EWR Alliance

East West Rail Phase 2

EWR Alliance

Flood Risk Assessment: CFSA Modelling Report (Launton Brook)
CFSA ID: 2A0326/5.2/FH

NGR: 461848, 223547

Section: 2A

Discipline/Grip Stage: Drainage Culverts / GRIP 5

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East West Rail Phase 2

Launton Brook

CFSA Modelling Report

September 2020

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Contents

Tables

Figures

Executive Summary

This report sets out the hydrological and hydraulic modelling approach adopted to assess the potential flood risk effects of the East West Rail Phase 2 project (EWR2) north-east of Launton at National Grid Reference (NGR) 461848, 223547, on the Launton Brook, on Route Section 2A. This report is submitted to discharge Planning Condition 13, 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 the Launton Brook, where receptors at flood risk in the baseline case are Network Rail land, parts of the highway network, agricultural land and a small number of properties. Following review comments from the Environment Agency the existing WSP/PB model has been improved with additional topographic data and has been extended further downstream. The improved hydrological and hydraulic model has been used to assess flood risk to EWR2, the potential impacts of the Scheme and mitigation options.

The hydrology applied in the WSP/PB modelling has not been changed. The baseline hydrological and hydraulic model was run for a range of flood return period events. The potential impacts of climate change were assessed by increasing flows by 70%. For all flood events there is out-of-bank flooding across the majority of the model reach.

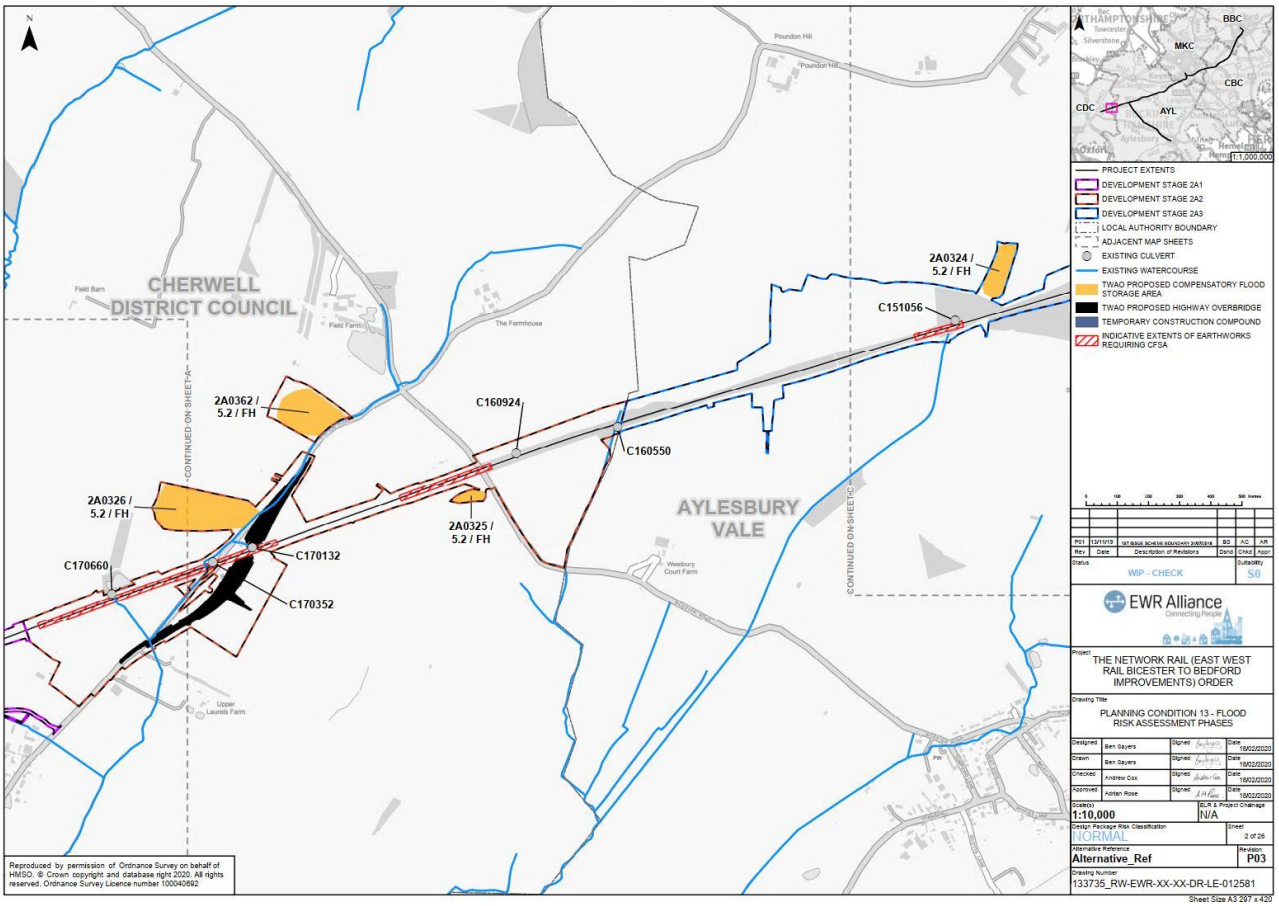
The hydrological and hydraulic model has been updated to include the With Scheme works (highway overbridge, railway embankment earthworks, river realignment and culvert rehabilitation) and used to size the proposed Compensatory Flood Storage Area (CFSA). The floodplain volume loss resulting from the highway overbridge and railway earthworks is a total of 3141m³ at the 1% annual chance (plus 70% climate change) event. This can be mitigated using a CFSA on the right (western) bank of the Launton Brook and will provide an over provision of floodplain storage, with a total volume of 4774m³ provided, an overprovision of 1633m³. There is therefore a catchment betterment provided by the Scheme.

1. Introduction

This report sets out the hydrological and hydraulic modelling approach adopted to assess the potential flood risk effects of the East West Rail Phase 2 project (EWR2) north-east of Launton at National Grid Reference (NGR) 461848, 223547, on the Launton Brook, on Route Section 2A. This report is submitted to discharge Planning Condition 13,in line with the Planning Condition 13 Phasing Strategy for assets C170660, C170352, OXD34A Station Road overbridge, realignment of the watercourse, temporary Compound A2, and railway earthworks associated with Compensatory Flood Storage Area (CFSA) 2A0326/5.2/FH and 2A0362/5.2/FH, and is located in development stage 2A2. The figure below shows the Phasing Strategy submission for this area.

CFSA 2A0362/5.2/FH is no longer required, this option was proposed as a potential CFSA alternative but CFSA 2A0326/5.2/FH is more suitable due to its closer proximity to the losses and favourable existing ground levels, therefore CFSA 2A0362/5.2/FH is not discussed further in this report.

Figure 1-1 Planning Condition 13 Phasing Strategy



As part of the EWR2 works there are sections of proposed railway embankment earthworks, and overbridge earthworks which fall within existing floodplain areas. 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 floodplain is created by re-landscaping a discrete area of land, close to the floodplain loss to provide new storage area for water in times of flood. Compensatory Flood Storage Areas (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 project wide Flood Risk Assessment (FRA) and Environmental Statement (ES) (The Network Rail (East West Rail Bicester to Bedford Improvements) Order, Environmental Statement, July 2018).

Objectives

This report sets out the location of the floodplain loss and CFSAs; the methods used to calculate losses and gains in the floodplain for earthworks associated with railway embankment widening in Route Section 2A, and the proposed Station Road Overbridge (OXD34A).

The objectives of this assessment and report are as follows:

- To develop a hydrological and hydraulic model of the river channels and floodplain to understand potential flood risk mechanisms more clearly;
- To test and inform the design of the CFSA and culvert works to ensure risks to EWR2 and receptors upstream and downstream are understood, including 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) and Environment Agency.

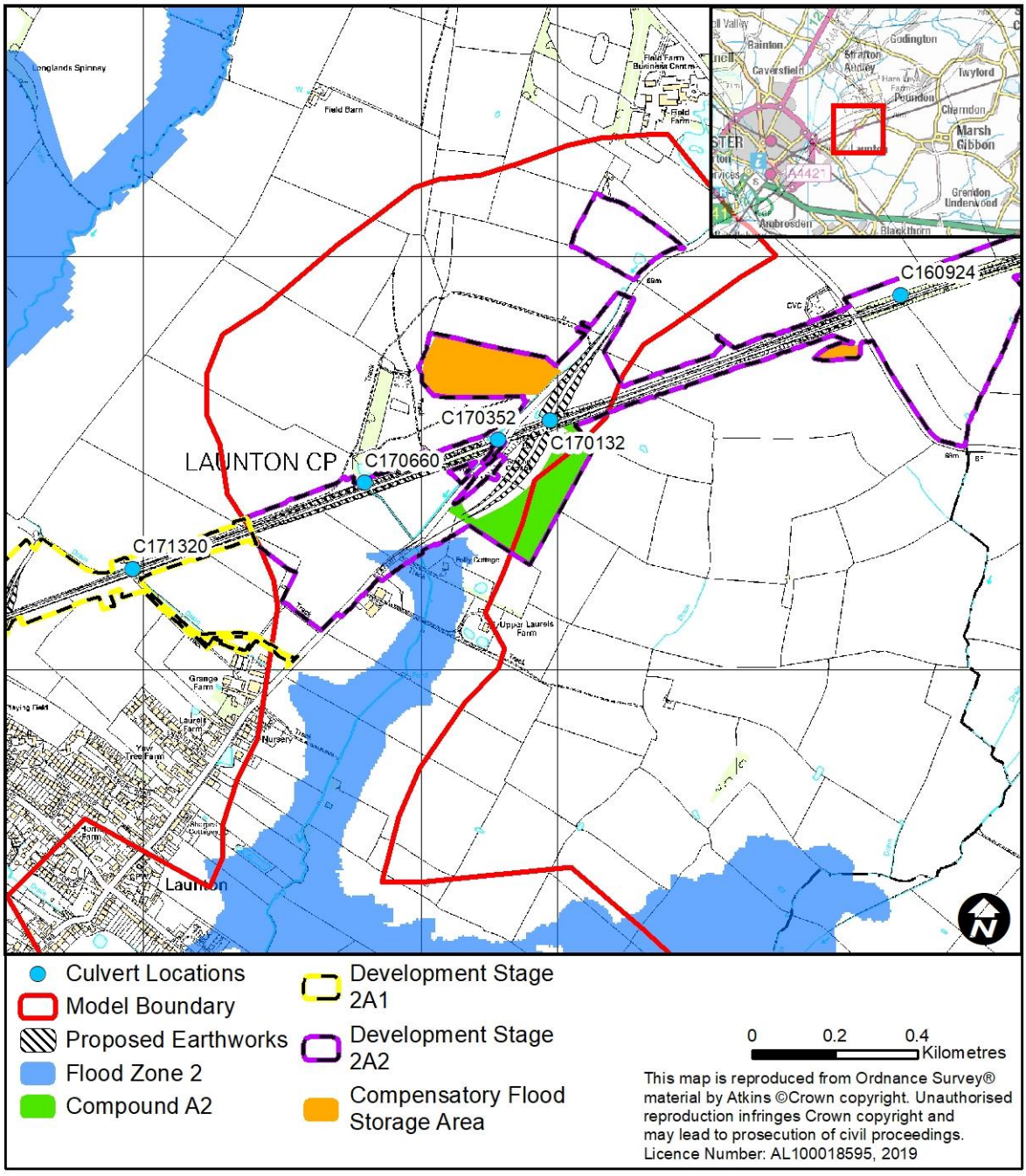
Site Description

The study area is located north-east of Launton on Route Section 2A, and adjacent to Station Road Overbridge (OXD 34A). The LLFA is OCC and the site falls within the Thames River Basin District. It is a rural setting; agricultural land is the predominant land use either side of EWR2 in this location, but with the village of Launton approximately 850m south of the EWR route.

