CONSULTING ENGINEERS LTD

TECHNICAL NOTE

Date: 22 September 2021

File Ref: SG/VL/P21-2315/01TN Vol. 1 of 3

Project: Land at Impington, Histon, Cambridgeshire

Subject: Summary of Flood Risk and Drainage Matters

1.0 INTRODUCTION

1.1 This report provides information with respect to Flood Risk and Drainage matters, by Create Consulting Engineers Ltd on behalf of Cirrus Impington Ltd, and proposes surface water drainage options whilst clarifying whether an outfall to the adjacent ditch can be achieved for the above site, located to the south of Villa Road, Impington, Cambridge, CB24 9NZ.

1.2 This report will inform strategic planning at the Site and will act as a basis for housing and layout design, if feasible.

1.3 A record of correspondence conducted by Create Consulting Engineers Ltd on behalf of the client, including information sources and consultation requests where appropriate, can be found in Table 1.1 below.

Consultee	Form of Consultation	Topics Discussed and Actions Agreed
Anglian Water Developer Services Team	Request for Asset Plans	Asset plans were requested in order to inform the foul and surface water drainage strategies. The asset plans (Appendix A), dated 16th June 2021, show surface and foul water assets in the vicinity of the Site as outlined in Section 2.0 below.
Cambridgeshire County Council Lead Local Flood Authority (LLFA)	Pre-Application consultation and subsequent email correspondence	The LLFA have confirmed that in this instance the fluvial modelling carried out can act as a proxy for the surface water flood mapping given the nature of the catchment means the fluvial modelling is

Consultee	Form of Consultation	Topics Discussed and Actions Agreed
		more representative of the likely flood extents. Correspondence is included in Appendix E.

Table 1.1 Summary of Consultation

Sources of Information

1.4 As part of this study, the following documents have been obtained and reviewed and are appended to this report:

- Cambridgeshire County Council Preliminary Flood Risk Assessment (PFRA) (Hyder, 2011);
- Cambridgeshire County Council Local Flood Risk Management Strategy (Cambridgeshire County Council, 2015);
- Cambridgeshire Flood and Water Supplementary Planning Document (Cambridgeshire County Council, 2016);
- Surface Water Drainage Guidance for Developers (Cambridgeshire County Council, 2019);
- Cambridgeshire County Council Surface Water Management Plan (SWMP) Countywide Update (Hyder, 2014);
- Cambridge and Milton Surface Water Management Plan—Detailed Assessment and Options Appraisal Report (Hyder & Edenvale Young, 2011);
- South Cambridgeshire Local Plan (South Cambridgeshire District Council, 2018);
- South Cambridgeshire and Cambridge City Level 1 Strategic Flood Risk Assessment (SFRA) (WSP, 2010);
- Anglian Water Foul Water Asset Plans (attached);
- King's Gate Site Plan (attached);
- Topographical Survey Drawings 2219-545-SU01 to 2219-545-SU16 (BB Surveys Ltd, March 2017, attached);
- Previous Create Consulting Engineers Ltd works relating to hydraulic modelling of the Public Drain.

2.0 SITE SETTING & EXISTING DRAINAGE

Location and Topography

2.1 The Site comprises approximately 6.62 ha of greenfield land immediately bounded by Villa Road to the north, residential development to the east and agricultural fields to the south and west. Further residential development is situated north of Villa Road, north east of the Site, and agricultural fields to the north west. The centre of the Site lies at Ordnance grid reference 543729E and 262621N, with its boundary shown on Figure 1.1.

2.2 LiDAR[1] data for the area indicates that the Site slightly falls towards the Public Drain crossing through the Site, however, generally the ground level is relatively consistent. Levels range from circa 10.76 mAOD to 13.41 mAOD in minor areas in the north west, however, for the majority of the Site levels are indicated around 11.0 mAOD. Invert levels taken from the appended survey (Drawings 2219-545-SU01 to 2219-545-SU16) of the Public Drain produced for the Watercourse Hydraulic Modelling for NIAB, further detail below, indicate levels range between 9.70 mAOD and 10.0 mAOD.

Hydrology

Surface Watercourses

2.3 The Public Drain crosses through the Site, towards the west, draining from south to north before reaching its confluence with the Beck Brook, approximately 2.60 km north west of the Site (Figure 2.1).

Groundwater

2.4 The Site is underlain by a Secondary A superficial deposit aquifer[2], however, does not lie within a Groundwater Source Protection Zone, as shown by the online mapping (DEFRA, accessed July 2021).

Artificial Water Bodies

2.5 The nearest artificial water bodies to the Site include a pond situated approximately 153 m to the north east, an agricultural reservoir approximately 810 m to the south west and Cawcutts Lake approximately 900 m to the south east.

[1] Department for Environment Food and Rural Affairs (DEFRA) Data Survey Website. (2020). *EA LiDAR Data*. [Online]. Available at: https://environment.data.gov.uk/DefraDataDownload/?Mode=survey. (Accessed July 2021).
[2] Department for Environment and Rural Affairs (DEFRA) Magic Website., 2010. [Online]. *Environment Agency Aquifer Designation Data.* Available at: https://magic.defra.gov.uk/MagicMap.aspx [Accessed July 2021].

Existing Water Supply and Drainage Infrastructure

2.6 Anglian Water foul and surface water assets are located in the area surrounding the Site with a 9 inch foul sewer running beneath South Road to the east of the Site and continuing north, serving residential development associated with Impington. Further foul sewer connections and a surface water network are present serving residential areas to the north of Villa Road.

3.0 FLOOD RISK ASSESSMENT

Scope of Work

3.1 The scope of this Technical Note considers the following:

- Flood risk to the development from all sources;
- Potential for the design, construction and operation of the Site to increase the risk of flooding to neighbouring properties;
- Climate change;
- Residual flood risks.

3.2 The approach is consistent with the NPPF[1] and its associated Technical Guidance[2] along with the requirements of local planning policy.

Flood Risk to the Proposed Development

Flood Risk from Fluvial/Tidal Sources

3.3 EA flood mapping[3], as shown on Figure 3.1, indicates that the majority of the Site is located within Flood Zones 2 and 3 and a minor area adjacent to the eastern boundary located within Flood Zone 1. Flood Zone 2 comprises land assessed as having between a 1 in 100 (1%) and 1 in 1000 (0.1%) annual probability of fluvial flooding in any one year, whereas Flood Zone 3 is classified as land which has a 1 in 100 (0.5%) or greater annual probability of fluvial flooding. Flood Zone 1 is described within the NPPF Technical Guidance as having less than 1 in 1000 (<0.1%) probability of flooding from rivers or the sea in any one year.

3.4 The development proposals have not yet been finalised, nonetheless, given the location of the Site within Flood Zones 2 and 3, the Sequential and Exception Tests may need to be undertaken for the purposes of the proposed development. However, these are beyond the scope of this report and it is assumed they will be provided as separate submissions as part of the planning application if the scheme is deemed viable.

3.5 Review of the PFRA and SWMP identified no historic records of flooding from this source affecting the Site itself or surrounding area. However, the SWMP highlights a record of fluvial flooding (4-10 years ago lasting 1-2 days) in Impington.

[3] Environment Agency, 2020. *Flood Map for Planning (Rivers and Sea) - Flood Zone 2 and Flood Zone 3. [Online]. Available at:* https://data.gov.uk/dataset/cf494c44-05cd-4060-a029-35937970c9c6/flood-map-for-planning-rivers-and-sea-flood-zone-2 [Accessed July 2021]

Flood Risk from Surface Water

3.6 The EA Surface Water Flood Maps (Figure 3.2) suggest that the majority of the Site is at a 'High' to 'Low' risk of surface water flooding from extreme rainfall which is defined as having between a 1 in 30 (3.3%) and 1 in 1000 (0.1%) chance of flooding, with a minor area of 'Very Low' risk to the north west, associated with a shallow topographical high.

3.7 Given the surface water flood risk extent closely follows the fluvial extent as a result of the Public Drain which passes through the Site, it is proposed that the updated surface water modelling for the 1 in 100 year + 35% CC and 1 in 100 year + 65% CC events relating to fluvial flood risk be used as a proxy for this. Further detail can be found below, pending consultation with the Lead Local Flood Authority.

3.8 Flood depths for the High (1 in 30 year) and Medium (1 in 100 year) risk scenarios are shown by available EA mapping to generally remain below 300 mm with minor areas reaching up to 600 mm (Figures 3.3-3.4). For the Low risk (1 in 1000 year) scenario flood depths across the majority of the Site reach up to 600 mm with the extent along the Public Drain reaching up to over 1200 mm. The area to the north of the western section of the Site, along with very minor areas within the Site reach up to 900 mm.

3.9 Review of the PFRA and SWMP identified no historic record of flooding from this source affecting the Site itself, however, the SFRA identified a record of flooding from surface water at Villa Road on 9th September 2005. Further to this the SFRA notes various records of surface water flooding in other areas of Impington and Histon in 2001 and 2005 and the SWMP notes a record from 2008 in Histon and records from 2005 and 2006 in Impington.

3.10 Surface water flood risk has been considered below as part of the fluvial modelling in that the fluvial modelling is considered to provide a suitable proxy for the surface water flood risks posed and so the above risks should not be considered as a true representation of what could occur at the site.

3.11 Flooding from surface water remains a residual risk due to the potential for rainfall to exceed the design standard of the proposed drainage system and the effects of climate change on the frequency and severity of rainfall events. The initial drainage layout proposed (Figure 4.1) sets out a preliminary option of providing sufficient sustainable drainage systems that if utilised will ensure that there are no significant changes in surface water runoff from the Site compared to the existing situation (for all rainfall events up to the 1 in 100 year rainfall event including an allowance for climate change). Further detail can be found in Section 4.0 below.

Fluvial Flood Modelling

Estimate of Flows in Watercourse

3.12 Hydraulic Modelling has previously been undertaken for the Public Drain in relation to another site (referred to as NIAB) further north west, using the HEC-RAS software. The modelling was requested by the EA with regard to the requirement for a site specific hydraulic analysis in order to determine the flood risk to the proposed development with an allowance for climate change (CC). This exercise was carried out by Create Consulting Engineers Ltd in 2017 and has been used here to assess the impact of fluvial flooding on the site. It has been confirmed with the LLFA that this can be used as a proxy for surface water flood risk too given the modelling better represents how the catchment reacts to rainfall compared to the methodology for the online surface water flood mapping.

