East West Rail Phase 2

Flood Risk Assessment: CFSA Modelling Report (Westbury Court, culverts C160924 & C160550)

CFSA ID: 2A0325/5.2/FH Culvert ID: C160924 & C160550

NGR: SP 6283 2392 & SP 6315 2399

Section: 2A

Discipline/Grip Stage: Drainage Culverts / GRIP 5

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East West Rail Phase 2

Westbury Court

CFSA Modelling Report

July 2020

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Executive Summary

This Technical Report sets out the hydrological and hydraulic modelling approach adopted to assess the potential flood risk effects of the proposed East West Rail Phase 2 (EWR2) Project on Route Section 2A (north-west of Marsh Gibbon) at National Grid Reference (NGR) 462832, 223908. Proposed EWR2 works in this area include culvert improvements and railway earthworks. This report is submitted to discharge Planning Condition 13 and is submitted in line with the Planning Condition 13 Phasing Strategy, and is located in development stage 2A2.

This assessment has improved the understanding of the flood risk mechanisms for this culvert, and upstream and downstream areas, where receptors indicated to be in the floodplain are Network Rail land, a Gas Utility Compound, adjoining agricultural land and Bicester Road. The potential impacts of climate change were assessed by increasing rainfall by 40%.

The detailed hydrological and hydraulic modelling and latest earthwork designs have been used to define the floodplain losses. The total floodplain volume losses as a result of the proposed earthworks are 26m^3. The improved drainage ditches have increased the cross-sectional area of the existing ditches and provide an additional floodplain volume of 1000m^3. Therefore, Compensatory Flood Storage Area 2A0325/5.2/FH is not required.

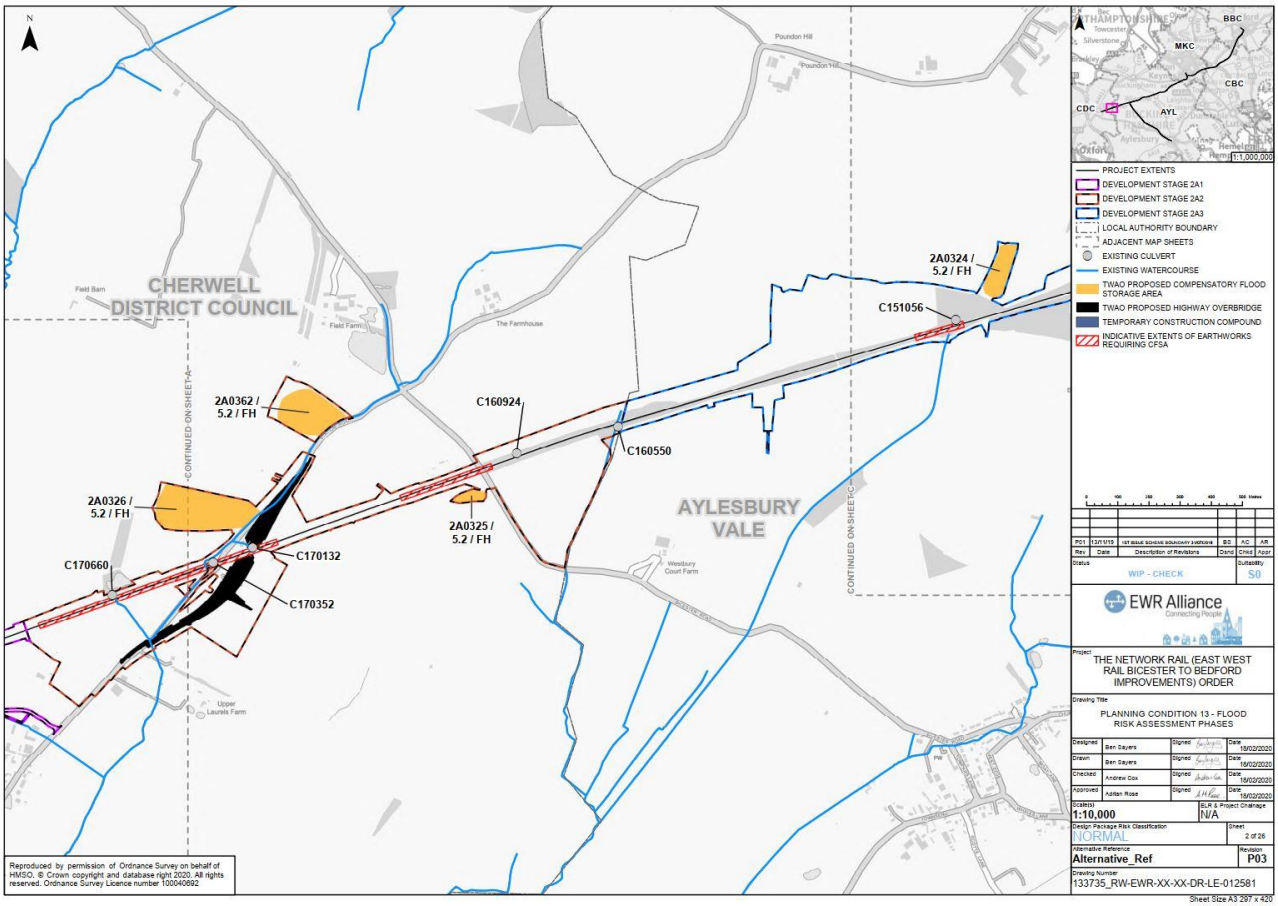
The Integrated Catchment Model was used to test the proposed culvert, earthworks and drainage improvements to assess potential changes in flood extents and levels upstream and downstream. Culvert C160924 is being replaced on a like for like basis therefore will result in no change upstream or downstream. Culvert C160550 is being improved with a liner. The Integrated Catchment Model demonstrates that there are generally either no changes or minor reductions in peak water level as a result of the proposed works. The only increases in peak water level are within the permanent red line boundary.

The modelling has confirmed that the culvert, earthwork and drainage improvements are acceptable from a flood risk perspective, with the precautionary assessment indicating no impact on flood risk.

1. Introduction

This Technical Report sets out the hydrological and hydraulic modelling approach adopted to assess the potential flood risk effects of the proposed East West Rail Phase 2 (EWR2) Project on Route Section 2A (north-west of Marsh Gibbon) at National Grid Reference (NGR) 462832, 223908. This report is submitted to discharge Planning Condition 13 and is submitted in line with the Planning Condition 13 Phasing Strategy for assets C160924 and C160550 and railway earthworks associated with Compensatory Flood Storage Area (CFSA) 2A0325/5.2/FH, and is located in development stage 2A2. The figure below shows the Phasing Strategy submission for this area.

Figure 1-1 Planning Condition 13 Phasing Strategy



Placing structures in the floodplain takes up space where floodwaters should flow or be stored and therefore results in a loss of floodplain storage. In order to ensure the risk of flooding is not increased elsewhere, where the consequences may be more severe, floodplain compensation is necessary. This is where new areas of land, in close proximity to the area of floodplain loss, are lowered to compensate for that loss. CFSAs should preferably be located on the edge of the floodplain, but need to be hydraulically connected, so water can flow or be stored in the compensation areas during times of flooding.

The location and maximum extent of the CFSAs were identified in the Flood Risk Assessment (FRA) and Environmental Statement (ES) in order to inform the redline boundary.

Objectives

The objectives of this assessment and technical report are as follows:

- To develop a hydrological and hydraulic model of the channel and floodplain system to understand potential flood risk mechanisms more clearly;
- To test and inform the design of the culvert works to ensure risks to EWR2 and receptors upstream and downstream are understood, incorporating an allowance for climate change; and
- Document this work and seek approval from the regulator, in this case the Lead Local Flood Authority (LLFA), Oxfordshire County Council (OCC).

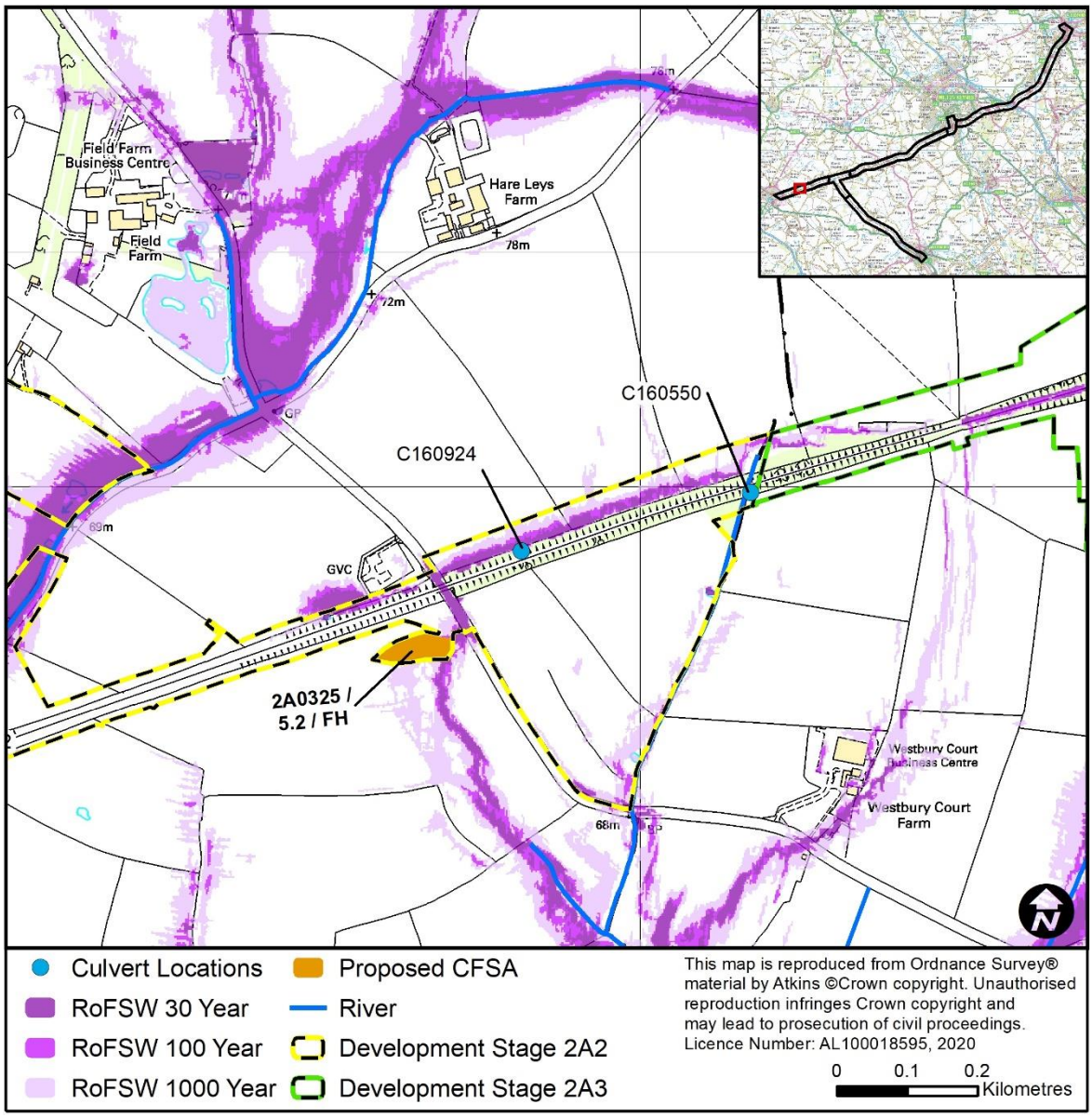
Site Description

The study area is located between Launton and Marsh Gibbon on Route Section 2A (NGR 462832, 223908). The LLFA is OCC and the site falls within the Thames River Basin District. The area is a rural setting with no properties directly adjacent the EWR2 route; agricultural land is the predominant land use either side of EWR2. There is no fluvial flood risk (as defined by the Environment Agency Flood Zone maps) in this area, with flood risk limited to surface water flooding, often associated with small Ordinary Watercourses and ditches.

At Bicester Road (adjacent to OXD34 Bicester Road Marsh Gibbon Underbridge), an area on the northern side of the railway embankment, and the road itself is shown to be at risk from the 3.3% annual chance event upwards. Flood depths at the 1% annual chance event are predicted to be up to 0.6 m against the northern side of the embankment. The existing EWR2 route is raised on embankment and is not shown to flood. The surface water flooding appears to be associated with overland flows with no ditches/small watercourses in the area. Receptors within the floodplain are Network Rail land, a Gas Utility Compound, adjoining agricultural land and Bicester Road.

The figure below displays the site location, key features and Risk of Flooding from Surface Water (RoFSW) flood outlines.

Figure 1-2 Site Location (including RoFSW outlines)



EWR2 Scheme

At this site the following EWR2 works are proposed which are considered as part of this assessment:

- Limited embankment works within a restricted area;
- General repairs and replacement deck to Bicester Road (OXD34) underbridge (note these minor works do not affect any watercourses or floodplain areas and are thus not considered any further);
- Culvert C160924 will be replaced on a like for like basis with the same culvert length. New precast headwalls to be installed at both ends;
- Culvert C160550 will be rehabilitated with a liner for the entire length of the culvert. New precast headwalls to be installed at both ends. No change in culvert length;

- Improvements to the existing toe drainage ditches; and
- A CFSA (2A0325/5.2/FH) was proposed to mitigate the potential loss of floodplain due to planned earthworks.

Previous Work

The following documents / assessments have been used to inform this modelling study:

- Project Wide Flood Risk Assessment (FRA, reference: The Network Rail (East West Rail Bicester to Bedford Improvements) Order, Environmental Statement, Volume 3, Appendix 13.1, July 2018); and
- Drainage Strategy (reference: The Network Rail (East West Rail Bicester to Bedford Improvements) Order, Environmental Statement, Volume 3, Appendix 13.1H, July 2018).

The Site Summary Report and CFSA summary for this location produced as part of the Project Wide FRA are provided in Appendix A and B respectively.

2. Method

As set out in the Project Wide FRA a proportionate approach to hydrological and hydraulic modelling has been adopted, taking into account the availability of data, the scale of the proposed works and the receptors which are potentially affected.

Data

The table below sets out the data that was available for this location and applied in developing the hydrological and hydraulic model for this site.

Table 2-1 Key Data Sources

Data Name	Description
Topographical Survey	Detailed ground model data (0.2m) is available for the area 60m either side of the railway embankment, which covers any surface channels feeding the culverts. Given the limited flood extents and receptors at risk in this area, this information (when combined with the LiDAR) is sufficient for this location to define key flood risk routes and extents, and assess the impact of the works.
LiDAR	Combination of LiDAR flown for the project at 0.2m resolution and 2m data downloaded from gov.uk available.
Culvert site photos	The upstream face of C160924 can be seen. The south facing downstream cannot as the picture does not clearly show the headwall of C160924. The upstream C160924 channel can be estimated based on the headwall dimensions. But the downstream C160924 channel is obscured by vegetation Both the upstream and downstream of C160550 are clearly defined in the photos and can be sized using the brick headwall as a reference.
CCTV Survey	CCTV survey is available for both culvert C160924 and C160550.
Culvert Master Assessment	CulvertMaster outputs were available for culvert C160924 but not C160550.
GRIP 4 Hydrology Assessment	Flow estimates were available for culvert C160924, but not C160550.
Other	Notes from site walkover: C160924 - Dry ditch, culvert doesn't receive flows from the channel parallel to the track. Notes from site walkover: C160550 – cable running through the culvert, headwall in poor condition, tree in front of downstream outlet.

Approach

The modelling approach has been selected based upon the level of data available and the stage of design. The GRIP 4 assessment utilised the WinDES component in MicroDrainage to derive peak flow estimates at the culvert locations. Bentley CulvertMaster software was then used to determine headwater levels where topographic survey was available. Climate change was applied by increasing

flow in line with the appropriate Department for Environment, Food and Rural Affairs (Defra) river basin guidance.

For this GRIP 5 assessment a hydraulic model has been constructed. Owing to the small catchment areas associated with these culvert locations (typically <2km^2), and poorly defined channel networks, a direct rainfall approach using ICM has been applied allowing overland flow paths to be determined using the model rather than specifying flow boundaries; this will provide a more accurate representation of the catchment flows and flow paths. Climate change is represented by increasing rainfall by 40% in line with current guidance (Defra 2016) for small catchments. Both culvert C160924 and culvert C160550 have been included in the ICM since the overland flow routes are potentially linked and may influence each other.

Hydrology

A direct rainfall approach was adopted where rainfall was distributed across the model domain, using the Revitalised Flood Hydrograph (ReFH) model, this will use the Flood Estimation Handbook (FEH) parameters as derived from the FEH Web Service. Following initial model simulations, the catchment area derived from FEH was adjusted based on the flow paths observed from the direct rainfall approach.

The following flood events will be simulated in the model:

- 50% annual chance event;
- 2% annual chance event;
- 1% annual chance event;
- 1% annual chance event plus climate change (40% for rainfall in line with guidance from https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances);
- 0.5% annual chance event; and
- 0.1% annual chance event.

The table below summarises the key catchment descriptors derived from the FEH Web Service.

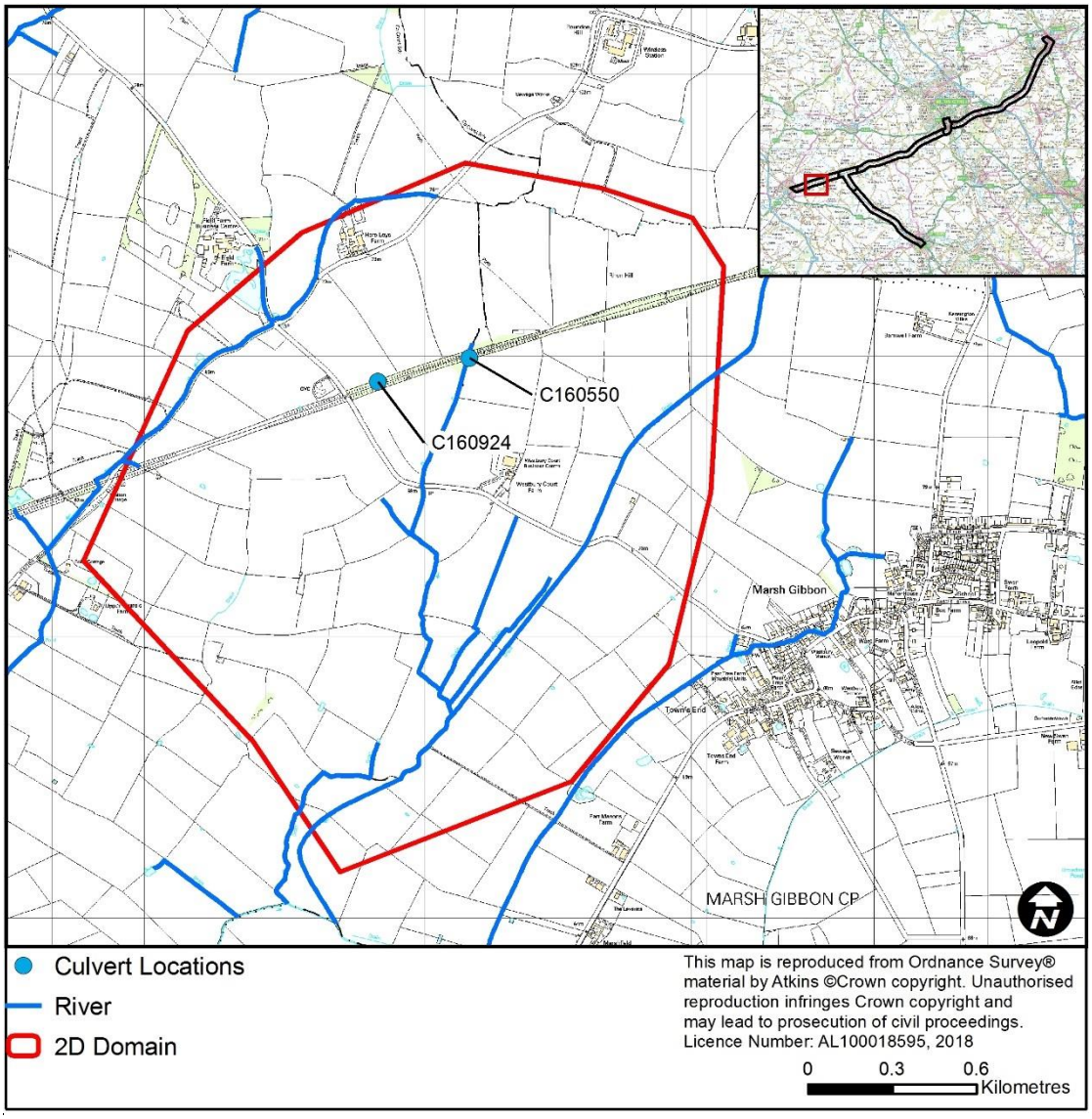
Table 2-2 Key FEH Parameters

Descriptor	**Value**
Catchment Area	2.57 km²
SPR	52.9 %
SAAR	613 mm
BFIHOST	0.222
URBEXT2000	0
PROPWET	0.32
C1	-0.023
D1	0.339
D2	0.305
D3	0.242
E1	0.293

Descriptor	Value
F1	2.474

The following figure illustrates the ICM 2D model domain, over which the direct rainfall was applied.

Figure 2-1 ICM 2D Domain



Critical storm durations were tested from 30-minutes to 150-minutes, to understand which duration gave the peak levels across the study area, focusing on the EWR2 culverts.

Hydraulics

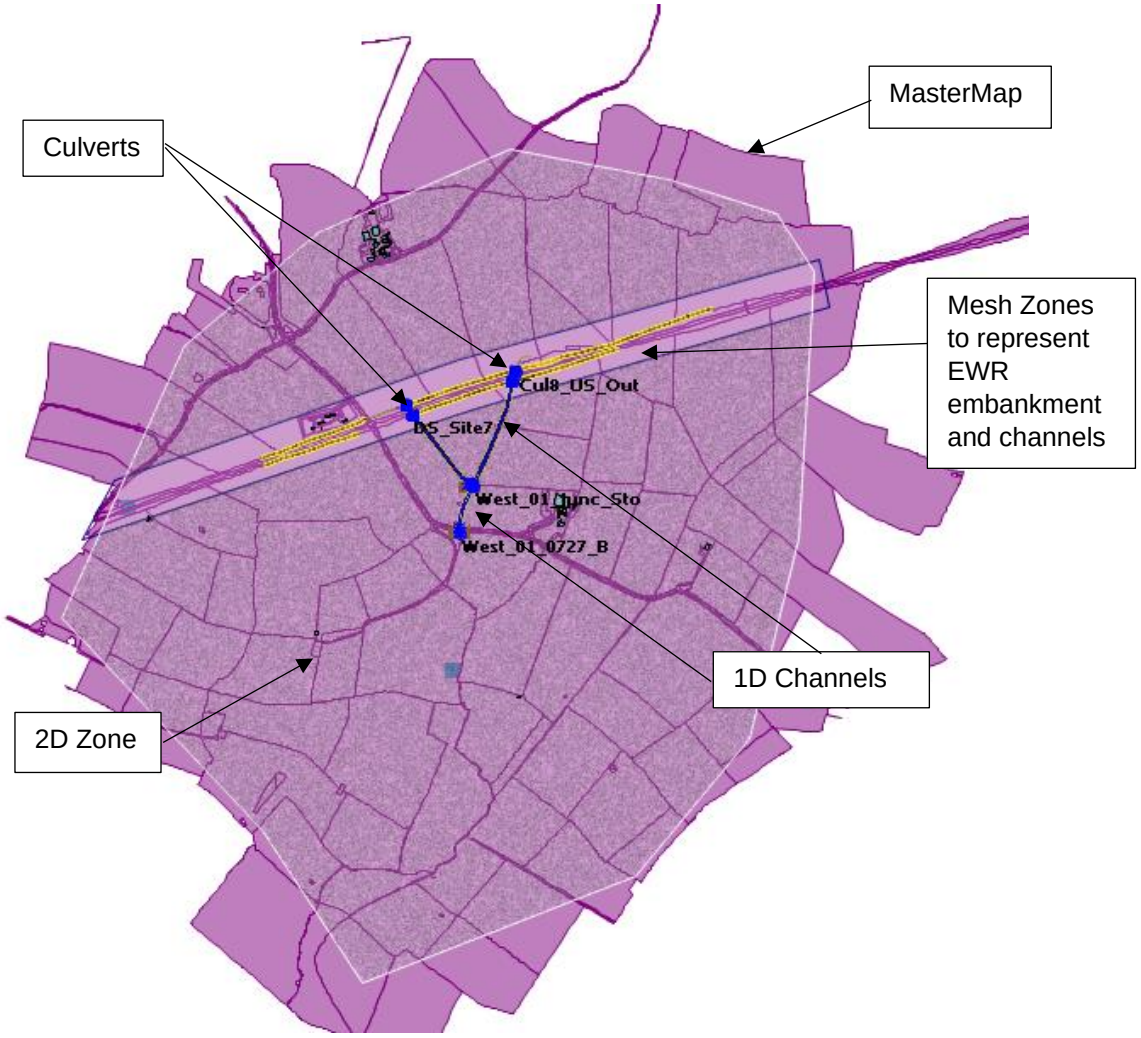
The table below summarises the key features of the hydraulic model.

Table 2-3 ICM Key Features

Model Feature	**Description / Value**
2D Zone Area	3.93km²
Model Duration	8-hours (based on 60-minutes critical storm duration)
2D Boundary	Normal condition boundary
Maximum 2D Zone Triangle Size	15m² with an area of detail around the embankment and culverts of 2m^2.
2D Zone Features	Buildings are included as roughness zones with a value of 1.00. Key buildings that are within the individual sites were converted to porous polygons.
Rainfall	Applied across entire domain. 100% rainfall applied. As a rural catchment a Winter storm profile has been applied. Since the assessment needs to assess potential upstream and downstream impacts, a catchment area covering both areas upstream and downstream of the EWR2 route has been applied. Catchment extents from FEH were refined based on the overland flow paths observed in initial model runs, and catchment area amended to 2.58km².
Runoff Zones	Fixed at 0.529 based on the SPRHOST of 52.9%. Since there are no urban areas and extremely limited impermeable areas (such as roads) in the 2D domain this is considered an appropriate representation of the system.
Roughness Zones (Mannings applied)	Based on MasterMap applying the roughness values provided in Appendix C.
Culvert Representation	The culverts have been represented as follows: C160924 Circular culvert; length of 24m and 350mm diameter; Manning's N of 0.01 for the top and bottom surfaces; upstream invert level of 72.39mAOD and downstream invert level of 71.89mAOD. C160550 Brick Arch with flat bottom; length of 26m and 900mm diameter; Manning's N of 0.015 for the top and 0.025 for the bottom surface; upstream invert level of 74.870 mAOD and downstream invert level of 74.810 mAOD.
Rivers	Open channels downstream of the culverts have been represented as 1D river channels with cross sections taken from the topographical survey.
Drainage Network	Existing drainage ditches represented with mesh zones.
CFSA	Not required, see section 3 below.

