

Results for 30 year Critical Storm Duration. Lowest mass balance: 95.27%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	S102	10	111.120	0.055	15.5	0.0851	0.0000	OK
15 minute summer	S103	10	110.075	0.071	24.9	0.0954	0.0000	OK
15 minute summer	S104L	10	110.070	0.067	22.4	0.1160	0.0000	OK
15 minute summer	S104	10	108.748	0.092	53.3	0.1154	0.0000	OK
15 minute summer	S105	10	107.765	0.157	59.0	0.1934	0.0000	OK
15 minute summer	S106	11	107.584	0.225	65.2	0.2815	0.0000	OK
15 minute summer	S107	11	107.530	0.231	68.3	0.2757	0.0000	OK
15 minute summer	S108	11	107.470	0.230	72.4	0.2791	0.0000	OK
15 minute summer	S109L	10	107.577	0.087	17.4	0.1406	0.0000	OK
15 minute summer	S109	11	107.397	0.216	98.6	0.2970	0.0000	OK
15 minute summer	S110L	10	107.239	0.133	19.7	0.2893	0.0000	OK
15 minute summer	S110	11	106.891	0.139	125.8	0.2062	0.0000	OK
15 minute summer	S111L	10	106.001	0.113	16.5	0.1941	0.0000	OK
15 minute summer	S111	11	105.732	0.212	144.7	0.2600	0.0000	OK
15 minute summer	S112	11	105.602	0.229	154.9	0.3363	0.0000	OK
15 minute summer	S113L	10	105.715	0.227	29.0	0.4684	0.0000	SURCHARGED
1440 minute summer	S113	1440	105.495	0.431	12.2	0.4877	0.0000	OK
1440 minute summer	HW21	1440	105.511	0.480	40.4	0.0000	0.0000	OK
15 minute summer	S114L	10	107.480	0.058	17.4	0.0875	0.0000	OK
15 minute summer	S114	10	106.769	0.104	29.5	0.1397	0.0000	OK
15 minute summer	S115La	10	106.662	0.111	42.5	0.2421	0.0000	OK
15 minute summer	S115Lb	10	106.557	0.107	14.5	0.1581	0.0000	OK
15 minute summer	S115	10	106.412	0.225	92.8	0.2912	0.0000	OK
15 minute summer	S116	11	106.307	0.184	109.5	0.2963	0.0000	OK
15 minute summer	S117La	10	106.019	0.108	20.1	0.1659	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	S102	1.000	S103	15.4	1.726	0.132	0.1901	
15 minute summer	S103	1.001	S104	24.7	2.327	0.214	0.2773	
15 minute summer	S104L	2.000	S104	22.3	2.937	0.408	0.0978	
15 minute summer	S104	1.002	S105	53.1	1.927	0.207	0.5522	
15 minute summer	S105	1.003	S106	58.6	1.251	0.527	1.1597	
15 minute summer	S106	1.004	S107	65.2	1.134	0.918	0.8378	
15 minute summer	S107	1.005	S108	68.6	1.179	0.971	0.8420	
15 minute summer	S108	1.006	S109	72.5	1.292	1.028	0.8156	
15 minute summer	S109L	3.000	S109	17.3	1.645	0.631	0.0708	
15 minute summer	S109	1.007	S110	98.2	1.813	0.884	2.0064	
15 minute summer	S110L	4.000	S110	19.4	1.198	1.095	0.0877	
15 minute summer	S110	1.008	S111	125.7	2.204	0.212	2.1192	
15 minute summer	S111L	5.000	S111	16.3	1.145	0.921	0.0959	
15 minute summer	S111	1.009	S112	144.5	1.882	0.447	1.1319	
15 minute summer	S112	1.010	S113	154.5	1.603	0.479	2.2826	
15 minute summer	S113L	6.000	S113	28.5	1.621	1.607	0.0854	
1440 minute summer	S113	1.011	HW21	12.0	0.172	0.046	2.2013	
1440 minute summer	HW21	Flow through pond	HW23	14.5	0.017	0.000	528.7038	
15 minute summer	S114L	7.000	S114	17.3	2.742	0.319	0.0415	
15 minute summer	S114	7.001	S115	29.2	1.049	0.263	1.1489	
15 minute summer	S115La	8.000	S115	42.3	2.182	0.489	0.1511	
15 minute summer	S115Lb	9.000	S115	14.4	1.068	0.862	0.0580	
15 minute summer	S115	7.002	S116	91.2	1.490	0.706	0.9349	
15 minute summer	S116	7.003	S117	109.3	1.433	0.498	3.2919	
15 minute summer	S117La	10.000	S117	20.0	1.475	0.866	0.0638	

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Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	S117Lb	10	106.344	0.069	20.1	0.1091	0.0000	OK
15 minute summer	S117	11	105.924	0.317	148.8	0.3581	0.0000	OK
15 minute summer	S118	11	105.879	0.342	155.1	0.4351	0.0000	OK
15 minute summer	S119	11	105.679	0.285	155.0	0.3224	0.0000	OK
15 minute summer	S120L	10	105.765	0.237	28.3	0.4324	0.0000	SURCHARGED
15 minute summer	S120	11	105.573	0.331	181.8	0.3741	0.0000	OK
1440 minute summer	HW22	1440	105.510	0.428	21.8	0.0000	0.0000	OK
1440 minute summer	HW23	1470	105.489	0.458	14.5	0.0000	0.0000	OK
1440 minute summer	S121	1470	105.489	0.478	0.2	2.7377	0.0000	SURCHARGED
15 minute summer	HW24	1	105.600	0.895	0.0	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	S117Lb	11.000	S117	20.0	2.484	0.433	0.0629	
15 minute summer	S117	7.004	S118	148.2	1.461	0.936	1.1403	
15 minute summer	S118	7.005	S119	155.0	1.581	1.220	3.4361	
15 minute summer	S119	7.006	S120	154.4	1.607	0.868	1.8510	
15 minute summer	S120L	12.000	S120	27.8	1.580	1.560	0.1054	
15 minute summer	S120	7.007	HW22	181.2	1.789	1.169	1.0260	
1440 minute summer	HW22	Flow through pond	HW23	14.5	0.017	0.000	528.7038	
1440 minute summer	HW23	1.012	S121	-0.2	0.132	-0.001	1.5816	
1440 minute summer	S121	Hydro-Brake®	HW24	0.0				0.0

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 95.27%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	S102	10	111.140	0.075	28.1	0.1155	0.0000	OK
15 minute summer	S103	10	110.101	0.097	45.3	0.1314	0.0000	OK
15 minute summer	S104L	10	110.100	0.097	40.7	0.1673	0.0000	OK
15 minute summer	S104	11	108.803	0.147	96.8	0.1848	0.0000	OK
15 minute summer	S105	12	108.502	0.894	107.2	1.1035	0.0000	SURCHARGED
15 minute summer	S106	12	108.317	0.958	109.0	1.1967	0.0000	SURCHARGED
15 minute summer	S107	12	108.181	0.882	112.0	1.0514	0.0000	SURCHARGED
15 minute summer	S108	12	108.029	0.789	117.6	0.9562	0.0000	SURCHARGED
15 minute summer	S109L	12	108.018	0.528	31.7	0.8574	0.0000	SURCHARGED
15 minute summer	S109	12	107.857	0.676	159.3	0.9285	0.0000	SURCHARGED
15 minute summer	S110L	10	107.415	0.309	35.9	0.6739	0.0000	SURCHARGED
15 minute summer	S110	11	106.933	0.180	207.1	0.2684	0.0000	OK
15 minute summer	S111L	10	106.155	0.267	29.9	0.4585	0.0000	SURCHARGED
15 minute summer	S111	11	105.824	0.304	241.2	0.3731	0.0000	OK
1440 minute summer	S112	1110	105.737	0.364	18.5	0.5349	0.0000	OK
15 minute summer	S113L	11	106.036	0.548	52.6	1.1318	0.0000	SURCHARGED
1440 minute summer	S113	1110	105.737	0.673	45.7	0.7615	0.0000	SURCHARGED
1440 minute summer	HW21	1200	105.782	0.751	138.0	0.0000	0.0000	OK
15 minute summer	S114L	11	107.510	0.087	31.7	0.1311	0.0000	OK
15 minute summer	S114	12	107.242	0.577	53.7	0.7750	0.0000	SURCHARGED
15 minute summer	S115La	12	107.287	0.736	77.1	1.6120	0.0000	SURCHARGED
15 minute summer	S115Lb	12	107.239	0.789	26.3	1.1647	0.0000	SURCHARGED
15 minute summer	S115	12	107.173	0.986	157.4	1.2752	0.0000	SURCHARGED
15 minute summer	S116	12	107.100	0.977	174.1	1.5712	0.0000	SURCHARGED
15 minute summer	S117La	12	106.940	1.029	36.5	1.5829	0.0000	SURCHARGED

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	S102	1.000	S103	28.0	2.026	0.240	0.2935	
15 minute summer	S103	1.001	S104	44.9	2.742	0.389	0.4281	
15 minute summer	S104L	2.000	S104	40.5	3.386	0.743	0.1542	
15 minute summer	S104	1.002	S105	96.4	2.062	0.376	1.0430	
15 minute summer	S105	1.003	S106	97.6	1.386	0.878	1.7542	
15 minute summer	S106	1.004	S107	106.3	1.510	1.497	1.0253	
15 minute summer	S107	1.005	S108	112.0	1.590	1.585	1.0193	
15 minute summer	S108	1.006	S109	118.6	1.685	1.682	1.0221	
15 minute summer	S109L	3.000	S109	27.5	1.731	1.003	0.1187	
15 minute summer	S109	1.007	S110	160.3	2.277	1.442	2.5771	
15 minute summer	S110L	4.000	S110	35.0	1.989	1.973	0.0941	
15 minute summer	S110	1.008	S111	206.5	2.395	0.349	3.2012	
15 minute summer	S111L	5.000	S111	29.3	1.667	1.658	0.1175	
15 minute summer	S111	1.009	S112	238.3	2.051	0.737	1.7744	
1440 minute summer	S112	1.010	S113	22.6	0.668	0.070	3.4738	
15 minute summer	S113L	6.000	S113	50.9	2.889	2.864	0.0862	
1440 minute summer	S113	1.011	HW21	-35.4	0.242	-0.135	2.3984	
1440 minute summer	HW21	Flow through pond	HW23	44.3	0.045	0.001	827.4185	
15 minute summer	S114L	7.000	S114	31.6	3.200	0.581	0.0928	
15 minute summer	S114	7.001	S115	52.4	1.098	0.472	2.8407	
15 minute summer	S115La	8.000	S115	72.2	2.449	0.836	0.3099	
15 minute summer	S115Lb	9.000	S115	24.1	1.367	1.445	0.0759	
15 minute summer	S115	7.002	S116	142.2	1.632	1.100	1.6798	
15 minute summer	S116	7.003	S117	164.9	1.501	0.752	4.7431	
15 minute summer	S117La	10.000	S117	31.2	1.772	1.354	0.0830	

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 95.27%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	S117Lb	12	106.996	0.721	36.5	1.1387	0.0000	SURCHARGED
15 minute summer	S117	12	106.802	1.195	223.6	1.3513	0.0000	SURCHARGED
15 minute summer	S118	12	106.659	1.122	234.2	1.4275	0.0000	SURCHARGED
15 minute summer	S119	12	106.165	0.771	234.4	0.8722	0.0000	SURCHARGED
15 minute summer	S120L	11	106.331	0.803	51.4	1.4666	0.0000	SURCHARGED
15 minute summer	S120	12	105.895	0.653	278.3	0.7381	0.0000	SURCHARGED
1440 minute summer	HW22	1260	105.743	0.662	30.8	0.0000	0.0000	OK
1440 minute summer	HW23	1230	105.706	0.675	44.3	0.0000	0.0000	SURCHARGED
1440 minute summer	S121	1230	105.706	0.695	4.1	3.9819	0.0000	SURCHARGED
15 minute summer	HW24	1	105.600	0.895	0.0	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	S117Lb	11.000	S117	31.1	2.413	0.672	0.1168	
15 minute summer	S117	7.004	S118	223.9	2.030	1.414	1.2283	
15 minute summer	S118	7.005	S119	234.4	2.126	1.845	3.8791	
15 minute summer	S119	7.006	S120	234.6	2.127	1.319	2.1176	
15 minute summer	S120L	12.000	S120	47.8	2.716	2.682	0.1065	
15 minute summer	S120	7.007	HW22	278.5	2.525	1.797	1.1175	
1440 minute summer	HW22	Flow through pond	HW23	44.3	0.045	0.001	827.4185	
1440 minute summer	HW23	1.012	S121	4.1	0.031	0.017	1.6814	
1440 minute summer	S121	Hydro-Brake®	HW24	3.8				155.4