3.13 With reference to the Watercourse Hydraulic Modelling Report (Create Consulting Engineers Ltd., 2017, attached ad Appendix D), the Public Drain is understood to be fed by a catchment 3.27 km^2 in size to the south, inferred from the FEH Web Mapping Service and verified against watershed analysis using GRASS software and Environment Agency LiDAR data.

3.14 There is no gauged flow data available for the Public Drain and therefore the flow regime has been estimated using both WINFAP 4 and ReFH2 with catchment descriptors extracted from the FEH Web Mapping Service. The median flow (QMED) for the study catchment (index flood) was calculated as 0.281 m^3/s from the catchment descriptors using WINFAP 4. Using the ReFH2 program and the inputs from the FEH online web service, estimates were obtained for various return periods.

3.15 WINFAP 4 uses flow records from either a single reliable gauged site in the same catchment or from a number of other gauged sites in hydrologically similar catchments to form a pooling group which is subjected to a statistical analysis. Following this the flood growth curve and flood frequency curve generated by the analysis are used to calculate a range of flood flows. This was carried out for the watercourse using the inputs from the FEH online web service. A default urban adjustment factor was applied (Urbext2000). A sensitivity analysis of the urban adjustment (URBext2000) factor was undertaken. The percentage of impermeable area was determined using aerial imagery and it was concluded that the percentage of impermeable area was approximately half of the default value presented by Urbext2000. The default Urbext2000 value was however utilised for calculating flows as this value was more conservative than the calculated value.

3.16 A sensitivity analysis was carried out to determine the impact of using a bankfull flow estimate for QMED. WINFAP 4 has the functionality to produce a bankfull estimate for QMED. The bankfull QMED was calculated using both the catchment descriptors and channel dimensions as an input into the pooling analysis. The channel was measured in several places and an average Bankfull Channel Width of 5.95 m was used.

3.17 To provide a conservative estimate of the flows in the Public Drain, peak flows from the bankfull analysis will be utilised in the flood model. Full details are included in Appendix D, however Table 3.1 below provides a summary of these.

Return Period (Years)	Flows Calculated from Bankfull Analysis (in WINFAP 4, m^3/s)	+25% Climate Change (m^3/s)	+35% Climate Change (m^3/s)	+65% Climate Change (m^3/s)
2	0.63	0.78	0.85	1.040
5	0.87	1.09	1.18	1.44
10	1.06	1.32	1.43	1.75
25	1.33	1.66	1.79	2.19
50	1.57	1.96	2.11	2.59
100	1.84	2.30	2.48	3.04
200	2.16	2.69	2.91	3.56
500	2.65	3.31	3.58	4.37
1000	3.10	3.87	4.18	5.12

Table 3.1: Flows calculated using bankfull analysis (in WINFAP) to include 25%, 35% and 65% climate change allowances

Climate Change Allowances

3.18 To incorporate the potential future effects of climate change the bankfull flows have been increased accordingly, as per Table 3.1 above.

3.19 For the purposes of this report, the original modelling has been utilised and updated in order to include the additional climate change allowances required for the residential land use vulnerability class. The proposed development is classified as 'more vulnerable' use according to the NPPF. Based on the EA's guidance the 'higher central' (35%) and 'upper end' (65%) allowances for the Anglian Basin 2070-2115 will be added on to the flows based on a development design life of 100 years. The 1 in 1000 year event will also be considered to classify Flood Zone 2.

3.20 Since the production of our draft report it should be noted the national climate change allowances have been updated, however given the minimal impacts the above have (as summarised below) it is considered that they represent a worst case, particularly given that this modelling is being considered as a proxy for the surface water flood mapping.

Methodology

3.21 The hydraulic model has been developed to estimate the flood extent of the Public Drain for the 1 in 100 year event. As the channel is both small and relatively straight a one dimensional model was chosen to represent the channel which has been constructed using HEC-RAS 6.0. A 700 m stretch of the drain ending at the guided busway at its northern extent was chosen to best represent water levels at the site. This reach comprises four bridges and one culvert. The model was run in a steady state scenario by using a constant flow input for the 1 in 100 year event (as the pooling analysis generates a peak flow only).

3.22 A detailed topographical survey (appended) was undertaken on 7 March 2017 (Drawings 2219-545-SU01 - 2219-545-SU16). 42 channel cross sections at 20 m intervals were generated using the topographical survey as well as a 3D surface.

3.23 The following surface roughness assumptions have been made for the channel and floodplain based on a combination of site photographs and google earth imagery. The values have been obtained from the HEC-RAS reference manual (US Army Corps Engineers, 2016). The Manning's 'n' values are shown in Table 3.2 below.

Geometry	Manning's 'n'	Description
Channel	0.35	Clean, straight, full, no rifts or deep pools but more stones and weeds
Floodplain	0.04	Mature field crops

Table 3.2: Manning's 'n' values used for the channel and floodplain in HEC-RAS

3.24 The four bridges have been modelled using the dimensions, soffit levels, and invert levels provided within the topographical survey. The bridges are clear span with no piers or edges so it was assumed the surface roughness would remain the same as the channel. The culvert (passing beneath the guided busway) located in the northern part of the model has been modelled as an arched culvert. The following surface roughness assumptions have been made and the Manning's 'n' values are shown in Table 3.3 below

Geometry	Manning's 'n'	Description
Bridges	0.35	Remained the same as channel
Culvert	0.015	Culvert with some debris

Table 3.3: Manning's 'n' values used for the channel and floodplain in HEC-RAS

3.25 Contraction and expansion coefficients for the bridges and culverts were obtained from the HEC-RAS manual as shown in Table 3.4 below.

Geometry	Contraction Coefficient	Expansion Coefficient	Description
Bridges	0.3	0.5	Typical bridge
Culvert	0.6	0.8	Abrupt transition

Table 3.4: Contraction and expansion values used in HEC-RAS

3.26 A bed slope of 0.0008 was used throughout the length of the model, which was calculated (from the topographic survey) as the average gradient of the channel along the section in question.

3.27 Full details on the modelling methodology are included in Appendix D.

Results

3.28 For the 1 in 100 year plus 35% climate change scenario, levels in the channel ranged from 11.24 mAOD to 11.40m mAOD between nodes 440 to 180 adjacent to the Site. Freeboard along the left bank ranges from 20 mm to 550 mm and along the right bank it ranges from 140 mm to 540 mm.

3.29 For the 1 in 100 year plus 65% climate change scenario a small amount of overtopping occurs on the left bank which protrudes into the western part of the site, as shown on Figure 3.6. Design flood levels in this locality are 11.45 mAOD with depths reaching 300 mm.

3.30 When assessing the 1 in 1000 year event it is clear this follows a very similar flood extent to the 1 in 100 year plus 65% climate change extent. Levels in this scenario are on average 13 mm higher than the mapped extent shown on Figure 3.6.

3.31 As mentioned earlier in the report, with reference to the 'High' risk of flooding from surface water across the Site it is considered (and has been agreed with the LLFA) that the above fluvial flood modelling be used as a proxy for the surface water food risk, as the main source of flooding for both is the Public Drain.

3.32 With regards to sensitivity testing of the model full details are included in Appendix D.

4.0 INITIAL FOUL AND SURFACE WATER DRAINAGE STRATEGY

Foul Water Drainage

4.1 Anglian Water (AW) are the statutory sewerage undertaker for the area and responsible for the operation and maintenance of public sewers serving Impington. Foul and surface water sewers present in the immediate vicinity of the Site are shown within sewerage asset mapping provided by AW (Appendix A) and comprise a 9 inch foul sewer running beneath South Road to the east of the Site and continuing north, serving residential development associated with Impington. Further foul sewer connections and a surface water network are present serving residential areas to the north of Villa Road.

4.2 It is suggested that the proposed development be connected to the AW foul sewer network to the north east of the Site at Villa Road MH9601. However, a Pre-Planning Enquiry will be required to be submitted to Anglian Water at the planning stage in order to confirm sewer capacity.

Surface Water Drainage

4.3 The Site has been split into 'Area 1' located to the east and 'Area 2' located to the west given it is intersected by the Public Drain, making two distinct catchments for surface water drainage. Calculations included in Appendix B estimate the current Greenfield runoff rates from the Site for Areas 1 & 2, as shown in Tables 4.1-4.2 below. These runoff rates are presented as equivalent rates for the assumed 60% impermeability used in the attenuation sizing calculations below.

Rainfall Event	Greenfield runoff rate (l/s)
Q 1 year	3.5
Q 30 year	9.9
Q 100 year	14.8

Table 4.1. Greenfield Runoff Rates for factored impermeable area only (60%) from Area 1 for Various Rainfall Events.

Rainfall Event	Greenfield runoff rate (l/s)
Q 1 year	1.0
Q 30 year	2.8
Q 100 year	4.2

Table 4.2. Greenfield Runoff Rates for factored impermeable area only (60%) from Area 2 for Various Rainfall Events.

4.4 Surface water flows should be attenuated using SUDS such that flows from the Site are restricted to equivalent greenfield rates (with an allowance for an increase in rainfall intensity of 40% due to climate change) prior to discharge into the Public Drain.