The following figure displays the ICM schematic.

Figure 2-2 ICM Schematic



Appendix E contains the model build summary.

Sensitivity

The following sensitivity tests were undertaken on the 1% annual chance event to assess the robustness of the ICM to changes in key model assumptions:

- Design rainfall +/- 20%;
- Mannings +/- 20% for overland roughness zones and Colebrook-White roughness values +/- 20% for conduits;
- Catchment draining to the upstream culvert inlet applied to derive a rainfall profile specific to the upstream culvert catchment;

- Runoff coefficient increased by +/-20%;
- Culvert siltation levels increased in line with site visit observations (15% of total diameter);
- Headloss coefficients increased by +/-20%; and
- Summer storm profile applied.

Scenarios

A range of scenarios were simulated in the hydrological and hydraulic model; these are set out in the table below.

Table 2-4 Model Scenarios

Scenario Number	Description
1	Baseline
2	Baseline Sensitivity Tests: 2a: Design rainfall 2b: Roughness 2c: Catchment area specific to culvert upstream inlet 2d: Runoff 2e: Siltation included in line with site visit observations 2f: Headloss 2g: Summer storm profile
3	With Scheme (proposed culverts, earthworks, drainage ditches)

Assumptions

The key points and assumptions relating to this assessment are as follows:

- A ‘normal’ boundary condition has been applied to the 2D domain extents;
- Baseline model does not include any observed siltation this is included as a sensitivity test;
- MasterMap data has been used to define key features and roughness zones;
- Runoff rates have been assessed as fixed based on SPRHOST, and have been applied consistently across the model domain;
- Channels have been represented using a combination of 1D river reaches where there is a defined channel shape, and mesh zones in the remaining areas. In the most part by applying a smaller mesh with increased detail, but in some cases by lowering the ground level based on the limited channel information or site photos available; and

  The FEH Web Service has been used to derive catchment descriptors, with the ReFH model used to derive rainfall.

CFSA Approach

Overview

As described above compensatory flood storage works are required where the Project would otherwise reduce the available volume of flood storage.

CIRIA 624 (Development and flood risk – guidance for the construction industry - Section A.3.3.10, 2004) states that:

"*compensatory flood storage must become effective at the same point in a flood event as the lost storage would have done (McPherson 2002). It should therefore provide the same volume, and be at the same level relative to flood level, as the lost storage. This requirement is often referred to as "level for level" or "direct" compensation".*

Therefore, CIRIA 624 classes level for level based on a flood frequency approach as direct level for level compensation. Where absolute level of level is not possible i.e. where the CFSA cannot be sited in the immediate vicinity of the loss the CIRIA approach will be adopted. This approach was discussed and agreed with the Environment Agency at a meeting 23/10/2018.[1]

The Environment Agency preference and EWR2 approach is that the CFSA should expand rather than lower the existing floodplain, therefore only areas on the edge of the maximum design flood extent were considered for compensation. Each CFSA connects hydraulically to the watercourse. The flood frequency/volume relationship defines the level at which a specific volume of storage needs to be provided based on a flood frequency approach.

GRIP5 Approach

This approach assesses the frequency of flooding to then apply a level-for-level assessment as described above in CIRIA 624:

- The hydraulic model will be used to calculate the volume lost for a range of return periods;
- Volumes for each flood frequency band will be calculated, giving a frequency volume relationship;
- The threshold of flooding for these return periods will be calculated at the proposed CFSA site and the corresponding volumes provided for each return period;
- A CAD/GIS approach will be used to shape the storage area; and
- This shape will be incorporated into the hydraulic model and run for a range of return periods.

CFSA

There is one CFSA allowed for within the Transport and Works Act Order (TWAO) in this model reach: CFSA 2A0325/5.2/FH which was required to compensate for proposed railway embankment earthworks. Proposed ground levels at the CFSA range from approximately 71m AOD to 71.6m AOD.

Since submission of the TWAO application the detailed designs of the earthworks have been completed, and alongside the detailed flood modelling outputs have been used to provide an updated CFSA assessment of the proposed works. This is described in section 3 below. In order to minimise the environmental impact of the works, the extent and scale of the earthworks have been reduced, hence the floodplain losses have been reduced.

[1] EA Attendees Clark Gordon, Ben Corne, Scott Salmon

3. Baseline Modelling

Baseline

Critical Storm Duration Assessment

A range of critical storm durations were simulated in the hydrological and hydraulic model, a summary of the results of these tests for the 1% annual chance event are shown in the table below. Four assessment points were selected to compare the critical storm durations, namely:

- Assessment Point 1: culvert C160924 inlet;
- Assessment Point 2: culvert C160924 outlet;
- Assessment Point 3: culvert C160550 inlet; and
- Assessment Point 4: 590m downstream of the EWR2 route, Ordinary Watercourse confluence, downstream of Bicester Road.

The table below summarises the results of the critical storm duration tests. Although there is limited variation in the depths across the different durations and assessment points, the critical storm duration can be seen to be 60-minutes.

Table 3-1 Critical Storm Duration Results (1% annual chance event)

Storm Duration (minutes)	Peak Water Depth (m) at 1% annual chance event			
	Assessment Point 1	**Assessment Point 2**	**Assessment Point 3**	**Assessment Point 4**
15	1.01	0.94	0.25	0.96
30	1.03	0.99	0.25	0.99
60	**1.08**	**1.04**	**0.28**	**1.01**
120	1.05	1.03	0.27	1.03
240	1.00	0.95	0.23	1.01
360	0.97	0.91	0.23	0.99
480	0.88	0.86	0.24	0.97

Model stability

Model stability is good, with an acceptable Mass Error Balance (-0.0002%), and a mass error of -0.208 m^3 for the 1% annual chance event in the Baseline scenario.

Sensitivity

The table below summarises the results of the sensitivity tests. The results suggest that the most significant change is where a summer storm profile is applied, with the total flooded area changing by 0.23km^2. These results are as expected as summer storm profiles are more intense than their winter equivalents. Consistent with FEH guidance as a rural catchment, the winter storm profile is the most appropriate profile.

The results of the remaining sensitivity tests demonstrate that the next most significant change is where rainfall or runoff rates are reduced by 20%, with the total flooded area reduced by 0.07km^2 in both instances; the other sensitivity tests result in limited changes. The average depth across the model domain is consistent across all the sensitivity tests. The siltation test had a minimal impact on peak flows through the culverts (a maximum change of <0.04 m^3/s for both culverts for the 1% annual chance event). These tests indicate that the ICM is not sensitive to the changes in the key parameters.

Table 3-2 Summary of sensitivity test results (1% annual chance event)

Scenario	Average Depth (m)	Maximum Depth (m)	Total Flooded Area (km²)	Difference from baseline Flooded Area (km²)
1: Baseline	0.11	1.31	0.37	N/A
2a: i. Design rainfall -20%	0.11	1.27	0.29	-0.07
2a: ii. Design rainfall +20%	0.12	1.35	0.43	0.07
2b: i. Roughness -20%	0.11	1.31	0.35	-0.01
2b: ii. Roughness +20%	0.11	1.31	0.37	0.01
2c: Catchment area specific to culvert upstream inlet	0.11	1.32	0.37	0.00
2d: i. Runoff -20%	0.11	1.27	0.29	-0.07
2d: ii. Runoff +20%	0.12	1.35	0.43	0.06
2e: Culvert siltation levels increased in line with site visit observations (15% siltation in culvert)	0.11	1.32	0.36	0.00
2f: i. Headloss coefficient -20%	0.11	1.31	0.37	0.00
2f: ii. Headloss coefficient +20%	0.11	1.31	0.36	0.00
2g: Summer storm profile	0.13	1.43	0.6	0.23

Verification

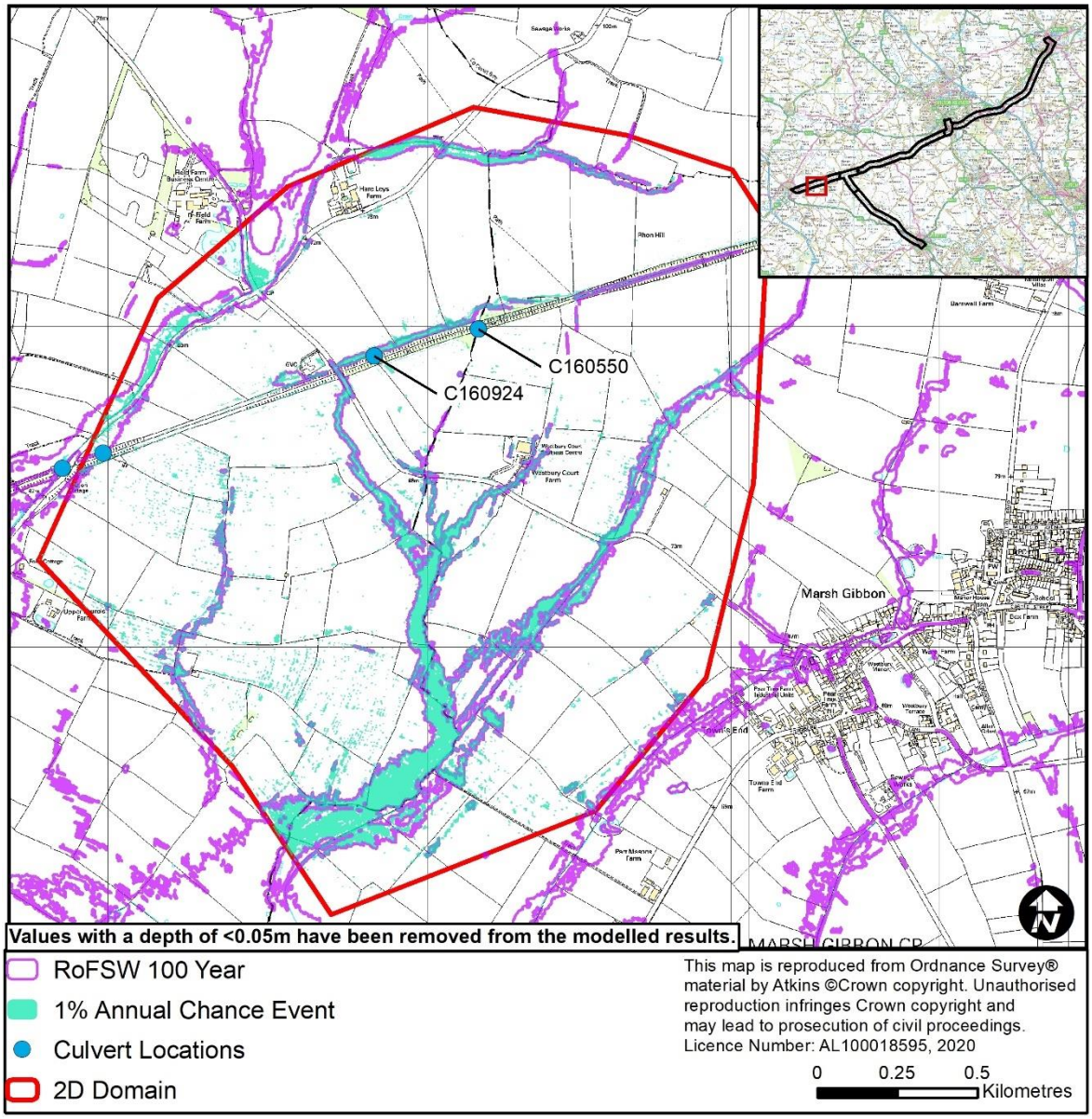
The baseline model predicts a peak flow of 0.89m³/s through culvert C160924 at the 1% annual chance event, and does not indicate a clear flow path to the culvert inlet, with flows moving in an east-west direction; this is consistent with the site visit notes (8th March 2018), which indicated that the ditch feeding the culvert was dry and that limited re-profiling was required to improve the connection. The principal flow route follows the northern side of the EWR2 embankment, then south along Bicester Road, before travelling in a south-easterly direction across agricultural land towards the Ordinary Watercourse south of Westbury Court Farm.

Existing Flood Outlines

Given the catchment size and the rural location, the availability of data to calibrate or verify the hydrological and hydraulic model outputs is limited. In the absence of other data, the model results have been compared with the existing Environment Agency flood extents (Flood Zones 2 and 3, and the RoFSW), in this location against the RoFSW, as shown in the figure below.

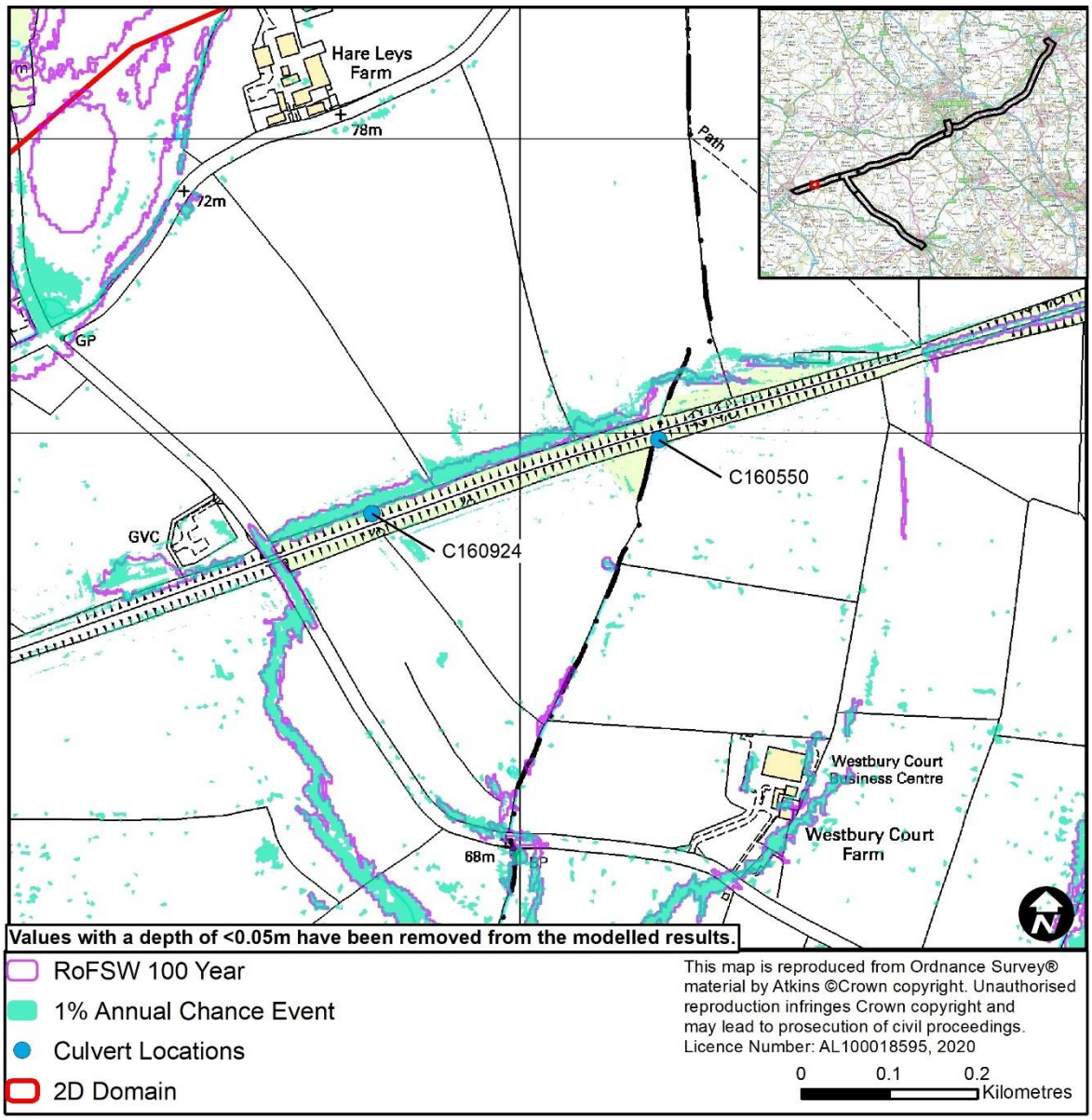
The RoFSW indicates that Bicester Road is at risk of flooding in four locations. This is consistent with the results obtained from the ICM, although flood extents in these locations vary.

Figure 3-1 Comparison of RoFSW and ICM flood extents (1% annual chance event)



At this scale it is clear that the RoFSW outlines and ICM are broadly similar. We would however expect the RoFSW and ICM results to differ in places since ICM includes finer mesh details to represent the channels (and to remove the effect of vegetation on LiDAR levels), and the culverts under the embankments are included, thus flows downstream (south) of the EWR2 route should be greater; this is demonstrated in the following figure which shows the flows path downstream of EWR2 indicated by the ICM, and also the defined flow path upstream of the EWR2 embankment to culvert C160550.

Figure 3-2 Comparison of RoFSW and ICM flood extents (1% annual chance event) – adjacent EWR2



Previous Assessments

The table below summarises the differences between the flows and headwater levels calculated from the direct rainfall method and those calculated during the GRIP 4 culvert assessment. The GRIP 4 assessment utilised the WinDES component in MicroDrainage to derive peak flow estimates at the culvert locations. Bentley CulvertMaster software was then used to determine headwater levels, using these flow estimates and the available topographic survey.

The GRIP 4 assessment increased flows by 70% (Thames river basin), whereas the ICM increases rainfall by 40%. Given the different modelling approaches, chosen to be most appropriate for each stage of analysis there are expected to be differences in results. This demonstrates that the ICM flow estimates are higher for both the 1% annual chance event, and climate change event; therefore, giving a precautionary assessment of flood risk. The difference in headwater levels is likely to be due to the

ICM including a better representation of any storage effects upstream of the culvert, which would lower headwater levels.

Table 3-3 Comparison of flow and level estimates at the upstream culvert inlet (C160924)

Return Period	GRIP 4 Estimate (m^3/s)	ICM Estimate (m^3/s)	Difference (m^3/s)	GRIP 4 Headwater Level (mAOD)	ICM Headwater Level (mAOD)
1% annual chance	0.21	0.28	0.07	73.22	73.03
1% annual chance plus climate change	0.35	0.40	0.05	74.36	73.05

Flow and CulvertMaster assessments were not undertaken at GRIP 4 for culvert C160550 and thus no comparison has been undertaken.

Floodplain Storage Loss Assessment

A loss assessment was completed to show the volume of floodplain losses due to the proposed works. All raster data was resampled to a 0.2m cell size in order to produce an accurate loss estimate due to the small size of the loss area. The following data was used in this assessment:

- Existing ground model;
- Proposed ground model; and
- Flood level grid for all return periods.

The calculated losses are based on comparison of the baseline and With Scheme ground models compared against modelled flood levels. The floodplain losses as a result of changes to the railway embankment in this model reach are shown in the table below.

Table 3-4 Floodplain volume losses

Annual Chance Event (%)	Railway earthworks water level (m AOD)	Total railway earthworks volume lost (m^3)	Volume lost at each return period (m^3)
50%	70.645	0.8	0.8
1%	70.660	20	19
0.5%	70.662	24	3.6
1% + climate change	70.832	26	2.0

The limited volume of lost floodplain has been compensated for within the drainage ditches, including an overprovision of floodplain storage, thus CFSA 2A0325/5.2/FH is not required. The improved drainage ditches have increased the cross-sectional area of the existing ditches by approximately $0.5m^2$ over a length of approximately 2km giving an additional floodplain capacity of over $1000m^3$, a significant oversizing from the total floodplain loss of $26m^3$.

4. With Scheme Modelling

Representation in the Hydraulic Model

The proposed EWR2 works in this location, represented in the ICM, are set out in the table below.

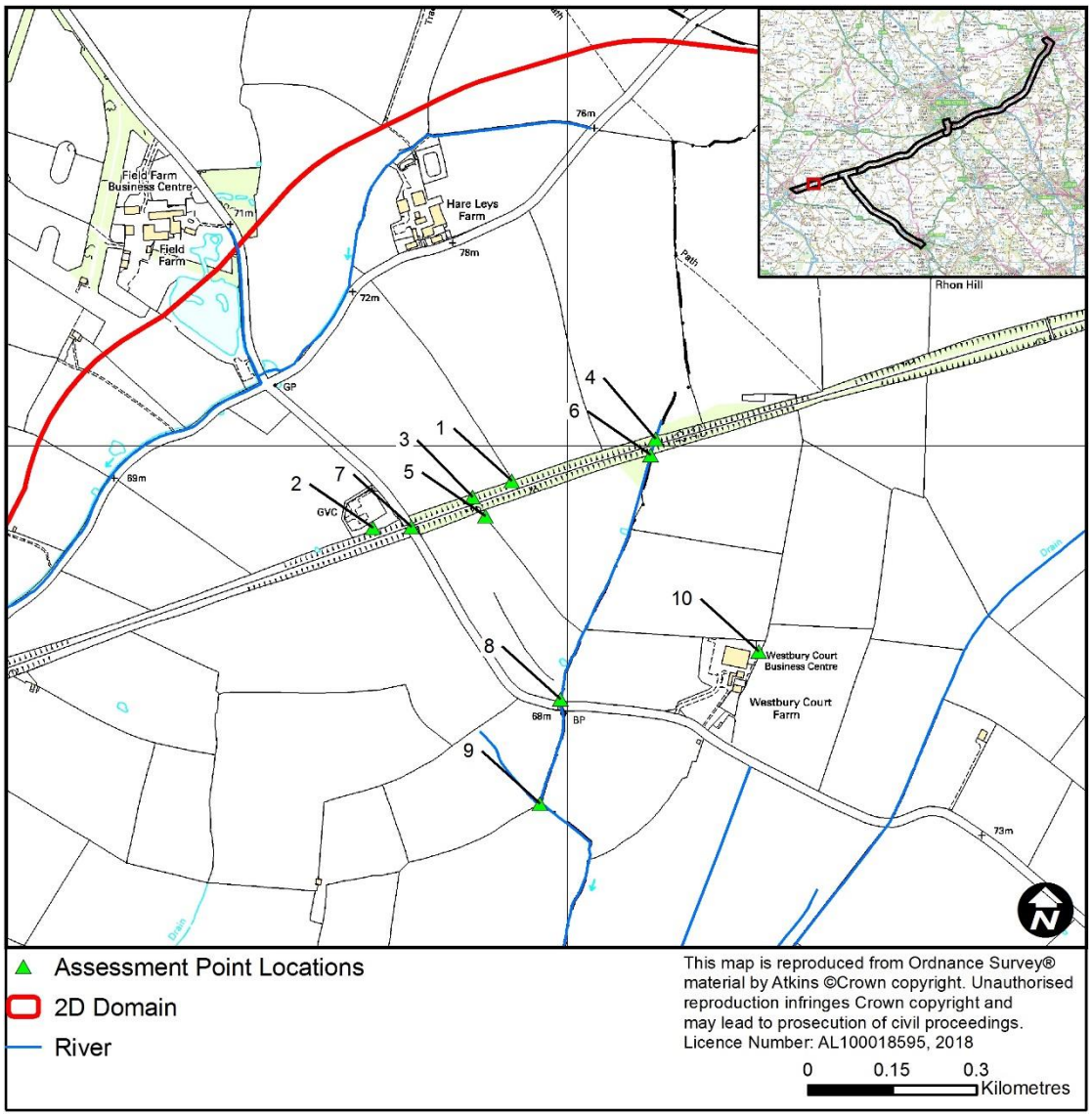
Table 4-1 Proposed works and representation in the model

EWR2 Proposed Work Item	Description of proposals	Representation in model
Culvert C160924	Culvert to be replaced on a like for like basis.	No change from the baseline.
Culvert C160550	CIPP liner for the entire length of the culvert. New precast headwalls to be installed at both ends. No change in culvert length.	Reduced culvert diameter by 40mm to represent liner.
Earthworks	Embankment works proposed along whole length of ICM extent. The proposed works vary along the length, with some extents extremely limited (<0.5m in width) and others 8-10m in width.	A mesh zone based on the detailed earthwork designs has been included.
Track and Land Drainage	The limited volume of lost floodplain has been provided in the drainage ditches, including an overprovision of floodplain storage, thus a separate CFSA is not required.	The improved drainage ditches have been represented as Mesh Level Zones.
CFSA	Not required as limited floodplain volume losses provided in the drainage ditch network.	N/A

Results

The following figure illustrates the location of the ICM results assessment points, referred to in the subsequent results tables.