EWR2 is on embankment in this reach. Flood risk in this area is from the Launton Brook, which flows from north to south through the existing EWR route. The eastern tributary of the Brook, upstream of EWR2 is defined as an Ordinary Watercourse, whilst the western branch shown to start immediately downstream of the EWR2 route is defined as Main River. There are three existing culverts through the EWR2 route. Assets within the floodplain are Network Rail land, parts of the highway network, agricultural land and a small number of properties.

The figure below displays the site location, key features and Environment Agency flood outlines.

Figure 1-2 Site Location



EWR2 Scheme

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

- New highway overbridge (OXD34A Station Road);
- Improvements to the existing railway embankments;

- Removal of culvert C170132. The removal of this culvert has been subject to earlier submissions and was agreed on 6th July 2020 (consent reference WAD-058), as a result culvert C170132 is not discussed any further in this report;
- Rehabilitation of culverts C170660 and C170352 with a liner;
- River realignment of the Launton Brook upstream of the EWR2 crossings; and
- Installation of a temporary works compound (Compound A2).

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);
- WSP/Parsons Brinckerhoff East West Rail Hydraulic Model Report, Network Rail (December 2016); and
- Drainage Strategy (reference: The Network Rail (East West Rail Bicester to Bedford Improvements) Order, Environmental Statement, Volume 3, Appendix 13.1H, July 2018).

2. Method

Data

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

Table 2-1 Key Data Sources

Data Name	Description
Topographical Survey	Topographical survey of the culverts is available. The hydraulic model is predominantly based on topographic survey collected by WSP/PB.
LiDAR	2m resolution LiDAR was available.
Culvert site photos	Available for all of the culverts except C170132.
CCTV Survey	Available for all of the culverts except C170352.
Other	The main source of information for this assessment was the existing Environment Agency approved WSP/PB hydrological and hydraulic model (Report 70023710-00 East West Rail-Launton Brook, Hydraulic Model Report, December 2016).

Sensitivity

Sensitivity tests were undertaken to assess the robustness of the hydrological and hydraulic as part of the WSP-PB (2016) modelling, which demonstrated limited / no sensitivity to key parameters. Since only minimal changes have been made to the WSP/Parsons Brinckerhoff model further sensitivity testing has not been undertaken.

Scenarios

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

Table 2-2 Model Scenarios

Scenario Number	Description
1	Baseline
2	With Scheme (proposed culvert works, earthworks, CFSA)
3	With Scheme (proposed culvert works, earthworks, CFSA) and 50% blockage of C170660 and C170352
4	With Scheme (proposed culvert works, earthworks, CFSA) and highway drainage flows from the proposed overbridge

Assumptions

The key points relating to this assessment are as follows:

- 5 m, 1 m and 0.2 m resolution LiDAR data, and detailed topographic survey was available within the site; and
- The modelling is based on an improved version of the Environment Agency approved WSP-PB (2016) model, with changes made as outlined in Section 3.

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 on 23/10/2018.

The Environment Agency preference 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.

Launton Brook CFSA

The proposed Launton Brook CFSA (2A0326/5.2/FH, shown in Figure 1-2) is located approximately 60m north east of the railway embankment loss and to the west of the overbridge floodplain loss, at NGR 461952, 223708. The CFSA preferentially should be located upstream of the floodplain loss. The selected site was the closest site outside the existing Launton Brook floodplain and will therefore extend the existing Launton Brook floodplain. The CFSA will connect to the Launton Brook by virtue of excavated ground levels. This location avoided the SGN high pressure gas main exclusion zone,

existing Station Road (which is being maintained as a private access) and the proposed compound and embankments associated with the project.

The topography slopes up from the loss to the CFSA with ground levels ranging from 65.8 - 67.6m AOD at the loss to 67.4 - 67.8m AOD at the proposed CFSA location. This level difference therefore means absolute level for level will not be possible or technically feasible. Therefore, based on the CIRIA 624 guidance, quoted above, a level for level approach based on flood frequency will be adopted. This will be designed so that the CFSA will operate at the same point in a flood event as that for which the area of loss currently operates.

3. Baseline Modelling

Overview

A hydraulic model built by WSP/Parsons Brinckerhoff in 2016 in ISIS Tuflow and reviewed and approved by the Environment Agency in 2017 has been modified to test the proposed EWR2 scheme at the Launton Brook. This model has been amended following review comments from the Environment Agency (received 23/6/20) and used as the updated baseline model. This updated baseline model has been modified to test the proposed EWR2 scheme and associated compensation measures at the Launton Brook.

Hydrology

The existing hydrology assessment has been reviewed and is considered to be appropriate, there have therefore been no changes to the existing hydrology as part of this assessment. The following flood events were simulated in the model:

- 50% annual chance event;
- 5% annual chance event;
- 1% annual chance event;
- 1% annual chance event plus climate change (70% flow in line with guidance from https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances); and
- 0.1% annual chance event.

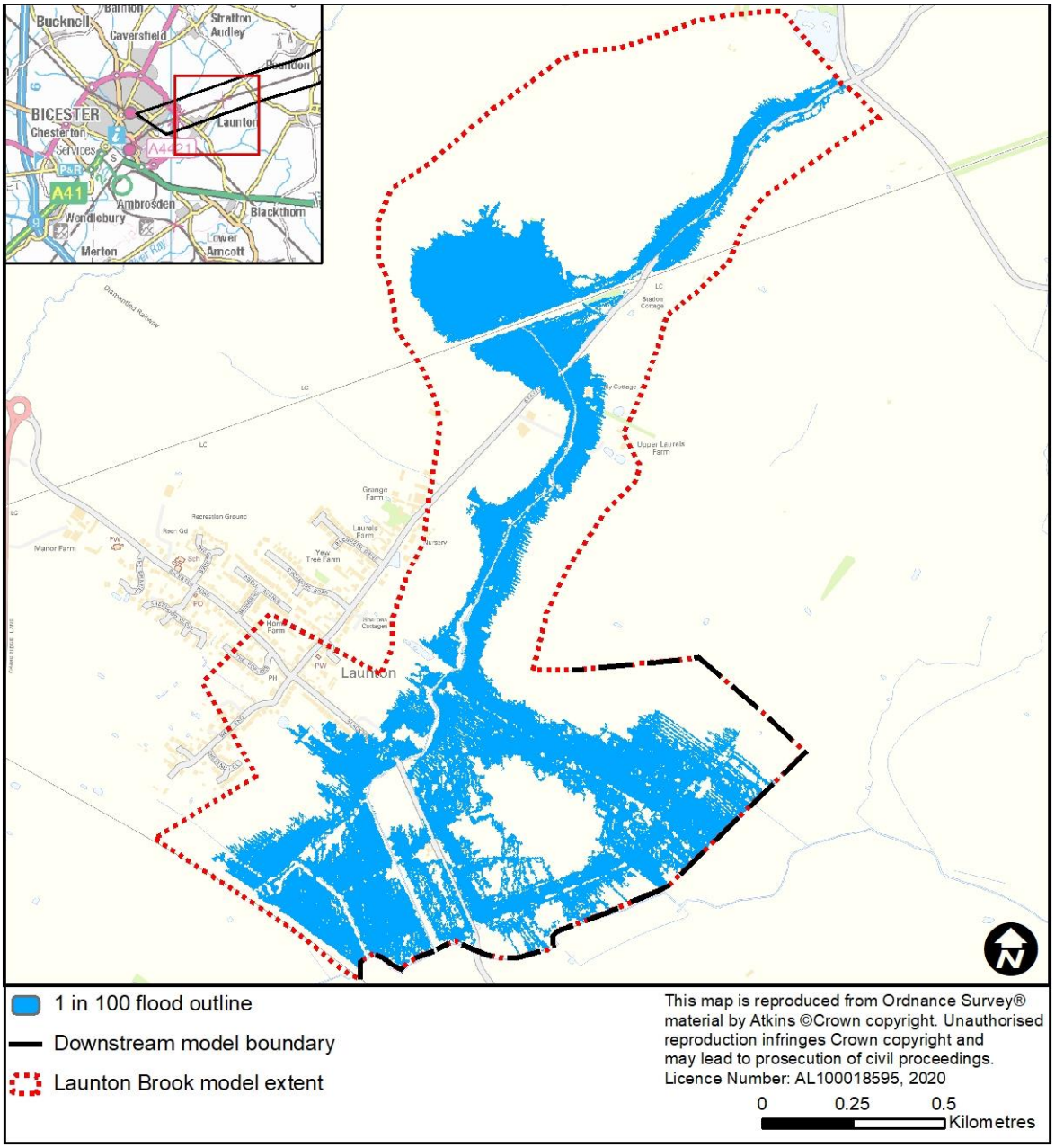
Updated Hydraulic Model

Following Environment Agency review comments on the baseline hydraulic model a number of improvements to the model have been undertaken to address these comments. Further detail is provided in Appendix D, with the key improvements being:

- The model boundary was extended, and the downstream boundary moved approximately 1km further downstream. The extension utilised the Maltby 2016 topographical survey of the Launton Brook;
- The model now utilises the 200mm resolution EWR2 project LiDAR, available along the EWR2 corridor;
- Additional survey was collected in July 2020 at the three structures beneath the current EWR2 route, culverts C170352, C170660, and OXD35 Castlemans Underbridge. This was compared against the current representation to validate the 2016 topographical survey. The model representation of OXD35 Castlemans Underbridge was updated based on this survey (with the width reduced from 4.5m to 3.03m, and the height reduced from 3.1m to 2.59m);
- Topographical survey collected by the EWR Alliance indicated that the representation of culvert C170352 in the existing model was incorrect. Culvert C170352 in the Existing Baseline model had dimensions of 1.12m by 0.56m, whereas the topographical survey recorded the dimensions of the culvert as 1.23m by 1.14m. The Updated Baseline has therefore corrected this culvert size; and
- The representation of culvert C170660 has been adjusted to remove model instabilities by simplifying the representation from a three stage culvert and 1D weir to a single stage culvert with the weir level continuing to be represented in 2D.

The figure below illustrates the updated hydraulic model extents, demonstrating the increased model area now the downstream boundary has been extended.

Figure 3-1 Hydraulic model extent



An extensive set of sensitivity tests were undertaken to assess the robustnes of the hydrological and hydraulic model to changes in key parameters, these are reported in detail in Appendix D.

Critical Storm Duration

The changes in the hydraulic model have not altered the critical storm duration which is consistent with the original model at 7.5-hours.

