Figure 2.1: *Culvert assumed to convey water from the western to eastern ditch along Yarnton/Green Lane*

Figure 2.2: *Eastern Drainage Ditch system looking downstream in a south-westerly direction. The solar farm is visible on the left bank.*

Sandy Lane it flows along the western side of Yarnton/Green Lane. Observations on site, along with the topographic survey, indicated that flow from the Rowel Brook is only routed along the western side.

The ditches along Yarnton/Green Lane appeared poorly maintained and the connectivity between the ditches was not always clear. A culvert close to the confluence with the Eastern Drainage Ditches appears to convey water from west to east below Yarnton/Green Lane, but water in either ditch was limited during the site visits and therefore this hypothesis is unconfirmed. This culvert is shown in figure 2.1. Section 4.8 outlines the assumptions made for these ditches.

2.4 Eastern Drainage Ditches

The watercourse is finally routed from Yarnton/Green Lane into field drainage ditches, which are referred to here as the Eastern Drainage Ditches. This flow route is assumed as the confluence between the Yarnton/Green Lane and the Eastern Drainage Ditch was dry during both site visits, but the morphology of the channels suggested that the dominant flow route during high flows would be into the eastern ditch system. During the second site visit, flow was evident in ditches closer to the canal and it was clear that this flow was eventually routed back towards the A44, south of the site. It was not possible to access this area for detailed survey. Figure 2.2 shows flow within the ditch system looking downstream.

Prior to the acquisition of topographic survey there was some uncertainty associated with the connectivity of the ditches either side of Yarnton/Green Lane. Some uncertainty remains, but it is now considered that:

- only the western channel along Yarnton Lane is connected to Rowel Brook at the upstream extent.
- flow along along both sides of Yarnton Lane is not continuous, with significant vegetation growth and debris blockages.
- the channels are connected to each other at their southern end via a culvert as shown in the watercourse map.
- the Eastern Drainage Ditches are eventually connected to the return crossing under the A44 via field drains to the east
- the Eastern Drainage Ditches are not directly connected into the Oxford Canal.

2.5 Thrupp Ditch

The Thrupp Ditch drains a catchment north of the site and flows south through an industrial estate, east of Oxford Airport. It runs just west of the Oxford Canal, flowing south, before entering a culvert under a footpath and joins with the Rowel Brook North and, shortly downstream, the Oxford Canal.

2.6 Oxford Canal

Figure 2.3: *Side spill at Kidlington Green Lock*

The Oxford Canal runs in a southerly direction from the northeast of the site, down the eastern edge of the site boundary. There are two pounds that affect the site. The most significant runs from Roundham Lock - just upstream of the confluence with the Rowel Brook and Thrupp Ditch - along the eastern boundary of the site to Kidlington Green Lock. The second pound starts here and runs south for a considerable distance, ending a short way upstream of the A40 at Dukes Lock.

Kidlington Green Lock has a substantial upstream side-spill weir, shown in Figure 2.3, to maintain the upper pound level. This discharges into a parallel channel around the lock on the western side and returns to the canal downstream. It should be noted that, whilst a field drainage ditch runs perpendicular to this offtake, it did not appear to be connected to the bypass channel. A similar structure can be observed at Dukes Lock in aerial photography, but no detailed survey was available.

2.7 Southern Drainage Ditch

The Southern Drainage Ditch originates to the west of the railway within the site boundary and flows southwest, beneath the A44 Woodstock Road and through Yarnton village, with no connections upstream.

MODELLING

3. Peak Flow Estimation

3.1 Overview

A full hydrological analysis has been undertaken in order to derive design flow hydrographs to be implemented as boundaries to the hydraulic model for the required events. Full details of the hydrological analysis are provided in the Flood Estimation Report (appendix A) included with this report. The analysis has been carried out in accordance to the requirements set out by current Environment Agency guidelines[1] and the FEH (Flood Estimation Handbook). Therefore, both the FEH Statistical and ReFH2 rainfall-runoff approaches have been applied for the purposes of the hydrological analysis. However, this has also been aided by the implementation of a Direct Rainfall Model (DRM) of the area of study.

The Flood Estimation Report covers the conceptual model and selection of estimated locations for the main watercourses, namely the Rowel Brook, Thrupp ditch and Southern Drainage ditch. Details of the FEH analysis at the locations selected for the purposes of flood estimation on these watercourses are also provided in the appendix. The intervening area at the downstream boundary of the model has been split into sub-catchments, according to the DRM results. Details of the DRM built to refine the FEH analysis and a summary of its outputs are provided in section 3.2. A summary of the FEH analysis outputs is provided in section 3.3.

3.2 Direct Rainfall Model

Due to limitations associated with the resolution at which the FEH catchments can be defined and to the characteristics of the topography of the area, it was necessary to refine the delineation of the overall runoff contributing area to the site of interest and to gain a better understanding of the surface flow routes which might affect the estimation of flood risk at the site. For this purpose, a broad scale 2D Direct Rainfall Model (DRM) has been built in TUFLOW version 2020-10-AC using LiDAR DTM data. Minor modifications were made to the topography based on-site observations and the topographic survey in order to ensure that a representative flow path was identified. Variations to 2D roughness values were applied to reflect different surface coverage within the model domain.

The model has been run with the 0.1% Annual Exceedance Probability design rainfall and evaluated in terms of unit flow and velocity modelled outputs within the 2D model domain. This process has allowed the refinement of the FEH catchment boundaries and the delineation of on- and off-site sub-catchments to be taken into account for the purposes of the hydraulic modelling.