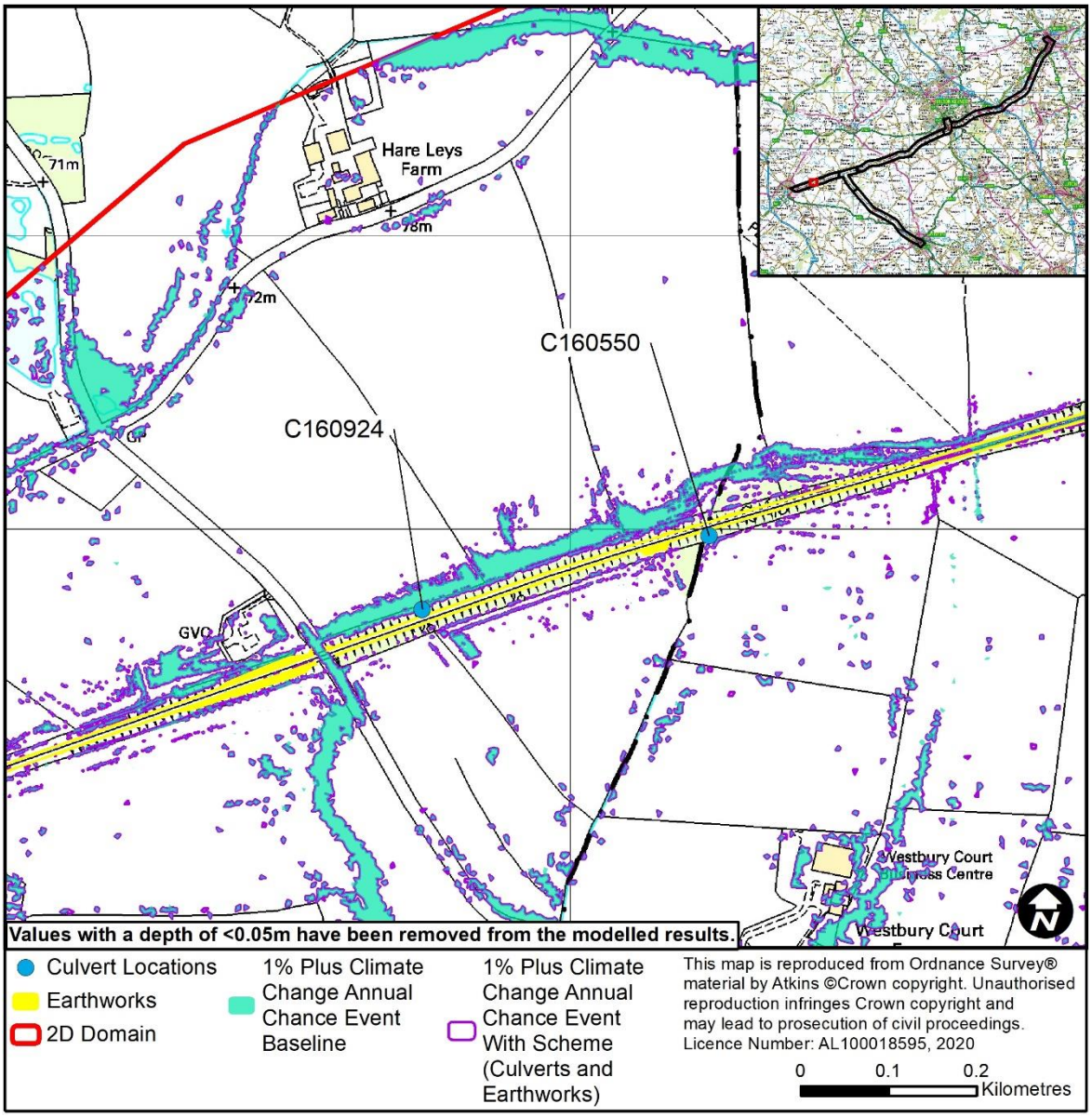
Figure 4-1 ICM Results Assessment Locations



The following figures and tables illustrate the results from the Baseline and With Scheme scenarios.

The differences in flood extent across the entire model domain are limited. The figure below shows the difference in floodplain outlines between the Baseline and With Scheme scenarios and shows that there are no discernible differences, which is supported by the comparisons of peak levels and flows below.

Figure 4-2 Comparison of Baseline and With Scheme flood extents (1% annual chance event plus climate change)



The table below compares the peak water levels between the baseline and With Scheme scenario; this demonstrates that there is limited change in flood levels (maximum change of 40mm), with most locations showing no change. Between the Gas Utility Compound and the EWR2 route there is an increase of 20mm at the 50% annual chance event. At culvert C160550 there are limited increases in peak water level of 40mm at the culvert inlet, and 20mm at the culvert outlet for the 1% annual chance plus climate change event. These changes are reflected in the minimal variation in flood extents shown above. All increases fall within the project red line boundary.

Table 4-2 Comparison of Baseline and With Scheme

No.	Location Description	Peak Water Level (mAOD)					
		50% annual chance event		1% annual chance event		1% annual chance + climate change event	
		Baseline	With Scheme	Baseline	With Scheme	Baseline	With Scheme
1	Northern side of the EWR2 route adjacent field boundary to the east of C160924	73.17	73.17	73.38	73.38	73.42	73.42
2	Between Gas Utility Compound and EWR2 route (within permanent land take)	71.94	71.96	72.23	72.22	72.26	72.26
3	Upstream culvert inlet (C160924)	72.76	72.76	73.06	73.05	73.11	73.11
4	Upstream culvert inlet (C160550)	74.96	74.96	74.98	75.01	74.99	75.03
5	Downstream culvert outlet (C160924)	72.19	72.19	72.32	72.32	72.35	72.35
6	Downstream culvert outlet (C160550)	74.91	74.91	74.93	74.94	74.93	74.95
7	Bicester Road at EWR2 crossing	70.42	70.42	71.30	71.30	71.48	71.48
8	Immediately upstream of the Ordinary Watercourse crossing of Bicester Road, west of Westbury Court Farm	67.93	67.93	68.33	68.33	68.40	68.40
9	Ordinary Watercourse confluence, downstream of Bicester Road	66.65	66.64	66.72	66.71	66.76	66.75
10	Westbury Court Farm	70.49	70.49	70.52	70.52	70.54	70.54

The following table illustrates the differences in peak water levels between the Baseline and With Scheme scenarios.

Table 4-3 Differences in peak water levels between Baseline and With Scheme

No.	Location Description	Difference in Peak Water Level (m)		
		Annual Chance Events		
		50% annual chance event	1% annual chance event	1% annual chance + climate change event
1	Northern side of the EWR2 route adjacent field boundary to the east of C160924	0.00	0.00	0.00
2	Between Gas Utility Compound and EWR2 route (within permanent land take)	0.02	-0.01	0.00
3	Upstream culvert inlet (C160924)	0.00	-0.01	0.00
4	Upstream culvert inlet (C160550)	0.00	0.03	0.04
5	Downstream culvert outlet (C160924)	0.00	0.00	0.00
6	Downstream culvert outlet (C160550)	-0.01	0.01	0.02
7	Bicester Road at EWR2 crossing	0.00	0.00	0.00
8	Immediately upstream of the Ordinary Watercourse crossing of Bicester Road, west of Westbury Court Farm	0.00	0.00	0.00
9	Ordinary Watercourse confluence, downstream of Bicester Road	0.00	0.00	0.00
10	Westbury Court Farm	0.00	0.00	0.00

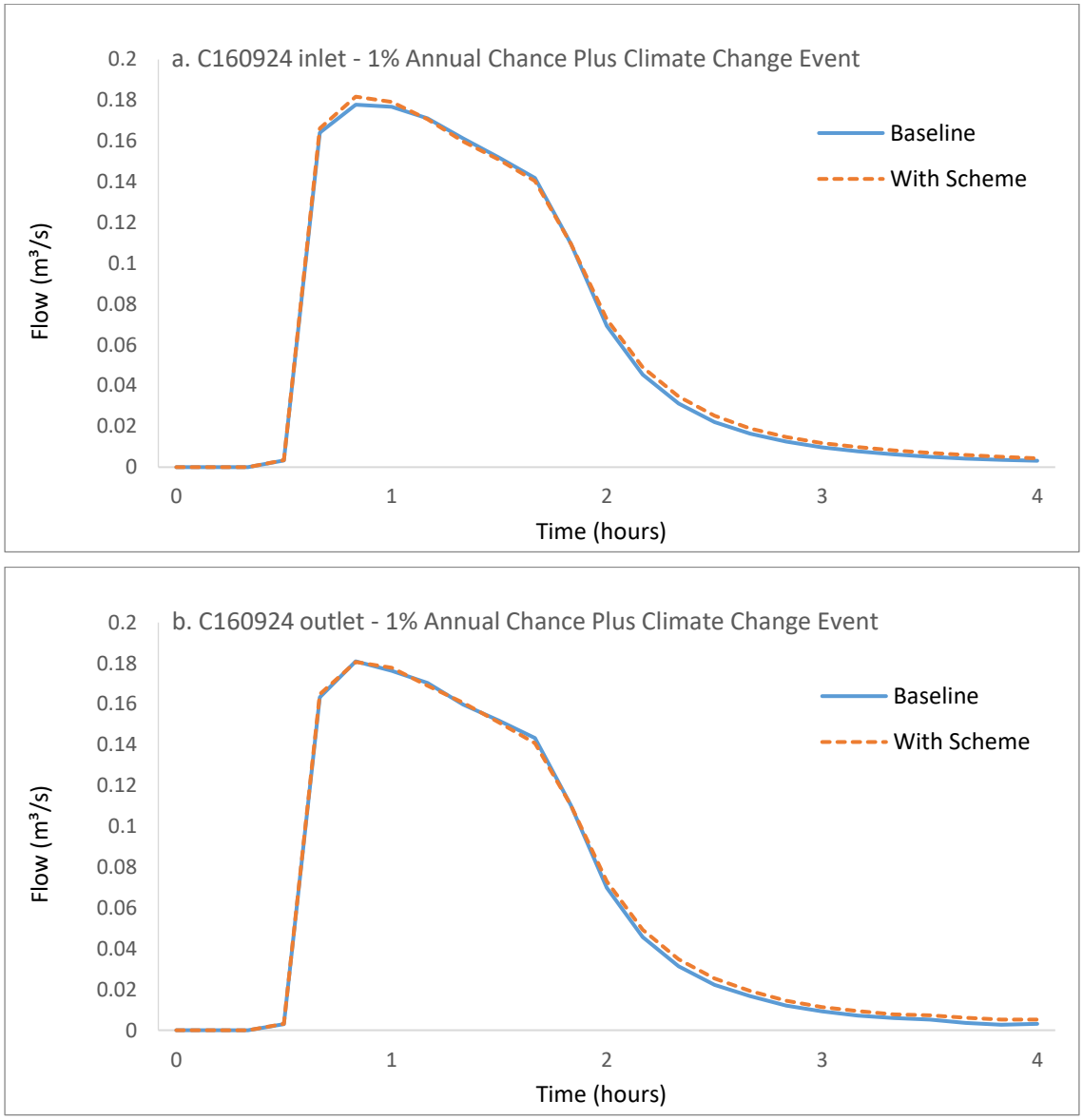
All increases in peak water level are within the red line boundary. The following table compares the peak flows for the Baseline and With Scheme scenarios, and confirms the pattern seen in the floodplain extents and peak water levels, with either no change or negligible differences in peak flows observed across the assessment points.

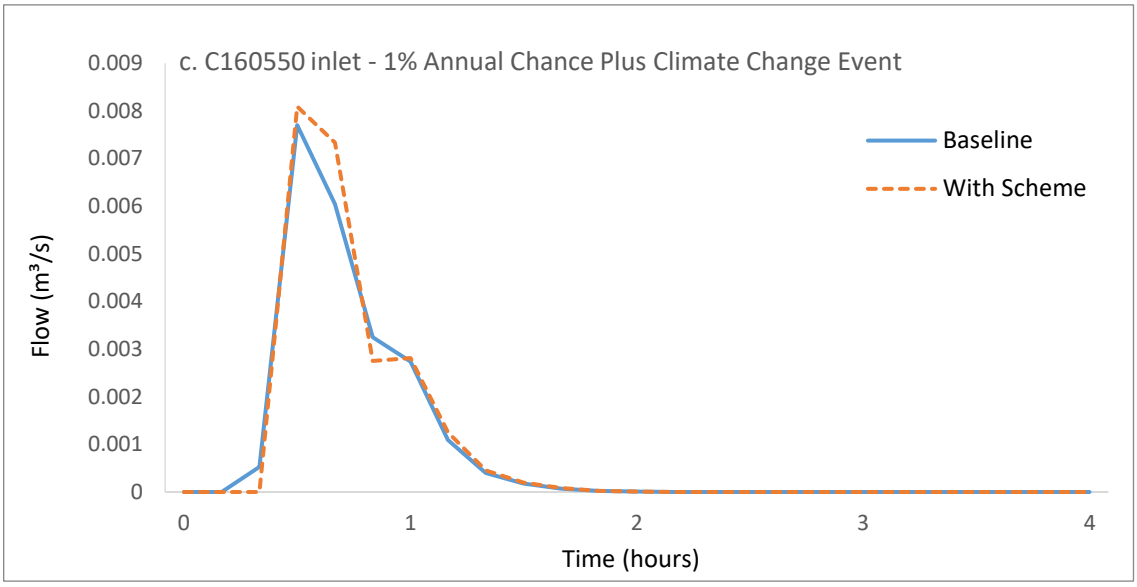
Table 4-4: Comparison of Peak Flows between Baseline and With Scheme

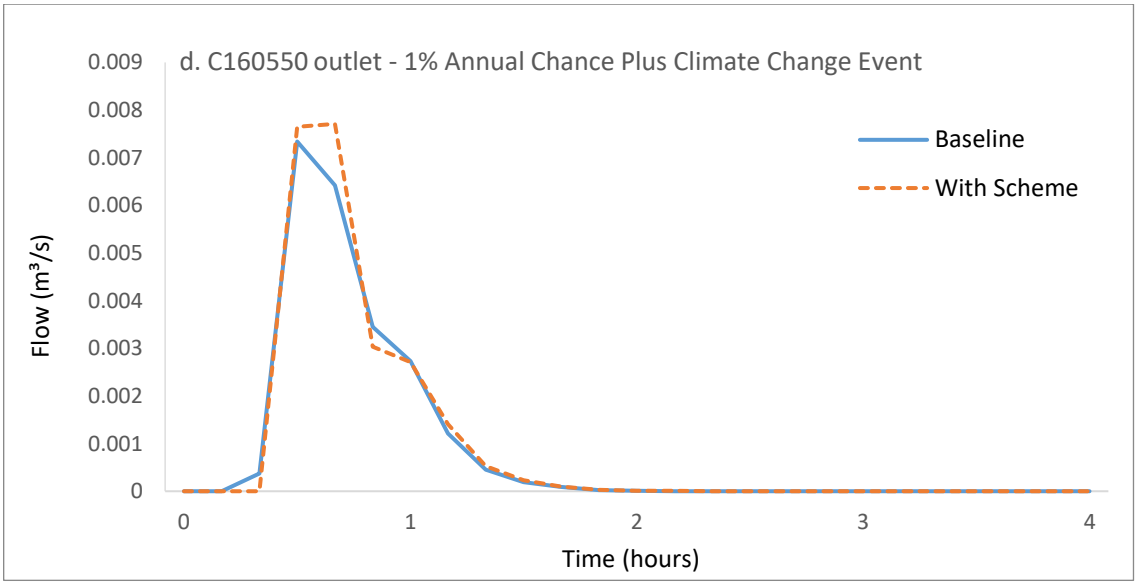
No.	Location Description	Peak Flow (m^3/s)					
		50% annual chance event		1% annual chance event		1% annual chance + climate change event	
		Baseline	With Scheme	Baseline	With Scheme	Baseline	With Scheme
1	Northern side of the EWR2 route adjacent field boundary to the east of C160924	0.10	0.10	0.61	0.61	0.84	0.82
2	Between Gas Utility Compound and EWR2 route	0.00	0.00	0.00	0.00	0.01	0.01
3	Upstream culvert inlet (C160924)	0.10	0.10	0.18	0.18	0.19	0.19
4	Upstream culvert inlet (C160550)	0.00	0.00	0.01	0.01	0.01	0.01
5	Downstream culvert outlet (C160924)	0.10	0.10	0.17	0.17	0.19	0.18
6	Downstream culvert outlet (C160550)	0.00	0.00	0.01	0.01	0.01	0.01
7	Bicester Road at EWR2 crossing	0.01	0.01	0.69	0.66	1.38	1.38
8	Immediately upstream of the Ordinary Watercourse crossing of Bicester Road, west of Westbury Court Farm	0.10	0.10	0.42	0.42	0.45	0.45
9	Ordinary Watercourse confluence, downstream of Bicester Road	0.06	0.05	0.82	0.79	1.71	1.67
10	Westbury Court Farm	0.00	0.00	0.01	0.01	0.01	0.01

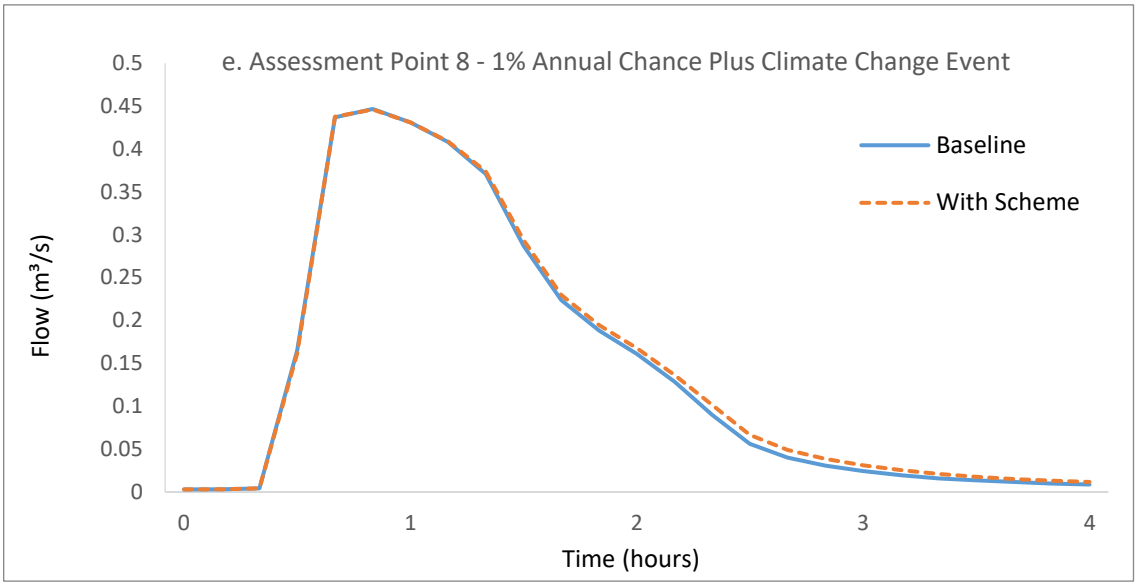
The following figure illustrates the flow hydrographs for the Baseline and With Scheme scenarios for the 1% annual chance plus climate change event. Small changes at the inlet and outlet of the culverts can be observed. While marginal, these increases are to be expected due to the minor increase in flow arriving at the culverts as a result of the improved drainage ditches. However, the hydrographs can be seen to be un-changed at assessment point 8 downstream of the culverts demonstrating any changes due to the works are localised and fall within the red line boundary. It should be noted that the flows through culvert C160550 are extremely limited, with peak flows of <0.01m^3/s at the 1% annual chance plus climate change event.

Figure 4-3 Flow hydrograph comparisons between Baseline and With Scheme (1% annual chance event plus climate change)




c. C160550 inlet - 1% Annual Chance Plus Climate Change Event
Flow (m³/s)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0
1
2
3
4
Time (hours)
Baseline
With Scheme


d. C160550 outlet - 1% Annual Chance Plus Climate Change Event
Flow (m³/s)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0
1
2
3
4
Time (hours)
Baseline
With Scheme



This assessment has demonstrated that the proposed culvert works, earthworks and drainage improvements have a minimal impact to peak water levels, flows and floodplain extents, with predicted increases within the red line boundary.

Blockage Assessment

The Project Wide FRA has indicated that a qualitative blockage assessment is required, owing to the rural location and receptors within the study area; a quantitative assessment using the ICM was not considered necessary.

Blockage of the C160924 culvert would increase culvert surcharge and water levels in the area upstream of the culvert. However, the EWR2 is on embankment in this location and LiDAR levels suggest there is >2m of freeboard to the track level for up to and including the 1% annual chance event with climate change (With Scheme (culverts and earthworks) scenario). Receptors upstream and downstream are limited to agricultural land and Bicester Road. In the event of blockage additional flows may be conveyed towards Bicester Road, and flood larger areas of agricultural land to the west of the culvert; however, given the duration and scale of the peak flows these impacts would be of limited duration.

If culvert C160550 blocks this would send additional flows downstream to the C160924 culvert, and subsequently Bicester Road. As stated above, given the duration and scale of the peak flows this impact would be of limited duration.

5. Conclusions

This CFSA Modelling Report has the following conclusions:

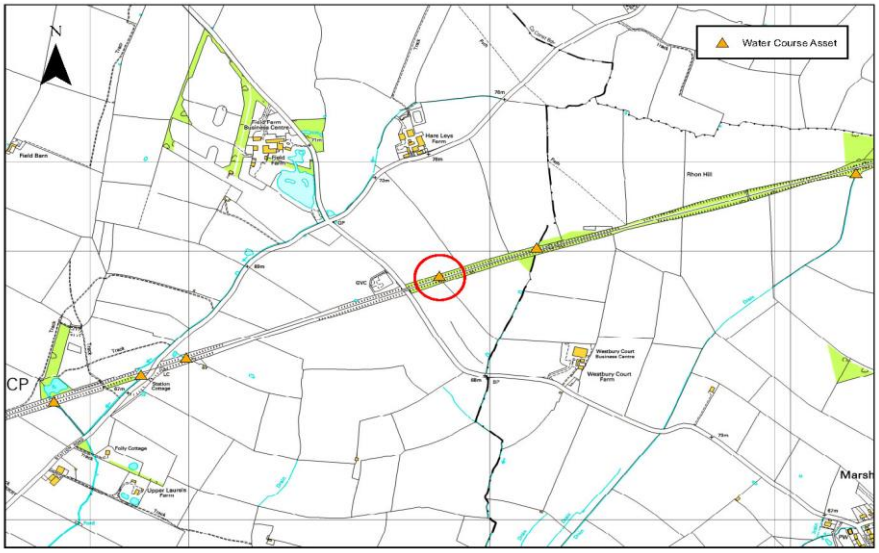
- This report is submitted to discharge Planning Condition 13 and is submitted in line with the Planning Condition 13 Phasing Strategy, and is located in development stage 2A2;
- This assessment has improved the understanding of the flood risk mechanisms for these culverts, and upstream and downstream areas, where receptors indicated to be in the floodplain in the baseline case are agricultural land, Bicester Road, the Gas Utility Compound and Westbury Court Farm. The potential impacts of climate change were assessed by increasing rainfall by 40%;
- The detailed hydrological and hydraulic modelling and latest earthwork designs have been used to define the floodplain losses. The total floodplain volume losses as a result of the proposed earthworks are 26m³. The improved drainage ditches have increased the cross-sectional area of the existing ditches and provide an additional floodplain volume of 1000m³. Therefore, CFSA 2A0325/5.2/FH is not required;
- The ICM was used to test the proposed culvert, earthworks and drainage improvements to assess potential changes in flood extents and levels upstream and downstream. Culvert C160924 is being replaced on a like for like basis therefore will result in no change upstream or downstream. Culvert C160550 is being improved with a liner. The ICM demonstrates that there are generally either no changes or minor reductions in peak water level as a result of the proposed works. The only increases in peak water level are within the permanent red line boundary; and
- The modelling has confirmed that the culvert, earthwork and drainage improvements are acceptable from a flood risk perspective, with the precautionary assessment indicating no impact on flood risk.

6. Appendix A – Project Wide FRA Site Summary Report

Summary Flood Risk Assessment

Asset Information

Site Location Map



Crossing reference/floodplain	7	
Route Section	2A	
Culvert ID	C160924	
NGR	462832, 223908	
EWR-ELR	OXD	
Lead Local Flood Authority	Oxfordshire County Council	
Environment Agency Region	Thames	
River Basin District	Thames	
Watercourse Type	Surface water flow path	
Water ES Chapter Watercourse Reference	N/A	
Existing Culvert/Crossing Size	350	(mm)
Existing Culvert/Crossing Length	24	(m)
Existing Culvert/Crossing Type	PVC/ Circular	

Proposed Works

Culvert Recommendation	Existing culvert to be replaced. New precast headwalls to be installed at both ends.	
Track Level	75.45	(mAOD)

Hydrological and Hydraulic Analysis

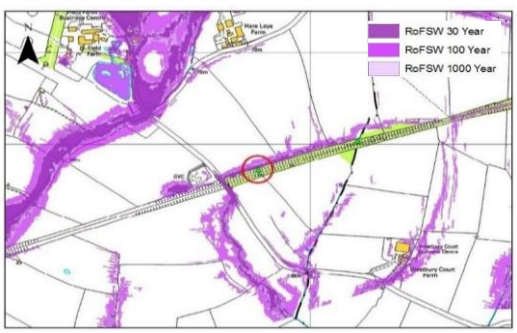
Climate Change allowance: 70 (%)

	Flows (l/s)	Headwater Level (mAOD)	Freeboard to track (m)
75-year	191.40	73.14	2.31
100-year	206.70	73.22	2.23
100-year + 70%CC	351.39	74.36	1.09

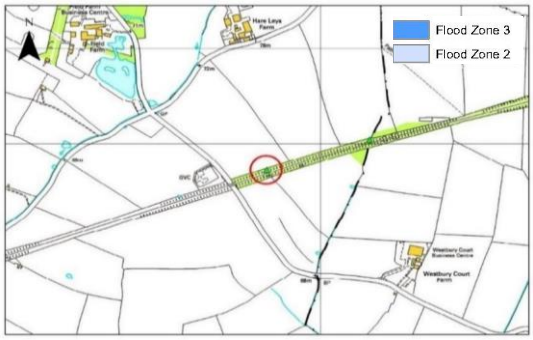
Performance Code	3	
Performance Code description	Culvert is under capacity i.e. HW elevation> culvert soffit level	
Freeboard at 100-year event	>1	(m)

Floodplain Maps

RoFSW



Environment Agency Flood Zones



Description of groundwater flooding	Very low / Limited flood risk
Groundwater flood risk	This zone is deemed as having a negligible risk from groundwater flooding due to the nature of the geological deposits.

