with the Design and Construction Guidance for Foul and Surface Water Sewers and EA guidance in relation to flood routing through the Proposed Development in the event of sewer blockages.

7 Flood Risk Vulnerability

7.1 In accordance with the NPPF technical guidance when building within a Flood Zone, the vulnerability of the development must be taken into consideration. The impacts of flooding will affect types of development differently.

7.2 The EA's vulnerability classification table is illustrated below in **Figure 7-1.** The table outlines the NPPF technical guidance for flood risk vulnerability and Flood Zone compatibility assessment to propose which type of development is appropriate for which sites.

Flood Zones	Flood Risk Vulnerability Classification				
	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test Required	✓	✓	✓
Zone 3a	Exception Test Required	X	Exception Test Required	✓	✓
Zone 3b	Exception Test Required	X	X	X	✓

Table 7-1: Environment Agency's Flood Risk Vulnerability Classification Table

7.3 Housing is considered as highly vulnerably infrastructure, and has been located within flood zone 1.

Sequential Testing

7.4 The aim of a sequential test is to ensure that new development is steered towards sites with the lowest probability of flooding.

7.5 The proposed built development lies entirely within flood zone 1, therefore an exception test does not need to be completed.

Exception Test

7.6 The exception test is:

"a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available."

7.7 The exception test assesses the suitability of locations within the site for development that are appropriate to the relevant levels of flood risk.

7.8 As all built development is located within flood zone 1, an exception test is not required.

8 Storm Drainage

Background

8.1 To understand the baseline provision for storm drainage in the area, a copy of Southern Water network records has been obtained. No public surface water sewers or combined sewers are shown to be present within the vicinity of the proposed development.

8.2 There is a rising main that crosses through the centre of development. Full details of the existing network can be seen in the Services and Utilities report submitted with this application.

8.3 As the site is currently greenfield, it is thought that storm water currently drains to the ground and collects within the existing ditch situated along the northern boundary.

SuDS Components

8.4 It is proposed to implement a SuDS scheme consistent with local and national policy at the proposed development.

8.5 At the head of the drainage network, across the site, source control measures will be implemented to reduce the amount of run-off being conveyed directly to piped drainage systems.

8.6 As the site is currently at outline planning the nature of source control measures to be implemented will need to remain flexible, providing each house builder with a 'toolkit' of options to reach an agreed target for peak discharge reduction and water treatment.

8.7 **Table 8-1** is an extract of Table 7.1 from the CIRIA SuDS Manual C753 which outlines a number of options available.

Component Types	Description	Collection Mechanism	Design Criteria					
			Water Quantity			Water Quality	Amenity	Biodiversity
			Peak Runoff Rate	Runoff Volumes: Small Events	Runoff Volumes: Large Events			
Rainwater Harvesting Systems	Systems that collect runoff from the roof of a building or other paved surface for use	P		●	●		●	
Green Roofs	Planted soil layers on the roof of buildings that slow and store runoff	S	○	●		●	●	●

Infiltration Systems	Systems that collect and store runoff, allowing it to infiltrate into the ground	P	●	●	●	●	●	●
Proprietary Treatment System	Subsurface structures designed to provide treatment of runoff	P				●		
Filter Strips	Grass strips that promote sedimentation and filtration as runoff is conveyed over the surface	L		●		●	○	○
Filter Drains	Shallow stone filled trenches that provide attenuation, conveyance and treatment of runoff	L	●	○		●	○	○
Swales	Vegetated channels (sometimes planted) used to convey and treat runoff	L	●	●	●	●	●	●
Bioretention Systems	Shallow landscaped depressions that allow runoff to pond temporarily on the surface, before filtering through vegetation and underlying soils	P	●	●	●	●	●	●
Trees	Trees within soil-filled tree pots, tree planters or structural soils used to collect, store and treat runoff	P	●	●		●	●	●
Pervious Pavements	Structural paving through which runoff can soak and subsequently be stored in the sub-base beneath, and/or allowed to infiltrate into the ground below	S	●	●	●	●	○	○
Attenuation Storage Tanks	Large, below ground voided spaces used to temporarily store runoff before infiltration, controlled release or use	P	●					
Detention Basins	Vegetated depressions that store and treat runoff	P	●	●		●	●	●
Ponds and Wetlands	Permanent pools of water used to facilitate treatment runoff – runoff can also be stored in an attenuation zone above the pool	P	●			●	●	●

Table 8-1: Ciria Guidance Table 7.1 (SuDS Component Delivery of Design Criteria)

* **Key**

P - Point, L - Lateral, S – Surface

● Likely Valuable Contribution ○ Some Potential Contribution to Delivery of Design Criterion **T**

Drainage Hierarchy

8.8 The following paragraphs in this section outline the proposed drainage strategy to meet national and local design requirements and guidance.

8.9 Current guidance[1] requires that new developments implement means of storm water control, known as SuDS (Sustainable Drainage Systems), to maintain flow rates discharged to the surface water receptor at the pre-development 'baseline conditions' and improve the quality of water discharged from the land.

8.10 When appraising suitable storm water discharge options for a development site, Part H of the Building Regulations 2002 (and associated guidance) provides the following search sequence for identification of the most appropriate drainage methodology.

"Rainwater from a system provided pursuant to sub-paragraphs (1) or (2) shall discharge to one of the following, listed in order of priority -

a) an adequate soakaway or some other adequate infiltration system; or where that is not reasonably practicable,

b) a watercourse; or where that is not reasonably practicable,

c) a sewer. "

8.11 Dealing with the search order in sequence:

a) Source control systems treat water close to the point of collection, in features such as soakaways, porous pavements, infiltration trenches and basins. The use of same can have the benefit of discharging surface water back to ground rather than just temporarily attenuating peak flows before discharging it to a receiving watercourse or sewer.

As source control measures generally rely upon the infiltration of surface water to ground, it is a prerequisite that the ground conditions are appropriate for such. Site ground investigations specific to flood risk have yet to be completed however published geology suggests the presence of potentially impermeable formations within the site.

b) Next in the search sequence, defined by Part H, is discharge to a watercourse or suitable receiving water body. Where coupled with appropriate upstream attenuation measures, this means of discharge can provide a sustainable drainage scheme that ensures that peak discharges and flood risk in the receiving water body are not increased.

The Pagham Rife lies approximately 120m west of the site, which part of its drainage network forming the northern boundary. As such represents an appropriate receptor for storm water discharge, have the potential to receive flows from the proposed development once restricted to the pre-existing 'greenfield' rates of run-off.

c) Last in the search sequence is discharge to a sewer. In the context of SuDS this is the least

[1] NPPF, CIRIA C522, C609, C753 et al.

preferable scheme as it relies on 'engineered' methods to convey large volumes of water from development areas, has a higher likelihood of flooding due to blockage and provides less intrinsic treatment to the water.

Southern Water records confirm the presence of public combined, storm sewer along Pagham Road that could be employed should the need arise.

8.12 **Table 8-2** outlines which options will be used within the outline application and which will be considered at reserved matters.

Component Types	To be Considered at Outline	To be Considered at Reserved Matters
Rainwater Harvesting Systems		
Green Roofs		
Infiltration Systems		
Proprietary Treatment System		
Filter Strips		
Filter Drains		
Swales		
Bioretention Systems		
Trees		✓
Pervious Pavements		✓
Attenuation Storage Tanks		
Detention Basins	✓	✓
Ponds and Wetlands		

Table 8-2: Types of SuDS Components to be Considered

8.13 The search sequence outlined above indicates that the existing ditch along the northern boundary is the most appropriate receptor of storm water from the proposed development, having the potential to employ source control measures and on-line SuDS to control peak discharges to no greater than the baseline conditions.

8.14 Proposals have been developed to inform the strategic drainage network across the development. It is proposed that the drainage system for the site utilises a SuDS system as the primary storm water management scheme.

8.15 Accordingly, a plan showing the conceptual drainage masterplan for the site is contained within the Appendix as drawing 10821-DR-01 A.

8.16 Coupled with the storm water control benefits, the use of SuDS can also provide betterment on water quality. National guidance in the form of CIRIA 753 outlines that by implementing SuDS, storm water from the site can be polished to an improved standard thus ensuring the development proposals have no adverse effects on the wider hydrology.

9 Preliminary Drainage Proposals

Primary Drainage Systems (source control)

9.1 The common aims of a Primary Drainage System are:

- Reduction in peak discharges to the agreed site wide run-off rate from the development areas.
- Provide water quality treatment where appropriate

9.2 Preliminary assessment of the requirements for storm drainage have been based on the following criteria as shown in **Table 9-1.**

Criteria	Measure/Rate/Factor
Application Site Area	4.91 ha
Developed Area	2.85 ha
Landscaped Area	2.06 ha
Impermeability - Residential	0.55
Sewer design return period[2]	1 in 1 year
Sewer flood protection[2]	1 in 30 years
Fluvial / Development flood protection [1]	1 in 100 years
C (1km)*	-0.026
D1 (1km)*	0.419
D2 (1km)*	0.243
D3 (1km) *	0.359
E (1km) *	0.308
F (1km)*	2.319
Minimum cover to sewers [1]	1.2 m
Minimum velocity [1]	1.0 m/sec
Pipe ks value [1]	0.6 mm
Allowance for climate change [3]	40%

Table 9-1: Drainage Criteria and Measure

* FEH Catchment Descriptors- Site constants for calculating rainfall depths

[2] Design and Construction Guidance for Foul and Surface Water Sewers
[3] NPPF requirements for residential development

Groundwater Monitoring

9.3 Groundwater monitoring was completed by GEG in January-March 2021 in 7 boreholes across the site. The trial pit location plan can be seen in **Appendix F.**

Borehole	Date	Depth of Installation (m)	Groundwater Depth (m)
WS01	22.01.21	2.50	1.00
	26.02.21		Flooded at Surface
	26.03.21		0.74
WS02	22.01.21	4.00	0.83
	26.02.21		0.88
	26.03.21		1.08
WS03	22.01.21	2.00	0.78
	26.02.21		0.77
	26.03.21		0.85
WS04	22.01.21	2.00	0.30
	26.02.21		0.44
	26.03.21		0.81
WS05	22.01.21	2.00	0.90
	26.02.21		0.86
	26.03.21		1.08
WS06	22.01.21	2.50	0.79
	26.02.21		1.15
	26.03.21		1.38
WS07	22.01.21	1.50	0.38
	26.02.21		0.76
	26.03.21		0.99

Table 9-2: Groundwater Monitoring Results

9.4 Monitoring has shown that groundwater is within 1m of ground level and therefore any designed SuDS will need to be lined in order to prevent groundwater contamination and groundwater ingress into the basin.

Detention Basins

9.5 To date infiltration testing has not been completed, but due to high groundwater levels infiltration basins will not be viable for this site.

9.6 National policy[1] requires that new developments control the peak discharge of storm water from a site to the baseline, undeveloped, site conditions. Over very large development areas, the baseline rate of run-off is normally estimated using the FEH methodologies. However, Paragraph 3.1.2 of the FEH guidance states:

9.7 "The frequency estimation procedures can be used on any catchment, gauged or ungauged, that drains an area of at least 0.5km2. The flood estimation procedures can be applied on smaller catchments only where the catchment is gauged and offers simple flood peak or flood event data".

9.8 On undeveloped and ungauged catchments of less than 0.5km2 in area, it is correct to complete baseline site discharge assessments using the nationally accepted IoH124 methodology for small rural catchments. Local policy is to employ IoH124 in a manner set out by CIRIA C697. This methodology requires that, for catchments of less than 50ha, the IoH assessment is completed for a 50ha area with the results linearly interpolated to determine the flow rate value based on the ratio of the development to 50ha.