APPENDIX L – DRAINAGE MAINTENANCE SCHEDULE

Drainage Maintenance Schedule - Burbage Field Farm

Schedule	Feature	Location	Inspection Type	Inspection Frequency	Required Action	Maintenance Works	Maintenance Intervals	Comments
Regular Maintenance	Foul Water Pump	Southern Boundary	Visual	3 Months	Inspection of outlet and cover grate, remove debris and litter and ensure outlet is clear	Silt / Debris removal	6 Months (or as required)	Maintenance interval subject to specialist maintenance agreement with supplier
	Rain Garden	Southern Parcel	Visual	3 Months	Removal of debris and weeding	Debris removal / Weeding	Monthly (or as required).	Maintenance interval subject to Visual Inspection findings
	Attenuation Basin	South Eastern Boundary	Visual	3 Months	Removal of litter and debris	Litter removal	Monthly (or as required).	Maintenance interval subject to Visual Inspection findings
	Attenuation Basin	South Eastern Boundary	Visual	3 Months	Inspect Outlets, Inlets and Overflows for Blockages and Clear if Required.	Repairs as required	Monthly (or as required).	Maintenance interval subject to Visual Inspection findings
	Attenuation Basin	South Eastern Boundary	Visual	3 Times per year (see comments)	Manage Other Vegetation and Remove Nuisance Plants.	Weed Removal	3 Times per year (see comments)	Maintenance interval subject to Visual Inspection findings
	Flow Control Chamber	S19, S66, S106, S122	Visual	3 Months	Removal of litter and debris	Silt / Debris removal	6 Months (or as required)	Maintenance interval subject to Visual Inspection findings
Occasional Maintenance	Foul & Surface Water Chambers	Entire site	Visual	6 Months	Remove silt and leaf build up from gullies, chambers, gutters etc.	Silt / Debris removal	As required (debris max. 60% of capacity)	Maintenance interval subject to Visual Inspection findings
	Foul Water Pump	Southern Boundary	Visual	6 Months	Mechanical silt removal from sump	Silt / Debris removal	As required (debris max. 60% of capacity)	Maintenance interval subject to Visual Inspection findings
	Flow Control Chamber	S19, S66, S106, S122	Visual	6 Months	Mechanical silt removal from sump	Silt / Debris removal	As required (debris max. 60% of capacity)	Maintenance interval subject to Visual Inspection findings
	Perforated Carrier Drains	Parking bays/area, southern boundary	Visual	6 Months	CCTV / Jetting	Silt / Debris removal	As required (debris max. 60% of capacity)	Maintenance interval subject to Visual Inspection findings
	Attenuation Basin	South Eastern Boundary	Visual	6 Months	Removal from debris	Silt / Debris removal	6 Months (or as required)	Maintenance interval subject to Visual Inspection findings
	Catchpit Chambers	Entire Site	Visual	6 Months	Mechanical silt removal from sump	Silt / Debris removal	As required (debris max. 60% of capacity)	Maintenance interval subject to Visual Inspection findings

Remedial Actions	Foul & Surface Water Drainage	Entire site	Visual	12 Months	Remove and dispose of oils or fuel (diesel & petrol) residues using safe standard practices.	Safe removal or contaminant residues	As required.	As required.
Monitoring	Foul & Surface Water Drainage	Entire site	Visual	12 Months	Walk over inspection for condition (breaks, lifting & missing) of chamber covers and grates.	Replace broken or cracked inspection chamber covers	As required.	Maintenance interval subject to Visual Inspection findings
	Attenuation Basin	South Eastern Boundary	Visual	12 Months	Survey inside of pond for sediment build-up and remove if necessary	Remove sediment as required	5 Years or as required.	Maintenance interval subject to Visual Inspection findings

* If weeds are persitent, weed killer may be used to reduce the requirement for manual weed removal.

** Any block which is to be replaced should be bedded on anew layer of grit / sand.

*** If re-construction is necessary, the following procedure should be followed: 1. Lift surface layer and laying course, 2. Remove and geotextile filter layer, 3. inspect sub-base and wash/replace if required, 4. Renew any geotextile layer as required, 5. Renew laying course, jointing material and block paviours. Note: this is deemed unlikely to occur and thus unlikely to be implemented

Maintenance procedures to be undertaken in accordance with Ciria 753. This schedule should be read in conjunction with all engineering drawings

APPENDIX M – EXISTING DITCH AND CULVERT ASSESSMENT

Burbage Fields Farm, Burbage

Hydraulic Modelling Study

Draft report

October 2020

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Revision History

Revision Ref/Date	Amendments	Issued to
S03-P01 / October 2020	Draft	Nick Fenton (Rodgers Leask)
S03-P02 / October 2020	Draft	Nick Fenton and Lance Hammond (Rodgers Leask)

Contract

JBA was contacted on 25/06/2020 by Nick Fenton (Rodgers Leask) on behalf of Redrow Homes. James Hookham of JBA Consulting carried out this work.

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Purpose

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Executive summary

JBA Consulting (JBA) were commissioned by Rodgers Leask Ltd to undertake a hydraulic modelling study of an unnamed watercourse in relation to a proposed development sites at Burbage Fields Farm, Burbage.

The watercourse was modelled using the Flood Modeller – TUFLOW hydraulic modelling package. LiDAR and topographic survey datum was used to provide ground levels throughout the floodplain. No historical flood risk records associated with the watercourse could be found. As a result, the hydraulic model is uncalibrated.

The baseline model results indicate that:

- Overtopping of the channel will occur within the 20-year, 100 year, 100-year plus 30% climate change, 100-year plus 50% climate change and 1000-year fluvial flood extent.
- The M69 culvert does have sufficient capacity to accommodate the 20-year, 100-year, 100-year plus 30% climate change and the 100-year plus 50% climate change peak flows however, the culvert is surcharged during the 1000-year flood scenario.
- The peak water levels within the site will range:
 - Between 101.38m AOD and 118.5m AOD during the 20-year (5% AEP) fluvial flood event;
 - Between 101.48m AOD and 118.62m AOD during the 100-year (1% AEP) fluvial flood event;
 - Between 101.52m AOD and 118.7m AOD during the 100-year (1% AEP) with 30% climate change fluvial flood event;
 - Between 101.53m AOD and 118.76m AOD during the 100-year (1% AEP) with 50% climate change fluvial flood event;
 - Between 101.56m AOD and 118.79m AOD during the 1,000-year (0.1% AEP) fluvial flood event.

A blockage analysis was carried out at the M69 culvert. Due to the nature of the surrounding environment (i.e. branches hanging over the channel), a 75% blockage was modelled at the culvert inlet. The results from this analysis show an increase in water depth of up to 1.6m for up to 120m upstream of the culvert.

The hydraulic model's sensitivity to changes in flow, downstream boundary and roughness values were also tested to improve confidence in the model results within the development site boundary. Results from the sensitivity analysis indicate that an increase of 20% to both the flow and roughness values increase the peak water level by 80mm and 70mm respectively, this suggests the model is moderately sensitive to changes in flow and roughness. An increase of +250mm at the downstream boundary increase the peak water level by 20mm so this the model results are relatively insensitive to changes at the downstream boundary site.

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Abbreviations

1D	One Dimensional
2D	Two Dimensional
CC	Climate Change
DTM	Digital Terrain Model
EA	Environment Agency
Flood Modeller	Primary 1D engine used by TUFLOW
FEH	Flood Estimation Handbook
FFL	Finished Floor Levels
GCS	Grantham Coates Surveyors
Ha	Hectares
HT	Head-Time
HQ	Head Flow
JBA	Jeremy Benn Associates
LiDAR	Light Detection and Ranging
m AOD	Metres Above Ordnance Datum
QMED	Median annual flow
QT	Flow-Time
ReFH	Revitalised Flood Hydrograph
RoFSW	Risk of Flooding from Surface Water
TUFLOW	2D Hydraulic Modelling Software

1 Introduction

1.1 Terms of reference

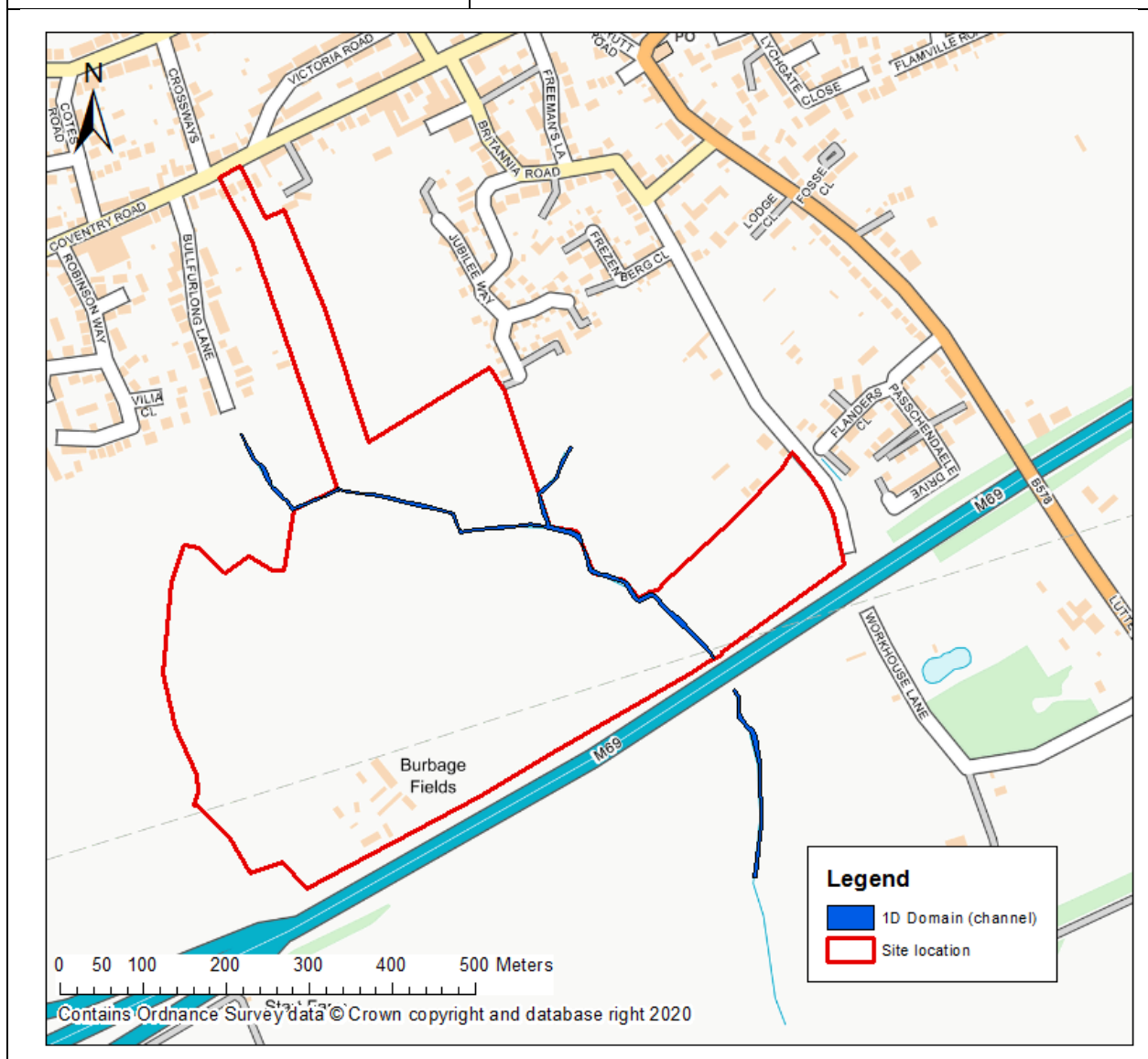
JBA Consulting (JBA) were commissioned by Rodgers Leask to undertake a hydraulic modelling study of an unnamed watercourse in relation to a proposed development sites at Burbage Fields Farm, Burbage.