Proposed Mitigation	CFSA
Principal Flood Risk Source	Surface Water
Blockage Assessment Required	Yes

Sensitivity of Receptors

1) Floodplain or defence protecting more than 100 residential properties from flooding	No
2) Areas where highly vulnerable development is at risk of flooding - such as essential infrastructure, emergency services and basement dwellings.	No
	N/A
1) Floodplain or defence protecting between 1 and 100 residential properties or industrial premises from flooding.	No
2) Areas where development that is more vulnerable is at risk of flooding; hospitals, residential units, educational facilities and waste management sites.	No
	N/A
1) Floodplain or defence protecting 10 or fewer industrial properties from flooding.	No
2) Areas where less vulnerable development is at risk of flooding - such as retail, commercial and general industrial units, agricultural/forestry sites	Yes
	Medium
1) Floodplain with limited constraints and a low probability of flooding of residential and industrial properties.	No
2) Areas that are considered to be water-compatible; flood control infrastructure, docks/marinas, pumping stations and landscape/recreational areas	No
	N/A

Sensitivity of Receptor:	Medium

Magnitude of Impact

Construction

Excluding Mitigation	Medium Adverse

	Rating	Definition
No	High Adverse	· Increase in peak flood level (1% annual probability event) > 100mm. · Loss of functional floodplain flood storage areas.- Increases flood risk to property and/or infrastructure
Yes	Medium Adverse	· Increase in peak flood level (1% annual probability event) > 50mm. - increases flood risk to third party farm land/open space
No	Low Adverse	· Increase in peak flood level (1% annual probability event) > 10mm. - increases flood risk to Network Rail land
No	Very Low Adverse	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor increase in flood risk to Network Rail land
No	No Change	· No predicted adverse or beneficial impact to the receptor.
No	High Beneficial	· Reduction in peak flood level (1% annual probability event) > 100mm. -Decreases flood risk to property and/or infrastructure
No	Medium Beneficial	· Reduction in peak flood level (1% annual probability event) > 50mm. - Decreases flood risk to third party farm land/open space
No	Low Beneficial	· Reduction in peak flood level (1% annual probability event) > 10mm. -Decreases flood risk to Network Rail land
No	Very Low Beneficial	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor decrease in flood risk to Network Rail land

Including Mitigation	Very Low Adverse

	Rating	Definition
No	High Adverse	· Increase in peak flood level (1% annual probability event) > 100mm. · Loss of functional floodplain flood storage areas.- Increases flood risk to property and/or infrastructure
No	Medium Adverse	· Increase in peak flood level (1% annual probability event) > 50mm. - increases flood risk to third party farm land/open space
No	Low Adverse	· Increase in peak flood level (1% annual probability event) > 10mm. - increases flood risk to Network Rail land
Yes	Very Low Adverse	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor increase in flood risk to Network Rail land
No	No Change	· No predicted adverse or beneficial impact to the receptor.
No	High Beneficial	· Reduction in peak flood level (1% annual probability event) > 100mm. -Decreases flood risk to property and/or infrastructure
No	Medium Beneficial	· Reduction in peak flood level (1% annual probability event) > 50mm. - Decreases flood risk to third party farm land/open space
No	Low Beneficial	· Reduction in peak flood level (1% annual probability event) > 10mm. -Decreases flood risk to Network Rail land
No	Very Low Beneficial	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor decrease in flood risk to Network Rail land

Operation

Excluding Mitigation	Medium Adverse

	Rating	Definition
No	High Adverse	· Increase in peak flood level (1% annual probability event) > 100mm. · Loss of functional floodplain flood storage areas.- Increases flood risk to property and/or infrastructure
Yes	Medium Adverse	· Increase in peak flood level (1% annual probability event) > 50mm. - increases flood risk to third party farm land/open space
No	Low Adverse	· Increase in peak flood level (1% annual probability event) > 10mm. - increases flood risk to Network Rail land
No	Very Low Adverse	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor increase in flood risk to Network Rail land
No	No Change	· No predicted adverse or beneficial impact to the receptor.
No	High Beneficial	· Reduction in peak flood level (1% annual probability event) > 100mm. -Decreases flood risk to property and/or infrastructure
No	Medium Beneficial	· Reduction in peak flood level (1% annual probability event) > 50mm. - Decreases flood risk to third party farm land/open space

No	Low Beneficial	· Reduction in peak flood level (1% annual probability event) > 10mm. -Decreases flood risk to Network Rail land
No	Very Low Beneficial	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor decrease in flood risk to Network Rail land

Including Mitigation	Very Low Adverse

	Rating	Definition
No	High Adverse	· Increase in peak flood level (1% annual probability event) > 100mm. · Loss of functional floodplain flood storage areas.- Increases flood risk to property and/or infrastructure
No	Medium Adverse	· Increase in peak flood level (1% annual probability event) > 50mm. - increases flood risk to third party farm land/open space
No	Low Adverse	· Increase in peak flood level (1% annual probability event) > 10mm. - increases flood risk to Network Rail land
Yes	Very Low Adverse	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor increase in flood risk to Network Rail land
No	No Change	· No predicted adverse or beneficial impact to the receptor.
No	High Beneficial	· Reduction in peak flood level (1% annual probability event) > 100mm. -Decreases flood risk to property and/or infrastructure
No	Medium Beneficial	· Reduction in peak flood level (1% annual probability event) > 50mm. - Decreases flood risk to third party farm land/open space
No	Low Beneficial	· Reduction in peak flood level (1% annual probability event) > 10mm. -Decreases flood risk to Network Rail land
No	Very Low Beneficial	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor decrease in flood risk to Network Rail land

Significance of Effect

Construction

Sensitivity of Receptor	Medium
Magnitude (beneficial/adverse) (excluding mitigation)	Medium Adverse
Potential Significance of Effect (excluding mitigation)	Moderate
Magnitude (beneficial/adverse) (including mitigation)	Very Low Adverse
Residual Significance of Effect (including mitigation)	Negligible
Include in Environmental Statement Main Body	YES

Operation

Sensitivity of Receptor	Medium
Magnitude (beneficial/adverse) (excluding mitigation)	Medium Adverse
Potential Significance of Effect (excluding mitigation)	Moderate
Magnitude (beneficial/adverse) (including mitigation)	Very Low Adverse
Residual Significance of Effect (including mitigation)	Negligible
Include in Environmental Statement Main Body	YES

Summary

This assessment has been based on existing Environment Agency RoFSW flooding and Flood Zones 2 and 3. The flood risk at this point is limited to surface water flooding, with the area on the northern side of the embankment shown to be at risk from the 30-year event upwards. EWR is raised on embankment and the area at risk of surface water flooding is very small, at the road crossing. The surface water flooding appears to be associated with overland flows with no ditches/small watercourses in the area. There is limited/very low fluvial or groundwater flood risk in this location. Assets within the floodplain are limited to the Network Rail land, the adjoining agricultural land and to Bicester Road. Works comprise - embankment works limited to a restricted area, with the Bicester Road underbridge to receive general repairs and replacement deck, and culvert to be replaced. A CFSA is proposed to mitigate the impact. Culvert assessment indicates that the culvert is performing under its capacity, i.e. the head water elevation is higher than the culvert soffit level. As compensation has been proposed to provide storage for the flood water displaced by the widening of the railway embankment footprint and for the works to the culvert, it is considered that the increase in flood risk is negligible. A haul road is proposed in this location, which crosses an area at risk of surface water flooding. The proposed haul road route does not cross any watercourse, and therefore will not require a new culvert crossing. The haul road route will be at existing ground level and will not therefore result in a loss of floodplain storage.

Summary Flood Risk Assessment

Asset Information

Site Location Map

Crossing reference/floodplain	8	
Route Section	2A	
Culvert ID	C160550	
NGR	463158, 223992	
EWR-ELR	OXD	
Lead Local Flood Authority	Oxfordshire County Council	
Environment Agency Region	Thames	
River Basin District	Thames	
Watercourse Type	Ordinary Watercourse	
Water ES Chapter Watercourse Reference	2A 005	
Existing Culvert/Crossing Size	800	(mm)
Existing Culvert/Crossing Length	26	(m)
Existing Culvert/Crossing Type	Brick Arch with Flat Bottom	

Proposed Works

Culvert Recommendation	CIPP liner for the entire length of the culvert. New precast headwalls to be installed at both ends.	
Track Level	77.58	(mAOD)

Hydrological and Hydraulic Analysis

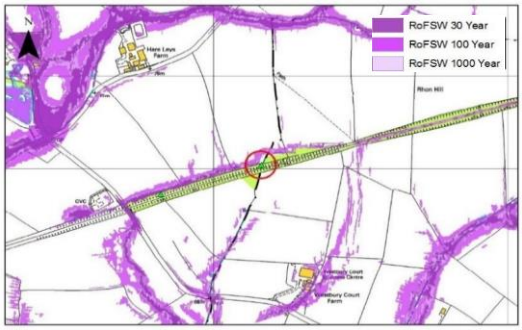
Climate Change allowance: 70 (%)

	Flows (l/s)	Headwater Level (mAOD)	Freeboard to track (m)
75-year	130.10	75.11	2.47
100-year	140.50	75.12	2.46
100-year + 70%CC	238.85	75.21	2.37

Performance Code	1	
Performance Code description	Culvert is performing in a free flowing condition i.e. Max HWL<HWE	
Freeboard at 100-year event	>1	(m)

Floodplain Maps

RoFSW



Environment Agency Flood Zones

Description of groundwater flooding	Very low / Limited flood risk
Groundwater flood risk	This zone is deemed as having a negligible risk from groundwater flooding due to the nature of the geological deposits.

Proposed Mitigation	None
Principal Flood Risk Source	Surface Water
Blockage Assessment Required	No

Sensitivity of Receptors

1) Floodplain or defence protecting more than 100 residential properties from flooding	No
2) Areas where highly vulnerable development is at risk of flooding - such as essential infrastructure, emergency services and basement dwellings.	No
	N/A
1) Floodplain or defence protecting between 1 and 100 residential properties or industrial premises from flooding.	No
2) Areas where development that is more vulnerable is at risk of flooding; hospitals, residential units, educational facilities and waste management sites.	No
	N/A
1) Floodplain or defence protecting 10 or fewer industrial properties from flooding.	No
2) Areas where less vulnerable development is at risk of flooding - such as retail, commercial and general industrial units, agricultural/forestry sites	Yes
	Medium
1) Floodplain with limited constraints and a low probability of flooding of residential and industrial properties.	No
2) Areas that are considered to be water-compatible; flood control infrastructure, docks/marinas, pumping stations and landscape/recreational areas	No
	N/A

Sensitivity of Receptor:	Medium

Magnitude of Impact

Construction

Excluding Mitigation	Very Low Adverse

	Rating	Definition
No	High Adverse	· Increase in peak flood level (1% annual probability event) > 100mm. · Loss of functional floodplain flood storage areas.- Increases flood risk to property and/or infrastructure
No	Medium Adverse	· Increase in peak flood level (1% annual probability event) > 50mm. - increases flood risk to third party farm land/open space
No	Low Adverse	· Increase in peak flood level (1% annual probability event) > 10mm. - increases flood risk to Network Rail land
Yes	Very Low Adverse	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor increase in flood risk to Network Rail land
No	No Change	· No predicted adverse or beneficial impact to the receptor.
No	High Beneficial	· Reduction in peak flood level (1% annual probability event) > 100mm. -Decreases flood risk to property and/or infrastructure
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No	Very Low Beneficial	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor decrease in flood risk to Network Rail land

Including Mitigation	Very Low Adverse

	Rating	Definition
No	High Adverse	· Increase in peak flood level (1% annual probability event) > 100mm. · Loss of functional floodplain flood storage areas.- Increases flood risk to property and/or infrastructure
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No	Very Low Beneficial	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor decrease in flood risk to Network Rail land

Operation

Excluding Mitigation	Very Low Adverse

	Rating	Definition
No	High Adverse	· Increase in peak flood level (1% annual probability event) > 100mm. · Loss of functional floodplain flood storage areas.- Increases flood risk to property and/or infrastructure
No	Medium Adverse	· Increase in peak flood level (1% annual probability event) > 50mm. - increases flood risk to third party farm land/open space
No	Low Adverse	· Increase in peak flood level (1% annual probability event) > 10mm. - increases flood risk to Network Rail land
Yes	Very Low Adverse	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor increase in flood risk to Network Rail land
No	No Change	· No predicted adverse or beneficial impact to the receptor.
No	High Beneficial	· Reduction in peak flood level (1% annual probability event) > 100mm. -Decreases flood risk to property and/or infrastructure
No	Medium Beneficial	· Reduction in peak flood level (1% annual probability event) > 50mm. - Decreases flood risk to third party farm land/open space

No	Low Beneficial	· Reduction in peak flood level (1% annual probability event) > 10mm. -Decreases flood risk to Network Rail land
No	Very Low Beneficial	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor decrease in flood risk to Network Rail land

Including Mitigation	Very Low Adverse

	Rating	Definition
No	High Adverse	· Increase in peak flood level (1% annual probability event) > 100mm. · Loss of functional floodplain flood storage areas.- Increases flood risk to property and/or infrastructure
No	Medium Adverse	· Increase in peak flood level (1% annual probability event) > 50mm. - increases flood risk to third party farm land/open space
No	Low Adverse	· Increase in peak flood level (1% annual probability event) > 10mm. - increases flood risk to Network Rail land
Yes	Very Low Adverse	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor increase in flood risk to Network Rail land
No	No Change	· No predicted adverse or beneficial impact to the receptor.
No	High Beneficial	· Reduction in peak flood level (1% annual probability event) > 100mm. -Decreases flood risk to property and/or infrastructure
No	Medium Beneficial	· Reduction in peak flood level (1% annual probability event) > 50mm. - Decreases flood risk to third party farm land/open space
No	Low Beneficial	· Reduction in peak flood level (1% annual probability event) > 10mm. -Decreases flood risk to Network Rail land
No	Very Low Beneficial	· Negligible change in peak flood level (1% annual probability event) < 10mm. - very minor decrease in flood risk to Network Rail land

Significance of Effect

Construction

Sensitivity of Receptor	Medium
Magnitude (beneficial/adverse) (excluding mitigation)	Very Low Adverse
Potential Significance of Effect (excluding mitigation)	Negligible
Magnitude (beneficial/adverse) (including mitigation)	Very Low Adverse
Residual Significance of Effect (including mitigation)	Negligible
Include in Environmental Statement Main Body	No

Operation

Sensitivity of Receptor	Medium
Magnitude (beneficial/adverse) (excluding mitigation)	Very Low Adverse
Potential Significance of Effect (excluding mitigation)	Negligible
Magnitude (beneficial/adverse) (including mitigation)	Very Low Adverse
Residual Significance of Effect (including mitigation)	Negligible
Include in Environmental Statement Main Body	No

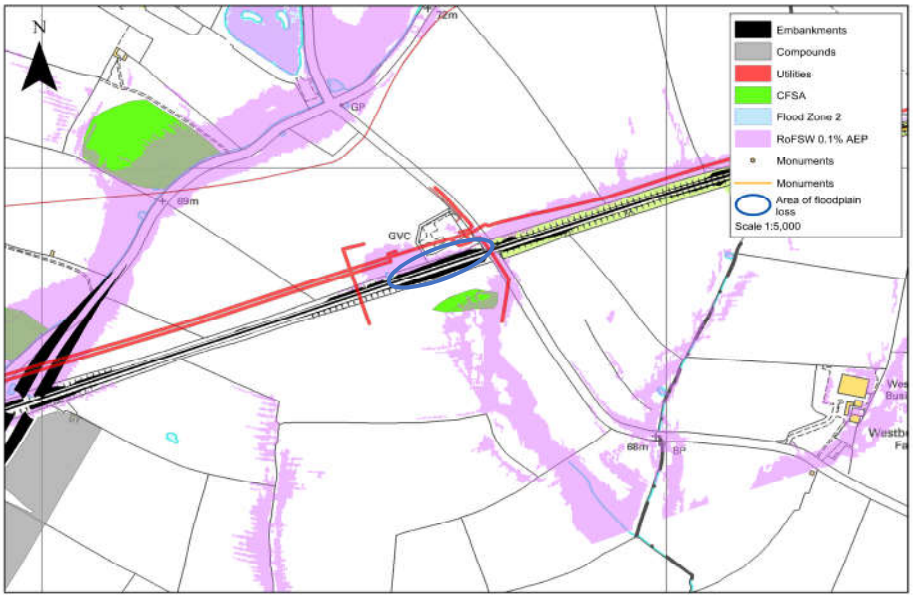
Summary

This assessment has been based on existing Environment Agency RoFSW flooding and Flood Zones 2 and 3. EWR is raised on embankment and is not at flood risk. The flood risk at this point is limited to surface water flooding, with an area on the northern side of the embankment shown to be at risk from the 30-year event upwards. The surface water flooding appears to be associated with overland flows, with no watercourses/ditches on the northern side of the track. There is limited/very low fluvial or groundwater flood risk in proximity of the track. Assets within the floodplain are limited to Network Rail land and adjoining agricultural land; the Westbury Court Business Centre (400m south of the track), is shown also to be at risk of surface water flooding. Limited works in this area - earthworks in a restricted area. Existing culvert to be rehabilitated. New headwalls to be installed at both ends of the culvert. The culvert assessment reveals that the culvert is performing in a free-flowing condition. Owing to the limited amount of the track works, and since the works on the culvert include only rehabilitation, mitigation is not considered to be necessary in this location.

7. Appendix B – CFSA Summary Report

CFSA Summary

Site Location Map



CFSA Number	2A0325 / 5.2 / FH
Route Section	2A
NGR	462663, 223771
EWR-ELR	OXD
Lead Local Flood Authority	Oxfordshire County Council
Environment Agency Region	Thames
Flood Risk Source	Surface water
Works requiring CFSA	Railway embankment works

Floodplain Loss Information

Area of proposed works in the 1000-year event floodplain	8	m^2
Indicative floodplain volume loss (1000-year)	244	m^3

	Minimum Elevation (m AOD)	Maximum Elevation (m AOD)	Difference in level (m)
Existing ground levels at the loss	72.0	73.10	1.1

Proposed CFSA

Estimated area required based on floodplain loss	758	m^2
Proposed CFSA area	1092	m^2
Minimum Indicative CFSA Volume (0.1m excavation depth)	55	m^3
Maximum Indicative CFSA Volume (excavation to maximum available depth)	327	m^3

	Minimum Elevation (m AOD)	Maximum Elevation (m AOD)	Difference in level (m)
Existing levels at proposed CFSA	71.0	71.6	0.6

Summary

This assessment has been based on existing Environment Agency RoFSW maps. The proposed CFSA has been designed to provide storage for losses arising from embankment widening. The CFSA is located approximately 40m south of the main areas of floodplain loss; this location avoids nearby gas and communication exclusion zones. The CFSA will connect back into the surface water flow path.

Loss of floodplain Storage calculation

1) At the loss of floodplain – in order to derive the level-area relationship for the land lost as floodplain the following steps are undertaken:
   a) Calculate the area (m^2) under the footprint of the Project that is flooded during a 1 in 1000-year event (using modelled data/RoFSW 1 in 1000-year outline / Environment Agency Flood Zone 2).
   b) An automated depth/area Arc GIS tool was used to calculate the level area relationship, to derive an estimate of floodplain volume lost.

a) Floodpain loss (m²)	8.00
Peak Water Level (mAOD)	73.10
b) Floodplain Volume Loss (m³)	244.35

Water Level Source: Environment Agency RoFSW 1000-year flood map

Level Area relationship embankment

WetArea (m²)	Elevation (mAOD)	DryArea (m²)	Volume (m³)
0.00	71.00	288.00	0.00
0.00	71.10	288.00	0.00
0.00	71.20	288.00	0.00
0.00	71.30	288.00	0.00
0.00	71.40	288.00	0.00
0.00	71.50	288.00	0.00
0.00	71.60	288.00	0.00
0.00	71.70	288.00	0.00
0.00	71.80	288.00	0.00
0.00	71.90	288.00	0.00
8.00	72.00	280.00	0.15
56.00	72.10	232.00	3.10
140.00	72.20	148.00	13.03
204.00	72.30	84.00	30.89
244.00	72.40	44.00	53.53
272.00	72.50	16.00	79.25
272.00	72.60	16.00	106.45
276.00	72.70	12.00	133.95
276.00	72.80	12.00	161.55
276.00	72.90	12.00	189.15
276.00	73.00	12.00	216.75
276.00	**73.10**	**12.00**	**244.35**
276.00	73.20	12.00	271.95
276.00	73.30	12.00	299.55
276.00	73.40	12.00	327.15
276.00	73.50	12.00	354.75
280.00	73.60	8.00	382.49
284.00	73.70	4.00	410.87
288.00	73.80	0.00	439.60
288.00	73.90	0.00	468.40
288.00	74.00	0.00	497.20

At proposed CFSA (see Figure for further detail)

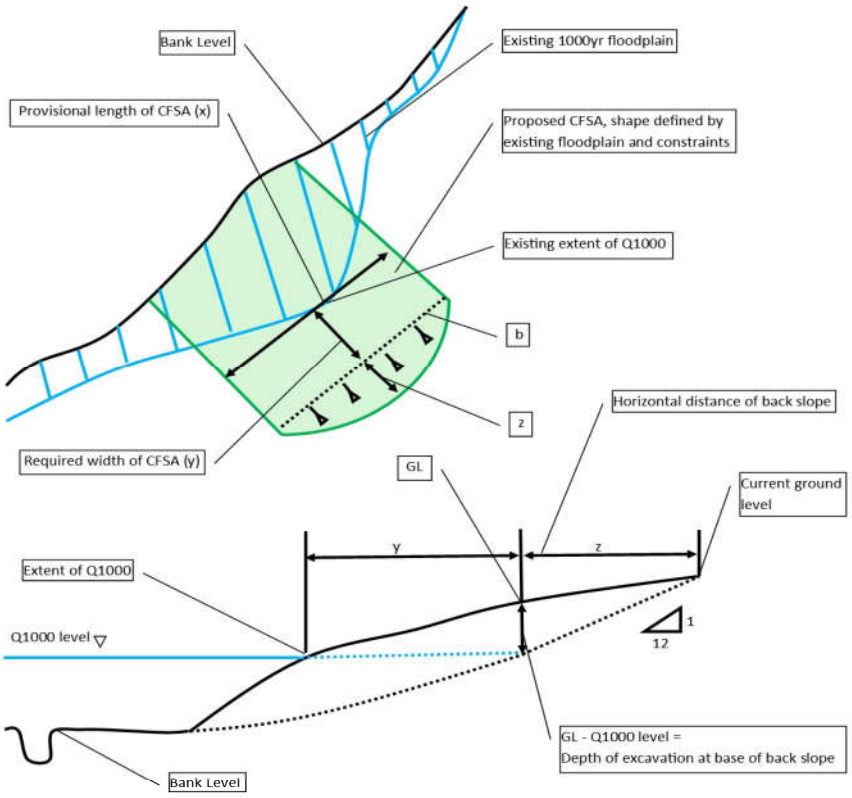
2) At the CFSA location - identify a location outside the existing floodplain where this level-area can be provided in accordance with the following criteria:
   a) The location was positioned outside the 1 in 1000-year flood outlines but would include for excavation to the bank level of an existing watercourse, drain or flood outline extent, in order to remain hydraulically connected and allow for level for level replacement where possible. Constraints such as existing infrastructure were avoided and the number of landowners minimised.
   b) The level of the 1 in 1000-year flood outline (whether modelled flood extent, Flood Zones or RoFSW) was taken at the CFSA location. This, and the local bank level, provides the depth of flood water over which storage could be provided, by extending the flooded area outside the current flood extents.
   c) The required storage will have a zero depth of water at its most inland point (away from the watercourse) with the maximum depth adjacent to the existing 1 in 1000-year flood extent. Hence a wedge shape with maximum depth at the existing extent of the flood outline and zero depth at the inland end requires double the plan area to provide the same volume.
   d) The width of the CFSA along the watercourse was measured. The required CFSA area (calculated above) was divided by this length which gave the width of the CFSA area inland. The difference between the existing ground level and the 1 in 1000-year water level is the depth of excavation required at this point. The level at the back of the CFSA, where water depth will be zero, would be the existing 1 in 1000-year flood level.

Bank level at CFSA location (m AOD)	1000yr WL at CFSA (m AOD)	Max storage depth 1000yr WL- Bank level (m)	Average area required (Volume/max storage depth) (m²)	Required storage area (Average area *2) (m²)	Proposed CFSA Area (m²)	Length along CFSA x (m)
71.00	71.64	0.64	379.07	758.15	1091.53	66.78

Back slope for excavation calculation

3) Make adequate provision for earthworks to tie the excavated area to existing ground levels in the proposed CFSA:
   a) The depth (m) of excavation is derived based on the difference between the ground level (m AOD), taken from LiDAR, at the rear (landward) side of the CFSA before back slope, and the 1 in 1000-year flood level (m AOD).
   b) Assume a 1 in 12 cut slope to obtain a horizontal length (m) of excavation.
   c) Apply that distance (m) as an offset to the rear (landward) boundary of the defined CFSA to describe the full area of land to be allowed for the CFSA.

Offset y (m)	Ground level GL (mAOD)	Depth of excavation (GL-1000yr WL) (m)	Backslope length (m)	Does this fit inside the drawn area?
11.35	71.62	-0.03	-0.31	Y



1) Bank level, assumed to be threshold at which flooding occurs.
2) 1000yr level taken from Flood Zone 2 or RoFSW 1000yr map at CFSA location.
3) x = distance of CFSA adjacent to the watercourse.
4) y = the flood free area of CFSA divided by distance x (CFSA Area /x = y).
5) Take ground level (GL) midway along line b.
6) Depth of excavation at base of back slope of storage area is GL midway along line b - Q1000 (GL - Q1000 elevation = depth of excavation).
7) z = Depth of excavation at the base of back slope x12

*All levels based on LiDAR.