4.5 The following provides a summary of the proposed method of management and disposal of surface water runoff from the Site:

- Two separate attenuation basins positioned in Area 1 and Area 2 (see Figure 4.1), however, the exact location of these are to be confirmed, however Figure 4.1 provides indicative locations which are positioned beyond the fluvial flood zones. Confirmation on these positions with regards to the surface water flood risks posed is awaited from the Lead Local Flood Authority.
- A flow control restricting runoff to the equivalent greenfield run off rate of 3.5 l/s for Area 1 and 1.0 l/s for Area 2 will be included prior to the discharge into the Public Drain, via two surface water outfalls using gravity connections. These will restrict flows to this level for all events up to and including the 1 in 100 year plus 40% climate change event.
- Micro Drainage calculations (Appendix C) indicate that a basin with 3478.7m^3 of storage is required for Area 1 and a basin with 986.1m^3 of storage for Area 2. The calculations assume a maximum basin depth of approximately 1.3 m for both Areas 1 and 2 (including an allowance for an appropriate freeboard) with 1 in 3 side slopes, which equates to an approximate surface area of 4141.3 m^2 for Area 1 and 1322.2 m^2 for Area 2. This allows for drainage from the Site to reach the basin with an appropriate cover. The area should be considered to be approximate at this stage, calculations undertaken as part of the detailed design will confirm the exact pond area and levels as the design progresses.
- The 3.5 l/s and 1.0 l/s restricting flow rates are equivalent to the 1 in 1 year greenfield runoff rate for a 60% impermeability factor of the anticipated developed area of the Site.
- An allowance for future urban creep has also been included, within the above calculations, of 10% of the potential impermeable area of the site.
- In line with South Cambridgeshire and Cambridgeshire County SUDS requirements a full treatment train should be included upstream of the attenuations basins, which themselves should be online and appropriately designed such that the SUDS Manual treatment criteria are met. This treatment train could include:
    - Tanked permeable paving for all private drives and roadways, with a positive overflow to the attenuation basins;
    - Swales positioned to one or either side of main adoptable roadways collecting and treating run-off and transmitting flows to the attenuation basins. This is particularly relevant to Area 1 basin where swales will be required to keep pipe runs as shallow as possible so they are able to enter the basin above the invert level.
    - Green roofs for all flat roofs where viable;

  - Subject to soakage testing at the planning stage, there may be potential for infiltration as cellular soakaways or permeable paving where viable.

- The SUDS manual provides guidance, in Table 26.2, on the expected pollutant loads for the various impermeable surfaces relevant to this site. These include residential roofs/roads which have pollution hazard indices of 0.2 and 0.5 respectively and Total Suspended Solids concentrations of 0.2 and 0.4 for Metals and 0.05 and 0.4 for Hydrocarbons. The above primary treatment train, if designed and linked appropriately, is expected to provide treatment over and above that based on the relevant indices provided within the SUDS Manual.

5.0 SUMMARY

5.1 Create Consulting Engineers Ltd have put forward a preliminary Flood Risk Assessment and drainage scheme for a proposed residential development on Land at Impington, Histon, Cambridgeshire.

5.2 Flood modelling has shown that by and large the site remains unimpacted by fluvial flood events with updated allowances for climate change. The Lead Local Flood Authority have been consulted to understand whether they are willing to accept this modelling as a proxy for the surface water flood extents which severely impact the site. This has been confirmed (Appendix E) due to the nature of the catchment being best represented by the above modelling study.

5.3 With regards surface water drainage it is proposed the Site will drain wholly via controlled outfall, therefore flows in the local drainage network will not be significantly affected as runoff will be restricted to as near to greenfield runoff rates as practicable. Indicative attenuation basin sizes and locations have been provided to demonstrate required land take.

5.4 Foul drainage in the local area has been assessed and connections appear to be available in close proximity to the site.

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Approved by: Graham Sinclair, BSc (Hons), MSc, DIC, C.WEM, MCIWEM

Enclosed

Figures:

Appendices:

Plans:

Kings Gate Site Plan;
Topographical Survey Drawings 2219-545-SU01 to 2219-545-SU16 (BB Surveys Ltd, March 2017).

References:

I. BGS. Geology and borehole records. [Online]. Available at: www.bgs.ac.uk/geoindex. (Accessed July 2021).

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III. Cambridgeshire County Council (2011). *Preliminary Flood Risk Assessment*. Hyder.

IV. Cambridgeshire County Council (2015). *Local Flood Risk Management Strategy.* Cambridgeshire County Council.

V. Cambridgeshire County Council (2016). *Cambridgeshire Flood & Water SPD.* Cambridgeshire County Council.

VI. Cambridgeshire County Council (2019). *Surface Water Drainage Guidance for Developers.* Cambridgeshire County Council.

VII. Cambridgeshire County Council (2014). *Surface Water Management Plan Countywide Update.* Hyder.

VIII. Cambridgeshire Flood Risk Management Partnership (2011). *Cambridge and Milton Surface Water Management Plan—Detailed Assessment and Options Appraisal Report.* Hyder, Edenvale Young.

IX. Cambridge and South Cambridgeshire Council (2010). South Cambridgeshire and Cambridge City Level 1 Strategic Flood Risk Assessment. WSP.

X. Cambridge and South Cambridgeshire Council (2011) Cambridge and Milton Surface Water Management Plan. Hyder & Edenvale Young.

XI. Department for Environment and Rural Affairs (DEFRA) Magic Website., 2010. [Online]. *Environment Agency Aquifer Designation Data.* Available at: https://magic.defra.gov.uk/MagicMap.aspx [Accessed September 2021].

XII. Department for Environment Food and Rural Affairs (DEFRA) Data Survey Website. (2020). *EA LiDAR Data*. [Online]. Available at: https://environment.data.gov.uk/DefraDataDownload/?Mode=survey. (Accessed September 2021).

XIII. Environment Agency Fluvial/Tidal Flood Maps, Surface Water, and Reservoir Flood Mapping. [Online]. Available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map (Accessed September 2021).

XIV. Environment Agency, 2021. Flood Map for Planning (Rivers and Sea) - Flood Zone 2 and Flood Zone 3. [Online]. Available at: https://data.gov.uk/dataset/cf494c44-05cd-4060-a029-35937970c9c6/flood-map-for-planning-rivers-and-sea-flood-zone-2 (Accessed September 2021).

XV. Environment Agency., 2020. Flood Risk Assessments: Climate Change Allowances. [Online]. Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances (Accessed September 2021).