The final contributing areas for the Rowel Brook, Thrupp ditch and Southern Drainage ditch, delineated as a result of the refinement of the FEH boundaries on the basis of the DRM results, are shown in

[1] LIT11832 Environment Agency Flood Estimation Guidelines, published 23/12/2022

figure 3.1. The overall contributing catchment downstream of the site of interest (at Kingsbridge, KB01) is also shown in figure 3.1.

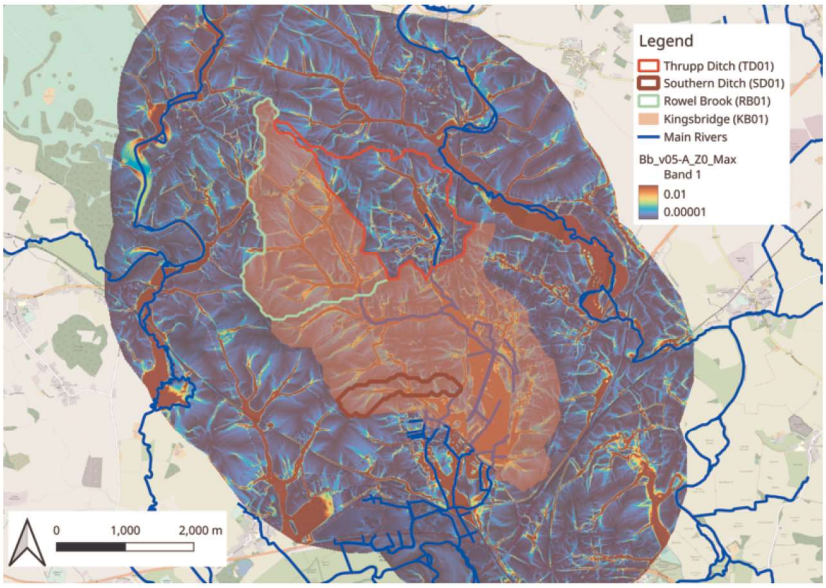

Figure 3.1: *Final contributing catchments at the locations selected for FEH analysis and the Direct Rainfall Model unit flow results*

Figure 3.2 shows the sub-catchments delineated as a result of the DRM outputs analysis. It should be noted that, according to the results of the DRM, the sub-catchment S08 has been identified as providing the most accurate representation of the runoff contributing to the Southern Drainage ditch.

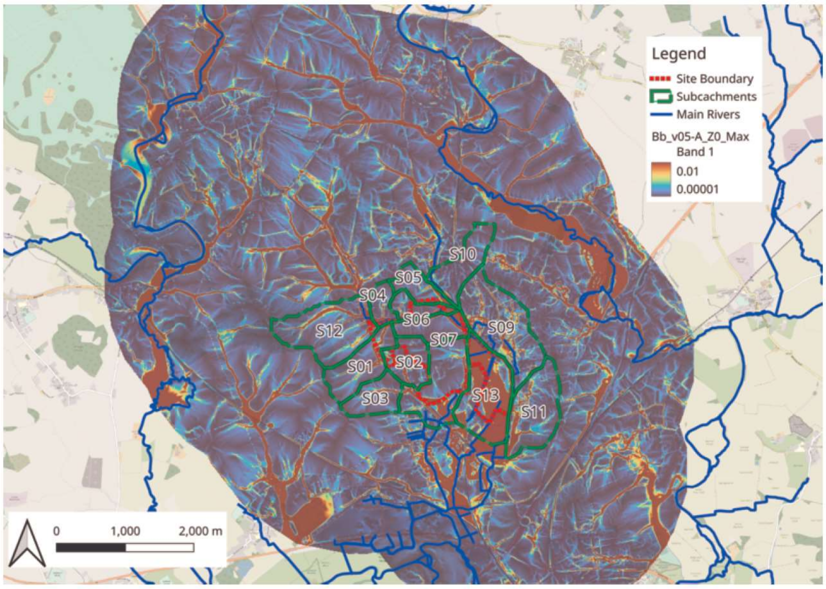

Figure 3.2: *Sub-catchments delineated using the DRM results for which lumped or distributed inflows are being incorporated in the hydraulic model.*

A summary of the final contributing areas for the estimation of the main inflows on the Rowel Brook (RB01), Thrupp ditch (TD01) and Southern Drainage ditch (SD01) is provided in table 3.1. The areas of all sub-catchments and the total contributing area at KB01 are also detailed in table 3.1. It should be noted that the sum of all contributing areas at the main estimate locations and for all sub-catchments accounts for about 90% of the total contributing area at KB01.

Node ID	Area (km^2)
KB01	14.056
RB01	3.55
TD01	2.67
SD01 (=S08)	0.811
S01	0.546
S02	0.382
S03	0.369
S04	0.189
S05	0.265
S06	0.221
S07	0.351
S09	1.076
S10	0.464
S11	0.757
S12	0.963
S13	0.894
Total	12.614

Table 3.1: *Contributing areas at main estimate locations and for all sub-catchments*

3.3 FEH analysis outputs

Q peak estimates

Final Q peak estimates at RB01, TD01, and SD01 are the statistical estimates. QMED has been estimated from catchment descriptors and adjusted by donor transfer and for urbanisation. Q peaks for events with AEP < 50% have been estimated by applying growth factors derived from pooled analysis at KB01. It should be noted that the peak estimates for all sub-catchments have been obtained from Qpeaks estimated at KB01, scaled by the ratio of catchment areas. A summary of Qpeaks for all AEPs(%) is provided in table 3.2.