9.9 The baseline IoH run-off rates are shown on **Table 9-3** below:

Event	IoH 124 (4.9ha)	IoH 124 Scaled to 1ha
1 in 1 year (l/s)	11.85	2.42
Qbar (l/s)	13.94	2.84
1 in 100 year (l/s)	44.45	9.07

Table 9-3: IoH124 baseline discharge rates

9.10 In order to determine the permitted rates of run-off from the development, the future impermeable catchment areas must be derived. This has been based on a BCL measured ratio from previous projects. Calculations below show these ratios and areas and how these correlate to the rates of discharge.

9.11 The calculations for this are shown in **Table 9-4** below:

Catchment	Land Use	Developable Area (ha)	Impermeable Area (ha)	Existing 100 Year Run-off (l/s)	Proposed 100 Year Run-off (l/s)
A	Residential	2.95	1.78	16.19	5.08

Table 9-4: Run-off calculation

9.12 Using these methods, development at the site will comply with the requirements set out in paragraph 9 of the Technical Guide to the National Planning Policy Framework (NPPF), with the discharge of surface water from the proposed developments not exceeding that of the existing greenfield sites, thus ensuring that there is no material increase in the flood risk to surrounding areas.

9.13 Assessments have thereafter been completed to determine the characteristics of proposed SuDS features to be situated within the development. Best practice methods have been employed by performing detention routing calculations for both the 1 in 1 and 1 in 100 years + 40% climate change.

Catchment A

9.14 Calculations demonstrate that storm water detention storage extending to maximum 1,677m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 5.08l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a circa 69% reduction on peak greenfield rates. **Table 9-5**, below summarises the overall detention requirements.

Catchment Area (ha)	Impermeable Area (ha)	1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)
2.95	1.78	5.01	1,677

Table 9-5: Summary run-off & detention assessment output

9.15 In accordance with legislative requirements, the detention proposals have been assessed for the potential effects of climate change. The 1 in 100 year (1% AEP) return events have been modelled for 40% climate change (including peak rainfall intensity). Calculations for the climate change scenarios are contained within the Appendix. Climate change assessments show each detention feature to perform adequately by retaining the additional flows within the system without overflow.

9.16 A hydro-brake will be provided on the detention features, at a level above the 1 in 100 year + 40% flood level to allow more extreme event flows to safely be conveyed away from properties, while at the same time not increasing flood risk to surrounding areas, in line with current good practice recommendations. The detailed design stage will provide further detail into the positioning of overflows and direction of flow.

9.17 The proposed strategic drainage masterplan is shown illustratively on drawing 10821-DR-01 A contained in **Appendix A.**

9.18 The summary calculations are contained in **Appendix C.**

Summary

9.19 A strategy for storm drainage at the site has been developed to meet both national and local policy. The above options outline the viability of the site to employ means of drainage to comply with NPPF guidance, together with the Arun District Council SFRA and other national and local policy and guidance.

9.20 The development drainage system will manage storm water by conveying surface water through a piped network before discharging into the detention basin at the low point of the site. The basin will ensure peak discharges from the developed land is not increase from the appraised baseline rates. The system will also provide to maintain the quality of water discharged from the development.

Objectives

9.21 The key objectives for the site drainage will be:

- Implementation of a sustainable drainage scheme in accordance with current national and local policy together with principles of good practice design.
- Control of peak discharges from the site to a rate commensurate with the baseline conditions.
- Development of storm water management proposals that maintain water quality and biodiversity of the site.
- Implementation of the storm water management system prior to first use of the site.

10 SuDS Management

Water Quality

10.1 Impermeable surfaces collect pollutants from a wide variety of sources including cleaning activities, wear from car tyres, vehicle oil and exhaust leaks and general atmospheric deposition (source: CIRIA C609). The implementation of SuDS in development drainage provides a significant benefit in removal of pollutant from development run-off.

10.2 The SuDS Manual C753 describes a 'Simple Index Approach' for assessing the pollution risk of surface run-off to the receiving environment using indices for likely pollution levels for different land uses and SuDS performance capabilities.

10.3 CIRIA document C753 Table 26.2, as shown in **Table 10-1** below, indicates the minimum treatment indices appropriate for contributing pollution hazards for different land use classifications. To deliver adequate treatment, the selected SuDS components should have a total pollution mitigation index (for each contaminant type) that equals or exceeds the pollution hazard index.

Land Use	Pollution Hazard Level	Total Suspended Solids (TSS)	Metals	Hydro-carbons
Residential roofs	Very Low	0.2	0.2	0.05
Individual property driveways, residential car parks, low traffic roads (e.g. cul-de-sacs, home zones and general access roads) and non-residential car parking with infrequent change (e.g. schools, offices) i.e. < 300 traffic movements/day	Low	0.5	0.4	0.4

Table 10-1: CIRIA 753 Table 26.2 Pollution Hazard Indices

10.4 For a residential type development, roof water requires a very low treatment of 0.2 for total suspended solids, 0.2 for heavy metals and 0.05 for hydrocarbons, and run-off from low traffic roads such as cul-de-sacs and individual property driveways requires low treatment of 0.5 for total suspended solids, 0.4 for heavy metals and 0.4 for hydrocarbons.

10.5 To provide the correct level of treatment, an assessment needs to be made of the mitigation provided by each SuDS feature. Tables 26.3 and 26.4 of The SuDS Manual CIRIA document C753 shown as **Table 10-2** for discharges to surface waters and groundwater respectively indicate the treatment mitigation indices provided by each SuDS feature.

Type of SuDS component	Total suspended solids (TSS)	Metals	Hydro-carbons
Swale	0.5	0.6	0.6
Detention basin	0.5	0.5	0.6
Proprietary treatment systems	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the one in 1-year return period event, for inflow concentrations relevant to the contributing drainage area.		

Table 10-2: CIRIA 753 Table 26.3 SuDS Mitigation Indices for discharges to surface waters.

10.6 Where more than one mitigation feature is to be used, CIRIA guidance states that the total mitigation index shall be calculated as follows:

Total SuDS mitigation index = Mitigation Index 1 + 0.5 x Mitigation Index 2

10.7 At present, the site and surrounding area does not benefit from any additional measures of stormwater treatment.

10.8 Due to the need to provide wider sustainability benefits and view the development at a strategic level, SuDS will be implemented to passively treat run off from the development so as to have a positive impact on the surrounding natural environment.

10.9 The site will employ SuDS features, such as detention basins. These are widely accepted to be of high pollutant removal efficiency (CIRIA 609). This provides for at least one stage of treatment onsite. A petrol interceptor can be provided at the inflow of the basin in order to provide another source of treatment to surface water.

10.10 Coupled with this however, the unknown watercourse should also be seen as an additional stage of treatment as the sedimentation process is not limited to artificial drainage systems but is taken from the natural processes observed within the water cycle.

10.11 As the site is not presently served by any means of storm water treatment mechanisms, by providing the afore mentioned SuDS within the proposed development it will be possible to maintain present water quality in the area and thus the development can be seen to be having no significant environmental impact in relation to water.

Exceedance Flows

10.12 Careful regard has to be made in respect of potential exceedance flows, being events that are more extreme than current design criteria. Various national guidance has been published on the matter of exceedance flows and measures that should be incorporated into a development to ensure the safety of occupiers and those using the infrastructure.

10.13 The principal aim is to direct any exceedance flows away from properties and along defined corridors. At a local level, this may mean water being conveyed along a length of highway, as long as the predicted flow

depths and velocities are acceptable. More strategically, the implementation of conveyance corridors is important in avoiding deep and high velocity flows that present a high risk. The drainage system being promoted for Pagham provides a good opportunity to incorporate exceedance flow routes into the design.

10.14 Clearly, many of the measures for dealing with exceedance flows must be dealt with at the detailed design stage. However, the strategic layout for proposed development at Pagham provides the framework of a network that can effectively deal with any future exceedance problems.

Implementation Proposals

10.15 The conceptual drainage proposals have been developed in a manner that will allow the site wide system to be designed to encourage passive treatment of discharged flows and to improve the water quality by removing the low-level silts, oils which could be attributed to track/parking area run off of this nature. Final design will provide for appropriate geometry and planting to maximise this benefit.

10.16 The storm water management features will be constructed and operational prior to the first use of the site.

10.17 It has previously been the case that the functionality of the storm water management system would be ensured by ongoing maintenance, completed by the Local Authority, Drainage Authority, or a private maintenance company as appropriate. It is proposed that, for this development, a private maintenance company will be appointed to carry out the maintenance regime below in **Table 10-3**.

10.18 It is usual for the following maintenance regime to be implemented:

Frequency	Operation
Post major storm events	Inspection and removal of debris.
Every two months	Grass mowing (growing season) & litter removal.
Annual	Weeding & vegetation maintenance. Minor swale clearance. Sweeping of
2 years	Tree pruning.
5-10 years	Desilting of channels. Remove silt around inlet and outlet structures.
15-20 years	Major vegetation maintenance and watercourse channel works.

Table 10-3: Framework maintenance of detention / retention system

10.19 The conceptual drainage masterplan proposals outlined in this report will be used for final drainage design and detailing. The storm water management system will be constructed and operational in full prior to first use of the relevant phase of development.

11 Foul Drainage

Background

11.1 A copy of the Southern Water sewerage network records has been obtained which confirms the presence of a rising main crossing through the development site. Foul and surface water sewers are located within Pagham Road which bounds the west of the site.

11.2 The proposed development area lies approximately 500m east from the treatment works believed to be serving the site.

Design Criteria / Network Requirements

11.3 Peak design discharges have been calculated based on the current development criteria as described in Section 2 of this report and for the following:

Domestic peak (peak) = *4,000 litres / dwelling / day*

11.4 Assessed in accordance with the Design and Construction Guidance for Foul and Surface Water Sewers requirements, the development will have a design peak discharge of approximately 5.5l/s.

11.5 A review of the Chichester Local Plan Website, includes for a note prepared by CDC in August 2021 noted that the Pagham Wastewater Treatment Works has an estimated remaining capacity for approximately 734 dwellings. This has been combined by CDC from Environment Agency and Southern Water data. Therefore, there is indicatively enough headroom in the Wastewater Treatment Works for the proposed development of Land at Pagham Road.

11.6 Furthermore, the *Statement of Common Ground between Chichester District Council, Environment Agency and Southern Water – Waste Water Treatment in Chichester Plan Area* document produced on the 24th November 2021, confirmed:

The improvement schemes at Pagham WWTW, which include a growth design horizon up to 2035 are due for completion by 2025 – more information about the options and capacity is expected to be available by the end of 2021

Combined growth and quality improvement schemes for Pagham WWTW due for completion by 2025 will provide additional capacity there.

11.7 Therefore, the document provides confirmation that capacity will be available for the proposed development Site.

Network Requirements / Options

11.8 SW has been contacted to provide a pre-development enquiry for the Site. SW has confirmed a connection from the proposed development to the 150mm sewer along Pagham Road, to the south-east of the Site currently has inadequate capacity to supply the proposed development. Therefore, additional off-site

sewers/improvements to the existing sewer will be required to provide sufficient capacity. With the Ofwat instigated changes in April 2018, SW has confirmed that they have a duty to provide network capacity from the practicable Point of Connection, funded through the New Infrastructure Charges.

11.9 SW have provided confirmation the nearest Point of Connection with sufficient capacity for 120 dwellings would be the Pagham Wastewater Treatment Works (WTW), situated approximately 600m west of the Site. Rights are not issued to a direct connection to the WTW and therefore the connection would need to be agreed with Southern Water, prior to the works being carried out.