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FIGURES

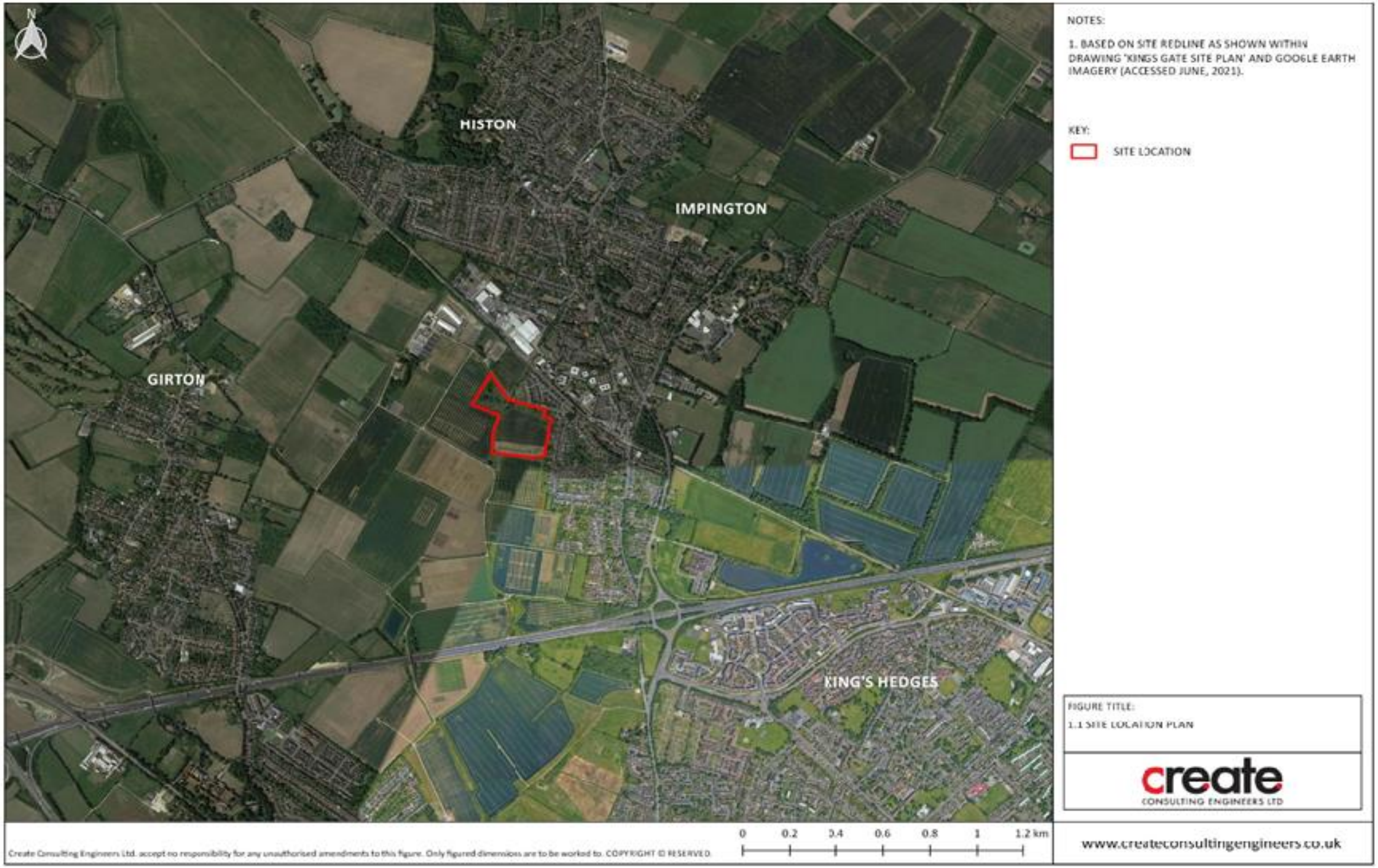

Figure 1.1: Site Location Plan

Figure 2.1: Identified Local Watercourse Map

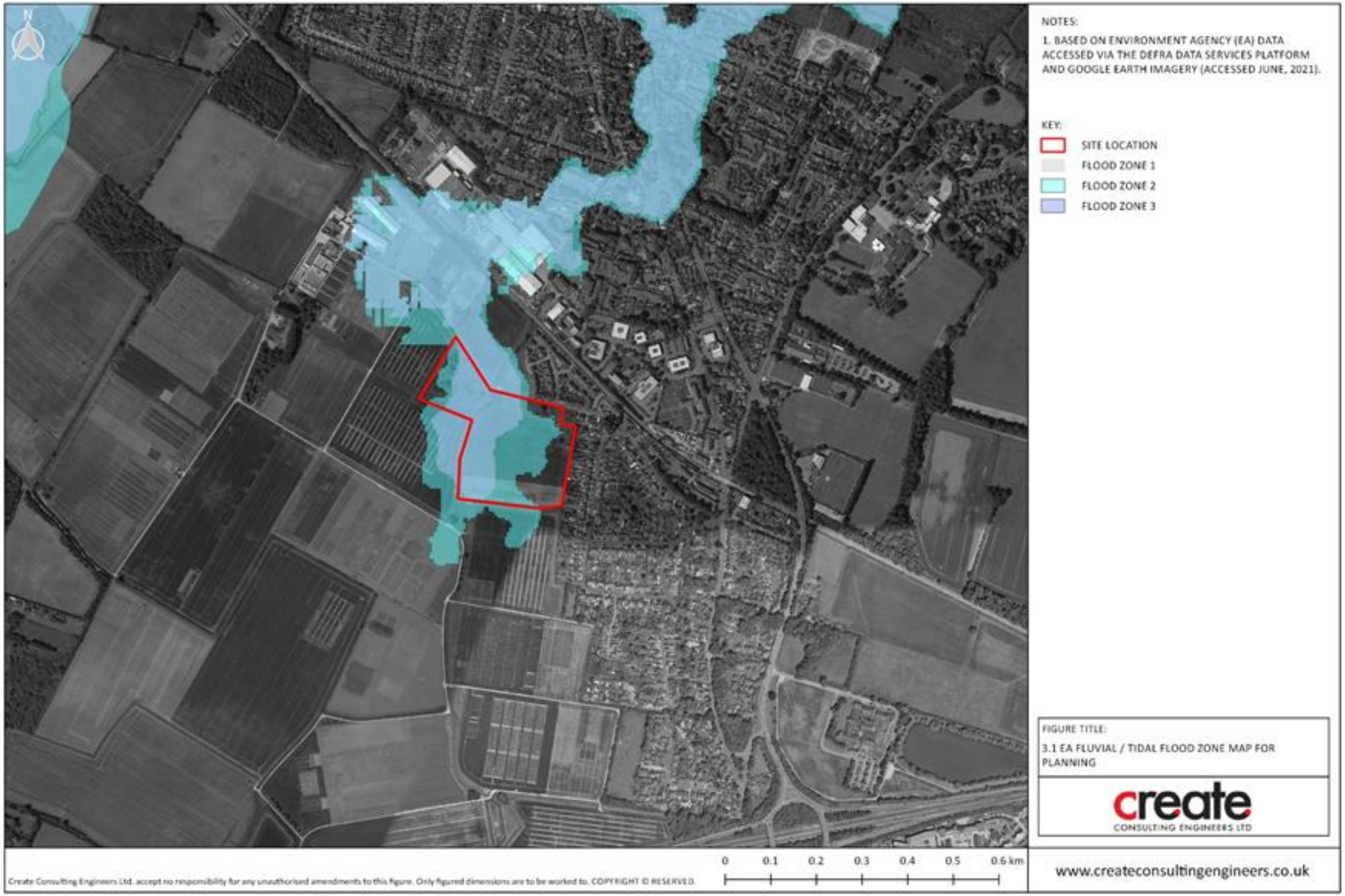

Figure 3.1: EA Fluvial/Tidal Flood Zone Map

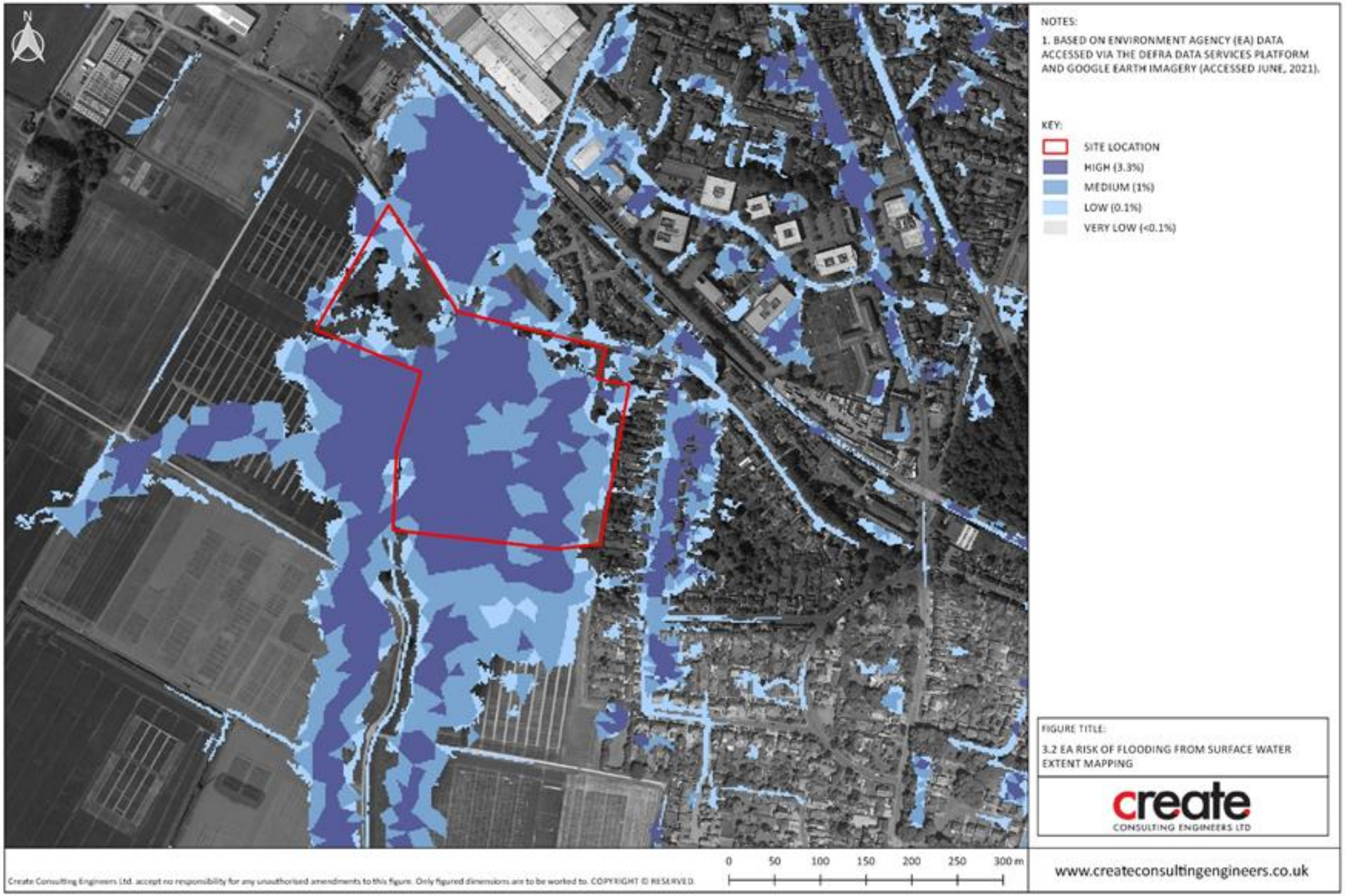

Figure 3.2: EA Risk of Flooding from Surface Water Extent Mapping

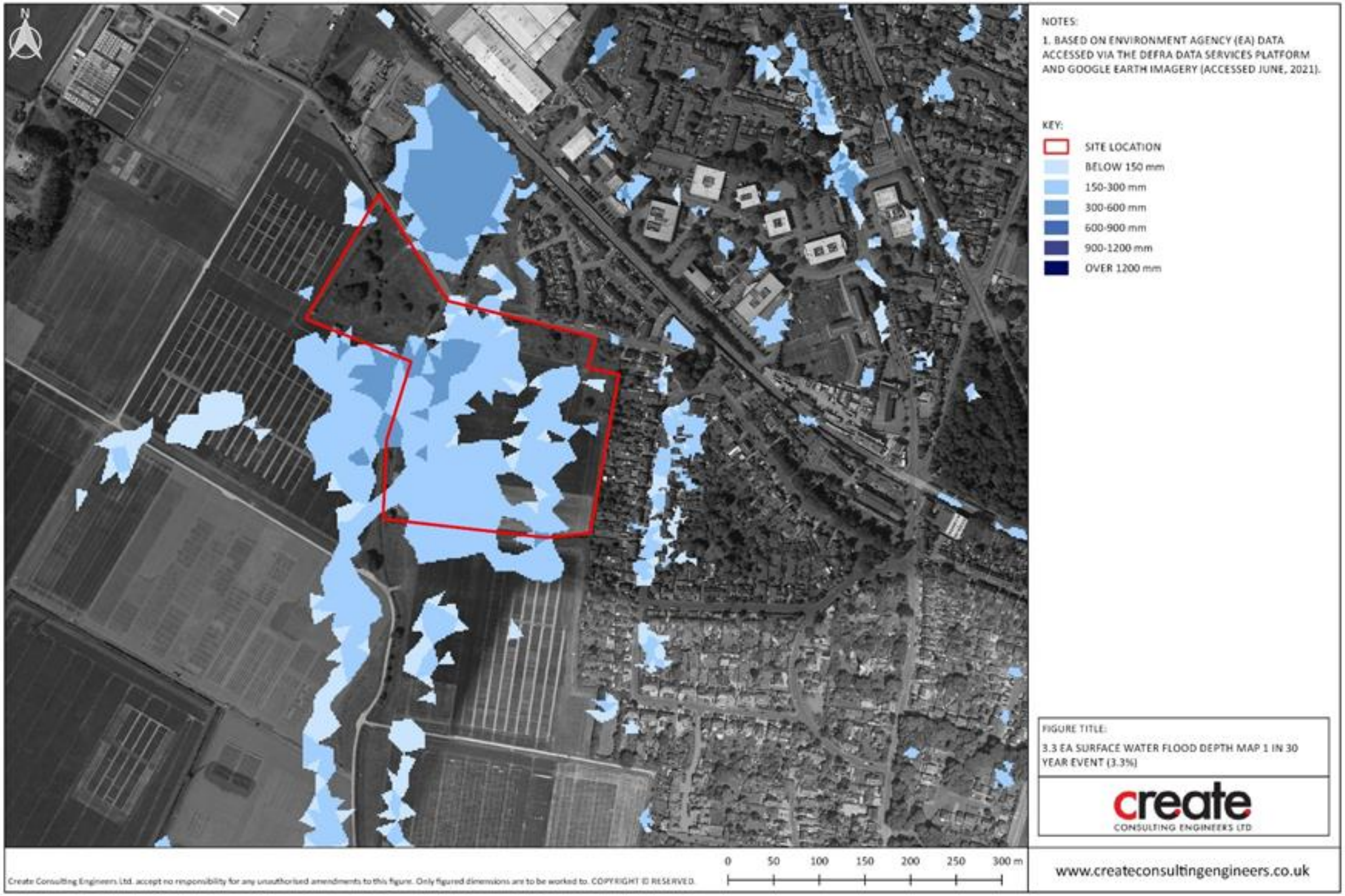

Figure 3.3: EA Surface Water Flood Depth Map 1 in 30 Year Event (3.3%)

