Flood Risk Assessment & SuDS Drainage Report

December 2023

EAS

Land to the West of Clatterbury Lane

Clavering,
Essex,
CB11 4QS

Baya Group Ltd.

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Document History

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The content of this report is based on information available as of December 2023, the validity of the statements made may therefore vary over time as planning guidance / policies and the evidence base change.

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1 Introduction

1.1 This Flood Risk Assessment and SuDS Strategy report has been prepared in support of an Outline Planning Application by BAYA Group on behalf of E&A Securities for the proposed development on land to the west of Clatterbury Lane, Clavering, Essex. The proposals are: *"Outline Application with all matters reserved except access for up to 28 dwellings (Class C3) including public open space, sustainable drainage systems, landscaping and associated infrastructure and development."*

1.2 The site is located off Stickling Green, Clavering Saffron Walden, CB11 4QS, and is 1.26ha in size. A location plan in enclosed in **Appendix A.** Development proposals are enclosed in **Appendix B**.

1.3 The site is shown to be at a low risk of a fluvial (river) flood event, being located within the Flood Zone 1 on the Flood Map for Planning. Flood Zone 1 is defined as having <0.1% annual probability of river flooding.

1.4 The western-most side of the site is shown by EA Long Term Flood Risk Mapping to be at risk of surface water flooding, which looks to be mainly attributed to greenfield runoff from the site itself becoming overland in only the very extreme events.

1.5 In a high-risk scenario (a 3.3% annual risk) no proposed dwellings are located within the flood extent. In a medium-risk scenario (between 3.3% and 1% annual risk), minor encroachment to 2no. proposed dwellings of the flood extent occurs, though it should be noted that the maximum depth reaches 150mm only. This Flood Risk Assessment includes demonstration that surface water flooding is suitably managed. The properties have therefore been sequentially located outside the highest surface water flood extent, with medium risk surface water flooding suitably mitigated.

1.6 The low-risk mapping shows flood water up to the 1:1000yr event and provides a useful exceedance event check and in this case shows low (up to 300mm) depth floodwater along the western boundary of the site. Following development, much of this greenfield runoff from the site will be collected and controlled by the site drainage and all properties will also be set a minimum of 300mm above the surrounding ground level. It is therefore determined that there is no risk to proposed dwellings even in the 1000yr event.

1.7 The underlying geology suggests infiltration could be viable at the site, however as this is an Outline Application, the SuDS Drainage Strategy will offer two Options. Option 1 will be based on an Infiltration Strategy, using typical infiltration coefficients from Table 25.1 in CIRIA SuDS Manual and Option 2 will be based on an Attenuation Strategy with outfall directed to watercourse, which would only be implemented should it be proven that infiltration is unviable. It is anticipated that a suitably worded Condition could be attributed to any Decision Notice which requires full BRE 365 Infiltration Testing to be undertaken at a later design stage. For this Outline Application, the two Options demonstrate that surface water runoff from the site can be suitably managed in line with NPPF and Lead Local Flood Authority requirements.

1.8 The contents of this report are based on the advice set out in the National Planning Policy Framework (NPPF) published in July 2021 and Annex 3: Flood risk vulnerability classification, also obtained from the NPPF, and PPG 'Guidance for Flood Risk and Coastal Change', updated August 2022.

1.9 This report is based on a site-specific topographic survey, BGS geological maps, Environment Agency (EA) flood maps, DEFRA flood data, local flood risk policy, and OS mapping.

1.10 This document includes the following sections:

Section 2 - describes the relevant policy;

Section 3 - site description, including site levels, proximity to watercourses etc.;

Section 4 – investigates each flood source and recommends any mitigation measures;

Section 5 - details specific mitigation measures;

Section 6 - details the SuDS policy and proposed infiltration drainage strategy;

Section 7 - details the SuDS policy and proposed attenuation drainage strategy;

Section 8 – describes the maintenance schedule for the proposed drainage strategies; and

Section 9 - concludes the report.

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2 Policy Context

Introduction

2.1 This section sets out the policy context. This report is based on the advice set out in the National Planning Policy Framework (NPPF) last updated in September 2023 and the Planning Practical Guidance (PPG) updated in August 2022.

2.2 Paragraph 167 footnote 55 of the NPPF states:

"A site-specific flood risk assessment should be provided for all developments in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving: sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a strategic flood risk assessment as being at increased flood risk in future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use."

2.3 The flood zones are defined as:

- Flood Zone 1 - less than a 0.1% (1 in 1000) annual probability of river or tidal flooding.
- Flood Zone 2 - between a 0.1% and 1% (1 in 1000 and 1 in 100) annual probability of river flooding; or between a 0.1% and 0.5% (1 in 1000 and 1 in 200) annual probability of flooding from tidal sources.
- Flood Zone 3a- This zone comprises land assessed as having a 1% (1 in 100) or greater annual probability of river flooding; and for tidal flooding at least a 0.5% (1 in 200) annual probability of flooding from tidal sources.
- Flood Zone 3b - This zone comprises land where water has to flow or be stored in times of flood. This classification is usually classified as land which had a 3.33% (1 in 30) annual probability of flooding.

2.4 Paragraph 159 discusses the suitability of development location, particularly with regards to future risks induced by climate change:

"Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere".

2.5 Paragraph 160 of the National Planning Policy Framework (NPPF) sets out how:

"Strategic policies should be informed by a strategic flood risk assessment, and should manage flood risk from all sources. They should consider cumulative impacts in, or affecting, local areas susceptible to flooding, and take account of advice from the Environment Agency and other relevant flood risk management authorities, such as lead local flood authorities and internal drainage boards".

2.6 Paragraphs 169 NPPF discusses the application of sustainable drainage systems:

"Major developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate. The systems used should:

- Take account of advice from the lead local flood authority;
- Have appropriate proposed minimum operational standards;
- Have maintenance arrangements in place to ensure an acceptable standard of operation of the lifetime of the development; and
- Where possible, provide multifunctional benefits."

2.7 The Flood Map for Planning shows that other than the River Bank, the site is located entirely in Flood Zone 1, at 'low' risk of flooding from fluvial sources. The EA Flood Map has been enclosed in **Appendix C.** This is considered to be an area with less than 0.1% annual chance of flooding.

Local Policy

The Sustainable Drainage Systems Design Guide for Essex

2.8 This guide was prepared by Essex County Council to aid developers, designers and consultants in the design of Sustainable Drainage Systems (SuDS) in Essex. The guidance is intended to advise on the planning, design and delivery of attractive and high-quality SuDS scheme to benefit both the environment and the community. The website contains all the information on the SuDS Design Guide for Essex and can be accessed here: https://www.essexdesignguide.co.uk/suds

2.9 This guidance was considered and used to inform the development of the proposed SuDS strategy for the site.

Uttlesford District Adopted Local Plan (2005)

2.10 The 'Uttlesford Local Plan 2019' draft was withdrawn in April 2020 and will now commence a new draft.

2.11 Once complete the new Local Plan will guide development in the district until 2033. The new local plan will set out areas suitable for new housing and will ensure the necessary infrastructure is put in place to support the growth expected in the district.

2.12 In the meantime, the Uttlesford Adopted Local Plan 2005 is the relevant document.

2.13 Policy GEN3: Flood Protection of the Adopted Local Plan 2005 states:

"Outside flood risk areas development must not increase the risk of flooding through surface water run-off. A flood risk assessment will be required to demonstrate this. Sustainable Drainage Systems should also be considered as an appropriate flood mitigation measure in the first instance.

For all areas where development will be exposed to or may lead to an increase in the risk of flooding applications will be accompanied by a full Flood Risk Assessment (FRA) which sets *out the level of risk associated with the proposed development. The FRA will show that the proposed development can be provided with the appropriate minimum standard of protection throughout its lifetime and will demonstrate the effectiveness of flood mitigation measures proposed."*

2.14 This report demonstrates that the proposed development will use SuDS methods to manage the volume and rate of surface water runoff and the proposals will not increase flood risk to the local area.

Uttlesford District Council Strategic Flood Risk Assessment (May 2016)

2.15 The Uttlesford Strategic Flood Risk Assessment (SFRA) was published in May 2016, providing an update to the original report (published in 2008) in response to several legislative changes including the Flood & Water Management Act of 2010 and SuDS guidance published in 2015.

2.16 Uttlesford is located within the headwaters of three major river catchments including the Great Ouse, North Essex and Thames. Surface water flooding and flooding sourced from ordinary watercourses is noted as a significant issue across the district.

2.17 Map 2 indicates the presence of an EA Main River of the Stickling Green Brook which runs in close proximity to the site before joining with the River Stort.

2.18 Map 3 depicts dominant superficial geology deposits sourced from the British Geological Survey (BGS), showing the site to be an area with Diamicton deposits – poorly sorted sedimentary rock with varying clast sizes combined via a matrix of mud and sand.

2.19 Map 4 shows there is an underlying bedrock geology of White Chalk Subgroup – a fine-grained calcium carbonate/calcite rock formation with high porosity.

2.20 Map 5 highlights that there are no historic flooding records at or near the site.

2.21 Map 6 confirms the site is located within Flood Zone 1, with an area which follows the watercourse, approximately 150m southwest of the site being in Flood Zone 3b.

2.22 Map 7 shows that there is a culvert approximately 200m to the west of the site, and two bridges within 300m south of the site.

2.23 Map 8 illustrates the site area would be affected by surface water flooding for 1 in 30, 1 in 100 and 1 in 1000 year storm events but depicting to what extent these flooding levels affect the site is unclear due to the low granularity of the map.

2.24 Map 9 shows the site is not located within an area which is susceptible to groundwater flooding.

2.25 Map 10 indicates that the site is located in an a postcode area with 1-5 properties on the sewer flooding register.

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3 Existing Site Assessment

Site Description

3.1 The site is located at the land off Stickling Green, Clavering, Saffron Walden, CB11 4QS, a location plan is included in **Appendix A**. At present, the site is entirely greenfield, with a site area of 1.26ha, bound by Stickling Green to the north, Clatterbury Lane to the east, and agricultural land to the south and west.

3.2 The proposed development plans are included at **Appendix B** and show the Outline Application site layout for up to 28no. residential dwellings with associated landscaping; car parking and amenity spaces and access to the north of the site via Stickling Green.

Local Watercourses

3.3 An "EA Main River", the Stickling Green Brook, runs approximately 120m southwest of the site flowing in a southerly direction before joining the River Stort in Clavering. A tributary of the Stickling Green Brook forms the western boundary of the site.

Site Levels

3.4 A topographical survey is enclosed in **Appendix D**. The site generally falls to the southwest, with highest levels on site recorded at 97.53m AOD located near the northeast corner of the site, whilst the lowest points are located near the southwest border of the site at around 93.95m AOD. It should be noted that the ground levels become steeper along the western half of the site.

Geology

3.5 With reference to the British Geological Survey online mapping [redacted], the site is located within an area underlain by a bedrock of Lewes Nodular Chalk Formation with subsidiary calcareous mudstone and flint. While the superficial deposits on site consist of the Lowestoft Formation – a chalky till with outwash sands, gravels, silts, and clays.

3.6 The underlying geology of chalk with superficial deposits of sands and gravels suggests that infiltration could be a viable option for the disposal of surface water runoff from the site.

Sewer Records

3.7 A map by Thames Water detailing the present sewer records and existing drainage is included in **Appendix E**. This map shows that there is one public foul water sewer that runs in close proximity to the east border of the site along Clatterbury Lane. There are not any public surface water sewers noted in close proximity to the site.

3.8 Map 10 from the Uttlesford SFRA indicates that the site is located in a postcode area (CB11 4) with 1-5 properties on the sewer flooding register.

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Existing Drainage

3.9 The existing site at present is greenfield, it is assumed that there are no drainage systems in place and that surface water flows would move west/southwards across and off towards the ditch along the western boundary of the site, with a percentage of said flows entering the ground via infiltration.

3.10 There are no levels provided for the ditch located along the western boundary of the site due to dense vegetation present, however, it can be anticipated that the ditch lies approximately 0.5m lower than the surrounding bank levels. It is also noted that the ditch gets wider and therefore is expected to be deeper towards the south of the site. It is expected that this ditch leads into the Stickling Green Brook further south of the site.

Infiltration Testing

3.11 The underlying geology suggests infiltration could be viable at the site, however as this is an Outline Application, the SuDS Drainage Strategy will offer two Options. Option 1 will be based on an Infiltration Strategy, using typical infiltration coefficients from Table 25.1 in CIRIA SuDS Manual and Option 2 will be based on an Attenuation Strategy with outfall directed to watercourse, which would only be implemented should it be proven that infiltration is unviable. It is anticipated that a suitably worded Condition could be attributed to any Decision Notice which requires full BRE 365 Infiltration Testing to be undertaken at a later design stage. For this Outline Application, the two Options demonstrate that surface water runoff from the site can be suitably managed in line with NPPF and Lead Local Flood Authority requirements.

4 Potential Sources of Flooding

Fluvial

4.1 A copy of the Environment Agency's Flood Map for Planning is enclosed in **Appendix C**. The site is located in Flood Zone 1. Land in Flood Zone 1 is defined as land having less than a 0.1% (1 in 1000) annual probability of river or tidal flooding.

4.2 The risk of fluvial flooding to the site is considered to be low.

Surface Water

4.3 Surface water flooding refers to flooding caused when the intensity of rainfall, particularly in urban areas, can create runoff which temporarily overwhelms the capacity of the local drainage systems or does not infiltrate into the ground. The water ponds on the ground and flows towards low-lying land. This source of flood risk is also known as 'pluvial'.

4.4 DEFRA surface water flooding data for 3.3%, 1.0% and 0.1% AEP scenarios with categorised flood depths, were analysed in QGIS then overlaid with the proposed development plans, as illustrated in **Appendix F**.

4.5 High risk scenario: 1 in 30 yr (3.3% AEP) - A high-risk scenario, mapping in **Appendix F,** indicates a greater than 3.3% annual exceedance probability (AEP) of surface water flooding, i.e., the most frequently occurring scenario. It can be seen from the overlaid flood depths for the 3.3% AEP event that no proposed dwellings are located within the flood extent.

4.6 Medium risk scenario: 1 in 100 yr (1.0% AEP) - A medium-risk scenario, mapping in **Appendix F**, indicates an AEP of surface water flooding between 3.3% and 1. It can be seen that minor encroachment of the flood extent to 2no. proposed dwellings occurs, though it should be noted that the maximum depth reaches 150mm only. It is considered that surface water flood mitigation shall be offered to mitigate this risk accordingly. As this is an Outline Application, site-specific surface water flood modelling would be disproportionate, as such, an assessment of site levels and flood volumes has been undertaken to confirm the viability of suitable mitigation. SK06 in **Appendix G** shows where surface waters within the 2no. dwelling footprints could be located within open space. The assessment also proves that additional surface water flood volume could be provided, which further demonstrates that should site-specific surface water flood modelling and compensation be undertaken at a later design stage, it is clear that it is achievable.

4.7 Low risk scenario (exceedance event): 1 in 1000 yr (0.1% AEP) - A low-risk scenario indicates an AEP of surface water flooding between 1% and 0.1%, (i.e. the least frequent but worst-case scenario). The low-risk mapping in **Appendix F** shows flood water up to the 1:1000yr event and provides a useful exceedance event check and in this case shows low (up to 300mm) depth floodwater along the western boundary of the site. Following development, much of this greenfield runoff from the site will be collected and controlled by the site drainage and all properties will also be set a minimum of 300mm above the surrounding ground level. It is therefore determined that there is no risk to proposed dwellings even in the 1000yr event.

4.8 Further mitigation measures are discussed in Section 5.

Groundwater

4.9 In reference to the DEFRA online magic map, the site is identified as being located above a Principal Bedrock Aquifer. Principal aquifers provide significant quantities of drinking water, and water for business needs. They may also support rivers, lakes and wetlands.

4.10 Based on the superficial drift, the site is located above a Secondary (undifferentiated) aquifer. These are defined as:

"Aquifers where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type. These have only a minor value."

4.11 The site is located within source protection zone III– Total Catchment. This zone is defined as the total area needed to support the abstraction or discharge from the protected groundwater source. These zones where known local conditions meant that potentially polluting activities could impact on a groundwater source even though the area is outside the normal catchment of that source.

4.12 The site is shown to be located in an area with 'medium' groundwater vulnerability with soluble rock risk. This means the aquifer is at increased risk of pollution via dissolution.

4.13 Because of these two factors, it is important to be aware of the risk discharge to ground poses to the area and those around it. Infiltration testing as well as a hydrological and hydro-geological assessment would need to be undertaken at a later design stage to confirm that discharge via infiltration is viable. The proposed Option 1 Infiltration Strategy ensures that waters are treated and cleansed in line with CIRIA mitigation indices requirements.

4.14 The Uttlesford SFRA identifies that the site is not located in an area with a susceptibility to groundwater flooding.

Reservoir

4.15 The Long Term Flood Map shows the site is not at risk of flooding from reservoirs, and there are no other artificial flood sources nearby. The risk from artificial sources is considered to be low.

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5 Mitigation Measures

5.1 As noted in Section 4, the site is at risk of surface water flooding. In a high risk scenario, no dwellings are affected, in a medium risk scenario 2no. dwellings are shown to be in the flood extent, however it is demonstrated that suitable mitigation in the form of relocating flood volumes, is achievable.

5.2 In an exceedance event (low risk – up to 1:1000yr), surface water flood depths are shown to be up to 300mm deep in the west of the site, broadly following the existing watercourse along the western boundary. The water is shown to develop mainly as a result of greenfield runoff from the development site itself becoming overland in only the very extreme events. Following development, much of this greenfield runoff from the site will be collected and controlled by the site drainage and all properties will also be set a minimum of 300mm above the surrounding ground level. It is therefore concluded that there is no risk of flooding to the proposed dwellings even in the 1000yr event.

Finished Floor Levels

5.3 Indicative proposed ground and FFL's for this Outline Application site are shown on SK06 in **Appendix G**. Raising of FFL's above the exceedance event (low risk 1:1000yr event) will suitably mitigate the surface water flood risk at the site. Further mitigation measures such as Flood Resilient and Resistance Construction Methods are discussed below.

Flood Resilient and Resistant Construction Methods

5.4 Standing Advice for Vulnerable Developments as per DEFRA's guidance on the gov.uk website states:

"The design should be appropriately flood resistant and resilient by:

- *using flood resistant materials that have low permeability to at least 600mm above the estimated flood level*
- *making sure any doors, windows or other openings are flood resistant to at least 600mm above the estimated flood level*
- *using flood resilient materials (for example lime plaster) to at least 600mm above the estimated flood level*
- *by raising all sensitive electrical equipment, wiring and sockets to at least 600mm above the estimated flood level*
- *making it easy for water to drain away after flooding such as installing a sump and a pump*
- *making sure there is access to all spaces to enable drying and cleaning*
- *ensuring that soil pipes are protected from back-flow such as by using non-return valves."*

5.5 There are many flood resilient/resistant construction methods available, which are detailed in the publication by DEFRA entitled 'Improving the Flood Performance of New Buildings.' It is recommended that the project architect/structural engineer reviews this document for further details. Advice is given on foundations, walls, fitting and fixtures and services, some flood resilience/resistant measures which could potentially be applied are included below.

5.6 Any flood resistant measures should be approved by the structural engineer as they may impact upon the building structure.

Floors

5.7 Floor insulation should be of the closed-cell type to minimise the impact of flood water. Insulation placed above the floor slab (and underneath the floor finish) rather than below would minimise the effect of floodwater on the insulation properties and be more easily replaced if required.

5.8 Floor finishes suited to flood resistant properties include ceramic or concrete based floor tiles, stone and sand/cement screeds. All tiles should be bedded on a cement-based adhesive/bedding compound and water-resistant grout should be used. Ceramic tiles and PVC should be used for skirting boards.

Walls

5.9 Raise air vents/bricks to 0.3m above the flood depths.

5.10 For masonry walls, ensure mortar joints are thoroughly filled to reduce the risk of water penetration. Bricks manufactured with perforations should not be used for flood resilient design.

5.11 Internal cement renders with good bond are effective at reducing leakage into a building and assist rapid drying of the internal surface of the wall.

Doors and Windows

5.12 Windows must be adequately sealed to the fabric of the building. Double glazing is recommended for windows and glass doors.

Fixtures and Fittings

5.13 Durable fittings should be used that are not significantly affected by floodwater and can be easily cleaned.

5.14 Electrical appliances, gas oven etc should be placed on plinths as high as practicable above the floor while still complying with building regulations, to ensure they are above the flood level.

5.15 Ensure adequate sealing of joints between kitchen units and surfaces to prevent penetration of water behind fittings.

5.16 Locate all electrical plug sockets at least 0.3m higher than internal floor level.

Services

5.17 Non-return valves are recommended in the drainage system to prevent back-flow.

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5.18 Water, electricity and gas meters, should be located above predicted flood level.

5.19 Electric ring mains should be installed at first floor level with drops to ground floor sockets and switches.

5.20 Heating systems: boiler units and ancillary devices should be installed above predicted flood level.

5.21 Communications wiring: wiring for telephone, TV, Internet, and other services should be protected by suitable insulation agreed with relevant service.