% AEP	Return Period	KB01	RB01	TD01	SD01	S01	S02	S03	S04	S05	S06	S07	S09	S10	S11	S12	S13
50	2	0.891	0.180	0.176	0.120	0.035	0.024	0.023	0.012	0.017	0.014	0.022	0.068	0.029	0.048	0.061	0.057
20	5	1.306	0.263	0.258	0.177	0.051	0.035	0.034	0.018	0.025	0.021	0.033	0.100	0.043	0.070	0.089	0.083
10	10	1.615	0.326	0.319	0.218	0.063	0.044	0.042	0.022	0.030	0.025	0.040	0.124	0.053	0.087	0.111	0.103
3.33	30	2.171	0.438	0.429	0.294	0.084	0.059	0.057	0.029	0.041	0.034	0.054	0.166	0.072	0.117	0.149	0.138
2	50	2.471	0.498	0.488	0.334	0.096	0.067	0.065	0.033	0.047	0.039	0.062	0.189	0.082	0.133	0.169	0.157
1	100	2.932	0.591	0.579	0.396	0.114	0.080	0.077	0.039	0.055	0.046	0.073	0.224	0.097	0.158	0.201	0.186
0.5	200	3.466	0.699	0.684	0.469	0.135	0.094	0.091	0.047	0.065	0.054	0.087	0.265	0.114	0.187	0.237	0.220
0.2	500	4.308	0.869	0.851	0.583	0.167	0.117	0.113	0.058	0.081	0.068	0.108	0.330	0.142	0.232	0.295	0.274
0.1	1000	5.068	1.022	1.001	0.685	0.197	0.138	0.133	0.068	0.096	0.080	0.127	0.388	0.167	0.273	0.347	0.322
QBAR		0.953	0.193	0.188	0.128	0.037	0.026	0.025	0.013	0.018	0.015	0.024	0.073	0.031	0.051	0.065	0.061

Table 3.2: *Qpeak estimates (m^3/s) at main estimate locations and sub-catchments*

Design Hydrographs

Design hydrographs have been derived as ReFH2 hydrographs scaled to match the statistical peaks. For this purpose, two storms applied consistently across the area of interest to the analysis have been selected, and these are detailed in table 3.3. The storms have been estimated from ReFH2 analysis as representative of the critical storm conditions for fast response hydrological features at the site location (SD=3.5hrs) and for the wider watershed including the site (SD=11hrs).

Storm Duration (hr)	DDF Model	Storm Area (km^2)	Areal Reduction Factor (ARF)
3.5	DDF13	0.811	0.977
11	DDF13	14.056	0.96

Table 3.3: *Summary of design storms*

4. Hydraulic Modelling

4.1 General Modelling Approach

The hydraulic model was constructed using ESTRY-TUFLOW. ESTRY was selected for the 1D component of the model due to the meandering, shallow gradient and ephemeral nature of the Rowel Brook and other watercourses. The model has been run using TUFLOW version 2020-10-AF and the HPC solver. Due to the comparatively small peak flows derived by the hydrological analysis, the model has been run using double precision.

4.2 Model Extent

The model domain is shown in figure 4.1, bounded by the green line. This extent fully covers the site of interest and extends upstream on the Rowel Brook and its tributaries as well as downstream as far as is practical. This image also shows the extent of the 1D network and the small number of channels have been represented in 2D.

The majority of the Digital Terrain Model (DTM) uses LiDAR data downloaded from the DeFRA website. In some locations, as described below, this has been superseded using detailed topographic survey. The model uses a 2m cell size throughout.

4.3 Representation of Channels

The mid-point approach for ESTRY cross section representation has been used. This approach reduces the amount of interpolation of data performed by the ESTRY solver and provides a representation of the channels that is closer to the surveyed data. This approach has also allowed a high detail model to be achieved through the use of a river centre-line that allows the modelled bed level to vary significantly between cross-sections.

Structures have been modelled using the appropriate channel type based on the supplied topographic survey. Figure 4.2 shows the extent of the 1D ESTRY network included within the model and the use of different channel types.

4.4 Topographic Survey

Detailed topographic survey of the site, including cross-sectional survey of channels and structures, was undertaken in early 2023 and this has been incorporated into the model build.

The river centreline was surveyed at a 2m spacing along each channel (coarser along the Oxford Canal) which has allowed critical high and low points in each channel to be identified and included in the modelling even where full cross-sections are not available at those locations.

Wider topographic survey of the site has also been undertaken. A Triangulated Irregular Network (TIN) based on this information has