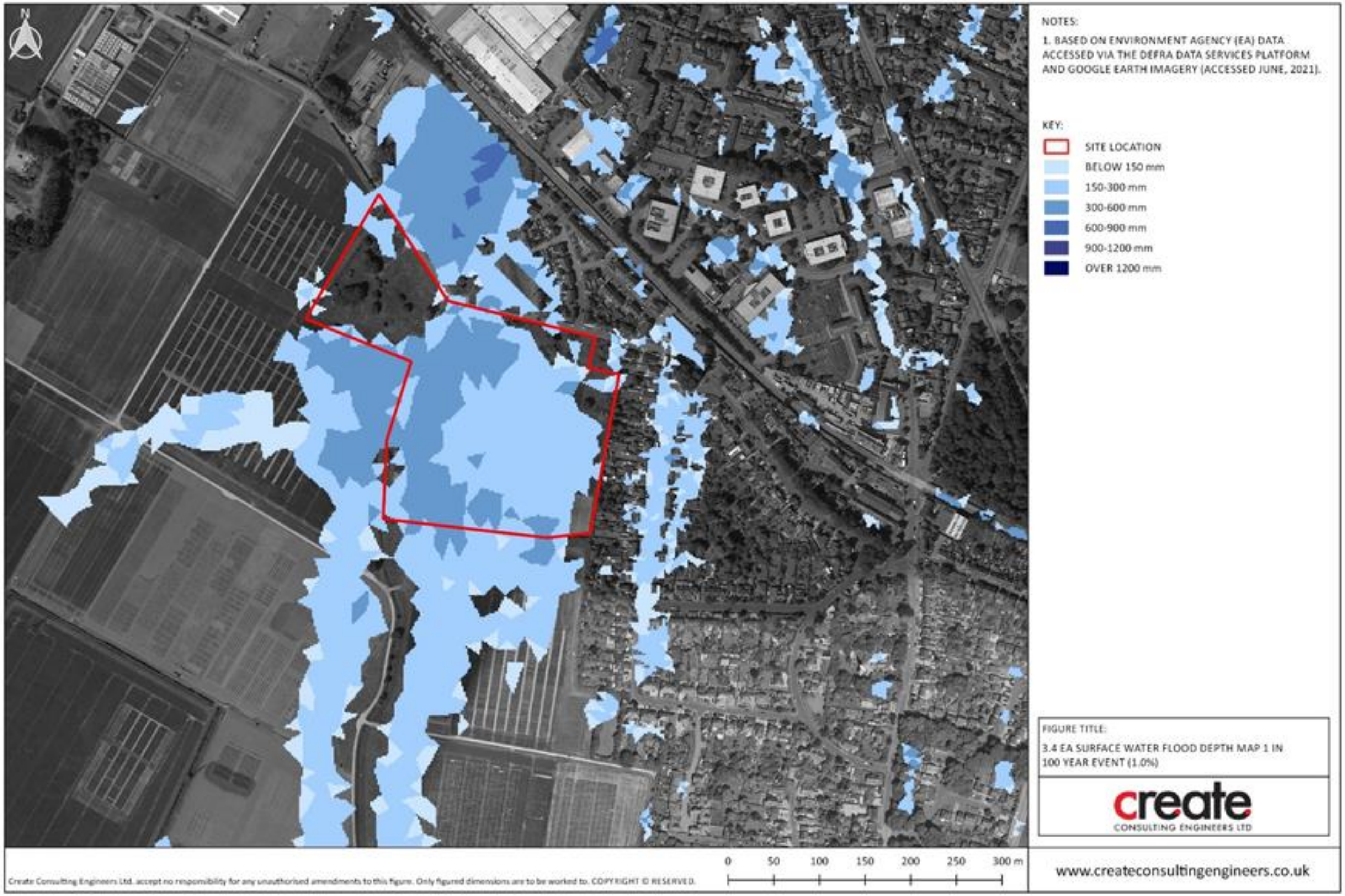

Figure 3.4: EA Surface Water Flood Depth Map 1 in 100 Year Event (1.0%)

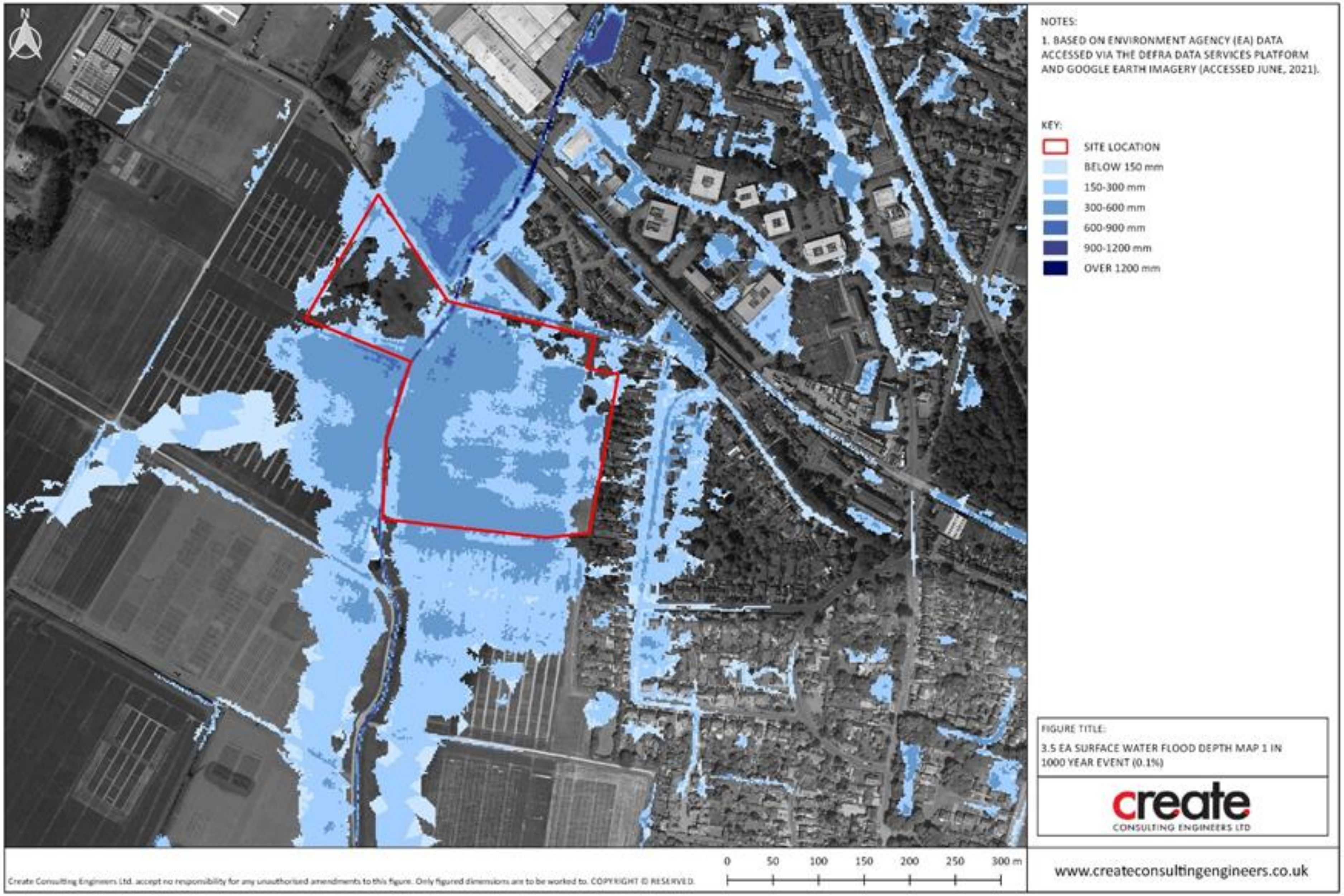

Figure 3.5: EA Surface Water Flood Depth Map 1 in 1000 Year Event (0.1%)

NOTES:

1. BASED ON TOPOGRAPHICAL SURVEY DRAWINGS 2219-545-SU01 TO 2219-545-SU16, LiDAR DATA ACCESSED VIA THE DEFRA DATA SERVICES PLATFORM, AND GOOGLE EARTH IMAGERY (ACCESSED JUNE, 2021).