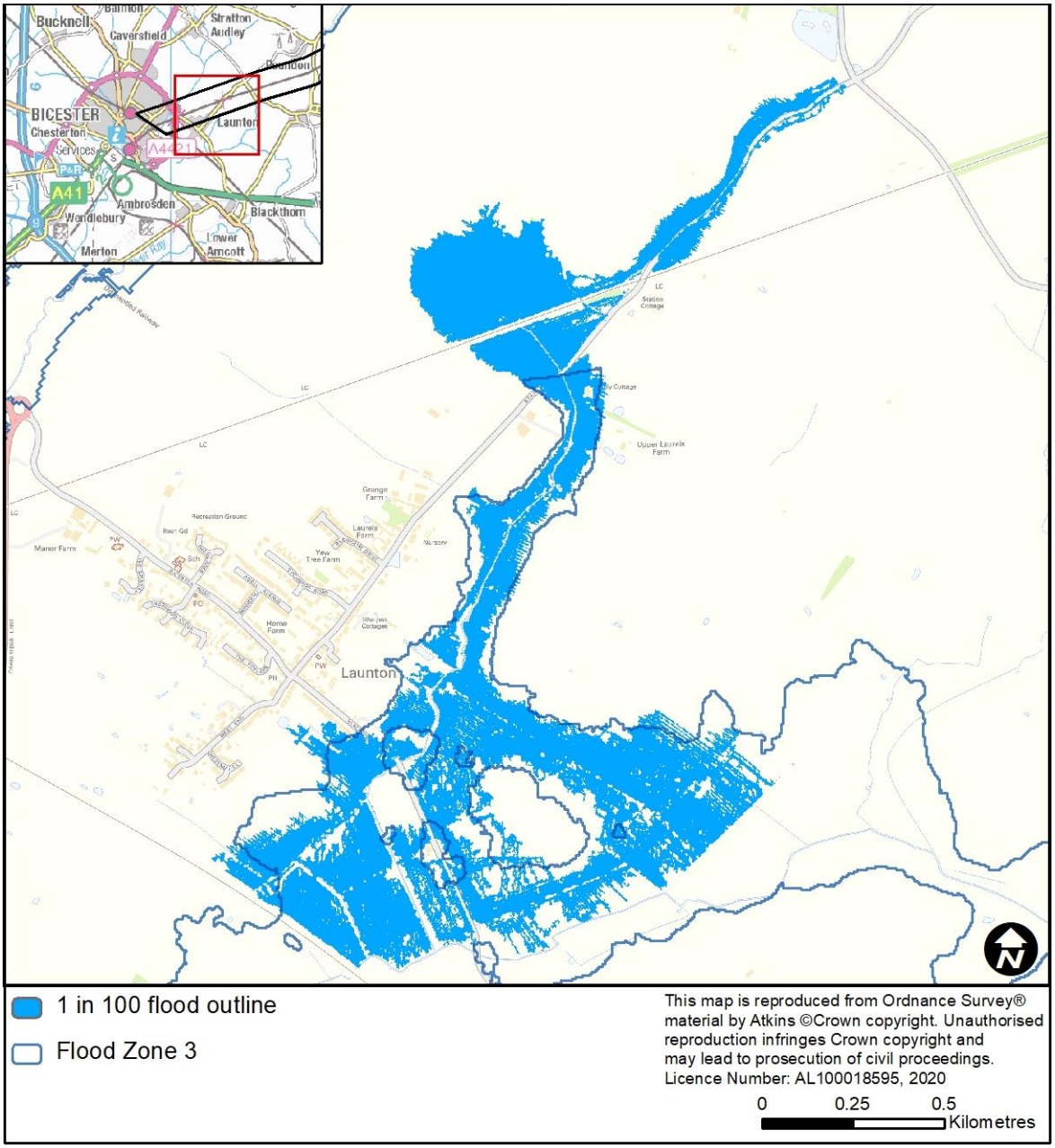
Verification

A detailed comparison of the model outputs between the 2009 Environment Agency model and the updated baseline incorporating Environment Agency review comments can be found in Appendix D.

Existing Flood Outlines

The model results have been compared with the Environment Agency Flood Zone 3, as shown in the figure below.

Figure 3-2 Comparison of Flood Zones and modelled 1% annual chance event



Comparison to WSP-PB (2016) Baseline

The updated baseline peak water levels have been compared with the WSP/PB original baseline model in the table below, the following figure shows the location of these key assessment points.

Figure 3-3 Key Assessment Point Locations

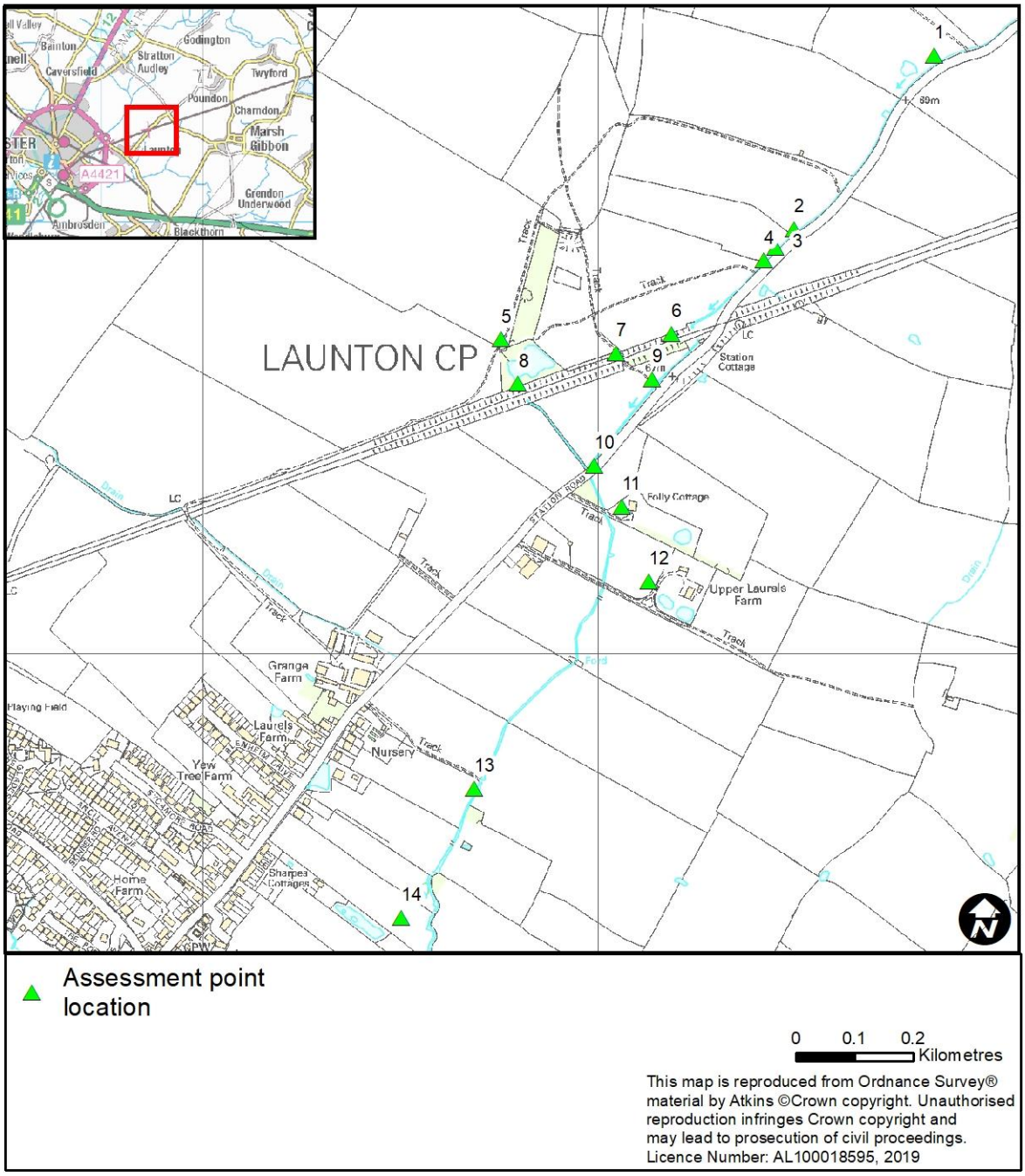


Table 3-1 Comparison of peak water levels between WSP/PB baseline model and updated baseline (1% annual chance event)

Assessment Point	Location Description	1% annual chance event Peak Water Level WSP-PB Baseline (m AOD)	1% annual chance event Peak Water Level Updated Baseline (m AOD)	Difference (m)
1	South of Field Farm.	68.66	68.68	0.02
2	Approximately 200m north east of Station Rd overbridge.	67.49	67.55	0.06
3	Approximately 150m north east of Station Rd overbridge.	67.45	67.51	0.06
4	Approximately 120m north east of Station Rd overbridge.	67.41	67.49	0.08
5	60m north west of the pond, to the west of Station Rd overbridge.	66.39	66.48	0.09
6	Upstream of culvert C170352.	66.79	66.81	0.02
7	Upstream of the underpass beneath the railway line.	66.45	66.54	0.09
8	Upstream of culvert C170660.	66.40	66.48	0.08
9	Downstream of C170352 and the underpass beneath the railway line.	66.47	66.48	0.01
10	Station Road.	66.06	66.07	0.01
11	Approximately 20m west of Folly Cottage.	65.99	66.00	0.01
12	Approximately 70m west of Upper Laurels Farm.	65.89	65.91	0.02
13	Approximately 200m south east of Green Close Nursery.	64.99	65.00	0.01
14	Approximately 150m south east of Sharpes Cottages.	64.56	64.60	0.04

This shows minor increases in peak water levels of 0.01-0.09m in the updated baseline; the updated baseline therefore provides a more precautionary assessment of flood risk compared to the WSP/PB model.