To support this assessment, a 1D-2D Flood Modeller – TUFLOW hydraulic model was produced to allow accurate representation of the flood levels, extents and hazards within the site boundary.

1.2 Site details

Table 1-1: Site details

Site name	Burbage Fields Farm, Burbage
Existing land-use	Predominantly greenfield
OS NGR	SP 44171 918652
County	Leicestershire
Country	England



1.3 Context

Redrow Homes wish to submit a planning application for a residential development at Burbage Fields Farm, Burbage.

The site is crossed by an unnamed watercourse and its tributary, for which no detailed (fluvial) hydraulic modelling results are available.

The EA's RoFSW maps show surface water ponding along the watercourse immediately upstream of the M69 culvert.

As a way forward, Redrow Homes wishes to refine the flood extents associated with the unnamed watercourse in order to inform their Masterplan, confirm whether the M69 culvert has sufficient capacity and determine the size of the new culverts required to support their development proposal.

1.4 General Approach

New survey of the unnamed watercourse was commissioned in order to accurately represent the watercourse within the vicinity of the sites. A total of 21 cross-sections were surveyed across the channel of the unnamed watercourse.

A hydrological assessment was carried out following the Environment Agency's FEH guidelines to derive fluvial flow estimates and a new 1D-2D linked Flood Modeller-TUFLOW hydraulic model has been developed to allow a more accurate understanding of flood levels, depths and extents within the site boundary. The model extends from the surface water sewer outfall off Bullfurlong Lane down to approximately 300m downstream of the site.

The model has been run for the baseline scenario for the 20-year, 100-year, 100-year with 30% and 50% climate change and 1000-year flood events in order to determine the existing flood risk to the site.

The hydraulic model's sensitivity to changes in flow, downstream boundary and roughness values was also tested to improve confidence in the model results within the development site boundary.

2 Model Approach

2.1 Model Geometry

2.1.1 Data availability

Grantham Coates Survey (GCS) were commissioned to collect channel survey data in August 2020. The survey consisted of 21 cross sections at regular intervals along the unnamed watercourses within the vicinity of the site. Key hydraulic structures along the watercourse are included within the survey. Typically, cross section survey was gathered from the upstream face of any structure (see Appendix B).

2m resolution LiDAR data flown in 2003 and 1m resolution LiDAR data flows in 2019 were obtained from the Open Data website and combined with site-specific topographic survey data (see Appendix A) to represent ground levels within the floodplain.

2.1.2 Model extent and development

The hydraulic model represents the unnamed watercourse with tributary and its corresponding floodplain in the vicinity of the proposed sites. The extent of the hydraulic model developed for this study is shown in Figure 2-1.

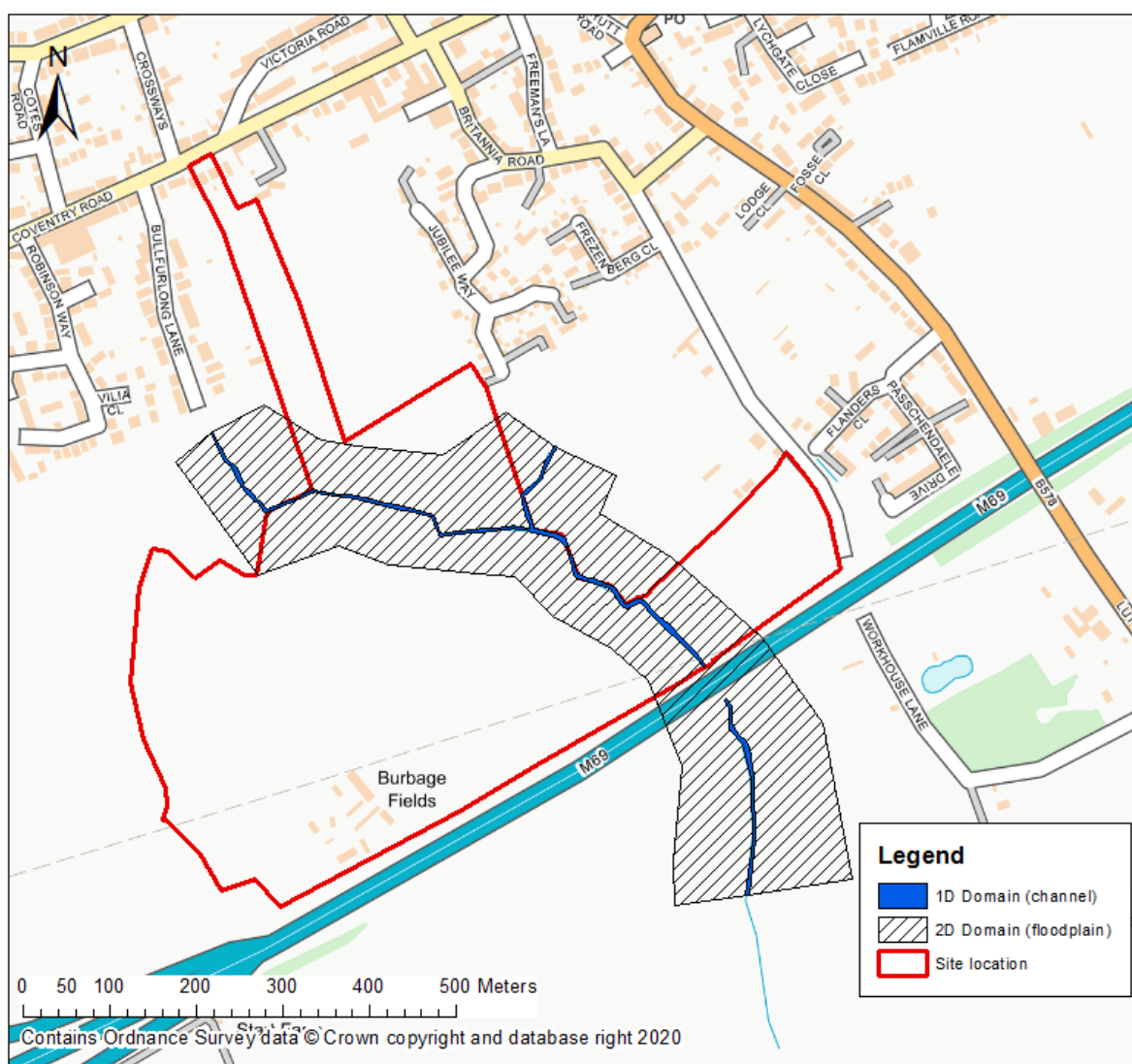


Figure 2-1 Model extent

The channels were represented as 1-dimensional (1D) features using Flood Modeller (version 4.3.0.290). The 1D model begins at the start of the unnamed watercourse and lateral tributary and ends approximately 0.4km downstream of the site. In total, the 1D domain covers approximately 1km of watercourse.

The 2D domain was represented using TUFLOW (2020-01-AA-iDP-W64) with floodplain topography represented using LiDAR data. The 2D domain has an area of 0.14km² and a 1m grid resolution. The orientation of the grid is southwest to northeast, representing the main direction of floodplain flows. The 1D and 2D domains can be seen in Figure 2-1.

2.1.3 Model roughness parameters

Manning's n was used to represent roughness values for the channel and floodplain. The values for channel roughness were based on photographs gathered by Grantham Coates Surveys during the site survey in August 2020. Manning's n values in the floodplain were based on different land uses in the 2D domain. Land uses were defined using OS mapping and satellite imagery. Table 2-1 gives the range of Manning's n values used in the 1D and 2D domains.

Table 2-1: Manning's n range within the hydraulic model	
1D Channel	0.040 (in channel) and between 0.060 and 0.065 (banks)
General Surface	0.060
Woodland	0.065
Roads and tracks	0.015
Buildings	0.300
Water	0.035
Rail	0.045

2.1.4 Model structures

Key hydraulic structures located along the unnamed watercourse were represented in the 1D domain using Flood Modeller 1D network units. Details of how these structures were modelled can be found in Appendix C.

2.2 Bank levels

Bank levels in the model were generated using surveyed bank levels and, where unavailable, LiDAR data.

2.3 Model boundary Conditions

2.3.1 Model inflows

A hydrological assessment was carried out on the unnamed watercourse and the lateral tributary to derive flow estimates at the upstream end and downstream end of the modelled watercourse (UNN_01 and TRB_01, respectively). The full hydrological assessment is documented in Appendix D.

The table below shows the peak flows for each of the inflow points.

Table 2-2: Peak flows

Site code	Flood peak (m ³ /s) for the following events		
	20-year	100-year	1000-year
UNN_01	0.38	0.56	1.03
TRIB1	0.18	0.27	0.50

In line with the guidance on Climate Change issued by the Environment Agency in February 2016¹, the effect of climate change was assessed by increasing peak flows by 30% and 50% (higher central and upper end allowances respectively for more vulnerable developments within the Humber river basin).

2.3.2 Downstream boundary conditions

A normal depth boundary condition based on the average bed slope between the last two channel sections in the model was used to represent the downstream boundary conditions in the channel.

In the 2D domain, two TUFLOW 'HQ lines' (i.e. normal depth downstream boundary conditions based on the average slope in the floodplain at the downstream end of the model) were used to represent the downstream boundary conditions in the floodplain/2D domain.

2.4 Calibration

No specific flood levels or flow data could be found over the modelled extent. As a result, the model is uncalibrated. However, sensitivity testing has been conducted to provide confidence in model parameters.

¹ <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

2.5 Model Runs

2.5.1 Modelled Scenarios

The following flood scenarios were simulated by the model:

- **[Baseline scenario]** 20-year (5% AEP) flood event - existing condition scenario;
- **[Baseline scenario]** 100-year (1% AEP) flood event - existing condition scenario;
- **[Baseline scenario]** 100-year (1% AEP) plus Climate Change (30%) flood event - existing condition scenario;
- **[Baseline scenario]** 100-year (1% AEP) plus Climate Change (50%) flood event - existing condition scenario;
- **[Baseline scenario]** 1000-year (0.1% AEP) flood event - existing condition scenario;
- **[Blockage scenario]** 100-year (1% AEP) plus Climate Change (30%) flood event - 75% blockage of the M69 Culvert (UNN_591)
- **[Sensitivity analysis]** 100-year (1% AEP) flood event with +20% increase in peak flows;
- **[Sensitivity analysis]** 100-year (1% AEP) flood event with +20% increase in roughness value;
- **[Sensitivity analysis]** 100-year (1% AEP) flood event with +250mm increase in water levels at the downstream model boundary;

The results of the baseline scenarios are discussed in the following section with sensitivity analysis included in Appendix E of this report.

3 Hydraulic Model Results

3.1 Baseline Flood extents

Flood extents for the 20-year, 100-year and 1,000-year fluvial flood events are shown in Figure 3-1.

