



# Flood Risk Assessment

**Proposed Residential Development  
Land north of Hookhams Lane  
Salph End  
Bedford**

**Revision 0: August 2019  
Report Reference: 248-FRA-01-0**



**Report Originator(s)**

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**Revision Record**

Revision	Date	Description	Written	Approved
0	29/08/19	Planning Issue	MJA	MJA

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## **1.0 Introduction**

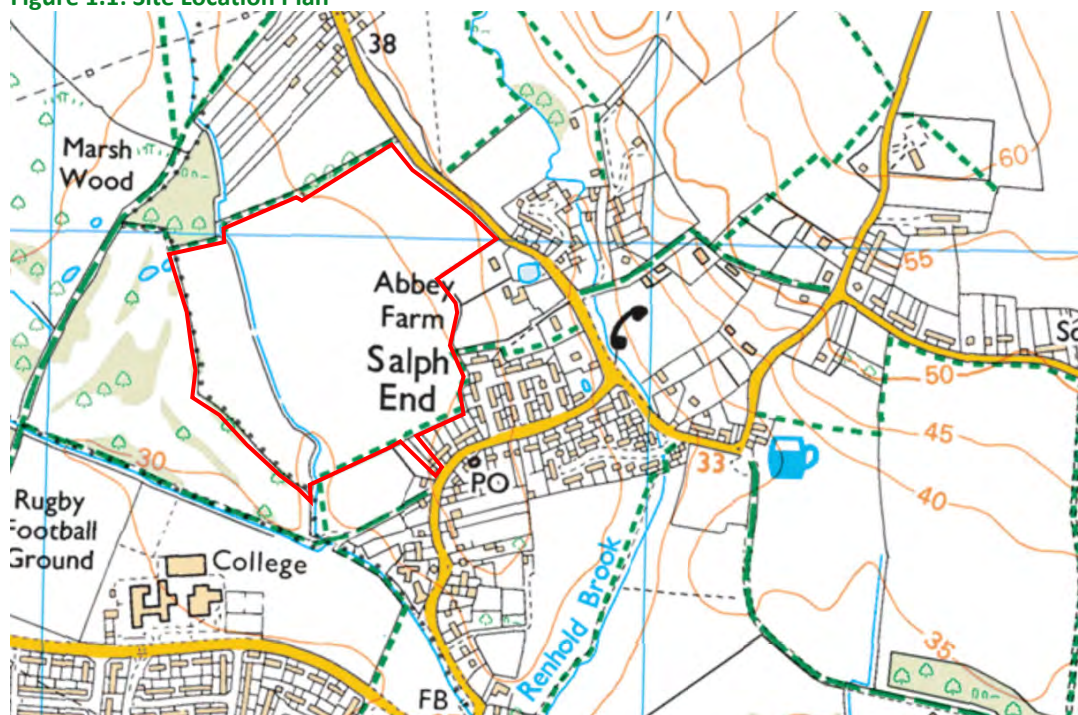
### **1.1 Instructions**

- 1.1.1 This Flood Risk Assessment has been prepared for Manor Oak Homes.
- 1.1.2 The report has been prepared to support the submission of an outline planning application.
- 1.1.3 The benefit of this report is to our instructing Client.

### **1.2 Site Location**

- 1.2.1 The proposed residential development is located at land between Hookhams Lane and Ravensden Road, Salph End, as shown in Figure 1.1 below and enclosed in Appendix A. The approximate National Grid Reference for the site is E507519 N252820.

**Figure 1.1: Site Location Plan**



### **1.3 Current Use and Description**

- 1.3.1 The site currently comprises agricultural land there has been no previous development on the site. The existing site is shown on the topographical survey enclosed in Appendix B.
- 1.3.2 A tributary of Renhold Brook runs through the site and forms the boundary between two of the site's fields.
- 1.3.3 There is a fall from north to south with both parcels either side of the watercourse falling towards the tributary.

### **1.4 Proposed Development**

- 1.4.1 The proposed development will comprise up to 400 residential dwellings and a two-form entry primary school. The proposed development layout is shown on the plan enclosed in Appendix C.
- 1.4.2 The proposed development will provide a 9m maintenance strip adjacent to the watercourse as per the requirements of the Internal Drainage Board (IDB).
- 1.4.3 Inline with paragraph 26 of the Planning Practice Guidance for 'Flood risk and climate change' the lifetime of a residential development is considered to be at least 100 years whilst the school would have an expected lifetime of 50 years.
- 1.4.4 The 'Flood Risk Vulnerability Classification' of various development types is defined within Table 2 of the Planning Practice Guidance for Flood Risk and Coastal Change (PPG). A residential development and school are both classified as More Vulnerable development. The relevant extract from Table 2 of the PPG is set out below.

#### More vulnerable

- Hospitals
- Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels.
- Buildings used for **dwelling houses**, student halls of residence, drinking establishments, nightclubs and hotels.
- Non-residential uses for health services, nurseries and **educational establishments**.
- Landfill\* and sites used for waste management facilities for hazardous waste.
- Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.

## 2.0 Site Specific Flood Risk

### 2.1 Risk of Fluvial / Tidal Flooding

2.1.1 The likelihood of fluvial and tidal flooding is defined on the Environment Agency's map 'Flood Map for Planning'. This flood map is published on the gov.uk website.

2.1.2 An extract of this flood map is provided below in Figure 2.1. The approximate site boundary is shown in red.

**Figure 2.1: Fluvial / Tidal Flood Risk - gov.uk – 16/07/19**



2.1.3 The Environment Agency's flood map shows that the proposed development site is located within Flood Zone 1 (Low Probability) and as such, the development is at a low (less than 1 in 1000 years) of flooding from rivers or the sea.



## 2.2 Risk of Surface Water Flooding

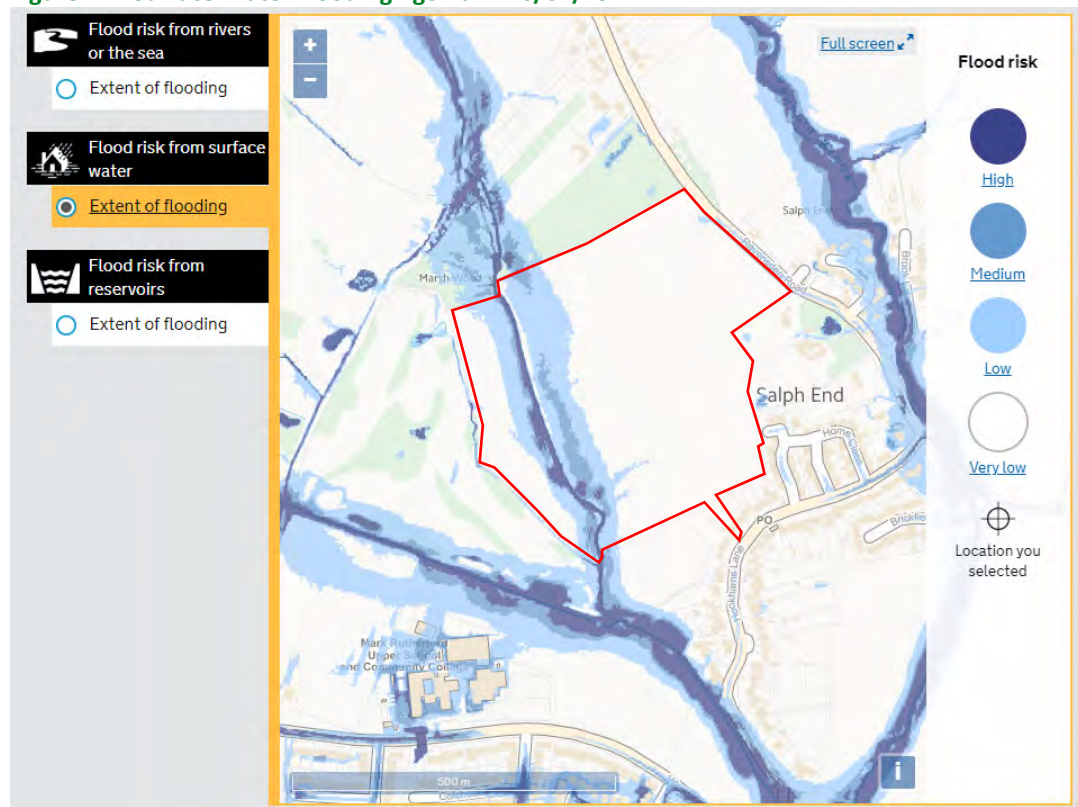
2.2.1 The likelihood of surface water flooding is defined on the Environment Agency's map 'Flood risk from surface water'. This flood map is published on the gov.uk website.