Flood Warning Measures

5.22 Warnings cannot be given for surface water flooding however surface water flooding is likely to correspond with heavy rainfall. Residents are advised to sign up to MET Office weather warning service which can be found here: https://www.metoffice.gov.uk/weather/warnings-and-advice/uk-warnings#?date=2023-10-16.

Emergency Access and Egress

5.23 In a low-risk surface water flood scenario, the flood depths at the proposed site access off Stickling Green is shown to be up to 150mm with some pockets of up to 300mm, which look to be attributed to localised low-spots

5.24 The ADEPT / EA document published September 2019 – 'Flood risk emergency plans for new development A guide for planners: How to consider emergency plans for flooding as part of the planning process', notes that:

- vehicular routes, including for some emergency services vehicles, should not exceed 30cm (12 inches) – less if water is fast flowing - as vehicles can become buoyant and could be swept away in flood conditions. The public should not be expected to drive vehicles through flood waters as part of an EP;

- some emergency services vehicles may be able to cope with slightly greater depths, but site-specific advice from the emergency services should be sought to confirm this;

- routes which are subject to a flood hazard rating of more than 2.0 ('danger for all') would be unsuitable for the emergency services;

5.25 Taking the above into consideration, access to and from the site during a low-risk (1:1000yr) exceedance event is viable and in line with the guidelines.

6 Surface Water Drainage Strategy – Option 1: Infiltration

SuDS Surface Water Drainage Strategy Options

6.1 The underlying geology of Lewes Nodular Chalk Formation and superficial deposits of sands, gravels, silts, and clays suggests infiltration could be viable at the site. As this is an Outline Application, the SuDS Drainage Strategy will offer two Options based on the SuDS Heirarchy.

6.2 Option 1 will be based on an Infiltration Strategy, most preferred method, using typical infiltration coefficients from Table 25.1 in CIRIA SuDS Manual.

6.3 Option 2 will be based on an Attenuation Strategy with outfall directed to watercourse, second most preferred method, which would only be implemented should it be proven that infiltration is unviable. It is anticipated that a suitably worded Condition could be attributed to any Decision Notice which requires full BRE 365 Infiltration Testing to be undertaken at a later design stage. For this Outline Application, the two Options demonstrate that surface water runoff from the site can be suitably managed in line with NPPF and Lead Local Flood Authority requirements.

6.4 The following describes **Option 1 – Infiltration Strategy.**

Relevant SuDS Policy

6.5 SuDS mimic natural drainage patterns and provide a method of surface water drainage which can decrease the quantity of water discharged, and hence reduce the risk of flooding. SuDS design should meet the "four pillars" of SuDS of: water quantity, water quality, amenity and biodiversity, wherever possible.

6.6 In decreasing order of preference, the preferred means of disposal of surface water runoff is:

- Discharge to ground.
- Discharge to a surface water body.
- Discharge to a surface water sewer.
- Discharge to a combined sewer.

Site-Specific SuDS – Infiltration Strategy

6.7 The various SuDS methods need to be considered in relation to site-specific constraints. Several SuDS options are available to reduce or temporarily hold back the discharge of surface water runoff. Table 6.1 outlines the constraints and opportunities to each of the SuDS devices in accordance with the hierarchical approach outlined in The SuDS Manual CIRIA C753. It also indicates what could and could not be incorporated within the development, based upon site-specific criteria.

Device	Description	Constraints / Comments	Appropriate
Living roofs (source control)	Provide soft landscaping at roof level which reduces surface water runoff.	Not possible on main buildings due to pitched roofs.	No
Infiltration devices & Soakaways (source control)	Store runoff and allow water to percolate into the ground via natural infiltration.	Not proposed.	No
Pervious surfaces (source control)	Storm water is allowed to infiltrate through the surface into a storage layer, from which it can either infiltrate and/or slowly release to sewers.	Permeable Paving to be used.	Yes
Rainwater harvesting (source control)	Reduces the annual average rate of runoff from the site by reusing water for non-potable uses e.g. toilet flushing, recycling processes.	Water butts not currently proposed but could be implemented at a later date.	Possibly
Swales (permeable conveyance)	Broad shallow channels that convey / store runoff, and allow infiltration (ground conditions permitting).	A swale has been included for conveyance	Yes
Filter drains & perforated pipes (permeable conveyance)	Trenches filled with granular materials (to take flows from adjacent impermeable areas) that convey runoff while allowing infiltration.	Not proposed.	No
Filter Strips (permeable conveyance)	Wide gently sloping areas of grass or dense vegetation that remove pollutants from run-off from adjacent areas.	Not proposed.	No
Infiltration basins (end of pipe treatment)	Depressions in the surface designed to store runoff and allow infiltration.	Infiltration basin proposed	Yes
Wet ponds & constructed wetlands (end of pipe treatment)	Provide water quality treatment & temporary storage above the permanent water level.	Not proposed.	No
Attenuation Underground (end of pipe treatment)	Oversized pipes or geo-cellular tanks designed to store water below ground level.	Not proposed.	No
Raingardens and Raingarden Planters	Bio-retention Facilities	Raingarden planters could be implemented at a later stage	Possibly

Table 6.1: Site Specific Sustainable Drainage

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Consideration of the SuDS Hierarchy

6.1 As described in paragraphs 6.1 to 6.3, the most preferred method for disposal of surface water runoff it to ground, via soakaway devices with the second most preferred method being disposal to a water-body/watercourse. As there is considered to be high potential for infiltration, the following SuDS Surface Water Drainage Strategy based on infiltration methods has been provided, using typical infiltration coefficients from Table 25.1 in CIRIA SuDS Manual. A conservative infiltration rate of 1×10^{-5} m/s has been applied.

6.2 Option 2, in Section 7 of this report, provides and alternative SuDS Surface Water Drainage Strategy, based on attenuation with outfall to watercourse, and would only be implemented should it be proven that infiltration is unviable via BRE 365 Infiltration Testing.

Surface Water Drainage Design Parameters

6.3 The following best practice design parameters have been considered:

- The local 2070s 'Upper End' Climate Change allowance is 40% and has been applied to the hydraulic drainage network design.
- The Hydraulic Model has been for a 1:2yr Storm Event, 1:10yr Storm Event, 1:30yr Storm Event, 1:30yr + 40% Climate Change Event, 1:100yr Storm Event and 1:100yr + 40% Climate Change Storm Event.
- FEH22 rainfall data has been used.
- The CV Value for Winter and Summer storms has been set to 1.0.
- A 5min time of entry has been used.
- In line with Essex LLFA Guidelines, all attenuation features either have 50% capacity available 24 hours after a 1 in 30-year storm event or have the capacity to store a subsequent 1 in 10-year storm event after a 1 in 30-year storm event.
- 10% urban creep allowance has been applied to roof areas (not to garage and flats roof areas), making the total contributing roof area 1703.83m^2.
- Since infiltration testing has not yet been carried out, an average infiltration rate for chalk of 1×10^{-5} m/s (0.036 m/hr) has been used and applied in the Causeway Flow modelling process.
- Non-Statutory Technical Guidance Policy S2 States:

  "For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event should never exceed the peak greenfield runoff rate for the same event."

- Non-Statutory Technical Guidance Policy S4 States:

  "Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100

year, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event."

- As the proposals are to discharge surface water to ground and not to a drain, water body or sewer, the volume check requirement does not apply.
- Attenuation Freeboard – for open water features, such as ponds, basins or swales, the maximum water level in the feature shall reach no more than 300mm to the top-of-bank.

Post Development Runoff Rate

6.4 This proposal allows for surface water discharge to ground, as such this does not apply.

Proposed Drainage Strategy – Infiltration

6.5 As outlined in Table 6.1 above, a number of SuDS Features shall be utilised to form the Surface Water Drainage Strategy in order to meet the 4 Pillars of SuDS.

- Water Quantity – Infiltration Basin, Permeable Paving, Raingarden Planters;
- Water Quality – Infiltration Basin, Permeable Paving, and Raingarden Planters;
- Biodiversity – Raingarden Planters, Swale, Infiltration Basin – a permanent water level in the basin as well as suitable planting around the embankments will provide a new habitat and biodiversity gain;
- Amenity – Raingarden Planters, Swale, Infiltration Basin – this feature will enhance the surroundings and provide a focal point.

6.6 Note that the Raingarden Planters are not proposed at this stage of application but are expected to be proposed at a later stage for each dwelling at location of downpipes in addition to the other features proposed in order to improve all pillars of SuDS for the development.

6.7 The proposed SuDS Layout is included in **Appendix H** and Causeway Flow Hydraulic Model Outputs are contained in **Appendix I**.

6.8 As this is an Outline Application, infiltration testing shall be undertaken at a later design stage. The following hydraulic calculations are therefore based on typical infiltration coefficients from Table 25.1 in CIRIA SuDS Manual. As described in para. 1.5 above, it is anticipated that a suitably worded Condition could be attributed to any Decision Notice which requires full BRE 365 Infiltration Testing to be undertaken at a later design stage.

6.9 For the management of surface water runoff, the proposed access road is to utilise a permeable paving construction throughout the site to allow surface water runoff to pass through its surface and into its subbase. The access road is to be divided into 3 separate sections of unlined permeable paving (PP1-3), with PP1 having a minimum subbase of 505mm, both PP2 & PP3 both are proposed with minimum subbases of 600mm, all of which are proposed to have a void ratio of 30%. These features manage surface water runoff themselves and from the respective adjacent impermeable footpaths and driveways and all drainage features on site infiltrate to ground at the predetermined rate of $1x10^{-5}$ m/s (0.036 m/hr).

6.10 PP1 manages itself and its surrounding impermeable hardstandings, before directing flows to the swale south of PP1 at a restricted rate due to the presence of a 21mm orifice plate. Both the swale and PP1 together function independently of the rest of the drainage system and discharge surface waters to ground via infiltration. The swale is proposed to provide amenity and biodiversity benefits for the development and is proposed as having a total depth of 700mm including a 300mm freeboard, and a surface area of 85.6m^2.

6.11 Both PP2 and PP3 also infiltrate at the aforementioned rate above, but also convey a percentage of surface waters towards the infiltration basin in the southwest of the site. Flows from PP2 are restricted by a 30mm orifice plate and then travel through a pipe network underneath PP3, before PP3 connects to this network at a chamber (MH1) before flowing into the infiltration basin.

6.12 The other main feature in this SuDS strategy is an infiltration basin which receives flows from all the roof areas along with a percentage of flow from PP2 and PP3 due to the connecting pipe. The base and top areas of this basin are proposed to be 124.2 and 350.0m^2 respectively, the infiltration basin is 1.2m in depth including a 300mm freeboard. It is also proposed to infiltrate to ground at a rate of $1x10^{-5}$ m/s (0.036 m/hr). This infiltration basin will also include a section within its area that is lined and not infiltrating, this is to provide a permanent water feature, but this section is not modelled in Causeway Flow, with specifics on size of section to be determined at a later stage in development.

6.13 Further details on the surface area and sizes of attenuation features and specific diameters of orifice plates in this system are included in **Appendix H** and **I**.

6.14 The hydraulic outputs in **Appendix I** show the half-drain down times for each proposed infiltration feature. The half-drain-times for each section of Permeable Paving and the infiltration basin all remain below the required 1440mins (24hrs) for 1 in 30 year storm events as specified by Essex LLFA.

6.15 As the proposal seeks to dispose surface water runoff via infiltration, Long Term Storage is not required.

Exceedance Event

6.16 The proposed surface water drainage infiltration strategy is designed to accommodate a 1:100yr + 40% Climate Change Storm Event. In the unlikely event that an exceedance event occurs, any flood waters would flow in a southwest direction due to the land falling in this direction before eventually entering the ditch along the western boundary of the site which flows into the EA Main River of Stickling Green Brook. The Exceedance Routes are identified in **Appendix H**.

Water Quality

6.17 The drainage system has been designed in order to meet the water quality requirements set out by Table 26.2 of the CIRIA SuDS Manual C753 which sets out the specific pollution hazard indices for residential roofs, residential car parks and low traffic roads in Table 6.2 below.

Land Use	Hazard Level	Pollution Hazard Indices		
		Suspended Solids	Metals	Hydrocarbons
Residential roofs	Very low	0.2	0.2	0.05
Individual property driveways, residential car parks and low traffic roads	Low	0.5	0.4	0.4

Table 6.2 Land Use Pollution Hazard Ratings. Extracted from the CIRIA SuDS Manual C753 Simple Index Approach Tool

SuDS Component	Pollution Mitigation Indices		
	Suspended Solids	Metals	Hydrocarbons
Permeable Paving	0.7	0.6	0.7
Infiltration Basin	0.7	0.7	0.5
Swale	0.5	0.6	0.6

Table 6.3 SuDS Component Pollution Mitigation for Permeable Paving Extracted and adapted from the CIRIA SuDS Manual C753 Simple Index Approach Tool

6.18 From Table 6.3 above, permeable paving and infiltration basins will meet and exceed the required level of pollution mitigation for removing total suspended solids, metals and hydrocarbons from the surface water runoff from the development site.

7 Surface Water Drainage Strategy – Option 2: Attenuation

SuDS Surface Water Drainage Strategy Options

7.1 As described in paragraphs 6.1 to 6.4 above, two SuDS Drainage Strategies are offered which follow the most preferred and second most preferred methods for disposal of surface water runoff.

7.2 Option 1 in Section 6 of this report is based on an Infiltration Strategy, the most preferred method, using typical infiltration coefficients from Table 25.1 in CIRIA SuDS Manual.

7.3 Option 2 , described in the paragraphs below, is based on an Attenuation Strategy with outfall directed to watercourse, the second most preferred method, and would only be implemented should it be proven that infiltration is unviable.

7.4 It is anticipated that a suitably worded Condition could be attributed to any Decision Notice which requires full BRE 365 Infiltration Testing to be undertaken at a later design stage.

7.5 The following describes **Option 2 – Attenuation Strategy.**

Site-Specific SuDS – Attenuation Strategy

7.6 The various SuDS methods need to be considered in relation to site-specific constraints. Several SuDS options are available to reduce or temporarily hold back the discharge of surface water runoff. Table 7.1 outlines the constraints and opportunities to each of the SuDS devices in accordance with the hierarchical approach outlined in The SuDS Manual CIRIA C753. It also indicates what could and could not be incorporated within the development, based upon site-specific criteria.

Device	Description	Constraints / Comments	Appropriate
Living roofs (source control)	Provide soft landscaping at roof level which reduces surface water runoff.	Not possible for residential buildings due to pitched roofs.	No
Infiltration devices & Soakaways (source control)	Store runoff and allow water to percolate into the ground via natural infiltration.	Not proposed.	No
Pervious surfaces (source control)	Storm water is allowed to infiltrate through the surface into a storage layer, from which it can either infiltrate and/or slowly release to sewers.	Lined permeable paving is proposed for this site.	Yes
Rainwater harvesting (source control)	Reduces the annual average rate of runoff from the site by reusing water for non-potable uses e.g. toilet flushing, recycling processes.	Water butts not currently proposed but could be implemented at a later date.	Possibly

Swales (permeable conveyance)	Broad shallow channels that convey / store runoff, and allow infiltration (ground conditions permitting).	Swale proposed for conveyance.	Yes
Filter drains & perforated pipes (permeable conveyance)	Trenches filled with granular materials (to take flows from adjacent impermeable areas) that convey runoff while allowing infiltration.	Not proposed as part of the site.	No
Filter Strips (permeable conveyance)	Wide gently sloping areas of grass or dense vegetation that remove pollutants from run-off from adjacent areas.	Not proposed.	No
Infiltration basins (end of pipe treatment)	Depressions in the surface designed to store runoff and allow infiltration.	Not proposed.	No
Wet ponds & constructed wetlands (end of pipe treatment)	Provide water quality treatment & temporary storage above the permanent water level.	Attenuation Basin proposed at end of system.	Yes
Attenuation Underground (end of pipe treatment)	Oversized pipes or geo-cellular tanks designed to store water below ground level.	Geo-cellular tanks proposed to attenuate flows from permeable paving and roof areas.	Yes
Raingardens and Raingarden Planters	Bio-retention Facilities	Raingarden planters could be implemented at a later stage	Possibly

Table 7.1: Site Specific Sustainable Drainage

Surface Water Drainage Design Parameters

7.7 The following best practice design parameters have been considered:

- The local 2070s 'Upper End' Climate Change allowance is 40% and has been applied to the hydraulic drainage network design.
- The Hydraulic Model has been set up for a 1:2yr Storm Event, 1:10yr Storm Event, 1:30yr Storm Event, 1:30yr + 40% Climate Change Event, 1:100yr Storm Event and 1:100yr + 40% Climate Change Storm Event.
- FEH22 rainfall data has been used.
- The CV Value for Winter and Summer storms has been set to 1.0.
- A 5min time of entry has been used.
- In line with Essex LLFA Guidelines, all attenuation features either have 50% capacity available 24 hours after a 1 in 30-year storm event or have the capacity to store a subsequent 1 in 10-year storm event after a 1 in 30-year storm event.

- 10% urban creep allowance has been applied to residential roof areas (not to garage and flats roof areas), making the total contributing roof area 1703.83 m^2.
- Non-Statutory Technical Guidance Policy S2 States:

  "For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event should never exceed the peak greenfield runoff rate for the same event."

- Non-Statutory Technical Guidance Policy S4 States:

  "Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event."

- As the proposed outfall rate matches the QBAR/1:1yr/1:2yr Greenfield Runoff Rate, the volume check requirement does not apply.
- Attenuation Freeboard – for open water features, such as ponds, basins or swales, the maximum water level in the feature shall reach no more than 300mm to the top-of-bank.

Pre-Development Runoff Rates and Discharge Volumes – Greenfield Sites

7.8 Greenfield runoff rates were estimated using the ReFH2 method on the Causeway Flow software. The results of which are included in **Appendix J**. The proposed impermeable area of the site is 0.5816ha, the following greenfield runoff rates for a range of storm events have been scaled accordingly:

1 in 2 year – 4.8 l/s/ha – 2.8 l/s

1 in 30 year – 12.8 l/s/ha – 7.4 l/s

1 in 100 year – 16.4 l/s/ha – 9.5 l/s

Post Development Runoff Rate

7.9 The proposals seek to match the 1:2yr Greenfield Runoff Rate (2.8 l/s) for all Storms up to and including the 1:100yr + 40% Climate Change Event.

Proposed Drainage Strategy – Discharge to Surface Water Body

7.10 As outlined in Table 7.1 above, a number of SuDS Features shall be utilised to form the Surface Water Drainage Strategy in order to meet the 4 Pillars of SuDS.

- Water Quantity – Attenuation Basin, Lined Permeable Paving, and Cellular Storage Crates;
- Water Quality – Attenuation Basin Lined Permeable Paving, Conveyance Swale, and Raingarden Planters;

- Biodiversity – Raingarden Planters; Attenuation Basin – a permanent water level in the basin as well as suitable planting around the embankments will provide a new habitat and biodiversity gain;
- Amenity – Conveyance Swale, Raingarden Planters; Attenuation Basin – this feature will enhance the surroundings and provide a focal point.

7.11 Note that the Raingarden Planters are not proposed at this stage of application but are expected to be proposed at a later stage for each dwelling at location of downpipes in addition to the other features proposed in order to improve all pillars of SuDS for the development.

7.12 The proposed SuDS Layout is included in **Appendix K** and Causeway Flow Hydraulic Model (FEH22 Method) Outputs are contained in **Appendix L**.

7.13 The proposed drainage scheme utilises key SuDS attenuation features to serve the development site: lined permeable paving, a conveyance swale, a geo-cellular storage tank, and an attenuation basin which help manage surface water runoff before outfalling to the ditch located at the southwest of the site at a rate of 2.7 l/s which does not contribute to flood risk on site or elsewhere in the local area in all modelled storm events up to and including the 1:100yr + 40% Climate Change Event.

7.14 For the management of surface water runoff, the proposed access road is to utilise a lined permeable paving construction. The access road is to be split into 3 different sections of lined permeable paving located across the site with different purposes within the system in providing the required attenuation and conveyance for storms up to and including the 1 in 100 year + 40% climate change event. These sections of permeable paving manage flows from themselves along with surface water from the respective adjacent sections of impermeable footpaths and driveways, before flowing into other attenuation features on site. Each section of permeable paving varies in function and specification as detailed below:

7.15 PP CONVEY1 – This section of permeable paving is located in the northwest of the site, with a function of management of surface waters from itself and surrounding roof areas and impermeable driveways via conveyance instead of attenuation. This allows surface waters to be transported from this area southwards through the conveyance swale before entering the attenuation basin in the southwest of the site. This feature is proposed to have a 30% void ratio with a minimum subbase of 500mm and surface area of 434m^2.

7.16 PP CONVEY2 – Similar to the previous section, this segment of permeable paving is designed to transport surface water from the paving itself and other surrounding hardstandings towards the end of the drainage system. This 496m^2 surface area section of permeable paving is located towards the south of the site and is proposed with a 30% void ratio and minimum subbase of 550mm.