Treatment Requirements

11.10 Water companies have a statutory obligation through the Water Industry Act 1991, 2003 et al., to provide capital investment in strategic treatment infrastructure to meet development growth. This investment planning is managed and regulated by OFWAT through the Asset Management Plan (AMP) process. The five yearly cyclical process requires that water companies allocate finances to a range of strategic projects to meet their statutory obligations.

11.11 Where development programming requirements necessitate the reinforcement of facilities ahead of allocation in an AMP period, mechanisms are available to ensure the infrastructure can be delivered in a timely fashion, to meet the development programme.

Implementation Proposals

11.12 The proposed drainage network across the site will be designed to current Design and Construction Guidance for Foul and Surface Water Sewers standards, employing a point of connection agreed with Southern Water. The system will be offered for the adoption of Southern Water under S104 of the Water Industry Act 1991.

Summary

11.13 A site drainage strategy has been developed that meets with current regulatory requirements by discharging drainage to a sewerage network with capacity to accommodate the flows.

11.14 Once development is complete, the network conveying flows from the site will be adopted by Southern Water and be maintained as part of their statutory duties.

Objectives

11.15 The key development objectives required for the site drainage scheme are:

- Implementation of a drainage scheme to convey water to the local Southern Water network which is designed and maintained to an appropriate standard.

12 Summary

12.1 This FRA has identified no prohibitive engineering constraints in developing the proposed site for the proposed developments.

12.2 The site is fully able to comply with NPPF guidance together with associated local and national policy and guidance.

12.3 In regards to policy W DM2 Flood Risk, the proposed SuDS will discharge to QBAR, reducing the flood risk further downstream. The detention basins has been designed to accommodate the 1 in 100 year + 40% storm event, with a 300mm freeboard.

12.4 And to policy W DM3 Sustainable Urban Drainage Systems, a full SI investigation will be completed at reserved matters. Until the SI has been completed the proposed strategy has not assumed any infiltration SuDS. The SuDS will provide at least 1 level of treatment before discharging surface water into the existing drainage network.

12.5 Assessment of fluvial flood risk shows the land to lie within Flood Zone 1 and hence be a preferable location for residential development when considered in the context of the NPPF Sequential Test. Assessment of other potential flooding mechanisms shows the land to have a low probability of flooding from overland flow, ground water and sewer flooding.

12.6 Storm water discharged from development will be disposed of by way of SuDS measures to the existing ditch within the site. A detention basin located at the lowest point of the site has been proposed to detention and discharge surface water to a rate of QBAR.

12.7 Means to discharge foul water drainage have been established that comply with current guidance and requirements of Southern Water.

13 Limitations

13.1 The conclusions and recommendations contained herein are limited to those given the general availability of background information and the planned usage of the site.

13.2 Third party information has been used in the preparation of this report, which Brookbanks, by necessity assumes is correct at the time of writing. While all reasonable checks have been made on data sources and the accuracy of data, Brookbanks accepts no liability for same.

13.3 The benefits of this report are provided solely to Hallam Land Management Ltd for the proposed development Land West of Pagham Road only.

13.4 Brookbanks excludes third party rights for the information contained in the report.

Appendix A - Drainage Plan

Original Drawing Size A1

NOTES:

1. Do not scale from this drawing.
2. All dimensions are in metres unless otherwise stated.
3. Brookbanks Consulting Ltd has prepared this drawing for the sole use of the client. The drawing may not be relied upon by any other party without the express agreement of the client and Brookbanks Consulting Ltd. Where any data supplied by the client or from other sources has been used, it has been assumed that the information is correct. No responsibility can be accepted by Brookbanks Consulting Ltd for inaccuracies in the data supplied by any other party. The drawing has been produced based on the assumption that all relevant information has been supplied by those bodies from whom it was requested.
4. No part of this drawing may be copied or duplicated without the express permission of Brookbanks Consulting Ltd.

KEY:

- Red Line Site Boundary
- Existing Watercourse and Drainage Network
- Catchment Boundary
- Flow Direction Arrows
- SuDS Basin
- Indicative Pipe Network
- Surface Water Outfall
- Foul Water Main (Southern Water)
- Surface Water Main (Southern Water)

A	Updated Masterplan	KM	LW	03.12.21
-	First Issue	KM	LW	01.11.21

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Hallam Land Management

Land at Pagham II

Illustrative Surface Water Drainage Strategy

Status		Status Date
Draft		DEC 2021
Drawn	Checked	Date
KM	LW	01.11.21
Scale	Number	Rev
1:1000	10821-DR-01	A

UNTIL TECHNICAL APPROVAL HAS BEEN OBTAINED FROM THE RELEVANT LOCAL AUTHORITIES, IT SHOULD BE UNDERSTOOD THAT ALL DRAWINGS ARE ISSUED AS PRELIMINARY AND NOT FOR CONSTRUCTION. SHOULD THE CONTRACTOR COMMENCE SITE WORK PRIOR TO APPROVAL BEING GIVEN, IT IS ENTIRELY AT HIS OWN RISK.

ARUN DISTRICT COUNCIL P/178/24/OUT

Appendix B - IoH Greenfield Runoff Rates

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Alejandro Ortiz
Site name:	Pagham II
Site location:	

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	50.78329° N
Longitude:	0.73661° W
Reference:	3315680026
Date:	Nov 01 2021 09:16

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 4.9

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics	Default	Edited
SOIL type:	3	3
HOST class:	N/A	N/A
SPR/SPRHOST:	0.37	0.37

Hydrological characteristics	Default	Edited
SAAR (mm):	694	694
Hydrological region:	7	7
Growth curve factor 1 year:	0.85	0.85
Growth curve factor 30 years:	2.3	2.3
Growth curve factor 100 years:	3.19	3.19
Growth curve factor 200 years:	3.74	3.74

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates	Default	Edited
Q_{BAR} (l/s):	13.94	13.94
1 in 1 year (l/s):	11.85	11.85
1 in 30 years (l/s):	32.05	32.05
1 in 100 year (l/s):	44.45	44.45
1 in 200 years (l/s):	52.12	52.12

Appendix C - WinDES Detention Calculations

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.203	0.203	4.8	238.9	O K
30 min Summer	0.252	0.252	5.0	298.8	O K
60 min Summer	0.311	0.311	5.1	371.9	O K
120 min Summer	0.379	0.379	5.1	458.7	O K
180 min Summer	0.423	0.423	5.1	515.5	O K
240 min Summer	0.455	0.455	5.1	557.8	O K
360 min Summer	0.501	0.501	5.1	618.8	O K
480 min Summer	0.533	0.533	5.1	661.7	O K
600 min Summer	0.557	0.557	5.1	693.6	O K
720 min Summer	0.575	0.575	5.1	718.0	O K
960 min Summer	0.565	0.565	5.1	705.3	O K
1440 min Summer	0.540	0.540	5.1	671.2	O K
2160 min Summer	0.507	0.507	5.1	626.2	O K
2880 min Summer	0.475	0.475	5.1	583.7	O K
4320 min Summer	0.443	0.443	5.1	541.7	O K
5760 min Summer	0.408	0.408	5.1	496.3	O K
7200 min Summer	0.374	0.374	5.1	452.3	O K
8640 min Summer	0.341	0.341	5.1	410.9	O K
10080 min Summer	0.311	0.311	5.1	373.1	O K
15 min Winter	0.227	0.227	4.9	267.9	O K
30 min Winter	0.281	0.281	5.0	335.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	72.878	0.0	209.3	26
30 min Summer	45.836	0.0	264.6	41
60 min Summer	28.828	0.0	366.3	70
120 min Summer	18.132	0.0	461.8	130
180 min Summer	13.824	0.0	527.7	188
240 min Summer	11.404	0.0	579.2	248
360 min Summer	8.694	0.0	657.3	366
480 min Summer	7.172	0.0	714.3	486
600 min Summer	6.178	0.0	754.6	604
720 min Summer	5.468	0.0	778.5	724
960 min Summer	4.288	0.0	777.5	960
1440 min Summer	3.044	0.0	749.0	1184
2160 min Summer	2.161	0.0	1021.4	1540
2880 min Summer	1.695	0.0	1065.3	1936
4320 min Summer	1.261	0.0	1174.0	2768
5760 min Summer	1.023	0.0	1304.1	3568
7200 min Summer	0.869	0.0	1384.4	4328
8640 min Summer	0.761	0.0	1452.0	5104
10080 min Summer	0.680	0.0	1507.7	5848
15 min Winter	72.878	0.0	235.4	26
30 min Winter	45.836	0.0	295.7	40

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.347	0.347	5.1	417.6	O K
120 min Winter	0.423	0.423	5.1	516.2	O K
180 min Winter	0.473	0.473	5.1	581.1	O K
240 min Winter	0.509	0.509	5.1	629.9	O K
360 min Winter	0.562	0.562	5.1	701.3	O K
480 min Winter	0.600	0.600	5.1	752.6	O K
600 min Winter	0.628	0.628	5.1	791.8	O K
720 min Winter	0.651	0.651	5.1	822.9	O K
960 min Winter	0.645	0.645	5.1	815.3	O K
1440 min Winter	0.619	0.619	5.1	778.7	O K
2160 min Winter	0.573	0.573	5.1	715.8	O K
2880 min Winter	0.530	0.530	5.1	657.3	O K
4320 min Winter	0.478	0.478	5.1	588.0	O K
5760 min Winter	0.422	0.422	5.1	514.0	O K
7200 min Winter	0.367	0.367	5.1	443.8	O K
8640 min Winter	0.318	0.318	5.1	380.8	O K
10080 min Winter	0.274	0.274	5.0	326.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	28.828	0.0	411.0	70
120 min Winter	18.132	0.0	517.3	128
180 min Winter	13.824	0.0	589.9	186
240 min Winter	11.404	0.0	645.9	244
360 min Winter	8.694	0.0	727.6	360
480 min Winter	7.172	0.0	779.1	476
600 min Winter	6.178	0.0	800.9	592
720 min Winter	5.468	0.0	809.2	708
960 min Winter	4.288	0.0	786.7	934
1440 min Winter	3.044	0.0	755.0	1360
2160 min Winter	2.161	0.0	1142.6	1672
2880 min Winter	1.695	0.0	1190.8	2112
4320 min Winter	1.261	0.0	1303.3	2992
5760 min Winter	1.023	0.0	1461.0	3856
7200 min Winter	0.869	0.0	1551.3	4616
8640 min Winter	0.761	0.0	1627.7	5368
10080 min Winter	0.680	0.0	1691.4	6064

Rainfall Details

Rainfall Model	FEH	D2 (1km)	0.243	Cv (Summer)	0.750
Return Period (years)	30	D3 (1km)	0.359	Cv (Winter)	0.840
FEH Rainfall Version	1999	E (1km)	0.308	Shortest Storm (mins)	15
Site Location		F (1km)	2.319	Longest Storm (mins)	10080
C (1km)	-0.026	Summer Storms	Yes	Climate Change %	+0
D1 (1km)	0.419	Winter Storms	Yes		

Time Area Diagram

Total Area (ha) 1.780

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.593	4	8	0.593	8	12	0.593

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1138.0	1.500	1773.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0104-5100-1200-5100
Design Head (m)	1.200
Design Flow (l/s)	5.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	104
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	5.1
Flush-Flo™	0.358	5.1
Kick-Flo®	0.749	4.1
Mean Flow over Head Range	-	4.5