2.2.2 An extract of this flood map is provided below in Figure 2.2. The approximate site boundary is shown in red.

2.2.3 Regarding the accuracy of this map the EA state that:

*"Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding. Because of this, we report the highest risk within 20m of a specific location, such as an individual property. This means reports for neighbouring properties may show different levels of risk."*

Figure 2.2: Surface Water Flooding - gov.uk - 16/07/19



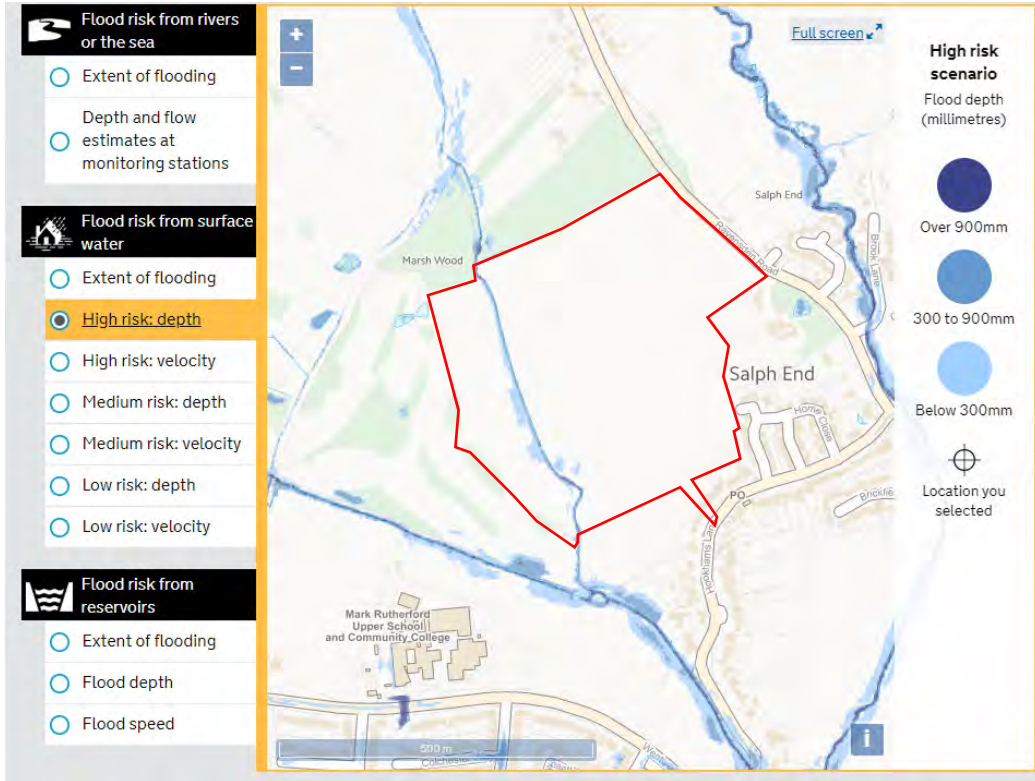
2.2.4 The site is located predominantly in an area of very low (less than 1 in 1000) risk of surface water flooding. Located towards the west and crossing the site north to south, an area of the site is shown to be at low (1 in 100 to 1 in 1000) risk, with small areas shown to be at medium (1 in 30 to 1 in 100) and high (greater than 1 in 30) risk of surface water flooding in a given year.

2.2.5 The areas of isolated surface water flooding are likely to be associated with low spots within the Lidar data used to create the map and would not occur post development of the site.



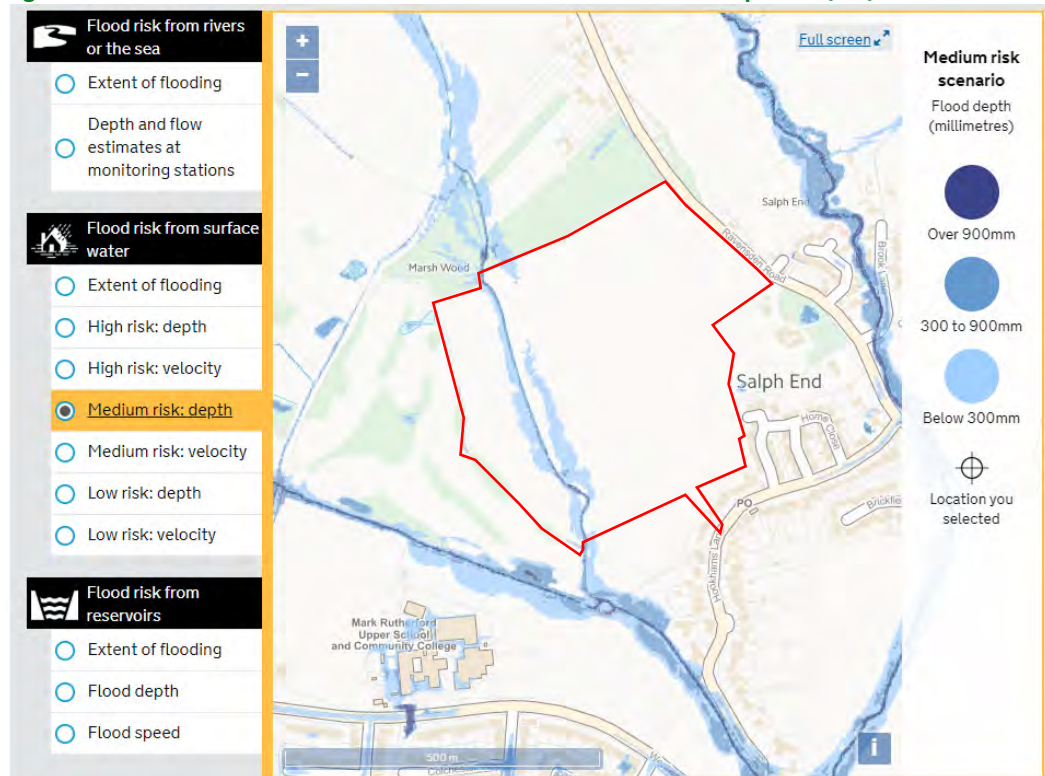
2.2.6 The extent and depth of flooding in the various return periods is shown in Figure 2.3, Figure 2.4 and Figure 2.5 below.

**Figure 2.3: Surface Water Flood Risk - High Risk - Extent and Depth - 16/07/19**

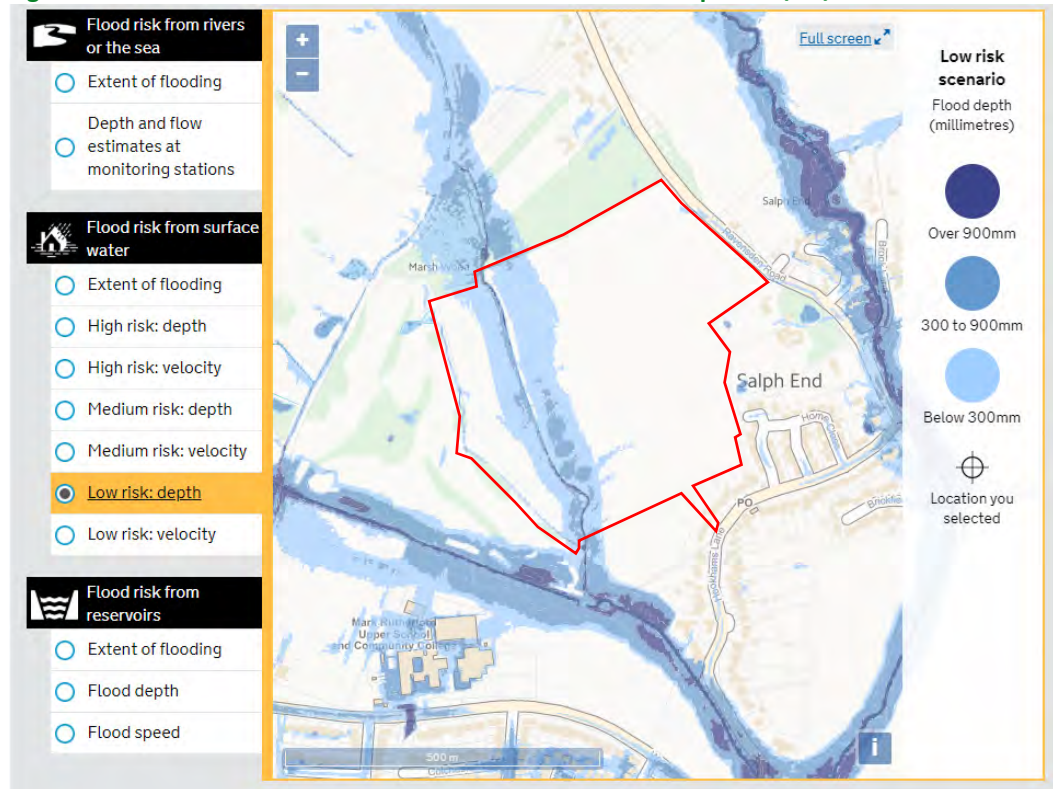


2.2.7

**Figure 2.4: Surface Water Flood Risk - Medium Risk - Extent and Depth - 16/07/19**



**Figure 2.5: Surface Water Flood Risk - Low Risk - Extent and Depth - 16/07/19**



2.2.8 The extent of high and medium risk surface water flooding is limited. The proposed development will avoid new development within the areas of high and medium risk flooding. The areas of high-risk flooding are predominately located within 9m of the watercourse and are therefore located within the maintenance strip required by the IDB.