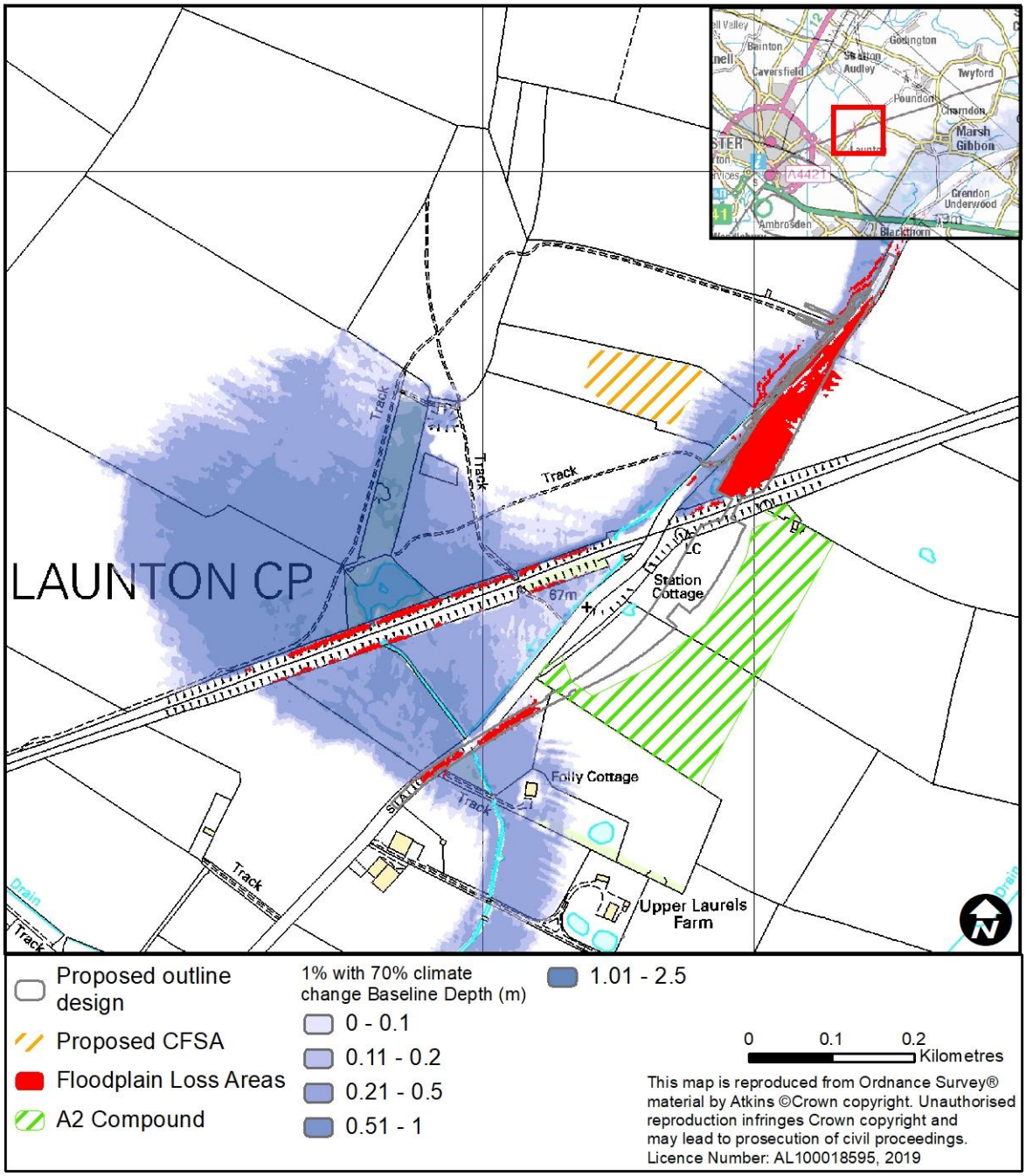
Floodplain Storage Loss Assessment

Floodplain losses from the proposed railway embankment earthworks and new overbridge (OXD/ OXD34A Station Road) were assessed (noting that Temporary Compound A2 is entirely outside of the floodplain). The assessment compared ground levels using gridded data 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 grids for all events from the hydraulic modelling.

The calculated losses are based on comparison of the baseline and With Scheme ground models compared against modelled flood levels. The location of loss in the floodplain is shown in the figure below. Appendix E contains the CFSA calculation record from this analysis.

Figure 3-4 Floodplain losses and proposed CFSA



The resulting level area relationship based on flood frequency for the loss areas is presented in the table below.

Table 3-2 Floodplain losses due to proposed earthworks

Annual Chance Event	Total Volume lost (m^3)	Flood level (mAOD)	Volume lost at Increment (m^3)
50%	731	67.34	731
5%	1484	67.45	753
1%	2035	67.51	550
1% + 70% climate change	3141	67.60	1106

The differences in peak flood levels shown above are too small to construct a viable compensation area at such a fine scale, therefore the total losses have been condensed into three 200mm bands deemed the minimum feasible for construction, as shown in Table 3-43 below.

Table 3-3 Floodplain losses condensed into 200mm bands

From Level (mAOD)	To Level (mAOD)	Total Volume (m^3)	Volume lost at Increment (m^3)
67.14	67.34	731	731
67.34	67.54	2035	1303
67.54	67.74	3141	1106

Table 3-4 CFSA Gains

From Level (mAOD)	To Level (mAOD)	Total Volume (m^3)	Volume gained at Increment (m^3)
67.14	67.34	1513	1513
67.34	67.54	3132	1618
67.54	67.74	4774	1643

The total cumulative floodplain compensation volume provided by the CFSA is 4774m^3.

4. With Scheme Modelling

As agreed with the Environment Agency on 4th February 2020, where a floodplain loss, caused by earthworks within the floodplain, is compensated for by a CFSA on a level for level basis then the With Scheme and CFSA modelling results do not need to be provided. The With Scheme scenario model will be provided as part of the modelling package supplied to the Environment Agency, and is reported on in Appendix D.

A CFSA will be provided to compensate for floodplain losses on a direct level for level basis. The CFSA has been designed on the western edge of the floodplain upstream of all floodplain losses, will extend the existing floodplain and is sized to include a significant over provision.

Blockage Assessment

The Project Wide FRA has indicated that a blockage assessment is required for culverts C170660 and C170352, and that a quantitative assessment using the hydraulic model was considered necessary. Appendix D contains details about the results of this blockage assessment.

5. Conclusion

This CFSA Modelling Report has the following conclusions:

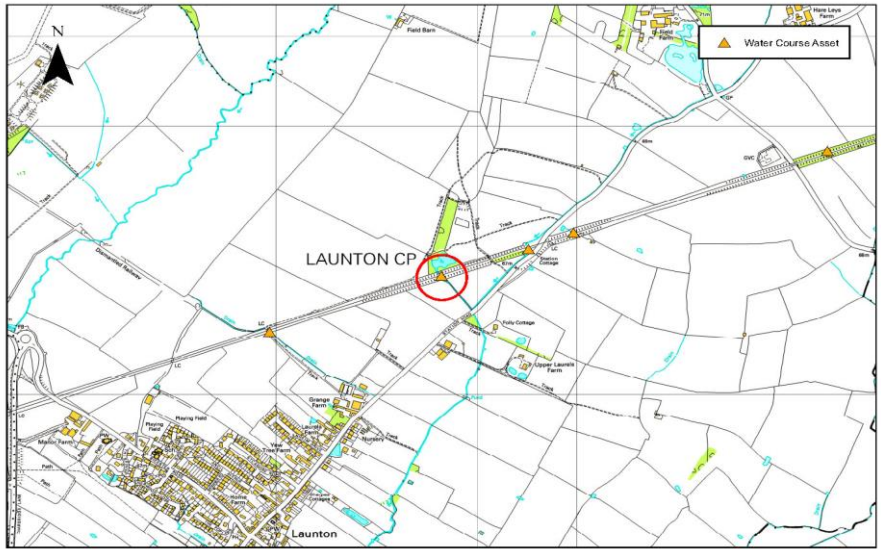
- This report is submitted to discharge Planning Condition 13 and is submitted in line with the Planning Condition 13 Phasing Strategy, and is located in development stage 2A2;
- Following review comments from the Environment Agency the existing WSP/PB model has been improved with additional topographic data and been extended further downstream. The improved hydrological and hydraulic model has been used to assess flood risk to EWR2, the potential impacts of the Scheme and mitigation options. The potential impacts of climate change were assessed by increasing flows by 70%;
- An assessment of the floodplain volume losses arising from railway earthwork embankment widening and highway overbridge works has been undertaken. The hydrological and hydraulic model has been updated to include the With Scheme proposal (including culvert works and river realignment), and used to test and size the proposed CFSA; and
- The CFSA will be in place prior to any ground raising in the floodplain being undertaken. The proposed CFSA has been designed in line with the CIRIA 624 level for level approach, and has a total volume of 4774m³, and provides an overprovision of 1633m³ when compared to the total floodplain losses. The Scheme is therefore providing a catchment betterment.

Appendix A. Project Wide FRA Site Summary Report

Summary Flood Risk Assessment

Asset Information

Site Location Map



Crossing reference/floodplain	4	
Route Section	2A	
Culvert ID	C170660	
NGR	461535, 223454	
EWR-ELR	OXD	
Lead Local Flood Authority	Oxfordshire County Council	
Environment Agency Region	Thames	
River Basin District	Thames	
Watercourse Type	Main River	
Water ES Chapter Watercourse Reference	2A 003	
Existing Culvert/Crossing Size	1450	(mm)
Existing Culvert/Crossing Length	22.7	(m)
Existing Culvert/Crossing Type	Brick Arch with Flat Bottom	

Proposed Works

Culvert Recommendation	CIPP liner for the entire length of the culvert. Existing headwalls on both sides to be repaired. Wingwalls to be re-tied to backwall on all four corners (upstream and downstream). Assume replacement of 10% blockwork and 50% repointing.	
Track Level (at crossing point)	69.71	(mAOD)

Hydrological and Hydraulic Analysis

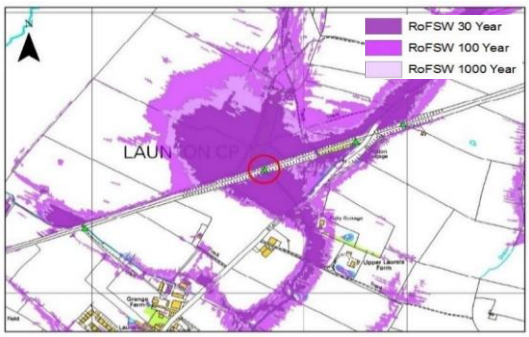
Climate Change allowance	70	(%)

	Flows (m³/s)	Embankment PWL (mAOD)	Freeboard to track (m)
100-year	0.68	66.39	3.32
100-year + 70% CC	0.85	66.76	2.95
1000-year	0.82	66.69	3.02

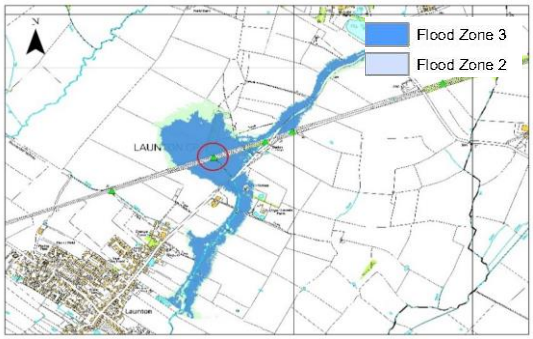
Performance Code	N/A	
Performance Code description	N/A	
Freeboard at 100-year event	>1	(m)

Floodplain Maps

RoFSW



Launton Brook Model



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	Fluvial
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.	Yes
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	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
Yes	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

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	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
Yes	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

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)	Low Adverse
Residual Significance of Effect (including mitigation)	Minor
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)	Low Adverse
Residual Significance of Effect (including mitigation)	Minor
Include in Environmental Statement Main Body	YES