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.5	1.200	5.1	3.000	7.8	7.000	11.7
0.200	4.8	1.400	5.5	3.500	8.4	7.500	12.1
0.300	5.1	1.600	5.8	4.000	9.0	8.000	12.5
0.400	5.1	1.800	6.2	4.500	9.5	8.500	12.8
0.500	5.0	2.000	6.5	5.000	10.0	9.000	13.2
0.600	4.8	2.200	6.8	5.500	10.4	9.500	13.5
0.800	4.2	2.400	7.0	6.000	10.9		
1.000	4.7	2.600	7.3	6.500	11.3		

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.420	0.420	5.1	512.0	O K
30 min Summer	0.508	0.508	5.1	628.2	O K
60 min Summer	0.611	0.611	5.1	768.6	O K
120 min Summer	0.731	0.731	5.1	936.6	O K
180 min Summer	0.808	0.808	5.1	1048.4	O K
240 min Summer	0.865	0.865	5.1	1132.6	O K
360 min Summer	0.948	0.948	5.1	1256.9	O K
480 min Summer	1.007	1.007	5.1	1347.7	O K
600 min Summer	1.052	1.052	5.1	1418.2	O K
720 min Summer	1.088	1.088	5.1	1475.0	O K
960 min Summer	1.089	1.089	5.1	1476.6	O K
1440 min Summer	1.073	1.073	5.1	1450.1	O K
2160 min Summer	1.026	1.026	5.1	1376.9	O K
2880 min Summer	0.978	0.978	5.1	1302.4	O K
4320 min Summer	0.947	0.947	5.1	1255.2	O K
5760 min Summer	0.914	0.914	5.1	1204.8	O K
7200 min Summer	0.879	0.879	5.1	1152.9	O K
8640 min Summer	0.844	0.844	5.1	1100.2	O K
10080 min Summer	0.807	0.807	5.1	1046.3	O K
15 min Winter	0.467	0.467	5.1	573.9	O K
30 min Winter	0.565	0.565	5.1	704.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	155.021	0.0	410.4	27
30 min Summer	95.387	0.0	429.3	41
60 min Summer	58.693	0.0	734.8	72
120 min Summer	36.115	0.0	825.7	130
180 min Summer	27.184	0.0	808.8	190
240 min Summer	22.222	0.0	790.3	250
360 min Summer	16.727	0.0	766.0	370
480 min Summer	13.673	0.0	753.6	488
600 min Summer	11.694	0.0	748.9	608
720 min Summer	10.292	0.0	750.3	728
960 min Summer	7.998	0.0	747.2	966
1440 min Summer	5.606	0.0	737.6	1444
2160 min Summer	3.929	0.0	1514.4	2144
2880 min Summer	3.053	0.0	1459.9	2448
4320 min Summer	2.243	0.0	1352.9	3204
5760 min Summer	1.802	0.0	2295.0	4032
7200 min Summer	1.521	0.0	2414.2	4840
8640 min Summer	1.324	0.0	2504.7	5704
10080 min Summer	1.177	0.0	2526.2	6552
15 min Winter	155.021	0.0	425.4	27
30 min Winter	95.387	0.0	431.0	41

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	0.679	0.679	5.1	862.7	O K
120 min Winter	0.811	0.811	5.1	1052.5	O K
180 min Winter	0.896	0.896	5.1	1178.3	O K
240 min Winter	0.959	0.959	5.1	1273.7	O K
360 min Winter	1.051	1.051	5.1	1415.7	O K
480 min Winter	1.117	1.117	5.1	1520.4	O K
600 min Winter	1.168	1.168	5.1	1602.6	O K
720 min Winter	1.209	1.209	5.1	1669.4	Flood Risk
960 min Winter	1.214	1.214	5.1	1677.0	Flood Risk
1440 min Winter	1.202	1.202	5.1	1658.8	Flood Risk
2160 min Winter	1.162	1.162	5.1	1593.7	O K
2880 min Winter	1.111	1.111	5.1	1511.1	O K
4320 min Winter	1.070	1.070	5.1	1446.7	O K
5760 min Winter	1.026	1.026	5.1	1376.9	O K
7200 min Winter	0.976	0.976	5.1	1300.3	O K
8640 min Winter	0.924	0.924	5.1	1220.5	O K
10080 min Winter	0.869	0.869	5.1	1138.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	58.693	0.0	801.0	70
120 min Winter	36.115	0.0	813.3	130
180 min Winter	27.184	0.0	789.3	188
240 min Winter	22.222	0.0	773.8	246
360 min Winter	16.727	0.0	760.2	364
480 min Winter	13.673	0.0	761.2	482
600 min Winter	11.694	0.0	773.1	598
720 min Winter	10.292	0.0	786.2	716
960 min Winter	7.998	0.0	785.3	948
1440 min Winter	5.606	0.0	773.7	1406
2160 min Winter	3.929	0.0	1528.0	2076
2880 min Winter	3.053	0.0	1482.4	2708
4320 min Winter	2.243	0.0	1420.4	3376
5760 min Winter	1.802	0.0	2566.6	4328
7200 min Winter	1.521	0.0	2692.1	5264
8640 min Winter	1.324	0.0	2736.9	6152
10080 min Winter	1.177	0.0	2624.3	7064

Rainfall Details

Rainfall Model	FEH	D2 (1km)	0.243	Cv (Summer)	0.750
Return Period (years)	100	D3 (1km)	0.359	Cv (Winter)	0.840
FEH Rainfall Version	1999	E (1km)	0.308	Shortest Storm (mins)	15
Site Location		F (1km)	2.319	Longest Storm (mins)	10080
C (1km)	-0.026	Summer Storms	Yes	Climate Change %	+40
D1 (1km)	0.419	Winter Storms	Yes		

Time Area Diagram

Total Area (ha) 1.780

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.593	4	8	0.593	8	12	0.593

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1138.0	1.500	1773.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0104-5100-1200-5100
Design Head (m)	1.200
Design Flow (l/s)	5.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	104
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	5.1
Flush-Flo™	0.358	5.1
Kick-Flo®	0.749	4.1
Mean Flow over Head Range	-	4.5

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.5	1.200	5.1	3.000	7.8	7.000	11.7
0.200	4.8	1.400	5.5	3.500	8.4	7.500	12.1
0.300	5.1	1.600	5.8	4.000	9.0	8.000	12.5
0.400	5.1	1.800	6.2	4.500	9.5	8.500	12.8
0.500	5.0	2.000	6.5	5.000	10.0	9.000	13.2
0.600	4.8	2.200	6.8	5.500	10.4	9.500	13.5
0.800	4.2	2.400	7.0	6.000	10.9		
1.000	4.7	2.600	7.3	6.500	11.3		

Appendix D – Southern Water Sewer Records

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WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.

Foul Gravity Sewer · Combined Gravity Sewer · Culverted Water Course or Treated Effluent · Surface Water Gravity Sewer · Rising Main, Vacuum or Syphon

Combined Outfall · Foul Outfall · Surface Water Outfall · Surface Water Inlet

Combined Pumping Station · Surface Water Pumping Station · Foul Pumping Station · Water Treatment Works · Section 104 Area · Building Over Agreement Area · Foul Manhole · Combined Manhole · Surface Water Manhole · Side Entry Manhole, Dissipation Chamber, Dummy Manhole or Surface Water Soakaway

adam.melia@brookbanks.com

Pagham

WATER for LIFE from Southern Water

ARUN DISTRICT COUNCIL P/174/24/OUT

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
0001	F	5.75	0.00	
0101	F	5.94	0.00	
0102	F	0.00	0.00	
0201	F	6.18	3.39	
0202	F	6.42	5.24	
0203	F	6.03	3.38	
0204	F	0.00	0.00	
0301	F	6.07	3.76	
0303	F	6.30	4.68	
0304	F	6.27	4.29	
0305	F	6.38	4.05	
0306	F	6.25	3.96	
0307	F	6.10	3.82	
0308	F	0.00	0.00	
0309	F	0.00	0.00	
0502	F	5.97	4.21	
0601	F	5.93	3.33	
0701	F	5.56	2.90	
0702	F	5.61	3.17	
0703	F	5.54	3.52	
0704	F	5.52	3.65	
0705	F	5.60	3.77	
0706	F	5.62	3.26	
0801	F	6.04	4.29	
0901	F	5.81	2.27	
0902	F	5.81	2.13	
1504	F	0.00	0.00	
1505	F	0.00	0.00	
1506	F	0.00	0.00	
2501	F	6.17	3.33	
2601	F	6.33	3.60	
2602	F	6.31	3.47	
2603	F	5.96	3.80	
2604	F	0.00	0.00	
2701	F	6.06	4.52	
2702	F	6.23	4.99	
2703	F	5.84	4.42	
2704	F	5.63	4.81	
2801	F	6.10	4.19	
3503	F	6.29	3.15	
3504	F	6.28	4.57	
3701	F	6.59	5.50	
3801	F	5.67	3.77	
4501	F	6.32	5.05	
4502	F	6.31	5.26	
4601	F	6.34	4.70	
4602	F	6.43	4.85	
4701	F	6.53	4.27	
4702	F	0.00	0.00	
4801	F	5.94	3.92	
4802	F	5.89	3.39	
5507	F	0.00	0.00	
5601	F	5.97	3.53	
5602	F	5.93	4.85	
5603	F	6.22	4.94	
5604	F	6.10	5.15	
5605	F	0.00	0.00	
5606	F	0.00	0.00	
5607	F	0.00	0.00	
5608	F	0.00	0.00	
5701	F	5.92	4.55	
5801	F	6.16	2.48	
5901	F	0.00	2.34	
5902	F	5.99	3.20	
6502	F	6.06	4.34	
6503	F	6.21	4.54	
6601	F	6.24	4.44	
6602	F	6.24	3.29	
6603	F	6.11	4.06	
6701	F	6.13	2.68	
6702	F	6.27	4.31	
6703	F	6.19	2.95	
6704	F	5.83	3.13	
6705	F	6.32	4.87	
6706	F	6.30	4.99	
6707	F	6.28	5.08	
6708	F	5.76	4.56	
6801	F	6.08	0.94	
6802	F	6.10	0.82	
6803	F	6.05	3.98	
6804	F	6.15	4.08	
6901	F	6.10	0.00	
6902	F	6.22	1.41	
6903	F	6.48	1.48	
6904	F	0.00	0.00	
6905	F	0.00	0.00	
6906	F	0.00	0.00	
6907	F	0.00	0.00	
6908	F	6.48	4.22	
6909	F	0.00	0.00	
6910	F	0.00	0.00	
7001	F	6.45	5.42	
7101	F	6.33	4.70	
7102	F	6.57	5.92	
7103	F	0.00	0.00	
7506	F	0.00	0.00	
7508	F	0.00	0.00	
7601	F	6.27	3.79	
7602	F	6.38	4.47	
7603	F	6.19	3.93	
7604	F	6.28	4.29	
7605	F	6.36	4.71	
7606	F	0.00	0.00	
7701	F	6.21	3.71	
7702	F	6.19	3.39	
7703	F	6.41	4.32	
7704	F	6.40	4.26	
7705	F	0.00	0.00	
7706	F	0.00	0.00	
7707	F	0.00	0.00	
7708	F	0.00	0.00	
7709	F	0.00	0.00	
7801	F	6.34	3.20	
7802	F	6.12	3.13	
7803	F	6.04	3.47	
7804	F	6.12	3.66	
7901	F	6.05	3.75	
7902	F	6.19	3.93	
7903	F	6.28	4.10	
7904	F	6.26	3.26	
7905	F	6.30	3.62	
7906	F	6.44	4.51	
8001	F	6.36	4.63	
8002	F	6.38	4.48	
8003	F	6.44	5.02	
8004	F	6.31	0.00	
8005	F	6.64	5.34	
8006	F	0.00	0.00	
8007	F	0.00	0.00	
8101	F	6.15	0.00	
8102	F	6.28	0.00	
8103	F	6.33	4.23	
8104	F	6.21	4.35	
8105	F	6.23	4.54	
8106	F	6.56	5.78	
8107	F	6.39	5.45	
8109	F	0.00	0.00	
8201	F	5.96	5.21	
8202	F	5.88	5.36	
8203	F	6.26	5.27	
8204	F	6.59	4.60	
8205	F	6.40	5.46	
8206	F	0.00	0.00	
8207	F	0.00	0.00	
8208	F	0.00	0.00	
8501	F	5.75	3.53	
8503	F	6.07	4.40	
8601	F	6.44	4.10	
8602	F	0.00	0.00	
8603	F	0.00	0.00	
8701	F	6.13	4.47	
8702	F	6.39	4.49	