2.2.9 The area of low risk surface water flooding is wider and has a chance of flooding of between 0.1% and 1%. The design standard for developments is to ensure that there is no risk of flooding for all events up to the 1% event. Hence, the area of low risk surface water flooding which has a less than 1% chance of flooding is appropriate for all of the proposed development types. However, the design of the development in areas of low risk surface water flooding will incorporate the following additional measures:

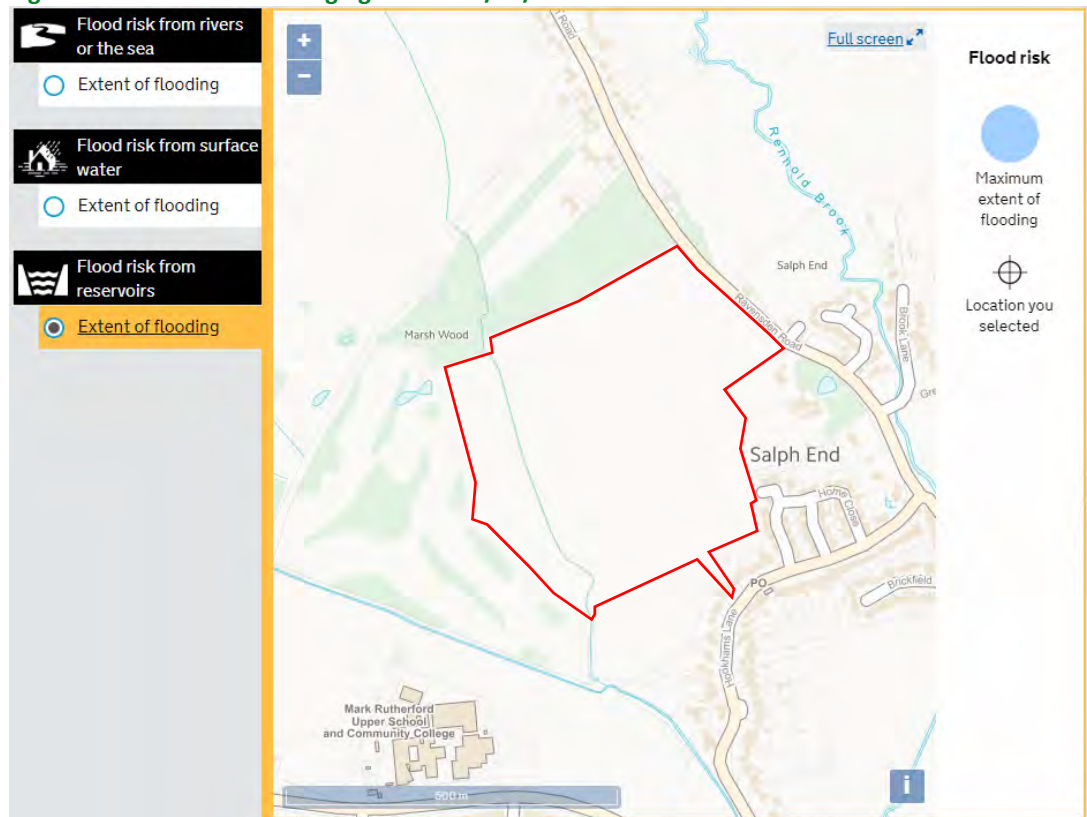
- Buildings will have a Finished Floor Level (FFL) raised 300mm above existing ground levels; and
- Layout will consider north to south flow of surface water during an extreme event.

## 2.3 Risk of Reservoirs, Canals and Other Artificial Sources Flooding

2.3.1 The likelihood of reservoir water flooding is defined on the Environment Agency’s map ‘Flood risk from reservoirs’. This flood map is published on the gov.uk website.

2.3.2 An extract of this flood map is provided below in Figure 2.6. The approximate site boundary is shown in red.

**Figure 2.6: Reservoir Flooding - gov.uk – 16/07/19**



2.3.3 The site is not at risk of reservoir flooding. We are not aware of any canals or other artificial sources which may cause flooding on the development site.

## 2.4 Risk of Ground Water Flooding

2.4.1 We do not have any records of ground water flooding within the vicinity of the site. We therefore consider the risk of ground water flooding to be low.

## 2.5 Risk of Sewer Flooding

2.5.1 We do not have any records of sewer flooding within the vicinity of the site. We therefore consider the risk of sewer flooding to be low.

## **2.6 Previous Flood Events**

- 2.6.1 The Environment Agency's Historic Flood Map does not show any flooding within the boundary of the site. The Environment Agency's "Historic Flood Map is a GIS layer showing the maximum extent of all individual Recorded Flood Outlines from river, the sea and groundwater springs and shows areas of land that have previously been subject to flooding in England. Records began in 1946 when predecessor bodies to the Environment Agency started collecting detailed information about flooding incidents".

## **2.7 Summary of Flood Risk**

- 2.7.1 With the exception of surface water, the proposed development is at a low risk of flooding from all sources and is located within Flood Zone 1.
- 2.7.2 The proposed development site has areas of high, medium and low surface water flooding. No development will be located in the high and medium surface water flood risk areas whilst development is appropriate within low risk surface water flooding areas. However, buildings in this area will have a raised FFL and the layout will be designed to accommodate the north to south overland flow routes during an extreme event with a less than 1% chance of occurring.



## 2.8 Flood Risk Vulnerability and Flood Zone ‘Compatibility’

2.8.1 The suitability of different development types to be built and occupied within a particular Flood Zone is defined within Table 3 of the Planning Practice Guidance for ‘Flood Risk and Coastal Change’ to the National Planning Policy Framework. Table 3 is replicated below in Table 2.1 below. This table maps vulnerability classes against the flood zones to indicate where development is ‘appropriate’ and where it should not be permitted.

2.8.2 The proposed residential and school development is located within Flood Zone 1 and is classified as More Vulnerable development. Based on this categorisation of the development it is considered ‘appropriate’.

**Table 2.1: Flood risk vulnerability and flood zone ‘compatibility’**

Flood Zone	Flood Risk Vulnerability Classification				
	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	×	Exception Test required	✓	
Zone 3b *	Exception Test required *	×	×	×	×

✓ Development is appropriate

X Development should not be permitted.

† In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

” \* “ In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

## 3.0 Surface Water Management

### 3.1 Existing Drainage

3.1.1 The is currently undeveloped with no positive drainage.

### 3.2 Existing Discharge Rate

3.2.1 The existing discharge rate for the site per hectare has been calculate using the IH124 method. Full calculations are enclosed in Appendix F. Whilst the input parameters and results are summarised in Table 3.1 below. The estimated allowable discharge rate based on predicted impermeable area is shown for each catchment in the table below.

**Table 3.1: Existing Runoff Rate Calculation Parameters and Results**

Parameter	Value	
Proposed Drained Area (ha)	1.000	
SAAR (mm)	558	
Soil Index / SPR	3 / 0.40	
Region	5	
Growth Factor 1 year	0.87	
Growth Factor 30 year	2.55	
Growth Factor 100 year	3.56	
Results	Value	
Q <sub>Bar</sub> (l/s/ha)	2.6	
Q1 (l/s/ha)	2.3	
Q30 (l/s/ha)	6.7	
Q100 (l/s/ha)	9.3	
Catchment	Area (ha)	Q <sub>Bar</sub> (l/s)
Residential	6.383	16.6
School	1.048	2.7

3.2.2 The allowable discharge rate for the site is the Q<sub>Bar</sub> rate of 2.6 l/s/ha. Surface water from the site post development will be restricted to a discharge rate of 2.6 l/s/ha via a hydrobrake.



### **3.3 Proposed Method of Discharge**

3.3.1 Paragraph 80 of the Planning Practice Guidance for ‘Flood Risk and Coastal Change’ defines the hierarchy of drainage options. Where reasonable practicable the aim should be to discharge surface water runoff as high up the following hierarchy of drainage options as reasonably practicable:

1. into the ground (infiltration);
2. to a surface water body;
3. to a surface water sewer, highway drain, or another drainage system; and
4. to a combined sewer.

3.3.2 Each of these is considered separately below:

#### **Into the ground**

3.3.3 Inspection of the British Geological Society’s maps show that there are limited superficial deposits across the site but where these are located they comprise Oadby Member or Alluvium – Clay. Below these the bedrock geology is thought to comprise Peterborough Member – mudstone.

3.3.4 Based on the above geology description we would anticipate that infiltration techniques across the site would be unviable. Infiltration testing will be undertaken at detailed design stage to confirm this assumption. Should infiltration be found to be viable the drainage strategy proposed for the development will be altered to take this into account.

#### **To a Surface Water Body**

3.3.5 A watercourse is located through the development site splitting the site into an eastern and western parcel for the purposes of drainage. This watercourse will be used as the outfall for surface water.