7.17 PP ATTENUATION – This section of permeable paving serves the central area of the site, receiving surface water flows from roof areas and other impermeable hardstandings in the central and eastern areas of the site. This feature has a main function of attenuating surface water received and releasing flows to further down the system to the oversized pipe at a restricted rate via a 25mm orifice plate. This attenuation feature has a proposed surface area of 679m^2 and is split into two sections: the regular subbase at 30% void ratio and minimum depth of 450mm; and the second section of subbase replacement below at 95% void ratio and minimum depth of 150mm is designed to store additional surface water flows.

7.18 An open water feature of a conveyance swale is proposed for the development, located on the western side of the site, receiving flows from the permeable paving segment in the north of the site (PP CONVEY1), it will act as a natural storage and transport feature, conveying surface water towards the attenuation basin in the south. It has a surface area of 85.6m^2 and depth of 700mm including 300mm freeboard. It will also have additional amenity and biodiversity benefits for the site.

7.19 A geo-cellular storage tank (STORAGE TANK) is also proposed to provide further storage and attenuation for water flows from the permeable paving and roof areas). This storage tank is proposed to be 800mm total) deep and will have a total surface area of 189.2m^2. As shown in **Appendix L**, the storage tank will be located in the southern side of the site, underneath the southern conveyance permeable paving (PP CONVEY2) and receive flows from the oversized pipe before leading flows into the attenuation basin at a restricted rate by the presence of a 38mm orifice plate.

7.20 Across the system, an oversized pipe of 450mm diameter is proposed to provide additional storage benefits for the drainage system. It will transport flows east to west for the site and direct surface water to and through the storage tank before conveying these flows to the attenuation basin.

7.21 The attenuation basin located in the southwest corner of the site at the end of the attenuation drainage system, receives all flows from all other SuDS features before storing and attenuating the surface water and restricting the final outfall to the open watercourse ditch at a rate of 2.7 l/s by the presence of a Hydro-Brake. The base and top areas of this basin to be used for attenuation are proposed to be 124.2 and 350.0m^2 respectively. The basin has been modelled to a depth of 1.2m including a 300mm freeboard. An additional 600mm of depth has been proposed in order for the attenuation basin to have a permanent water level. This feature will also have a 2m maintenance track surrounding it.

7.22 It is important to note that the exact extents and levels of the outfall ditch are unknown as this was unable to be surveyed in the topographical survey due to issues with dense vegetation. Therefore, assumptions have been made at this stage for discharge of surface waters on site, these levels will need to be confirmed at a later stage.

7.23 All flows between different attenuation and storage features for the proposed development are restricted to different rates (these specific rates for different storm events are included in **Appendix L**) via orifice plates with different diameters to ensure efficient management of surface water flows in all modelled scenarios.

7.24 Further details on the surface area and sizes of attenuation features and specific diameters of orifice plates in this system are included in **Appendix K and L**.

7.25 All orifice plates are to be located within chambers with suitable protective filters.

7.26 The hydraulic outputs shown in **Appendix L** show the half-drain down times for each proposed attenuation feature. The half-drain-times for all features including: the sections of Permeable Paving, storage tanks and the attenuation basin, all remain below the required 24 hours (1440mins) for 1 in 30 year storm events as specified by Essex LLFA.

7.27 The proposals seek to match the existing 1:2yr Greenfield Runoff Rate for all storms up to and including the 1:100yr + 40% Climate Change Event, as such Long Term Storage is not required.

Exceedance Event

7.28 The proposed surface water drainage attenuation strategy is designed to accommodate a 1:100yr + 40% Climate Change Storm Event. In the unlikely event that an exceedance event occurs, any flood waters would flow in a southwest direction before eventually entering the ditch along the western boundary of the site which flows into the EA Main River of Stickling Green Brook. The Exceedance Routes are shown in **Appendix K**.

Water Quality

7.29 The drainage system has been designed in order to meet the water quality requirements set out by Table 26.2 of the CIRIA SuDS Manual C753 which sets out the specific pollution hazard indices for residential roofs, residential car parks and low traffic roads in Table 7.2 below.

Land Use	Hazard Level	Pollution Hazard Indices		
		Suspended Solids	Metals	Hydrocarbons
Residential roofs	Very low	0.2	0.2	0.05
Individual property driveways, residential car parks and low traffic roads	Low	0.5	0.4	0.4

Table 7.2 Land Use Pollution Hazard Ratings. Extracted from the CIRIA SuDS Manual C753 Simple Index Approach Tool

SuDS Component	Pollution Mitigation Indices		
	Suspended Solids	Metals	Hydrocarbons
Permeable Paving	0.7	0.6	0.7
Attenuation Basin	0.7	0.7	0.5
Swale	0.5	0.6	0.6

Table 7.3 SuDS Component Pollution Mitigation for Permeable Paving, Swales & Attenuation Basins, Extracted and adapted from the CIRIA SuDS Manual C753 Simple Index Approach Tool

7.30 From Table 7.3 above, permeable paving, swales and attenuation basins will meet and exceed the required level of pollution mitigation for removing total suspended solids, metals and hydrocarbons from the surface water runoff from the development site.

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8 Maintenance of Development Drainage – Infiltration & Attenuation

8.1 The maintenance of the SuDS features will remain the responsibility of the site owner or an appointed maintenance company. The site owner/appointed management company will be responsible for maintaining the permeable paving and green roofs.

8.2 Regular inspections and maintenance should be carried out for each the following elements, particularly after periods of heavy rainfall. Maintenance tasks and frequencies for permeable paving are detailed in the CIRIA SUDS Manual (C753) and have been summarised below in Table 8.1 – 8.4.

8.3 For the infiltration strategy, see tables 8.1, 8.3 and 8.4. For the attenuation strategy, see tables 8.1, 8.2, 8.3 and 8.4.

Maintenance Schedule	Required Action	Frequency
Regular maintenance	Brushing and vacuuming.	Three times per year at end of winter, mid-summer, after autumn leaf fall, or as required based on site specific observations of clogging or manufacturer's recommendations.
Occasional maintenance	Stabilise and mow contributing and adjacent areas.	As required.
	Removal of weeds.	As required
Remedial actions	Remediate any landscaping which, through vegetation maintenance of soil slip, has been raised to within 50mm of the level of the paving.	As required
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance of a hazard to the user.	As required
	Rehabilitation of surface and upper sub-surface.	As required (if infiltration performance is reduced as a result of significant clogging.)
Monitoring	Initial inspection	
	Inspect for evidence of poor operation and/or weed growth. If required, take remedial action.	Monthly for 3 months after installation. 3 monthly, 48 hours after large storms.
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually.
	Monitor inspection chambers.	Annually.

Table 8.1: Maintenance tasks for permeable paving (Source: CIRIA C753, The SUDS Manual)

Maintenance Schedule	Required Action	Frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for 3 months, then annually.
	Remove debris from the catchment surface (where it may cause risks to performance)	Monthly.
	For systems where rainfall infiltrates into the tank from above, check surface or filter for blockage by sediment, algae or other matter; remove and replace surface infiltration medium as necessary.	Annually.
	Remove sediment from pre-treatment structures and/or internal forebays.	Annually, or as required.
Remedial actions	Repair/rehabilitate inlets, outlet, overflows, and vents.	As required
Monitoring	Initial inspection	
	Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed.	Annually.
	Survey inside of tank for sediment build-up and remove if necessary.	Every 5 years or as required.

Table 8.2: Maintenance tasks for attenuation storage tanks (Source: CIRIA C753, The SUDS Manual)

Maintenance Schedule	Required Action	Frequency
Regular maintenance	Remove litter and debris.	Monthly (or as required)
	Cut the grass – public areas	Monthly (during growing season)
	Cut the meadow grass	Half yearly (spring, before nesting season and autumn)
	Inspect marginal and bankside vegetation and remove nuisance plants (for first 3 years).	Monthly (at start, then as required)
	Inspect inlets, outlets, banksides, structures, pipework etc for evidence of blockage and□or physical damage.	Monthly
	Inspect water body for signs of poor water quality.	Monthly (May – October)
	Inspect silt accumulation rates in any forebay and in main body of the pond and establish appropriate removal frequencies; undertake contamination testing once some build-up has occurred, to inform management and disposal options.	Bi-yearly

	Check any mechanical devices, eg. penstocks.	Bi-yearly
	Hand cut submerged and emergent aquatic plants (at minimum of 0.1m above pond base; include max 25% of pond surface).	Annually
	Remove 25% of bank vegetation from water's edge to a minimum of 1m above water level.	Annually
	Tidy all dead growth (scrub clearance) before start of growing season □Note□ tree maintenance is usually part of overall landscape management contract).	Annually
	Remove sediment from any forebay.	Every 1-5 years, or as required
	Remove sediment and planting from one quadrant of the main body of ponds without sediment forebays.	Every 5 years, or as required
Occasional maintenance	Remove sediment from the main body of big ponds when pool volume is reduced by 20%	With effective pre-treatment, this will only be required rarely, eg every 25–50 years
Remedial actions	Repair erosion or other damage	As required
	Replant where necessary	As required
	Aerate pond when signs of eutrophication are detected	As required
	Realign rip-rap or repair other damage	As required
	Repair/rehabilitate inlets, outlets and overflows	As required
Monitoring	Inspect silt traps and note rate of sediment accumulation	Monthly in the first year and then annually
	Check soakaway to ensure emptying is occurring	Annually.

Table 8.3: Maintenance tasks for ponds and wetlands (Source: CIRIA C753, The SUDS Manual)

Maintenance Schedule	Required Action	Frequency
Regular maintenance	Remove litter and debris	Monthly, or as required
	Cut grass – to retain grass height within specified design range	Monthly (during growing season) or as required
	Manage other vegetation and remove nuisance plants	Monthly at start, then as required

	Inspect inlets, outlets and overflows for blockages, and clear if required	Monthly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water ponding for > 48 hours	Monthly, or when required
	Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Half yearly
Occasional maintenance	Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required	As required or if bare soil is exposed over 10% or more of the swale treatment area.
Remedial actions	Repair erosion or other damage by re-turfing or reseeding	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface.	As required
	Removal build-up of sediment on upstream gravel trench, flow spreader or a top of filter strip	As required
	Remove and dispose of oils or petrol residues using safe standard practices	As required

Table 8.4: Maintenance tasks for swales (Source: CIRIA C753, The SUDS Manual)

8.4 It is recommended that during the first 12 months of operation all SuDS and drainage features are visually inspected on a monthly basis to determine any seasonal patterns this includes all SuDS features, inspection chambers, inlets and outlets. This will determine whether or not the recommended service intervals set out by CIRIA in the figures above will be sufficient for maintenance beyond the first year.

8.5 After the first 12 months, the maintenance schedule should be designed to at least meet the requirements set out by CIRIA based on the outcome of the monitoring.

Manholes, Sewers and Inspection Chambers

8.6 All inspection chambers and manholes should be inspected on a bi-annual basis with further visual checks carried out throughout the year, such as in November after the heaviest leaf-fall has occurred.

8.7 Should a blockage occur at any time, it is advised to seek professional help to jet the drainage system to clean and clear the system.

Gutters and Downpipes

8.8 It is good practice to ensure that these are occasionally inspected to ensure they are in good order and free of leaves & debris. Once every 6 months should be sufficient.

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9 Summary & Conclusion

9.1 This Flood Risk Assessment and SuDS Strategy report has been prepared in support of an Outline Planning Application by BAYA Group on behalf of E&A Securities for the proposed development on land to the west of Clatterbury Lane, Clavering, Essex. The proposals are: *"Outline Application with all matters reserved except access for up to 28 dwellings (Class C3) including public open space, sustainable drainage systems, landscaping and associated infrastructure and development."*

Flood Risk Summary

9.2 The site is shown to be at a low risk of a fluvial (river) flood event, being located within the Flood Zone 1 on the Flood Map for Planning. Flood Zone 1 is defined as having <0.1% annual probability of river flooding.

9.3 Surface Water Flood High risk scenario: 1 in 30 yr (3.3% AEP) - A high-risk scenario mapping in **Appendix F** indicates a greater than 3.3% annual exceedance probability (AEP) of surface water flooding, i.e., the most frequently occurring scenario. It can be seen from the overlaid flood depths for the 3.3% AEP event that no proposed dwellings are located within the flood extent.

9.4 Surface Water Flood Medium risk scenario: 1 in 100 yr (1.0% AEP) - A medium-risk scenario indicates an AEP of surface water flooding between 3.3% and 1. Minor encroachment of the flood extent to 2no. proposed dwellings occurs, though it should be noted that the maximum depth reaches 150mm only. It is considered that surface water flood mitigation shall be offered to mitigate this risk accordingly. As this is an Outline Application, site-specific surface water flood modelling would be disproportionate, as such, an assessment of site levels and flood volumes has been undertaken and confirms the viability of suitable mitigation. The assessment also proves that additional surface water flood volume could be provided, which further demonstrates that should site-specific surface water flood modelling and compensation be undertaken at a later design stage, it is clear that it is achievable.

9.5 Suitable mitigation measures are achievable and proposed to manage surface water flood risk at the site.

9.6 In line with the ADEPT / EA document published September 2019, Emergency Access and Egress from the site is achievable, with flood depths of 150mm in Stickling Green and localised low-spots showing up to 300mm maximum depth of surface water flooding in an exceedance (1:1000yr) event.

SuDS Strategy Summary

9.7 The underlying geology suggests infiltration could be viable at the site, however as this is an Outline Application, the SuDS Drainage Strategy will offer two Options. Option 1 will be based on an Infiltration Strategy, using typical infiltration coefficients from Table 25.1 in CIRIA SuDS Manual and Option 2 will be based on an Attenuation Strategy with outfall directed to watercourse, which would only be implemented should it be proven that infiltration is unviable. It is anticipated that a suitably worded Condition could be attributed to any Decision Notice which requires full BRE 365 Infiltration Testing to be undertaken at a later design stage. For this Outline Application, the two Options demonstrate that surface water runoff from the site can be suitably managed in line with NPPF and Lead Local Flood Authority requirements.

Option 1 - Infiltration Strategy (discharge to ground):

9.8 This strategy has been modelled on an average infiltration rate of chalk due to the geology of the area, with the rate being $1x10^{-5}$ m/s (0.036 m/hr). Further calculations and modelling will be required at a later stage once data from infiltration tests are acquired to ensure the system will work for the resultant infiltration rates.

9.9 The proposed strategy includes 3 independent sections of permeable paving, 2 of which (PP2 & PP3) with a minimum subbase depth of 600mm and 1 (PP1) with a minimum subbase of 505mm. These sections of permeable paving manage themselves along with flows from the path and driveways adjacent to each section. All of these sections of permeable paving will infiltrate direct to ground at the aforementioned rate.

9.10 While none of these sections are directly connected as they infiltrate direct to ground, PP1 along the northwest side of the site is proposed to convey flows to the infiltration swale (through a 21mm orifice plate) to allow further storage and infiltration – this section of the drainage system will remain separate from other features on site. PP2 and PP3 are proposed to both flow into a connection chamber (MH1) before outfalling to the infiltration basin in the southwest of the site.

9.11 The infiltration basin is proposed to be 1.2m deep (including a 300mm freeboard) and will have a surface area at the top of the feature of 350.0m^2, and a base area of 124.2m^2.

Option 2 - Attenuation Strategy (discharge to waterbody):

9.12 This approach focuses on attenuation of surface water through the presence of various features which attenuate and store surface water flows before outfalling to the ditch in the southwest of the site which is connected to the Stickling Green Brook. The outfall is proposed to improve on the current greenfield 1 in 2 year storm event runoff rate with a proposed rate of 2.7 l/s for all storms up to and including 1 in 100 year + 40% climate change events with the presence of a Hydro-Brake at the end of the system.

9.13 The proposed strategy includes 3 separate sections of permeable paving, 2 of which (PP CONVEY1&2) will convey surface waters towards other attenuation features on site, and 1 (PP ATTENUATION) which shall attenuate flows before directing waters to the attenuation basin via an oversized pipe system and storage tank.

9.14 PP CONVEY1 in the northwest of the site will transport flows from itself and surrounding hardstandings through to the conveyance swale along the site's western boundary which then in turn conveys surface waters to the attenuation basin in the southwest corner of the site. It is proposed with a minimum subbase of 500mm void ratio of 30%, and surface area of 434m^2.

9.15 PP CONVEY2 functions in a similar manner to the permeable paving in the paragraph above but in the southwest side of the proposed development and immediately directs water flows from itself and surrounding hardstandings to the attenuation basin. It is proposed with a minimum subbase of 550mm, 30% void ratio, and 496m^2 surface area.

9.16 PP ATTENUATION located in the centre of the site is proposed to receive surface water from central and eastern sections of the development, this feature's function of attenuating flows is assisted by the presence of a subbase replacement tank below it in order to provide additional storage benefits before directing flows to the oversized pipe, storage tank and finally the attenuation basin. It is proposed with a minimum subbase of 450mm, 30% void ratio and 679m^2 surface area, while the subbase replacement tank below is proposed with 150mm depth, 95% void ratio and 433m^2 surface area.

9.17 The conveyance swale along the western boundary of the site is proposed to be 700mm deep (including 300mm freeboard) and has a surface area of 85.6m^2.

9.18 A geo-cellular storage tank is proposed for this strategy, located underneath PP CONVEY2 but receives flows from the oversized pipe (450mm diameter) and PP ATTENUATION to provide the necessary storage of surface waters on site before directing flows to the attenuation basin in the southwest at a restricted rate due to the presence of an orifice plate. The storage tank is proposed to be 173.6m^2 in surface area and depth of 800mm.

9.19 The attenuation basin is proposed to be 1.2m deep with a 300mm freeboard and will have a surface area at the top of the feature of 350.0m^2, and a base area of 124.2m^2. It will store and attenuate surface waters before outfalling to the ditch at the southwest vertex of the site at a consistent rate of 2.7 l/s via a Hydro-Brake. It is important to note that the outfall levels have been approximated due to the topographical survey being unable to obtain levels for the ditch along the site's western boundary because of dense vegetation – levels will be required at a later stage in development.

9.20 Each section of permeable paving, storage tanks and attenuation are proposed to have restricted outflow of varying rates due to orifice plates being proposed for each feature.

9.21 There is an expectation in both strategies for raingarden planters to be based at downpipes for each residential property for biodiversity and amenity purposes.

9.22 All features in both strategies are expected to achieve the required half-drain time of under 1440mins (24hrs) under modelled 1 in 30 year storms.

Conclusion

9.23 The proposals of both strategies of discharge to ground and discharge to open waterbody do not increase flood risk onsite or elsewhere and the necessary mitigation measures have been detailed in this report. The proposed development is considered to be suitably and sustainably located and is in line with local and national policies.