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
8901	F	6.32	3.00	
9001	F	6.02	3.82	
9002	F	6.28	5.79	
9003	F	6.35	5.33	
9004	F	6.00	3.66	
9005	F	5.98	0.00	
9101	F	6.25	4.83	
9102	F	6.17	5.25	
9201	F	6.25	4.99	
9202	F	6.15	0.00	
9203	F	5.78	4.70	
9204	F	5.77	4.90	
9205	F	6.41	5.29	
9206	F	6.33	5.26	
9301	F	6.19	0.00	
9302	F	6.26	4.67	
9303	F	6.24	0.00	
9304	F	6.09	0.00	
9501	F	5.52	3.39	
9601	F	6.47	4.87	
9602	F	5.87	4.12	
9603	F	5.86	3.79	
9605	F	0.00	0.00	
9606	F	0.00	0.00	
9608	F	0.00	0.00	
9701	F	6.19	4.69	
9702	F	6.05	4.48	
9801	F	6.02	4.26	
9802	F	6.06	4.56	
9803	F	6.03	4.38	
9804	F	6.04	4.57	
9805	F	6.07	4.78	
9806	F	6.07	4.96	
9807	F	6.14	5.07	
9901	F	6.06	2.73	
9902	F	6.01	0.00	
9903	F	6.01	2.56	
9904	F	0.00	0.00	
0051	S	6.01	4.28	
0052	S	5.74	0.00	
0053	S	5.96	4.38	
0151	S	5.92	4.62	
0152	S	5.95	4.83	
0251	S	6.20	3.90	
0351	S	6.16	4.07	
0352	S	6.30	4.98	
0353	S	6.27	4.30	
0354	S	6.38	4.23	
0355	S	6.29	4.21	
0356	S	6.15	4.12	
0357	S	6.18	4.72	
0358	S	6.18	4.07	
0551	S	5.99	4.90	
0552	S	5.75	4.71	
0751	S	5.60	3.58	
0752	S	5.66	3.65	
0753	S	5.71	3.79	
0754	S	5.79	3.57	
0951	S	5.81	3.96	
0952	S	5.82	3.87	
0953	S	5.71	3.80	
0954	S	5.89	3.80	
0955	S	5.86	3.77	
1552	S	5.39	4.61	
1651	S	5.50	4.69	
2751	S	5.60	4.37	
2752	S	5.86	4.44	
2753	S	6.19	5.31	
3751	S	6.54	4.96	
3851	S	6.17	4.15	
3951	S	6.25	4.04	
3952	S	6.17	3.97	
5554	S	6.14	4.43	
5651	S	6.00	4.54	
5652	S	6.23	4.73	
5653	S	6.12	4.75	
5751	S	5.76	5.13	
6552	S	6.02	4.85	
6553	S	6.12	4.86	
6651	S	6.26	4.83	
6652	S	0.00	4.28	
6653	S	6.19	4.54	
6654	S	6.25	4.27	
6655	S	6.15	4.30	
6751	S	6.37	4.28	
6752	S	6.15	4.88	
6753	S	5.86	4.98	
6754	S	5.96	4.81	
6755	S	6.04	5.17	
6851	S	6.11	5.26	
6852	S	5.99	5.26	
6853	S	6.07	5.13	
7051	S	6.56	5.54	
7151	S	6.47	5.66	
7651	S	6.31	4.68	
7652	S	6.36	5.04	
7653	S	6.13	5.30	
7654	S	6.27	5.03	
7751	S	6.22	4.81	
7752	S	6.04	4.54	
7753	S	6.31	4.98	
7754	S	6.16	4.68	
7851	S	6.29	5.20	
7852	S	6.20	4.78	
7853	S	6.12	4.87	
8051	S	6.35	5.33	
8052	S	6.46	5.48	
8151	S	6.09	5.46	
8152	S	6.04	5.29	
8153	S	6.41	0.00	
8154	S	6.42	5.17	
8251	S	6.32	5.27	
8551	S	5.59	4.59	
8651	S	6.24	4.92	
8652	S	6.26	4.97	
8751	S	6.27	5.16	
8752	S	6.27	5.37	
8753	S	6.45	5.23	
9051	S	6.27	0.00	
9053	S	5.95	4.73	
9054	S	5.98	4.67	
9055	S	6.00	4.55	
9056	S	5.94	0.00	
9151	S	0.00	0.00	
9152	S	6.29	5.05	
9153	S	6.17	5.03	
9154	S	6.11	5.17	
9155	S	5.95	5.03	
9251	S	6.22	5.27	
9252	S	6.20	5.47	
9351	S	6.16	4.25	
9352	S	6.19	5.09	
9353	S	6.07	5.07	
9651	S	6.43	5.28	
9652	S	5.74	4.09	
9653	S	5.92	4.20	
9751	S	6.07	5.36	
9851	S	6.03	4.53	
9852	S	6.00	4.71	
9853	S	5.98	4.64	
9854	S	5.78	5.04	
9951	S	6.07	4.27	
9952	S	6.03	4.23	
9953	S	5.98	4.32	

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

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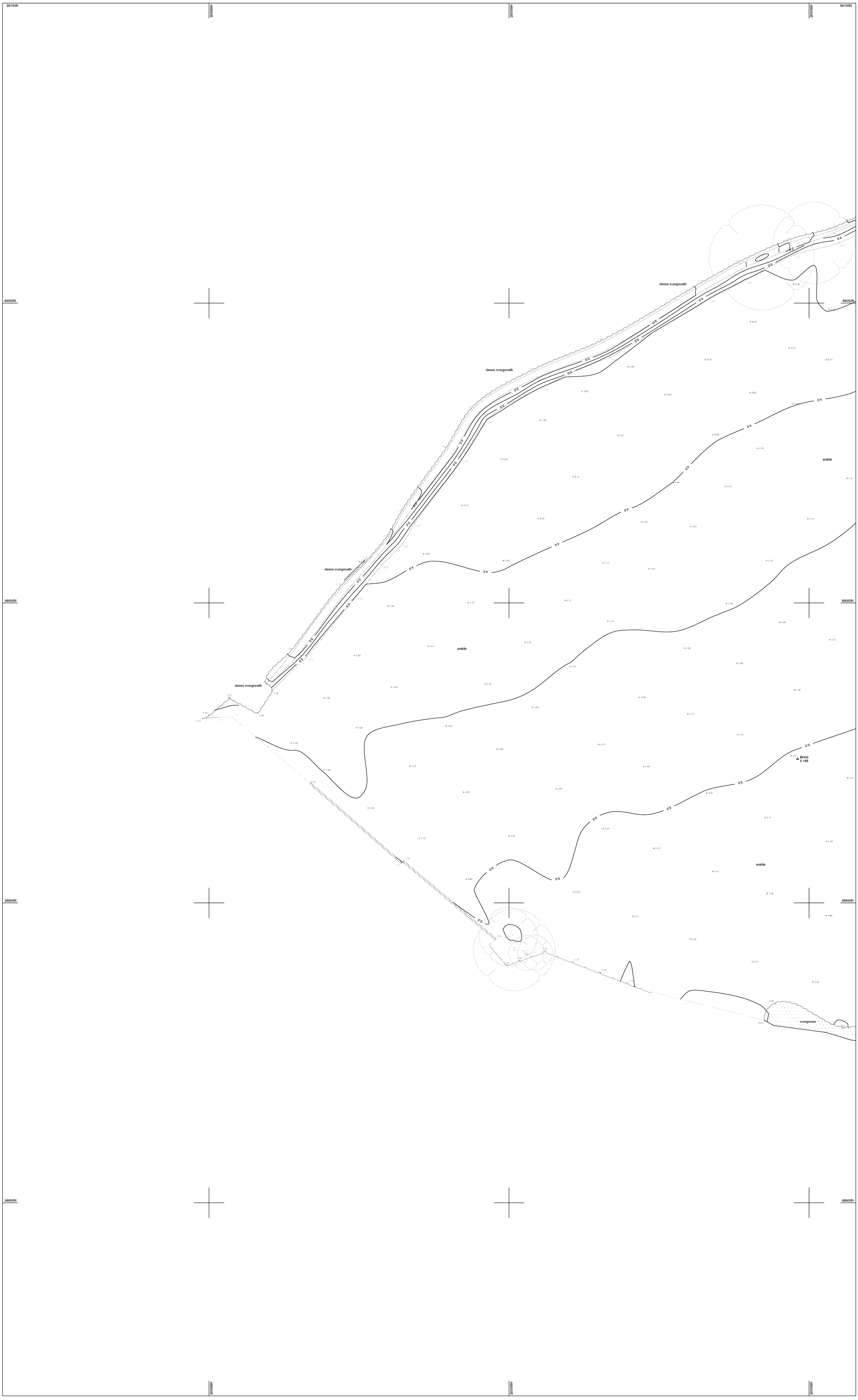
Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Appendix E – Topographic Survey



Symbol & Abbreviation Key.

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- SURVEY STATION
- ORDNANCE SURVEY BENCH MARK

A/C	AIR CONDITIONING UNIT	KO	KERB OFFLET
AV	AIR VALVE	LC	LIGHTING COLUMN
BOL	BOLLARD	LP	LAMP POST
BH	BOREHOLE	NP	NAME PLATE
BL	BED LEVEL	NB	NOTICE BOARD
BM	BENCH MARK	PR	PIPE RISER
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CTV	CABLE TV	RS	ROAD SIGN
CL	COVER LEVEL	SP	SIGN POST
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DP	DOWN PIPE	TL	TRAFFIC LIGHT
ER	EARTH ROD	TP	TELEGRAPH POLE
EP	ELECTRICITY POLE	TOF	TOP OF FENCE
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GU	GULLY	WL	WATER LEVEL
HM	HYDRANT MARKER	WM	WATER MARKER
IL	INVERT LEVEL	WO	WASH OUT

General.

This survey has been prepared with a scaling accuracy for a plot at a scale of 1:200.

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Notes.

Coordinates related to previous survey, drawing number 210841.
Levels related to previous survey, drawing number 210841.

INDICATIVE ONLY

Rev	Details of Revision	Drawn	Date

Surveyed	Drawn	Date	Checked	Date	Approved	Date
BH	BH	15/10/21	GD	18/10/21	GD	18/10/21

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Client.

HALLAM LAND MANAGEMENT SOUTH EAST EAST
3RD FLOOR
43 PORTLAND ROAD
LONDON
W1B 1QH

Title.

TOPOGRAPHICAL SURVEY

LAND WEST OF PAGHAM ROAD
PAGHAM
WEST SUSSEX
(PAGHAM II)

Dwg No. **210841** Sheet **1 of 3**

Scale 1:200 A0 Sheet Rev. -

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3RD FLOOR
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LONDON
W1B 1QH

Title.