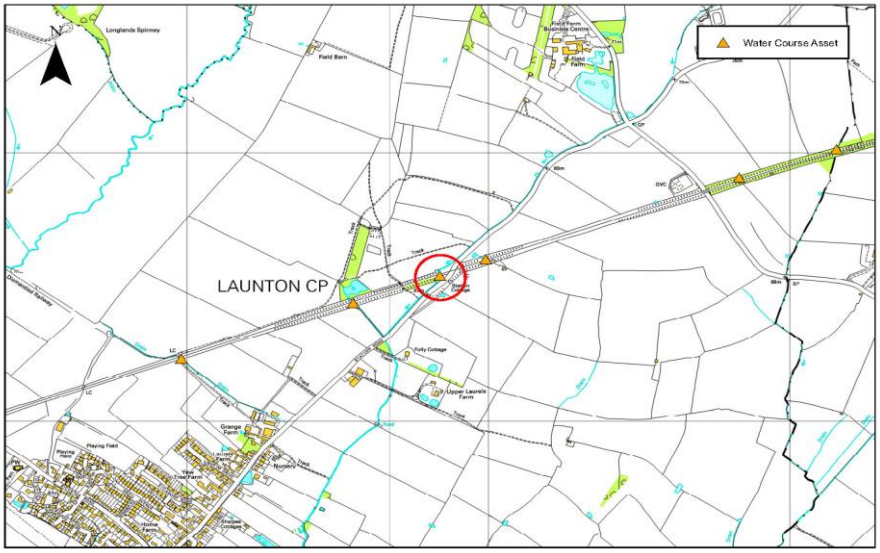
Summary

This assessment has been based on existing Environment Agency RoFSW flooding and Flood Zones 2 and 3, and the Launton Brook Hydraulic Model (ISIS/TUFLOW). The Environment Agency map shows that fluvial flood risk is limited to Station Road and some cottages that lie in Flood Zone 2 and 3, approximately 150m on the south of the track - however this is because the Flood Zone model does not extend any further upstream. An ISIS/TUFLOW model has been developed which covers the EWR route and upstream areas. Assets within the floodplain are Network Rail land, Station Road, adjoining agricultural land, and some cottages. There is limited/very low groundwater flood risk in this area. Works comprise - earthworks and the existing highway level crossing replacement with an overbridge; existing underbridge to be retained with some general repairs; footpath to be diverted. The new EWR embankments result in a loss of floodplain storage. The culvert needs to be rehabilitated using CIPP liner for the entire length of the culvert. Wingwalls to be re-tied to backwall on all four corners (upstream and downstream). Assume replacement of 10% blockwork and 50% repointing. The ISIS/TUFLOW model shows that there is approximately 3m of freeboard to the track for events up to 1000-year in this location. A CFSA is proposed to mitigate the impact of the works. 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 there will be minor change to the existing situation. A haul road is proposed in this location, which crosses an area at risk of fluvial (Flood Zone 2 and 3) and 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	5	
Route Section	2A	
Culvert ID	C170352	
NGR	461839, 223541	
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 004	
Existing Culvert/Crossing Size	1210	(mm)
Existing Culvert/Crossing Length	28.31	(m)
Existing Culvert/Crossing Type	Brick/ unknown shape	

Proposed Works

Culvert Recommendation	Existing culvert to be replaced. New precast headwalls to be installed at both ends.	
Track Level	69.82	(mAOD)

Hydrological and Hydraulic Analysis

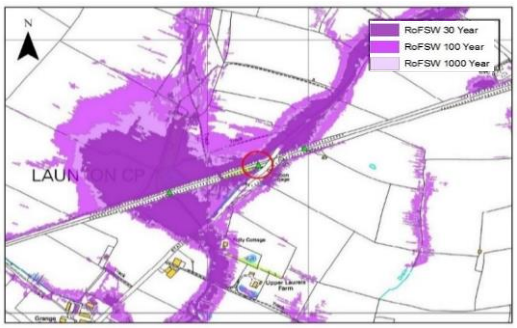
Climate Change allowance: 70 (%)

	Flows (m³/s)	Embankment PWL (mAOD)	Freeboard to track (m)
100-year	1.35	67.03	2.79
100-year+70%CC	1.43	67.13	2.69
1000-year	1.41	67.11	2.71

Performance Code	N/A	
Performance Code description	N/A	
Freeboard at 100-year event	>1	(m)

Floodplain Maps

RoFSW



Launton Brook Model

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	Fluvial
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.		Yes
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	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
Yes	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
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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	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
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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)	Low Adverse
Residual Significance of Effect (including mitigation)	Minor
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)	Low Adverse
Residual Significance of Effect (including mitigation)	Minor
Include in Environmental Statement Main Body	YES

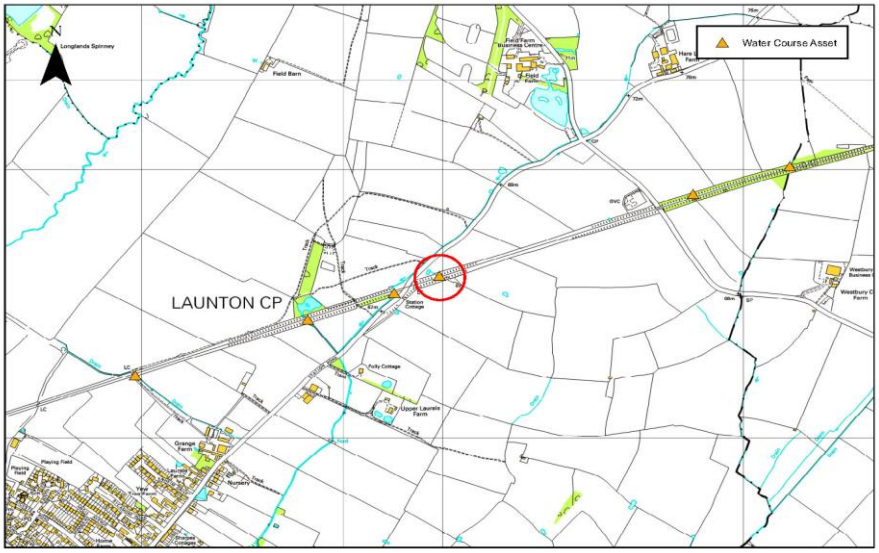
Summary

This assessment has been based on existing Environment Agency RoFSW flooding and Flood Zones 2 and 3, and the Launton Brook Hydraulic Model (ISIS/TUFLOW). Environment Agency map shows that fluvial flood risk is limited to Station Road and some cottages that lie in Flood Zone 2 and 3, approximately 150m on the south of the track - however this is because the Flood Zone model does not extend any further upstream; this has since been extended in the Launton Brook ISIS/TUFLOW model. The assets within the floodplain are limited to Network Rail land, Station Road, adjoining agricultural land, and some cottages. There is limited/very low groundwater flood risk in this area. Works comprise - earthworks and the existing highway level crossing to be replaced with an overbridge. Existing culvert to be replaced. The Launton Brook model indicates that the culvert has >2m freeboard. The 100-year, 100-year plus 70% climate change, and 1000-year return periods have been modelled. The 100-year flow is 1.35m³/s at this point. A CFSA is proposed to mitigate the impact of the works, and swales and an attenuation pond are proposed to mitigate for the increase in impermeable surfaces. 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 there will be minor change from the existing situation. The road embankment will lie on the top of the watercourse. It is thus assumed that the watercourse realignment is needed to the west of the proposed works. 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	6	
Route Section	2A	
Culvert ID	C170132	
NGR	461985, 223605	
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	N/A	
Existing Culvert/Crossing Size	375	(mm)
Existing Culvert/Crossing Length	20	(m)
Existing Culvert/Crossing Type	Circular Pitch Fibre	

Proposed Works

Culvert Recommendation	Existing culvert to be replaced. New precast headwalls to be installed at both ends.	
Track Level	70.42	(mAOD)

Hydrological and Hydraulic Analysis

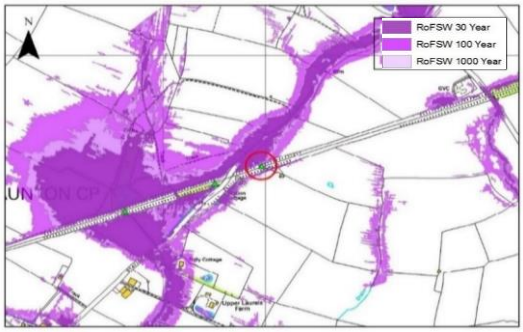
Climate Change allowance: 70 (%)

	Flows (m³/s)	Embankment PWL (mAOD)	Freeboard to track (m)
100-year	0.68	67.40	3.02
100-year + 70% CC	0.85	67.52	2.90
1000-year	0.82	67.49	2.93

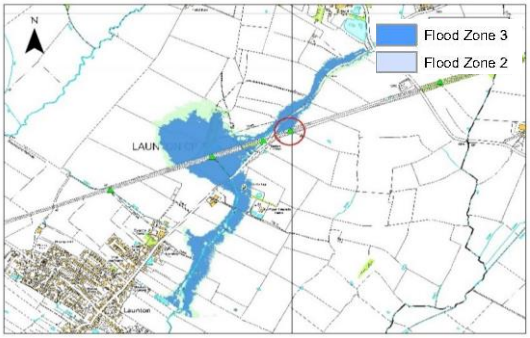
Performance Code	1	
Performance Code description	Culvert is performing in a free flowing condition i.e. Max HWL<HWE	
Freeboard at 100-year event	>1	(m)

Floodplain Maps

RoFSW



Launton Brook Model



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	Fluvial
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.		Yes
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	High Adverse

	Rating	**Definition**
Yes	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
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	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
Yes	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

Operation

Excluding Mitigation	High Adverse

	Rating	**Definition**
Yes	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
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	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
Yes	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

Significance of Effect

Construction

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

Operation

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

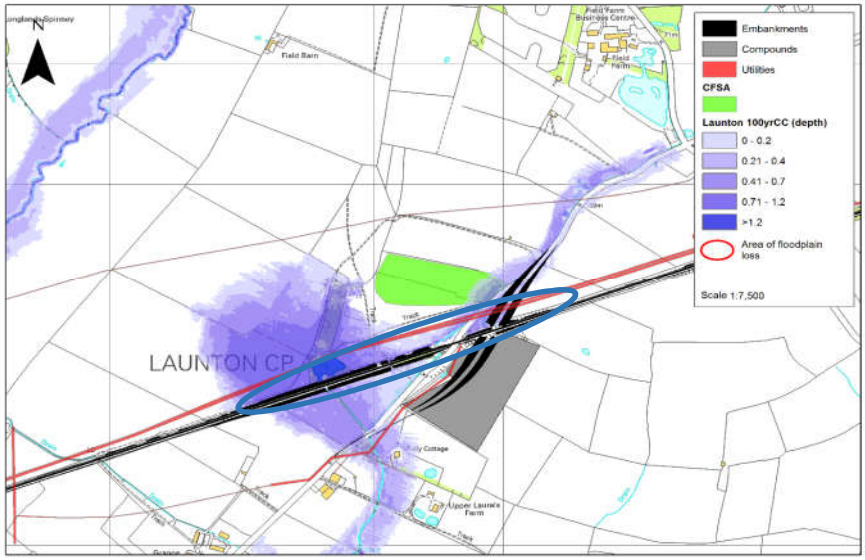
Summary

This assessment has been based on existing Environment Agency RoFSW flooding and Flood Zones 2 and 3, and the Launton Brook Hydraulic Model (ISIS/TUFLOW). The Environment Agency map shows that fluvial flood risk is limited to Station Road and some cottages that lie in Flood Zone 2 and 3, approximately 150m on the south of the track - however this is because the Flood Zone model does not extend any further upstream; this has since been extended in the Launton Brook ISIS/TUFLOW model. Assets within the floodplain are limited to Network Rail land, Station Road, adjoining agricultural land, and some cottages. There is limited/very low groundwater flood risk in this area. Works comprise - earthworks and the existing highway level crossing to be replaced with an overbridge, along with a site compound (A2 Launton). The new overbridge is to be on embankment which results in a loss of floodplain storage; a CFSA is proposed to mitigate this impact, and swales and an attenuation pond are proposed to mitigate for the increase in impermeable surfaces. The culvert needs to be replaced with a culvert approximately 5.3m longer than the existing one. The 100-year, 100-year plus 70% climate change, and 1000-year return periods have been modelled. The ISIS/TUFLOW model shows that there is >2m of freeboard to track for events up to 1000-year in this location. The culvert assessment indicates that the culvert is performing in a free-flowing condition. 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 there will be minimal change from the existing situation. The compound is not within the ISIS/TUFLOW model outlines. 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.