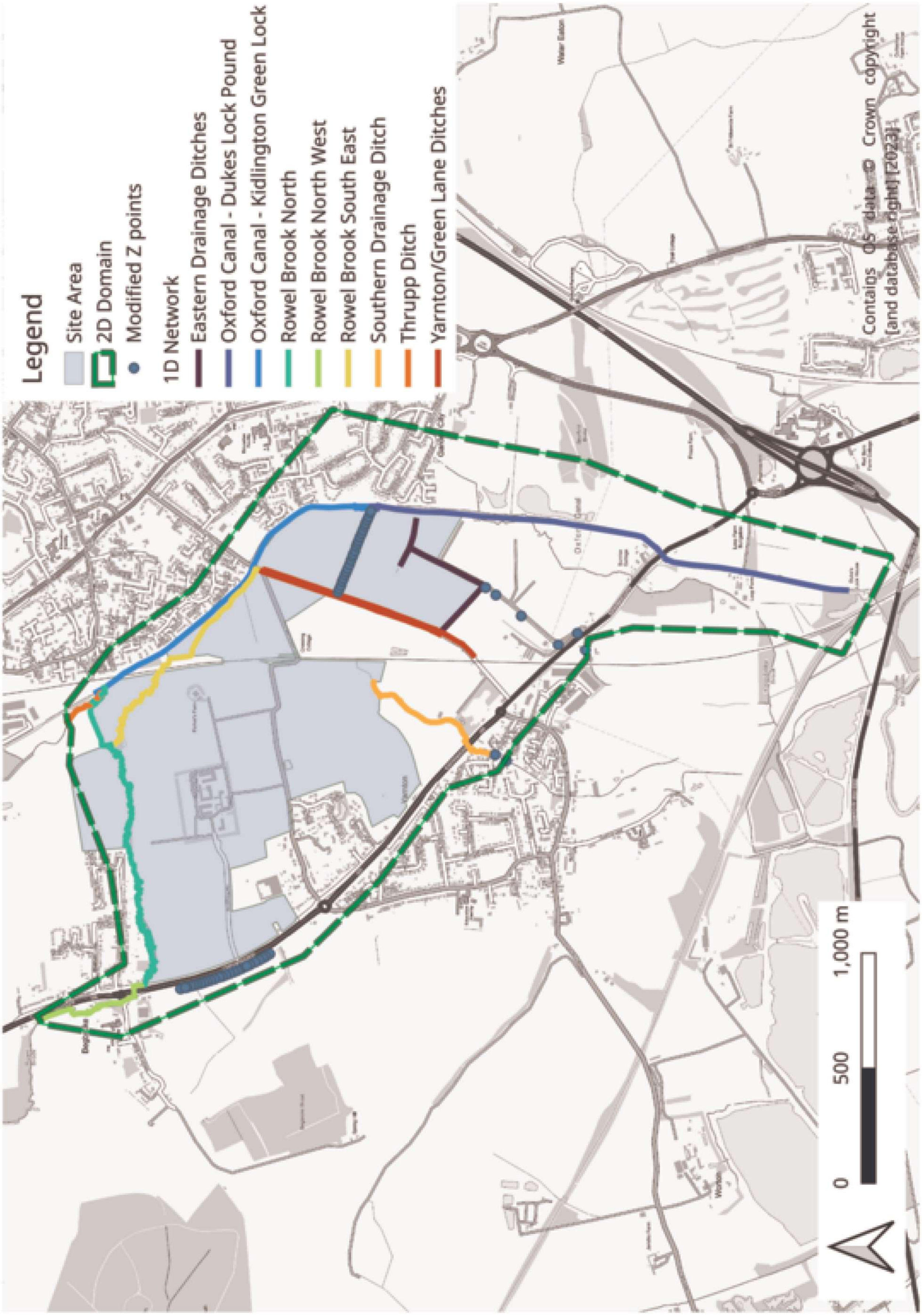

Figure 4.1: *Model domain and 1D/2D channels*

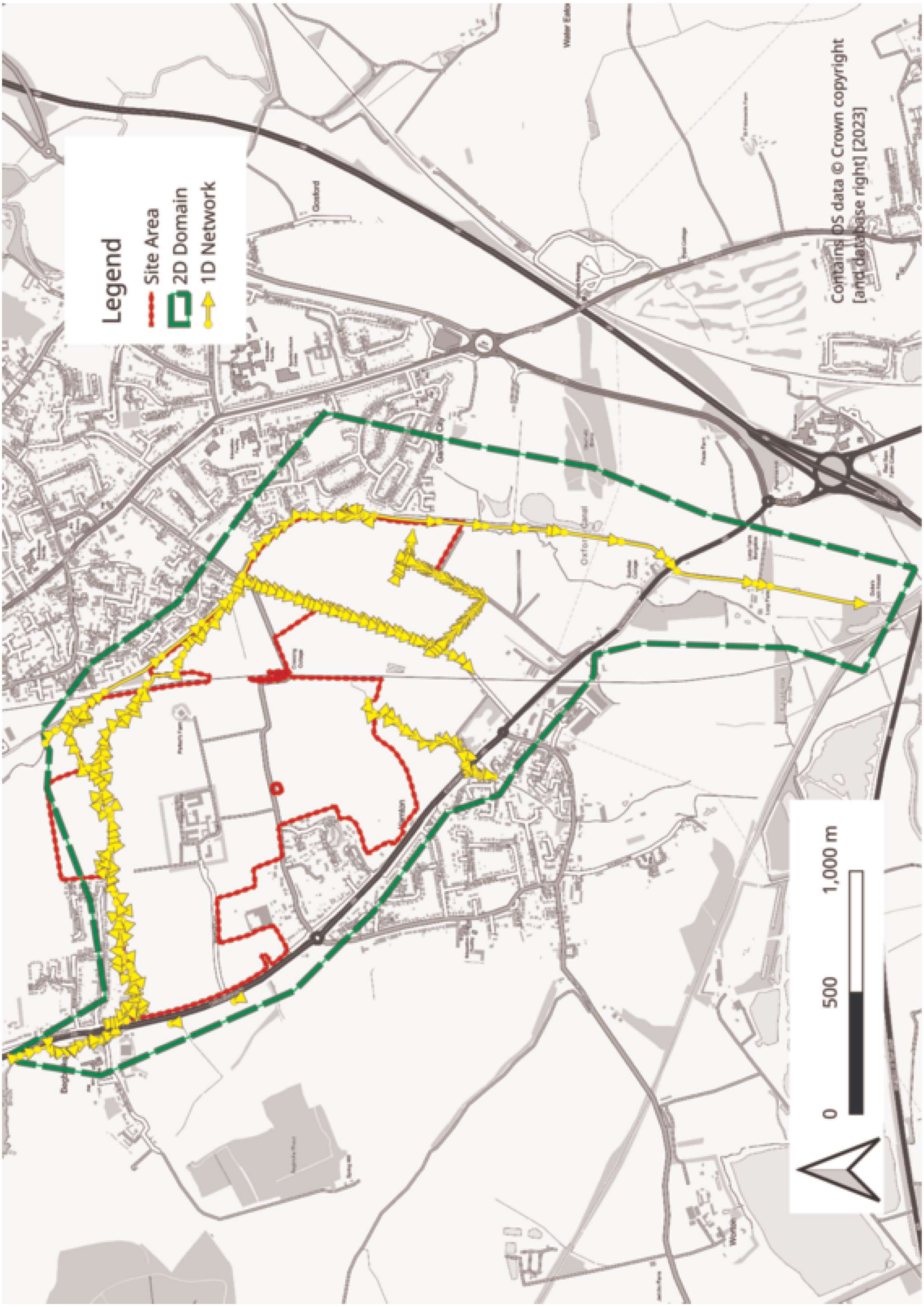

Figure 4.2: *Model domain and 1D channels*

Watercourse	Roughness	Commentary
Rowel Brook, North West	0.04 - 0.07	Particularly overgrown at upstream extent
Rowel Brook, North	0.0805	Based on Cowan's method
Rowel Brook South East	0.07 - 0.0805	
Thrupp Ditch	0.07	
Oxford Canal	0.03	
Southern Drainage Ditch	0.05 - 0.07	Limited photographic evidence available. Consistent with other ditches on site
Green/Yarnton Lane Ditches	0.07	pBlockage attribute also utilised
Eastern Drainage Ditches	0.04 - 0.07	Recent vegetation clearance evident on some reaches

Table 4.1: *1D Model roughness values*

been applied in some targetted locations, as described later in this report.

4.5 Other Topographic Modifications

Banklines have been applied along most watercourses, based on a combination of cross-sectional and bank top survey, to ensure that the onset of flooding from these channels is accurately represented. This ensures that water will spill from the 1D domain into the 2D domain at an appropriate elevation.

As shown in figure 4.1, a number of drainage ditches were identified on-site but detailed cross-sectional survey was not available in all locations. In these instances, channels have been represented in the 2D model based on an approximate channel width. Bed elevations have been set using channel bed survey where available.

4.6 Hydraulic Roughness Values

Hydraulic roughness coefficients have been applied based on representative reaches of the channel observed during the site visit. Table 4.1 sets out the 1D roughness values for the modelled reaches within the model.

To account for the very high sinuosity of the Rowel Brook as it runs across the northern edge of the site, Cowan's method was used to determine an appropriate roughness coefficient.

Table 4.2 sets out the roughness parameter values in the 2D domain. These are based on Edenvale Young's standard TUFLOW modelling template, giving consistency with a large number of existing models in the UK, many of them well-calibrated to observed data.