3.3.6 As a surface water body is viable the use of alternative drainage methods will not be considered further in this report.

### 3.4 Proposed Drainage Strategy

3.4.1 Surface water discharge from the proposed development will outfall to the watercourse located within the development site. The surface water discharge rate from the site will be restricted to greenfield equivalent runoff rates to ensure that the rate of surface water runoff from the site does not increase as a result of the proposed development.

3.4.2 The proposed drainage strategy for the residential areas will comprise a:

- A piped network;
- Hydrobrake flow control’;
- Detention Basin – online; and
- Permeable paving to private drives – tanked.

3.4.3 For the school attenuation will be provided below ground within geocellular attenuation for safety reasons.

3.4.4 The proposed surface water drainage strategy is shown on the drawing enclosed in in Appendix D.

#### Design Parameters

3.4.5 Surface water drainage will be designed using the rainfall parameters from the Flood Estimation Handbook (FEH)

3.4.6 Climate change allowance are defined by the Environment Agency in their document ‘Flood risk assessments: climate change allowances’ first published in February 2016. Table 2 of this document shows anticipated changes in extreme rainfall intensity in small and urban catchments. The Environment Agency advise that flood risk assessments and strategic flood risk assessments, assess both the central and upper end allowances to understand the range of impact. Table 2 of the Environment Agency’s guidance is replicated below in Table 3.2.

**Table 3.2: Table 2 Peak rainfall intensity allowance in small and urban catchments**

Applies across all of England	Total potential change anticipated for the ‘2020s’ (2015 to 2039)	Total potential change anticipated for the ‘2050s’ (2040 to 2069)	Total potential change anticipated for the ‘2080s’ (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

3.4.7 To ensure a worst-case assessment is undertaken a 40% climate change allowance will be used throughout.

### 3.5 Attenuation Design

3.5.1 Surface water attenuation is required to store excess water during an extreme event whilst maintaining a greenfield discharge rate of. Surface water will be attenuated within detention basins. Full calculations are enclosed in Appendix G and H whilst design parameters are set out below.

**Table 3.3: Attenuation Calculation Parameters and Results**

Parameter	Value
Return Period (years)	100 + 40% Climate Change
Rainfall Parameters	FEH13
<b>Eastern Catchment – Appendix G</b>	
Drained Area (ha)	7.021, see Appendix E includes 10% urban creep
Discharge Rate (l/s)	16.6
Storage Requirement (m <sup>3</sup> )	6050
<b>School – Appendix H</b>	
Drained Area (ha)	1.048
Discharge Rate (l/s)	2.7
Storage Requirement (m <sup>3</sup> )	910

### 3.6 Maintenance Requirements

3.6.1 The drainage will be designed in line with Building Regulations, Sewers for Adoption and SUDS guidance to ensure compliance with best practice guidance thus minimising the maintenance requirements. A full maintenance plan for the site will be developed at detailed design stage.

3.6.2 The person / authority responsible for maintenance of the drainage will depend on ownership which will vary across the site as detailed design and adoption progresses the exact body responsible for adoption of the various surface water aspects will become clear. Typical responsibilities are set out below in Table 3.4.

**Table 3.4: Surface Water Maintenance**

Drainage	Maintainer
Drains	Home owner / school
Private Sewers	Home owner / management company / school
Household SUDS	Home owner
Communal SUDS - private	Management company / home owner.
Adopted SUDS	SUDS Body: Local Authority / water company / other SUDS adopting body.
Adopted sewers	Water company

## **4.0 Foul Water Management**

### **4.1 Existing Drainage**

4.1.1 The site is currently a field, therefore does not have any existing foul water infrastructure.

4.1.2 Existing adopted sewers within the vicinity of the site are shown on the asset plan enclosed in Appendix J.

### **4.2 Proposed Drainage Strategy**

4.2.1 Foul water will discharge to Anglian Water's sewer located within Hookhams Lane.

### **4.3 Maintenance Requirements**

4.3.1 The drainage will be designed in line with Building Regulations, Sewers for Adoption to ensure compliance with best practice guidance thus minimising the maintenance requirements. A full maintenance plan for the site will be developed at detailed design stage.

4.3.2 The person / authority responsible for maintenance of the drainage will depend on ownership which will vary across the site as detailed design and adoption progresses the exact body responsible for adoption of the various surface water aspects will become clear. Typical responsibilities are set out below in Table 4.1.

**Table 4.1: Foul Water Maintenance**

<b>Drainage</b>	<b>Maintainer</b>
Drains	Home owner / school
Private Sewers	Home owner / management company / school
Adopted sewers	Water company

## **5.0 Conclusions**

### **5.1 Site location and proposed development**

5.1.1 The proposed residential development is located at land between Hookhams Lane and Ravensden Road, Salph End

5.1.2 The proposed development will comprise up to 400 residential dwellings and a two-form entry primary school.

### **5.2 Flood Risk**

5.2.1 With the exception of surface water, the proposed development is at a low risk of flooding from all sources and is located within Flood Zone 1.

5.2.2 The proposed development site has areas of high, medium and low surface water flooding. No development will be located in the high and medium surface water flood risk areas whilst development is appropriate within low risk surface water flooding areas. However, buildings in this area will have a raised FFL some 300mm above existing ground level and the layout will be designed to accommodate the north to south overland flow routes during an extreme event with a less than 1% chance of occurring.

5.2.3 The proposed development's vulnerability classification is compatible with the Flood Zone therefore the development is appropriate.

### **5.3 Surface Water Management**

5.3.1 The key proposed surface water parameters are:

- Discharge rate: Greenfield equivalent – Residential catchment 16.6 l/s and School 2.7 l/s
- Outfall: watercourse
- Attenuation requirement: East catchment 6050 m<sup>3</sup>, School 910 m<sup>3</sup>
- SUDS features:
  - A piped network;
  - Hydrobrake flow control';
  - Detention Basin – online - residential;
  - Geocellular attenuation – online - school; and
  - Permeable paving to private drives – tanked.

### **5.4 Foul Water Management**

5.4.1 Foul water will discharge to the adopted sewer located in Hookhams Lane.

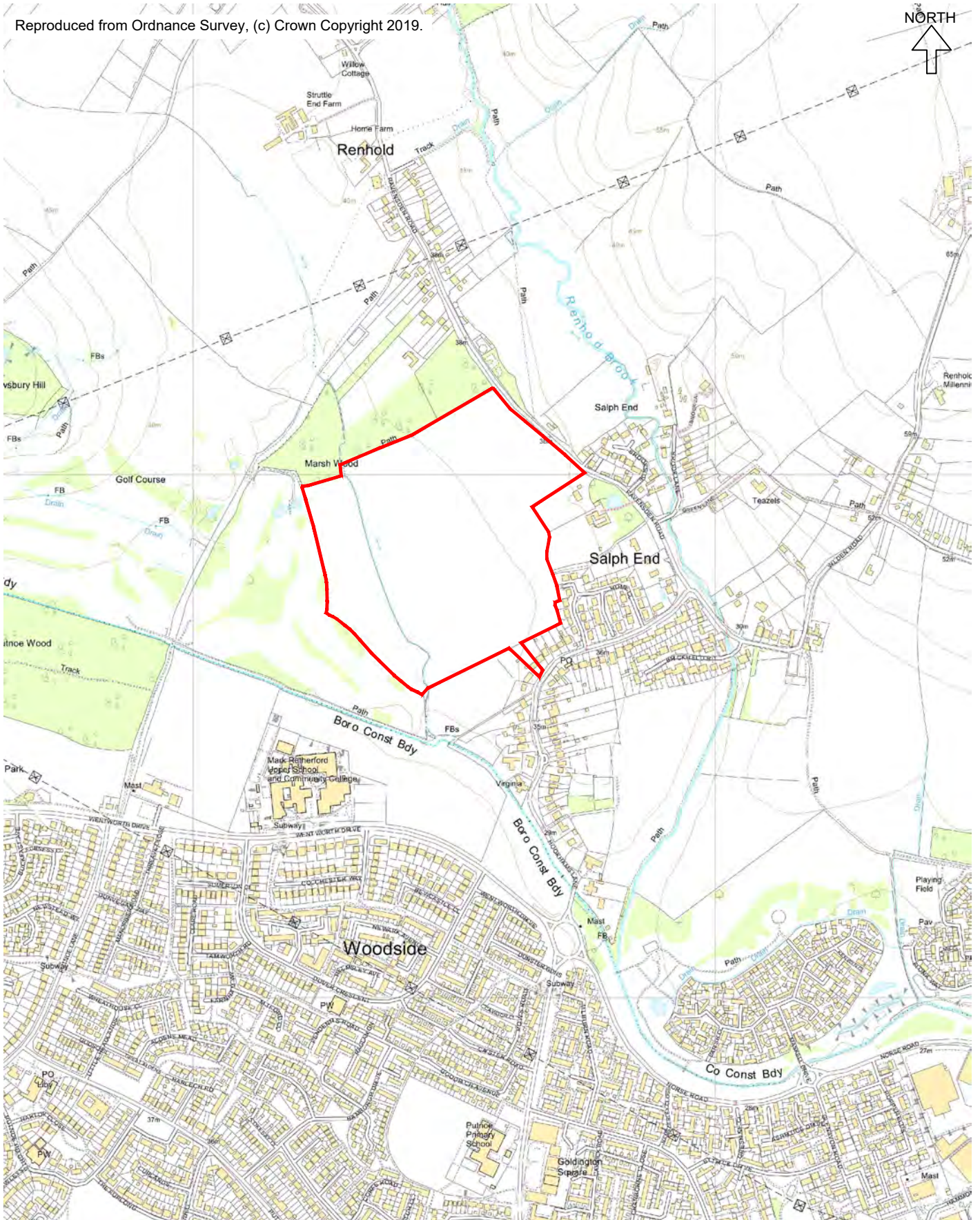


**Appendix A**

Location Plan

MAC drawing no. 248-FRA01





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 Martin Andrews Consulting Ltd