KEY:

SITE LOCATION

1 IN 100 YEAR + 65% CC EXTENT

FIGURE TITLE:

3.6 MODELLED 1 IN 100 YEAR + 65% CLIMATE CHANGE FLOOD EXTENT

create
CONSULTING ENGINEERS LTD

0 25 50 75 100 125 150 m

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Figure 3.6: Modelled 1 in 100 Year + 65% Climate Change Flood Extent

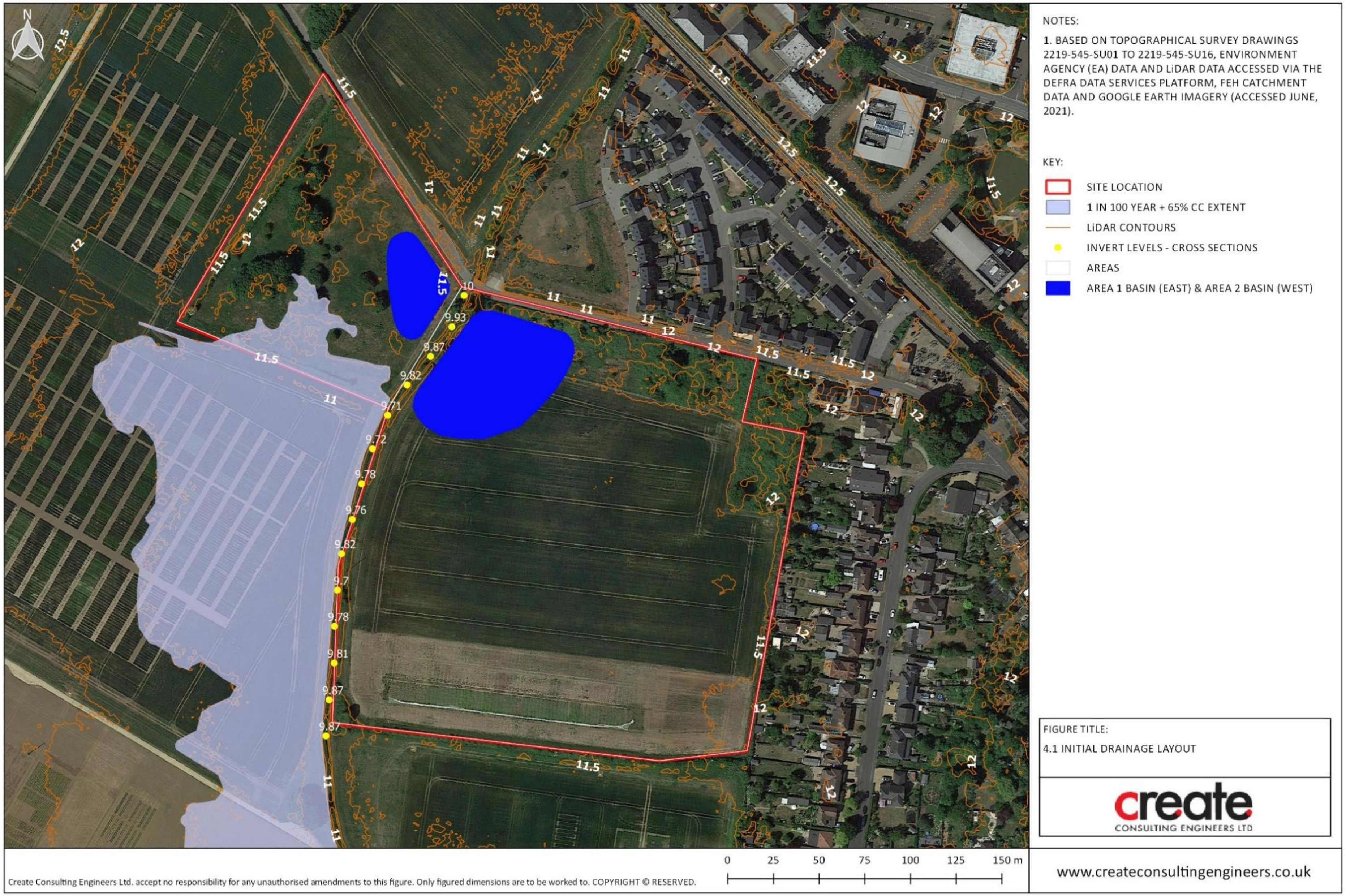

Figure 4.1: Initial Surface Water Drainage Layout

APPENDICES

APPENDIX A

Date: 16/06/21

Scale: 1:1250

Map Centre: 543610,262734

Data updated: 31/05/21

Our Ref: 579811 - 1

Wastewater Plan A0

Foul Sewer
Surface Sewer
Combined Sewer
Final Effluent
Rising Main*
Private Sewer*
Decommissioned Sewer*

Outfall*
Inlet*
Manhole*

Sewage Treatment Works
Public Pumping Station
Decommissioned Pumping Station

*(Colour denotes effluent type)

claire.seymour@createconsultingengineers.co.uk

2315 - Impington

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Manhole Reference	Easting	Northing	Liquid Type	Cover Level	Invert Level	Depth to Invert
0001	544057	263086	F	10.829	8.379	2.45
0002	544081	263009	F	11.392	9.412	1.98
0003	544051	263077	F	-	-	-
0004	544010	263074	F	-	-	-
0005	544019	263023	F	-	-	-
0006	544005	263062	F	-	-	-
0101	544045	263169	F	10.664	8.144	2.52
0102	544077	263177	F	10.755	8.5	2.255
0103	544094	263147	F	10.98	8.69	2.29
0104	544063	263116	F	-	-	-
0105	544072	263113	F	-	-	-
0106	544078	263111	F	-	-	-
0108	544029	263172	F	-	-	-
0109	544021	263170	F	-	-	-
0201	544081	262286	F	14.039	12.747	1.292
0202	544083	262273	F	14.228	12.192	2.036
0301	544004	262402	F	12.607	12.482	0.125
0302	544099	262397	F	13.984	12.091	1.893
0303	544074	262338	F	13.786	12.482	1.304
0501	544042	262574	F	-	-	-
0502	544092	262506	F	-	-	-
0601	544005	262625	F	-	-	-
0901	544001	262995	F	-	-	-
0902	544010	262936	F	-	-	-
0903	544078	262923	F	-	-	-
1001	544166	263013	F	11.717	10.057	1.66
1002	544110	263098	F	-	-	-
1101	544110	263156	F	-	8.795	-
1102	544125	263156	F	11.12	9.135	1.985
1103	544138	263170	F	11.28	9.62	1.66
1105	544176	263132	F	11.36	9.8	1.56
1106	544122	263150	F	10.8	9.3	1.5
1107	544127	263103	F	-	-	-
1202	544193	262280	F	-	-	-
1301	544198	262306	F	-	-	-
1401	544165	262462	F	14.515	12.89	1.625
1402	544153	262430	F	14.432	12.741	1.691
1701	544179	262728	F	-	-	-
1702	544181	262743	F	-	-	-
1703	544189	262745	F	-	-	-
1801	544141	262865	F	-	-	-
1802	544145	262849	F	-	-	-
1803	544154	262813	F	-	-	-
1901	544128	262908	F	-	-	-
2001	544231	263019	F	12.353	10.363	1.99
2002	544235	263017	F	13.146	10.766	2.38
2003	544260	263005	F	13.768	10.968	2.8
2004	544249	263031	F	12.45	10.195	2.255
2005	544242	263034	F	12.45	10.207	2.243
2006	544269	263074	F	12.33	10.44	1.89
2100	544298	263172	F	-	-	-
2101	544294	263139	F	-	-	-
2201	544205	262280	F	-	-	-
2202	544294	262255	F	-	-	-
2301	544210	262377	F	-	-	-
2401	544211	262459	F	15.325	13.411	1.914
2402	544210	262487	F	14.978	13.692	1.286
2501	544213	262560	F	-	-	-
2502	544217	262563	F	-	-	-
2601	544208	262633	F	-	-	-
2602	544259	262678	F	-	-	-
2603	544241	262692	F	-	-	-
2604	544240	262691	F	-	-	-
2605	544239	262688	F	-	-	-
2606	544253	262685	F	-	-	-
2701	544289	262774	F	-	-	-
2801	544209	262896	F	-	-	-
2901	544273	262998	F	-	-	-
2902	544276	262994	F	-	-	-
2903	544243	262958	F	-	-	-
2904	544255	262966	F	-	-	-
2905	544264	262963	F	-	-	-
2906	544279	262959	F	-	-	-
2907	544269	262977	F	-	-	-
3101	544305	263132	F	12.76	10.775	1.985
3102	544338	263119	F	12.45	10.905	1.545
3201	544307	262264	F	-	-	-
3302	544325	262331	F	-	-	-
3401	544301	262425	F	16.039	13.792	2.247
3801	544323	262865	F	-	-	-
3802	544308	262880	F	-	-	-
3803	544327	262874	F	-	-	-
3804	544310	262885	F	-	-	-
7101	543777	263193	F	11.119	9.525	1.594
7202	543707	263219	F	11.656	9.906	1.75
7700	543780	262786	F	-	-	-
7701	543779	262794	F	-	-	-
7702	543792	262744	F	-	-	-
7703	543790	262755	F	-	-	-
7704	543787	262768	F	-	-	-
7800	543800	262841	F	-	-	-
8101	543852	263165	F	10.961	9.135	1.826
8700	543896	262744	F	-	-	-
8701	543864	262774	F	-	-	-
8702	543860	262775	F	-	-	-
8703	543839	262770	F	-	-	-
8704	543842	262752	F	-	-	-
8705	543843	262729	F	-	-	-
8800	543825	262806	F	-	-	-
8801	543816	262830	F	-	-	-
8802	543817	262828	F	-	-	-
8803	543823	262813	F	-	-	-
8810	543863	262881	F	-	-	-
8900	543872	262917	F	-	-	-
8901	543856	262940	F	-	-	-
8902	543866	262909	F	-	-	-
9001	543971	263075	F	11.177	9.446	1.731
9002	543924	263088	F	10.979	9.754	1.225
9003	543982	263076	F	-	-	-
9004	543981	263058	F	-	-	-
9005	543980	263045	F	-	-	-
9010	543991	263059	F	-	-	-
9013	543973	263048	F	-	-	-
9016	543959	263047	F	-	-	-
9017	543972	263043	F	-	-	-
9018	543974	263027	F	-	-	-
9019	543977	263038	F	-	-	-
9101	543950	263180	F	10.976	8.504	2.472
9102	543923	263139	F	11.092	8.754	2.338
9201	543901	262295	F	-	-	-
9202	543994	262284	F	-	-	-
9203	543974	262287	F	-	-	-
9401	543923	262492	F	-	-	-
9402	543908	262401	F	-	-	-
9501	543932	262566	F	-	-	-
9601	543923	262683	F	-	-	-
9602	543946	262662	F	-	-	-
9701	543940	262764	F	-	-	-
9702	543938	262720	F	-	-	-
9703	543929	262711	F	-	-	-
9704	543916	262724	F	-	-	-
9705	543940	262726	F	-	-	-
9801	543975	262902	F	-	-	-
9802	543954	262806	F	-	-	-
9803	543960	262846	F	-	-	-
9804	543909	262877	F	-	-	-
9901	543998	262969	F	11.539	8.625	2.914
9902	543945	262987	F	11.64	10.29	1.35
9903	543962	262924	F	-	-	-
9904	543959	262914	F	-	-	-
9905	543947	262918	F	-	-	-
9906	543933	262922	F	-	-	-
9907	543935	262927	F	-	-	-
9908	543937	262933	F	-	-	-
6250	543678	262253	S	-	-	-
7750	543767	262773	S	-	-	-
7751	543781	262778	S	-	-	-
7752	543779	262784	S	-	-	-
7753	543772	262774	S	-	-	-
7754	543796	262791	S	-	-	-
7755	543785	262769	S	-	-	-
7756	543788	262758	S	-	-	-
7757	543790	262747	S	-	-	-
7758	543791	262735	S	-	-	-
7850	543776	262802	S	-	-	-
7851	543802	262841	S	-	-	-
8750	543809	262797	S	-	-	-
8751	543833	262789	S	-	-	-
8752	543840	262772	S	-	-	-
8753	543858	262776	S	-	-	-
8754	543866	262775	S	-	-	-
8755	543887	262755	S	-	-	-
8756	543898	262744	S	-	-	-
8757	543843	262755	S	-	-	-
8758	543840	262705	S	-	-	-
8759	543845	262724	S	-	-	-
8760	543845	262731	S	-	-	-
8850	543822	262803	S	-	-	-
8851	543828	262805	S	-	-	-
8852	543822	262819	S	-	-	-
8853	543818	262830	S	-	-	-
8854	543812	262835	S	-	-	-
8860	543878	262896	S	-	-	-
8952	543870	262917	S	-	-	-
9252	543972	262274	S	-	-	-
9261	543974	262257	S	-	-	-
9650	543923	262690	S	-	-	-
9651	543924	262699	S	-	-	-
9750	543913	262729	S	-	-	-
9751	543933	262710	S	-	-	-
9752	543941	262721	S	-	-	-
9850	543905	262878	S	-	-	-