Material	d_1	n_1	d_2	n_2
General	0.1	0.5	0.2	0.05
Roads	—	0.02	—	—
Trees/ Wooded	0.1	1.0	0.2	0.1
Buildings	—	1.0	—	—
Water-course	—	0.035	—	—
Ditches	—	0.065	—	—

Table 4.2: *2D Model roughness values*

4.7 Model Boundaries

Figure 4.3 shows the location of the key model inflows. These have been selected with reference to the direct rainfall model to best simulate how water from each of the subcatchments is expected to reach the channels. The majority of the subcatchment inflows are applied as point inflows to the 1D domain; one inflow (S06) is distributed across a reach of the Rowel Brook North and two inflows (S01 and S07) are applied directly to the 2D domain.

4.8 Watercourse Specific Considerations

Rowel Brook, North West

The upstream modelled extent on the Rowel Brook is located adjacent to Woodstock Road, upstream of Begbroke village, as shown in figure 1.1. This location was determined by the upstream extent of the detailed topographic survey and the reach incorporates a number of structures and features which are expected to provide a flow control upstream of the site. The culverts under the A44 at the north western corner of the site have been explicitly modelled in the 1D network, connecting the Rowel Brook North West reach to the Rowel Brook North.

It was noted that the uppermost reach of the watercourse, to the west of Woodstock Road, was particularly overgrown. This reach has been applied a higher roughness value than the majority of the Rowel Brook North West.

Rowel Brook, North

The Rowel Brook meanders along the northern boundary of the site and south of Fernhill Road. The channel is notably sinuous in this location. Modelling individual meander bends in quick succession can result in stability issues as water rapidly passes between 1D and 2D components of the model. To avoid this, the sinuosity of this channel has been represented using Manning's "n" roughness values. An appropriate Mannings "n" value was determined using the estimation method described in Cowan (1956)[1], which considers channel sinuosity. As such, in the Rowel Brook North, a roughness value of 0.0805 is applied to the channels.