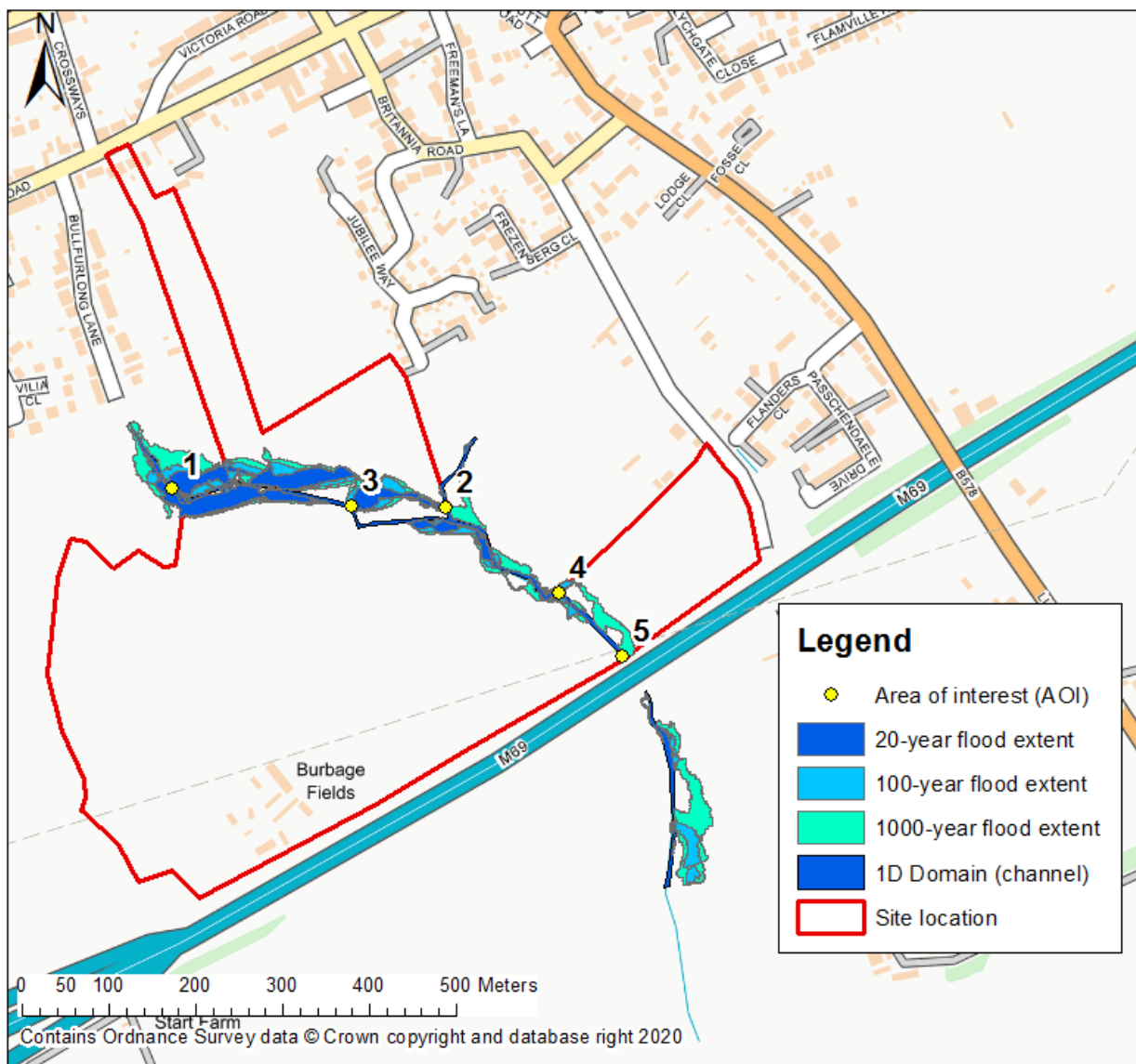


Figure 3-1: Baseline flood extents (20yr, 100yr and 1,000yr)

Figure 3-1: shows that flooding does not generally remain confined to or along the river channel during all modelled fluvial flood event. Overtopping of the channel occurs at Area of Interest (AOI) 1 during each simulation. A site walkover carried on the 23/09/2020 confirmed the bank elevations were relatively low (i.e. less than 0.5m high) at this location.

Following overtopping of the bank, overland flows run eastwards, meet exceedance flows from another overtopping location (see AOI 3 in Figure 3-1) before re-turning into the channel at AOI 2.

A similar flood mechanism occurs downstream during the 1,000-year simulation whereby overtopping of the bank occurs at AOI 4 before returning back into the channel at AOI 5 (next to the M69 culvert inlet).

Flood extents for the 100-year with (+30%) climate change and 100-year with (+50%) climate change fluvial flood events are represented in Figure 3-2.

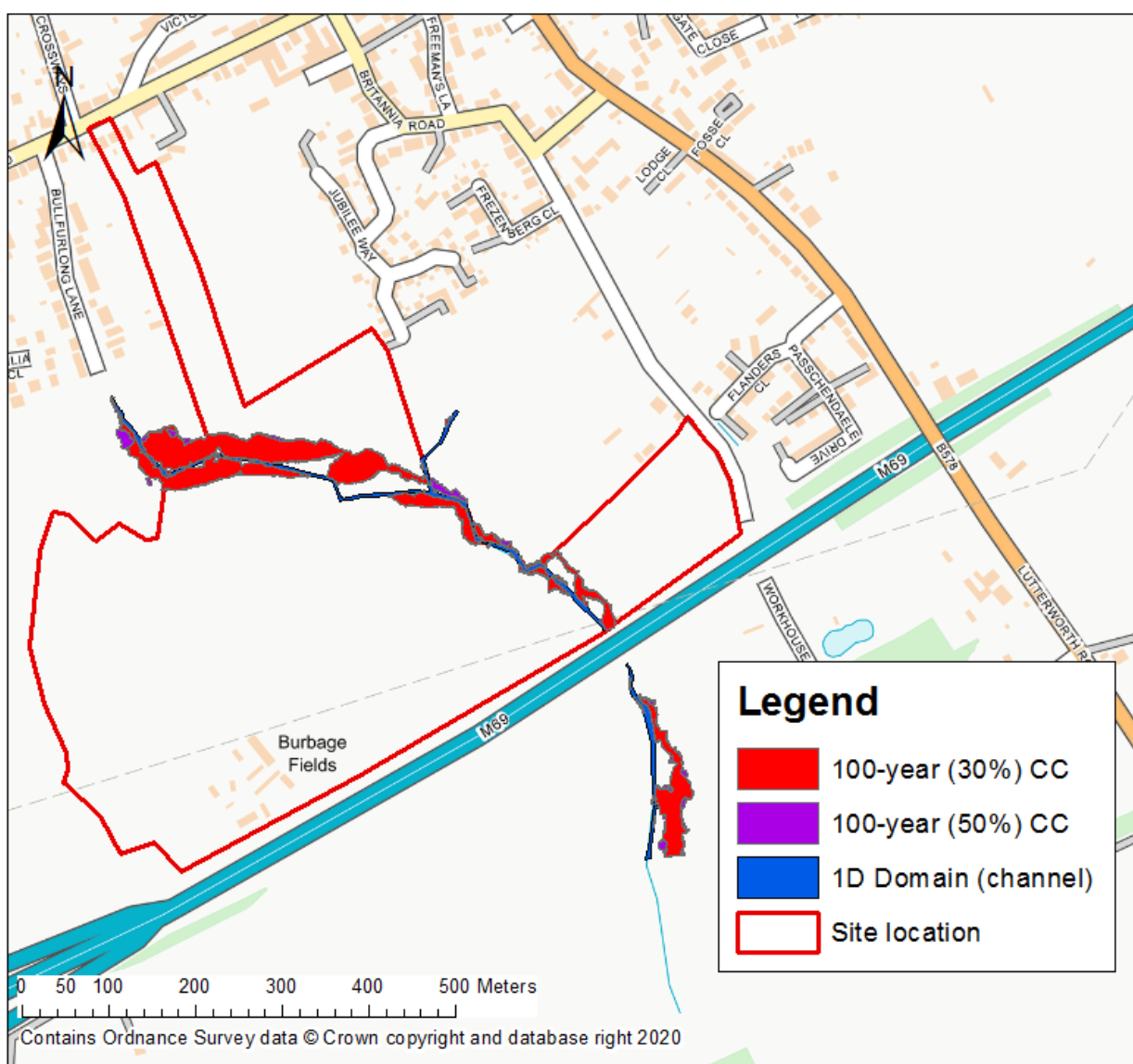


Figure 3-2: Baseline 100-Year flood extents with climate change

Figure 3-2 shows the 100-year with (+30%) climate change and the 100-year with (+50%) climate change similar fluvial flood event generate a similar extent. Their flooding mechanisms are similar to those observed during the 1,000-year flood event (see Figure 3-1).

3.2 Baseline Flood depths

The baseline flood depths during the 100-year with 30% climate change and 100-year with 50% climate change year events are shown in Figure 3-1 and Figure 3-2, respectively.

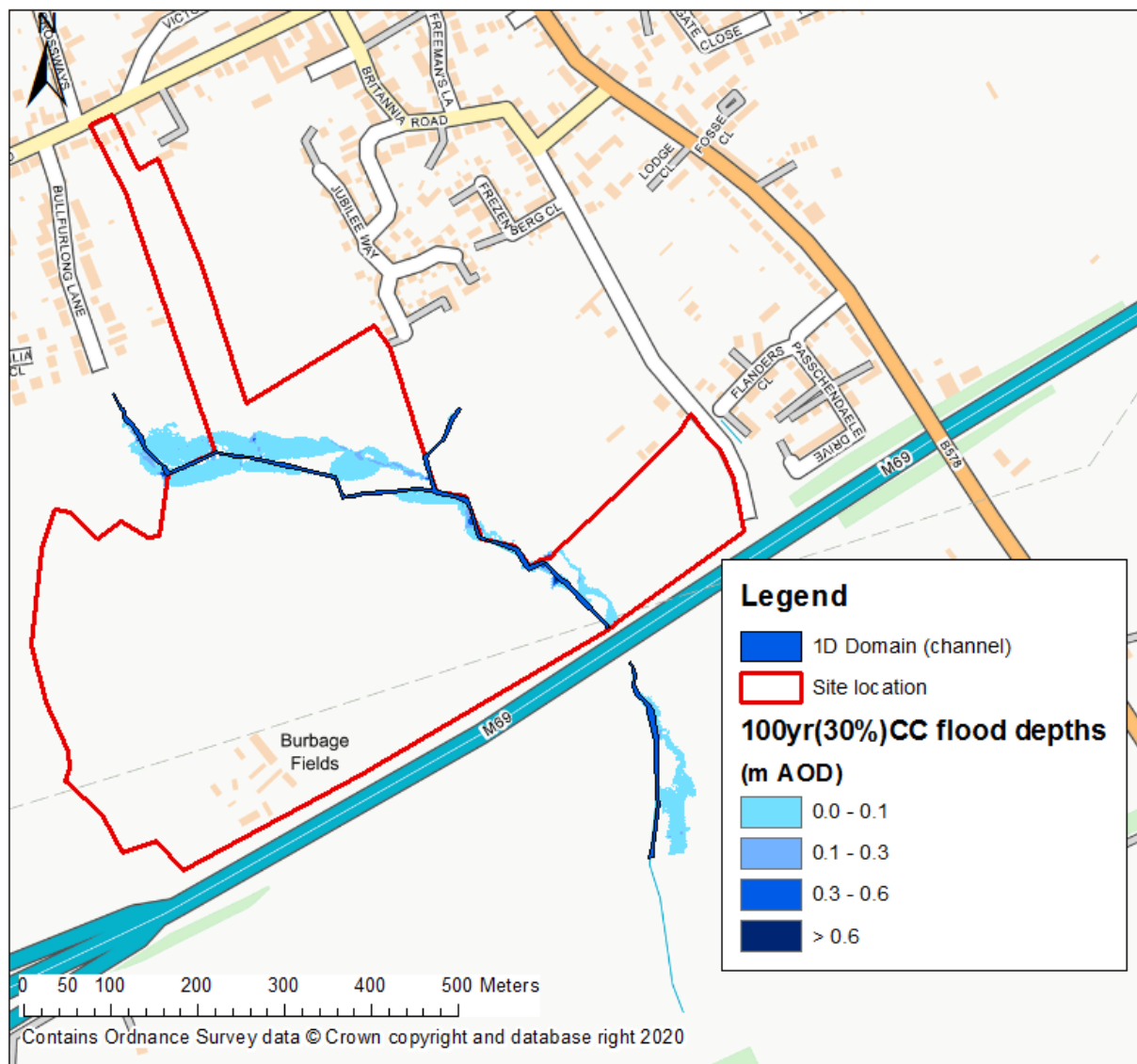


Figure 3-3: Baseline 100-year flood depths with 30% climate change

Figure 3-3 shows that the maximum flood depth outside of the river channel during the 100-year with 30% climate change event does not exceed 0.1m.