APPENDIX B

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CONSULTING ENGINEERS LTD

IoH 124 Calculation of Greenfield Runoff Rate

Project:	P21-2315 Land at Impington, South Cambridgeshire			
	Area 1			
OS Location	543729	E	262621	N
Date:	16.06.21			
Written By:	TT	Checked By:	GS	

SAAR	539	mm
Pro Rata Site Area =	50	ha
	0.5	km^2
Soil WRA Class	2	
Soil Type SPR Value	0.3	

$Qbar_{rural}$ = 0.00108 x (AREA)0.89 X (SAAR)1.17 X (SOIL)2.17

Qbar-50ha = 0.067 m^3/s

From Regional Growth Curve Factor

Region: 5

Return period	1	2	5	10	25	30	50	100	500
Growth Factor	0.85	0.89	1.29	1.65	2.25	2.37	2.83	3.56	5.02

Q_1 50ha =	0.057	m^3/s	=	57.05	l/s	=	1.141	l/s/ha
Q_2 50ha =	0.060	m^3/s	=	59.73	l/s	=	1.195	l/s/ha
Q_5 50ha =	0.087	m^3/s	=	86.58	l/s	=	1.732	l/s/ha
Q_{10} 50ha =	0.111	m^3/s	=	110.74	l/s	=	2.215	l/s/ha
Q_{25} 50ha =	0.151	m^3/s	=	151.01	l/s	=	3.020	l/s/ha
Q_{30} 50ha =	0.159	m^3/s	=	159.06	l/s	=	3.181	l/s/ha
Q_{50} 50ha =	0.190	m^3/s	=	189.94	l/s	=	3.799	l/s/ha
Q_{100} 50ha =	0.239	m^3/s	=	238.93	l/s	=	4.779	l/s/ha
Q_{500} 50ha =	0.337	m^3/s	=	336.92	l/s	=	6.738	l/s/ha

Factored for Development Impermeable Area

Site Area = 0.87

Q_{bar} site =	0.001	m^3/s	=	1.2	l/s	=	1.3	l/s/ha
Q_1 site =	0.001	m^3/s	=	1.0	l/s	=	1.1	l/s/ha
Q_2site =	0.001	m^3/s	=	1.0	l/s	=	1.2	l/s/ha
Q_5site =	0.002	m^3/s	=	1.5	l/s	=	1.7	l/s/ha
Q_{10} site =	0.002	m^3/s	=	1.9	l/s	=	2.2	l/s/ha
Q_{25} site =	0.003	m^3/s	=	2.6	l/s	=	3.0	l/s/ha
Q_{30} site =	0.003	m^3/s	=	2.8	l/s	=	3.2	l/s/ha
Q_{50} site =	0.003	m^3/s	=	3.3	l/s	=	3.8	l/s/ha
Q_{100} site =	0.004	m^3/s	=	4.2	l/s	=	4.8	l/s/ha
Q_{500} site =	0.006	m^3/s	=	5.9	l/s	=	6.7	l/s/ha

Note: For greenfield site, the critical duration is generally not relevant and the prediction of the peak rate of runoff using IoH124 does not require consideration of storm duration.

create
CONSULTING ENGINEERS LTD

IoH 124 Calculation of Greenfield Runoff Rate

Project:	P21-2315 Land at Impington, South Cambridgeshire			
	Area 2			
OS Location	543729	E	262621	N
Date:	16.06.21			
Written By:	TT	**Checked By:**	GS	

SAAR	539	mm
Pro Rata Site Area =	50	ha
	0.5	km^2
Soil WRA Class	2	
Soil Type SPR Value	0.3	

$Qbar_{rural}$ = 0.00108 x (AREA)0.89 X (SAAR)1.17 X (SOIL)2.17

Qbar-50ha = 0.067 m^3/s

From Regional Growth Curve Factor

Region: 5

Return period	1	2	5	10	25	30	50	100	500
Growth Factor	0.85	0.89	1.29	1.65	2.25	2.37	2.83	3.56	5.02

Q_1 50ha =	0.057	m^3/s	=	57.05	l/s	=	1.141	l/s/ha
Q_2 50ha =	0.060	m^3/s	=	59.73	l/s	=	1.195	l/s/ha
Q_5 50ha =	0.087	m^3/s	=	86.58	l/s	=	1.732	l/s/ha
Q_{10} 50ha =	0.111	m^3/s	=	110.74	l/s	=	2.215	l/s/ha
Q_{25} 50ha =	0.151	m^3/s	=	151.01	l/s	=	3.020	l/s/ha
Q_{30} 50ha =	0.159	m^3/s	=	159.06	l/s	=	3.181	l/s/ha
Q_{50} 50ha =	0.190	m^3/s	=	189.94	l/s	=	3.799	l/s/ha
Q_{100} 50ha =	0.239	m^3/s	=	238.93	l/s	=	4.779	l/s/ha
Q_{500} 50ha =	0.337	m^3/s	=	336.92	l/s	=	6.738	l/s/ha

Factored for Development Impermeable Area

Site Area = 3.1

Q_{bar} site =	0.004	m^3/s	=	4.2	l/s	=	1.3	l/s/ha
Q_1 site =	0.004	m^3/s	=	3.5	l/s	=	1.1	l/s/ha
Q_2site =	0.004	m^3/s	=	3.7	l/s	=	1.2	l/s/ha
Q_5site =	0.005	m^3/s	=	5.4	l/s	=	1.7	l/s/ha
Q_{10} site =	0.007	m^3/s	=	6.9	l/s	=	2.2	l/s/ha
Q_{25} site =	0.009	m^3/s	=	9.4	l/s	=	3.0	l/s/ha
Q_{30} site =	0.010	m^3/s	=	9.9	l/s	=	3.2	l/s/ha
Q_{50} site =	0.012	m^3/s	=	11.8	l/s	=	3.8	l/s/ha
Q_{100} site =	0.015	m^3/s	=	14.8	l/s	=	4.8	l/s/ha
Q_{500} site =	0.021	m^3/s	=	20.9	l/s	=	6.7	l/s/ha

Note: For greenfield site, the critical duration is generally not relevant and the prediction of the peak rate of runoff using IoH124 does not require consideration of storm duration.