The flow split between the north eastern and south eastern branches of the Rowel Brook occurs in a small wooded area within the site boundary, close to its northern edge. The connectivity of channels in this location was uncertain, although direct connectivity during normal flow conditions was not observed on either site visit. A surface DTM was supplied for incorporation into the model in this area and has been integrated into the model, superseding the LiDAR and setting the elevation of the boundary cells on the right bank of the Rowel Brook. This means that the direction of flow within the

[1] Cowan, W.L. Systematic Method for Estimation Roughness Coefficients. Agricultural Engineering. 1956

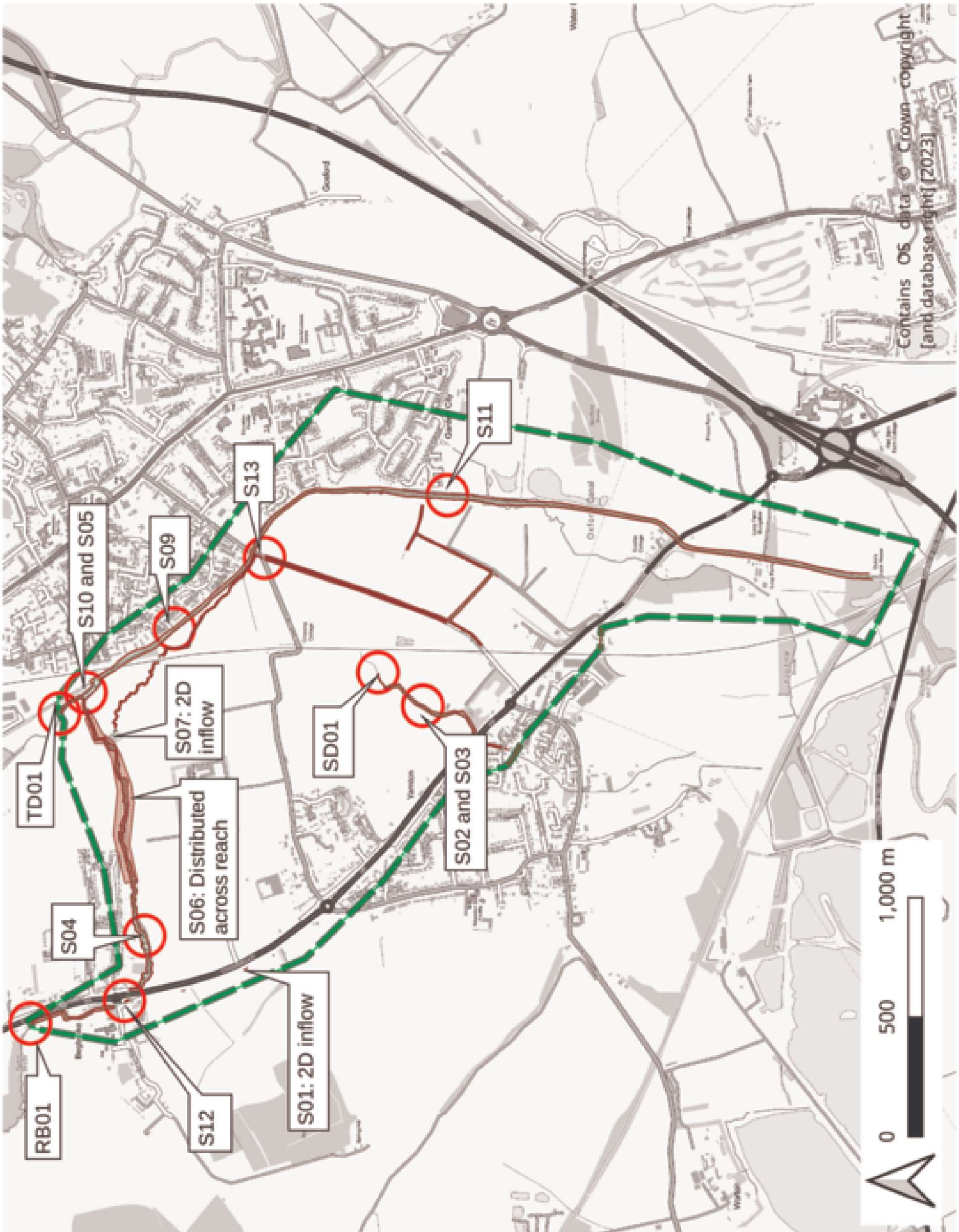

Figure 4.3: *Location of model inflows*

EdenvaleYoung

copse during high flows events is determined hydraulically rather than by assumptions made during the model build.

An Initial Water Level (IWL) consistent with the downstream weir crest has been applied to the pond in the copse area. The pond and weir are shown in figure 4.4. This is considered conservative and means that the 2D inflow located within the pond will immediately initiate overtopping of the weir.

The Rowel Brook North is connected to the Thrupp Ditch immediately upstream of Oxford Canal in the far northern corner of the site. Prior to their confluence, the two watercourses run either side of a footpath, which has been modelled in 1D using a weir channel rather than in 2D. The Rowel Brook North eventually connects to the Oxford Canal.

Figure 4.4: *Pond and weir crest within copse*

Thrupp Ditch

The upstream extent on the Thrupp Ditch is located approximately 180m upstream of its confluence with the Rowel Brook and the site's red line.

The hydrological inflow point is located downstream (south) of the industrial estate and the inflow hydrograph therefore does not explicitly include any attenuation associated with flood risk measures, flow constrictions or flooding in the industrial estate or upstream. This is a conservative assumption.

Rowel Brook, South East

This reach of the Rowel Brook has been modelled consistently with the North and North West reaches. The culvert under the railway line has been modelled as open channel, but results were checked to ensure that the soffit height of the culvert was not exceeded during modelled flood conditions. The reach downstream of the railway was considerably overgrown and has been modelled with a comparatively high roughness value until it discharges into a clearer and better-maintained ditch running parallel to the Oxford Canal.