Client: Manor Oak Homes

Project: Land North of Hookhams Lane  
 Salph End

Date: 28/08/19

Drw: MJA

Chk: MJA

Scale: 1:10,000

Size: A4

Title: Location Plan

Drawing No. 248-FRA01

Revision A

- Transport Assessments
- Flood Risk Assessments
- Highway Advice
- Drainage Strategies

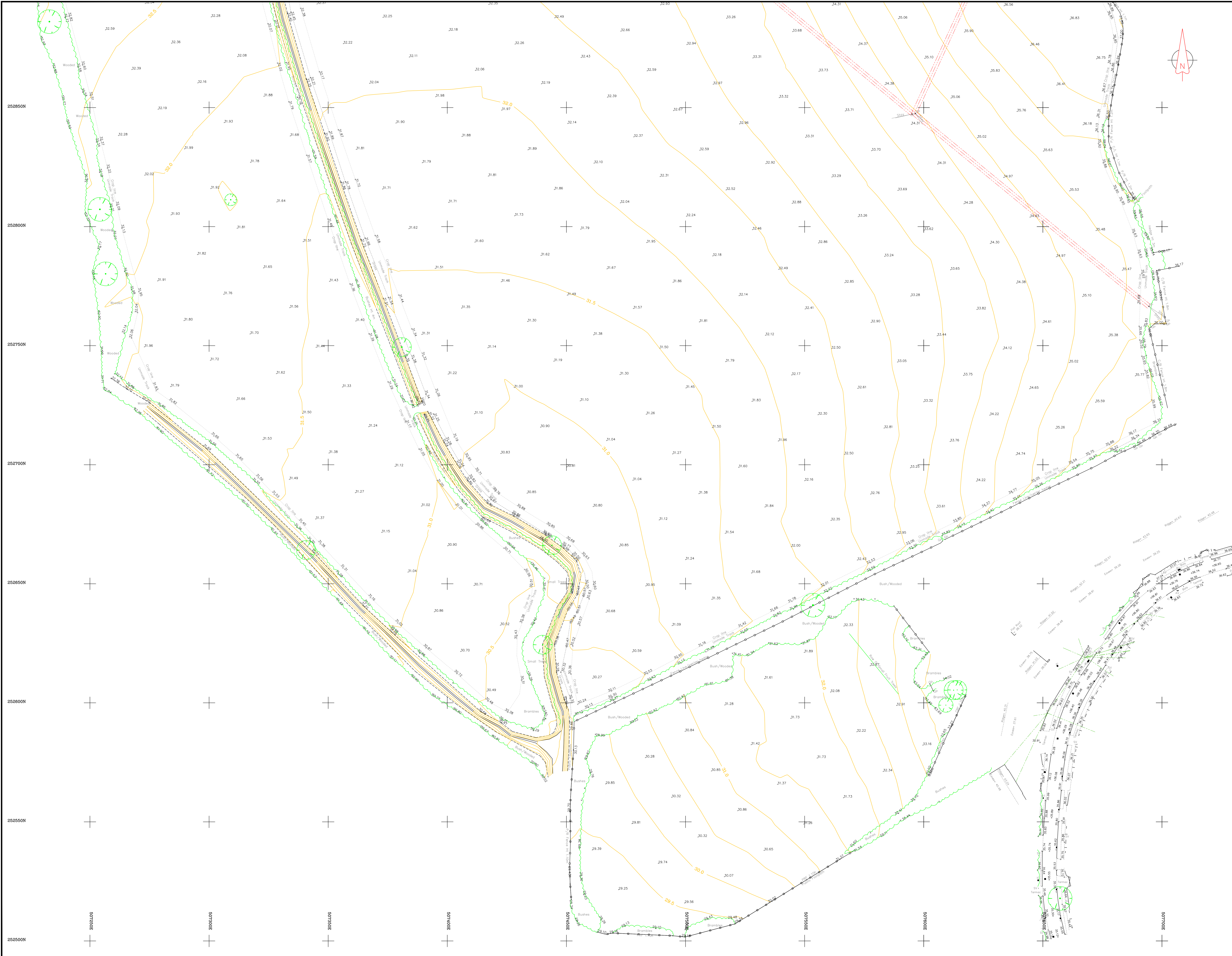
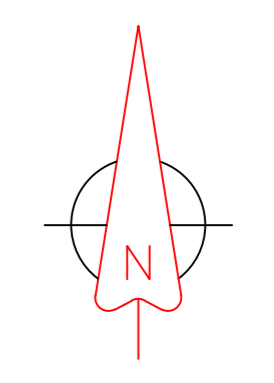


**Appendix B**

Topographical Survey  
MSurv drawing no. 1215/2272/1, 2 and 3



Notes  
Grid and levels have been aligned to O.S. National Grid OSGB36(15).



Suffix	Revision	Date	Initial

**MSURV**  
your surveying solution

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OX17 3DT  
Tel: 01295 814417  
Fax: 01295 814410

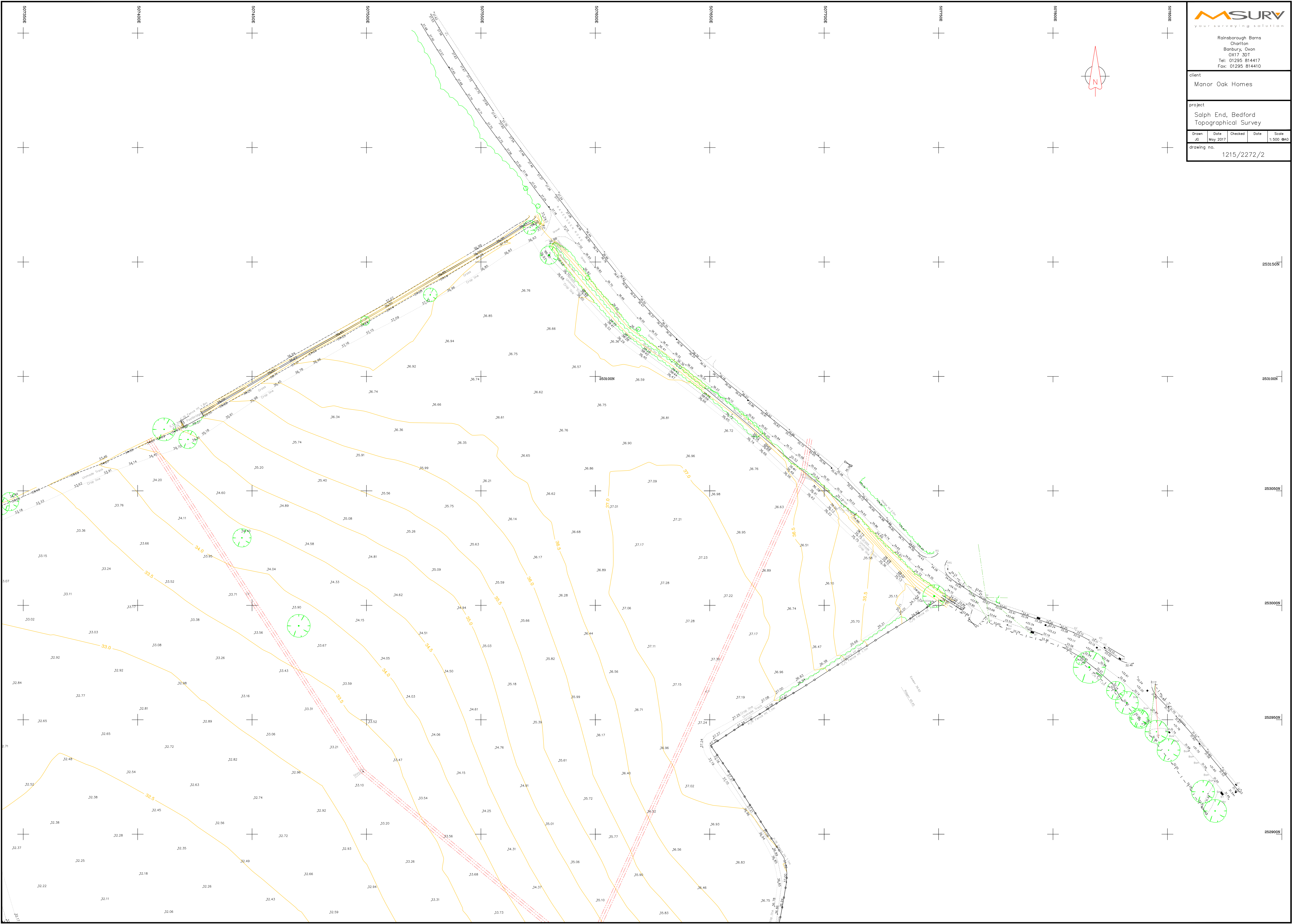
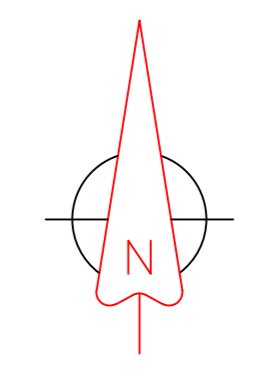
client  
Manor Oak Homes