8. Appendix C – Mannings Roughness

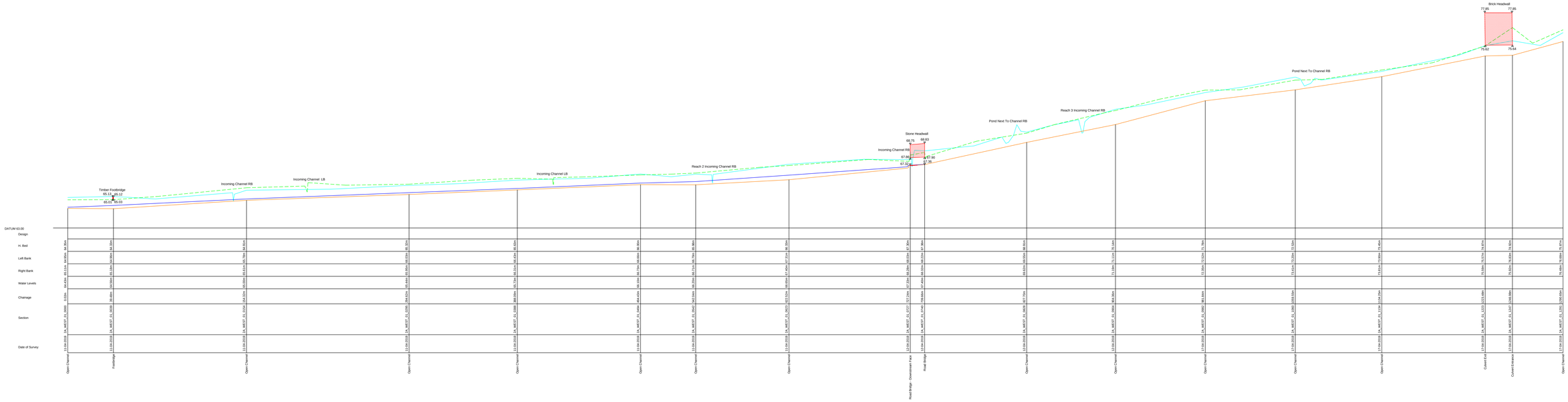
MasterMap Feature	Mannings Roughness Value
Manmade land	0.025
Building	1
Manmade road/track/path	0.018
Rail track	0.035
Manmade roadside	0.018
Property land	0.05
Historic interest land	Case by case basis
Natural land - general	0.04
Water	0.016
Natural land - coniferous trees	0.055
Natural land - coppice	0.06
Natural land - scrub	0.07
Natural land - Marsh	0.05
Natural land - Non-coniferous trees	0.055
Natural land - Orchard	0.045
Natural land - rough grass	0.04
Natural roadside	0.04
Natural road/track/path	0.035
Unclassified land	Case by case basis
General land - unknown	Case by case basis
Rail unknown	Case by case basis
Unknown roadside	Case by case basis
Building	1

9. Appendix D – Topographic Survey

LONG SECTION KEY:

- WATER LEVEL
- BED LEVEL
- SILT LEVEL
- STRUCTURES
- RIGHT BANK
- LEFT BANK

VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'C' ON CROSS SECTIONS ARE ADDITIONAL POINTS BETWEEN SECTIONS



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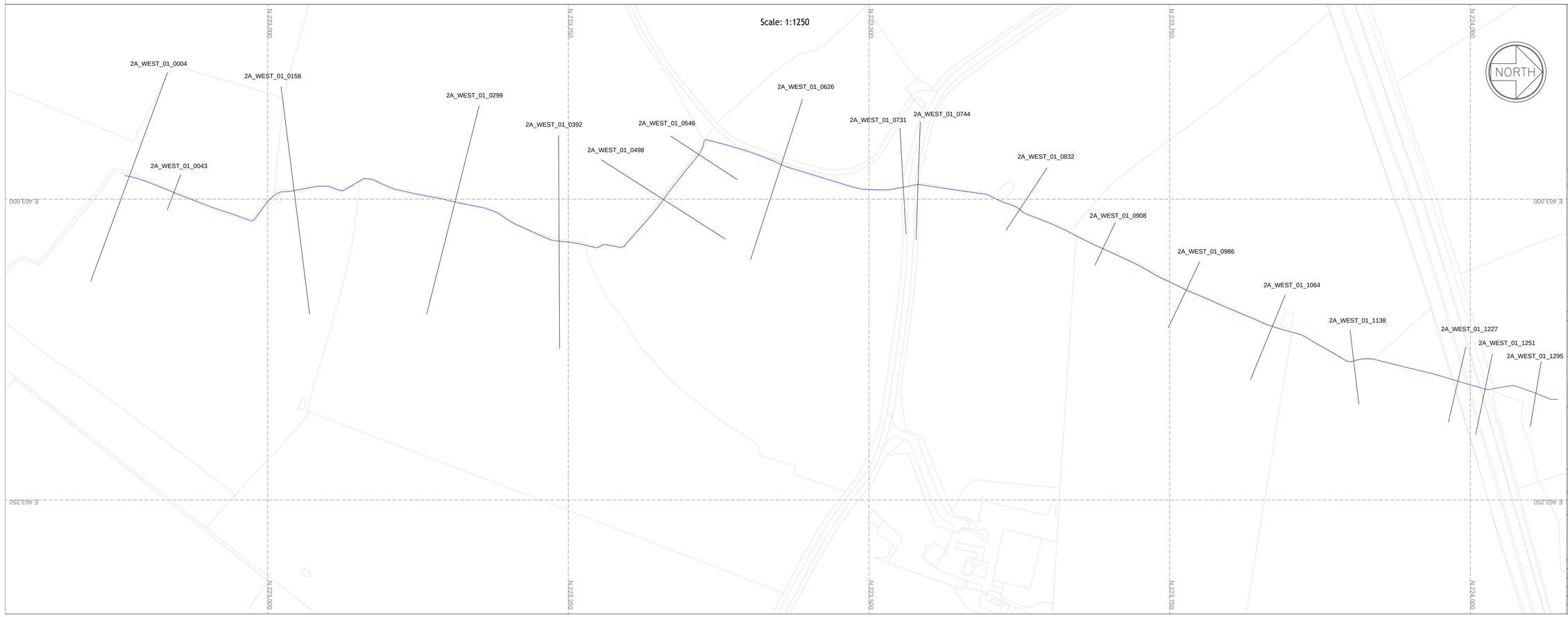
Scale: 1:1250



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NOTES:
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHA	FIRE HYDRANT ALARKER	RE	RIGHT BANK
BH	BOREHOLE	FL	FLOOD LIGHT	RF	RAILWAY FENCE
BS	BOLLARD BULLDN	FP	FENCE POST	RL	ROAD SIGN
BSP	BOUNDARY	FWH	FOUL WATER MANHOLE	RTW	RETAINING WALL
BT	BT MANHOLE	G	GULLY	SA	SOIL VENT PIPE
BL	BED LEVEL	GL	GROUND LEVEL	SL	STOP LOCK
BW	BRICKWORK	GP	GATE POST	SP	STAND PIPE
CB	CATCH PIT	GV	GAS VALVE	SW	SOAKAWAY
BH	BENCH MARK	GV	GAS VALVE	TL	TOPPED LEVEL
BM	BARRIER	HW	HEADWALL	TM	TELEPHONE MANHOLE
BWP	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	UP	WATCH METAL PEANG
CP	CLOSE BOARDED PICKET	IL	INVERT LEVEL	UP	WATCH POST
CF	CLOSE BOARDED FENCE	M	IRON MARKING FENCE	UP	IRON PALLISADE FENCE
CL	COVER LEVEL	INT	INTERVENTION FENCE	UTA	STUDENT
CLF	CHAIN LINK FENCE	K	KERB	UTA	UTILITY MARKER
CONC	CONCRETE	KB	KERB BUILT CAULD	VP	SUB. VENT PIPE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CONCRETE POST & PLANC FENCE	LP	LAMP POST	TCP	TELEPHONE CABLE BOX + POST
CR	CYCLE RACK	LP	LAMP POST	TP	TELECOM CABINET
CTV	CABLE T. V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
DE	DRAIN END	MF	MOORING POST STACKING	TR	TRAFFIC LIGHT
DI	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MHP	MANHOLE	TLB	TRAFFIC LIGHT BOX
DP	DOWN PIPE	MP	MILE POST POLE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MPF	METAL RAILING FENCE	TSL	TIMBER RUBBING STRIP
DR	DRAIN	NS	NAILE STONE	TL	TREE STUMP
DW	DRAIN WATER MH.	OA	OVERHEAD CABLE TO MAJAKO	UC	UNDER CUT
EA	ENVIRONMENT AGENCY	OBA	AUTHORAL BEVER AUTHORITY	UP	VENT PIPE
EB	ELECTRICITY BO.	OHC	OVERHEAD CABLE	WB	WASTE BIN
ECP	ELECTRICITY CONTROL PANEL	OP	OPEN POLE	WM	WATER MANHOLE WATER LINE
ECP	ELECTRICITY CABLE PIT	OW	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	PILE	WMF	WIRE MESH FENCE
EP	ELECTRICITY POST	PA	PARKING AUTO	WP	WATER POST
ES	EARTHING BOX	PB	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSFEBERH LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PP	POST & RAIL FENCE	YD	YARD GULLY
FM	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		observations apply to GS survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

DESCRIPTION	Easting	Northing	Height
B	462910.756	223555.613	68.713

STORM GEOMATICS
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www.storm-geomatics.com

CLIENT
East West Rail Alliance

PROJECT
Watercourse At Wrestbury Court Topographical Survey

SITE
Reach 01, Watercourse At Westbury Court
2A, Westbury, Bicester
Long Section & Location Plan
Sheet 1 of 1

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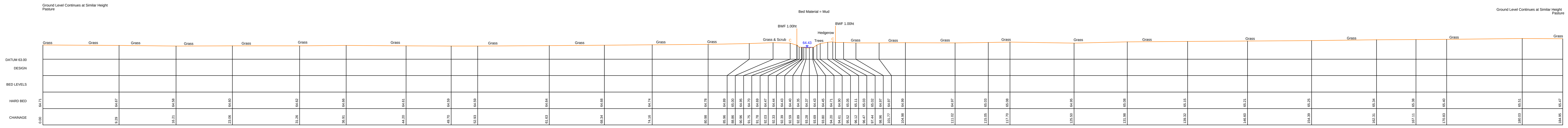
WATER LEVEL
BED LEVEL
SILT LEVEL



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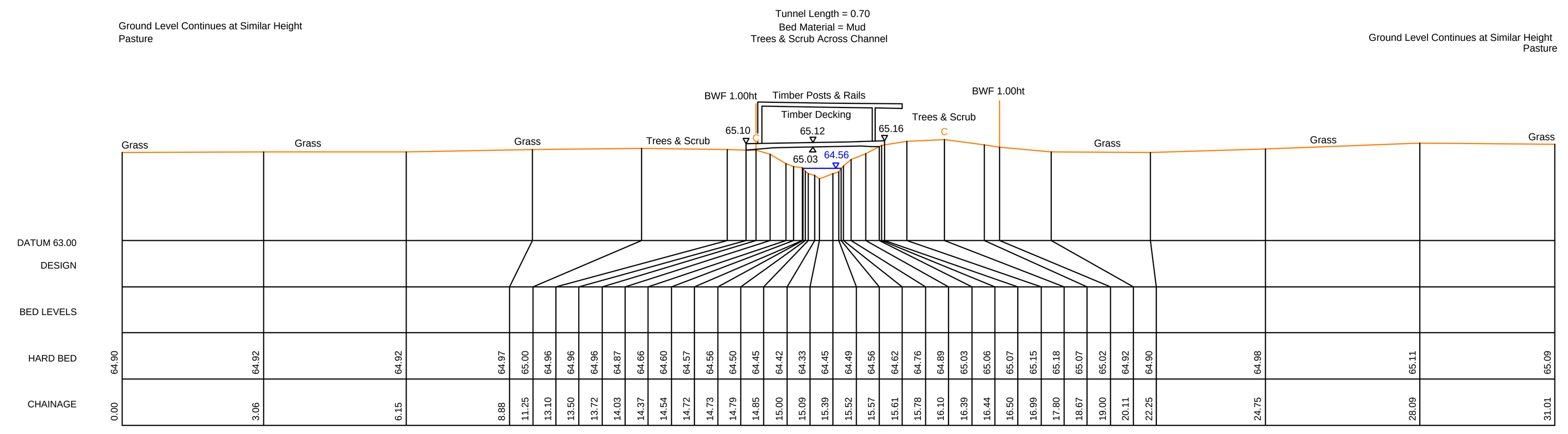

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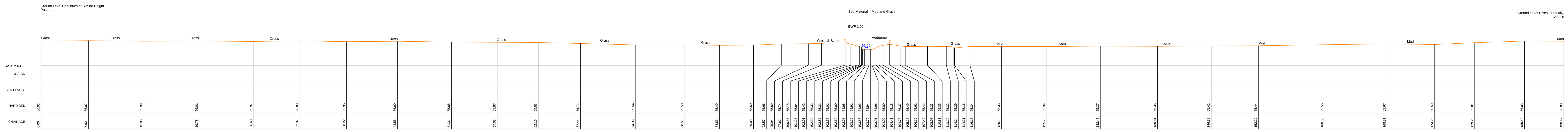

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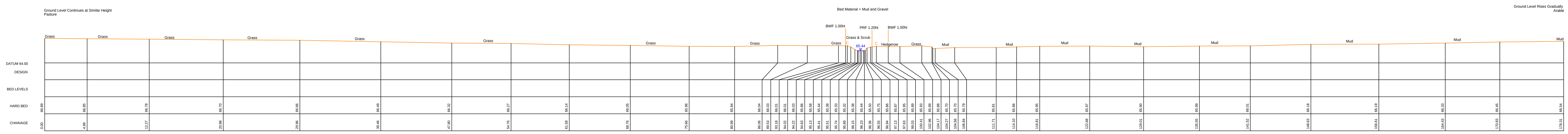

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NOTES:
ALL CROSS SECTIONS VIEWED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RB	RIGHT BANK
B	BOLLARD	FL	FLOOR LEVEL	RE	RODDING EYE
BB	BELISHA BEACON	FP	FENCE POST	RS	ROAD SIGN
BDY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTW	RETAINING WALL
BH	BOREHOLE	G	GULLY	RWP	RAINWATER PIPE
BL	BED LEVEL	GL	GROUND LEVEL	SC	STOP COCK
BRK	BRICKWORK	GP	GATE POST	SDP	STAND PIPE
BS	BUS STOP	GM	GAS MARKER	SK	SOAKAWAY
BM	BENCH MARK	GV	GAS VALVE	SL	SOFFIT LEVEL
BW	BRICK WALL	HW	HEAD WALL	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
CBF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	SP	SIGN POST
CIF	CORRUGATED IRON FENCE	IRF	IRON RAILING FENCE	SPF	STEEL PALLISADE FENCE
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	STN	STATION
CLF	CHAIN LINK FENCE	JB	JUNCTION BOX	SV	SLUICE VALVE
CONC	CONCRETE	KIG	KERB INLET GULLY	SVP	SOIL VENT PIPE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CHESTNUT PALING FENCE	LFB	LIFEBUOY	TCB/TCP	TELEPHONE CALL BOX/POST
CR	CYCLE RACK	LP	LAMP POST	TC	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
CUL	CULVERT	MF	MISCELLANEOUS FENCING	THL	THRESHOLD LEVEL
DK	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DOWNPIPE	MP	MOORING PILE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DR	DRAIN	MS	MILE STONE	TS	TREE STUMP
DWB	DOG WASTE BIN	NB	NOTICE BOARD	TSR	TUBULAR STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	VP	VENT PIPE
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	WB	WASTE BIN
ECF	ELECTRIC CABLE FENCE	OS	OS Grid (15)	WL	WATER LEVEL/WATER LINE
ECP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	PILE	WMF	WIRE MESH FENCE
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PRF	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

DESCRIPTION	Easting	Northing	Height
B	462910.756	223555.613	68.713

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CLIENT
East West Rail Alliance

PROJECT
Watercourse At Wrestbury Court Topographical Survey

SITE
Reach 01, Watercourse Westbury Court
2A, Westbury, Bicester
2A_WEST_01_0000 to 2A_WEST_01_0295
Sheet 1 of 5

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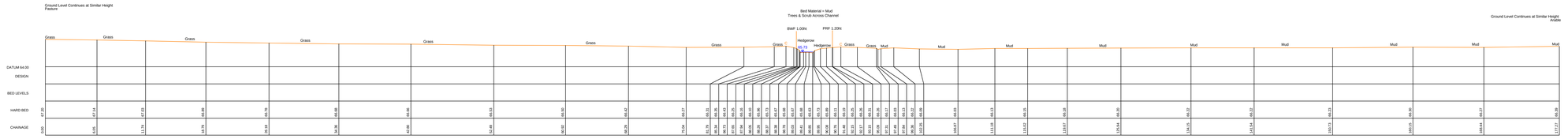

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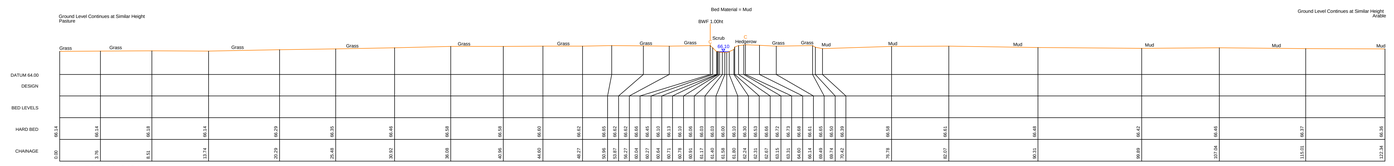

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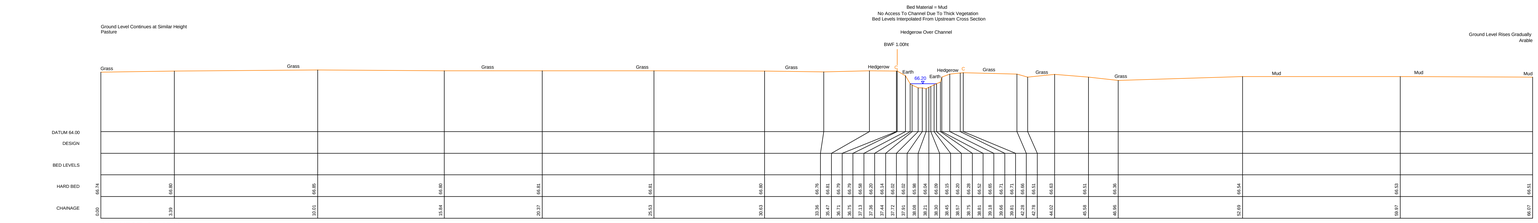

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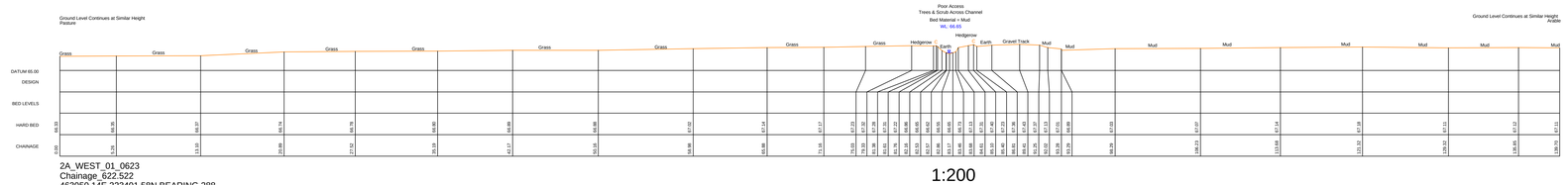

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463050.14E 223401.58N BEARING 288
Open Channel
11-04-2019

1:200

CROSS SECTION KEY:

WATER LEVEL
BED LEVEL
SILT LEVEL

NOTES:

ALL CHCKS SECTIONS YSURED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS IN CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AP	AIR MAST	PH	PIPE HEIGHT	PRT	POST & WIRE FENCE
AV	AIR VALVE	PHM	PIPE HEIGHT MARKER	RD	RIGHT BANK
BH	BOREHOLE	PL	PIPE INVERT	RE	RAILWAY LINE
BI	BUOY/BUOYON	PO	POLICE POST	RG	ROAD SIGN
BM	BOATMAST	PWH	POLL WATER HARVEST	RTW	RETAINING WALL
BO	BOLLARD	R	RAIL	SA	SERVICE ACCESS
BL	BOLLARD	SA	SERVICE ACCESS	SC	STOP COCK
BS	BUS STOP	SB	SIGN BOARD	SG	SIGNAL GANTRY
BS	BUS STOP	SH	SIGN POST	SL	SIGNAL MAST
BW	BOUNDARY WALL	SP	SPOT LEVEL	SP	SPOT LEVEL
BW	BRICK WALL	TP	UTILITY POLE	SPM	SUPPLY METER MARKER
BWP	BARBED WIRE FENCE	TC	INSPECTION CHAMBER	SWP	SHEET METAL FLUME
CA	CONCRETE APRON	TC	TELECOM CABINET	TB	TELEGRAPH BOX
CF	CONCRETE FENCE	TP	TELEGRAPH POLE	TF	STEEL PALISADE FENCE
CL	COVER LEVEL	WP	WOODWOOD FENCE	UN	STATION
CLF	CHAIN LINK FENCE	WT	WATER TANK	UP	UTILITY POLE
CONC	CONCRETE	POL	BOOM POLES ABOUT	UR	UR - KNOCKED
CP	CONCRETE POST	LS	LOOSE SLEEPER	TPM	TEMPORARY BENCH MARK
CS	CONCRETE SLAB ON EDGE	LB	LOOSE BRICK	TSP	TEMPORARY SURVEY POINT
CT	CABLE TELEVISION	LP	LAMP POST	TL	TELECOM CABINET
CTA	CABLE T.V. MARKER	AB	ANCHORING BOLLARD	TMK	TELECOM MARKER
DE	DOG LEG	AF	ANTI-CLIMB WIRE FENCING	TL	TELEGRAPH POLE
DP	DEEP KERB	AW	AUDIO POLE	TL	TEMPOR. LOAM
DI	DOOR LEVEL	AW	AUDIO POST	TLB	TEMPOR. LOAM BOX
DP	DRAIN POST	BF	BARBED WIRE (PL)	TP	TEMPORARY PEG
DPC	DRAIN PIPOST COURT	BW	BRICK WALL	TPC	TARGET NUMBERED STAY
DR	DRAIN	CL	KILB STONE	TL	TREE STUMP
DW	DRAIN WATER BIN	CL	CONCRETE KERB	TW	TIMBER POST OR RAILING
EA	EARTH/MOIST ACTACY	CW	NATIONAL WORKS AUTHORITY	VP	VENT PIPE
EB	ELECTRICITY BOX	DPC	DAMPROOF COURSE	WB	WASTE BIN
ECP	ELECTRICITY CONTROL PO	DW	DRAIN WATER	WC	WATER COURSE/WATER LINE
ELP	ELECTRICITY CABLE POT	EDP	DRY STEEL PALISADE	WM	WATER METER
EMK	ELECTRICITY MARKER	EL	EDGE LINE	WMP	WIRE MESH FENCE
EP	ELECTRICITY POST	FL	FILLER BOX	WP	WOODEN POST
ET	EARTHING POST	FM	FLEXIBLE METER	WPR	WOODEN POST & RAIL FENCE
FB	FLOOD BARRIER/BOOM LINE	FP	FLOOD	WT	WATER TANK
FL	FLOWING WD	PPT	POST & RAIL FENCE	YG	YARD GULLY
FM	FLOW METER	PTN	PARKING TICKETS MACHINE		

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

DESCRIPTION	Easting	Northing	Height
B	462910.756	223555.613	68.713

STORM GEOMATICS
Tel: 01608 664910
mail@storm-geomatics.com
www.storm-geomatics.com

CLIENT
East West Rail Alliance

PROJECT
Watercourse At Wrestbury Court Topographical Survey

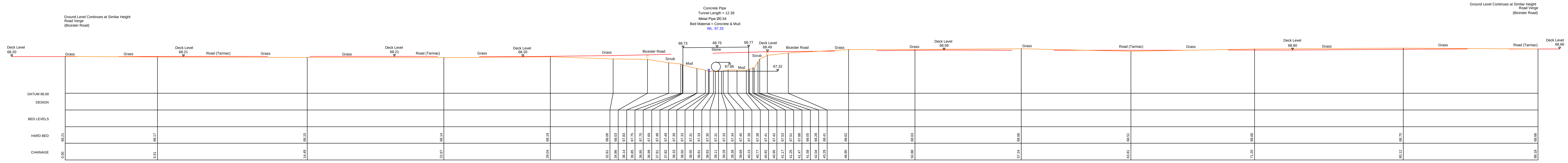
SITE
Reach 01, Watercourse Westbury Court
2A, Westbury, Bicester
2A_WEST_01_0388 to 2A_WEST_01_0623
Sheet 2 of 5

SURVEYED BY: Storm Geomatics Ltd		Project Ref: 13471657
SURVEY DATE: April 2019		
SCALE: 1:100 Unless Specified (A0 Sheet)	DRN: SB	CHKD: TM
DATUM: OS Newlyn (15)	DATE: 23/04/2019	DATE: 26/04/2019
GRID: OS Grid (15)	DRAWING NO. WEST_5167214/02	REV. —

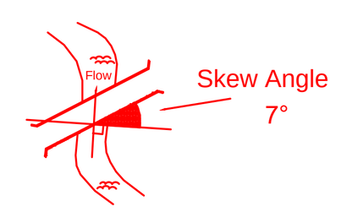
CAD FILENAME: 2A_WEST_01_XS.dwg

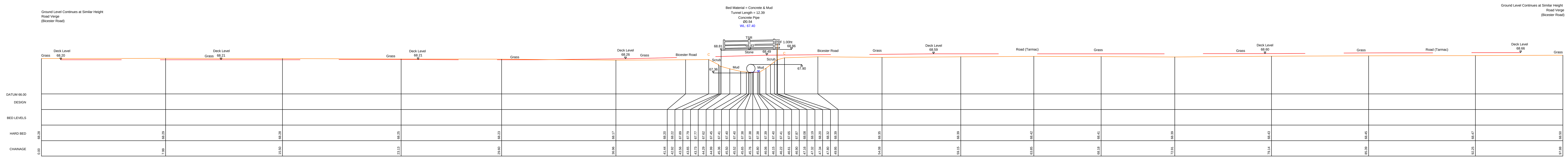
CROSS SECTION KEY:

- WATER LEVEL
- BED LEVEL
- SILT LEVEL

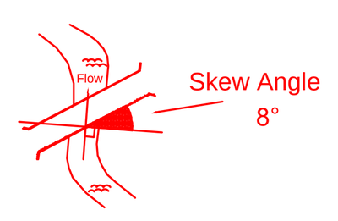


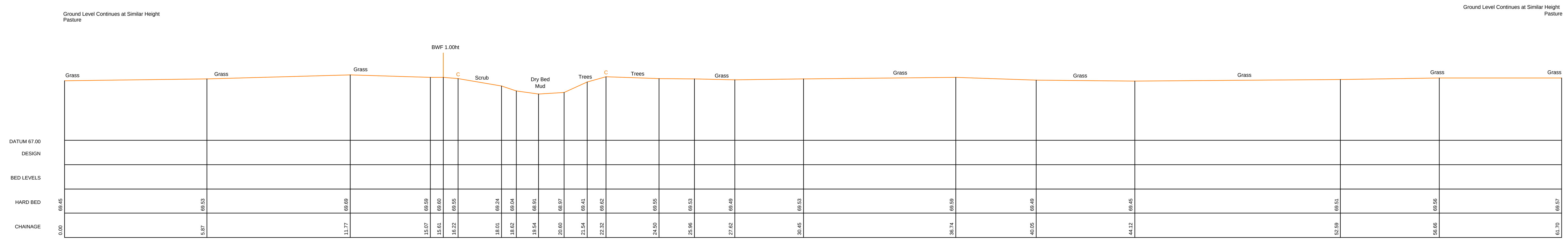
2A_WEST_01_0727
Chainage_727.237
463028.98E 223530.82N BEARING 267
Road Bridge - Downstream Face
12-04-2019