Figure 4.5: *Example of the condition of the ditches running parallel to Yarnton/Green Lane*

Yarnton/Green Lane

The parallel ditches running either side of Yarnton/Green Lane have been modelled as separate 1D model elements; the road itself is modelled in 2D.

As noted previously, the channels either side of Yarnton/Green Lane are poorly maintained. Observations made during the site visit also indicated that the flow path along the ditches may not be continuous, although it was not possible to assess all instances of channel blockage on the site visit. To provide some representation of this, the pBlockage attribute has been included in some network lines along both the western and eastern ditches, applying intermittent 50% blockages to the channels. An example of the condition of the ditches is shown in figure 4.5.

The southern extremities of both ditches - beyond the confluence with the Eastern Drainage Ditch System - terminate where the cross-sectional survey ends. No water was visible here on either site visit.

Eastern Drainage Ditches

The Eastern Drainage Ditch system connects to the Yarnton/Lane Ditches at the confluence shown on figure 1.1 via the 1D network in this location. Some stretches of the ditch system appear to have been recently cleared, as shown in figure 4.6 and lower roughness values have been applied here compared to other ditches within the model.

Figure 4.6: *Example of apparent recent vegetation clearance along the Eastern Drainage Ditch system*

The downstream extent of the Eastern Drainage Ditches—which may be considered as a continuation of the Rowel Brook South East—was not surveyed due to access constraints. The culvert shown in figure 4.7 has been included as part of the 1D network but subsequently discharges into the 2D domain via an SX boundary. The channel downstream of this location has been represented in the 2D domain to ensure a continuous flow path but bed elevations have been estimated from LiDAR. Any structures which may be present have not been included due to lack of survey. The structure which conveys the ditch beneath the A44 Woodstock Road has been modelled as open channel as it assumed that the road crossing does not represent a constriction. On this basis, model results in this location should be viewed with caution, but this should not affect the conclusions of this report as the area lies outside the site boundary.

The downstream boundary of the Eastern Drainage Ditches has been modelled with a HQ boundary in 2D. A slope of 0.01 has been applied.

Figure 4.7: *End of 1D network along Eastern Drainage Ditch*

Oxford Canal

Two pounds of the canal have been modelled, from Roundham Lock just north east of the site to Duke's Lock approximately 900m downstream of the A44. These pounds are shown on Figure 1.1. Cross sectional survey of the canal was specified to be sparse as the geometry is largely consistent throughout the modelled reach. Where constrictions were observed on aerial photography and had not been surveyed, estimates of the width of the canal were made from aerial photography with a simple rectangular channel profile created to represent these locations. The bed level of the canal in the supplied cross-sections has been manually adjusted to an assumed water depth of 1.5 metres, based on engineering judgement. The initial water levels (IWLs) in the pounds were based on information from the Canal and Rivers Trust and set out in table 4.3.

Kidlington Green Lock is located midway along this reach and adjacent to the site. A significant side-spill weir at Kidlington Green Lock has been modelled explicitly, which helps understand whether flood flows entering the canal via the Rowel Brook further upstream

Lock Name	Pound Level (mAOD)	IWL (mAOD)
Kidlington Green Lock	61.618	61.618
Duke's Lock	60.149	60.25

Table 4.3: *Canal pound levels and modelled initial water levels*

are able to leave the canal and flood the site from this location. The bypass channel itself has been modelled in 2D based on surveyed channel bed levels, with reconnection to the canal downstream of the lock included as a 1D element.

Aerial photograph indicates that a similar offtake structure exists at Duke's Lock. No topographic survey was available Duke's Lock to model this in detail. Instead, an IWL 0.1m higher than the maintained pound level was included as a HT boundary. This increase above the maintained pound level will allow for some superelevation of the downstream water levels due to flood flows.

The modelling shows flooding along the left bank of the canal, downstream of Kidlington Green Lock. It should be noted that detailed topographic survey was limited along the left bank of the canal and therefore information on bank heights in this location is sparse. Whilst banklines set the elevation of boundary cells along the left bank of the canal, the model does not represent local variation in elevation and therefore the flood extents in this area should be viewed with caution. It should, however, be noted that the area that should be viewed with caution is outside the site boundary.

The canal is assumed not to be carrying unusually high flows originating from catchments not discussed in this analysis during the design flood events. In general canals are not designed or intended to convey flood flows and it is considered to be beyond the scope of this work to identify other catchments upstream or downstream that might discharge into the canal, raising its water levels significantly beyond the maintained pound levels. The canal has been represented using 1D modelling, allowing backwater effects from significant discharges into the canal originating from the Rowel Brook and Thrupp Ditch catchments to be modelled.

Southern Drainage Ditch

It was not possible to access most of the Southern Drainage Ditch and therefore on-site observations could not be used to inform the application roughness values. Mannings 'n' roughness values have been estimated based on the limited number of photographs available and with consideration of the maintenance of other ditches on-site. The downstream boundary has been modelled using a HQ boundary in the 2D domain with a gradient of 0.01.

Road and Other Ditches

Overland flow from Begbroke Hill, to the west of the site, is a plausible flood mechanism that may result in overland flow reaching the site. A number of drainage ditches run along the west of Woodstock

Road which may intercept overland flow originating on Begbroke Hill. Whilst detailed cross-sectional survey was unavailable, the elevations for the bottom and top of bank were supplied for these ditches; this has been used to model the ditch in the 2D domain. Given the 2m cell size, a cell width factor (CWF) was applied to the area in order to better reflect the actual flow width of this ditch. Figure 4.1, highlights the location of the road ditches explicitly included within the model. It should be noted that, given the available information, there is some uncertainty associated with the capacity of this ditch.