TRANSPORT PLANNING ■ HIGHWAYS AND DRAINAGE ■ FLOOD RISK
1st Floor Millers House, Roydon Road, Stanstead Abbotts, SG12 8HN. Tel 01920 871 777 e: contact@eastp.co.uk www.eastp.co.uk

EAS

Appendices

TRANSPORT PLANNING ■ HIGHWAYS AND DRAINAGE ■ FLOOD RISK

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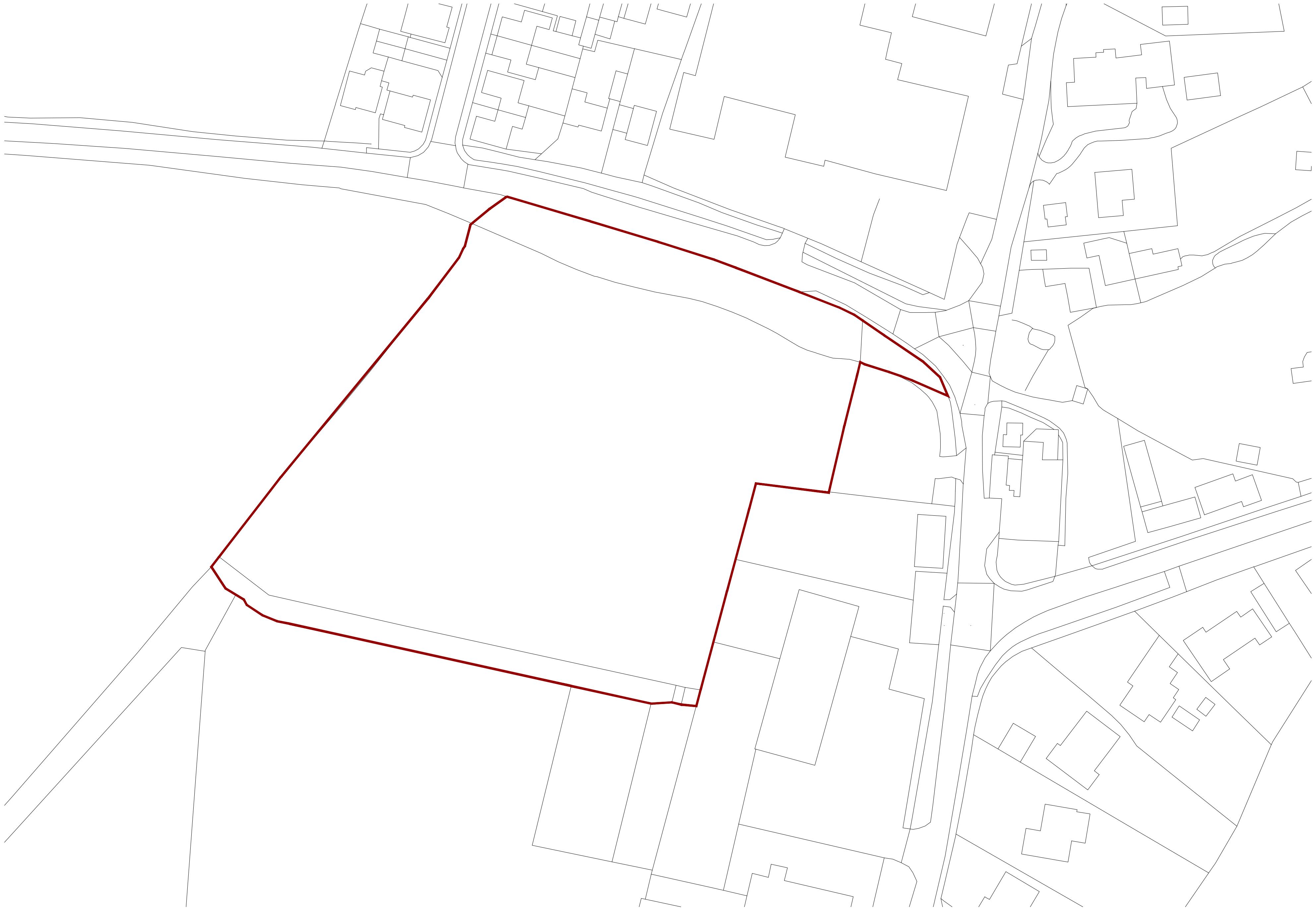
EAS

Appendix: A - Location Plan



01 Site Location Plan
1:1250@A3

Drawing Key

Rev	Description	By	Date
P1	Issued for Planning	MJP	04.12.23

N

5m 10m 15m 20m 25m

PLANNING

Site Location Plan

Site
Stickling Green, Clavering

Date	Drawn	Checked
December 2023	MJP	XXX

Scale
1:1250 @ A3

Drawing No:	Rev:
BH_002_SLP.01	P1

BAYA

General Notes
Nine Hills Road,
Cambridge.
CB2 1GE

T: 01223 803852

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Appendix: B – Proposed Development Plans

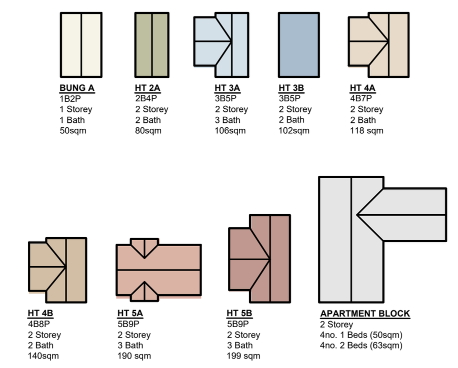
01 Proposed Site Plan
1:1000 @ A3 / 1:500 @ A1

Development Summary

Proposed Development
2no. 1 Bed Flats (50sqm)
4no. 2 Bed Flats (63sqm)
2no. 1 Bed Bungalows
4no. 2 Bed
9no. 3 Bed
4no. 4 Bed
3no. 5 Bed

TOTAL: 28no. Units

Drawing Key



Rev	Description	By	Date
P1	Issued for Planning	MJP	XX.XX.XX

APPRAISAL

Proposed Site Plan

Site
Land to the West of Clatterbury Lane, Clavering, Essex

Date	Drawn	Checked
Nov 2023	MJP	XXX

Scale
1:1000 @ A3 / 1:500 @ A1

Drawing No:	Rev:
BH002_SP.01	

BAYA

General Notes

 Levels are in AOD unless otherwise stated. Dimensions are in millimeters unless otherwise stated. BAYA Group Ltd must be informed of any drawing errors immediately in writing. This drawing is for planning purposes only.

General Notes

Nine Hills Road,
Cambridge.
CB2 1GE

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EAS

Appendix: C – EA Flood Map

TRANSPORT PLANNING ■ HIGHWAYS AND DRAINAGE ■ FLOOD RISK
1st Floor Millers House, Roydon Road, Stanstead Abbotts, SG12 8HN. Tel 01920 871 777 e: contact@eastp.co.uk www.eastp.co.uk

Flood map for planning

Your reference	Location (easting/northing)	Created
<Unspecified>	**548060/232698**	**23 Oct 2023 14:27**

Your selected location is in flood zone 1, an area with a low probability of flooding.

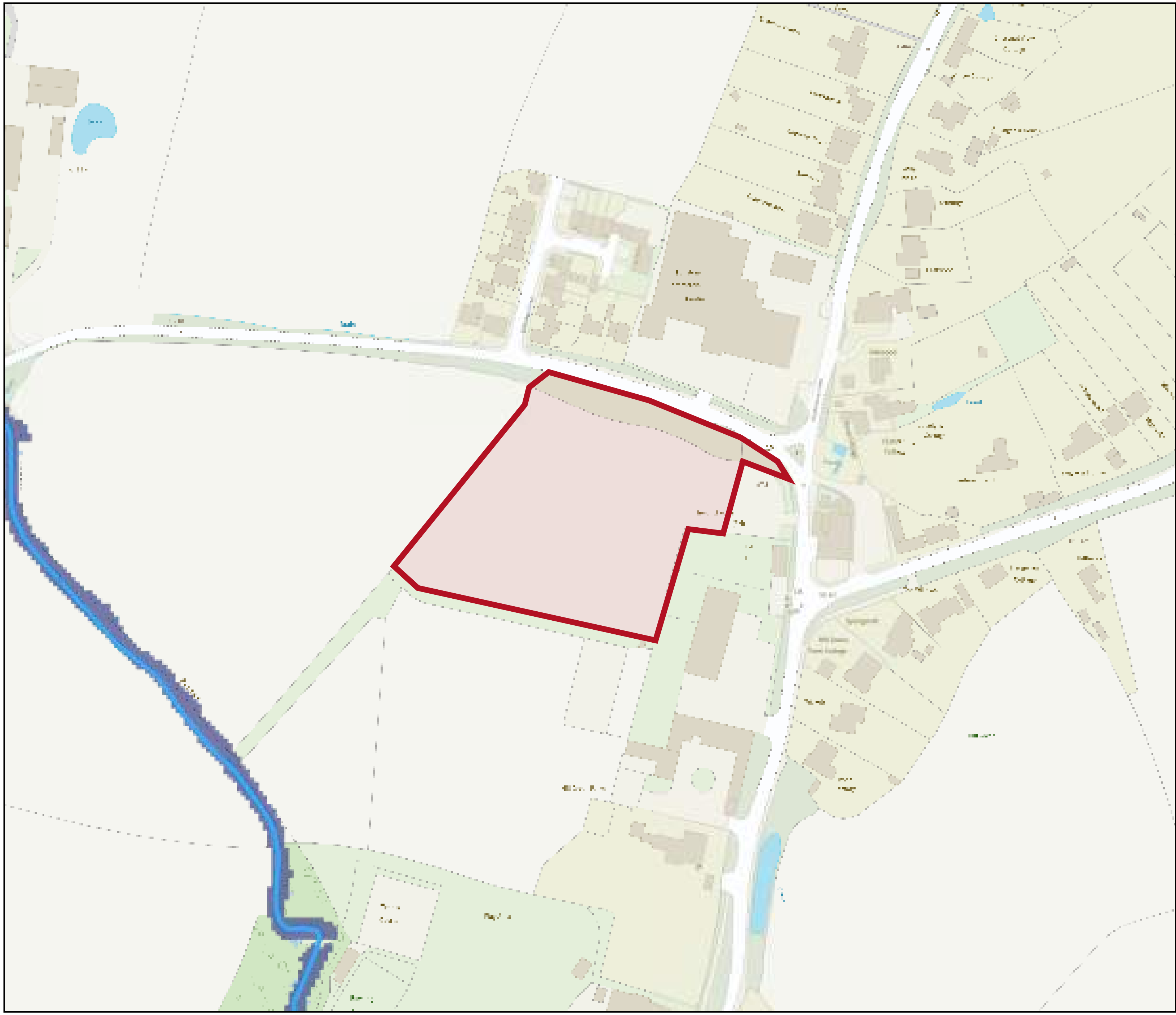
You will need to do a flood risk assessment if your site is **any of the following:**

- bigger that 1 hectare (ha)
- In an area with critical drainage problems as notified by the Environment Agency
- identified as being at increased flood risk in future by the local authority's strategic flood risk assessment
- at risk from other sources of flooding (such as surface water or reservoirs) and its development would increase the vulnerability of its use (such as constructing an office on an undeveloped site or converting a shop to a dwelling)

Notes

The flood map for planning shows river and sea flooding data only. It doesn't include other sources of flooding. It is for use in development planning and flood risk assessments.

This information relates to the selected location and is not specific to any property within it. The map is updated regularly and is correct at the time of printing.



Environment Agency

Flood map for planning

Your reference
<Unspecified>

Location (easting/northing)
548060/232698

Scale
1:2500

Created
23 Oct 2023 14:27

- Selected area
- Flood zone 3
- Flood zone 2
- Flood zone 1
- Flood defence
- Main river
- Water storage area

0 20 40 60m

Appendix: D – Topographical Survey

TRANSPORT PLANNING ■ HIGHWAYS AND DRAINAGE ■ FLOOD RISK
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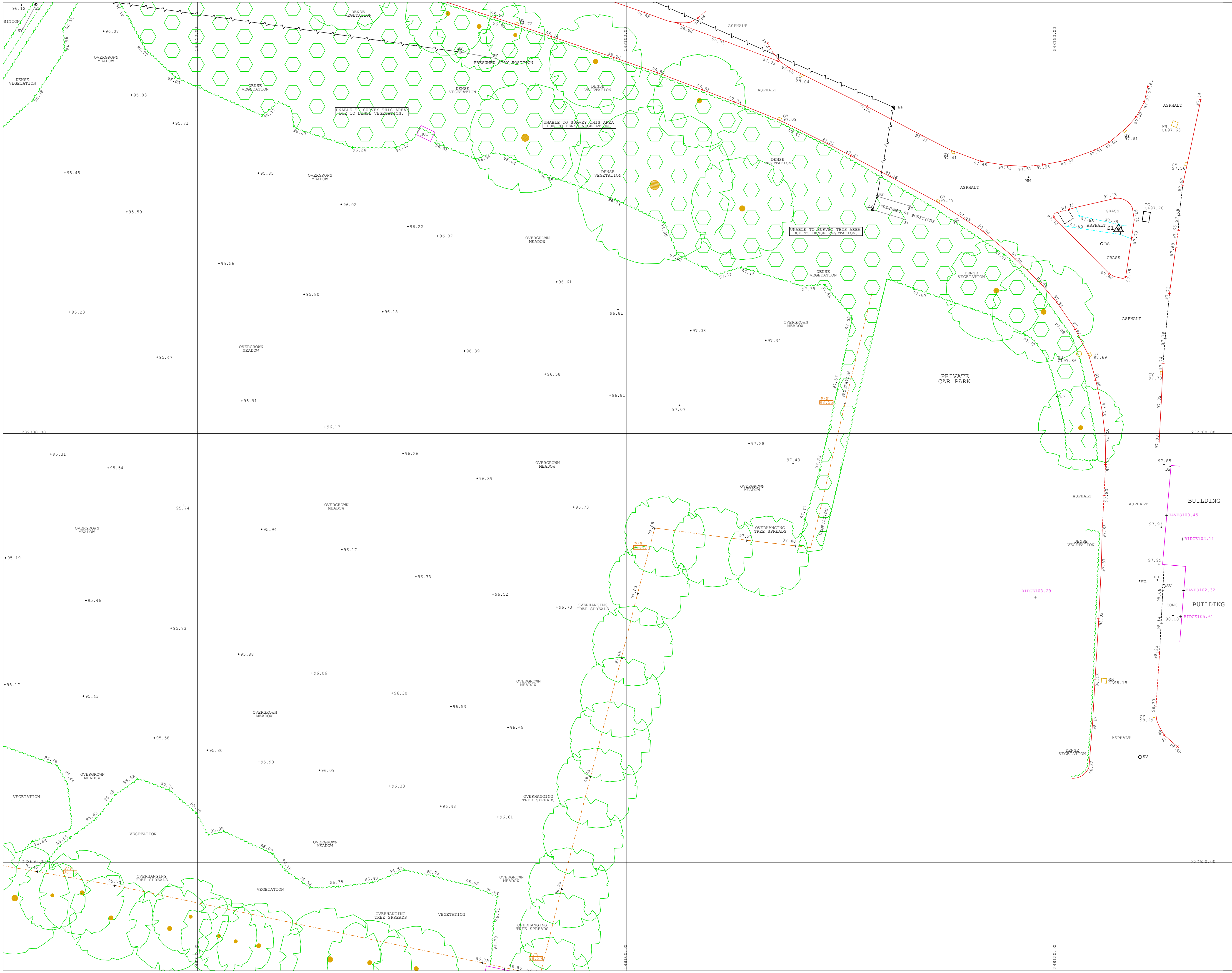
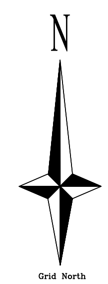


Co-ordinate Table				
Station	Type	Easting (mE)	Northing (mN)	Level (mZ)
S1	PK Nail	548157.299	232723.800	97.791
S2	PK Nail	548085.667	232755.072	96.791
S3	PK Nail	548031.090	232769.503	96.319

SURVEY RELATED TO OSGB36(15) ORDNANCE SURVEY GRID CO-ORDINATES TRANSFORMED FROM ETRS89 (WGS84) USING GEIOD MODELS OSGM15/OSTN15



PLEASE NOTE:
SITE WAS HEAVILY VEGETATED IN MANY AREAS AT TIME OF SURVEY, OBSCURING SOME BOUNDARY LINES AND POSSIBLE GROUND FEATURES.

NOTES

1. GRID AND LEVELS RELATED TO ORDNANCE SURVEY GPS NETWORK
2. ALL LEVELS ON KERB LINES ARE CHANNEL LEVELS UNLESS NOTED OTHERWISE.
3. SERVICE ROUTES HAVE BEEN IDENTIFIED BY LIFTING OF INSPECTION COVERS & VISUAL INSPECTION FROM THE SURFACES.
4. FOR SAFETY REASONS, DRAINAGE PIPE SIZES HAVE BEEN DETERMINED FROM THE SURFACE AND SHOULD BE TREATED AS APPROXIMATE ONLY.
5. DRAINAGE PIPE SIZES ARE DIAMETERS AND ARE SHOWN IN MILLIMETERS.
6. TREE SPECIES SHOULD BE CHECKED BY AN ARBORIST IF CRITICAL.

Revisions	
A	
B	
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Drawing No: SJG4359 — Revision: - — Sheet: 1/4

Surveyed By:-	Drawn By:-	Checked By:-	Sheet Size	Date
MS	MS	SJ	A1	22/09/2023

Client:- BAYA Group.

Scale:- 1:200

Project:-
Clatterbury Lane, Stickling Green, Clavering, CB11 4QU.

SYMBOLS

Banking
Hedge
Tree
Bush
Gate
O/H Electric
O/H Telecom
S1 Control Station

LEGEND

AV	Air Valve	MH	Manhole
BD	Bollard	MK	Marker
BH	Borehole	NP	Name Plate
CB	Cable Box	O/H	Overhead
CHY	Chimney	OSBM	Ordnance Bench Mark
CL	Cover Level	P	Post Or Pillar
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FENCE TYPES

B/W	Barbed Wire	C/P	Chestnut Paling	P/S	Palisade
C/B	Close Boarded	I/R	Iron Railing	P/W	Post & Wire
C/I	Corrugated Iron	I/W	Interwoven		
C/L	Chainlink	P/R	Post & Rail		

BOX AROUND LEVEL INDICATES LEVEL AT TOP OF FEATURE - FOR EXAMPLE - WALL 1.35

SURVEYED BY:-

48c Thoroughfare
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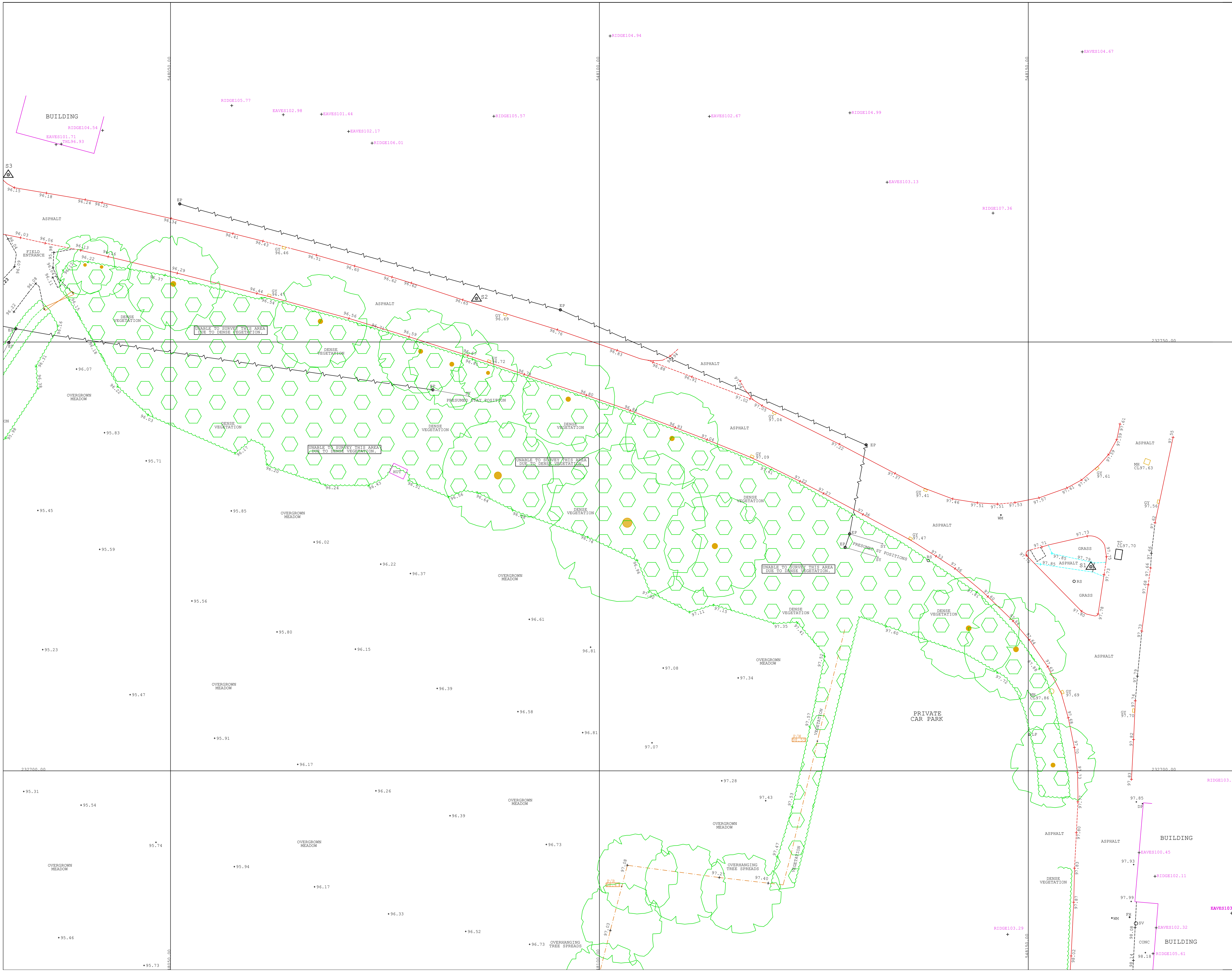
web. www.sjgeomatics.co.uk