2A_WEST_01_0740
Chainage_739.662
463033.48E 223539.07N BEARING 272
Road Bridge
12-04-2019





2A_WEST_01_0828
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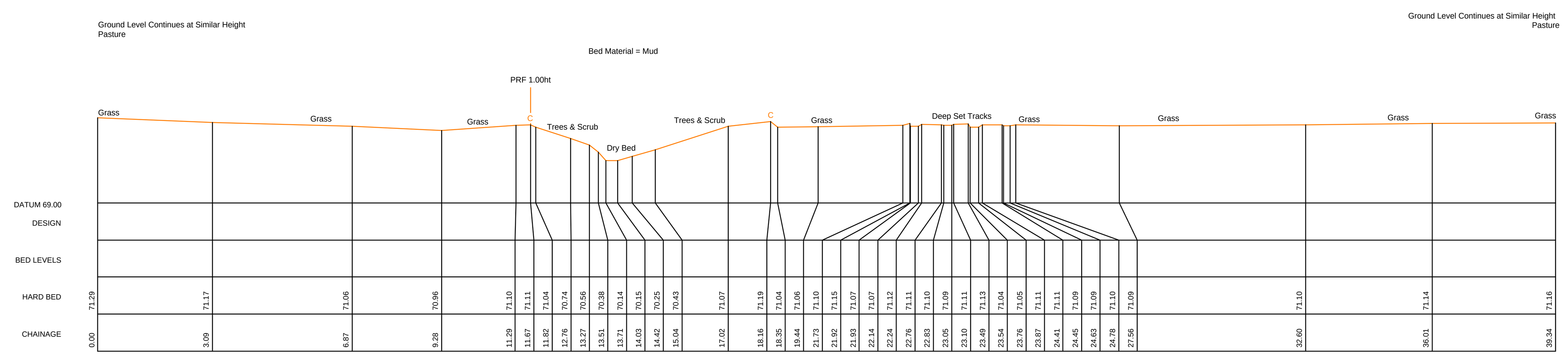
Open Channel
12-04-2019



2A_WEST_01_0904
Chainage_904.357
463054.98E 223687.81N BEARING 296
Open Channel
12-04-2019

NOTES:
ALL CROSS SECTIONS VIEWED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RB	RIGHT BANK
B	BOLLARD	FL	FLOOR LEVEL	RE	RODDING EYE
BB	BELISHA BEACON	FP	FENCE POST	RS	ROAD SIGN
BDY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTW	RETAINING WALL
BH	BOREHOLE	G	GULLY	RWP	RAINWATER PIPE
BL	BED LEVEL	GL	GROUND LEVEL	SC	STOP COCK
BRK	BRICKWORK	GP	GATE POST	SDP	STAND PIPE
BS	BUS STOP	GM	GAS MARKER	SK	SOAKAWAY
BM	BENCH MARK	GV	GAS VALVE	SL	SOFFIT LEVEL
BW	BRICK WALL	HW	HEAD WALL	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
CBF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	SP	SIGN POST
CIF	CORRUGATED IRON FENCE	IRF	IRON RAILING FENCE	SPF	STEEL PALLISADE FENCE
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	STN	STATION
CLF	CHAIN LINK FENCE	JB	JUNCTION BOX	SV	SLUICE VALVE
CONC	CONCRETE	KIG	KERB INLET GULLY	SVP	SOIL VENT PIPE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CHESTNUT PALING FENCE	LFB	LIFEBUOY	TCB/TCP	TELEPHONE CALL BOX/POST
CR	CYCLE RACK	LP	LAMP POST	TC	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
CUL	CULVERT	MF	MISCELLANEOUS FENCING	THL	THRESHOLD LEVEL
DK	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DOWNPIPE	MP	MOORING PILE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DR	DRAIN	MS	MILE STONE	TS	TREE STUMP
DWB	DOG WASTE BIN	NB	NOTICE BOARD	TSR	TUBULAR STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	VP	VENT PIPE
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	WB	WASTE BIN
ECF	ELECTRIC CABLE FENCE	OS	OS Grid (15)	WL	WATER LEVEL/WATER LINE
ECP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	PILE	WMF	WIRE MESH FENCE
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PRF	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

DESCRIPTION	Easting	Northing	Height
B	462910.756	223555.613	68.713

STORM GEOMATICS
Tel: 01608 664910
mail@storm-geomatics.com
www.storm-geomatics.com

CLIENT
East West Rail Alliance

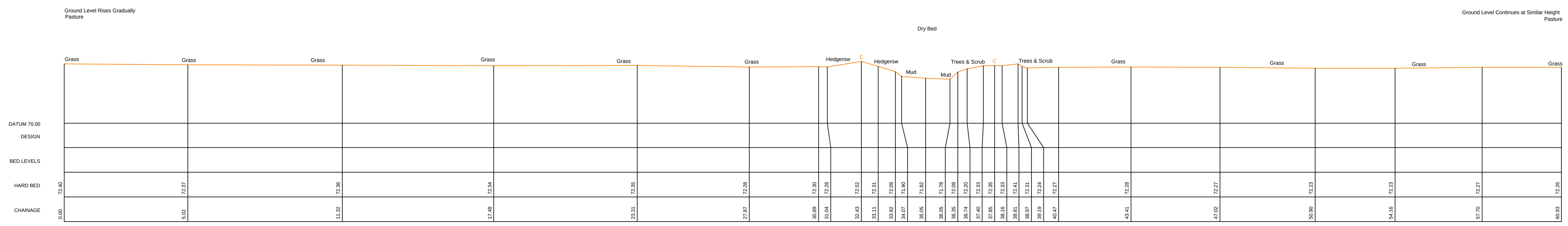
PROJECT
Watercourse At Wrestbury Court Topographical Survey

SITE
Reach 01, Watercourse Westbury Court
2A, Westbury, Bicester
2A_WEST_01_0727 to 2A_WEST_01_0904
Sheet 3 of 5

SURVEYED BY: Storm Geomatics Ltd		Project Ref: 19AT1657
SURVEY DATE: April 2019		
SCALE: 1:100 Unless Specified (A0 Sheet)	DRN: SB	CHKD: TM
DATUM: OS Newlyn (15)	DATE: 23/04/2019	DATE: 26/04/2019
GRID: OS Grid (15)	DRAWING NO. WEST_5167214/03	REV. –
CAD FILENAME: 2A_WEST_01_XS.dwg		

CROSS SECTION KEY:

WATER LEVEL
BED LEVEL
SILT LEVEL



2A_WEST_01_0982
Chainage_981.844
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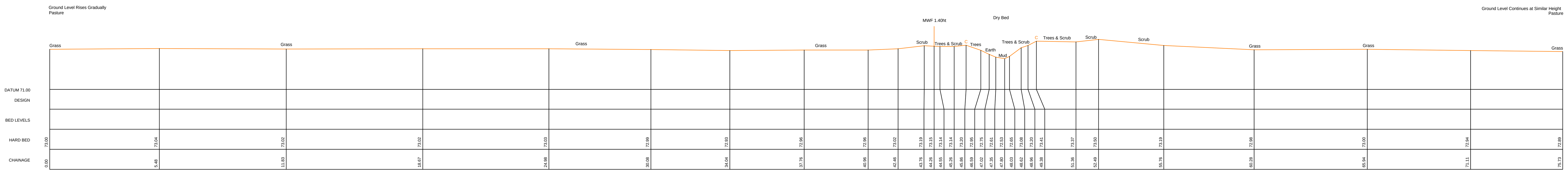
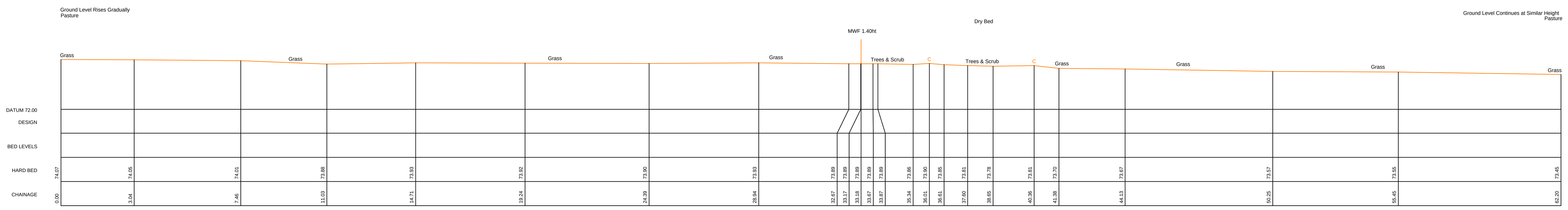
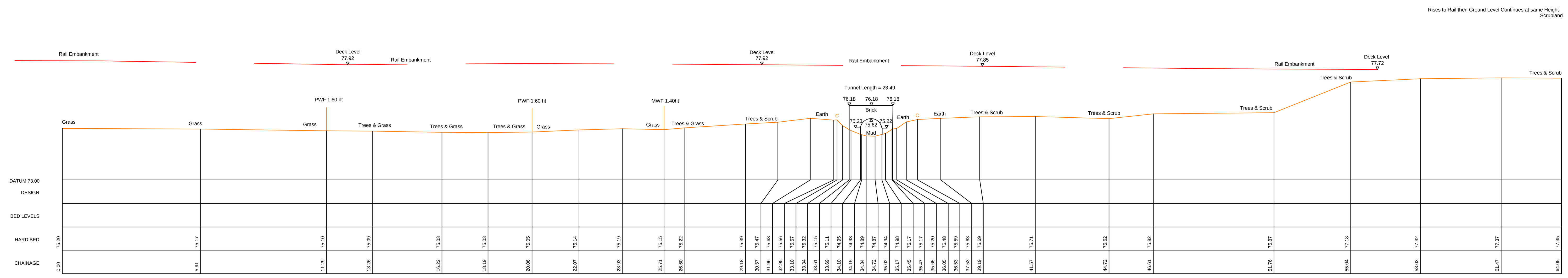
Open Channel
17-04-2019



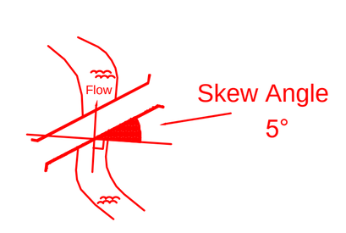
2A_WEST_01_1060
Chainage_1059.547
463149.94E 223817.26N BEARING 292
Open Channel
17-04-2019



2A_WEST_01_1134
Chainage_1134.247
463170.67E 223907.31N BEARING 263
Open Channel
17-04-2019



2A_WEST_01_1223
Chainage_1223.482
463185.31E 223981.79N BEARING 283
Culvert Exit
17-04-2019



NOTES:
ALL CROSS SECTIONS VIEWED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

(Abbreviations apply to EA survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

DESCRIPTION	Easting	Northing	Height
B	462910.756	223555.613	68.713

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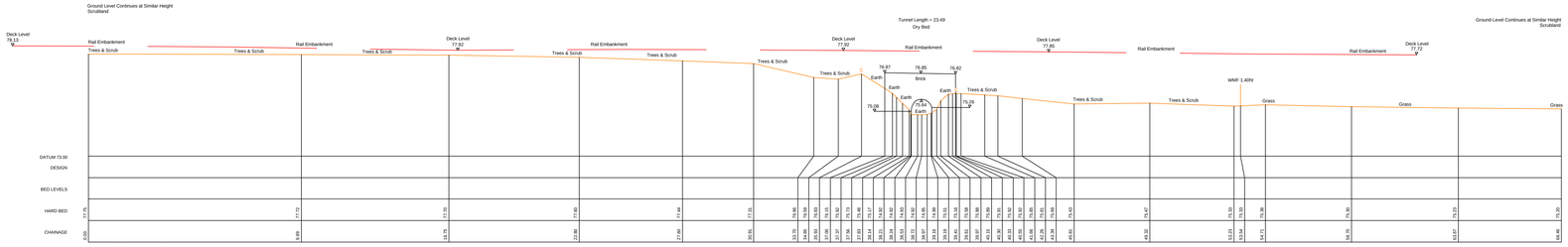
mail@storm-geomatics.com
www.storm-geomatics.com

CLIENT
East West Rail Alliance

PROJECT
Watercourse At Wrestbury Court Topographical Survey

SITE
Reach 01, Watercourse Westbury Court
2A, Westbury, Bicester
2A_WEST_01_0982 to 2A_WEST_01_1123
Sheet 4 of 5

SURVEYED BY: Storm Geomatics Ltd — Project Ref: 19AT1657
SURVEY DATE: April 2019
SCALE: 1:100 Unless Specified (A0 Sheet) | DRN: SB | CHKD: TM
DATUM: OS Newlyn (15) | DATE: 23/04/2019 | DATE: 26/04/2019
GRID: OS Grid (15) | DRAWING NO. WEST_5167214/04 | REV. –
CAD FILENAME: 2A_WEST_01_XS.dwg



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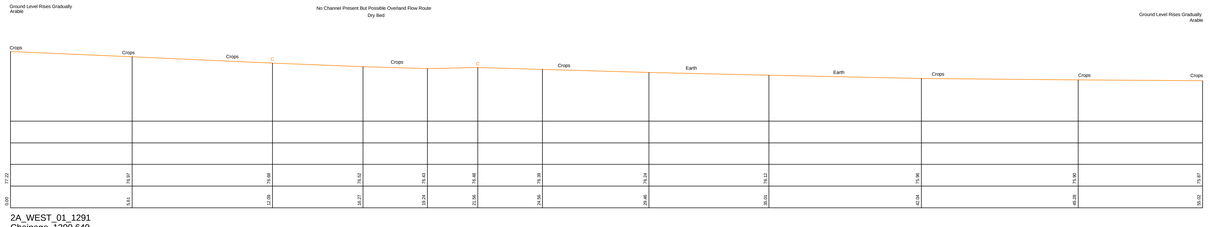
463195.71E 224004.40N BEARING 282
Culvert Entrance
17-04-2019



2A_WEST_01_1291
Chainage_1290.649
463189.23E 224049.78N BEARING 280
Open Channel
17-04-2019

CROSS SECTION KEY:

WATER LEVEL

BED LEVEL

SILT LEVEL

NOTES:
ALL CHCKS SECTIONS VIEWED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE AS METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWT	POST & WIRE FENCE
AV	AIR VALVE	FHM	FIRE HYDRANT MARKER	RD	RIGHT DOWN
BH	BOREHOLE	FP	FLOOD POST	RE	RAILWAY ELECTRIC
BI	BUS/IRON BOLLON	FR	FENCE RAIL	RG	ROAD GRID
BRT	BOUNDARY	FWH	FOUL WATER MANHOLE	RTW	RETAINING WALL
BS	BUS STOP	G	GATE	SA	SERVICE ACCESS
BL	BOLLARD	GI	GRID INLET	SC	STOP COCK
BTL	BOUNDARY	GL	GARAGE	SD	SOAKAWAY
BS	BUS STOP	GM	GAS MARKER	SL	SIGNALS/LIGHT
BT	BOUNDARY POST	GP	GUARD POST	SM	SERVICE MARKER
BW	BRICK WALL	HW	HEDGE WALL	SMH	SURFACE WATER MANHOLE
BWP	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL FLING
CAB	CONCRETE ACCESS SLAB	IP	INSPECTION PIT	SP	SIGN POST
CF	CONCRETE FENCE POST	KV	KERB VALVE MARKER	SPF	STEEL PALLADIN FENCE
CL	COVER LEVEL	MP	MOTORCROSS FENCE	STH	STATION
CLF	CHAIN LINK FENCE	MT	MANHOLE TOP	SW	SOIL VENT PIPE
CONC	CONCRETE	PCL	PATH CRACK LINE	SYP	SIGN POST ONLY
CP	CONCRETE POST	LS	LOOSE SLAB	TBM	TEMPORARY BENCH MARK
CPF	CHAIN LINK & PALE FENCE	LSB	LOOSE SLAB	TBP	TEMPORARY BENCH MARK POST
CT	CABLE TV	LP	LAMP POST	TC	TELECOM CABINET
CTK	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TCM	TELECOM MANHOLE
DF	DRAIN	MF	METAL RAILINGS FENCING	TL	TRAFFIC LIGHT
DP	DEEP HOLE	MH	MANHOLE	TM	TRAFFIC LIGHT
EI	DOOR LEVEL	MR	MANHOLE	TLB	TRAFFIC LIGHT BOX
EL	ELECTRIC BOX	MRF	METAL RAIL (RL)	TP	TELEGRAPH POLE
EPC	FLAME PROOF COURT	MW	METAL SALVAGE FENCE	TPS	TARGET RUBBING STAY
EW	EDGE	NI	NEW STOOP	TS	TREE STUMP
FB	FLOOD WATER BIN	OB	OBSERVATION CHAMBER	TW	TIMBER POST & RAILINGS
FC	EARTHQUAKE ACTACT	OGS	NATIONAL WATER AUTHORITY	UP	VENT PIPE
FD	ELECTRICITY BOX	OHL	OVERHEAD CABLE	VB	WASTE BIN
ELP	ELECTRICITY BOLLARD	OP	OPEN PIT	WC	WATER CONTROL VALVE CHC
ELP	ELECTRICITY CABLE POT	OSS	OPEN STEEL RAILINGS	WM	WATER METER
EMH	ELECTRICITY MANHOLE	P	POST	WMP	WIRE MESH FENCE
EP	ELECTRICITY POST	PL	PILLAR BOX	WP	WOODEN POST
ET	EARTHING POST	PR	PUBLIC RIGHTS	WPR	WOODEN POST & RAIL FENCE
FL	FLOOD LEVEL	PW	PUBLIC WATER	YB	YORKSTONE BOLLARD
FM	FLOWING NO	PWF	POST & RAIL FENCE	YG	YARD GULLY
HM	HISTORICAL	PWR	PARKING TICKETS MACHINE		

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

DESCRIPTION	Easting	Northing	Height
B	462910.756	223555.613	68.713

STORM GEOMATICS
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mail@storm-geomatics.com
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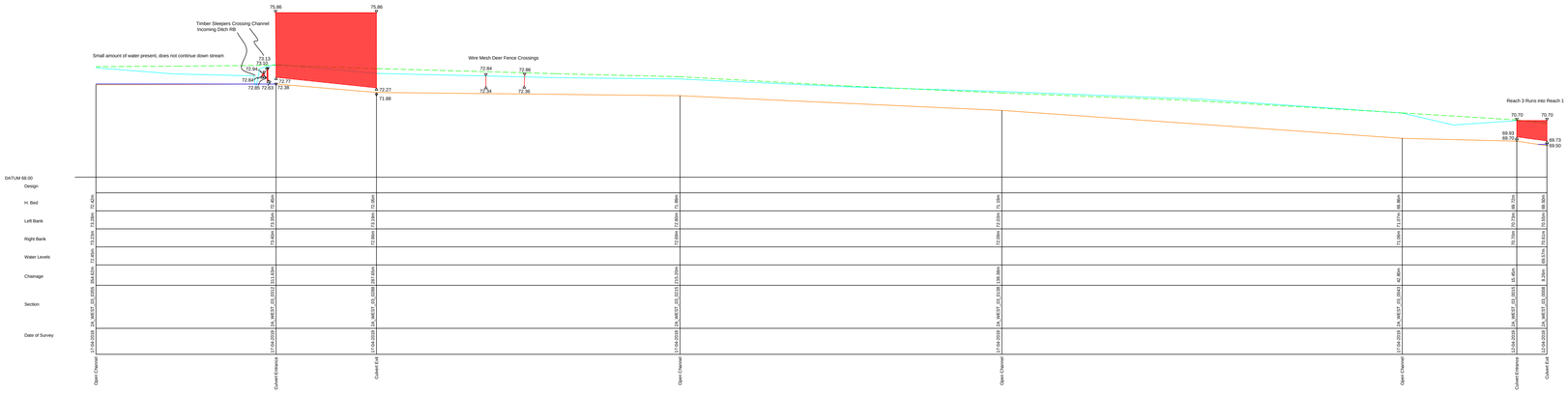
CLIENT
East West Rail Alliance

PROJECT
Watercourse At Wrestbury Court Topographical Survey

SITE
Reach 01, Watercourse Westbury Court
2A, Westbury, Bicester
2A_WEST_01_1247 to 2A_WEST_01_1291
Sheet 5 of 5

SURVEYED BY: Storm Geomatics Ltd		Project Ref: 18471657
SURVEY DATE: April 2019		
SCALE: 1:100 Unless Specified (A0 Sheet)	DRN: SB	CHKD: TM
DATUM: OS Newlyn (15)	DATE: 23/04/2019	DATE: 26/04/2019
GRID: OS Grid (15)	DRAWING NO. WEST_5167214/05	REV. —
CAD FILENAME: 2A_WEST_01_XS.dwg		



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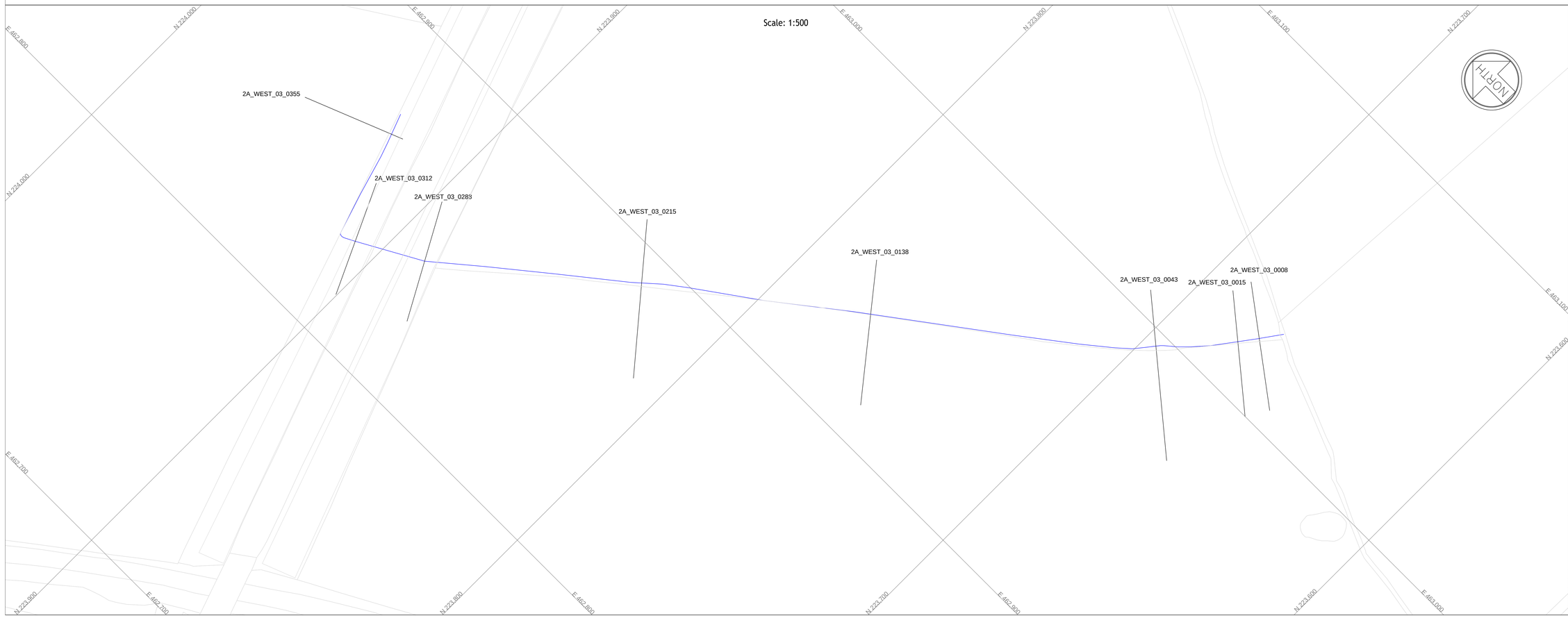

LONG SECTION KEY:

- WATER LEVEL
- BED LEVEL
- SILT LEVEL
- STRUCTURES
- RIGHT BANK
- LEFT BANK

VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'C' ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS

Sheet Layout (not to scale)

NOTES:
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
AV	AIR VALVE	FHA	FIRE HYDRANT ALARM	RB	RIGHT BANK
BH	BOREHOLE	FL	FLOOD LIGHT	RE	RAILWAY ELEC
BR	BOLLARD REACON	FP	FENCE POST	RL	ROAD SIGN
BSP	BOUNDARY	FWH	FOUL WATER MANHOLE	RTW	RETAINING WALL
BT	BT MANHOLE	G	GULLY	SA	SOIL VENT PIPE
BL	BUS LEVEL	GL	GROUND LEVEL	SC	STOP COCK
BW	BRICKWORK	GP	GATE POST	SDP	STAND PIPE
CA	CABLE ARCH	GV	GAS VALVE	SL	STREET LIGHT
MH	BOXED MARK	CV	GAS VALVE	SL	SUPPLY LEVEL
BWP	BARBED WIRE FENCE	HH	HANDHOLE	SMH	SURFACE WATER MANHOLE
BWP	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
CP	CLOSE BOARDED PEDC	IL	INVERT LEVEL	SP	SIGN POST
CP	CLOSE BOARDED FENCE	KV	KIOSK ELECTRIC	SP	SERVICE POLE/LAMP
CI	COVER LEVEL	MAT	MATTENGRATE FENCE	STA	STATION
CLF	CHAIN LINK FENCE	MH	MANHOLE	SW	SOIL WASTE PIPE
CONC	CONCRETE	MK	KERB MUST CALL)	SW	SUB. WATER MAIN
CP	CONCRETE POST	LS	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CHAIN LINK PLANC FENCE	LCB	LOW CONCRETE	TC	TELECOM CABINET BOX POST
CX	CYCLE RACK	LP	LAMP POST	TCB	TELECOM CABINET
CTX	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
DP	DRAIN PIPE	MF	MESH WIRE FENCE STACKING	TL	TRAFFIC LIGHT
DR	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MHT	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DRAIN PIPE	MP	MARKER POLE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MSF	METAL RAILING FENCE	TSS	TIMBER SLEEPERS STEP
DR	DRAIN	NS	NAILS STONE	TS	TREE STUMP
E	ELECTRIC MH	OHL	OVERHEAD LINES	TW	TOP OF RETAINING WALL
EA	ENVIRONMENT AGENCY	HSA	HUTCHINS, BEVERS, AUTHORITY	UP	VENT PIPE
ES	ELECTRICITY BOX	OHC	OVERHEAD CABLE	WB	WASTE BIN
ESP	ELECTRICITY BOX POST	OP	OPEN PIPE	WM	WATER MAIN/WATER LINE
ECP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WMa	WATER METER
EWH	ELECTRICITY MANHOLE	P	PILE	WMP	WIRE MESH POST
EP	ELECTRICITY POLE	PC	PEDESTRIAN CROSS	WP	WOOD POST
ES	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWER BED	PRF	POST & RAIL FENCE	YP	YORKSTONE PAVING
FM	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		(observations apply to GS survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