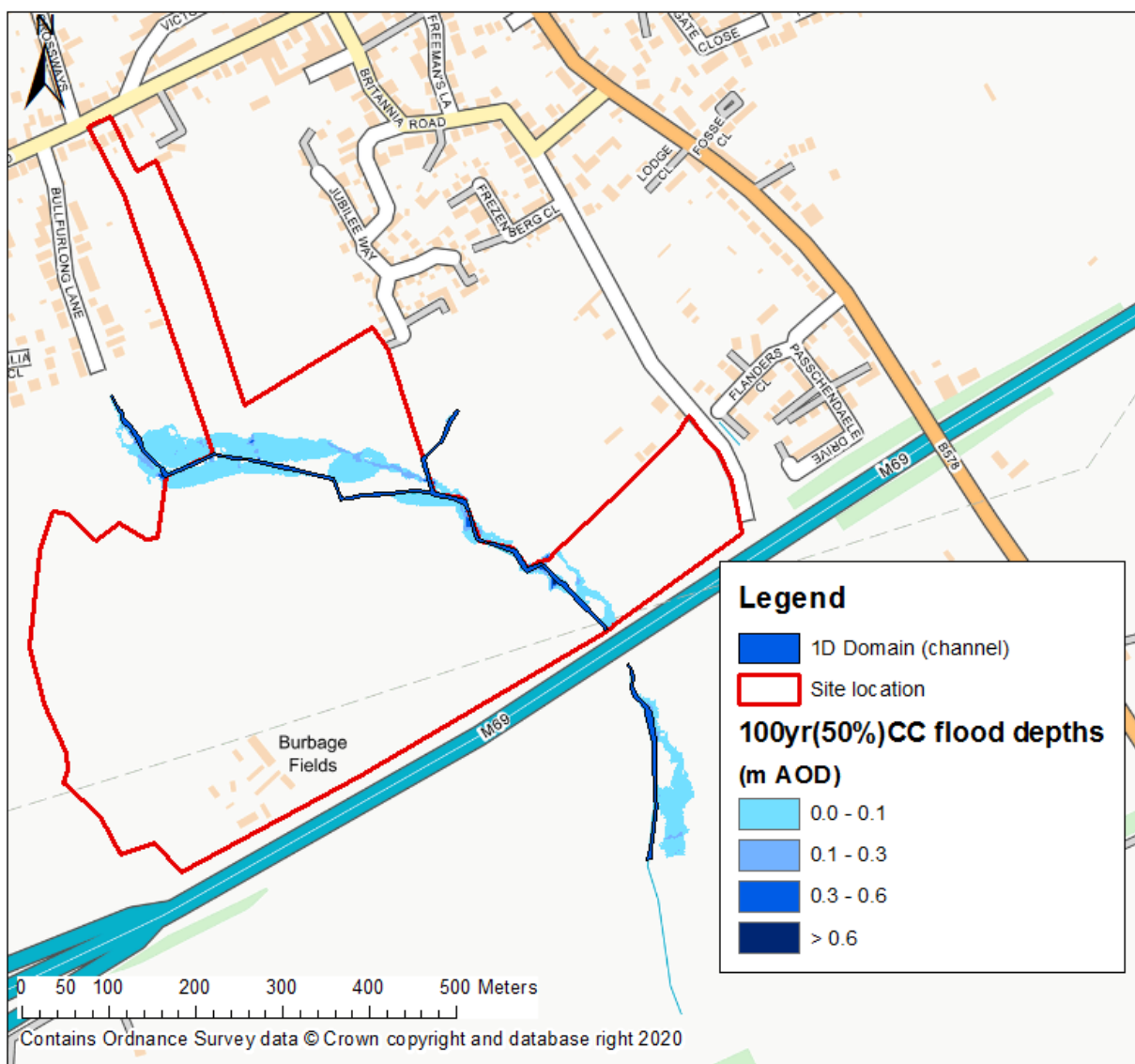


Figure 3-4: Baseline 100-year flood depths with 50% climate change

Figure 3-4 shows that the maximum flood depth outside of the river channel during the 100-year with 50% climate change event is approximately 0.1m.

Given the relatively shallow flood depths generated within the site boundary during the 100-year with 30% climate change and 100-year with 50% climate change scenarios, flood mitigation options aiming to capture overland flows and to store flood water should be explored in order to maximise the development potential of the site.

3.3 Baseline Flood levels

Flood levels for all baseline scenarios are shown in Appendix E.

Appendix E shows that the peak water level within the site will range:

- Between 101.38m AOD and 118.5m AOD during the 20-year (5% AEP) fluvial flood event;
- Between 101.48m AOD and 118.62m AOD during the 100-year (1% AEP) fluvial flood event;
- Between 101.52m AOD and 118.7m AOD during the 100-year (1% AEP) with 30% climate change fluvial flood event;
- Between 101.53m AOD and 118.76m AOD during the 100-year (1% AEP) with 50% climate change fluvial flood event;
- Between 101.56m AOD and 118.79m AOD during the 1,000-year (0.1% AEP) fluvial flood event.

3.4 Culvert capacity

Figure 3-6 shows a longitudinal section plot of peak water levels at the approach of the M69 culvert during the 100-year with 30% climate change, 100-year with 50% climate change and 1000-year flood events.

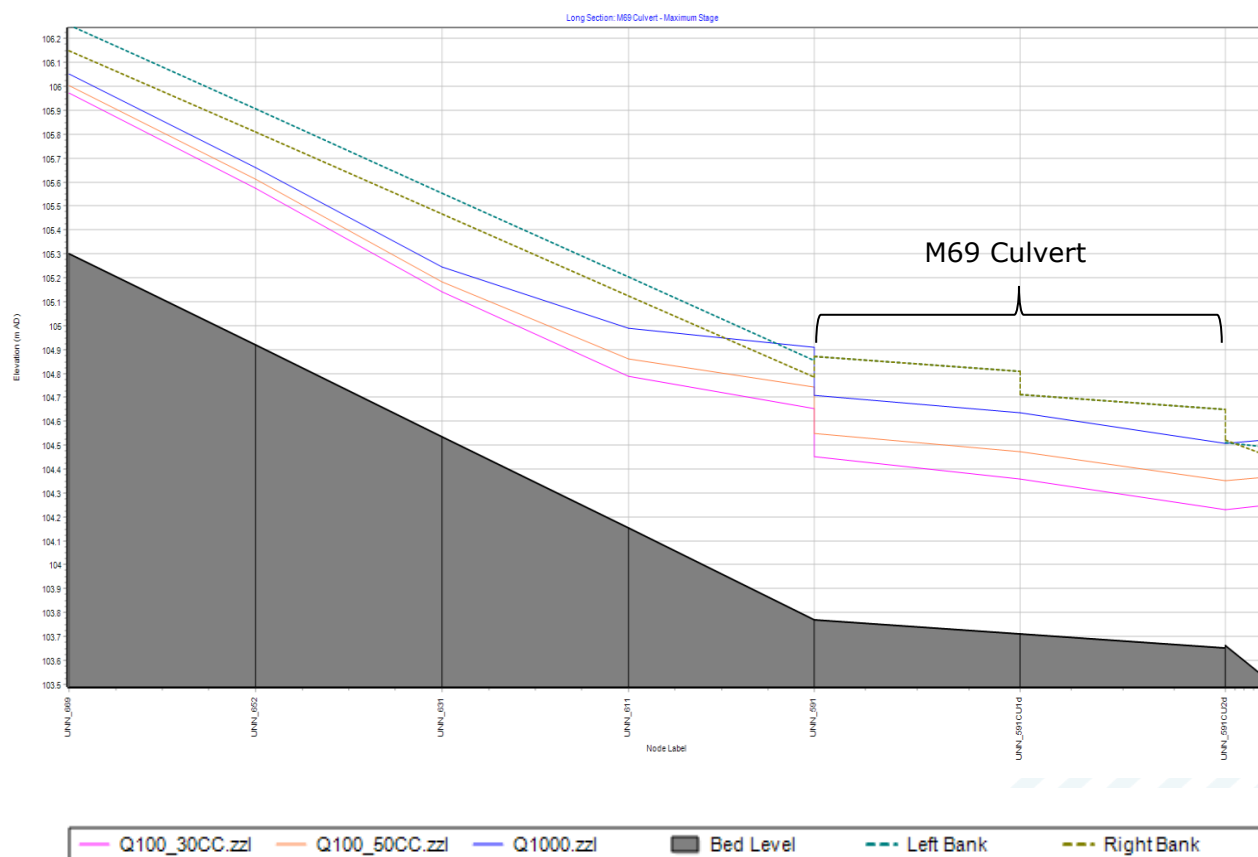


Figure 3-7: M69 Culvert capacity

Figure 3-7 shows that the M69 culvert (UNN_591) has sufficient capacity to convey the 100-year with 30% climate change and 100-year with 50% climate change flows although it will surge during the 1000-year flood event.

3.5 Blockage risk analysis

The impact of a 75% blockage at the M69 culvert (UNN_591) was modelled during the 100-year plus 30% climate change baseline scenario. Results indicate an increase in flood depths when compared to the 100-year plus 30% climate change base scenario which back up at this culvert.

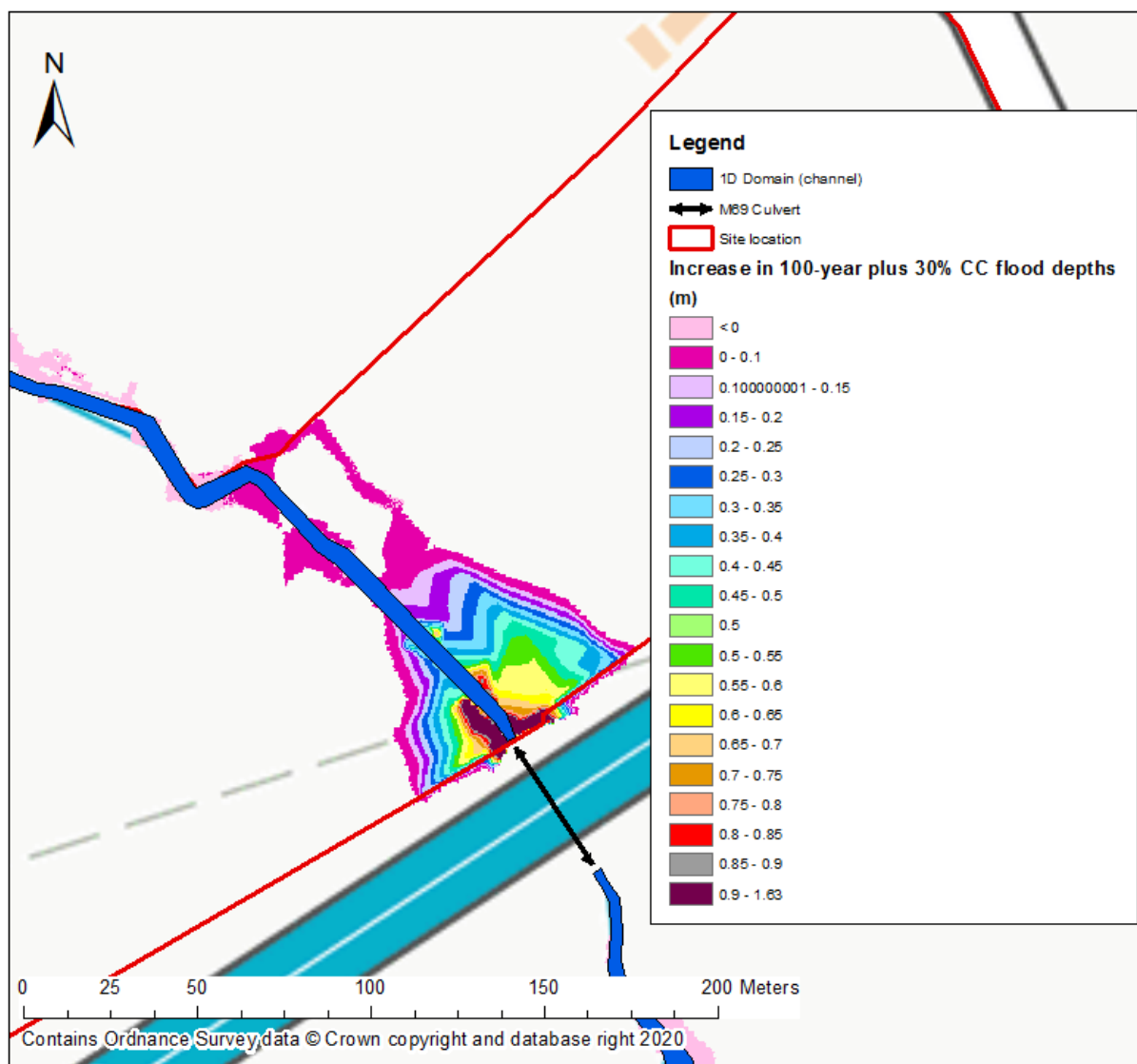


Figure 3-8 Baseline Blockage Analysis (100-year plus 30% climate change)

Due to the nature of the surrounding environment (i.e. branches hanging over the channel) a 75% blockage was put on the culvert running underneath the M69. During this scenario, flood levels at the upstream face of the culvert increase by up to a 1.6m for 120m upstream. 1D model results indicate that the 100-year 30% climate peak water level at the inlet of the blocked culvert reaches 105.95m AOD.