Company Registration Number 8081329



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Drawing No: SJG4359

Revision: -
Sheet: 2/4

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MS	MS	SJ	A1	22/09/2023

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Scale:- 1:200

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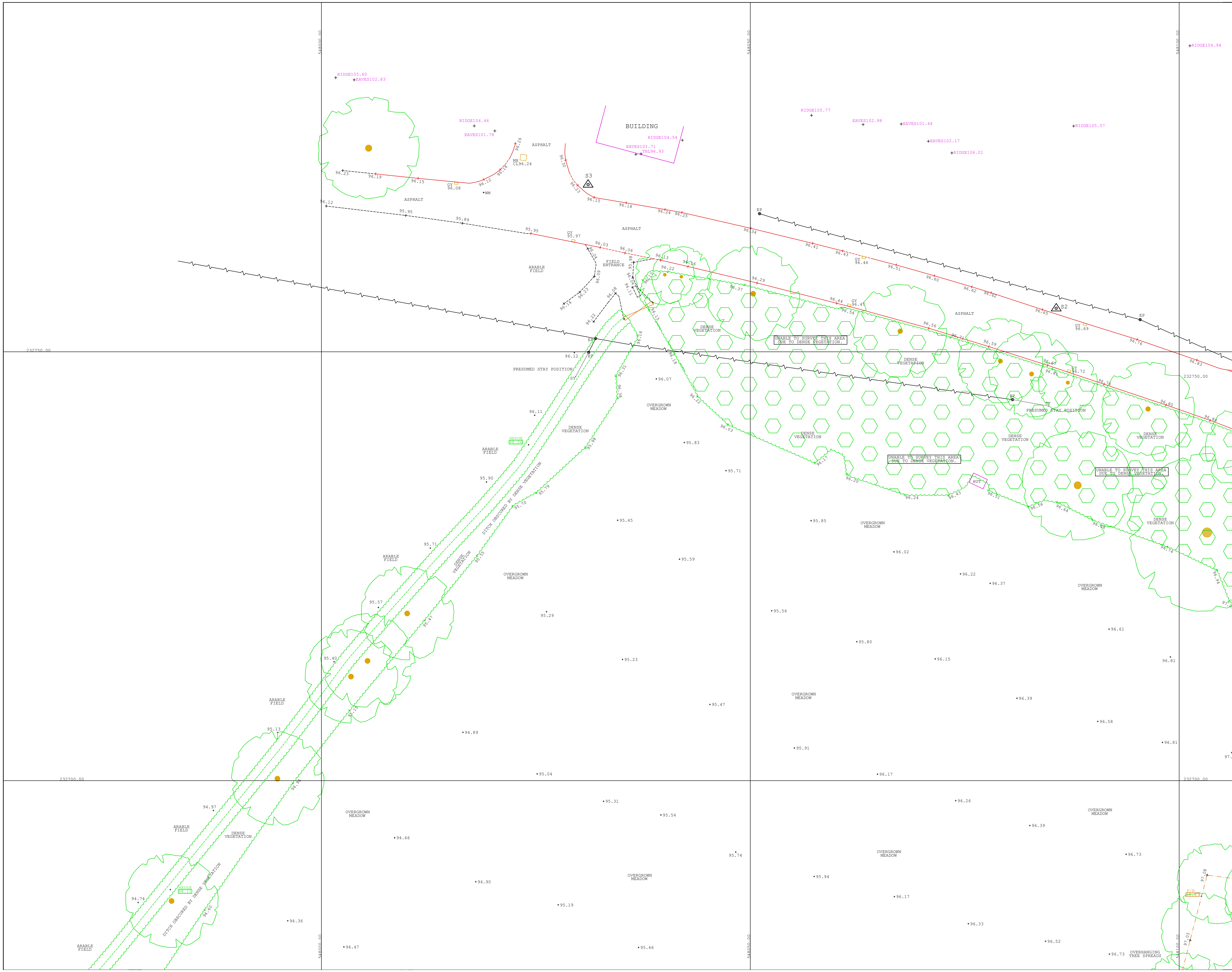

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N

Grid North

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MS	MS	SJ	A1	22/09/2023

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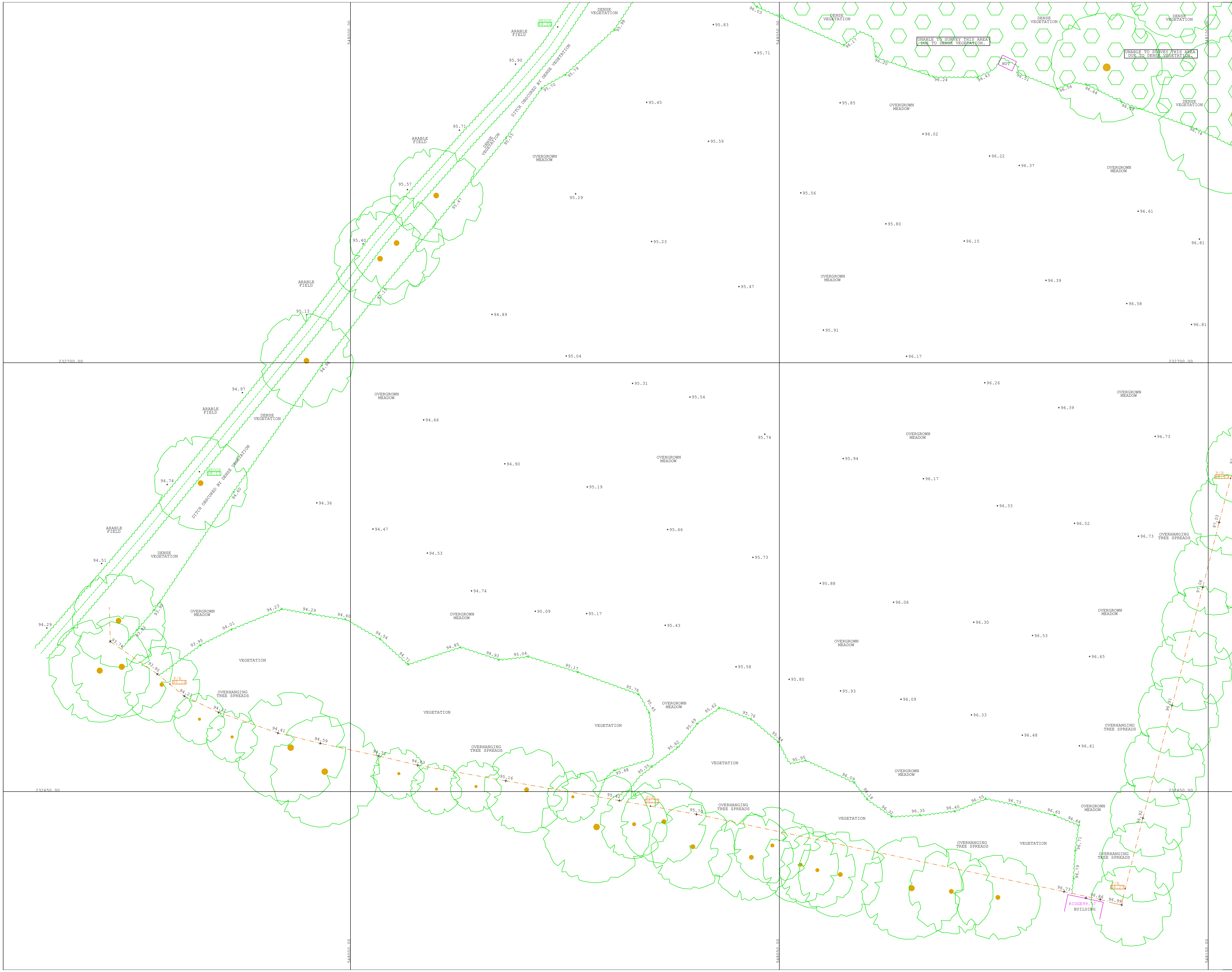

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Grid North

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Drawing No: SJG4359 — Revision: - — Sheet: 4/4

Surveyed By:-	Drawn By:-	Checked By:-	Sheet Size	Date
MS	MS	SJ	A1	22/09/2023

Client:-
BAYA Group.

Scale:- 1:200

Project:-
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C/I	Corrugated Iron	I/W	Interwoven		
C/L	Chainlink	P/R	Post & Rail		

BOX AROUND LEVEL INDICATES LEVEL AT TOP OF FEATURE - FOR EXAMPLE - WALL 1.35

SURVEYED BY:-
SJ GEOMATICS
48c Thoroughfare
Halesworth
Suffolk
IP19 8AR
Tel. 01986 872716
email. mail@sjgeomatics.co.uk
web. www.sjgeomatics.co.uk

Company Registration Number 8081329

EAS

Appendix: E – Thames Water Sewer Maps

Based on the Ordnance Survey Map with the sanction of the Controller of H.M Stationary Office License Number 10019345

ALS/ALS Standard/2023_4901441

0 12.5 25 50 75 100
Meters

Scale:	1:2294
Width:	454m
Printed By:	tlove
Print Date:	25/10/2023
Map Centre:	548178,232720
Grid Reference:	TL4832NW

Comments:

ALS/ALS Standard/2023_4901441

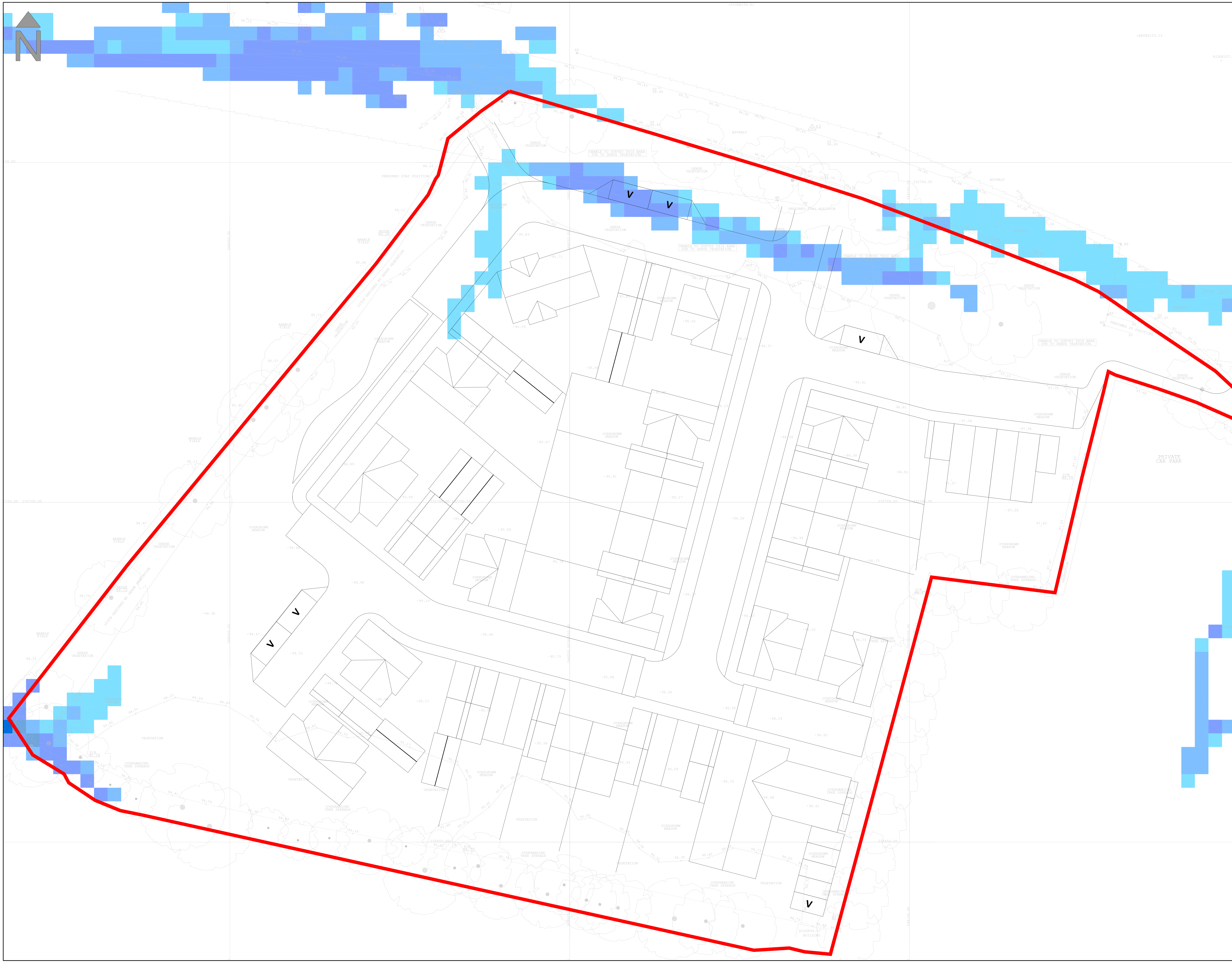
NB: Level quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates no Survey information is available.

REFERENCE	COVER LEVEL	INVERT LEVEL
1801		
1601		
1803	98.72	96.76
2801	100.59	99.11
2602	101.29	97.09
3701	103.01	97.44
1501	98.23	94.15
171A		
161A		
1701	97.63	95.5

REFERENCE	COVER LEVEL	INVERT LEVEL
1502	98.76	94.67
1802	100.6	99.5
1804	99.63	98.13
2601	100.31	96.76
2603	101.53	97.19
3703	104	97.9
3702	103.66	97.61
151A		
161B		

Appendix: F – DEFRA Surface Water Flood Risk Maps

TRANSPORT PLANNING ■ HIGHWAYS AND DRAINAGE ■ FLOOD RISK
1st Floor Millars House, Roydon Road, Stanstead Abbotts, SG12 8HN. Tel 01920 871 777 e: contact@eastp.co.uk www.eastp.co.uk



1 IN 30 YEAR STORM FLOOD DEPTH LEVELS

- 0 – 150mm
- 150 – 300mm
- 300 – 600mm
- 600 – 900mm
- 900 – 1200mm
- > 1200mm

REV	DATE	BY	DESCRIPTION	CHK	APD
–	–	–	–	–	–

DRAWING STATUS: OUTLINE APPLICATION

1st Floor Millers House, Roydon Road,
Stanstead Abbotts, Hertfordshire, SG12 8HN
Tel: 01920 871777

www.eastp.co.uk

CLIENT: BAYA GROUP LTD.

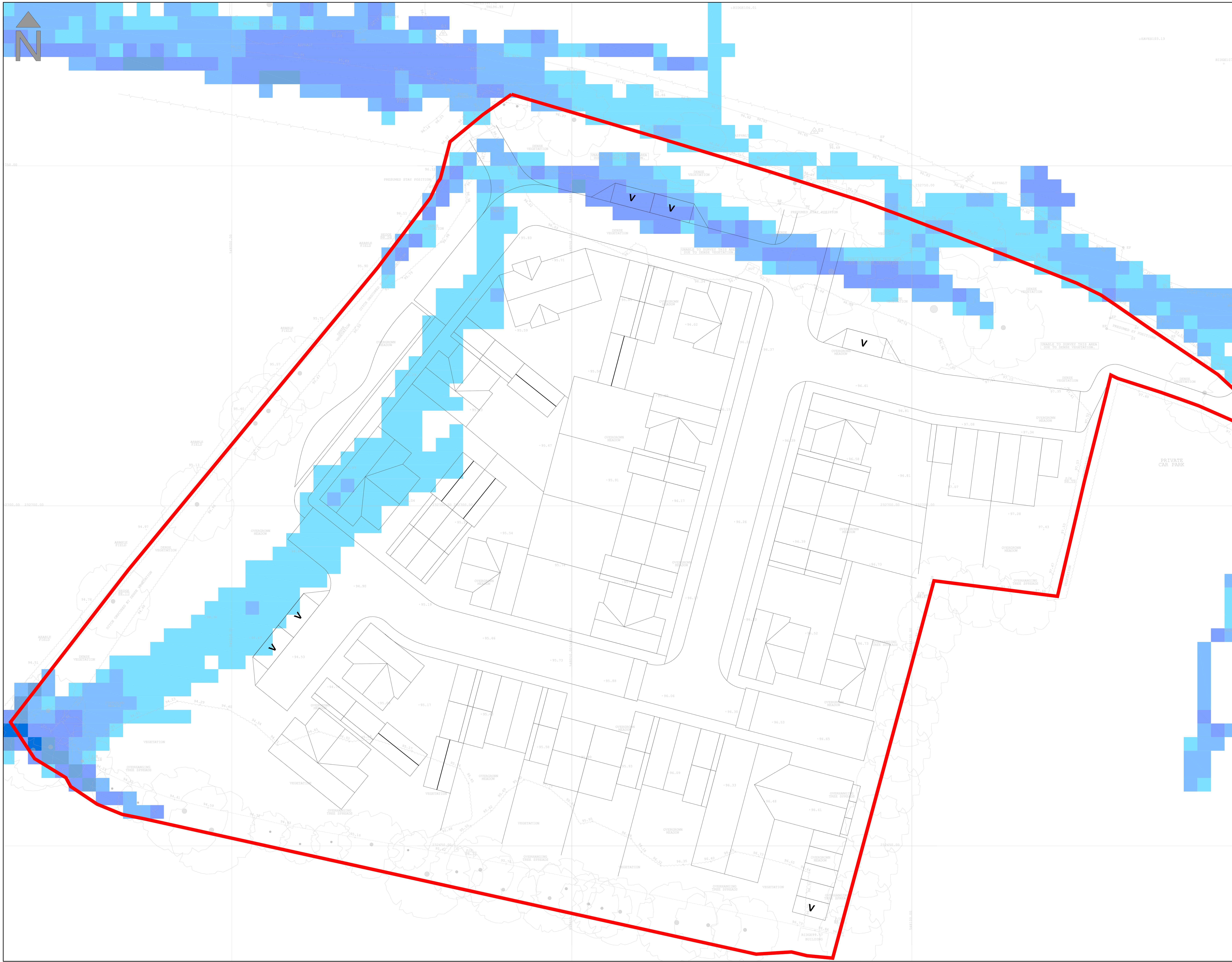
ARCHITECT:

PROJECT: LAND TO THE WEST OF CLATTERBURY LANE CLAVERING, ESSEX, CB11 4QS

TITLE: DEFRA 3.3% AEP SURFACE WATER FLOOD DEPTHS OVERLAID ON PROPOSED DEVELOPMENT PLANS

SCALE @ A1:	DESIGN–DRAWN:	DATE:
1:250m	MS	22/11/2023

PROJECT No:	DRAWING No:
4641/2023	SK01



1 IN 100 YEAR STORM FLOOD DEPTH LEVELS

- 0 – 150mm
- 150 – 300mm
- 300 – 600mm
- 600 – 900mm
- 900 – 1200mm
- > 1200mm

REV	DATE	BY	DESCRIPTION	CHK	APD
–	–	–	–	–	–

DRAWING STATUS: OUTLINE APPLICATION

EAS
1st Floor Millers House, Roydon Road,
Stanstead Abbotts, Hertfordshire, SG12 8HN
Tel: 01920 871777
www.eastp.co.uk

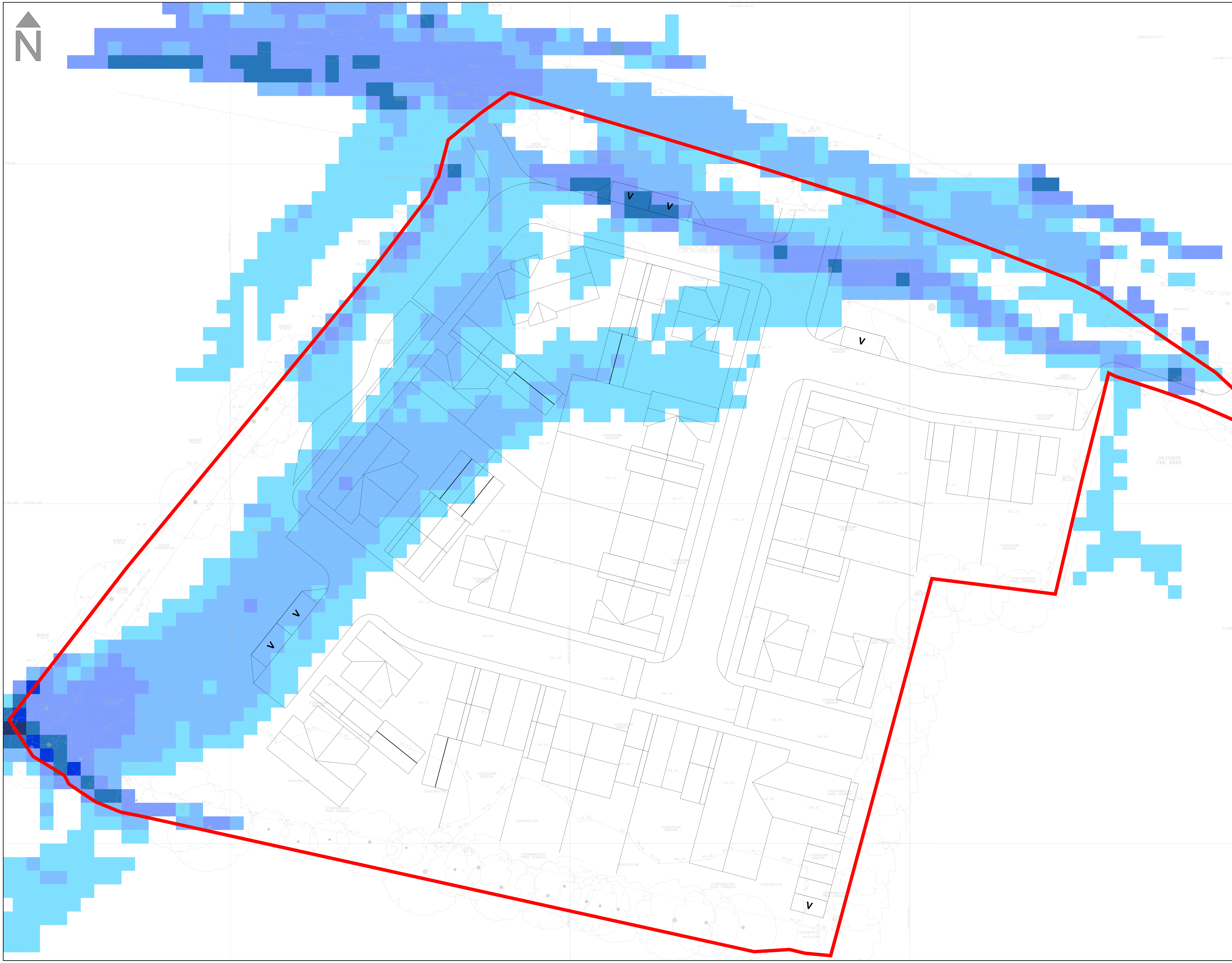
CLIENT: BAYA GROUP LTD.