DESCRIPTION	Easting	Northing	Height
B	462910.756	223555.613	68.713

STORM GEOMATICS
Tel: 01608 664910
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www.storm-geomatics.com

CLIENT: East West Rail Alliance

PROJECT: Watercourse At Wrestbury Court Topographical Survey

SITE: Reach 03, Watercourse At Westbury Court
2A, Westbury, Bicester
Long Section & Location Plan
Sheet 1 of 1

SURVEYED BY: Storm Geomatics Ltd — *Project Ref: 19ATH057*

SURVEY DATE: April 2019

SCALE: As Shown (A0 Sheet)	DRN: SB	CHKD: TM
DATUM: OS Newlyn (15)	DATE: 24/04/2019	DATE: 26/04/2019
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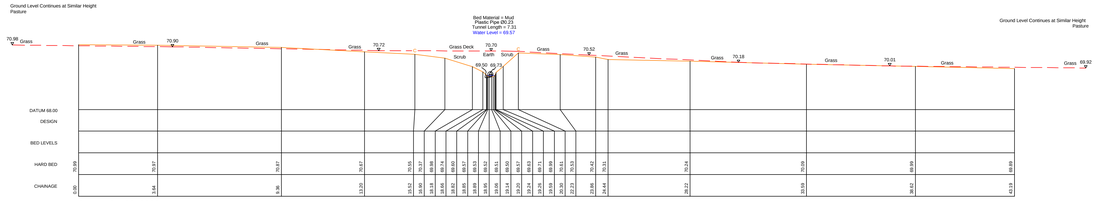

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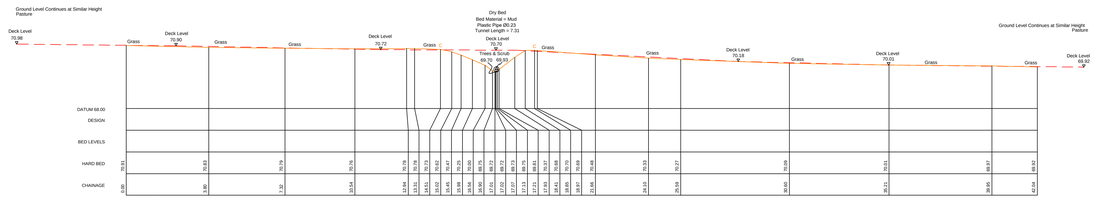
Culvert Exit
12/04/2019



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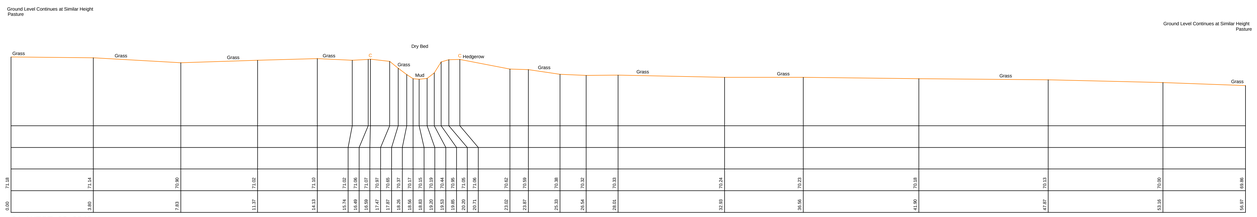
Culvert Entrance
12/04/2019



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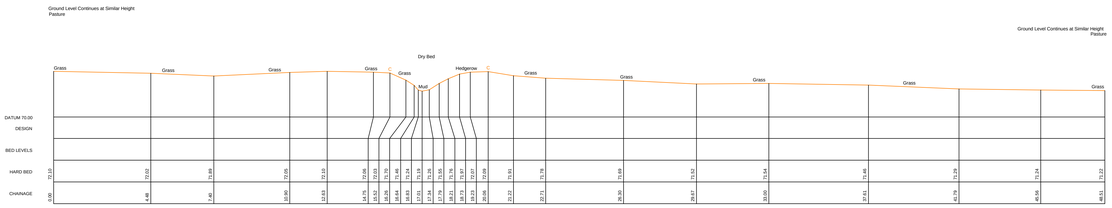
17/04/2019



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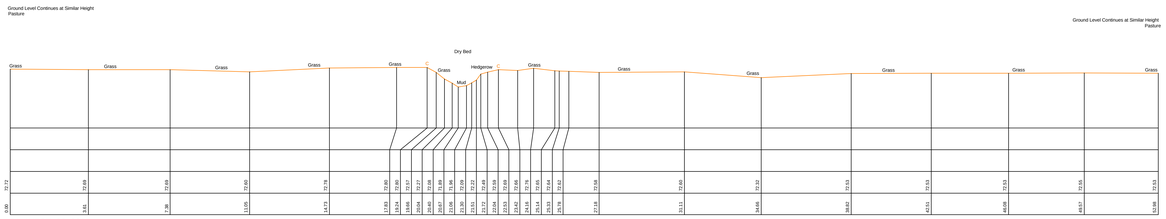
17/04/2019



CROSS SECTION KEY:

WATER LEVEL

BED LEVEL

SILT LEVEL

NOTES:

ALL CHAIN SECTIONS VIEWED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE METRES ABOVE ORDNANCE DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS IN CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AP	APP BRICK	PH	POST & WIRE FENCE
BI	BRIDGE INVERT	PM	PEDESTRIAN
BL	BOLLARD	PO	POST
BO	BOREHOLE	PP	POWER POLE
BR	BRICK WALL	PR	PROTECTIVE POST
BT	BURIED MINE TOAST	PS	PUMP STATION
BW	BRICK WALL ON KERB	PT	PETROL TANK
CA	CONCRETE APRON	PW	PARAPET WALL
CC	CONCRETE COLUMN	RA	RAILWAY
CF	CONCRETE FENCE	RB	RAILWAY BUFFER
CH	CHIMNEY	RC	RAILWAY CROSSING
CL	CLOSE	RE	RAILWAY ELECTRIC
CO	CONCRETE	RF	RAILWAY FENCING
CP	CONCRETE POST	RL	RAILWAY LINE
CR	CONCRETE RING	RS	RAILWAY SIGNAL
CS	CONCRETE SURFACE	RT	RAILWAY TRACK
CT	CATTLE TRUCK	SA	SAMP
CV	CULVERT	SB	SOIL BANK
DA	DRAIN	SC	SCRUB
DC	DRAIN COVER	SD	SOAKAWAY
DE	DRAIN END	SE	SOIL EXPOSED
DI	DRAIN INVERT	SF	SOFT SPOT
DK	DRAIN KERB	SG	SIGN
DM	DRAIN MANHOLE	SH	SHRUB
DO	DOOR	SI	SILT
DP	DRAIN POINT	SK	SKETCH
DR	DRAIN	SL	SLOPE
DW	DRAIN WATER BIN	SM	SMALL
EA	ELECTRICITY ASSOCIATION	SO	SOIL
EB	ELECTRICITY BOX	SP	SPOT
EC	ELECTRIC CABLE PEACH	SR	SOIL RAMP
EG	ELECTRICITY GUARD	SS	SOIL SLOPE
EH	ELECTRICITY HANDHOLE	ST	STEPS
EP	ELECTRICITY POLE	SU	SUMP
ES	ELECTRICITY SUB STATION	SV	SOIL VEGETATION
ET	ELECTRICITY TRANSFORMER	TA	TARMAC
FB	FLOWED BED	TB	TIMBER BOARD
FE	FENCE	TC	TELECOM CABLE
FH	FIRE HYDRANT	TD	TELECOM DUCT
FM	FLOW METER	TE	TELECOM ENCLOSURE
FO	FOOTPATH	TF	TELECOM FIBRE
FP	FENCE POST	TG	TELECOM GUARD
FR	FRAME	TH	TELECOM HOUSE
FS	FLOOD SIGN	TK	TANK
GA	GATE	TL	TELECOM LINE
GB	GRAB	TM	TELECOM MANHOLE
GC	GAS CONTROL	TO	TELECOM POST
GD	GUARD RAIL	TP	TELEPHONE POLE
GE	GAS EXPOSED	TR	TREE
GF	GAS FENCE	TS	TELECOM STEPS
GH	GAS HOUSE	TT	TELECOM TOWER
GI	GAS INVERT	TW	TELECOM MANHOLE
GL	GAS LINE	UC	UNDERGROUND CABLE
GM	GAS MARKER	UP	UTILITY POLE
GP	GAS POST	VA	VALVE
GR	GRATE	VC	VEGETATION
GT	GAS TANK	VP	VENT PIPE
GV	GAS VALVE	WA	WATER
HA	HEDGE	WB	WATER BOARD
HB	HEDGE BANK	WC	WATER COURSE
HC	HEDGE CUT	WE	WATER ENCLOSURE
HE	HEDGE	WF	WATER FLOW
HH	HEDGE HIGH	WG	WATER GUARD
HL	HEDGE LOW	WH	WATER HOUSE
HM	HEDGE MATURE	WI	WATER INVERT
HO	HOUSE	WL	WATER LEVEL
HP	HEDGE POST	WM	WATER METER
HR	HEDGE REMAINS	WO	WATER OUTLET
HS	HEDGE SIDE	WP	WATER POST
HT	HEDGE TOP	WR	WATER RAIL
HW	HEDGE WIDE	WS	WATER SOLE
IC	INSPECTION CHAMBER	WT	WATER TANK
IL	INVERT LEVEL	WV	WATER VALVE
IP	IRON PIPE	WW	WATER WELL
IW	INTERWOVEN FENCE	XX	CROSS
KE	KERB EXPOSED	YA	YARD
LA	LATH	YD	YARD DRAIN
LE	LEAT	YH	YARD HYDRANT
LG	LOG	YP	YARD POST
LP	LAMP POST	YT	YARD TAP
MB	MARKER BOLLARD	YW	YARD WALL
MF	MARKER POST/FENCING	ZA	ZANJA
MH	MANHOLE	ZB	ZANJA BOARD
MI	MINE	ZC	ZANJA CONCRETE
MP	MARKER PEG	ZD	ZANJA DRAIN
MR	MARKER POST	ZE	ZANJA EXPOSED
MS	MARKER STAKE	ZF	ZANJA FENCE
MT	MARKER TAG	ZG	ZANJA GRATE
NA	NAIL	ZH	ZANJA HEDGE
NB	NOTICE BOARD	ZI	ZANJA INVERT
NC	NATURAL CHANNEL	ZL	ZANJA LOG
NE	NOTICE	ZM	ZANJA MARKER
NP	NOTICE POST	ZP	ZANJA POST
OB	OBSTRUCTION	ZR	ZANJA RAIL
OF	OFFICE	ZS	ZANJA SIDE
OH	OVERHEAD	ZT	ZANJA TOP
OP	OPEN	ZW	ZANJA WIDE
PA	PATH		
PB	PILLAR BOX		
PC	PETROL CAP/FILLER		
PD	POST		
PH	POST & RAIL STOCK		
PW	PARAPET WALL		

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

DESCRIPTION		Easting	Northing	Height
B	I	462910.756	223555.613	68.713

STORM GEOMATICS
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www.storm-geomatics.com

CLIENT

East West Rail Alliance

PROJECT

Watercourse At Wrestbury Court Topographical Survey

SITE

Reach 03, Watercourse Westbury Court
2A, Westbury, Bicester
2A_WEST_03_0008 to WEST_03_0215
Sheet 1 of 2

SURVEYED BY: Storm Geomatics Ltd		*Project Ref: 19417657*
SURVEY DATE: April 2019		
SCALE: 1:100 (A0 Sheet)	DRN: SB	CHKD: TM
DATUM: OS Newlyn (15)	DATE: 24/04/2019	DATE: 26/04/2019
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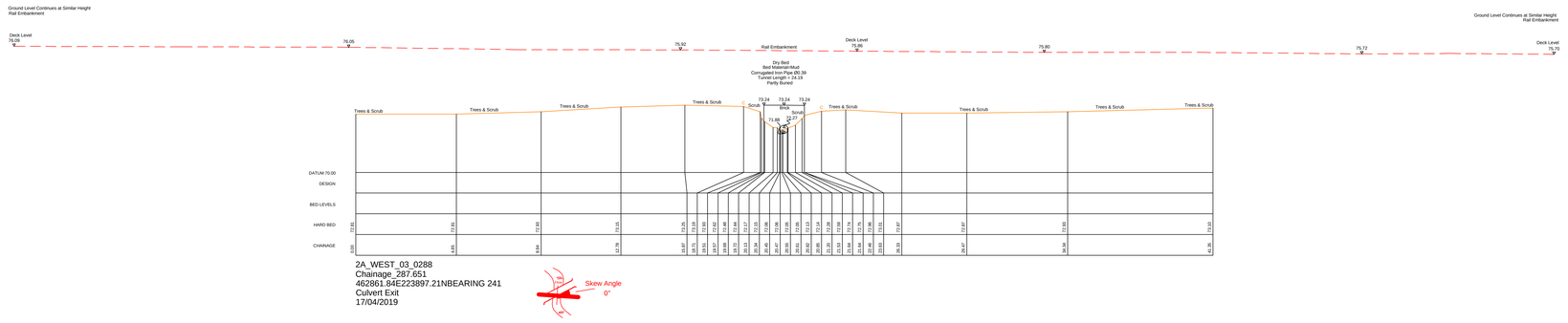

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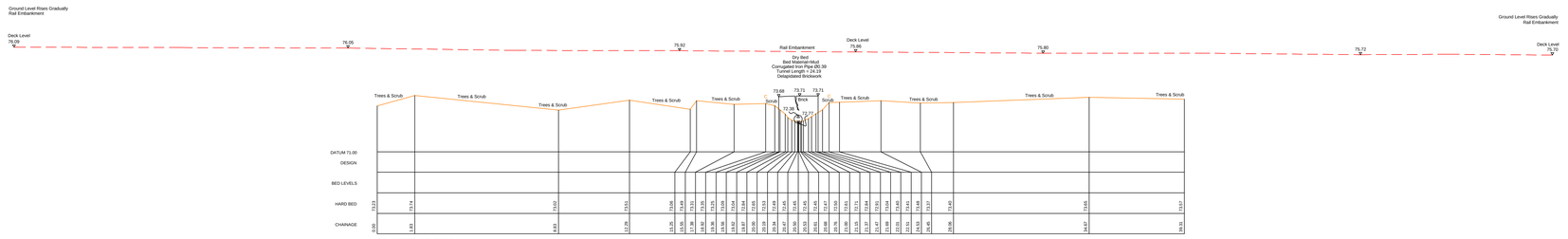
17/04/2019



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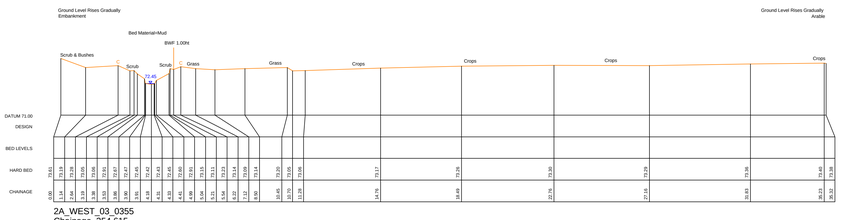
17/04/2019



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Open Channel
17/04/2019

CROSS SECTION KEY:

WATER LEVEL

BED LEVEL

SILT LEVEL

NOTES:

ALL CROSS SECTIONS VIEWED IN A DOWNSTREAM DIRECTION UNLESS OTHERWISE STATED.
ALL LEVELS ARE RELATIVE TO ARBITRARY DATUM UNLESS OTHERWISE STATED.
ALL DIMENSIONS & CHAINAGES ARE IN METRES UNLESS OTHERWISE STATED.

SURVEY LEGEND

AP	APP BRICK	FH	POST & WIRE FENCE
AV	AIR VALVE	FHA	FIRE HYDRANT MARKER
B	BOLLARD	FL	FLOOR LEVEL
BC	BACK OF KERB	FM	FLOOD MARK
BD	BOUNDARY	FWA	FULL WATER MARK/SET
BE	BOREHOLE	G	GULLY
BH	BUS HALT	GC	GAS CONTROL
BN	BRICK/CONC	GT	GATE POST
BS	BUS STOP	GV	GAS VALVE/PT
BT	BOTTOM OF	HC	HEDGE CUT
BW	BRICK WALL	HY	HEDGE WALL
BWF	BURIED WEB TOACE	IC	INSPECTION CHAMBER
C	CENTRE LINE OF RIVER	IP	IRON PIPE
CF	CONDUCTOR IRON ROAD	IW	IRON RAILING/FENCE
CL	COVER LEVEL	MF	MOTORWAY FENCE
CLF	CHAIN LINK FENCE	MH	MANHOLE
COAC	COACH/TR	PO	NON-FLUID SPIRIT
CP	COACH/TR POST	LB	LOW BANK
CR	CROSS RAIL/ALL FENCE	LP	LAMP POST
CV	CAST IRON	LW	LAMP POST
CTK	CABLE T.P. MARKER	MB	MOORING BOLLARD
D	DRAIN	MF	MOTORWAY BOUNDARY FENCING
DP	DROP KERB	MH	MANHOLE
E	ELECTRICITY	MO	MOORING
EP	DOWNPIPE	MP	MOORING PILE
ER	EDGE OF ROAD/ COURSE	MW	MASONRY WALL/ ALL FENCE
ES	DRAIN	NF	HALF A TON
FHR	DISC WATER MAIN	NT	NOTICE BOARD
EA	ELECTRICITY ARMOUR/ DUCT	OA	OVERHEAD CABLE/ AUTHORITY
EL	ELECTRICITY CABLE	OHL	OVERHEAD CABLE
ECP	ELECTRIC CABLE PEACH	OS	OIL CHAMBER
EM	ELECTRICITY MARKER POST	PA	PAVING/ TILE/ PATIO
EMP	ELECTRICITY MARKER	P	PIER
EP	ELECTRICITY POLE	PB	PILLAR BOX
ET	ELECTRICITY TOWER	PC	PETROL/ WATER
ETL	ELECTRICITY TOWER/OBSOLUTE	PO	POST
FB	FLOWET BED	PPT	POST & RAIL/ETC
FBR	FACTOR/BELL	PTA	PARKING TASTE ANCHOR
PWP	POST & WIRE FENCE		
RL	REVIT RAIL		
RP	RUBSHAL/ET		
RT	RAIL TRACK		
RTW	RETAINING WALL		
RWP	RAINWATER PIPE		
S	SIGN		
SAP	STAND PIPE		
SB	SOAKAWAY		
SC	SOIL VENT PIPE		
SHP	SUP ACC WATER WHEELS		
SMF	SHEET METAL FLANG		
SP	SIGN POST		
SPF	STEEL PALLISADE FENCE		
STA	STATION		
SV	SOIL VENT PIPE		
SW	SW. VENT PIPE		
TBA	TEMPORARY BENCH MARK		
TC	TOP OF CUTTING/ TOP OF BANK		
TL	TELECOM CABLE		
TLM	TELECOM MANHOLE		
TP	TELEGRAPH POLE		
TT	TRAFFIC LIGHT		
TW	TOP OF WALL/ TOP OF KERB		
TX	TELEGRAPH MAST		
TY	TRAFFIC LIGHT CONTROL STOP		
TYL	TREE/ TUMBLE		
TYU	TUSSLE AT TOP/ RAILINGS		
UC	UNDER CUT		
VA	WATER VALVE		
VL	WATER LEVEL/ WATER LINE		
WA	WATER TAP		
WBP	WEB BEAM/ STRUT		
WF	WEDGE/ POST		
WM	WATER MAIN/ U. Wat. STACK		
WV	WATER VALVE		
YG	YARD GULLY		

(All dimensions are in OS Survey data only)

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

DESCRIPTION	Easting	Northing	Height
B	462910.756	223555.613	68.713

STORM GEOMATICS
Tel: 01608 664910
mail@storm-geomatics.com
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CLIENT
East West Rail Alliance

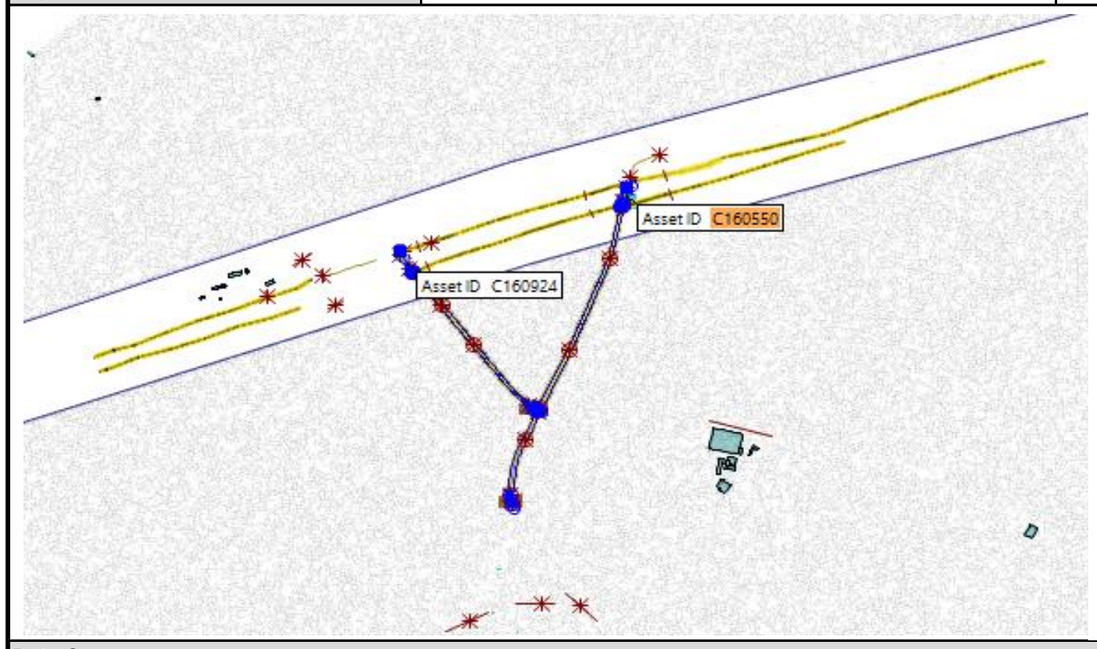
PROJECT
Watercourse At Wrestbury Court Topographical Survey

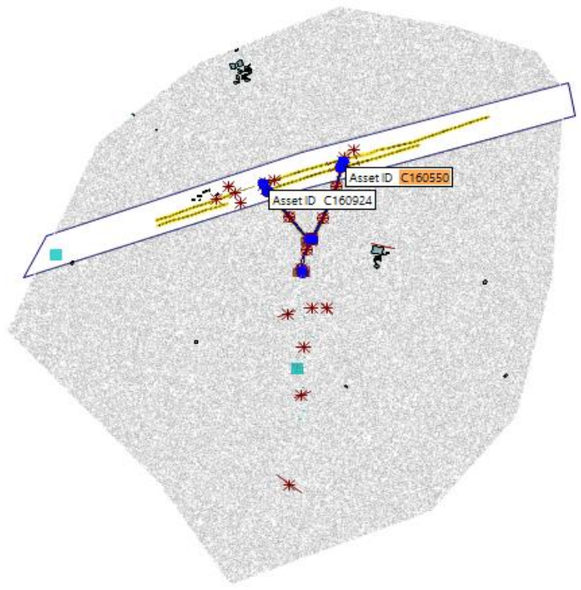
SITE
Reach 03, Watercourse Westbury Court
2A, Westbury, Bicester
2A_WEST_03_0288 to 2A_WEST_03_0355
Sheet 2 of 2

SURVEYED BY: Storm Geomatics Ltd		Project Ref: 18478857
SURVEY DATE: April 2019		
SCALE: 1:100 (A0 Sheet)	DRN: SB	CHKD: TM
DATUM: OS Newlyn (15)	DATE: 24/04/2019	DATE: 26/04/2019
GRID: OS Grid (15)	DRAWING NO. WEST_5167214/11	REV. --
CAD FILENAME: 2A_WEST_03_XS.dwg		

10. Appendix E – Model Build Summary

Project title	EWR2 GRIP5	Purpose of the model
Modeller	William Rust	Hydraulic assessment of culverts C160924 and C160550, and assessing the impact the proposed EWR2 works may have on flood risk.
Date commenced	01/07/2020	
Project location	Section 2A	





Data Sources

List out and provide a description of all data sources used to build the model e.g: topo-survey, hydrometric data, site visit, historic data, data to calibrate/validate model, photos, google maps, bing maps, council or client data etc. Provide hyperlinks to the data used.

1/ Photos (C160924: DSCF0674 to DSCF0688 and C160550: DSCF0640 to DSCF0666): \\wsatkins.com\project\WandE\LEM\5141xxx\5141357 - East West Rail Phase 2\4 Meetings\4.3 Other\180308 - Section 2A Walkout

2/ Culvert inspection report: P:\WandE\LEM\5141xxx\5141357 - East West Rail Phase 2\7 WIP\Culverts\Culvert Site Information\2A\; and

3/ Culvert master spreadsheet: 133735_RW-EWR-XX-XX-SH-DC-000012 (PW - currently Shared for Stage Approval)

4/ Site walkover notes (page 6): \\wsatkins.com\project\WandE\LEM\5141xxx\5141357 - East West Rail Phase 2\4 Meetings\4.3 Other\180308 - Section 2A Walkout\2A- Site Visit Notes.pdf

5/ Culvert team Runoff calculations: pw:\\ewr-pw.bentley.com:EWR2\Documents\Projects\133735%20-%20East%20West%20Rail%20Phase%202\RW\DC_Drainage%20Culverts\Documents\133735_RW-EWR-XX-XX-CA-DC-

6/ Topo survey: P:\INBLC\W&E\R and C\005 Projects\East West Rail\Site 7\Updated topo_30-04-2019\19AT1657 - Westbury Court\No.1 2A_WEST_01 and No.1 2A_WEST_03

7/ WSP site walkover photos: \\wsatkins.com\project\WandE\LEM\5141xxx\5141357 - East West Rail Phase 2\6 Incoming\6.1 External\17-04-12 - WSP site walkover notes

8/ BLOM point cloud data: P:\WandE\LEM\5141xxx\5141357 - East West Rail Phase 2\7 WIP\Hydro GRIP5\6.1 Incoming\EWR DTM\DTM

9/ 2m LiDAR: P:\WandE\LEM\5141xxx\5141357 - East West Rail Phase 2\7 WIP\Hydro\GIS\Rasters\LiDAR\ss\EWR_2m_DTM.tif

Overview of model build

1. 2D Zone mesh of the site generated using a Digital Terrain Model (DTM) of the site 2m LiDAR from online. Size of the elements of the 2D Zone have been set to a maximum of 15m². A band of increase mesh resolution was constructed using Mesh Zones at a 70m buffer around the rail line, with a maximum triangle size of 2m2. Total size of the 2D Zone is 393.03ha.