project  
Salph End, Bedford  
Topographical Survey

Drawn	Date	Checked	Date	Scale
JS	May 2017			1:500 BAO

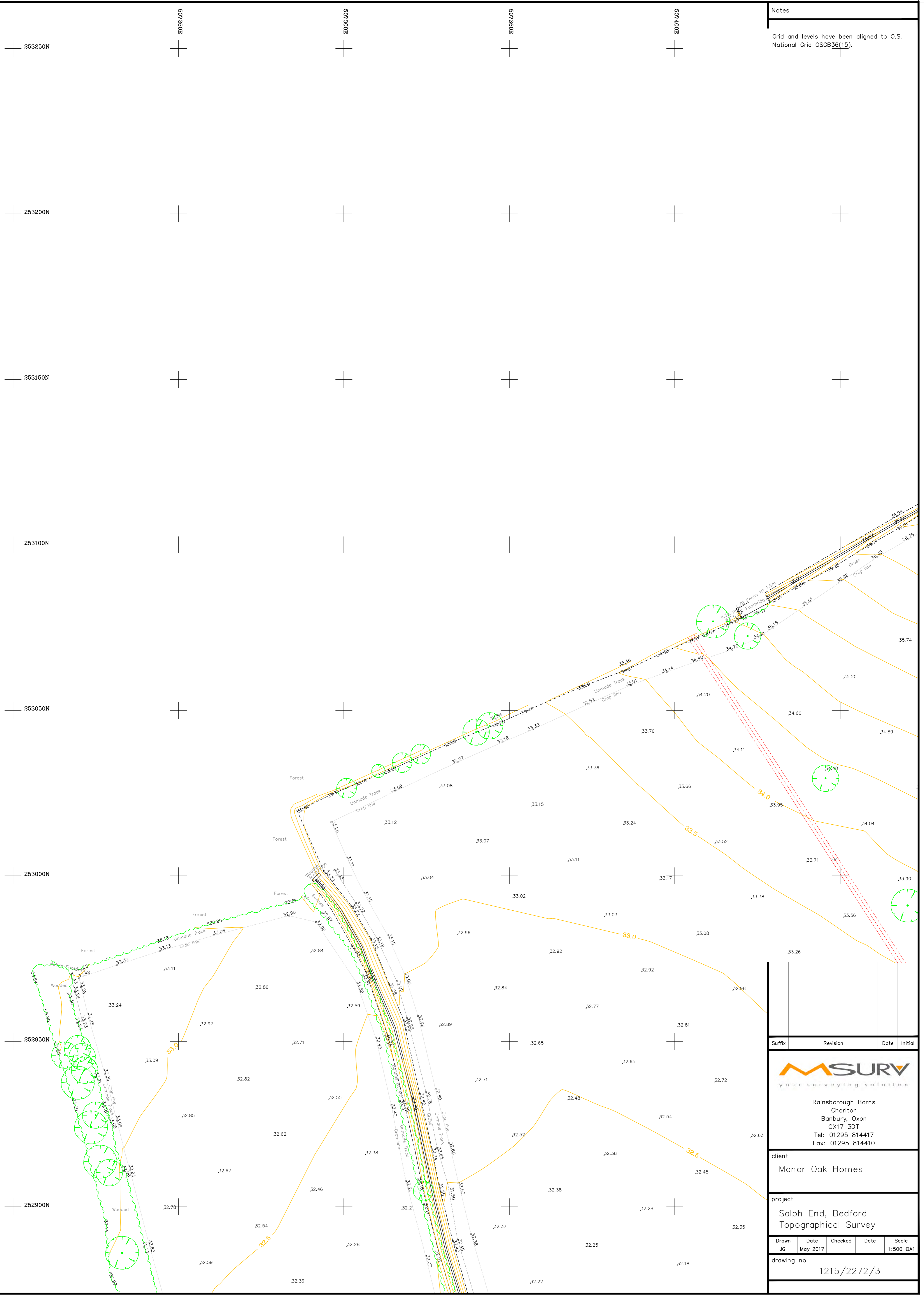
drawing no. 1215/2272/1







Notes  
 Grid and levels have been aligned to O.S. National Grid OSGB36(15).



Suffix	Revision	Date	Initial

**MSURV**  
 your surveying solution

Rainsborough Barns  
 Charlton  
 Banbury, Oxon  
 OX17 3DT  
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client  
 Manor Oak Homes

project  
 Salph End, Bedford  
 Topographical Survey

Drawn	Date	Checked	Date	Scale
JG	May 2017			1:500 @A1

drawing no.  
 1215/2272/3







- Site area 19.57ha
- Open Space 3.17ha
- Developable area 10.75ha  
Includes primary route
- School area 2.1ha
- Attenuation basins 0.59ha  
Area excluded from open space calculation
- Flood zone 1.88ha
- Sports pitches 1.08ha
- Primary route
- Indicative vehicular access and parking  
for sports pitches.
- Easement

Revision:	Date:
A Plan updated with revised distribution of POS and relocation of site access.	12.08.19 HW/DW
B Developable, open space and attenuation areas updated.	20.08.19 HW/DW
C Attenuation basin amended. Site area added to key.	22.08.19 HW/DW



Architects · Project Managers · Quantity Surveyors  
 130 New Walk  
 Leicester, LE1 7JA  
 Tel: 0116 204 5800, Fax: 0116 204 5801  
 email: design@rg-p.co.uk, www.rg-p.co.uk

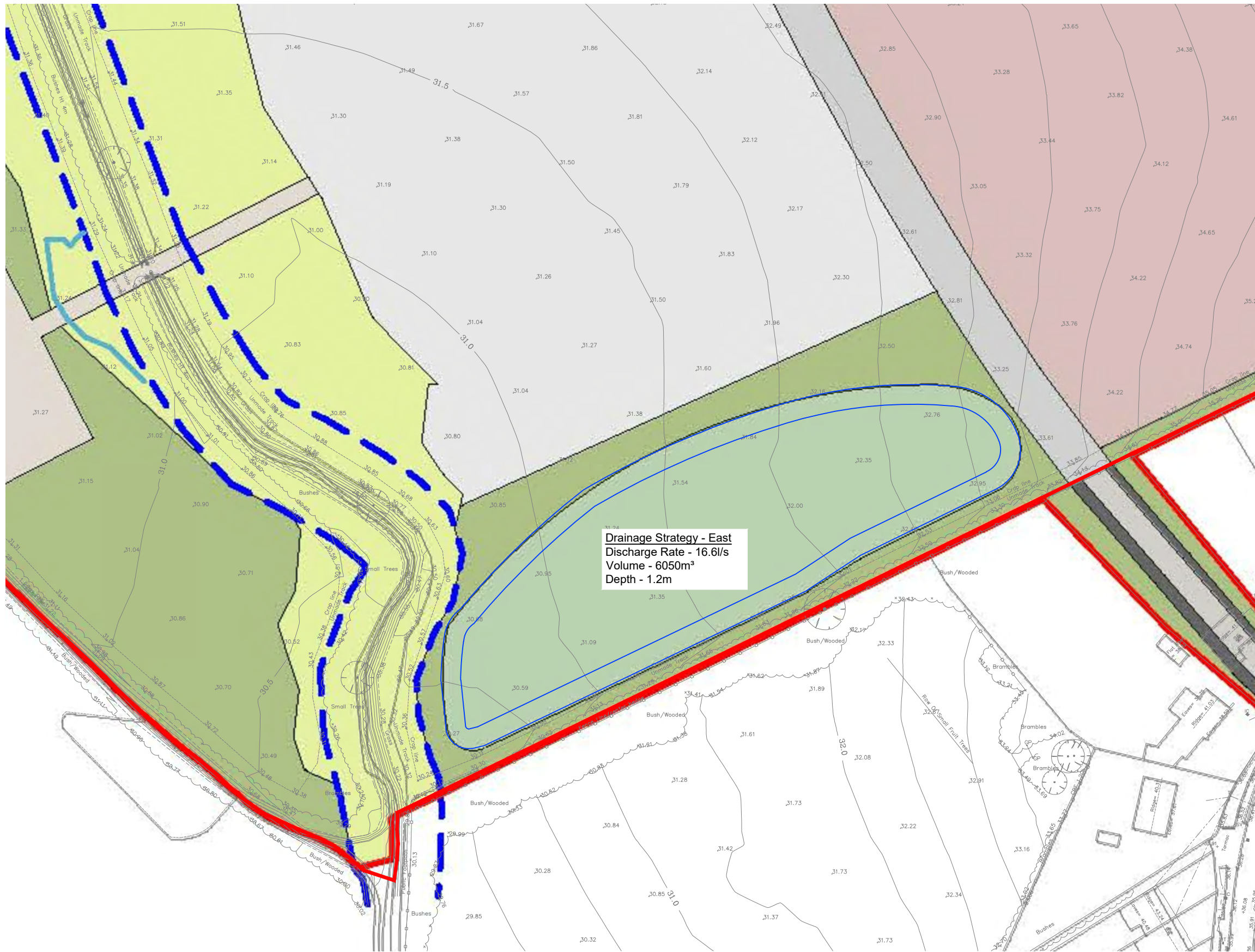
Project:	A development at Salph End, Bedford	
Client:	Manor Oak Homes	
Sheet title:	Parameters Plan	
Ref:	40986 013C	
Scale:	1:2500 @ A3	
Date:	25.07.19	
Drawn:	HW	Checked: DW