APPENDIX C

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	10.776	0.316	3.5	1052.6	O K
30 min Summer	10.863	0.403	3.5	1354.0	O K
60 min Summer	10.949	0.489	3.5	1656.3	O K
120 min Summer	11.067	0.607	3.5	2082.3	O K
180 min Summer	11.138	0.678	3.5	2341.6	O K
240 min Summer	11.186	0.726	3.5	2518.1	O K
360 min Summer	11.245	0.785	3.5	2738.4	O K
480 min Summer	11.278	0.818	3.5	2862.8	O K
600 min Summer	11.298	0.838	3.5	2940.1	O K
720 min Summer	11.311	0.851	3.5	2990.8	O K
960 min Summer	11.326	0.866	3.5	3046.1	O K
1440 min Summer	11.334	0.874	3.5	3077.4	O K
2160 min Summer	11.328	0.868	3.5	3056.0	O K
2880 min Summer	11.318	0.858	3.5	3014.9	O K
4320 min Summer	11.297	0.837	3.5	2938.1	O K
5760 min Summer	11.279	0.819	3.5	2867.1	O K
7200 min Summer	11.267	0.807	3.5	2821.2	O K
8640 min Summer	11.262	0.802	3.5	2805.9	O K
10080 min Summer	11.267	0.807	3.5	2823.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	165.200	0.0	300.9	19
30 min Summer	106.400	0.0	295.5	34
60 min Summer	65.240	0.0	579.4	64
120 min Summer	41.160	0.0	523.4	124
180 min Summer	30.963	0.0	503.8	184
240 min Summer	25.060	0.0	513.0	244
360 min Summer	18.293	0.0	530.7	364
480 min Summer	14.442	0.0	540.5	484
600 min Summer	11.947	0.0	546.5	604
720 min Summer	10.197	0.0	550.5	724
960 min Summer	7.896	0.0	554.9	964
1440 min Summer	5.466	0.0	557.6	1442
2160 min Summer	3.770	0.0	1095.1	2164
2880 min Summer	2.905	0.0	1097.6	2884
4320 min Summer	2.041	0.0	1096.1	4320
5760 min Summer	1.610	0.0	2124.2	5760
7200 min Summer	1.358	0.0	2129.6	6992
8640 min Summer	1.194	0.0	2134.7	7688
10080 min Summer	1.080	0.0	2127.5	8464

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Winter	10.813	0.353	3.5	1179.4	O K
30 min Winter	10.910	0.450	3.5	1517.3	O K
60 min Winter	11.005	0.545	3.5	1856.7	O K
120 min Winter	11.136	0.676	3.5	2335.0	O K
180 min Winter	11.215	0.755	3.5	2626.2	O K
240 min Winter	11.268	0.808	3.5	2825.3	O K
360 min Winter	11.333	0.873	3.5	3074.6	O K
480 min Winter	11.370	0.910	3.5	3216.5	O K
600 min Winter	11.393	0.933	3.5	3305.6	O K
720 min Winter	11.408	0.948	3.5	3365.0	O K
960 min Winter	11.426	0.966	3.5	3432.4	O K
1440 min Winter	11.438	0.978	3.5	3478.7	O K
2160 min Winter	11.436	0.976	3.5	3470.8	O K
2880 min Winter	11.428	0.968	3.5	3441.5	O K
4320 min Winter	11.415	0.955	3.5	3389.6	O K
5760 min Winter	11.403	0.943	3.5	3343.9	O K
7200 min Winter	11.398	0.938	3.5	3325.7	O K
8640 min Winter	11.398	0.938	3.5	3325.7	O K
10080 min Winter	11.403	0.943	3.5	3344.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Winter	165.200	0.0	299.3	19
30 min Winter	106.400	0.0	290.5	34
60 min Winter	65.240	0.0	559.3	64
120 min Winter	41.160	0.0	503.5	124
180 min Winter	30.963	0.0	520.2	182
240 min Winter	25.060	0.0	535.4	242
360 min Winter	18.293	0.0	553.4	362
480 min Winter	14.442	0.0	562.9	480
600 min Winter	11.947	0.0	568.6	598
720 min Winter	10.197	0.0	572.0	718
960 min Winter	7.896	0.0	575.1	954
1440 min Winter	5.466	0.0	574.6	1428
2160 min Winter	3.770	0.0	1136.1	2136
2880 min Winter	2.905	0.0	1134.0	2828
4320 min Winter	2.041	0.0	1122.7	4196
5760 min Winter	1.610	0.0	2198.2	5584
7200 min Winter	1.358	0.0	2205.5	6912
8640 min Winter	1.194	0.0	2204.8	8208
10080 min Winter	1.080	0.0	2195.0	9384

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 543800 262900 TL 43800 62900
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 3.410

Time From:	**(mins) To:**	**Area (ha)**
0	4	3.410

Model Details

Storage is Online Cover Level (m) 11.760

Tank or Pond Structure

Invert Level (m) 10.460

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	3223.9	1.300	4141.3

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0087-3500-1100-3500
Design Head (m)	1.100
Design Flow (l/s)	3.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	87
Invert Level (m)	10.360
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.100	3.5	Kick-Flo®	0.684	2.8
Flush-Flo™	0.329	3.5	Mean Flow over Head Range	-	3.1

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.7	1.200	3.6	3.000	5.6	7.000	8.3
0.200	3.4	1.400	3.9	3.500	6.0	7.500	8.6
0.300	3.5	1.600	4.2	4.000	6.4	8.000	8.9
0.400	3.5	1.800	4.4	4.500	6.7	8.500	9.1
0.500	3.4	2.000	4.6	5.000	7.1	9.000	9.4
0.600	3.2	2.200	4.8	5.500	7.4	9.500	9.6
0.800	3.0	2.400	5.0	6.000	7.7		
1.000	3.3	2.600	5.2	6.500	8.0		

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	10.461	0.341	0.8	296.6	O K
30 min Summer	10.551	0.431	0.8	381.6	O K
60 min Summer	10.638	0.518	0.8	466.9	O K
120 min Summer	10.755	0.635	0.8	587.0	O K
180 min Summer	10.824	0.704	0.9	660.1	O K
240 min Summer	10.871	0.751	0.9	710.1	O K
360 min Summer	10.927	0.807	0.9	772.6	O K
480 min Summer	10.959	0.839	0.9	808.1	O K
600 min Summer	10.979	0.859	0.9	830.4	O K
720 min Summer	10.992	0.872	0.9	845.2	O K
960 min Summer	11.006	0.886	1.0	861.7	O K
1440 min Summer	11.016	0.896	1.0	872.5	O K
2160 min Summer	11.013	0.893	1.0	869.2	O K
2880 min Summer	11.005	0.885	1.0	860.1	O K
4320 min Summer	10.990	0.870	0.9	842.9	O K
5760 min Summer	10.975	0.855	0.9	826.3	O K
7200 min Summer	10.966	0.846	0.9	816.3	O K
8640 min Summer	10.965	0.845	0.9	815.0	O K
10080 min Summer	10.971	0.851	0.9	821.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	165.200	0.0	57.4	19
30 min Summer	106.400	0.0	61.0	34
60 min Summer	65.240	0.0	127.4	64
120 min Summer	41.160	0.0	138.3	124
180 min Summer	30.963	0.0	144.2	184
240 min Summer	25.060	0.0	147.8	244
360 min Summer	18.293	0.0	151.9	364
480 min Summer	14.442	0.0	153.8	484
600 min Summer	11.947	0.0	154.7	604
720 min Summer	10.197	0.0	155.1	724
960 min Summer	7.896	0.0	155.0	964
1440 min Summer	5.466	0.0	153.1	1442
2160 min Summer	3.770	0.0	305.5	2164
2880 min Summer	2.905	0.0	302.6	2880
4320 min Summer	2.041	0.0	295.5	4320
5760 min Summer	1.610	0.0	588.1	5760
7200 min Summer	1.358	0.0	587.1	6848
8640 min Summer	1.194	0.0	584.3	7440
10080 min Summer	1.080	0.0	579.1	8272

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Winter	10.499	0.379	0.8	332.2	O K
30 min Winter	10.598	0.478	0.8	427.5	O K
60 min Winter	10.694	0.574	0.8	523.2	O K
120 min Winter	10.823	0.703	0.9	658.0	O K
180 min Winter	10.898	0.778	0.9	740.3	O K
240 min Winter	10.949	0.829	0.9	796.5	O K
360 min Winter	11.011	0.891	1.0	867.2	O K
480 min Winter	11.046	0.926	1.0	907.7	O K
600 min Winter	11.068	0.948	1.0	933.3	O K
720 min Winter	11.083	0.963	1.0	950.5	O K
960 min Winter	11.100	0.980	1.0	970.5	O K
1440 min Winter	11.112	0.992	1.0	985.4	O K
2160 min Winter	11.113	0.993	1.0	986.1	O K
2880 min Winter	11.108	0.988	1.0	980.5	O K
4320 min Winter	11.100	0.980	1.0	970.8	O K
5760 min Winter	11.093	0.973	1.0	962.3	O K
7200 min Winter	11.092	0.972	1.0	961.0	O K
8640 min Winter	11.095	0.975	1.0	964.3	O K
10080 min Winter	11.102	0.982	1.0	972.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Winter	165.200	0.0	58.2	19
30 min Winter	106.400	0.0	63.3	34
60 min Winter	65.240	0.0	132.7	64
120 min Winter	41.160	0.0	144.0	124
180 min Winter	30.963	0.0	150.0	182
240 min Winter	25.060	0.0	153.7	242
360 min Winter	18.293	0.0	157.8	362
480 min Winter	14.442	0.0	159.7	480
600 min Winter	11.947	0.0	160.5	598
720 min Winter	10.197	0.0	160.7	716
960 min Winter	7.896	0.0	160.2	954
1440 min Winter	5.466	0.0	157.5	1428
2160 min Winter	3.770	0.0	316.1	2136
2880 min Winter	2.905	0.0	312.0	2824
4320 min Winter	2.041	0.0	301.9	4196
5760 min Winter	1.610	0.0	609.0	5544
7200 min Winter	1.358	0.0	605.0	6848
8640 min Winter	1.194	0.0	599.1	8128
10080 min Winter	1.080	0.0	591.0	9376

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 543800 262900 TL 43800 62900
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.960

Time From:	(mins) To:	Area (ha)
0	4	0.960

Model Details

Storage is Online Cover Level (m) 11.420

Tank or Pond Structure

Invert Level (m) 10.120

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	808.8	1.300	1322.2

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0046-1000-1100-1000
Design Head (m)	1.100
Design Flow (l/s)	1.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	46
Invert Level (m)	10.020
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.100	1.0	Kick-Flo®	0.408	0.6
Flush-Flo™	0.200	0.8	Mean Flow over Head Range	-	0.8

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.7	1.200	1.0	3.000	1.6	7.000	2.3
0.200	0.8	1.400	1.1	3.500	1.7	7.500	2.4
0.300	0.8	1.600	1.2	4.000	1.8	8.000	2.5
0.400	0.7	1.800	1.2	4.500	1.9	8.500	2.5
0.500	0.7	2.000	1.3	5.000	2.0	9.000	2.6
0.600	0.8	2.200	1.4	5.500	2.1	9.500	2.7
0.800	0.9	2.400	1.4	6.000	2.2		
1.000	1.0	2.600	1.5	6.500	2.2		