2. Mesh Level zones were added to the baseline and proposed at locations of proposed drainage ditch improvements. This is to ensure that the new drainage ditch dimensions are included in the proposed, maintaining the same mesh delineation in the baseline.

Ground Model Generation

1. The catchment features were generated using 50m Ordnance Survey data.

2. The final ground model uses a mosaic of the 2m downloaded LiDAR and the 0.2m pointcloud data

Baseline Ground model with no earthworks	P:\WandE\LEM\5141xxx\5141357 - East West Rail Phase 2\7 WIP\Hydro GRIP5\6.2 Work In Progress\GIS\DTM Generation\Site 7&8\site_7_baseline\site_7_merged_dtm_v2.asc
Proposed Earthworks	P:\WandE\LEM\5141xxx\5141357 - East West Rail Phase 2\7 WIP\Hydro GRIP5\6.2 Work In Progress\GIS\DTM Generation\Site 7&8\Site 7 EWKs\Site_7&8_EWKS.tif

Atkins acquired topographical survey from Storm Geomatics in March 2019. This survey along with the Alliance site visit notes and photographs provided all the information required to construct the 1D part of the model. As the model was being used to model several overland flow paths a ground model was required. The site did not have a single source of LiDAR that covered the entire hydrological catchment, so the final baseline DTM was generated by mosaicking a number of different DTM sources. 2m LiDAR sources were downloaded from the data.gov website and combined with the route wide, EWR point cloud data to form the baseline ground model. The addition of the 0.2m point cloud data ensured that key small-scale features, such as field drains and existing drainage ditches, were included in the baseline scenario.

River Reaches

a. A total of 7 River Reach sections have been added into the hydraulic model with individual hydraulic structures included

b. Each of the River Reach sections are based on cross-sectional topographic surveys that were commissioned as part of this scheme. These have been connected to the 2D Zone by combining these with Bank lines. Each Bankline has been updated using the Baseline DTM for this site.

c. The Roughness of the River Reach Sections are based on the underlying Roughness Zones/site photos.

d. Where the River Reach Sections meet at a junction, these have been connected through a combination of storage nodes and Inline Banks, both of which have been updated using the Baseline DTM for this site. A total of 2 main junctions have been added into this model.

e. Culvert structures (excluding the railway culverts, which are detailed below) that convey flow from these River Reaches have been included as 1D conduit structures, with corresponding culvert inlet links. Irregular weirs have also been added to model overflow in line with the culvert structure if the culvert structure appears to surcharge. The structure of the conduit, culvert inlet, and irregular weir are based on topographic surveys.

f. Where the River Reach ultimately starts or ends, these have been connected with the 2D Zone using Inline Banks, which have been updated using the Baseline DTM for this site.

Existing Structures

Culvert 160924
The existing structure consists of a circular culvert 160924 which is of dia. 350mm flowing from the up side to the down side into an open ditch.
The existing structure has been built into the system in the following way:
a. Upstream storage node (US_Site7) has been modelled as a storage node to improve the stability between 1D and 2D model components. Storage array within this node has been taken from the ground model that represents the channel immediately upstream of the culvert inlet. Inline banks allowing spill from this storage area have been set up with Discharge Coefficient of 1.1 and Modular Limits of 0.9.
b. a Culvert inlet object has been used to account for the headlosses between the 2D river channel to the North, and the piped culvert. Parameters for this have been set to: Invert 72.380mAOD; Equation A; K 0.0098; M 2.000; c 0.0398; Y 0.67; Ki 0.50. This represents a standard concrete winged headwall. Similarly, a culvert outlet object has been placed at the downstream end of the culvert to represent expansion losses. These culvert objects have been connected in-line using break nodes.
c. A downstream storage node (DS_Site7) has been modelled as a break node that connects with the 1D river reach immediately downstream of C160924 via the culvert outlet object.
c. A link in the form of a conduit has been added to connect both Nodes US_Site7 and DS_Site7 to represent the culvert. The length, upstream invert level and downstream invert level are 24m, 72.38mAoD and 71.88mAoD respectively based on the topographical survey. The diameter of this culvert has been set to 350mm, with upper and lower roughnesses of 0.01 (mannings).

Culvert 160550
The existing structure consists of an arch culvert which is of 900mm*800mm (height*width) dimensions, flowing from the up side to the down side into an open ditch.
The existing structure has been built into the system in the following way:

a. Upstream storage node (US_Site8) has been modelled as a storage node to improve the stability between 1D and 2D model components. Storage array within this node has been taken from the ground model that represents the channel immediately upstream of the culvert inlet. Inline banks allowing spill from this storage area have been set up with Discharge Coefficient of 1.1 and Modular Limits of 0.9.
b. a Culvert inlet object has been used to account for the headlosses between the 2D river channel to the North, and the piped culvert. Parameters for this have been set to: Invert 74.920mAOD; Equation A; K 0.0098; M 2.000; c 0.0398; Y 0.67; Ki 0.50. This represents a standard concrete winged headwall. Similarly, a culvert outlet object has been placed at the downstream end of the culvert to represent expansion losses. These culvert objects have been connected in-line using break nodes.
c. A downstream storage node (Site8_in) has been modelled as a break node that connects with the 1D river reach immediately downstream of C160550 via the culvert outlet object.
d. A link in the form of a conduit has been added to connect both Nodes US_Site8 and DS_Site8 to represent the culvert. The length, upstream invert level and downstream invert level are 23.5m, 74.92mAoD and 74.87mAoD respectively based on the topographical survey. Roughness of conduits set to 0.025 bottom side and 0.015 for upper side.
e. Culvert C160550 is connected with open ditch at the downstream end which is passing below the Bicester Road.

Other Structures

The following structures have also been included in the hydraulic model.

Asset ID/ US Node Name	River Reach	Structure Type	Size (mm)	Upstream Invert Level (m AOD)	Downstream Invert Level (m AOD)	Length (m)
West_03_0015_Break	NODE_0001.1	Circular culvert with irregular weir	230	69.700	69.500	7.31
West_01_DS_break	West_01_junc_Sto.1	Circular culvert with irregular weir	540	67.360	67.320	12.39

Hydrology

The FEH web service has been used to extract the catchment parameters for Westbury Court. An SPR of 52% was used to represent a fixed percentage infiltration for Westbury Court

	A	B	C	D	E	F	G	H	I
1	VERSION	"FEH CD-ROM"	Version	3	exported	09:28:17	GMT	Thu	########
2	CATCHMENT	GB	462600	222150	SP 62600	22150			
3	CENTROID	GB	463658	223955	SP 63658	23955			
4	AREA	2.5775							
5	ALTBAR	79							
6	ASPBAR	191							
7	ASPVAR	0.6							
8	BFIHOST	0.222							
9	DPLBAR	2.51							
10	DPSBAR	24.8							
11	FARL	1							
12	FPEXT	0.2302							
13	FPDBAR	1.253							
14	FPLOC	0.58							
15	LDP	4.87							
16	PROPWET	0.32							
17	RMED-1H	10.1							
18	RMED-1D	31.9							
19	RMED-2D	38.9							
20	SAAR	613							
21	SAAR4170	651							
22	SPRHOST	52.94							
23	URBCONC1990	-999999							
24	URBEXT1990	0							
25	URBLOC1990	-999999							
26	URBCONC2000	-999999							
27	URBEXT2000	0							
28	URBLOC2000	-999999							
29	C	-0.02319							
30	D1	0.33946							
31	D2	0.30538							
32	D3	0.24194							
33	E	0.2928							
34	F	2.47386							
35	C(1 km)	-0.023							
36	D1(1 km)	0.33							
37	D2(1 km)	0.318							
38	D3(1 km)	0.238							
39	E(1 km)	0.291							
40	F(1 km)	2.482							
41									

FEH Catchment Descriptors 46260

A critical duration assessment was carried out and a 60 min duration storm was determined to be the most critical.

Channel and Floodplain Roughness

Roughness zones have been integrated into the model using the OS Mastermap. All buildings have been represented using porous polygons with a porosity of 0.1. The Mannings roughness of each object are as follows:

ID	Type	Suggested rough	Potential Changes	Final	Comment
1	Manmade land	0.025		0.025	Hard surfaces
2	Building	1.000		1.000	Building not represented by porous polygon
3	Manmade road/track/path	0.025		0.018	Hard surfaces
4	Rail track	0.030	0.035	0.035	Railway track - gravel/rubble
5	Manmade roadside	0.025		0.018	Hard surfaces
6	Property land	0.050		0.050	Land around properties. Includes effects of fences/hedges etc
7	Historic interest land				Check these on a case by case basis if they overlap the modelled areas
8	Natural land - general	0.035	0.040	0.040	General value for natural land - mostly pasture/crop
9	Water	0.020	0.016	0.016	Water
101	Natural land - coniferous trees	0.050	0.055	0.055	As stated
102	Natural land - coppice	0.050	0.060	0.060	As stated
103	Natural land - scrub	0.070		0.070	As stated
104	Natural land - Marsh	0.050		0.050	As stated
105	Natural land - Non-coniferous tree	0.050	0.055	0.055	As stated
106	Natural land - Orchard	0.040	0.045	0.045	As stated
107	Natural land - rough grass	0.035	0.040	0.040	As stated
16	Natural roadside	0.035	0.040	0.040	Assumed to be grass / light scrub
11	Natural road/track/path	0.030	0.035	0.035	Natural track /path - short grass / gravel
12	Unclassified land				Check these on a case by case basis if they overlap the modelled areas
13	General land - unknown				Check these on a case by case basis if they overlap the modelled areas
14	Rail unknown				Check these on a case by case basis if they overlap the modelled areas
15	Unknown roadside				Check these on a case by case basis if they overlap the modelled areas
17	Building	1.000		1.000	To be revised to 0.05 where porous polygons are introduced

1D-2D Links

1D connection of the conduit to the 2D zone is via the storage nodes, the associated storage areas , the inline banks, and the outfall nodes (refer to Existing Structures section for details).

Model Boundaries

1. Model boundary conditions have been set to Normal. All flows reaching the edge of the mesh are represented by a normal depth hydraulic condition.
2. Direct rainfall is applied everywhere in the mesh.
3. An infiltration surface has been applied with a fixed runoff coefficient of 0.52 (the same as the FEH SPRHOST for this site).

With Scheme

C160924

This culvert is a like-for-like replacement so has no changes between the Baseline and With Scheme scenario.

C160550

This culvert has been replaced from an Archsprung culvert to a circular culvert of 600mm diameter. The upstream and downstream inverts for this culvert remain the same.

EWR2 earthworks

Proposed EWR2 earthworks were incorporated into the existing ground model based on the detailed earthwork designs.

Land Drainage system

The improved drainage ditches have been represented as Mesh Level Zones.

Model Runs

Model Scenario	Description of scenario	Return Periods
Westbury 2020 > Base	Baseline	All RPs
Westbury 2020 > Base>With Scheme	With Scheme	All RPs
Site 7 & 8_v2 Updated Headlosses_Updated_topo_05-11-19_HT > Sensitivity-Mannings+20%	Baseline Model - Sensitivity Test: Flows +20%	1% annual chance event
Site 7 & 8_v2 Updated Headlosses_Updated_topo_05-11-19_HT > Sensitivity-Mannings-20%	Baseline Model - Sensitivity Test: Flows -20%	1% annual chance event

Site 7 & 8_v2 Updated Headlosses_Updated_topo_05-11-19_HT > Sensitivit-Runoff+20%	Baseline Model - Sensitivity Test: Roughness +20%	1% annual chance event
Site 7 & 8_v2 Updated Headlosses_Updated_topo_05-11-19_HT > Sensitivit-Runoff-20%	Baseline Model - Sensitivity Test: Roughness -20%	1% annual chance event
Site 7 & 8_v2 Updated Headlosses_Updated_topo_05-11-19_HT > Sensitivit-Headloss+20%	Baseline Model - Sensitivity Test: Runoff +20%	1% annual chance event
Site 7 & 8_v2 Updated Headlosses_Updated_topo_05-11-19_HT > Sensitivit-Headloss-20%	Baseline Model - Sensitivity Test: Runoff -20%	1% annual chance event

11. Appendix F – CFSA Calculation Record

Appendix F: CFSA Calculation Record

This assessment has been undertaken to assess the volume of floodplain losses due to the EWR2 scheme and size the proposed Compensatory Flood Storage Areas (CFSA). A frequency-for-frequency approach has been adopted where volumes lost during a given flood event are replaced at the same event in the flood hydrograph. The following data was used in this assessment:

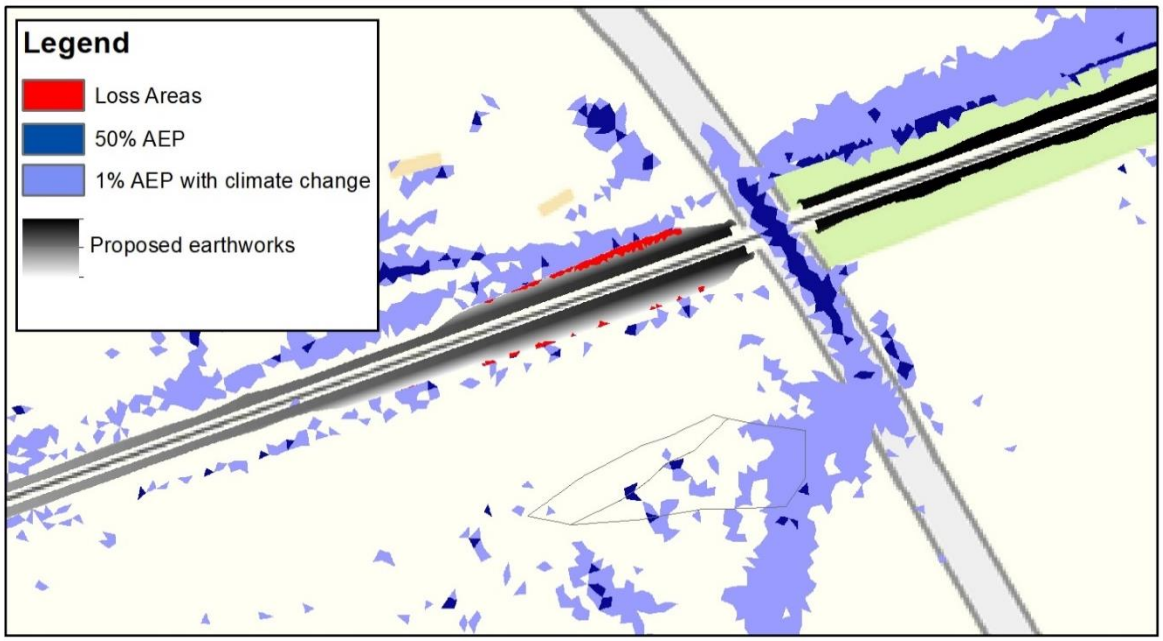
- Existing ground model
- Proposed ground model
- Flood level grids from the Westbury Court hydraulic model

Floodplain Losses

The volume of floodplain lost is listed in the fourth column in the table below.

Annual Chance Event (%)	**Total Volume lost (m^3)**	**Flood level at gain site (mAOD)**	**Volume lost at Increment (m^3)**
50%	0.8	70.645	0.8
1%	20	70.660	19
0.5%	24	70.662	3.6
1 % with 40% climate change	26	70.832	2.0

As shown in the figure below, these losses are all confined to the toe of the improved embankment and therefore are likely associated with surface water drainage pathways. A separate CFSA for these losses is not necessary if suitable toe drainage is installed providing replacement volume.



CFSA

The limited volume of lost floodplain has been compensated for within the drainage ditches, including an overprovision of floodplain storage, thus CFSA 2A0325/5.2/FH is not required. The improved drainage ditches have increased the cross-sectional area of the existing ditches by approximately 0.5m² over a length of approximately 2km giving an additional floodplain capacity of over 1000m³, a significant oversizing from the total floodplain loss of 26m³.

12. Appendix G – All Model Results

Result Point	Peak Water Level (mAOD)									
	Baseline					With Scheme				
	50%	2%	1%	1% + CC	0.1%	50%	2%	1%	1% + CC	0.1%
NRP 1	71.94	72.15	72.23	72.26	72.30	71.96	72.16	72.22	72.26	72.30
NRP 13	76.98	77.03	77.05	77.08	77.10	76.98	77.03	77.04	77.07	77.10
NRP 14	76.02	76.02	76.02	76.02	76.02	75.97	75.97	75.97	75.97	75.97
NRP 16	76.11	76.11	76.11	76.11	76.11	76.16	76.16	76.16	76.16	76.16
NRP 2	71.84	71.85	71.85	71.85	71.86	71.85	71.86	71.86	71.86	71.87
NRP 24	66.55	66.64	66.65	66.69	66.73	66.55	66.64	66.65	66.69	66.73
NRP 25	66.65	66.70	66.72	66.76	66.80	66.64	66.70	66.71	66.75	66.80
NRP 26	66.67	66.73	66.74	66.77	66.80	66.67	66.73	66.74	66.77	66.80
NRP 27	66.04	66.12	66.15	66.19	66.24	66.04	66.12	66.15	66.19	66.24
NRP 28	65.20	65.32	65.35	65.40	65.45	65.20	65.32	65.35	65.40	65.45
NRP 29	63.64	63.75	63.78	63.82	63.87	63.63	63.76	63.78	63.82	63.87
NRP 3	70.40	71.27	71.31	71.37	71.43	70.41	71.26	71.30	71.37	71.43
NRP 4	73.17	73.35	73.38	73.42	73.47	73.17	73.35	73.38	73.42	73.46
NRP 5	72.98	73.06	73.10	73.16	73.20	72.98	73.06	73.09	73.16	73.20
NRP 7	71.77	71.81	71.82	71.85	71.91	71.83	71.86	71.87	71.90	71.95
NRP 8	73.47	73.47	73.47	73.47	73.48	73.53	73.53	73.53	73.54	73.54
DS_Site7	72.19	72.31	72.32	72.35	72.39	72.19	72.31	72.32	72.35	72.39
DS_Site8	74.91	74.92	74.93	74.93	74.94	74.91	74.93	74.94	74.95	74.96
hl	72.53	72.60	72.61	72.63	72.66	72.53	72.59	72.60	72.62	72.66
hl2	74.96	74.97	74.98	74.98	75.00	74.96	75.00	75.01	75.02	75.05
NODE_0001	72.15	72.27	72.29	72.32	72.35	72.15	72.27	72.28	72.31	72.35
NODE_0007	74.29	74.32	74.32	74.34	74.36	74.29	74.32	74.33	74.34	74.37
Site7_in	72.19	72.28	72.29	72.32	72.35	72.19	72.28	72.29	72.31	72.34
Site8_in	74.40	74.41	74.42	74.43	74.44	74.40	74.42	74.42	74.43	74.44
US_Site7	72.76	73.02	73.06	73.11	73.14	72.76	73.02	73.05	73.11	73.15
US_Site8	74.96	74.98	74.98	74.99	75.01	74.96	75.00	75.01	75.03	75.05
West_01_0727_B	67.91	67.96	67.98	68.00	68.02	67.90	67.96	67.98	68.00	68.02
West_01_0727_Cout	67.92	68.11	68.14	68.18	68.22	67.91	68.11	68.14	68.18	68.22
West_01_0740_Cin	67.92	68.21	68.25	68.31	68.36	67.92	68.21	68.25	68.31	68.36
West_01_DS_B1	67.91	67.97	67.98	68.00	68.02	67.90	67.96	67.98	68.00	68.02

Result Point	Peak Water Level (mAOD)									
	Baseline					With Scheme				
	50%	2%	1%	1% + CC	0.1%	50%	2%	1%	1% + CC	0.1%
West_01_DS_break	67.93	68.28	68.33	68.40	68.46	67.93	68.28	68.33	68.40	68.46
West_01_junc_Sto	69.71	69.85	69.88	69.94	70.00	69.71	69.85	69.88	69.94	70.00
West_03_0008_Break	69.74	69.86	69.89	69.95	70.01	69.74	69.86	69.89	69.95	70.01
West_03_0008_Cout	69.90	70.05	70.09	70.13	70.18	69.90	70.05	70.09	70.13	70.18
West_03_0015_Break	70.35	70.39	70.40	70.42	70.44	70.35	70.39	70.40	70.42	70.44
West_03_0015_Cin	70.09	70.26	70.29	70.32	70.36	70.09	70.26	70.29	70.32	70.36
NRP 10	71.42	71.52	71.53	71.58	71.63	71.42	71.52	71.53	71.58	71.63
NRP 11	72.15	72.27	72.29	72.32	72.36	72.15	72.27	72.29	72.32	72.35
NRP 12	69.75	69.87	69.89	69.95	70.01	69.75	69.87	69.89	69.95	70.01
NRP 17	73.21	73.25	73.26	73.27	73.29	73.21	73.25	73.25	73.27	73.30
NRP 18	71.77	71.83	71.85	71.88	71.92	71.76	71.83	71.85	71.88	71.92
NRP 19	74.29	74.32	74.33	74.34	74.36	74.29	74.32	74.33	74.34	74.37
NRP 20	69.72	69.89	69.93	70.00	70.07	69.72	69.89	69.93	70.00	70.08
NRP 21	68.99	69.09	69.12	69.18	69.25	68.99	69.09	69.12	69.18	69.25
NRP 22	69.72	69.89	69.93	70.00	70.07	69.72	69.89	69.93	70.00	70.08
NRP 23	67.91	67.97	67.98	68.00	68.02	67.90	67.96	67.98	68.00	68.02
NRP 9	72.04	72.15	72.16	72.19	72.23	72.04	72.15	72.16	72.19	72.23
element 225041	70.49	70.51	70.52	70.54	70.56	70.49	70.51	70.52	70.54	70.56
NRP3_2	70.42	71.26	71.30	71.48	71.43	70.42	71.26	71.30	71.48	71.43

Result Point	Flow (m3\s)									
	Baseline					With Scheme				
	50%	2%	1%	1% + CC	0.1%	50%	2%	1%	1% + CC	0.1%
us hl.1	0.10	0.17	0.18	0.19	0.19	0.10	0.17	0.18	0.19	0.19
us hl2.1	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.02
ds hl.1	0.10	0.17	0.17	0.19	0.19	0.10	0.17	0.17	0.18	0.19
ds hl2.1	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.02
NRP 10	0.10	0.19	0.21	0.26	0.31	0.10	0.19	0.21	0.26	0.33
NRP 11	0.10	0.18	0.19	0.22	0.25	0.10	0.18	0.19	0.21	0.24
NRP 12	0.08	0.09	0.09	0.09	0.09	0.08	0.09	0.09	0.09	0.09

Result Point	Flow (m3\s)									
	Baseline					With Scheme				
	50%	2%	1%	1% + CC	0.1%	50%	2%	1%	1% + CC	0.1%
NRP 17	0.00	0.01	0.01	0.02	0.02	0.00	0.01	0.01	0.02	0.03
NRP 18	0.01	0.07	0.10	0.16	0.23	0.01	0.07	0.10	0.16	0.24
NRP 19	0.00	0.01	0.01	0.01	0.02	0.00	0.01	0.01	0.01	0.02
NRP 20	0.09	0.29	0.36	0.53	0.76	0.09	0.29	0.36	0.53	0.77
NRP 21	0.10	0.32	0.40	0.59	0.86	0.10	0.32	0.40	0.59	0.86
NRP 22	0.09	0.29	0.36	0.53	0.76	0.09	0.29	0.36	0.53	0.77
NRP 23	0.10	0.38	0.41	0.43	0.45	0.10	0.38	0.41	0.43	0.45
NRP 9	0.10	0.18	0.19	0.22	0.26	0.10	0.18	0.19	0.22	0.25
1	0.00	0.07	0.11	0.19	0.30	0.00	0.08	0.12	0.20	0.31
2	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.01	0.01	0.02	0.02	0.00	0.01	0.02	0.02	0.03
5	0.10	0.56	0.70	1.02	1.40	0.10	0.56	0.71	1.02	1.40
6	0.00	0.01	0.02	0.02	0.03	0.00	0.01	0.01	0.02	0.02
NRL 1	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.01	0.04
NRL 13	0.04	0.28	0.37	0.56	0.80	0.05	0.28	0.35	0.52	0.74
NRL 14	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
NRL 2	0.01	0.02	0.03	0.04	0.06	0.01	0.02	0.03	0.04	0.06
NRL 24	0.05	0.42	0.59	0.98	1.52	0.05	0.42	0.59	0.98	1.53
NRL 25	0.06	0.60	0.82	1.71	3.20	0.05	0.59	0.79	1.67	3.18
NRL 26	0.07	0.59	0.81	1.35	2.12	0.07	0.59	0.81	1.36	2.12
NRL 27	0.11	1.49	2.13	3.64	5.67	0.10	1.48	2.12	3.63	5.68
NRL 28	0.11	1.55	2.23	3.84	6.18	0.10	1.55	2.22	3.84	6.18
NRL 29	0.09	2.12	3.01	5.02	7.80	0.09	2.13	3.01	5.02	7.80
NRL 3	0.00	0.48	0.79	1.50	2.46	0.00	0.45	0.77	1.47	2.49
NRL 4	0.10	0.51	0.61	0.84	1.11	0.10	0.50	0.61	0.82	1.08
NRL 5	0.10	0.25	0.31	0.42	0.58	0.10	0.25	0.31	0.42	0.58
NRL 7	0.02	0.58	0.84	1.50	2.32	0.03	0.56	0.82	1.46	2.35
NRL3_2	0.01	0.46	0.69	1.38	2.45	0.01	0.44	0.66	1.38	2.42
West_01_0740_Cin.1	0.10	0.40	0.42	0.45	0.46	0.10	0.40	0.42	0.45	0.46

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