All dimensions to be checked on site. This drawing is the copyright of the Architect, and not to be reproduced without their permission. Ordnance Survey map information reproduced with permission of HMSO Crown Copyright reserved. rg+p Ltd. Trading as rg+p



**Appendix D**

Proposed Drainage Strategy  
MAC drawing no. 248-FRA03



**Drainage Strategy - East**  
 Discharge Rate - 16.6l/s  
 Volume - 6050m<sup>3</sup>  
 Depth - 1.2m

**Notes**

1. Based on MSurv 'Topographical Survey' drawing number 1215/2272/1.
2. Based on RGP 'Parameters Plan' drawing number 40986 013 C
3. Based on Ordnance Survey mapping.

**Key**

- Site Boundary
- Proposed Surface Water Drainage
- Proposed Surface Water Attenuation - Residential

 T: 01604 340544 Northampton Office E: info@mac-ltd.co.uk W: mac-ltd.co.uk Martin Andrews Consulting Ltd	<ul style="list-style-type: none"> <li>• Transport Assessments</li> <li>• Flood Risk Assessments</li> <li>• Highway Advice</li> <li>• Access Design</li> <li>• Drainage Strategies</li> <li>• Vehicle tracking</li> </ul>	<b>Client:</b> Manor Oak Homes	<b>Project:</b> Land North off Hookhams Lane, Salph End
		<b>Title:</b> Proposed Drainage Strategy	<b>Date:</b> 28/08/19 <b>Drw:</b> MJA <b>Chk:</b> MJA
<b>Drawing No:</b> 248-FRA03	<b>Revision:</b> C	<b>Scale:</b> 1:2500 <b>Size:</b> A3	

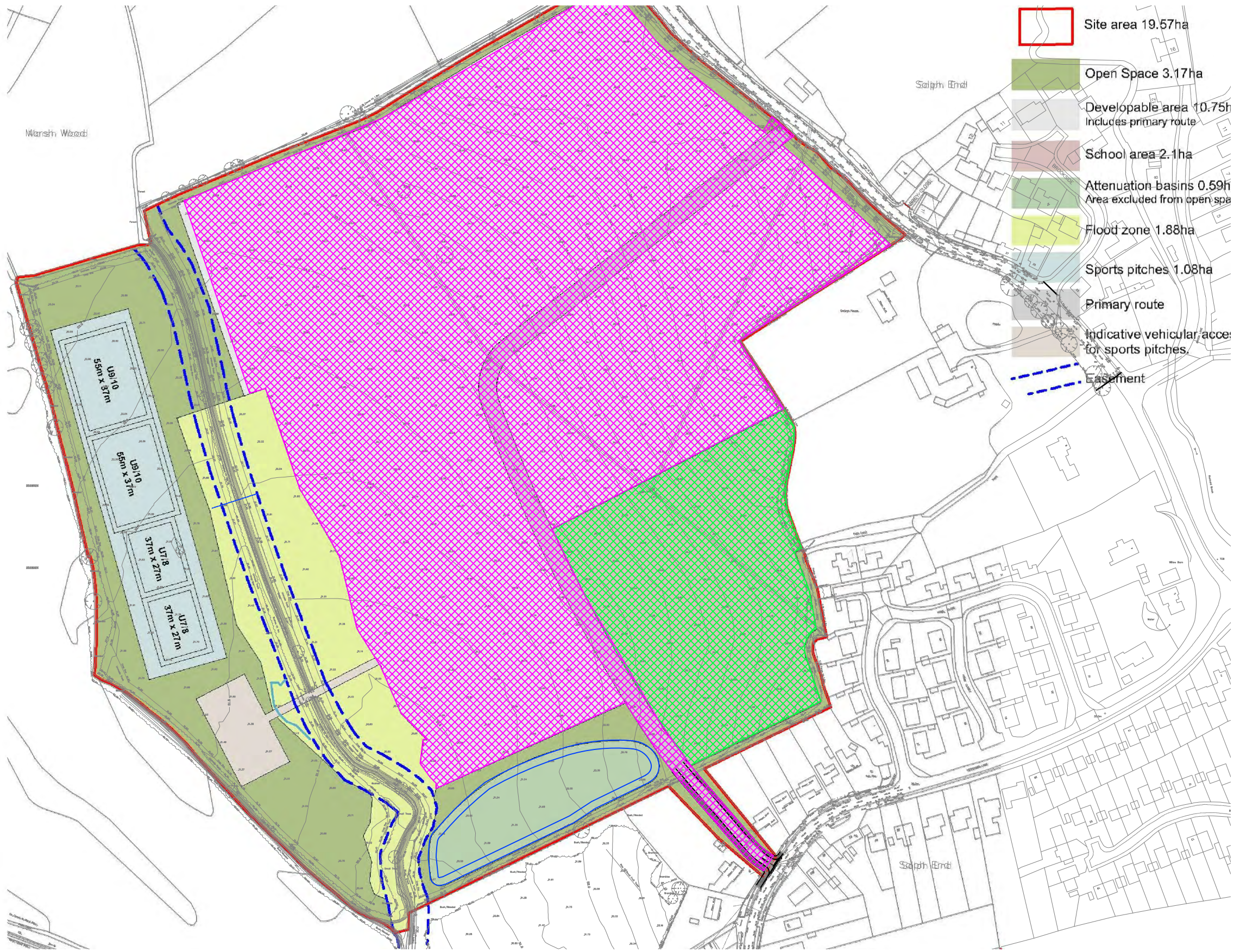




**Appendix E**

Proposed Impermeable Area  
MAC drawing no. 248-FRA02





- Site area 19.57ha
- Open Space 3.17ha
- Developable area 10.75ha  
Includes primary route
- School area 2.1ha
- Attenuation basins 0.59ha  
Area excluded from open space
- Flood zone 1.88ha
- Sports pitches 1.08ha
- Primary route
- Indicative vehicular access for sports pitches
- Easement

**Notes**

1. Based on MSurv 'Topographical Survey' drawing number 1215/2272/1.
2. Based on RGP 'Parameters Plan' drawing number 40986 013 C
3. Based on Ordnance Survey mapping.