ARCHITECT:

PROJECT: LAND TO THE WEST OF CLATTERBURY LANE CLAVERING, ESSEX, CB11 4QS

TITLE: DEFRA 1.0% AEP SURFACE WATER FLOOD DEPTHS OVERLAID ON PROPOSED DEVELOPMENT PLANS

SCALE @ A1:	DESIGN–DRAWN:	DATE:
1:250m	MS	22/11/2023
PROJECT No: 4641/2023	DRAWING No: SK02	



1 IN 1000 YEAR STORM (EXCEEDANCE EVENT) FLOOD DEPTH LEVELS

- 0 – 150mm
- 150 – 300mm
- 300 – 600mm
- 600 – 900mm
- 900 – 1200mm
- > 1200mm

REV	DATE	BY	DESCRIPTION	CHK	APD
–	–	–	–	–	–

DRAWING STATUS: OUTLINE APPLICATION

1st Floor Millers House, Roydon Road,
Stanstead Abbotts, Hertfordshire, SG12 8HN
Tel: 01920 871777

www.eastp.co.uk

CLIENT: BAYA GROUP LTD.

ARCHITECT:

PROJECT: LAND TO THE WEST OF CLATTERBURY LANE CLAVERING, ESSEX, CB11 4QS

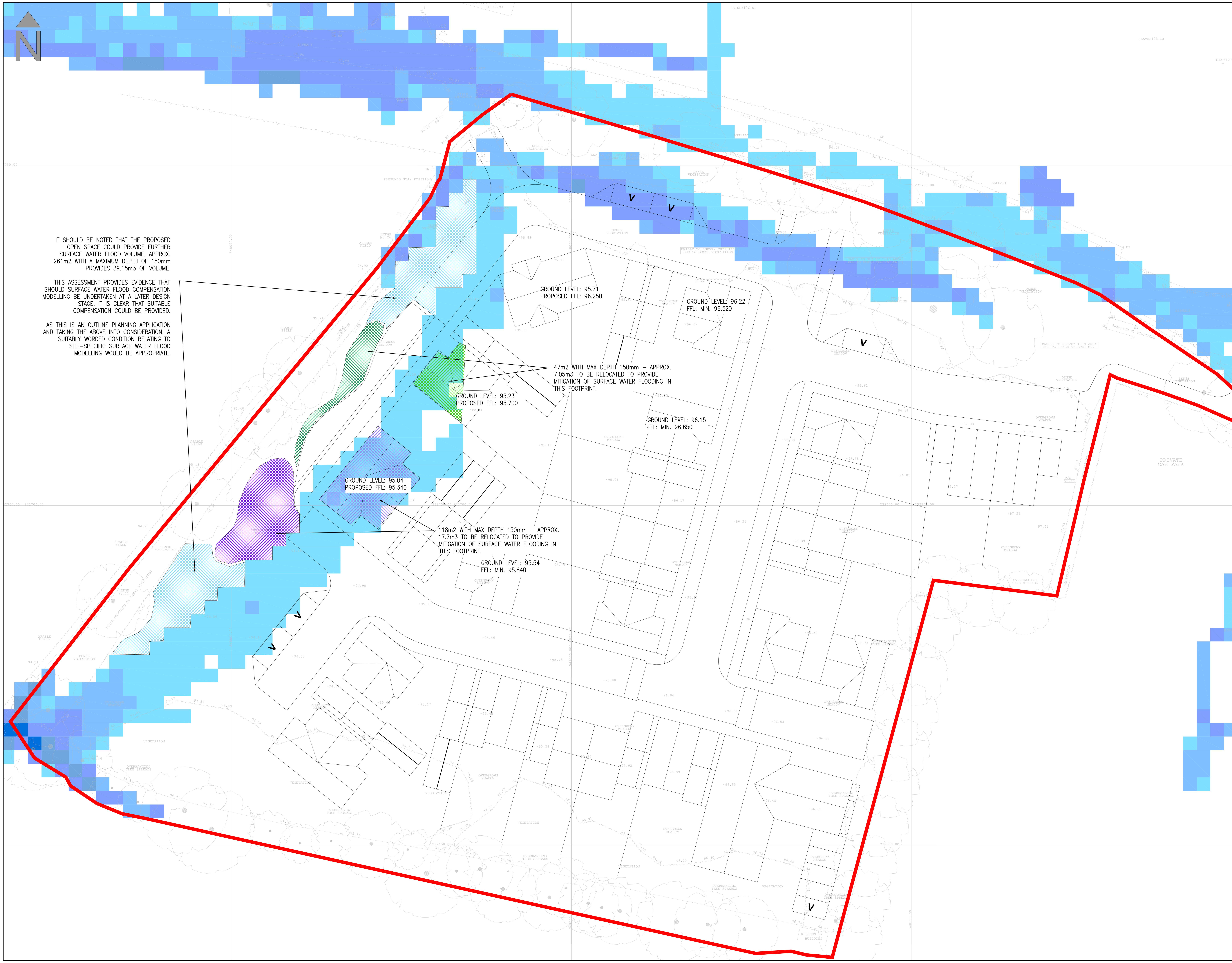
TITLE: DEFRA (EXCEEDANCE EVENT) 0.1% AEP SURFACE WATER FLOOD DEPTHS OVERLAID ON PROPOSED DEVELOPMENT PLANS

SCALE @ A1:	DESIGN–DRAWN:	DATE:
1:250m	MS	22/11/2023

PROJECT No:	DRAWING No:
4641/2023	SK02

Appendix: G – Surface Water Flood Mitigation Potential

TRANSPORT PLANNING ■ HIGHWAYS AND DRAINAGE ■ FLOOD RISK
1st Floor Millars House, Roydon Road, Stanstead Abbotts, SG12 8HN. Tel 01920 871 777 e: contact@eastp.co.uk www.eastp.co.uk



1 IN 100 YEAR STORM FLOOD DEPTH LEVELS

- 0 - 150mm
- 150 - 300mm
- 300 - 600mm
- 600 - 900mm
- 900 - 1200mm
- > 1200mm

REV	DATE	BY	DESCRIPTION	CHK	APD
-	-	-	-	-	-

DRAWING STATUS: OUTLINE APPLICATION

EAS
1st Floor Millers House, Roydon Road,
Stanstead Abbotts, Hertfordshire, SG12 8HN
Tel: 01920 871777
www.eastp.co.uk

CLIENT: BAYA GROUP LTD.

ARCHITECT:

PROJECT: LAND TO THE WEST OF CLATTERBURY LANE CLAVERING, ESSEX, CB11 4QS

TITLE: DEFRA 1.0% AEP SURFACE WATER FLOOD MITIGATION POTENTIAL

SCALE @ A1:	DESIGN-DRAWN:	DATE:
1:250	MD	22/11/2023

PROJECT No:	DRAWING No:
4641/2023	SK06

Appendix: H – Infiltration SuDS Strategy Layout

TRANSPORT PLANNING ■ HIGHWAYS AND DRAINAGE ■ FLOOD RISK
1st Floor Millers House, Roydon Road, Stanstead Abbotts, SG12 8HN. Tel 01920 871 777 e: contact@eastp.co.uk www.eastp.co.uk

REV	DATE	BY	DESCRIPTION	CHK	APD

DRAWING STATUS: OUTLINE APPLICATION

1st Floor Millers House, Roydon Road,
Stanstead Abbotts, Hertfordshire, SG12 8HN
Tel: 01920 871777
www.eastp.co.uk

CLIENT: BAYA GROUP LTD.

ARCHITECT:

PROJECT: CLAVERING, ESSEX, CB11 4QS
LAND TO THE WEST OF CLATTERBURY LANE

TITLE: SuDS INFILTRATION STRATEGY

SCALE @ A1:	DESIGN-DRAWN:	DATE:
1:250	MS	27/11/2023

PROJECT No:	DRAWING No:
4641/2023	SK03

Appendix: I – Infiltration Strategy Causeway Flow Outputs

Design Settings

Rainfall Methodology	FEH-22
Return Period (years)	30
Additional Flow (%)	0
CV	1.000
Time of Entry (mins)	5.00
Maximum Time of Concentration (mins)	30.00
Maximum Rainfall (mm/hr)	50.0
Minimum Velocity (m/s)	1.00
Connection Type	Level Soffits
Minimum Backdrop Height (m)	0.200
Preferred Cover Depth (m)	1.200
Include Intermediate Ground	✓
Enforce best practice design rules	x

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
PP1	0.094	5.00	95.500		44.873	79.150	0.730
PP2	0.172	5.00	96.100		58.401	68.116	0.730
PP3	0.264	5.00	94.800		45.258	70.588	0.730
MH1			94.800	1200	45.411	60.552	0.800
ATTENUATION BASIN			94.700		38.927	58.040	1.100
DUMMY OUTFALL			94.700	1200	28.126	56.279	0.481
SWALE			95.150		40.803	75.892	0.700

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
3.000	PP1	SWALE	5.213	0.600	94.770	94.450	0.320	16.3	150	5.03	50.0
1.000	PP2	MH1	15.032	0.600	95.370	94.070	1.300	11.6	150	5.08	50.0
2.000	PP3	MH1	10.037	0.600	94.070	94.000	0.070	143.4	225	5.15	50.0
1.001	MH1	ATTENUATION BASIN	9.940	0.600	94.000	93.600	0.400	24.9	225	5.22	50.0
DUMMY PIPE	ATTENUATION BASIN	DUMMY OUTFALL	10.944	0.600	94.500	94.219	0.281	38.9	100	5.36	50.0

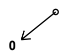
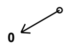
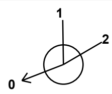
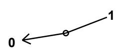
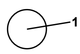
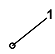
Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
3.000	2.508	44.3	17.0	0.580	0.550	0.094	0.0	64	2.341
1.000	2.979	52.6	31.1	0.580	0.580	0.172	0.0	83	3.099
2.000	1.090	43.3	47.7	0.505	0.575	0.264	0.0	225	1.110
1.001	2.635	104.8	78.8	0.575	0.875	0.436	0.0	146	2.886
DUMMY PIPE	1.239	9.7	78.8	0.100	0.381	0.436	0.0	100	1.273

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
3.000	5.213	16.3	150	Circular	95.500	94.770	0.580	95.150	94.450	0.550
1.000	15.032	11.6	150	Circular	96.100	95.370	0.580	94.800	94.070	0.580
2.000	10.037	143.4	225	Circular	94.800	94.070	0.505	94.800	94.000	0.575
1.001	9.940	24.9	225	Circular	94.800	94.000	0.575	94.700	93.600	0.875
DUMMY PIPE	10.944	38.9	100	Circular	94.700	94.500	0.100	94.700	94.219	0.381

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
3.000	PP1		Junction		SWALE		Junction	
1.000	PP2		Junction		MH1	1200	Manhole	Adoptable
2.000	PP3		Junction		MH1	1200	Manhole	Adoptable
1.001	MH1	1200	Manhole	Adoptable	ATTENUATION BASIN		Junction	
DUMMY PIPE	ATTENUATION BASIN		Junction		DUMMY OUTFALL	1200	Manhole	Adoptable

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections		Link	IL (m)	Dia (mm)
PP1	44.873	79.150	95.500	0.730			0	3.000	94.770	150
PP2	58.401	68.116	96.100	0.730			0	1.000	95.370	150
PP3	45.258	70.588	94.800	0.730			0	2.000	94.070	225
MH1	45.411	60.552	94.800	0.800	1200		1	2.000	94.000	225
							2	1.000	94.070	150
							0	1.001	94.000	225
ATTENUATION BASIN	38.927	58.040	94.700	1.100			1	1.001	93.600	225
							0	DUMMY PIPE	94.500	100
DUMMY OUTFALL	28.126	56.279	94.700	0.481	1200		1	DUMMY PIPE	94.219	100
SWALE	40.803	75.892	95.150	0.700			1	3.000	94.450	150

Simulation Settings

Rainfall Methodology	FEH-22	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	1.000	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	1.000	Drain Down Time (mins)	1440	Check Discharge Volume	x

Storm Durations

15	30	60	120	180	240	360	480	600	720	960	1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
2	0	0	0
10	0	0	0
30	0	0	0
30	40	0	0
100	0	0	0
100	40	0	0

Node PP2 Online Orifice Control

Flap Valve	x	Replaces Downstream Link	✓	Diameter (m)	0.030
Downstream Link	1.000	Invert Level (m)	95.370	Discharge Coefficient	0.600

Node PP1 Online Orifice Control

Flap Valve	x	Replaces Downstream Link	✓	Diameter (m)	0.021
Downstream Link	3.000	Invert Level (m)	94.770	Discharge Coefficient	0.600

Node PP1 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.03600	Invert Level (m)	94.770	Slope (1:X)	80.0
Side Inf Coefficient (m/hr)	0.03600	Time to half empty (mins)	200	Depth (m)	0.600
Safety Factor	2.0	Width (m)	20.845	Inf Depth (m)	
Porosity	0.30	Length (m)	20.845		

Node PP2 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.03600	Invert Level (m)	95.370	Slope (1:X)	250.0
Side Inf Coefficient (m/hr)	0.03600	Time to half empty (mins)	220	Depth (m)	0.600
Safety Factor	2.0	Width (m)	9.996	Inf Depth (m)	
Porosity	0.30	Length (m)	69.808		

Node PP3 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.03600	Invert Level (m)	94.070	Slope (1:X)	100.0
Side Inf Coefficient (m/hr)	0.03600	Time to half empty (mins)	9	Depth (m)	0.600
Safety Factor	2.0	Width (m)	8.097	Inf Depth (m)	
Porosity	0.30	Length (m)	91.075		

Node ATTENUATION BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.03600	Safety Factor	2.0	Invert Level (m)	93.500
Side Inf Coefficient (m/hr)	0.03600	Porosity	1.00	Time to half empty (mins)	1170

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	124.2	124.2	1.200	350.0	350.0

Node SWALE Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.03600	Safety Factor	2.0	Invert Level (m)	94.450
Side Inf Coefficient (m/hr)	0.03600	Porosity	1.00	Time to half empty (mins)	788

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	5.6	5.6	0.700	85.6	85.6

Results for 2 year Critical Storm Duration. Lowest mass balance: 99.96%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
180 minute summer	PP1	120	94.952	0.182	6.2	8.7733	0.0000	SURCHARGED
180 minute summer	PP2	120	95.573	0.203	11.4	16.4015	0.0000	SURCHARGED
15 minute summer	PP3	11	94.232	0.162	43.3	3.2898	0.0000	OK
15 minute summer	MH1	11	94.100	0.100	38.9	0.1129	0.0000	OK
480 minute winter	ATTENUATION BASIN	472	93.880	0.280	6.6	60.7594	0.0000	OK
15 minute summer	DUMMY OUTFALL	1	94.219	0.000	0.0	0.0000	0.0000	OK
720 minute winter	SWALE	615	94.676	0.226	0.3	4.1890	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
180 minute summer	PP1	Orifice	SWALE	0.4				
180 minute summer	PP1	Infiltration		1.6				
180 minute summer	PP2	Orifice	MH1	0.8				
180 minute summer	PP2	Infiltration		2.6				
15 minute summer	PP3	2.000	MH1	38.3	1.597	0.884	0.2390	
15 minute summer	PP3	Infiltration		0.7				
15 minute summer	MH1	1.001	ATTENUATION BASIN	38.8	2.369	0.370	0.1628	
480 minute winter	ATTENUATION BASIN	DUMMY PIPE	DUMMY OUTFALL	0.0	0.000	0.000	0.0000	0.0
480 minute winter	ATTENUATION BASIN	Infiltration		0.9				
720 minute winter	SWALE	Infiltration		0.1				

Results for 10 year Critical Storm Duration. Lowest mass balance: 99.96%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
180 minute summer	PP1	124	95.036	0.266	11.2	18.3251	0.0000	SURCHARGED
180 minute summer	PP2	124	95.667	0.296	20.5	34.2495	0.0000	SURCHARGED
15 minute summer	PP3	12	94.376	0.306	91.3	9.7067	0.0000	SURCHARGED
15 minute summer	MH1	12	94.140	0.140	66.3	0.1582	0.0000	OK
600 minute winter	ATTENUATION BASIN	585	94.098	0.498	9.1	107.9874	0.0000	OK
15 minute summer	DUMMY OUTFALL	1	94.219	0.000	0.0	0.0000	0.0000	OK
720 minute winter	SWALE	705	94.735	0.285	0.4	6.2498	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
180 minute summer	PP1	Orifice	SWALE	0.5				
180 minute summer	PP1	Infiltration		2.2				
180 minute summer	PP2	Orifice	MH1	1.0				
180 minute summer	PP2	Infiltration		3.6				
15 minute summer	PP3	2.000	MH1	65.5	1.799	1.512	0.3297	
15 minute summer	PP3	Infiltration		1.3				
15 minute summer	MH1	1.001	ATTENUATION BASIN	66.2	2.678	0.632	0.2457	
600 minute winter	ATTENUATION BASIN	DUMMY PIPE	DUMMY OUTFALL	0.0	0.000	0.000	0.0000	0.0
600 minute winter	ATTENUATION BASIN	Infiltration		1.2				
720 minute winter	SWALE	Infiltration		0.2				

Results for 30 year Critical Storm Duration. Lowest mass balance: 99.96%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
180 minute summer	PP1	128	95.084	0.314	14.2	24.7977	0.0000	SURCHARGED
180 minute summer	PP2	132	95.723	0.353	25.9	46.2442	0.0000	SURCHARGED
15 minute summer	PP3	12	94.466	0.396	121.4	15.4282	0.0000	SURCHARGED
600 minute winter	MH1	585	94.191	0.191	11.2	0.2156	0.0000	OK
600 minute winter	ATTENUATION BASIN	585	94.191	0.591	11.2	130.6318	0.0000	OK
15 minute summer	DUMMY OUTFALL	1	94.219	0.000	0.0	0.0000	0.0000	OK
720 minute winter	SWALE	720	94.762	0.312	0.4	7.3111	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
180 minute summer	PP1	Orifice	SWALE	0.5				
180 minute summer	PP1	Infiltration		2.2				
180 minute summer	PP2	Orifice	MH1	1.1				
180 minute summer	PP2	Infiltration		3.7				
15 minute summer	PP3	2.000	MH1	77.0	2.044	1.777	0.3485	
15 minute summer	PP3	Infiltration		1.7				
600 minute winter	MH1	1.001	ATTENUATION BASIN	11.2	1.239	0.106	0.3760	
600 minute winter	ATTENUATION BASIN	DUMMY PIPE	DUMMY OUTFALL	0.0	0.000	0.000	0.0000	0.0
600 minute winter	ATTENUATION BASIN	Infiltration		1.2				
720 minute winter	SWALE	Infiltration		0.2				

Results for 30 year +40% CC Critical Storm Duration. Lowest mass balance: 99.96%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
180 minute summer	PP1	140	95.185	0.415	19.8	38.1712	0.0000	SURCHARGED
180 minute summer	PP2	144	95.838	0.468	36.3	70.9368	0.0000	FLOOD RISK
15 minute summer	PP3	13	94.602	0.532	169.9	26.5551	0.0000	FLOOD RISK
600 minute winter	MH1	585	94.354	0.354	15.3	0.3999	0.0000	SURCHARGED
600 minute winter	ATTENUATION BASIN	585	94.354	0.754	15.3	174.5418	0.0000	OK
15 minute summer	DUMMY OUTFALL	1	94.219	0.000	0.0	0.0000	0.0000	OK
720 minute summer	SWALE	750	94.807	0.357	0.5	9.2918	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
180 minute summer	PP1	Orifice	SWALE	0.6				
180 minute summer	PP1	Infiltration		2.3				
180 minute summer	PP2	Orifice	MH1	1.3				
180 minute summer	PP2	Infiltration		3.7				
15 minute summer	PP3	2.000	MH1	92.7	2.362	2.139	0.3749	
15 minute summer	PP3	Infiltration		2.3				
600 minute winter	MH1	1.001	ATTENUATION BASIN	15.3	1.235	0.146	0.3953	
600 minute winter	ATTENUATION BASIN	DUMMY PIPE	DUMMY OUTFALL	0.0	0.000	0.000	0.0000	0.0
600 minute winter	ATTENUATION BASIN	Infiltration		1.4				
720 minute summer	SWALE	Infiltration		0.2				