3.6 Sensitivity analysis

The model's sensitivity to changes in flow value, roughness parameters and downstream boundary condition was checked (see Appendix F).

Appendix F shows that, at the proposed development site, the model results are moderately sensitive to changes in flow and roughness values and relatively insensitive to changes in downstream boundary conditions.

4 Conclusions and Recommendations

4.1 Conclusions

- JBA Consulting (JBA) were commissioned by Rodgers Leask Ltd on behalf of Redrow Homes to undertake a hydraulic modelling study of an unnamed watercourse in relation to a proposed development sites at the Land South West of Lutterworth Road in Burbage.
- The model was run for the 20-year, 100-year, 100-year with (+30%) climate change, 100-year with (+50%) climate change and 1,000-year fluvial flood event. The model results' sensitivity to changes in flows, roughness values and downstream boundary conditions was tested.
- The results of the modelling show that:
 - Model results at the site are moderately sensitive to changes in roughness values, flows and downstream boundary conditions.
 - Overtopping occurs in all modelled flood scenarios at AOI 1 which can be seen in Figure 3-1.
 - Overtopping occurs at many locations along the river bank particularly during the 1000-year, 100-year with (+30%) and 100-year (+50%) climate change fluvial flood events. Given the relatively shallow flood depths generated within the site boundary during the 100-year with 30% climate change and 100-year with 50% climate change scenarios, flood mitigation options aiming to capture overland flows and to store flood water should be explored in order to maximise the development potential of the site.
 - The M69 culvert has sufficient capacity to convey the 100-year with 30% climate change and 100-year with 50% climate change flows although it will surcharge during the 1000-year flood event.
 - There are increases of up to 1.6m at the M69 culvert when a 75% blockage is applied at the culvert inlet, however this is within the close proximity to the channel. The water levels return to normal heights 120m upstream of the culvert inlet.
 - The peak water level within the site will range:
 - Between 101.38m AOD and 118.5m AOD during the 20-year (5% AEP) fluvial flood event;
 - Between 101.48m AOD and 118.62m AOD during the 100-year (1% AEP) fluvial flood event;
 - Between 101.52m AOD and 118.7m AOD during the 100-year (1% AEP) with 30% climate change fluvial flood event;
 - Between 101.53m AOD and 118.76m AOD during the 100-year (1% AEP) with 50% climate change fluvial flood event;
 - Between 101.56m AOD and 118.79m AOD during the 1,000-year (0.1% AEP) fluvial flood event.

4.2 Recommendations

- The blockage risk analysis was only carried out on the M69 culvert. It is recommended that remaining undersized culverts on site are replaced to prevent the risk of blockage in the future.
- It is recommended that flood mitigation strategies are explored for this site in order to mitigate flood risk on site while ensuring third-party lands are not affected by the development proposal.

Appendices

A Topographic Survey

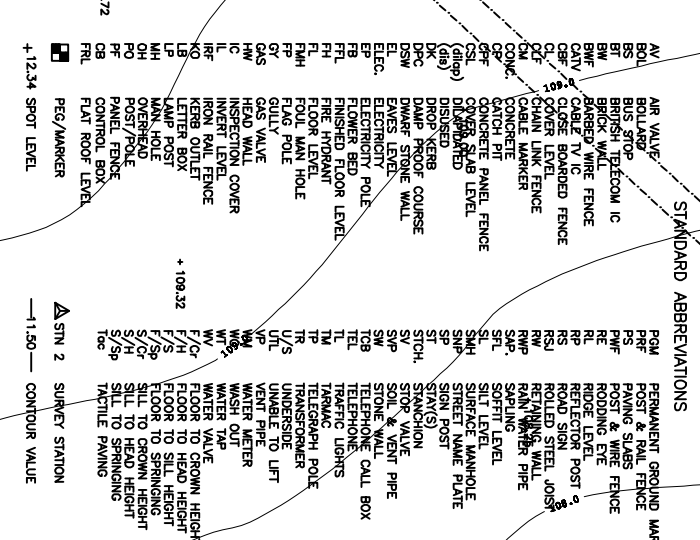
A.1 Topographic survey data

[illegible]

 Geoff Perry Associates Limited The Buildings Association Road Warrington Cheshire WA1 1AA Tel: 01925 34 600 Fax: 01925 34 601 enquiries@geoffperry.co.uk		NO. 1000000000 Date of Completion NO. 1000000000 Date of Issue	
Project: Surveying Road Burroughs		Client: Redfern Homes Ltd	
Title: Site Survey Sheet 1 of 4		Date: Nov 2018 Scale: 1:500 @ A0 Drawn by: JCP Checked by: JCP Job No. 1007 Dwg No. 1007 Rev.	
Scale Check:   			

[illegible]

GP SURVEYING	Geoff Parry Associates Limited 20 The Quadrant Road Wokingham, RG40 3AB Tel: 01344 892400 Fax: 01344 892401 E-mail: enquiries@geoffparry.co.uk	XXX XXXXXXXXXX XXX XXXXXXXXXX XXX XXXXXXXXXX	Client: Redrow Homes Ltd Project: Cemetery Road Buildings Title: Site Survey Sheet 2 of 4
Date: 14/07/02 Drawn by: GPB Job No. S 219	Scale: 1:500 @ A0 Checked by: XXX Dwg No. 1067 Rev.	Scale Check: 	

[illegible]

**Geoff Perry
Associates Limited**



The Broadway,
25 Eddington Road,
Addicks
W8 2BH

†: 01822 744 800
e: enquiries@geoffperry.co.uk

SURVEYING

Client:
Redrow Homes Ltd

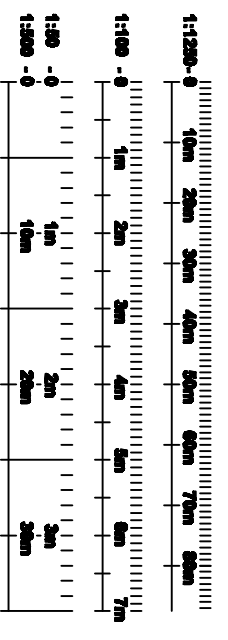
**Coventry Road
Burbage**

Site Survey
Sheet 4 of 4

Date: Nov 2019 Scale: 1:500 @ A0
Drawn by: ICP Checked by: XXX

Job No.	Drq No.
S 219	1067

Scale Check:



[illegible][illegible]

A.2 Quality assessment

The topographic survey data for the site was compared with 1m LiDAR data flown in 2011 and 2m LiDAR data flown in 2003 (where 1m LiDAR data were not available) downloaded on 17 August 2020 from Defra's data service website². Results are shown in Figure A-1.

Figure A-1: Quality assessment (topographic survey minus LiDAR)

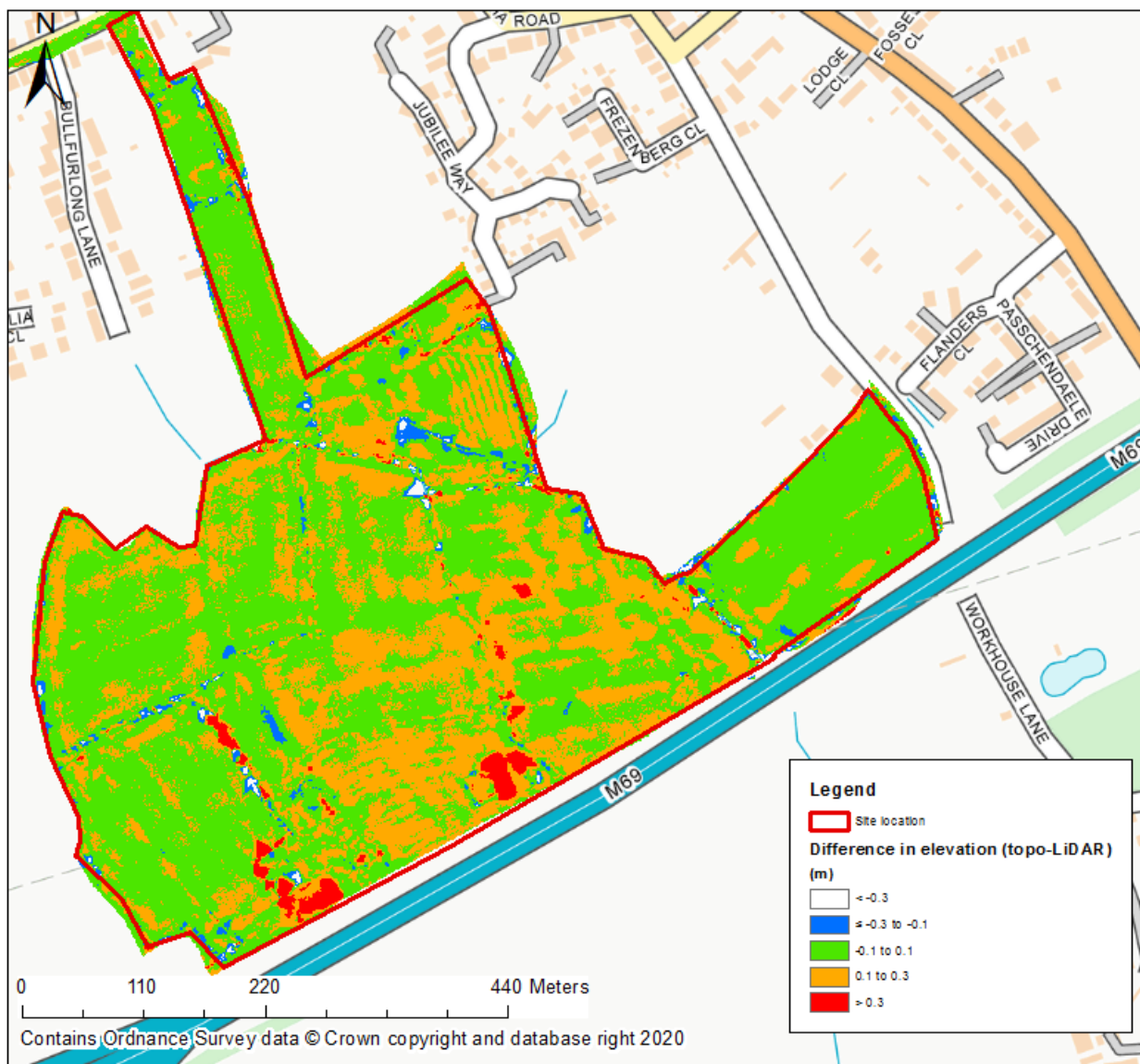
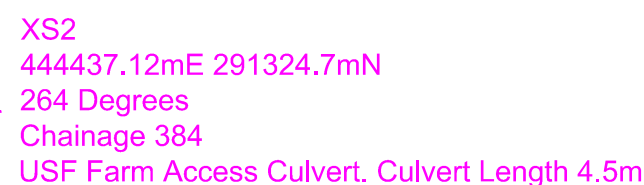
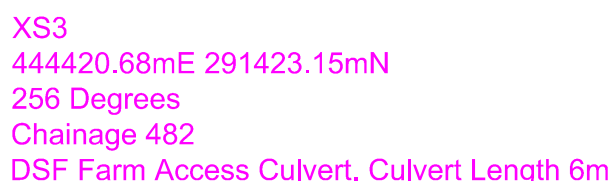
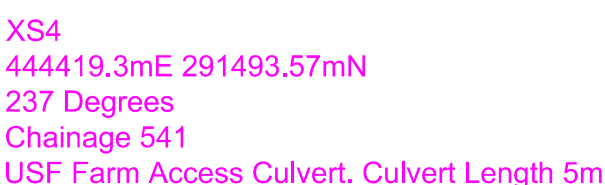
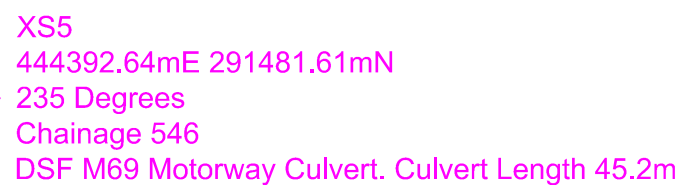
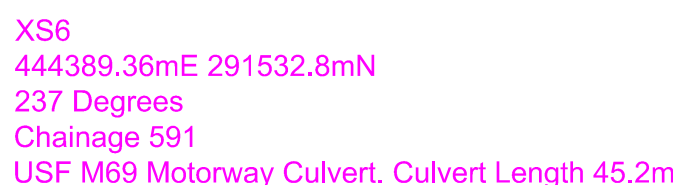
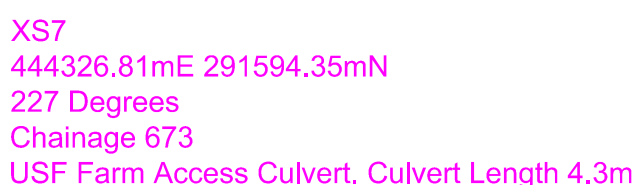
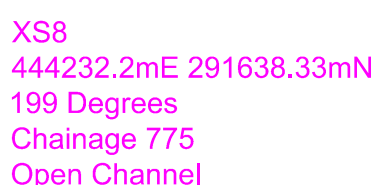
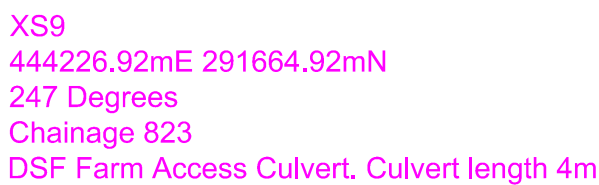
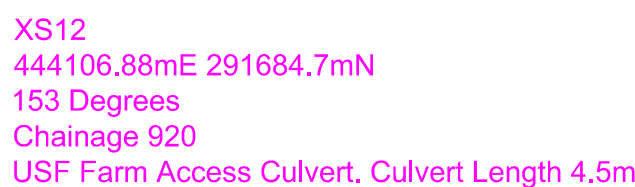
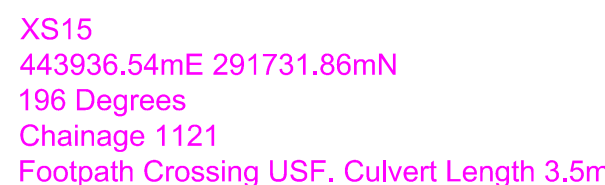
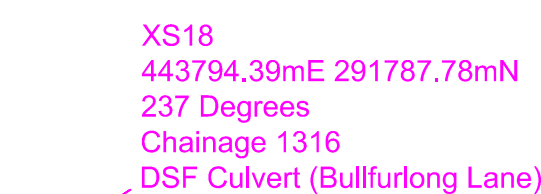