**Key**

- Site Boundary = 194,518m<sup>2</sup>
- Proposed Development Area East  
Development Area = 106,380m<sup>2</sup>  
Pimp = 60%  
Impermeable Area = 63,828m<sup>2</sup>  
Urban Creep = 10%  
Drained Area = 70,211m<sup>2</sup>
- Proposed Development Area School  
Development Area = 20,957m<sup>2</sup>  
Pimp = 50%  
Impermeable Area = 10,479m<sup>2</sup>

<p style="font-size: 0.8em; margin-top: 5px;">T: 01604 340544 Northampton Office E: info@mac-ltd.co.uk W: mac-ltd.co.uk Martin Andrews Consulting Ltd</p>	<ul style="list-style-type: none"> <li>• Transport Assessments</li> <li>• Flood Risk Assessments</li> <li>• Highway Advice</li> <li>• Access Design</li> <li>• Drainage Strategies</li> <li>• Vehicle tracking</li> </ul>	<p><b>Client:</b> Manor Oak Homes</p> <p><b>Project:</b> Land North off Hookhams Lane, Salph End</p>	<p><b>Date:</b> 29/08/19</p> <p><b>Drw:</b> MJA</p> <p><b>Chk:</b> MJA</p>	
	<p><b>Title:</b> Proposed Impermeable Area</p>		<p><b>Scale:</b> 1:2500</p> <p><b>Size:</b> A3</p>	
	<p><b>Drawing No:</b> 248-FRA02</p>		<p><b>Revision:</b> C</p>	





**Appendix F**  
Greenfield Runoff Calcs



# Drainage Design Report

## Flow+

v8.1

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<b>Network</b>	Storm Network
<b>Filename</b>	C:\Users\Martin\OneDrive - Martin Andrews Consulting Ltd\Projects 200 - 299\248 - Salph End, Bedford\Design\FRA\Flow\248-Drainage Design-East.pfd
<b>Username</b>	Martin Andrews (martin.andrews@mac-ltd.co.uk)
<b>Last analysed</b>	22/07/2019 10:29:19
<b>Report produced on</b>	24/07/2019 09:07:44

### Causeway Sales

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<b>Email:</b>	marketing@causeway.com
<b>Web:</b>	www.causeway.com

### Technical support web portal:

<http://support.causeway.com>

<b>Rainfall Methodology</b>	FEH-13
<b>Return Period (years)</b>	100
<b>Additional Flow (%)</b>	0
<b>CV</b>	0.750
<b>Time of Entry (mins)</b>	5.00
<b>Maximum Time of Concentration (mins)</b>	30.00
<b>Maximum Rainfall (mm/hr)</b>	50.0
<b>Minimum Velocity (m/s)</b>	1.00
<b>Connection Type</b>	Level Soffits
<b>Minimum Backdrop Height (m)</b>	0.200
<b>Preferred Cover Depth (m)</b>	1.200
<b>Include Intermediate Ground</b>	
<b>Enforce best practice design rules</b>	





**Appendix G**  
Drainage Design Calculations - Eastern

# Drainage Design Report

## Flow+

v8.1

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<b>Network</b>	Storm Network
<b>Filename</b>	C:\Users\Martin\OneDrive - Martin Andrews Consulting Ltd\Projects 200 - 299\248 - Salph End, Bedford\Design\FRA\Flow\248-Drainage Design-East.pfd
<b>Username</b>	Martin Andrews (martin.andrews@mac-ltd.co.uk)
<b>Last analysed</b>	22/07/2019 10:29:19
<b>Report produced on</b>	24/07/2019 09:07:44

### Causeway Sales

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<b>Email:</b>	marketing@causeway.com
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### Technical support web portal:

<http://support.causeway.com>

<b>Rainfall Methodology</b>	FEH-13
<b>Return Period (years)</b>	100
<b>Additional Flow (%)</b>	0
<b>CV</b>	0.750
<b>Time of Entry (mins)</b>	5.00
<b>Maximum Time of Concentration (mins)</b>	30.00
<b>Maximum Rainfall (mm/hr)</b>	50.0
<b>Minimum Velocity (m/s)</b>	1.00
<b>Connection Type</b>	Level Soffits
<b>Minimum Backdrop Height (m)</b>	0.200
<b>Preferred Cover Depth (m)</b>	1.200
<b>Include Intermediate Ground</b>	
<b>Enforce best practice design rules</b>	

	Name	Area (ha)	T of E (mins)	Add Inflow (l/s)	Cover Level (m)	Node Type	Manhole Type	Diameter (mm)	Width (mm)	Easting (m)	Northing (m)	Depth (m)	Notes
1		5.936	5.00		100.000	Manhole		1200		100.000	100.000	2.000	



Rainfall Methodology	FEH-13	Return Period (years)		Climate Change (%)	
Summer CV	0.750	100		40	
Winter CV	0.840				
Analysis Speed	Normal				
Skip Steady State	x				
Drain Down Time (mins)	240				
Additional Storage (m <sup>3</sup> /ha)	20.0				
Storm Durations (mins)	15				
	30				
	60				
	120				
	180				
	240				
	360				
	480				
	600				
	720				
	960				
	1440				
Check Discharge Rate(s)					
1 year (l/s)	2.2				
30 year (l/s)	5.1				
100 year (l/s)	6.5				
Check Discharge Volume					
100 year 360 minute (m <sup>3</sup> )					



Hydro-Brake®													
Node	Flap Valve	Online / Offline	Downstream Link	Replaces Downstream Link	Loop to Node	Invert Level (m)	Design Depth (m)	Design Flow (l/s)	Objective	Sump Available	Product Number	Min Outlet Diameter (m)	Min Node Diameter (mm)
1	x	Online				98.000	1.000	14.0	(HE) Minimise upstream storage		CTL-SHE-0170-1400-1000-1400	0.225	1200

Depth/Area/Inf Area									
Node	Base Inf Coefficient (m/hr)	Side Inf Coefficient (m/hr)	Safety Factor	Porosity	Invert Level (m)	Time to half empty (mins)	Depth (m)	Area (m <sup>2</sup> )	Inf. Area (m <sup>2</sup> )
1	0.00000	0.00000	2.0	1.00	98.000		0.000	5160.0	0.0
							1.000	5160.0	0.0
							1.001	0.0	0.0

Results for 100 year +40% Critical Storm Duration. Lowest mass balance: 99.99%

Event	US Node ID	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status	Link ID	DS Node ID	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
960 minute winter	1	945	98.987	0.987	250.8	5154.1550	0.0000	OK	Hydro-Brake®		13.9				782.0



**Appendix H**  
Drainage Design Calculations - Western



**Appendix I**  
Drainage Design Calculations - School



# Drainage Design Report

## Flow+

v8.1

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<b>Network</b>	Storm Network
<b>Filename</b>	C:\Users\Martin\OneDrive - Martin Andrews Consulting Ltd\Projects 200 - 299\248 - Salph End, Bedford\Design\FRA\Flow\248-Drainage Design-School.pfd
<b>Username</b>	Martin Andrews (martin.andrews@mac-ltd.co.uk)
<b>Last analysed</b>	22/07/2019 11:46:59
<b>Report produced on</b>	24/07/2019 09:08:48

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## Technical support web portal:

<http://support.causeway.com>

<b>Rainfall Methodology</b>	FEH-13
<b>Return Period (years)</b>	100
<b>Additional Flow (%)</b>	0
<b>CV</b>	0.750
<b>Time of Entry (mins)</b>	5.00
<b>Maximum Time of Concentration (mins)</b>	30.00
<b>Maximum Rainfall (mm/hr)</b>	50.0
<b>Minimum Velocity (m/s)</b>	1.00
<b>Connection Type</b>	Level Soffits
<b>Minimum Backdrop Height (m)</b>	0.200
<b>Preferred Cover Depth (m)</b>	1.200
<b>Include Intermediate Ground</b>	
<b>Enforce best practice design rules</b>	

	Name	Area (ha)	T of E (mins)	Add Inflow (l/s)	Cover Level (m)	Node Type	Manhole Type	Diameter (mm)	Width (mm)	Easting (m)	Northing (m)	Depth (m)	Notes
1		1.069	5.00		100.000	Manhole		1200		100.000	100.000	2.000	

Rainfall Methodology	FEH-13	Return Period (years)	100	Climate Change (%)	40
Summer CV	0.750				
Winter CV	0.840				
Analysis Speed	Normal				
Skip Steady State	x				
Drain Down Time (mins)	240				
Additional Storage (m <sup>3</sup> /ha)	20.0				
Storm Durations (mins)	15				
	30				
	60				
	120				
	180				
	240				
	360				
	480				
	600				
	720				
	960				
	1440				
Check Discharge Rate(s)					
1 year (l/s)	2.2				
30 year (l/s)	5.1				
100 year (l/s)	6.5				
Check Discharge Volume					
100 year 360 minute (m <sup>3</sup> )					



Hydro-Brake®													
Node	Flap Valve	Online / Offline	Downstream Link	Replaces Downstream Link	Loop to Node	Invert Level (m)	Design Depth (m)	Design Flow (l/s)	Objective	Sump Available	Product Number	Min Outlet Diameter (m)	Min Node Diameter (mm)
1	x	Online				98.000	1.000	2.8	(HE) Minimise upstream storage		CTL-SHE-0080-2800-1000-2800	0.100	1200

Depth/Area/Inf Area									
Node	Base Inf Coefficient (m/hr)	Side Inf Coefficient (m/hr)	Safety Factor	Porosity	Invert Level (m)	Time to half empty (mins)	Depth (m)	Area (m <sup>2</sup> )	Inf. Area (m <sup>2</sup> )
1	0.00000	0.00000	2.0	1.00	98.000		0.000	910.0	0.0
							1.000	910.0	0.0
							1.001	0.0	0.0

Results for 100 year +40% Critical Storm Duration. Lowest mass balance: 99.99%

Event	US Node ID	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status	Link ID	DS Node ID	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
960 minute winter	1	945	98.985	0.985	45.2	907.7075	0.0000	OK	Hydro-Brake®		2.8				165.7





**Appendix J**  
Water Company Asset Plans