Results for 100 year Critical Storm Duration. Lowest mass balance: 99.96%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
120 minute summer	PP1	102	95.142	0.372	23.5	32.4926	0.0000	SURCHARGED
180 minute summer	PP2	136	95.790	0.420	32.1	60.6038	0.0000	SURCHARGED
15 minute summer	PP3	13	94.557	0.487	153.1	22.5000	0.0000	FLOOD RISK
600 minute winter	MH1	585	94.286	0.285	13.6	0.3229	0.0000	SURCHARGED
600 minute winter	ATTENUATION BASIN	585	94.285	0.685	13.6	155.5928	0.0000	OK
15 minute summer	DUMMY OUTFALL	1	94.219	0.000	0.0	0.0000	0.0000	OK
720 minute summer	SWALE	735	94.789	0.339	0.5	8.4433	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
120 minute summer	PP1	Orifice	SWALE	0.6				
120 minute summer	PP1	Infiltration		2.3				
180 minute summer	PP2	Orifice	MH1	1.2				
180 minute summer	PP2	Infiltration		3.7				
15 minute summer	PP3	2.000	MH1	87.8	2.262	2.026	0.3664	
15 minute summer	PP3	Infiltration		2.1				
600 minute winter	MH1	1.001	ATTENUATION BASIN	13.6	1.251	0.130	0.3953	
600 minute winter	ATTENUATION BASIN	DUMMY PIPE	DUMMY OUTFALL	0.0	0.000	0.000	0.0000	0.0
600 minute winter	ATTENUATION BASIN	Infiltration		1.3				
720 minute summer	SWALE	Infiltration		0.2				

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.96%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
180 minute summer	PP1	152	95.272	0.502	24.5	49.7762	0.0000	FLOOD RISK
180 minute winter	PP2	168	95.940	0.570	30.9	92.7153	0.0000	FLOOD RISK
15 minute summer	PP3	13	94.715	0.645	214.4	38.0046	0.0000	FLOOD RISK
600 minute winter	MH1	585	94.466	0.466	18.5	0.5269	0.0000	SURCHARGED
600 minute winter	ATTENUATION BASIN	585	94.466	0.866	18.2	207.7078	0.0000	OK
15 minute summer	DUMMY OUTFALL	1	94.219	0.000	0.0	0.0000	0.0000	OK
720 minute summer	SWALE	780	94.841	0.391	0.6	10.9385	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
180 minute summer	PP1	Orifice	SWALE	0.6				
180 minute summer	PP1	Infiltration		2.3				
180 minute winter	PP2	Orifice	MH1	1.4				
180 minute winter	PP2	Infiltration		3.8				
15 minute summer	PP3	2.000	MH1	102.2	2.570	2.359	0.3992	
15 minute summer	PP3	Infiltration		2.9				
600 minute winter	MH1	1.001	ATTENUATION BASIN	18.2	1.240	0.174	0.3953	
600 minute winter	ATTENUATION BASIN	DUMMY PIPE	DUMMY OUTFALL	0.0	0.000	0.000	0.0000	0.0
600 minute winter	ATTENUATION BASIN	Infiltration		1.5				
720 minute summer	SWALE	Infiltration		0.2				

Design Settings

Rainfall Methodology	FEH-22	Minimum Velocity (m/s)	1.00
Return Period (years)	30	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	1.000	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	x
Maximum Rainfall (mm/hr)	50.0		

Simulation Settings

Rainfall Methodology	FEH-22	Analysis Speed	Normal	Additional Storage (m³/ha)	20.0
Summer CV	1.000	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	1.000	Drain Down Time (mins)	1440	Check Discharge Volume	x

Storm Durations

15	30	60	120	180	240	360	480	600	720	960	1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
2	0	0	0
30	0	0	0

Node PP1 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.03600	Invert Level (m)	94.770	Slope (1:X)	80.0
Side Inf Coefficient (m/hr)	0.03600	Time to half empty (mins)	201	Depth (m)	0.600
Safety Factor	2.0	Width (m)	20.845	Inf Depth (m)	
Porosity	0.30	Length (m)	20.845		

Node PP2 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.03600	Invert Level (m)	95.370	Slope (1:X)	250.0
Side Inf Coefficient (m/hr)	0.03600	Time to half empty (mins)	88	Depth (m)	0.600
Safety Factor	2.0	Width (m)	9.996	Inf Depth (m)	
Porosity	0.30	Length (m)	69.808		

Node PP3 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.03600	Invert Level (m)	94.070	Slope (1:X)	100.0
Side Inf Coefficient (m/hr)	0.03600	Time to half empty (mins)	4	Depth (m)	0.600
Safety Factor	2.0	Width (m)	8.097	Inf Depth (m)	
Porosity	0.30	Length (m)	91.075		

Node ATTENUATION BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.03600	Safety Factor	2.0	Invert Level (m)	93.500
Side Inf Coefficient (m/hr)	0.03600	Porosity	1.00	Time to half empty (mins)	645

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	104.1	104.1	1.200	317.1	317.1

Appendix: J – Causeway Flow Greenfield Runoff Rates

EAS

Appendix: K – Attenuation SuDS Strategy Layout

TRANSPORT PLANNING ■ HIGHWAYS AND DRAINAGE ■ FLOOD RISK
1st Floor Millers House, Roydon Road, Stanstead Abbotts, SG12 8HN. Tel 01920 871 777 e: contact@eastp.co.uk www.eastp.co.uk

KEY

- SITE BOUNDARY (TOTAL SITE AREA 1.26ha)
- PROPOSED RESIDENTIAL BUILDING (INCLUDED IN 10% URBAN CREEP)
- PROPOSED GARAGE OR FLAT BUILDING (NOT INCLUDED IN 10% URBAN CREEP)
- CONVEYANCE PERMEABLE PAVING (PP CONVEY1) WITH MIN. 500mm SUB-BASE
- CONVEYANCE PERMEABLE PAVING (PP CONVEY2) WITH MIN. 550mm SUB-BASE
- ATTENUATION PERMEABLE PAVING (PP ATTENUATION) WITH MIN. 450mm SUB-BASE
- SUB-BASE REPLACEMENT TANK (PP ATTENUATION) WITH 150mm DEPTH
- IMPERMEABLE HARDSTANDINGS (PATHS/DRIVEWAYS)
- PROPOSED GEO-CELLULAR STORAGE TANK (0.8m X 6.0m X 31.6m)
- ATTENUATION BASIN (DEPTH: 1.2m; TOP OF POND: 350.0m²; BASE OF POND: 124.2m²)
- PERMANENT WATER WITHIN ATTENUATION BASIN (600mm DEPTH)
- CONVEYANCE SWALE (DEPTH: 0.7m; SURFACE AREA: 85.0m²)
- SURFACE WATER PIPE NETWORK
- SURFACE WATER MANHOLE
- PERMAVOID DIFFUSER UNIT
- VARYING SIZE ORIFICE PLATE WITH SUITABLE FILTER TO RESTRICT RUNOFF
- HYDRO-BRAKE TO RESTRICT SURFACE WATER RUNOFF TO MAXIMUM OF 2.7 L/S
- FLOW ARROW
- EXCEEDANCE FLOW ARROW

REV	DATE	BY	DESCRIPTION	CHK	APD
–	–	–	–	–	–

DRAWING STATUS: OUTLINE APPLICATION

EAS
1st Floor Millers House, Roydon Road,
Stanstead Abbotts, Hertfordshire, SG12 8HN
Tel: 01920 871777
www.eastp.co.uk

CLIENT: BAYA GROUP LTD.

ARCHITECT:

PROJECT: CLAVERING, ESSEX, CB11 4QS
LAND TO THE WEST OF CLATTERBURY LANE

TITLE: SuDS ATTENUATION STRATEGY

SCALE @ A1:	DESIGN–DRAWN:	DATE:
1:250m	MS	22/11/2023

PROJECT No:	DRAWING No:
4641/2023	SK05

EAS

Appendix: L – Attenuation Strategy Causeway Flow Outputs

Design Settings

Rainfall Methodology	FEH-22	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	1.000	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	x
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
SW1	0.007	5.00	97.500	1500	108.825	59.661	2.996
SW2	0.007	5.00	96.800	1500	97.074	59.702	2.398
SW3	0.007	5.00	96.640	1500	86.554	59.748	2.357
SW4	0.029	5.00	96.513	1500	86.821	48.567	2.358
SW5	0.006	5.00	96.385	1800	96.356	38.893	2.418
PP ATTENUATION	0.068	5.00	96.385		87.287	27.264	0.600
SW6	0.039	5.00	96.385	1800	87.252	38.831	2.508
SW7	0.024	5.00	95.400	1800	72.219	39.049	1.642
STORAGE TANK	0.018	5.00	95.000		63.228	39.757	1.284
PP CONVEY2	0.050	5.00	94.800		66.878	24.848	0.600
SW9	0.045	5.00	94.800	1350	52.950	31.925	1.143
SW10	0.013	5.00	96.700	1500	74.062	65.685	1.853
SW11	0.013	5.00	96.100	1500	64.565	69.331	1.423
PP CONVEY1	0.043	1.00	95.500		39.995	72.561	0.550
SW12	0.013	5.00	95.400	1500	55.773	59.789	0.835
CONVEY SWALE	0.018	5.00	95.150		48.225	48.267	0.700
ATTENUATION BASIN			94.800		38.450	32.035	1.200
1			94.700	1200	19.714	29.453	1.200

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	SW1	SW2	20.400	0.600	94.504	94.402	0.102	200.0	300	5.31	50.0
1.001	SW2	SW3	23.700	0.600	94.402	94.283	0.119	199.2	300	5.66	50.0
1.002	SW3	SW4	25.000	0.600	94.283	94.155	0.128	195.3	300	6.03	50.0
1.003	SW4	SW6	25.500	0.600	94.155	94.027	0.128	199.2	300	6.42	50.0
2.000	SW5	SW6	27.000	0.600	93.967	93.877	0.090	300.0	450	5.39	50.0
3.000	PP ATTENUATION	SW6	6.000	0.600	95.785	95.377	0.408	14.7	100	5.05	50.0
1.004	SW6	SW7	35.800	0.600	93.877	93.758	0.119	300.8	450	6.93	50.0

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
1.000	1.108	78.3	1.3	2.696	2.098	0.007	0.0	27	0.416
1.001	1.110	78.5	2.5	2.098	2.057	0.014	0.0	37	0.512
1.002	1.121	79.3	3.8	2.057	2.058	0.021	0.0	44	0.582
1.003	1.110	78.5	9.0	2.058	2.058	0.050	0.0	68	0.745
2.000	1.168	185.8	1.1	1.968	2.058	0.006	0.0	24	0.320
3.000	2.025	15.9	12.3	0.500	0.908	0.068	0.0	66	2.232
1.004	1.167	185.5	29.5	2.058	1.192	0.163	0.0	120	0.860

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.005	SW7	STORAGE TANK	12.700	0.600	93.758	93.716	0.042	302.4	450	7.11	50.0
1.006	STORAGE TANK	SW9	17.700	0.600	93.716	93.657	0.059	300.0	450	7.36	50.0
4.000	PP CONVEY2	SW9	4.000	0.600	94.200	93.957	0.243	16.5	150	5.03	50.0
1.007	SW9	ATTENUATION BASIN	11.000	0.600	93.657	93.620	0.037	297.3	450	7.52	50.0
5.000	SW10	SW11	34.000	0.600	94.847	94.677	0.170	200.0	300	5.51	50.0
5.001	SW11	SW12	22.400	0.600	94.677	94.565	0.112	200.0	300	5.85	50.0
6.000	PP CONVEY1	SW12	20.300	0.600	94.950	94.640	0.310	65.5	100	1.36	50.0
5.002	SW12	CONVEY SWALE	13.774	0.600	94.565	94.450	0.115	119.8	300	6.01	50.0
5.003	CONVEY SWALE	ATTENUATION BASIN	10.000	0.600	94.450	93.620	0.830	12.0	100	6.08	50.0
1.008	ATTENUATION BASIN	1	10.000	0.600	93.600	93.500	0.100	100.0	150	7.69	50.0

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
1.005	1.164	185.1	33.8	1.192	0.834	0.187	0.0	130	0.894
1.006	1.168	185.8	37.0	0.834	0.693	0.205	0.0	136	0.920
4.000	2.495	44.1	9.0	0.450	0.693	0.050	0.0	46	1.968
1.007	1.174	186.7	54.2	0.693	0.730	0.300	0.0	166	1.023
5.000	1.108	78.3	2.3	1.553	1.123	0.013	0.0	35	0.500
5.001	1.108	78.3	4.7	1.123	0.535	0.026	0.0	50	0.616
6.000	0.953	7.5	7.8	0.450	0.660	0.043	0.0	86	1.080
5.002	1.435	101.5	14.8	0.535	0.400	0.082	0.0	77	1.033
5.003	2.238	17.6	18.1	0.600	1.080	0.100	0.0	85	2.542
1.008	1.005	17.8	72.3	1.050	1.050	0.400	0.0	150	1.023

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.000	20.400	200.0	300	Circular	97.500	94.504	2.696	96.800	94.402	2.098
1.001	23.700	199.2	300	Circular	96.800	94.402	2.098	96.640	94.283	2.057
1.002	25.000	195.3	300	Circular	96.640	94.283	2.057	96.513	94.155	2.058
1.003	25.500	199.2	300	Circular	96.513	94.155	2.058	96.385	94.027	2.058
2.000	27.000	300.0	450	Circular	96.385	93.967	1.968	96.385	93.877	2.058
3.000	6.000	14.7	100	Circular	96.385	95.785	0.500	96.385	95.377	0.908
1.004	35.800	300.8	450	Circular	96.385	93.877	2.058	95.400	93.758	1.192
1.005	12.700	302.4	450	Circular	95.400	93.758	1.192	95.000	93.716	0.834
1.006	17.700	300.0	450	Circular	95.000	93.716	0.834	94.800	93.657	0.693
4.000	4.000	16.5	150	Circular	94.800	94.200	0.450	94.800	93.957	0.693

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.000	SW1	1500	Manhole	Adoptable	SW2	1500	Manhole	Adoptable
1.001	SW2	1500	Manhole	Adoptable	SW3	1500	Manhole	Adoptable
1.002	SW3	1500	Manhole	Adoptable	SW4	1500	Manhole	Adoptable
1.003	SW4	1500	Manhole	Adoptable	SW6	1800	Manhole	Adoptable
2.000	SW5	1800	Manhole	Adoptable	SW6	1800	Manhole	Adoptable
3.000	PP ATTENUATION		Junction		SW6	1800	Manhole	Adoptable
1.004	SW6	1800	Manhole	Adoptable	SW7	1800	Manhole	Adoptable
1.005	SW7	1800	Manhole	Adoptable	STORAGE TANK		Junction	
1.006	STORAGE TANK		Junction		SW9	1350	Manhole	Adoptable
4.000	PP CONVEY2		Junction		SW9	1350	Manhole	Adoptable

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.007	11.000	297.3	450	Circular	94.800	93.657	0.693	94.800	93.620	0.730
5.000	34.000	200.0	300	Circular	96.700	94.847	1.553	96.100	94.677	1.123
5.001	22.400	200.0	300	Circular	96.100	94.677	1.123	95.400	94.565	0.535
6.000	20.300	65.5	100	Circular	95.500	94.950	0.450	95.400	94.640	0.660
5.002	13.774	119.8	300	Circular	95.400	94.565	0.535	95.150	94.450	0.400
5.003	10.000	12.0	100	Circular	95.150	94.450	0.600	94.800	93.620	1.080
1.008	10.000	100.0	150	Circular	94.800	93.600	1.050	94.700	93.500	1.050

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.007	SW9	1350	Manhole	Adoptable	ATTENUATION BASIN		Junction	
5.000	SW10	1500	Manhole	Adoptable	SW11	1500	Manhole	Adoptable
5.001	SW11	1500	Manhole	Adoptable	SW12	1500	Manhole	Adoptable
6.000	PP CONVEY1		Junction		SW12	1500	Manhole	Adoptable
5.002	SW12	1500	Manhole	Adoptable	CONVEY SWALE		Junction	
5.003	CONVEY SWALE		Junction		ATTENUATION BASIN		Junction	
1.008	ATTENUATION BASIN		Junction		1	1200	Manhole	Adoptable

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
SW1	108.825	59.661	97.500	2.996	1500	0	1.000	94.504	300
SW2	97.074	59.702	96.800	2.398	1500	1	1.000	94.402	300
						0	1.001	94.402	300
SW3	86.554	59.748	96.640	2.357	1500	1	1.001	94.283	300
						0	1.002	94.283	300
SW4	86.821	48.567	96.513	2.358	1500	1	1.002	94.155	300
						0	1.003	94.155	300
SW5	96.356	38.893	96.385	2.418	1800	0	2.000	93.967	450
PP ATTENUATION	87.287	27.264	96.385	0.600		0	3.000	95.785	100
SW6	87.252	38.831	96.385	2.508	1800	1	3.000	95.377	100
						2	2.000	93.877	450
						3	1.003	94.027	300
						0	1.004	93.877	450

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
SW7	72.219	39.049	95.400	1.642	1800	1	1.004	93.758	450
						0	1.005	93.758	450
STORAGE TANK	63.228	39.757	95.000	1.284		1	1.005	93.716	450
						0	1.006	93.716	450
PP CONVEY2	66.878	24.848	94.800	0.600		0	4.000	94.200	150
SW9	52.950	31.925	94.800	1.143	1350	1	4.000	93.957	150
						2	1.006	93.657	450
						0	1.007	93.657	450
SW10	74.062	65.685	96.700	1.853	1500	0	5.000	94.847	300
SW11	64.565	69.331	96.100	1.423	1500	1	5.000	94.677	300
						0	5.001	94.677	300
PP CONVEY1	39.995	72.561	95.500	0.550		0	6.000	94.950	100
SW12	55.773	59.789	95.400	0.835	1500	1	6.000	94.640	100
						2	5.001	94.565	300
						0	5.002	94.565	300
CONVEY SWALE	48.225	48.267	95.150	0.700		1	5.002	94.450	300
						0	5.003	94.450	100
ATTENUATION BASIN	38.450	32.035	94.800	1.200		1	5.003	93.620	100
						2	1.007	93.620	450
						0	1.008	93.600	150
1	19.714	29.453	94.700	1.200	1200	1	1.008	93.500	150

Simulation Settings

Rainfall Methodology	FEH-22	Analysis Speed	Normal	Additional Storage (m^3/ha)	20.0
Summer CV	1.000	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	1.000	Drain Down Time (mins)	1440	Check Discharge Volume	x

Storm Durations

15	30	60	120	180	240	360	480	600	720	960	1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
2	0	0	0
10	0	0	0
30	0	0	0
30	40	0	0
100	0	0	0
100	40	0	0

Node PP ATTENUATION Online Orifice Control

Flap Valve	x	Replaces Downstream Link	✓	Diameter (m)	0.025
Downstream Link	3.000	Invert Level (m)	95.605	Discharge Coefficient	0.600

Node ATTENUATION BASIN Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Downstream Link	1.008	Sump Available	✓
Replaces Downstream Link	✓	Product Number	CTL-SHE-0080-2700-0900-2700
Invert Level (m)	93.600	Min Outlet Diameter (m)	0.100
Design Depth (m)	0.900	Min Node Diameter (mm)	1200
Design Flow (l/s)	2.7		

Node STORAGE TANK Online Orifice Control

Flap Valve	x	Replaces Downstream Link	✓	Diameter (m)	0.038
Downstream Link	1.006	Invert Level (m)	93.716	Discharge Coefficient	0.600

Node PP CONVEY2 Online Orifice Control

Flap Valve	x	Replaces Downstream Link	✓	Diameter (m)	0.130
Downstream Link	4.000	Invert Level (m)	94.200	Discharge Coefficient	0.600

Node PP ATTENUATION Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	95.935	Slope (1:X)	300.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)		Depth (m)	
Safety Factor	2.0	Width (m)	8.562	Inf Depth (m)	
Porosity	0.30	Length (m)	79.311		

Node PP CONVEY2 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	94.200	Slope (1:X)	40.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	25	Depth (m)	
Safety Factor	2.0	Width (m)	5.480	Inf Depth (m)	
Porosity	0.30	Length (m)	62.000		

Node PP CONVEY1 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	94.950	Slope (1:X)	40.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	27	Depth (m)	
Safety Factor	2.0	Width (m)	5.640	Inf Depth (m)	
Porosity	0.30	Length (m)	55.000		

Node STORAGE TANK Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	93.716
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	173.6	0.0	0.800	173.6	0.0	0.801	0.0	0.0

Node CONVEY SWALE Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	94.450
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	26

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	5.6	0.0	0.700	85.6	0.0

Node PP ATTENUATION Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	95.785	Slope (1:X)	300.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)		Depth (m)	0.150
Safety Factor	2.0	Width (m)	6.179	Inf Depth (m)	
Porosity	0.95	Length (m)	74.906		

Node ATTENUATION BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	93.600
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	124.2	0.0	1.200	350.0	0.0