Figure A-1 shows a good match between the topographic survey levels and LiDAR data. Differences in elevation exceeding 0.3m can be observed however these are areas which contain a lot of dense vegetation which affect LiDAR readings.

As a result, both datasets were used in the model.

² <https://environment.data.gov.uk/>

B Channel Survey Data



Chainage starts at Pond / Lake
(No further information)



Notes

This survey should only be relied upon for its original purpose. Grantham Coates Surveys Limited accepts no responsibility for use of this plan outside of the original remit, or by use of any party other than the original client.

Whilst every effort has been made to identify all above ground details, it should be noted that some items may have been obscured at time of survey.

Below ground drainage information as been visually inspected from the surface and should therefore be treated as approximate only.

Where this survey has been carried out for the purpose of enabling trackside drainage design. The position of any running rail has been surveyed in line with a general topographic survey and should not be used for the purpose of track design.

All dimensions to be checked on site prior to design and construction

Legend

BAR VALVE	AV	WATER TAP	TAP
BELL	BD	TEMPORARY BENCH MARK	TEBM
BELL TELEPHONE	BT	TELEPHONE CALL BOX	TCB
BUS STOP	BS	TELEPHONE POST	TEL
BT INSPECTION COVER	BT	THRESHOLD LEVEL	THL
BT CABLE INSPECTION COVER	CTV	TRAFFIC LIGHT	TL
DOWN PIPE	DP	TOP OF WALL	TOW
DROPPED KERB	DK	TELEGRAPH POLE	TP
EMERGENCY CONTROL BOX	ECB	UNLAKED TOILET	UTL
EASES HEIGHT	EH	VENT PIPE	VP
EMERGENCY MANHOLE	EM	RAIL WELD	RW
ELECTRICITY POLE	EP	WATER METER	WM
EARTH ROD	ER	WASHOUT	WO
FINISHED FLOOR LEVEL	FFL		
FIRE HYDRANT	FW		
FY WATER	FY	SURVEY STATION	△ GCS1
GULLY	GU		
GATE POST	GP	BUSHES	⊗
GAS VALVE	GV		
INSULATED JOINT KICK	IJK		
INSPECTION COVER	IC	HEDGES	⊗
INVERT LEVEL	IL		
KERBS OUTLET	KO		
LAMPPOST	LP		
LITTER BIN	LB	TREES	⊗
MANHOLE	MK		
MALE POST	MP	Height Specimen (Spread to scales)	⊗
POST	PO		
PODDING EYE	PE		
HEIGHT EYE	RE	GATE	⊗
ROAD NAME	RN		
ROAD SIGN	RS		
STUMP	SP	SECURITY FENCE	— x — x —
SPOTT LEVEL	SL	FENCE	— x —
STREET LIGHT	SL	OVERHEAD CABLES	— o —
SIGNAL POST	SP	FOUL WATER	— FL —
SIGNALS AND TELECOMS BOX	STB	— SW —	
SIGNALS AND TELECOMS CABLE	STC	UG POWER LINE	— PL —
SIGNALS AND TELECOMS CABLE	STC	STORM WATER	— SW —
SIGN POST	SP	UTL WATER MAIN	— WM —
STOP	ST		
STOP VALVE	SV		
STAY	ST		
STORM WATER	SW		

Control Table

Station	Description	Eastings	Northings	Height

Grid and Datum

Grid: OS *National Grid* **Datum:** *Ordnance Datum Newlyn*
Survey related to Ordnance Survey National Grid (OSGB36) via GPS and the OS Active Network.
A National Grid (OSGB36) coordinate has been established on site via Transformation OSTN15 and Geoid Model OSGM15, a further OS coordinate was used to orientate the survey to Ordnance Grid.
No scale factor has been applied to the survey

Title

WATERCOURSE SURVEY AT
BURBAGE FIELDS FARM
(Key Plan)

Client

JBA CONSULTING
The Library
St. Philip's Courtyard
Coleshill
Warwickshire B46 3AD



Land - Engineering - Building Surveyors

2 Arden Court, Arden Road, Alcester
Warwickshire, B49 6HN

Tel: 01789 764420

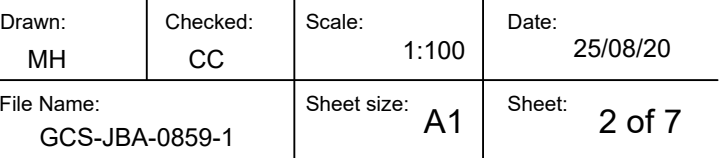
E-Mail: info@gcsurveys.co.uk
Web Site: www.gcsurveys.co.uk

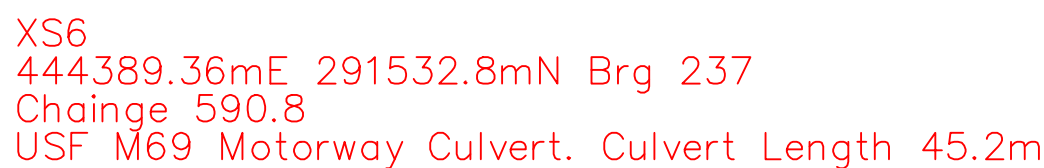
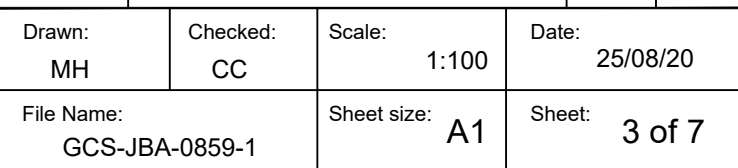
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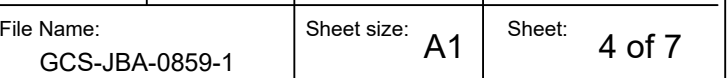
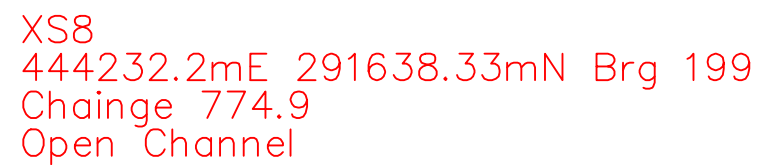
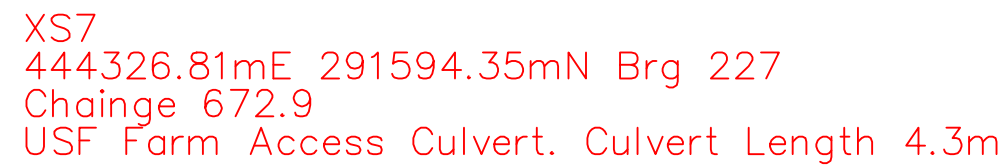
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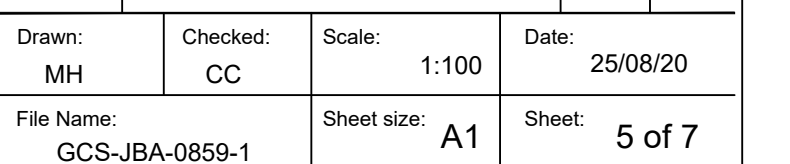
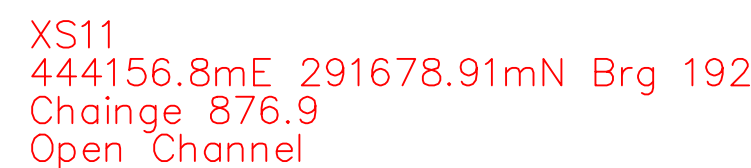
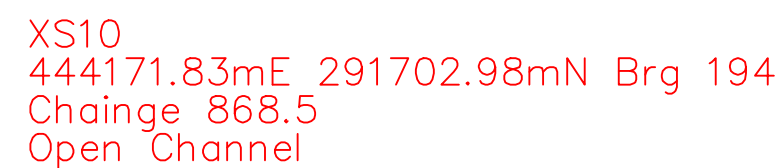
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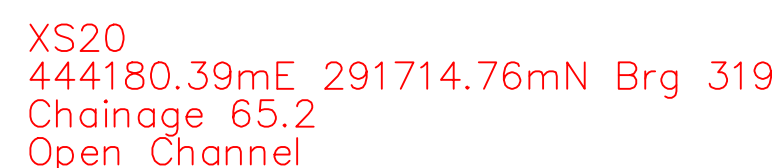
File Name: GCS-JBA-0859-1	Sheet size: A1	Sheet: 1 of 7
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This survey should only be relied upon for its original purpose. Grantham Coates Surveys Limited accepts no responsibility for use of this plan outside of the original remit, or by use of any party other than the original client.