TOPOGRAPHICAL SURVEY

LAND WEST OF PAGHAM ROAD
PAGHAM
WEST SUSSEX
(PAGHAM II)

Dwg No. **210841** Sheet **2 of 3**

Scale 1:200 A0 Sheet Rev. -

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TOPOGRAPHICAL SURVEY

LAND WEST OF PAGHAM ROAD
PAGHAM
WEST SUSSEX
(PAGHAM II)

Dwg No. **210841** Sheet **3 of 3**

Scale 1:200 A0 Sheet Rev. -

Appendix F – GEG Groundwater Monitoring

GEG | Geo Environmental Group
Geotechnical, Environmental & Ecological Consultants

GEG House, 17 Graham Road, Malvern, WR14 2HR
[redacted]

GROUNDWATER & INITIAL GAS MONITORING FACTUAL REPORT

'PAGHAM PHASE II'
LAND WEST OF PAGHAM ROAD
PAGHAM, WEST SUSSEX
PO21 3PY

APRIL 2021

Prepared for:

Hallam Land Management

BROOKBANKS

Registered Company - GEG Ltd
Registered in England No 6469985
Registered Office: Granta Lodge, 71 Graham Rd, Malvern, WR14 2JS

REPORT TITLE: GROUNDWATER & INITIAL GAS MONITORING FACTUAL REPORT

Site Address:

'Pagham Phase II'
Land West of Pagham Road
Pagham
West Sussex
PO21 3PY

Performed By:
Geo Environmental Group
GEG House
17 Graham Road
Malvern
WR14 2HR

On Behalf Of:
Hallam Land Management
c/o Brookbanks
6150 Knights Court
Solihull Parkway
Birmingham
B37 7WY

Written by:

[redacted]

Matthew Perks
BSc(Hons) MSc FGS
Principal Geo-Environmental Engineer

Checked & Approved by:

[redacted]

Mark Rawlings
BSc(Hons) MSc FGS CGeol
Associate Director

Project Reference: GEG-20-666

Report Reference: GEG-20-666/GW

Issue Status: FINAL

Date of Issue: Rev. 00: 6th April 2021

TABLE OF CONTENTS *PAGE*

Title *Appendix*

1. INTRODUCTION

1.1 General

Geo Environmental Group (GEG) were commissioned by Brookbanks on behalf of Hallam Land Management (HLM) (the Client) to undertake groundwater monitoring at a site known as 'Land at Pagham Phase II, West Sussex'.

The aim of the investigation was to:

- Undertake the installation of groundwater monitoring boreholes with subsequent groundwater over the winter months.
- Produce a factual report detailing the work undertaken.

A Phase I Review & Phase II Geo-Environmental Assessment was previously undertaken on a site adjacent to the north east known as 'Land at Pagham, West Sussex' by GEG on behalf of Brookbanks/HLM (Ref. GEG-19-623/PI_PII, dated 30th January 2020).

1.2 Available Information

The following drawings were supplied by Brookbanks:

- 'Pagham Phase II - Groundwater Monitoring Location Plan Request,' Brookbanks on behalf of HLM, Drawing No. 10461-SI-02, dated 10th December 2020.
- Various utility company service drawings.

GEG also purchased additional utility company service drawings of the site.

1.3 Proposed Site Development

It is understood that the site is proposed for residential development; no further information is available at this stage.

1.4 Scope

The works performed by GEG included:

- Preliminary ground investigation for the installation of standpipes for subsequent groundwater monitoring.

Limitations to the scope of the report are outlined in Section 6.

2. SITE SETTING

2.1 Site Location

The site is located in Pagham (approximately 4.5 km west of the centre of Bognor Regis) in West Sussex, at the approximate National Grid Reference 489149E, 98972N. It lies on the western side of Pagham Road south of Rookery Farm and covers an area of approximately 4.6 ha.

A section of the 1:25,000 Ordnance Survey (OS) map identifying the site location is shown in Figure 1 of Appendix A. The site layout plan is presented in Figure 2 (Appendix A) and a photographic record is provided in Appendix B.

2.2 Site Description

The site comprised a relatively level arable agricultural field bounded by mature hedgerow with occasional deciduous trees.

Topographically, the site was relatively level at an elevation of approximately 5m AOD.

2.3 Adjacent Land Uses

A summary of surrounding land-use in the immediate vicinity of the site is provided below.

North East	Small drain followed by Rockery Farm.
South East	Pagham Road followed by an agricultural field.
South West	Residential development.
North West	Residential development and agricultural fields.

3. GEOLOGY, HYDROLOGY, HYDROGEOLOGY

3.1 Published Geology

Reference to the 1:50,000 scale British Geological Survey digital mapping of the area (solid and drift) indicates that the solid geology beneath the site comprises the London Clay Formation of the Palaeogene period. It is described as poorly laminated, blue grey or grey brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay. It commonly contains thin courses of carbonate concretions ('cementstone nodules') and disseminated pyrite. It also includes a few thin beds of shells and fine sand partings or pockets of sand.

The solid geology is conjectured to be overlain by superficial deposits of River Terrace Deposits (RTD) across the majority of the site, described generically as sand and gravel, locally with lenses of silt, clay or peat. The westernmost section of the site is conjectured to be overlain by Raised Beach Deposits 1, generically described as shingle, sand, silt and clay. Raised Marine Deposits (clay, silt, sand and gravel) are also indicated to overlie the central part of the western boundary.

No faults are conjectured to intersect the site at the surface.

3.2 Hydrogeology

3.2.1 Groundwater Designation

The database search report indicates that the solid geology directly beneath the site is designated as Unproductive Strata.

Unproductive Strata - are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

The superficial deposits of the River Terrace Deposits are characterised as a Secondary A Aquifer and the Raised Beach and Marine Deposits as a Secondary Undifferentiated Aquifer.

Secondary A Aquifers are defined as permeable layers capable of supporting water supplies at a local rather than a strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

Secondary (Undifferentiated) Aquifers are assigned where it is not possible to attribute either category A or B to a rock type. In general these layers have previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

3.2.2 Groundwater Source Protection Zone

The site does not lie within a currently defined Groundwater Source Protection Zone (GWSPZ).

3.3 Hydrology

3.3.1 Nearest Watercourse

The nearest surface water feature is a drain adjacent to the north of the site flowing westwards (via a pond approximately 25m west of the site) towards the Pagham Rife approximately 225m west of the site.

3.3.2 Surface Water Flooding

According to the Environment Agency online 'Flood Map for Planning', the majority of the site lies within Flood Zone 1, being land that lies outside the 1 in 1000 year (0.1%AEP) flood risk area and hence has a low probability of flooding.

However, Flood Zones 2 and 3 marginally extend over the north western boundary of the site.

Flood Zone 2: This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.

Flood Zone 3: 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.

3.4 Ordnance

According to regional unexploded bomb risks maps provided by Zetica, the site falls within an area of low bomb risk and therefore no further action is required.

4. INTRUSIVE INVESTIGATION

4.1 Site Works Overview

The following section outlines the scope of the intrusive investigation carried out by GEG in accordance with the Brookbanks specification and details the ground conditions encountered and the chemical testing undertaken.

All work was undertaken in general accordance with British Standard guidance (BS:5930:2015 and BS:10175) and the ICE UK Specification for Ground Investigation (2nd Edition 2012) guidelines.

Prior to commencement of the works, service plans were viewed in order to investigate the location of all major services and each exploratory hole location screened with a cable avoidance tool.

The exploratory holes were logged and sampled by an experienced geo-environmental engineer from GEG. The ground conditions encountered were recorded on the exploratory hole logs (Appendix C). Where the sample is disturbed but some guidance as to the in-situ consistency can be sensibly given, the consistency term is given in brackets, in accordance with BS:5930:2015.

The locations of the exploratory holes are shown on Figure 2 presented in Appendix A.

4.1.1 Limitations of Intrusive Investigation

There were no limitations to access across the site for the duration of the intrusive investigation.

4.1.2 Reinstatement

All boreholes were installed with 50mm diameter gas and groundwater monitoring standpipes and lockable flush cover. The surface covers were removed following completion of the groundwater monitoring to allow crop rotation.

4.2 Site Works

4.2.1 General

The intrusive investigation was undertaken on 21st and 22nd January 2021 and comprised window sample boreholes.

4.2.2 *Window Sample Holes*

7 No. window sample boreholes (WS01-WS07) were drilled using a Competitor Dart dynamic sampling rig to a maximum depth of 5.00m. Each window sample hole was preceded by concrete coring and a hand excavated service avoidance pit to a maximum depth of 1.20m below ground level (BGL).

All boreholes were installed with 50mm diameter standpipes to depths detailed on the exploratory hole logs for subsequent groundwater monitoring. Although, boreholes typically refused on dense SAND prior to reaching 5.00m depth, all standpipes were installed below the groundwater level encountered during drilling.

4.2.3 *Rationale for Exploratory Holes*

The rationale for the exploratory locations, which was undertaken in accordance with the Brookbanks' specification, is given in Table 1 below. A plan showing the location of the exploratory holes is included as Figure 2.

Table 1. Rationale for Exploratory Holes

Exploratory Hole	Rationale
WS01-WS07	General coverage

4.2.4 *Initial Gas Monitoring*

Initial gas monitoring was undertaken on 26th February and 26th March 2021. The standpipes were monitored for methane, carbon dioxide, oxygen, hydrogen sulphide and the borehole flow rate using a GA2000 gas analyser. Atmospheric pressure and trend was also recorded.

Table 2. Gas Monitoring Results

Borehole	Date	Atmospheric Pressure (mb)	Atmospheric Pressure Trend	Methane (% Vol.)	Carbon Dioxide (% Vol.)	Oxygen (% Vol.)	Hydrogen Sulphide (ppm)	Borehole Flow (l/hr)
WS01	26/02/21	Borehole location flooded at surface						
	26/03/21	1008	Falling	0.0	0.3	18.8	0	0.0
WS02	26/02/21	1035	Rising	0.0	0.2	19.6	0	0.5
	26/03/21	1008	Falling	0.0	0.5	16.5	0	0.0
WS03	26/02/21	1033	Rising	0.0	0.0	20.3	0	0.7
	26/03/21		Falling	0.0	0.0	21.1	0	0.0
WS04	26/02/21	Borehole location flooded at surface						
	26/03/21	1007	Falling	0.0	0.1	20.5	0	0.0
WS05	26/02/21	1035	Rising	0.0	0.1	21.1	0	0.3

Borehole	Date	Atmospheric Pressure (mb)	Atmospheric Pressure Trend	Methane (% Vol.)	Carbon Dioxide (% Vol.)	Oxygen (% Vol.)	Hydrogen Sulphide (ppm)	Borehole Flow (l/hr)
	26/03/21	1008	Falling	0.0	0.1	20.8	0	0.0
WS06	26/02/21	1033	Rising	0.0	0.6	20.1	0	1.0
	26/03/21	1007	Falling	0.0	0.9	19.4	0	0.1
WS07	26/02/21	1035	Rising	0.0	0.0	21.2	0	0.2
	26/03/21	1007	Falling	0.0	0.3	20.7	0	0.1

The gas monitoring results recorded low methane concentrations of 0.0% and low carbon dioxide concentrations of 0.0% to 0.9% with a maximum borehole flow rate 1.0 l/hr.

The water levels were monitored using a dip meter; results are presented in Section 4.3.6.

4.3 Ground Conditions Encountered

The ground conditions encountered are described below and broadly confirmed the published geology.

4.3.1 Made Ground

No Made Ground was encountered in the exploratory holes.

4.3.2 Topsoil

Typically soft CLAY topsoil was encountered across site to depths of 0.30m to 0.40m.