Results for 2 year Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	SW1	11	94.529	0.025	1.1	0.0448	0.0000	OK
15 minute summer	SW2	11	94.436	0.034	2.2	0.0619	0.0000	OK
15 minute summer	SW3	12	94.323	0.040	3.2	0.0733	0.0000	OK
15 minute summer	SW4	11	94.218	0.063	7.6	0.1268	0.0000	OK
15 minute summer	SW5	11	93.989	0.022	1.0	0.0583	0.0000	OK
360 minute winter	PP ATTENUATION	344	96.006	0.221	5.0	29.0708	0.0000	SURCHARGED
15 minute summer	SW6	11	93.963	0.086	14.9	0.2443	0.0000	OK
600 minute summer	SW7	600	93.939	0.181	4.1	0.5144	0.0000	OK
600 minute summer	STORAGE TANK	600	93.939	0.223	4.4	36.8914	0.0000	OK
15 minute summer	PP CONVEY2	12	94.331	0.131	10.4	1.0644	0.0000	OK
360 minute summer	SW9	264	93.872	0.215	7.2	0.4766	0.0000	OK
15 minute summer	SW10	11	94.880	0.033	2.1	0.0631	0.0000	OK
15 minute summer	SW11	11	94.722	0.045	4.1	0.0887	0.0000	OK
15 minute summer	PP CONVEY1	9	95.053	0.103	12.3	0.5769	0.0000	SURCHARGED
15 minute summer	SW12	10	94.640	0.075	13.6	0.1559	0.0000	OK
15 minute summer	CONVEY SWALE	11	94.524	0.074	16.2	0.7630	0.0000	OK
360 minute summer	ATTENUATION BASIN	264	93.872	0.272	11.7	40.7032	0.0000	SURCHARGED
15 minute summer	1	1	93.500	0.000	2.4	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute summer	SW1	1.000	SW2	1.1	0.315	0.014	0.0723	
15 minute summer	SW2	1.001	SW3	2.1	0.431	0.027	0.1174	
15 minute summer	SW3	1.002	SW4	3.1	0.388	0.039	0.2036	
15 minute summer	SW4	1.003	SW6	7.3	0.697	0.093	0.2678	
15 minute summer	SW5	2.000	SW6	0.9	0.084	0.005	0.3218	
360 minute winter	PP ATTENUATION	Orifice	SW6	0.8				
15 minute summer	SW6	1.004	SW7	14.5	0.662	0.078	0.7851	
600 minute summer	SW7	1.005	STORAGE TANK	3.9	0.600	0.021	0.8777	
600 minute summer	STORAGE TANK	Orifice	SW9	1.3				
15 minute summer	PP CONVEY2	Orifice	SW9	9.0				
360 minute summer	SW9	1.007	ATTENUATION BASIN	6.9	0.354	0.037	0.9122	
15 minute summer	SW10	5.000	SW11	2.0	0.380	0.026	0.1852	
15 minute summer	SW11	5.001	SW12	4.0	0.438	0.051	0.2249	
15 minute summer	PP CONVEY1	6.000	SW12	7.8	1.070	1.048	0.1535	
15 minute summer	SW12	5.002	CONVEY SWALE	13.3	1.038	0.131	0.1835	
15 minute summer	CONVEY SWALE	5.003	ATTENUATION BASIN	15.6	2.522	0.888	0.0619	
360 minute summer	ATTENUATION BASIN	Hydro-Brake®	1	2.7				141.7

Results for 10 year Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	SW1	10	94.539	0.035	2.4	0.0641	0.0000	OK
15 minute summer	SW2	11	94.451	0.049	4.7	0.0897	0.0000	OK
15 minute summer	SW3	11	94.342	0.059	7.0	0.1081	0.0000	OK
15 minute summer	SW4	11	94.251	0.096	16.5	0.1925	0.0000	OK
720 minute summer	SW5	735	94.099	0.132	0.2	0.3422	0.0000	OK
360 minute winter	PP ATTENUATION	360	96.088	0.303	8.5	57.8942	0.0000	FLOOD RISK
720 minute summer	SW6	735	94.099	0.222	4.7	0.6337	0.0000	OK
720 minute summer	SW7	735	94.099	0.341	5.7	0.9671	0.0000	OK
720 minute summer	STORAGE TANK	735	94.099	0.383	6.0	63.2534	0.0000	OK
15 minute summer	PP CONVEY2	13	94.449	0.249	22.0	3.0030	0.0000	SURCHARGED
360 minute summer	SW9	312	94.048	0.391	11.3	0.8681	0.0000	OK
15 minute summer	SW10	11	94.895	0.048	4.5	0.0909	0.0000	OK
15 minute summer	SW11	11	94.744	0.067	8.8	0.1303	0.0000	OK
15 minute summer	PP CONVEY1	10	95.187	0.237	25.8	2.4104	0.0000	SURCHARGED
15 minute summer	SW12	11	94.664	0.099	21.8	0.2056	0.0000	OK
15 minute summer	CONVEY SWALE	14	94.631	0.181	28.1	2.9717	0.0000	SURCHARGED
360 minute summer	ATTENUATION BASIN	312	94.048	0.448	19.1	74.5718	0.0000	SURCHARGED
15 minute summer	1	1	93.500	0.000	2.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute summer	SW1	1.000	SW2	2.3	0.393	0.030	0.1238	
15 minute summer	SW2	1.001	SW3	4.7	0.544	0.059	0.2050	
15 minute summer	SW3	1.002	SW4	6.9	0.479	0.087	0.3639	
15 minute summer	SW4	1.003	SW6	16.3	0.868	0.207	0.4784	
720 minute summer	SW5	2.000	SW6	0.2	0.050	0.001	1.5729	
360 minute winter	PP ATTENUATION	Orifice	SW6	0.9				
720 minute summer	SW6	1.004	SW7	4.7	0.361	0.025	3.6994	
720 minute summer	SW7	1.005	STORAGE TANK	5.3	0.602	0.029	1.7308	
720 minute summer	STORAGE TANK	Orifice	SW9	1.6				
15 minute summer	PP CONVEY2	Orifice	SW9	15.1				
360 minute summer	SW9	1.007	ATTENUATION BASIN	10.8	0.399	0.058	1.6609	
15 minute summer	SW10	5.000	SW11	4.4	0.474	0.056	0.3202	
15 minute summer	SW11	5.001	SW12	8.7	0.555	0.111	0.3571	
15 minute summer	PP CONVEY1	6.000	SW12	8.8	1.130	1.181	0.1559	
15 minute summer	SW12	5.002	CONVEY SWALE	22.2	1.059	0.219	0.4111	
15 minute summer	CONVEY SWALE	5.003	ATTENUATION BASIN	18.7	2.505	1.065	0.0782	
360 minute summer	ATTENUATION BASIN	Hydro-Brake®	1	2.7				223.5

Results for 30 year Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	SW1	10	94.545	0.041	3.2	0.0739	0.0000	OK
15 minute summer	SW2	11	94.459	0.057	6.3	0.1038	0.0000	OK
15 minute summer	SW3	11	94.352	0.069	9.4	0.1258	0.0000	OK
15 minute summer	SW4	11	94.267	0.112	22.0	0.2264	0.0000	OK
600 minute winter	SW5	690	94.201	0.234	0.2	0.6077	0.0000	OK
360 minute winter	PP ATTENUATION	360	96.131	0.346	10.5	75.1799	0.0000	FLOOD RISK
600 minute winter	SW6	675	94.201	0.324	4.7	0.9261	0.0000	OK
600 minute winter	SW7	675	94.201	0.443	5.3	1.2574	0.0000	OK
600 minute winter	STORAGE TANK	690	94.201	0.485	5.6	80.1561	0.0000	SURCHARGED
30 minute summer	PP CONVEY2	21	94.524	0.324	27.4	4.7034	0.0000	FLOOD RISK
360 minute summer	SW9	360	94.157	0.500	13.6	1.1095	0.0000	SURCHARGED
15 minute summer	SW10	10	94.902	0.055	6.0	0.1047	0.0000	OK
15 minute summer	SW11	11	94.754	0.077	11.8	0.1506	0.0000	OK
15 minute summer	PP CONVEY1	11	95.255	0.305	34.4	3.8001	0.0000	FLOOD RISK
15 minute summer	SW12	15	94.696	0.131	26.7	0.2718	0.0000	OK
15 minute summer	CONVEY SWALE	14	94.692	0.242	35.5	4.8211	0.0000	SURCHARGED
360 minute summer	ATTENUATION BASIN	360	94.157	0.557	23.2	98.3656	0.0000	SURCHARGED
15 minute summer	1	1	93.500	0.000	2.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute summer	SW1	1.000	SW2	3.1	0.426	0.040	0.1524	
15 minute summer	SW2	1.001	SW3	6.3	0.590	0.080	0.2540	
15 minute summer	SW3	1.002	SW4	9.3	0.521	0.118	0.4536	
15 minute summer	SW4	1.003	SW6	22.0	0.941	0.280	0.5956	
600 minute winter	SW5	2.000	SW6	0.2	0.051	0.001	2.7769	
360 minute winter	PP ATTENUATION	Orifice	SW6	0.9				
600 minute winter	SW6	1.004	SW7	4.4	0.371	0.024	5.0165	
600 minute winter	SW7	1.005	STORAGE TANK	4.9	0.606	0.027	2.0091	
600 minute winter	STORAGE TANK	Orifice	SW9	1.7				
30 minute summer	PP CONVEY2	Orifice	SW9	18.0				
360 minute summer	SW9	1.007	ATTENUATION BASIN	13.1	0.416	0.070	1.7429	
15 minute summer	SW10	5.000	SW11	5.8	0.514	0.074	0.3927	
15 minute summer	SW11	5.001	SW12	11.6	0.635	0.148	0.4211	
15 minute summer	PP CONVEY1	6.000	SW12	9.4	1.205	1.260	0.1565	
15 minute summer	SW12	5.002	CONVEY SWALE	27.6	1.070	0.272	0.6181	
15 minute summer	CONVEY SWALE	5.003	ATTENUATION BASIN	18.2	2.457	1.036	0.0782	
360 minute summer	ATTENUATION BASIN	Hydro-Brake®	1	2.7				253.5

Results for 30 year +40% CC Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	SW1	10	94.552	0.048	4.5	0.0870	0.0000	OK
15 minute summer	SW2	11	94.470	0.068	8.9	0.1234	0.0000	OK
720 minute winter	SW3	810	94.419	0.136	0.9	0.2491	0.0000	OK
720 minute winter	SW4	810	94.419	0.264	2.3	0.5323	0.0000	OK
720 minute winter	SW5	825	94.419	0.452	0.3	1.1737	0.0000	SURCHARGED
480 minute winter	PP ATTENUATION	480	96.213	0.428	11.8	112.1418	0.0000	FLOOD RISK
720 minute winter	SW6	810	94.419	0.542	5.1	1.5493	0.0000	SURCHARGED
720 minute winter	SW7	810	94.420	0.662	5.7	1.8767	0.0000	SURCHARGED
720 minute winter	STORAGE TANK	810	94.420	0.704	6.4	116.2232	0.0000	SURCHARGED
30 minute summer	PP CONVEY2	22	94.641	0.441	38.3	8.0883	0.0000	FLOOD RISK
360 minute winter	SW9	352	94.352	0.695	13.3	1.5417	0.0000	SURCHARGED
15 minute summer	SW10	10	94.912	0.065	8.4	0.1239	0.0000	OK
15 minute summer	SW11	15	94.776	0.099	16.6	0.1933	0.0000	OK
15 minute summer	PP CONVEY1	11	95.351	0.401	47.8	6.3025	0.0000	FLOOD RISK
30 minute summer	SW12	24	94.775	0.210	32.1	0.4357	0.0000	OK
30 minute summer	CONVEY SWALE	24	94.774	0.324	41.1	7.9688	0.0000	SURCHARGED
360 minute winter	ATTENUATION BASIN	352	94.352	0.752	21.9	146.5386	0.0000	SURCHARGED
15 minute summer	1	1	93.500	0.000	2.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute summer	SW1	1.000	SW2	4.4	0.466	0.056	0.1947	
15 minute summer	SW2	1.001	SW3	8.8	0.647	0.113	0.3244	
720 minute winter	SW3	1.002	SW4	0.9	0.273	0.011	1.2112	
720 minute winter	SW4	1.003	SW6	2.3	0.497	0.030	1.7362	
720 minute winter	SW5	2.000	SW6	0.3	0.050	0.002	4.2771	
480 minute winter	PP ATTENUATION	Orifice	SW6	1.0				
720 minute winter	SW6	1.004	SW7	4.6	0.364	0.025	5.6723	
720 minute winter	SW7	1.005	STORAGE TANK	5.2	0.617	0.028	2.0122	
720 minute winter	STORAGE TANK	Orifice	SW9	1.6				
30 minute summer	PP CONVEY2	Orifice	SW9	21.6				
360 minute winter	SW9	1.007	ATTENUATION BASIN	12.4	0.456	0.066	1.7429	
15 minute summer	SW10	5.000	SW11	8.2	0.565	0.105	0.5000	
15 minute summer	SW11	5.001	SW12	16.4	0.692	0.209	0.7939	
15 minute summer	PP CONVEY1	6.000	SW12	10.2	1.308	1.367	0.1588	
30 minute summer	SW12	5.002	CONVEY SWALE	30.9	1.033	0.305	0.8470	
30 minute summer	CONVEY SWALE	5.003	ATTENUATION BASIN	18.5	2.524	1.050	0.0782	
360 minute winter	ATTENUATION BASIN	Hydro-Brake®	1	2.7				256.6

Results for 100 year Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	SW1	10	94.550	0.046	4.1	0.0831	0.0000	OK
15 minute summer	SW2	11	94.466	0.064	8.1	0.1173	0.0000	OK
15 minute summer	SW3	11	94.361	0.078	11.9	0.1423	0.0000	OK
720 minute winter	SW4	795	94.325	0.170	2.1	0.3418	0.0000	OK
720 minute winter	SW5	795	94.325	0.358	0.3	0.9281	0.0000	OK
480 minute winter	PP ATTENUATION	472	96.178	0.393	10.3	95.7555	0.0000	FLOOD RISK
720 minute winter	SW6	795	94.325	0.448	4.7	1.2788	0.0000	OK
720 minute winter	SW7	795	94.325	0.567	5.3	1.6078	0.0000	SURCHARGED
720 minute winter	STORAGE TANK	810	94.325	0.609	5.6	100.5643	0.0000	SURCHARGED
30 minute summer	PP CONVEY2	22	94.605	0.405	34.9	6.9635	0.0000	FLOOD RISK
360 minute winter	SW9	352	94.272	0.615	11.6	1.3640	0.0000	SURCHARGED
15 minute summer	SW10	10	94.908	0.061	7.5	0.1172	0.0000	OK
15 minute summer	SW11	11	94.764	0.087	14.8	0.1693	0.0000	OK
15 minute summer	PP CONVEY1	11	95.320	0.370	43.3	5.4163	0.0000	FLOOD RISK
30 minute summer	SW12	24	94.749	0.184	29.7	0.3820	0.0000	OK
30 minute summer	CONVEY SWALE	25	94.749	0.299	38.9	6.9404	0.0000	SURCHARGED
360 minute winter	ATTENUATION BASIN	352	94.272	0.672	19.3	125.8754	0.0000	SURCHARGED
15 minute summer	1	1	93.500	0.000	2.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute summer	SW1	1.000	SW2	4.0	0.455	0.051	0.1813	
15 minute summer	SW2	1.001	SW3	8.0	0.631	0.102	0.3025	
15 minute summer	SW3	1.002	SW4	11.9	0.555	0.151	0.5433	
720 minute winter	SW4	1.003	SW6	2.1	0.485	0.027	1.4210	
720 minute winter	SW5	2.000	SW6	0.2	0.051	0.001	3.9613	
480 minute winter	PP ATTENUATION	Orifice	SW6	1.0				
720 minute winter	SW6	1.004	SW7	4.3	0.364	0.023	5.6693	
720 minute winter	SW7	1.005	STORAGE TANK	4.9	0.606	0.026	2.0122	
720 minute winter	STORAGE TANK	Orifice	SW9	1.7				
30 minute summer	PP CONVEY2	Orifice	SW9	20.6				
360 minute winter	SW9	1.007	ATTENUATION BASIN	10.8	0.447	0.058	1.7429	
15 minute summer	SW10	5.000	SW11	7.3	0.548	0.094	0.4622	
15 minute summer	SW11	5.001	SW12	14.6	0.680	0.187	0.6366	
15 minute summer	PP CONVEY1	6.000	SW12	10.0	1.275	1.333	0.1588	
30 minute summer	SW12	5.002	CONVEY SWALE	29.7	1.033	0.292	0.7959	
30 minute summer	CONVEY SWALE	5.003	ATTENUATION BASIN	18.2	2.504	1.034	0.0782	
360 minute winter	ATTENUATION BASIN	Hydro-Brake®	1	2.7				261.4

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	SW1	930	94.806	0.302	0.3	0.5479	0.0000	SURCHARGED
960 minute winter	SW2	930	94.806	0.404	0.9	0.7372	0.0000	SURCHARGED
960 minute winter	SW3	930	94.806	0.523	1.1	0.9547	0.0000	SURCHARGED
960 minute winter	SW4	930	94.805	0.650	2.2	1.3094	0.0000	SURCHARGED
960 minute winter	SW5	930	94.806	0.839	0.4	2.1757	0.0000	SURCHARGED
480 minute winter	PP ATTENUATION	480	96.275	0.490	14.4	141.7617	0.0000	FLOOD RISK
960 minute winter	SW6	930	94.806	0.929	4.9	2.6518	0.0000	SURCHARGED
960 minute winter	SW7	930	94.805	1.047	5.4	2.9711	0.0000	SURCHARGED
960 minute winter	STORAGE TANK	930	94.805	1.089	6.2	132.3234	0.0000	FLOOD RISK
30 minute summer	PP CONVEY2	24	94.746	0.546	48.7	11.9100	0.0000	FLOOD RISK
600 minute winter	SW9	600	94.492	0.835	10.9	1.8527	0.0000	SURCHARGED
15 minute summer	SW10	10	94.920	0.073	10.6	0.1394	0.0000	OK
30 minute summer	SW11	26	94.844	0.167	18.8	0.3261	0.0000	OK
30 minute summer	PP CONVEY1	22	95.444	0.494	40.1	9.3007	0.0000	FLOOD RISK
30 minute summer	SW12	26	94.844	0.279	38.7	0.5793	0.0000	OK
30 minute summer	CONVEY SWALE	25	94.841	0.391	48.0	11.1192	0.0000	SURCHARGED
600 minute winter	ATTENUATION BASIN	600	94.492	0.892	17.7	185.6726	0.0000	SURCHARGED
15 minute summer	1	1	93.500	0.000	2.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
960 minute winter	SW1	1.000	SW2	0.3	0.206	0.004	1.4363	
960 minute winter	SW2	1.001	SW3	-0.8	0.289	-0.010	1.6689	
960 minute winter	SW3	1.002	SW4	-1.0	0.276	-0.013	1.7605	
960 minute winter	SW4	1.003	SW6	2.2	0.490	0.028	1.7957	
960 minute winter	SW5	2.000	SW6	0.3	0.049	0.001	4.2780	
480 minute winter	PP ATTENUATION	Orifice	SW6	1.1				
960 minute winter	SW6	1.004	SW7	4.3	0.347	0.023	5.6723	
960 minute winter	SW7	1.005	STORAGE TANK	5.0	0.598	0.027	2.0122	
960 minute winter	STORAGE TANK	Orifice	SW9	1.7				
30 minute summer	PP CONVEY2	Orifice	SW9	24.5				
600 minute winter	SW9	1.007	ATTENUATION BASIN	10.1	0.428	0.054	1.7429	
15 minute summer	SW10	5.000	SW11	10.4	0.595	0.133	0.7046	
30 minute summer	SW11	5.001	SW12	18.6	0.704	0.238	1.2161	
30 minute summer	PP CONVEY1	6.000	SW12	10.7	1.367	1.429	0.1588	
30 minute summer	SW12	5.002	CONVEY SWALE	35.1	1.024	0.346	0.9548	
30 minute summer	CONVEY SWALE	5.003	ATTENUATION BASIN	18.3	2.529	1.043	0.0782	
600 minute winter	ATTENUATION BASIN	Hydro-Brake®	1	2.7				289.9

Design Settings

Rainfall Methodology	FEH-22	Minimum Velocity (m/s)	1.00
Return Period (years)	100	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	1.000	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	x
Maximum Rainfall (mm/hr)	50.0		

Node PP ATTENUATION Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	95.935	Slope (1:X)	300.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	664	Depth (m)	
Safety Factor	2.0	Width (m)	8.562	Inf Depth (m)	
Porosity	0.30	Length (m)	79.311		

Node PP CONVEY2 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	94.200	Slope (1:X)	40.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	12	Depth (m)	
Safety Factor	2.0	Width (m)	5.480	Inf Depth (m)	
Porosity	0.30	Length (m)	62.000		

Node PP CONVEY1 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	94.950	Slope (1:X)	40.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	8	Depth (m)	
Safety Factor	2.0	Width (m)	5.640	Inf Depth (m)	
Porosity	0.30	Length (m)	55.000		

Node STORAGE TANK Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	93.716
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Time to half empty (mins)	600

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	189.2	0.0	0.800	189.2	0.0	0.801	0.0	0.0

Node CONVEY SWALE Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	94.450
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	0

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	5.6	0.0	0.700	85.0	0.0

Node PP ATTENUATION Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	95.785	Slope (1:X)	300.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	960	Depth (m)	0.150
Safety Factor	2.0	Width (m)	6.179	Inf Depth (m)	
Porosity	0.95	Length (m)	74.906		

Node ATTENUATION BASIN Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	93.600
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	20

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	124.2	0.0	1.200	350.0	0.0