Appendix B. Environmental Statement CFSA Summary Report

CFSA Summary

Site Location Map



CFSA Number	2A0326 / 5.2 / FH
Route Section	2A
NGR	461799, 223728
EWR-ELR	OXD
Lead Local Flood Authority	Oxfordshire County Council
Environment Agency Region	Thames
Flood Risk Source	Fluvial
Works requiring CFSA	Highway and railway embankment works

Floodplain Loss Information

Area of proposed works in the 1000-year event floodplain	11620	m^2
Indicative floodplain volume loss (1000-year)	3620	m^3

		Minimum Elevation (m AOD)	Maximum Elevation (m AOD)	Difference in level (m)
Existing ground levels at the loss	Embankment	65.8	67.6	1.8

Proposed CFSA

Estimated area required based on floodplain loss	15678	m^2
Proposed CFSA area	29843	m^2
Minimum Indicative CFSA Volume (0.1m excavation depth)	1492	m^3
Maximum Indicative CFSA Volume (excavation to maximum available depth)	5969	m^3

	Minimum Elevation (m AOD)	Maximum Elevation (m AOD)	Difference in level (m)
Existing levels at proposed CFSA	67.4	67.8	0.5

Summary

This assessment has been based on the Launton Brook hydraulic modelling results. The proposed CFSA has been designed to provide storage for losses arising from rail embankment widening and highway works. The CFSA is located approximately 60m north east of the floodplain loss; this location avoids nearby gas exclusion zones. The CFSA will drain back into the Launton Brook.

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)	11620.00
Peak Water Level (mAOD)	67.60
b) Floodplain Volume Loss (m³)	3620.50

Water Level Source: Launton Brook Modelling

Level Area relationship embankment

WetArea (m²)	Elevation (mAOD)	DryArea (m²)	Volume (m³)
0	65	11864	0.00
0	65.1	11864	0.00
0	65.2	11864	0.00
0	65.3	11864	0.00
0	65.4	11864	0.00
0	65.5	11864	0.00
0	65.6	11864	0.00
0	65.7	11864	0.00
8	65.8	11856	0.29
76	65.9	11788	3.76
176	66	11688	14.54
364	66.1	11500	38.68
640	66.2	11224	88.75
964	66.3	10900	168.15
1180	66.4	10684	276.34
1428	66.5	10436	408.73
1716	66.6	10148	566.83
1960	66.7	9904	751.49
2224	66.8	9640	960.69
2448	66.9	9416	1195.01
2700	67	9164	1454.72
2864	67.1	9000	1731.92
2992	67.2	8872	2025.01
3132	67.3	8732	2330.97
3472	67.4	8392	2658.09
4964	67.5	6900	3070.02
6040	**67.6**	**5824**	**3620.50**
7004	67.7	4860	4275.41
7932	67.8	3932	5026.48
8964	67.9	2900	5870.03
10164	68	1700	6835.62
10940	68.1	924	7899.16
11320	68.2	544	9012.30
11464	68.3	400	10152.03
11552	68.4	312	11303.36
11620	68.5	244	12462.65
11696	68.6	168	13628.44
11732	68.7	132	5969.00
11760	68.8	104	15975.03
11764	68.9	100	17151.02
11796	69	68	18329.46
11816	69.1	48	19509.99
11832	69.2	32	20692.23
11832	69.3	32	21875.51
11836	69.4	28	23058.99
11840	69.5	24	24242.66
11840	69.6	24	25426.64
11844	69.7	20	26610.91
11848	69.8	16	27795.46
11848	69.9	16	28980.25
11848	70	16	30165.03
11848	70.1	16	31349.81
11848	70.2	16	32534.59
11848	70.3	16	33719.46
11848	70.4	16	34904.25
11848	70.5	16	36089.03
11848	70.6	16	37273.81
11848	70.7	16	38458.59
11848	70.8	16	39643.46
11848	70.9	16	40828.25
11848	71	16	42013.03
11848	71.1	16	43197.81
11848	71.2	16	44382.59
11848	71.3	16	45567.46
11848	71.4	16	46752.25
11848	71.5	16	47937.03
11848	71.6	16	49121.81
11848	71.7	16	50306.59
11848	71.8	16	51491.46
11848	71.9	16	52676.25
11848	72	16	53861.03
11848	72.1	16	55045.81
11848	72.2	16	56230.59
11848	72.3	16	57415.46
11848	72.4	16	58600.25
11856	72.5	8	59785.32
11860	72.6	4	60971.24
11864	72.7	0	62157.61
11864	72.8	0	63344.08
11864	72.9	0	64530.46
11864	73	0	65716.84

At proposed CFSA (see Figure for further detail)

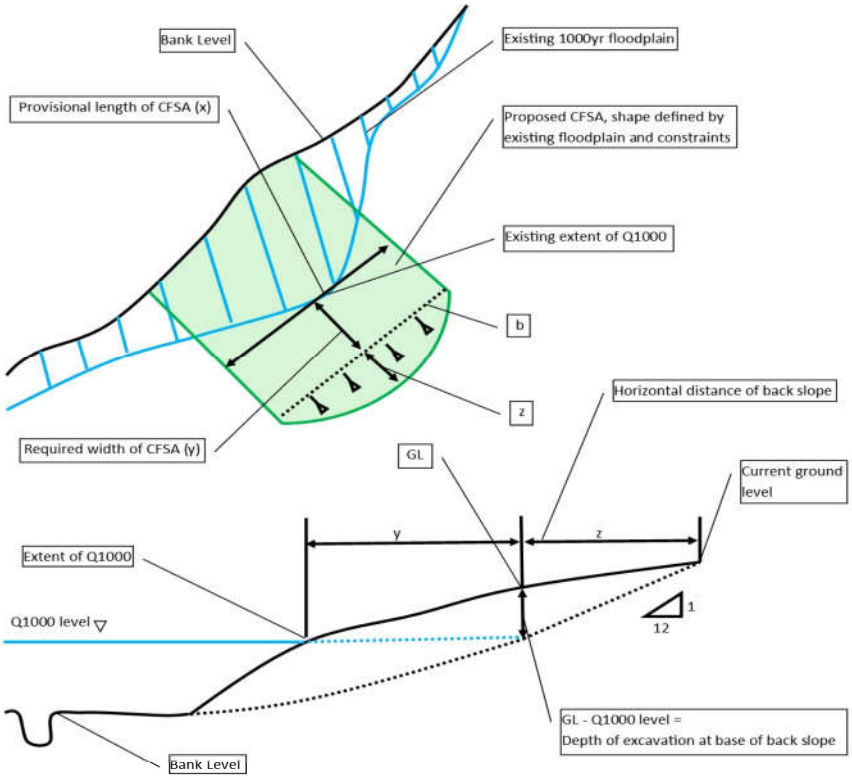
2) At the CFSA location - identify a location outside the existing floodplain where this level-area can be provided in accordance with the following criteria:
   a) The location was positioned outside the 1 in 1000-year flood outlines but would include for excavation to the bank level of an existing 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)
67.38	67.84	0.46	7838.99	15677.98	29842.82	112.49

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?
139.37	68.14	0.30	3.57	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).

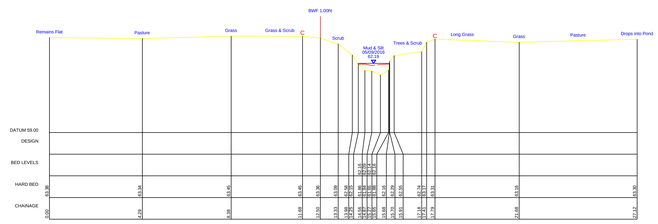
5) Take ground level (GL) midway along line b.

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.

Appendix C. Topographic Survey



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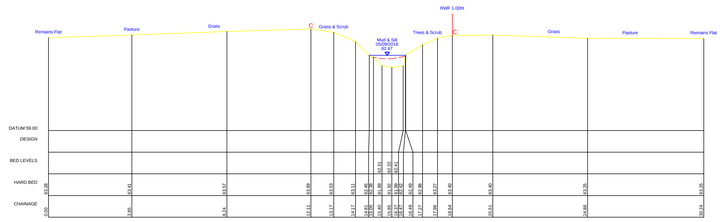
Open Channel



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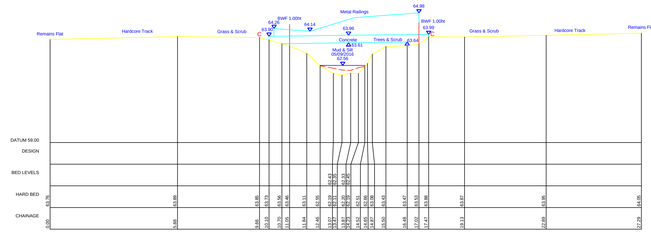

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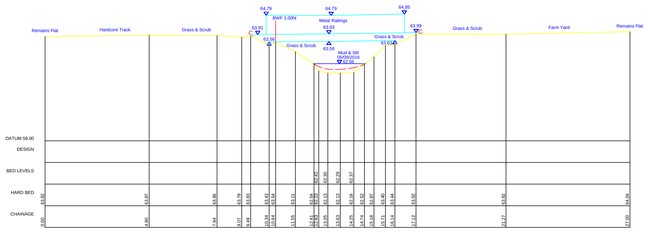
Access Bridge D/S Face
Tunnel Length = 4.06m



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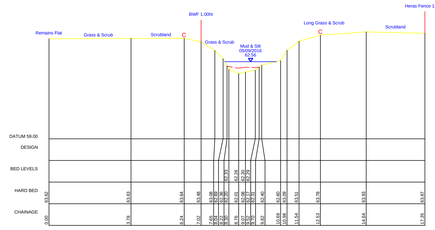
Access Bridge U/S Face
Tunnel Length = 4.06m