4.3.3 River Terrace Deposits

River Terrace Deposits were encountered underlying the topsoil to depths of >2.50m to >4.00m and typically comprised horizons of variably gravelly firm CLAY and medium dense to dense SAND. Soft to firm CLAY was encountered from 1.60m to 2.30m in WS05.

4.3.4 Raised Beach / Marine Deposits

Raised Beach / Marine Deposits were not encountered in the exploratory holes. However, as these deposits are potentially similar in composition to the River Terrace Deposits, differentiation between the stratums is sometimes problematic.

4.3.5 London Clay Formation

The London Clay Formation was encountered underlying the River Terrace Deposits in 1 No. location (WS02) from a depth of 3.00m to the base the exploratory hole. It comprised stiff CLAY.

4.3.6 *Groundwater*

Groundwater was encountered in all of the exploratory holes during the investigation, as detailed in Table 3A.

Table 3A. Groundwater Inflows Recorded During the Investigation

Exploratory Hole	Groundwater Depth (m)	Stratum
WS01	1.00	River Terrace Deposits
WS02	0.83	
WS03	0.78	
WS04	0.30	
WS05	0.90	
WS06	0.79	
WS07	0.38	

Groundwater levels recorded in the boreholes during the subsequent monitoring visits are summarised in Table 3B.

Table 3B. Groundwater Levels Recorded During the Monitoring Visits

Borehole	Date	Depth of Installation (m)	Groundwater Depth (m)
WS01	26.02.21	2.50	Flooded at Surface
	26.03.21		0.74
WS02	26.02.21	4.00	0.88
	26.03.21		1.08
WS03	26.02.21	2.00	0.77
	26.03.21		0.85
WS04	26.02.21	2.00	0.44
	26.03.21		0.81
WS05	26.02.21	2.00	0.86
	26.03.21		1.08
WS06	26.02.21	2.50	1.15
	26.03.21		1.38
WS07	26.02.21	1.50	0.76
	26.03.21		0.99

It should be noted that groundwater levels may vary due to seasonal and other effects.

5. REFERENCES

1. British Standard Institute (1990) BS: 1377 Parts 1-9. Methods of Tests for Soils for Civil Engineering Purposes.

2. British Standard Institute (2015) BS: 5930 Code of Practice for Site Investigations. BSI, London.

3. British Standard Institute (2015+A1:2019) BS: 8485 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.

4. British Standard Institute (2011) BS: 10175 Code of Practice for Investigation of Potentially Contaminated Sites. BSI, London.

5. BRE Report 414 (2001). Protective measures for housing on gas-contaminated land. BRE Press, Berkshire.

6. BRE Digest 412 (February 1996). Desiccation in clay soils.

7. ICE Publishing (2012) UK Specification for Ground Investigation – Second Edition. Site Investigation Steering Group.

8. Wilson, S. & Card, G. CIRIA/Environmental Protection UK Ground Gas Seminar – 22nd June 2011 and 13th September 2011. A pragmatic approach to ground gas risk assessment for the 21st Century.

6. LIMITATIONS

As with all intrusive site investigations, there is a possibility that localised contamination 'hotspots'/geotechnical features remain undetected on the site. Therefore, as with standard practices, this report does not provide a warranty to cover limited localised contamination 'hotspots'/geotechnical features or any post-investigation importation of contamination.

The conclusions and recommendations stated herein are based on information available at the time of production. These may not necessarily apply if the site is to be utilised for a more or less sensitive purpose in the future, or if operational procedures or management alter over time.

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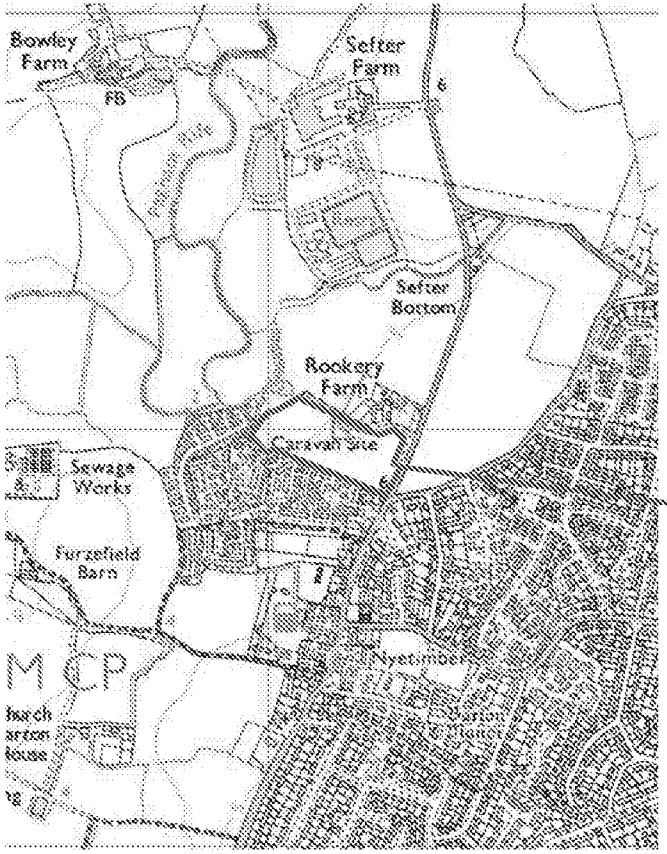
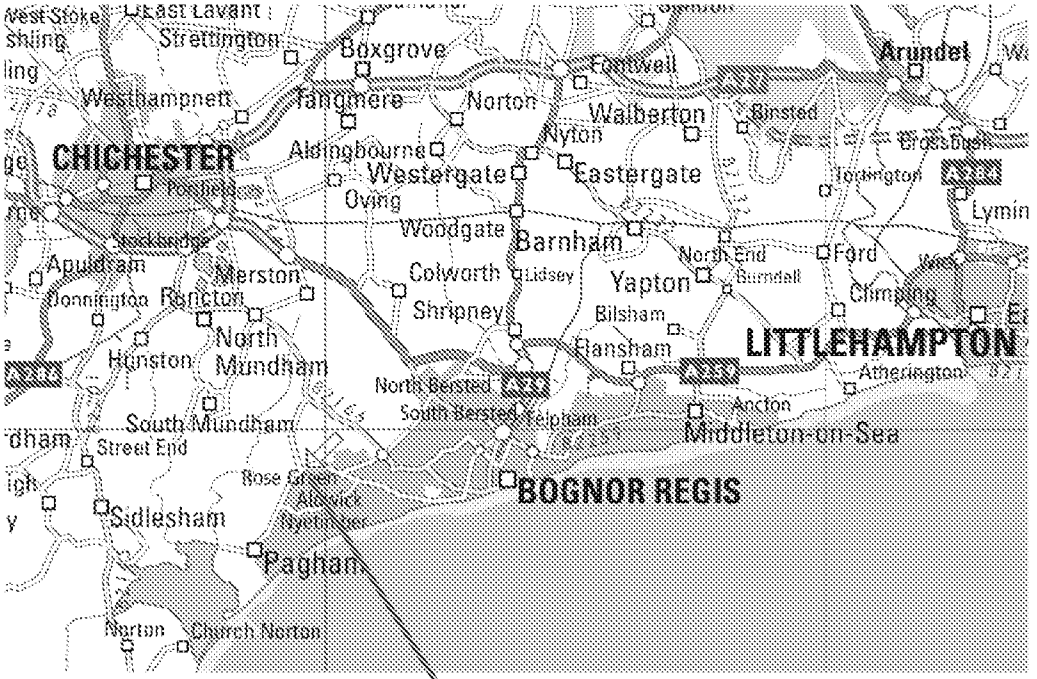
Whilst GEG may identify the presence of potential invasive plant species during the standard geo-environmental walkover and/or investigations, the Client should be aware that ecological issues including an invasive species surveys etc. are beyond the scope of the works and as such no associated liability is accepted by GEG.

APPENDIX A

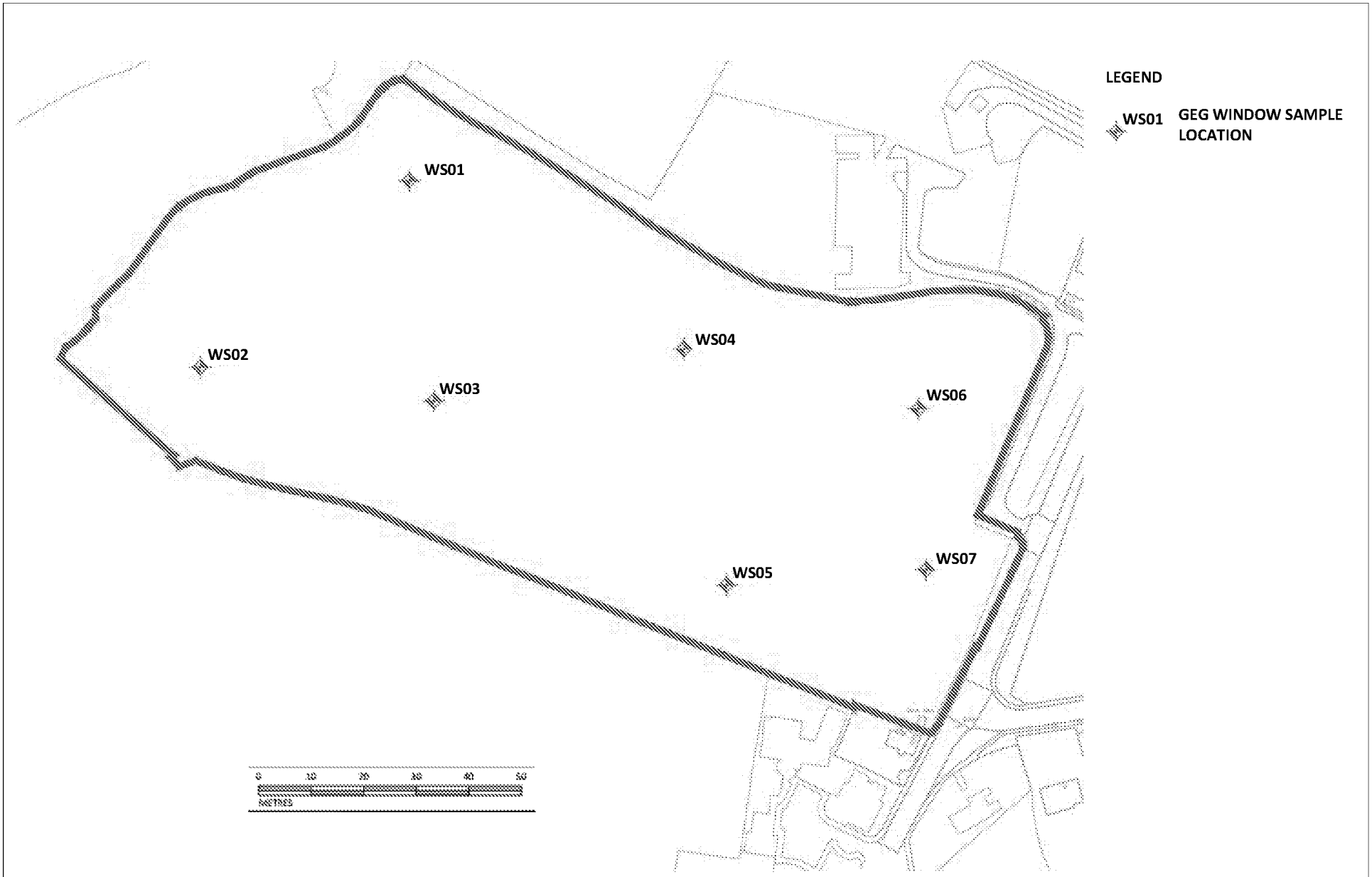
FIGURES AND PLANS





SITE LOCATION

TITLE: FIGURE 1: SITE LOCATION PLAN	**CLIENT:** BROOKBANKS / HLM		**DRAWN/CHECKED:** MP / MR		GEG House, 17 Graham Road Malvern, WR14 2HR Tel. 01684 212526 Fax 01684 576917 admin@g-eg.co.uk, www.g-eg.co.uk Geo Environmental Group
SITE: PAGHAM PHASE II, WEST SUSSEX	**PROJECT No.:** GEG-20-666	**SCALE:** NTS	**DATE:** 03/02/21	**REVISION:** A	