Whilst every effort has been made to identify all above ground details, it should be noted that some items may have been obscured at time of survey.

Below ground drainage information has been visually inspected from the surface and should therefore be treated as approximate only.

Where this survey has been carried out for the purpose of enabling trackside drainage design. The position of any running rail has been surveyed in line with a general topographic survey and should not be used for the purpose of track design.

All dimensions to be checked on site prior to design and construction

Legend

AIR VALVE	AV	WATER TAP	TAP
BOLLARD	BD	TEMPERARY BENCH MARK	TBM
BORING HOLE	BO	TELEPHONE CALL BOX	TGB
BUS STOP	BS	TELEPHONE POST	TP
BT INSPECTION COVER	BT	THRESHOLD LEVEL	THL
CABLE TV INSPECTION COVER	CTV	TRAFFIC LIGHT	TOL
CANAL	CA	TOP OF WALL	TOW
DOWN PIPE	DP	UNABLE TO LIFT	UTL
DROPPED KERB	DK	VENT PIPE	VP
ELECTRICITY CONTROL BOX	ECB	RAIL WELD	WR
EAVES HEIGHT	EH	WATER METER	WM
ELECTRICITY MANHOLE	EM	WASHOUT	WO
ELECTRICITY POLE	EP		
ERTH ROAD	ER		
FINISHED FLOOR LEVEL	FFL		
FIRE HYDRANT	FH		
FOUR WATER	FW		
GALLY	GY		
GATE POST	GP		
GAS VALVE	GV		
INSULATED BLOCK JOINT	IBJ		
INVERT LEVEL	IL		
KERB OUTLET	KO		
LAUNDRY	LB		
LITTER BIN	LB		
MANHOLE	MA		
MILE POST	MP		
POST	PO		
ROOFING EYE	RE		
RIIDGE HEIGHT	RH		
ROAD NAMEPLATE	RN		
RS	RS		
STUMP	SP		
SOFT FILL	SF		
SIGNAL POST	SIG		
RAIL SUPER ELEV	SE		
SIGNALS AND TELECOMS BOX	STB		
SIGNALS AND TELECOMS CABLE	STC		
STORM MAIN	SM		
SIGN POST	SN		
STOP	SV		
STOP VALVE	SV		
STAY	ST		
STORM WATER	SW		

SURVEY STATION

BUSHES

HEDGES

TREES

GATE

SECURITY FENCE

FENCE

OVERHEAD CABLES

FOUL WATER

SHADY MAIN

LOW POWER LINE

STORM WATER

WATER MAIN

GC51

Height

Scale

(Spread to scale)

— x — x —

— o — o —

— F — F —

— M — M —

— PL — PL —

— SW — SW —

— TM — TM —

Control Table

Station	Description	Eastings	Northings	Height

Grid and Datum

Grid: *OS National Grid* **Datum:** *Ordnance Datum Newlyn*
Survey related to Ordnance Survey National Grid (OSGB36) via GPS and the OS Active Network.
A National Grid (OSGB36) coordinate has been established on site via Transformation OSTN15 and Geoid Model OSGM15, a further OS coordinate was used to orientate the survey to Ordnance Grid.
No scale factor has been applied to the survey

Title:

WATERCOURSE SURVEY AT
BURBAGE FIELDS FARM
(Cross Sections)

Client:

JBA CONSULTING
The Library
St. Philip's Courtyard
Coleshill
Warwickshire B46 3AD



Land - Engineering - Building Surveyors

2 Arden Court, Arden Road, Alcester
Warwickshire, B49 6HN

E-Mail: info@gcsurveys.co.uk
Web Site: www.gcsurveys.co.uk



Drawing No: GCS/JBA/0859/1				Rev: -	
Date:		Notes:		Name: Rev:	
Drawn: MH		Checked: CC		Scale: 1:100	
File Name: GCS-JBA-0859-1				Sheet size: A1	
				Date: 25/08/20	
				Sheet: 7 of 7	

C Key Modelled Structures

C.1 Bullfurlong Lane Culvert

Included in model? (state reason if not):	No (upstream end of model)
Model label:	UNN 1316
Type:	Circular concrete culvert
How has structure been modelled?	The structure was not represented in the model

Culvert outlet, looking upstream.



C.2 Footpath Crossing, Culvert

Included in model? (state reason if not): Model label: Type: How has structure been modelled?	Yes					
	UNN_1121					
	Concrete pipes					
	These pipes were modelled as a circular conduit units using Flood Modeller.					
	Overtopping of the weir was represented within the 1D domain using a spill unit.					
		UNN_1121	RIVER	SECTION		
		UNN_1121	JUNCTION	OPEN	UNN_1121Cui	UNN_1121Su
		UNN_1121Cui	CULVERT	INLET	UNN_1121CUu	UNN_1121
		UNN_1121CUu	CONDUIT	CIRCULAR		
		UNN_1121Cud	CONDUIT	CIRCULAR		
		UNN_1121Cud	CULVERT	OUTLET	UNN_1121CUo	UNN_1118
		UNN_1121Su	SPILL		UNN_1121Sd	
		UNN_1121CUo	JUNCTION	OPEN	UNN_1118	UNN_1121Sd
		UNN_1118	RIVER	SECTION		

Upstream face, looking downstream.



Downstream face, looking upstream.



C.3 Farm Access Culvert

Included in model?
(state reason if not):
Model label:
Type:
How has structure been modelled?

Yes

UNN_920

Concrete culvert

The pipe was modelled as a circular conduit unit using Flood Modeller.
Overtopping of the pipe was represented within the 1D domain using a spill unit.

	UNN_920	RIVER	SECTION			
	UNN_920	JUNCTION	OPEN	UNN_920Cui	UNN_920Su	
	UNN_920Cui	CULVERT	INLET	UNN_920CUu	UNN_920	
	UNN_920CUu	CONDUIT	CIRCULAR			
	UNN_920Cud	CONDUIT	CIRCULAR			
	UNN_920Cud	CULVERT	OUTLET	UNN_920CUo		UNN_916
	UNN_920Su	SPILL		UNN_920Sd		
	UNN_920CUo	JUNCTION	OPEN	UNN_916	UNN_920Sd	
	UNN_916	RIVER	SECTION			

Upstream face, looking downstream



C.4 Farm Access Culvert

Included in model?
(state reason if not):
Model label:
Type:
How has structure been modelled?

Yes

UNN_823

Concrete culvert

The pipe was modelled as a circular culvert using Flood Modeller.
Overtopping of the bridge was represented within the 1D domain using a spill unit.

	UNN_823	RIVER	SECTION			
	UNN_823	JUNCTION	OPEN	UNN_823CUI	UNN_823Su	
	UNN_823CUI	CULVERT	INLET	UNN_823CUu	UNN_823	
	UNN_823CUu	CONDUIT	CIRCULAR			
	UNN_823CUd	CONDUIT	CIRCULAR			
	UNN_823CUd	CULVERT	OUTLET	UNN_823CUo		UNN_819
	UNN_823Su	SPILL		UNN_823Sd		
	UNN_823CUo	JUNCTION	OPEN	UNN_819	UNN_823Sd	
	UNN_819	RIVER	SECTION			

Upstream face, looking downstream



C.5 Farm access bridge

Included in model? (state reason if not): Model label: Type: How has structure been modelled?	Yes																																									
	UNN_673																																									
	Arch Bridge																																									
	The bridge was modelled as an arch bridge using Flood Modeller.																																									
	Overtopping of the bridge was represented within the 1D domain using a spill unit.																																									
	<table><tr><td></td><td>UNN_673</td><td>RIVER</td><td>SECTION</td><td></td><td></td><td></td></tr><tr><td></td><td>UNN_673</td><td>JUNCTION</td><td>OPEN</td><td>UNN_673BRu</td><td>UNN_673Su</td><td></td></tr><tr><td></td><td>UNN_673BRu</td><td>BRIDGE</td><td>ARCH</td><td>UNN_673BRd</td><td>UNN_673</td><td>UNN_669</td></tr><tr><td></td><td>UNN_673Su</td><td>SPILL</td><td></td><td>UNN_673Sd</td><td></td><td></td></tr><tr><td></td><td>UNN_673BRd</td><td>JUNCTION</td><td>OPEN</td><td>UNN_669</td><td>UNN_673Sd</td><td></td></tr><tr><td></td><td>UNN_669</td><td>RIVER</td><td>SECTION</td><td></td><td></td><td></td></tr></table>		UNN_673	RIVER	SECTION					UNN_673	JUNCTION	OPEN	UNN_673BRu	UNN_673Su			UNN_673BRu	BRIDGE	ARCH	UNN_673BRd	UNN_673	UNN_669		UNN_673Su	SPILL		UNN_673Sd				UNN_673BRd	JUNCTION	OPEN	UNN_669	UNN_673Sd			UNN_669	RIVER	SECTION		
	UNN_673	RIVER	SECTION																																							
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	UNN_673BRu	BRIDGE	ARCH	UNN_673BRd	UNN_673	UNN_669																																				
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	UNN_673BRd	JUNCTION	OPEN	UNN_669	UNN_673Sd																																					
	UNN_669	RIVER	SECTION																																							

Upstream face, looking downstream.



C.6 Motorway Culvert

Included in model? (state reason if not):	Yes																																																																													
Model label:	UNN_591																																																																													
Type:	Concrete culvert																																																																													
How has structure been modelled?	The culvert was modelled as a circular conduit unit, two conduit units were connected to represent the upstream and downstream section of the culvert using Flood Modeller. Overtopping of the bridge was not represented using a spill unit as the height of the culvert means there was no requirement. <table><tr><td></td><td>UNN_591</td><td>RIVER</td><td>SECTION</td><td></td><td></td><td></td></tr><tr><td></td><td>UNN_591</td><td>JUNCTION</td><td>OPEN</td><td>UNN_591CUI</td><td></td><td></td></tr><tr><td></td><td>UNN_591CUI</td><td>CULVERT</td><td>INLET</td><td>UNN_591CU1u</td><td>UNN_591</td><td></td></tr><tr><td></td><td>UNN_591CU1u</td><td>CONDUIT</td><td>CIRCULAR</td><td></td><td></td><td></td></tr><tr><td></td><td>UNN_591CU1d</td><td>CONDUIT</td><td>CIRCULAR</td><td></td><td></td><td></td></tr><tr><td></td><td>UNN_591CU1d</td><td>JUNCTION</td><td>OPEN</td><td>UNN_591CU2u</td><td></td><td></td></tr><tr><td></td><td>UNN_591CU2u</td><td>CONDUIT</td><td>CIRCULAR</td><td></td><td></td><td></td></tr><tr><td></td><td>UNN_591CU2d</td><td>CONDUIT</td><td>CIRCULAR</td><td></td><td></td><td></td></tr><tr><td></td><td>UNN_591CU2d</td><td>CULVERT</td><td>OUTLET</td><td>UNN_591CUo</td><td></td><td>UNN_546</td></tr><tr><td></td><td>UNN_591CUo</td><td>JUNCTION</td><td>OPEN</td><td>UNN_546</td><td></td><td></td></tr><tr><td></td><td>UNN_546</td><td>RIVER</td><td>SECTION</td><td></td><td></td><td></td></tr></table>		UNN_591	RIVER	SECTION					UNN_591	JUNCTION	OPEN	UNN_591CUI				UNN_591CUI	CULVERT	INLET	UNN_591CU1u	UNN_591			UNN_591CU1u	CONDUIT	CIRCULAR					UNN_591CU1d	CONDUIT	CIRCULAR					UNN_591CU1d	JUNCTION	OPEN	UNN_591CU2u				UNN_591CU2u	CONDUIT	CIRCULAR					UNN_591CU2d	CONDUIT	CIRCULAR					UNN_591CU2d	CULVERT	OUTLET	UNN_591CUo		UNN_546		UNN_591CUo	JUNCTION	OPEN	UNN_546				UNN_546	RIVER	SECTION			
	UNN_591	RIVER	SECTION																																																																											
	UNN_591	JUNCTION	OPEN	UNN_591CUI																																																																										
	UNN_591CUI	CULVERT	INLET	UNN_591CU1u	UNN_591																																																																									
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