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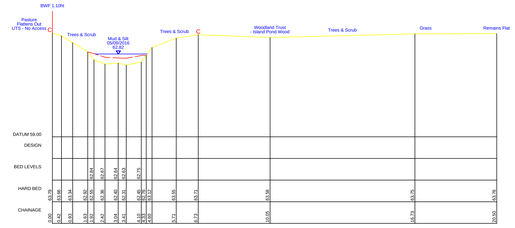

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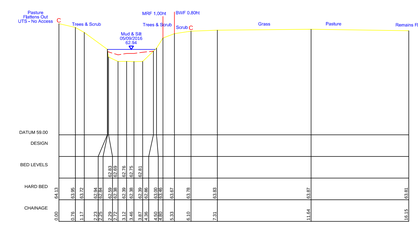

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Open Channel

LAUN01_0589
461203.17mE 222220.75mN Brg 331
Open Channel

LAUN01_0596
461218.5mE 222213.56mN Brg 321
Culvert Exit
Tunnel Length = 8.65m

LAUN01_0605
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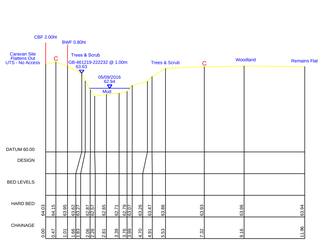
Culvert Entrance
Tunnel Length = 8.65m



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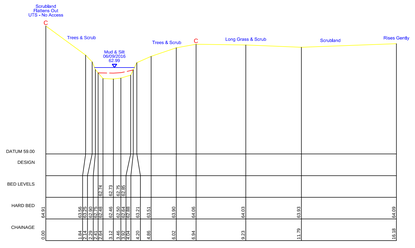

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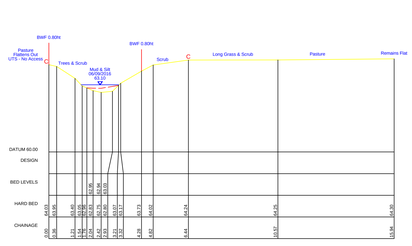

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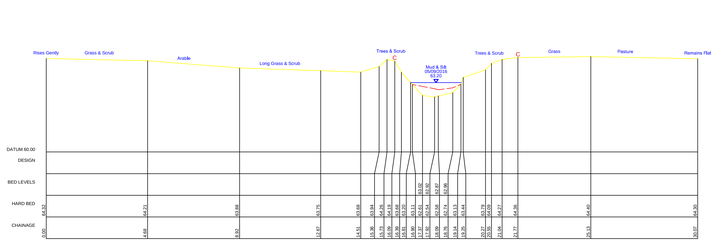

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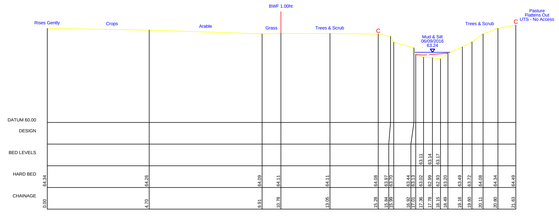

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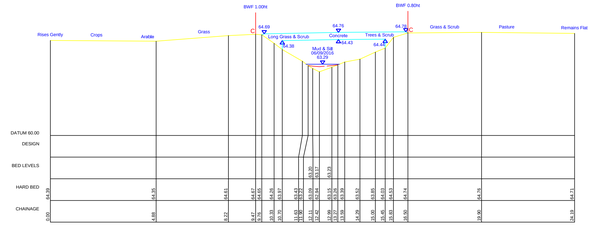

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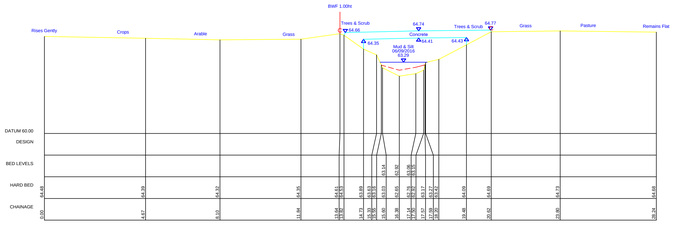
Access Bridge D/S Face
Tunnel Length = 4.13m



LAUN01_1050
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Access Bridge U/S Face
Tunnel Length = 4.13m

KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C — BANK CREST

KEY TO LONGITUDINAL SECTION ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

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

SURVEY LEGEND

AB	AIR BRICK	Fh	FIRE HYDRANT	PMF	POST & MIRE FENCE
AV	AIR VALVE	FHW	FIRE HYDRANT MARKER	RE	RIGHT EYE
BH	BOREHOLE	FL	FLOOD LIGHT	RG	RODDING EYE
BB	BILLIONG BEACON	FP	FENCE POST	RSJ	ROLLED STEEL JOIST
BSY	BOUNDARY	FWM	FOUL WATER MANHOLE	RTM	RETAINING WALL
BT	BT MANHOLE	G	GULLY	SCP	SCAFFOLD POLE
BL	BED LEVEL	GB	GRADEBOARD	SO	STOP VALVE
BRK	BRICKWORK	GL	GROUND LEVEL	SVP	SOAKAWAY PIT
BW	BRICK WALL	GM	GAS MARKER	SW	SOAKAWAY
BH	BENCH MARK	GV	GAS VALVE	TL	TOPOGRAPHICAL LEVEL
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	TMP	TELEPHONE MANHOLE
BWF	BARBED WIRE FENCE	IL	INVERT LEVEL	TMP	SHEET METAL PILING
CDF	CLOSE BOARDED FENCE	IP	IRON PEG	TP	TEST PIT
CF	CLOSE BOARDED TIMBER FENCE	IS	IRON SILING FENCE	TR	TRAP
CL	COVER LEVEL	MF	INTERMOVEN FENCE	SV	SLUICE VALVE
CLF	CHAIN LINK FENCE	MH	MANHOLE COVER	SWF	SHEEP WIRE FENCE
CONC	CONCRETE POST	MS	KERB INLET GULLY	SWF	SHEEP WIRE FENCE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CONCRETE PALING FENCE	LP	LAMP POST	TBP	TELEPHONE POLE / BOLTPOST
CR	CYCLE RACK	LV	LAMP POST	TC	TELEGRAM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELEGRAM MANHOLE
DF	DEER FENCE	MF	MOORING OBSTRUCTIONS FENCING	TP	TELEPHONE POLE
DH	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DRAIN PIPE	MP	MOORING PILE	TP	TELEPHONE POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DS	DOWNSTREAM	MS	MILE STONE	TS	TREE STUMP
DWB	DRY STONE WALL	NB	NAVIGATION BUOY	TSF	TIMBER STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	UC	UPSTREAM
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	UTL	UNABLE TO SURVEY
EF	ELECTRICITY CABLE FENCE	OP	OBSERVATION POST	UW	UNDERGROUND WATER LINE
EOF	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WA	WATER METER
EMH	ELECTRICITY MANHOLE	PILE	PILE	WMF	WIRE MESH FENCE
ES	ELECTRICITY SERVICE	PM	PARKING METER	WP	WOODEN POST
ES	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	POST	POST	WV	WATER VALVE
FB	FLOWER BED	PV	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

REV.	NOTES	DWN	DATE

ISO 9001 REGISTERED FIRM — Certificate Number: GB 6562

MEMBERS OF THE SURVEY ASSOCIATION

ISO 14001 REGISTERED FIRM — Certificate Number: GB 11414

Notes:

GRID AND LEVELS RELATE TO OS ACTIVE NETWORK
A REPORT HAS BEEN PRODUCED FOR THIS SURVEY

Control Used:
E5-461772-223450 SP 6177 2345 66.522m

LAND AND ENGINEERING SURVEYORS

MALTBY LAND SURVEYS LTD
2 QUEENS ROAD
HAYWARDS HEATH
WEST SUSSEX
RH16 1EB
Tel: 01444 416 246
Fax: 01444 417 697
E-Mail: mail@maltbysurveys.com
WebSite: http://www.maltbysurveys.com

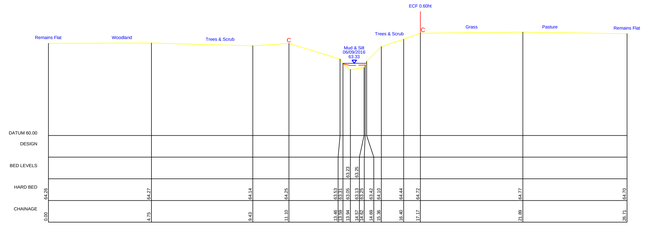
SURVEYED	DW	EWR ALLIANCE
DRAWN	DW	
CHECKED	RAM	
		SCALE
		1:100 (A0 Sheet)

LAUNTON BROOK & TRIBUTARIES

LAUNTON BROOK (LAUN01)
CROSS SECTIONS
LAUN01_0000 TO LAUN01_1050

Job No	Rev	Drawing Number
16_240		16_240_01

Date : SEPTEMBER 2016



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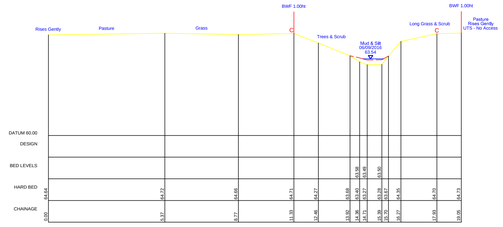

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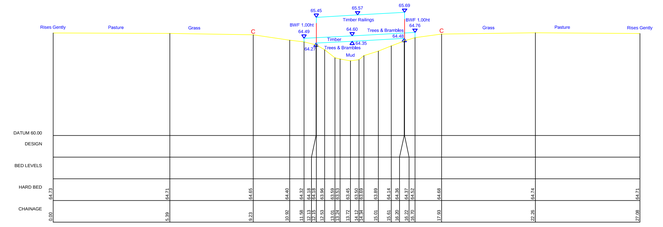

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Footbridge
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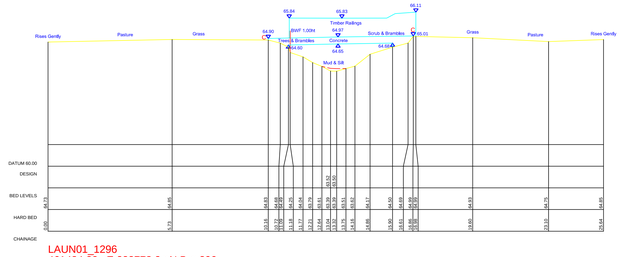

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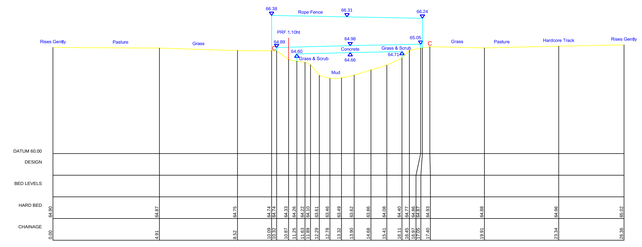
Tunnel Length = 4.02m