TITLE: FIGURE 2: EXPLORATORY HOLE LOCATION PLAN	**CLIENT:** BROOKBANKS / HLM		**DRAWN/CHECKED:** JM / MP		GEG House, 17 Graham Road Malvern, WR14 2HR Tel. 01684 212526 Fax 01684 576917 admin@g-eg.co.uk, www.g-eg.co.uk Geo Environmental Group
SITE: PAGHAM PHASE II, WEST SUSSEX	**PROJECT No.:** GEG-20-666	**SCALE:** AS SHOWN	**DATE:** 15/03/21	**REVISION:** A	

APPENDIX B

PHOTOGRAPHIC RECORD

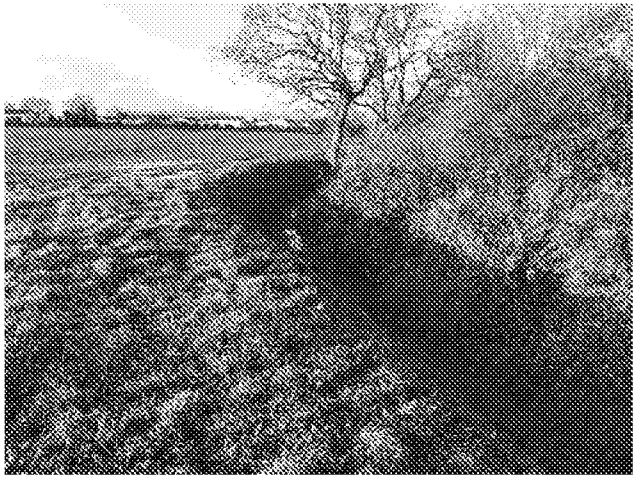


Photo 1: View west across the northern boundary of the site.

Photo 2: View south across the eastern section of the site.

Photo 3: View south west across the site.

Photo 4: View west across the site.

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GEG House
17 Graham Road
Malvern
WR14 2HR

Client: Brookbanks / HLM

Project: Pagham Phase II, West Sussex

Project No.: GEG-20-666

APPENDIX C

EXPLORATORY HOLE LOGS

Borehole Log

Geo Environmental Group

Borehole No. **WS01**

Sheet 1 of 1

Project Name: Pagham II	Project No. GEG-20-666	Co-ords:	Hole Type WS
Location: Hook Lane, Rose Green, Bognor Regis, PO21 3PD		Level:	Scale 1:31
Client: Brookbanks / HLM		Dates: 21/01/2021	Logged By AT

Well	Water Strikes	Sample and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
					0.00			Soft brown slightly gravelly silty CLAY. Gravel is fine to medium mixed lithologies. (TOPSOIL)
					0.30			Firm light brown slightly sandy CLAY. (RIVER TERRACE DEPOSITS)
					1.60			Medium dense light brown slightly clayey gravelly fine to medium SAND. Gravel is fine to coarse sub-rounded to sub-angular flint. (RIVER TERRACE DEPOSITS)
					2.50			End of Borehole at 2.500m

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5

Remarks

1. Service pit to 1.20m. 2. Groundwater encountered at 1.00m. 3. Borehole refused on medium dense SAND with continual collapse of sides due to groundwater. 4. 50mm standpipe installed 2.50m, response zone 2.50-1.00m, bentonite seal 1.00-0.30m, flush cover concreted 0.30-0.00m. 5. Equipment used: Dando Terrier Window Sampling Rig.

Borehole Log

Geo Environmental Group

Borehole No. **WS02**

Sheet 1 of 1

Project Name: Pagham II	Project No. GEG-20-666	Co-ords:	Hole Type WS
Location: Hook Lane, Rose Green, Bognor Regis, PO21 3PD		Level:	Scale 1:31
Client: Brookbanks / HLM		Dates: 22/01/2021	Logged By AT

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.00			Soft brown slightly gravelly silty CLAY. Gravel is fine to coarse sub-angular flint. (TOPSOIL)
					0.40			Firm brown slightly sandy CLAY. (RIVER TERRACE DEPOSITS)
	▼				0.70			Firm brown sandy gravelly CLAY. Gravel is fine to coarse sub-angular to sub-rounded flint. (RIVER TERRACE DEPOSITS)
					1.00			Firm light brown sandy CLAY. (RIVER TERRACE DEPOSITS)
					3.00			Stiff grey CLAY. (LONDON CLAY FORMATION)
					5.00			End of Borehole at 5.000m

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5

Remarks

1. Service pit to 1.20m. 2. Groundwater encountered at 0.83m. 3. 50mm standpipe installed 4.00m, response zone 4.00-1.00m, bentonite seal 1.00-0.30m, flush cover concreted 0.30-0.00m. 4. Equipment used: Dando Terrier Window Sampling Rig.

Borehole Log

Geo Environmental Group

Borehole No. **WS03**

Sheet 1 of 1

Project Name: Pagham II	Project No. GEG-20-666	Co-ords:	Hole Type WS
Location: Hook Lane, Rose Green, Bognor Regis, PO21 3PD		Level:	Scale 1:31
Client: Brookbanks / HLM		Dates: 22/01/2021	Logged By AT

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
	▼				0.00			Soft brown silty CLAY. (TOPSOIL)
					0.30			Firm light brown sandy CLAY. (RIVER TERRACE DEPOSITS)
					1.50			Medium dense light brown clayey slightly gravelly fine to medium SAND. Gravel is fine to coarse sub-angular to sub-rounded flint. (RIVER TERRACE DEPOSITS)
					2.50			End of Borehole at 2.500m

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5

Remarks

1. Service pit to 1.20m. 2. Groundwater encountered at 0.78m. 3. Borehole refused on medium dense SAND with continual collapse of sides due to groundwater. 4. 50mm standpipe installed 2.00m, response zone 2.00-1.00m, bentonite seal 1.00-0.30m, flush cover concreted 0.30-0.00m. 5. Equipment used: Dando Terrier Window Sampling Rig.

Borehole Log

Geo Environmental Group

Borehole No. **WS04**

Sheet 1 of 1

Project Name: Pagham II	Project No. GEG-20-666	Co-ords:	Hole Type WS
Location: Hook Lane, Rose Green, Bognor Regis, PO21 3PD		Level:	Scale 1:31
Client: Brookbanks / HLM		Dates: 21/01/2021	Logged By AT

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
	▼				0.00			Soft brown slightly gravelly silty CLAY. Gravel is fine to medium sub-angular to sub-rounded mixed lithologies. (TOPSOIL)
					0.30			Firm light brown slightly sandy CLAY. (RIVER TERRACE DEPOSITS)
					1.50			Medium dense orangish brown slightly clayey slightly gravelly fine to medium SAND. Gravel is fine to coarse sub-angular to sub-rounded flint. (RIVER TERRACE DEPOSITS)
					3.00			End of Borehole at 3.000m

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5

Remarks

1. Service pit to 1.20m. 2. Groundwater encountered at 0.30m. 3.Borehole refused on medium dense SAND with continual collapse of sides due to groundwater. 4. 50mm standpipe installed 2.00m, response zone 2.00-1.00m, bentonite seal 1.00-0.30m, flush cover concreted 0.30-0.00m. 5. Equipment used: Dando Terrier Window Sampling Rig.

Borehole Log

Geo Environmental Group

Borehole No. **WS05**

Sheet 1 of 1

Project Name: Pagham II	Project No. GEG-20-666	Co-ords:	Hole Type WS
Location: Hook Lane, Rose Green, Bognor Regis, PO21 3PD		Level:	Scale 1:31
Client: Brookbanks / HLM		Dates: 22/01/2021	Logged By AT

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
	▼				0.00			Soft brown silty CLAY. (TOPSOIL)
					0.30			Firm brown slightly sandy CLAY. (RIVER TERRACE DEPOSITS)
					1.60			Soft to firm light brown sandy slightly gravelly CLAY. Gravel is fine to coarse sub-angular flint. (RIVER TERRACE DEPOSITS)
					2.30			Dense light brown slightly gravelly fine to medium SAND. Gravel is fine to coarse sub-angular to sub-rounded flint. (RIVER TERRACE DEPOSITS)
					3.00			End of Borehole at 3.000m

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5

Remarks

1. Service pit to 1.20m. 2. Groundwater encountered at 0.90m. 3. Borehole refused on medium dense SAND with continual collapse of sides due to groundwater. 4. 50mm standpipe installed 2.00m, response zone 2.00-1.00m, bentonite seal 1.00-0.30m, flush cover concreted 0.30-0.00m. 5. Equipment used: Dando Terrier Window Sampling Rig.

Borehole Log

Borehole No. **WS06**

Sheet 1 of 1

Project Name: Pagham II	Project No. GEG-20-666	Co-ords:	Hole Type WS
Location: Hook Lane, Rose Green, Bognor Regis, PO21 3PD		Level:	Scale 1:31
Client: Brookbanks / HLM		Dates: 21/01/2021	Logged By AT

Well	Water Strikes	Sample and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
					0.00			Soft brown slightly gravelly silty CLAY. Gravel is fine to medium sub-angular to sub-rounded mixed lithologies. (TOPSOIL)
					0.30			Firm light brown slightly sandy CLAY. (RIVER TERRACE DEPOSITS)
					1.80			Medium dense light brown slightly clayey slightly gravelly fine to medium SAND. Gravel is fine to coarse sub-angular to sub-rounded flint. (RIVER TERRACE DEPOSITS)
					4.00			End of Borehole at 4.000m

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5

Remarks

1. Service pit to 1.20m. 2. Groundwater encountered at 0.79m. 3. Borehole refused on medium dense SAND with continual collapse of sides due to groundwater. 4. 50mm standpipe installed 2.50m, response zone 2.50-1.00m, bentonite seal 1.00-0.30m, flush cover concreted 0.30-0.00m. 5. Equipment used: Dando Terrier Window Sampling Rig.

Borehole Log

Borehole No. **WS07**

Sheet 1 of 1

Project Name: Pagham II	Project No. GEG-20-666	Co-ords:	Hole Type WS
Location: Hook Lane, Rose Green, Bognor Regis, PO21 3PD		Level:	Scale 1:31
Client: Brookbanks / HLM		Dates: 21/01/2021	Logged By AT

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
	▼				0.00			Soft brown slightly gravelly CLAY. Gravel is fine to medium sub-angular to sub-rounded mixed lithologies. (TOPSOIL)
					0.30			Firm brown silty CLAY. (RIVER TERRACE DEPOSITS)
					1.90			Medium dense light brown slightly clayey slightly gravelly fine to medium SAND. Gravel is fine to medium sub-angular flint. (RIVER TERRACE DEPOSITS)
					2.00			End of Borehole at 2.000m

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5

Remarks

1. Service pit to 1.20m. 2. Groundwater encountered at 0.38m. 3. Borehole refused on medium dense SAND with continual collapse of sides due to groundwater. 4. 50mm standpipe installed 1.50m, response zone 1.50-1.00m, bentonite seal 1.00-0.30m, flush cover concreted 0.30-0.00m. 5. Equipment used: Dando Terrier Window Sampling Rig.

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