RESULTS

5. Hydraulic Model Results

5.1 Baseline Model Results

Figures 5.1–5.5 show the maximum depth results from each of the modelled design events with the longer, 11-hour storm duration. Equivalent results for the shorter, 3.5-hour storm duration are shown in figures 5.6–5.10.

The majority of out of bank flooding is located towards the east of the site, close to Oxford Canal. This is not unexpected, as the Eastern Drainage Ditches where much of the water from the site is routed, do not appear to be designed with extreme flood risk in mind. The flood extents in this area should be viewed with some caution as much of the channel that would drain this area was not surveyed due to access constraints, and it is therefore possible that, if this channel was particularly well-maintained, the flood extents in this area would be less.

The model shows significant flooding to Kidlington from the east bank of the Oxford Canal, outside of the site boundary. This is predominantly driven by the flows from the Rowel Brook and Thrupp Ditch which discharge into the canal and cause a backwater from Kidlington Green Lock—a structure which was likely not designed to handle such high flows.

Flooding associated with the Rowel Brook North is typically confined to a narrow corridor either side of the channel. In the largest events, a shallow flow route fed by run-off from Begbroke Hill overtops Woodstock Road from the west and crosses the north west corner of the site.

The Southern Drainage Ditch is shown to cause out-of-bank flooding in adjacent fields, particularly on the right bank. Water ponds upstream of the Woodstock Road although the road is not shown to overtop.

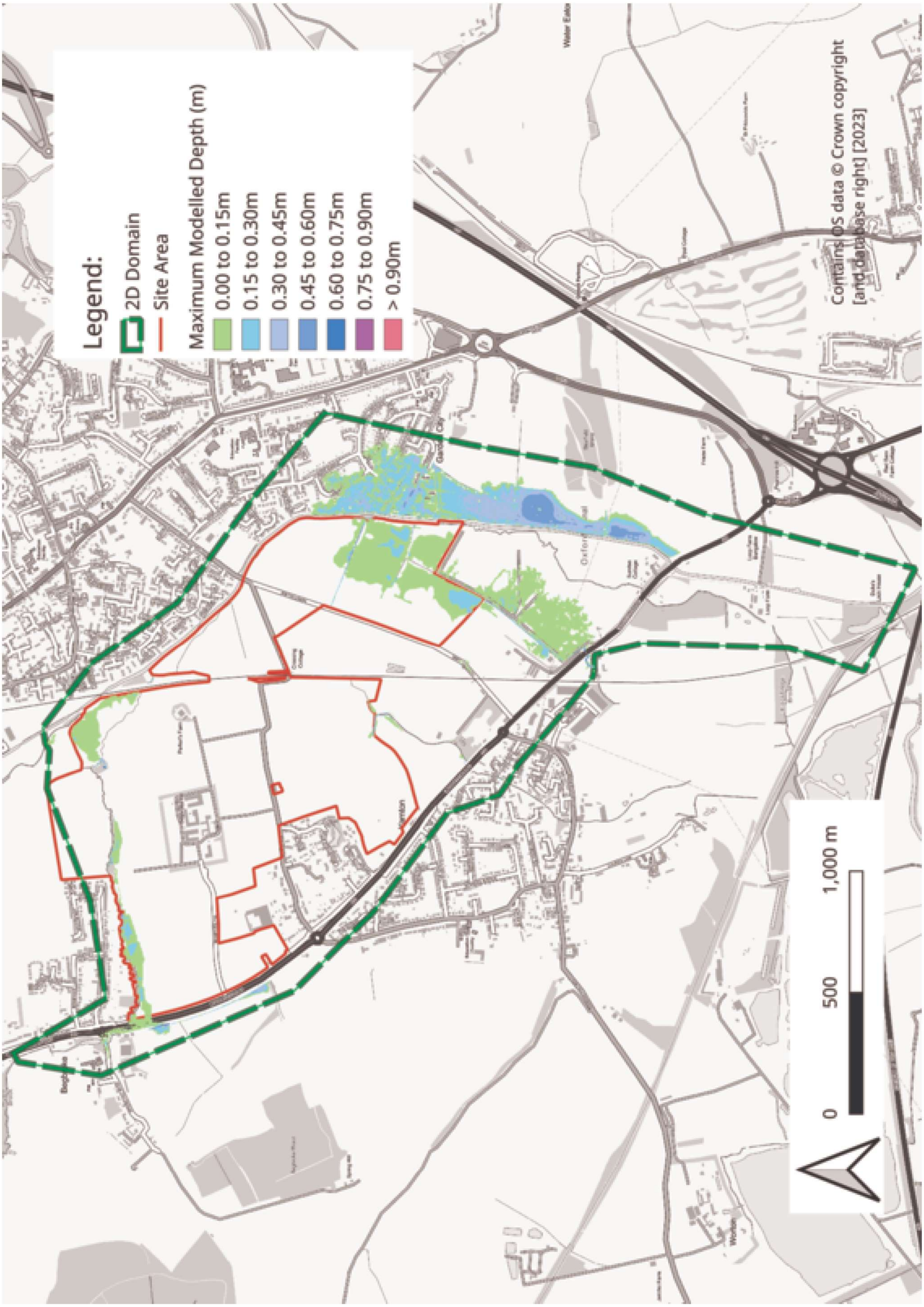

Figure 5.1: *Maximum modelled depth in the 3.33% AEP event, 11 hour storm duration*