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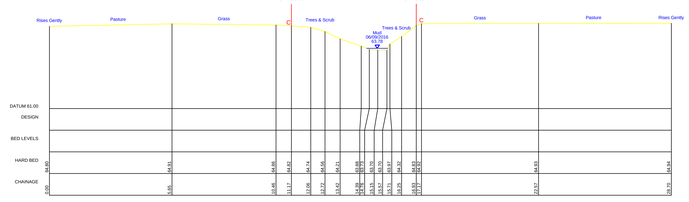
Tunnel Length = 4.02m



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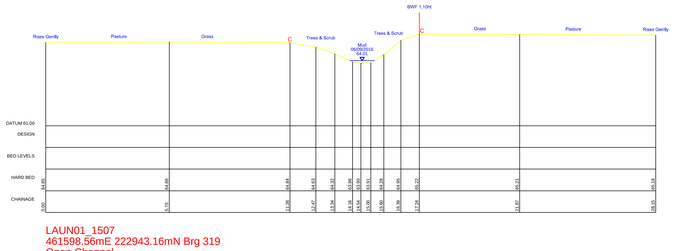

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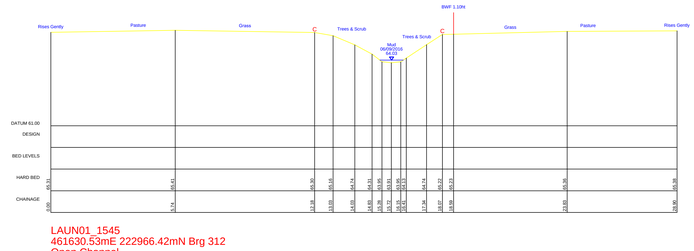
Open Channel



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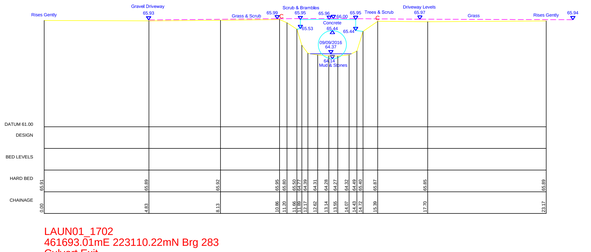
Open Channel



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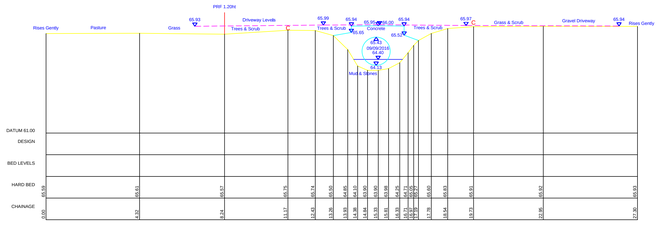
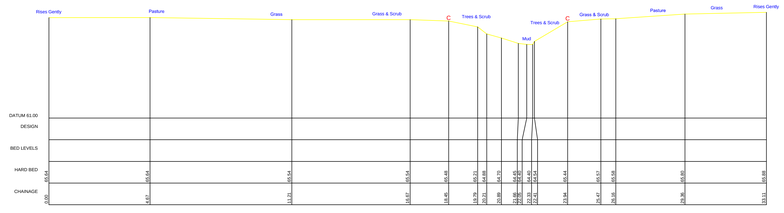
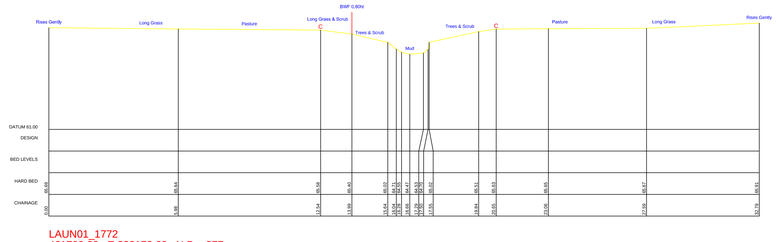
Culvert Exit
Tunnel Length = 5.19m



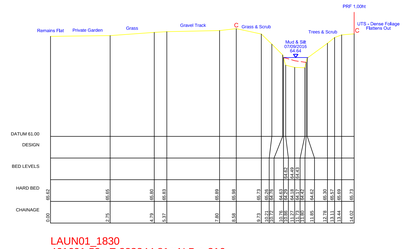
LAUN01_1708
461696.11mE 223115.14mN Brg 282
Culvert Entrance
Tunnel Length = 5.19m



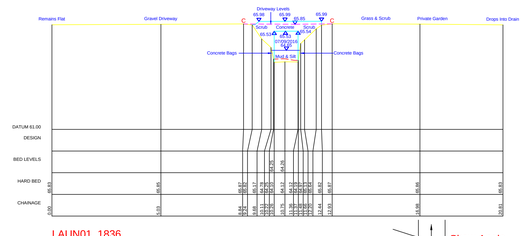
LAUN01_1714
461702.19mE 223125mN Brg 269
Open Channel



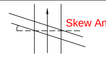
LAUN01_1772
461709.28mE 223179.69mN Brg 277
Open Channel

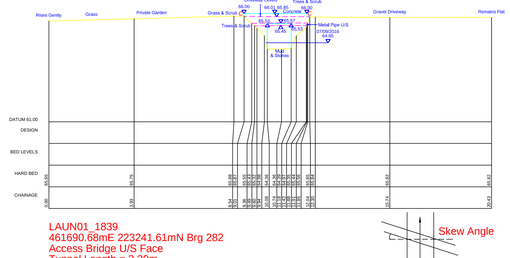


LAUN01_1830
461691.53mE 223244.81mN Brg 216
Open Channel

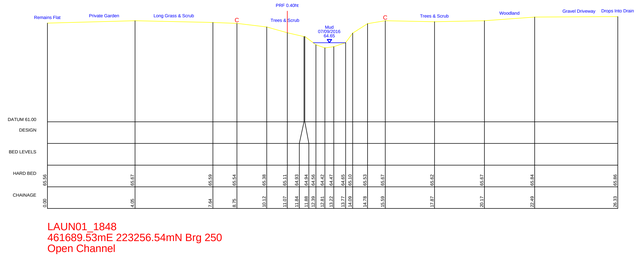


LAUN01_1836
461691.18mE 223238.58mN Brg 282
Access Bridge D/S Face
Tunnel Length = 3.20m
Skew Angle = 25°

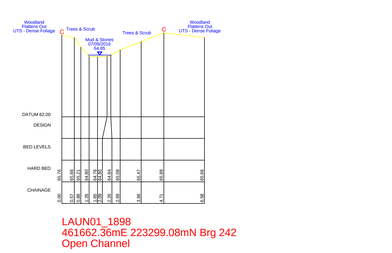




LAUN01_1839
461690.68mE 223241.61mN Brg 282
Access Bridge U/S Face
Tunnel Length = 3.20m
Skew Angle = 25°



LAUN01_1848
461689.53mE 223256.54mN Brg 250
Open Channel



LAUN01_1898
461662.36mE 223299.08mN Brg 242
Open Channel

KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C — BANK CREST

KEY TO LONGITUDINAL SECTION ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

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

SURVEY LEGEND

AB	AIR BRICK	Fh	FIRE HYDRANT	PW	POST & WIRE FENCE
AV	AIR VALVE	FHW	FIRE HYDRANT MARKER	RE	RIGHT EDGE
BH	BOREHOLE	FL	FLOOD LIGHT	RG	RIVER GAUGE
BS	BRIDGE BEACON	FP	FENCE POST	RSJ	ROLLED STEEL JOIST
BSY	BOUNDARY	FWH	FOUL WATER MANHOLE	RTM	RETAINING WALL
BT	BT MANHOLE	G	GATE	SCR	SCRAPE MARK
BL	BED LEVEL	GB	GRASSBANK	SO	STOP VALVE
BRK	BRICKWORK	GL	GROUND LEVEL	SOP	SIGNAL POST
BW	BRICK WALL	GM	GAS METER	SP	SIGNAL POST
BH	BENCH MARK	GV	GAS MARKER	SL	SLOPE LEVEL
BWF	BARBED WIRE FENCE	HC	HEDGE CUTTING	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SWP	SHEET METAL PILING
CBF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	TA	TOWER ANTI
CBF	CLOSE BOARDED TRICK FENCE	IP	IRON RAILING FENCE	TH	TOWER HIGH
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	TV	SLUICE VALVE
CLF	CHAIN LINK FENCE	KO	KERB OPENING	UM	UNKNOWN MANHOLE
CONC	CONCRETE POST	KS	KERB SALT / GULLY	UNF	UNDER RAIL FENCE
CP	CONCRETE POST	LB	LEFT BANK	TBM	TEMPORARY BENCH MARK
CPF	CONCRETE POST & PANEL FENCE	LP	LAMP POST	TBP	TEMPORARY BENCH MARK POST
CP	CYCLE PEDAL	LV	LAMP POST	TC	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
DI	DRAIN INLET	MF	MESH & CONCRETE FENCING	TL	TRAFFIC LIGHT
DM	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DRAIN POINT	MP	MARKER POST	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DS	DOWNSTREAM	MS	MILE STONE	TS	TREE STUMP
DWB	DRY STONE WALL	NAV	NAVIGATION BOARD	TSR	TUBULAR STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	UI	UPSTREAM
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	UTS	UNABLE TO SURVEY
EF	ELECTRICITY CABLE FENCE	OP	OPEN STEEL RAILINGS	UU	UNKNOWN UTILITY LINE
EGF	ELECTRICITY CABLE PT	OSR	OPEN STEEL RAILINGS	WA	WATER AUTHORITY
EMH	ELECTRICITY MANHOLE	PILE	PILE	WMF	WIRE MESH FENCE
ES	ELECTRICITY SERVICE	PM	PARISH MARK	WP	WOODEN POST
ES	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	POST	POST	WV	WATER VALVE
FB	FLOWER BED	PSV	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

REV.	NOTES	DWN	DATE

ISO 9001 REGISTERED FIRM
Certificate Number: GB 6562

MEMBERS OF THE SURVEY ASSOCIATION

ISO 14001 REGISTERED FIRM
Certificate Number: GB 11414

Notes:

GRID AND LEVELS RELATE TO OS ACTIVE NETWORK
A REPORT HAS BEEN PRODUCED FOR THIS SURVEY

Control Used:
E5-461772-223450 SP 6177 2345 66.522m

LAND AND ENGINEERING SURVEYORS

MALTBY LAND SURVEYS LTD
2 QUEENS ROAD
HAYWARDS HEATH
WEST SUSSEX
RH16 1EB

Tel: 01444 416 246
Fax: 01444 417 697
E-Mail: mail@maltbysurveys.com
WebSite: http://www.maltbysurveys.com

SURVEYED	DW	EWR ALLIANCE
DRAWN	DW	
CHECKED	RAM	SCALE
		1:100 (A0 Sheet)

LAUNTON BROOK & TRIBUTARIES

LAUNTON BROOK (LAUN01)
CROSS SECTIONS
LAUN01_1091 TO LAUN01_1898

Job No	Rev	Drawing Number
16_240		16_240_02

Date : SEPTEMBER 2016

KEY TO SECTIONS:

WATER LEVEL

VISIBLE BED (TOP OF SILT) AND GROUND

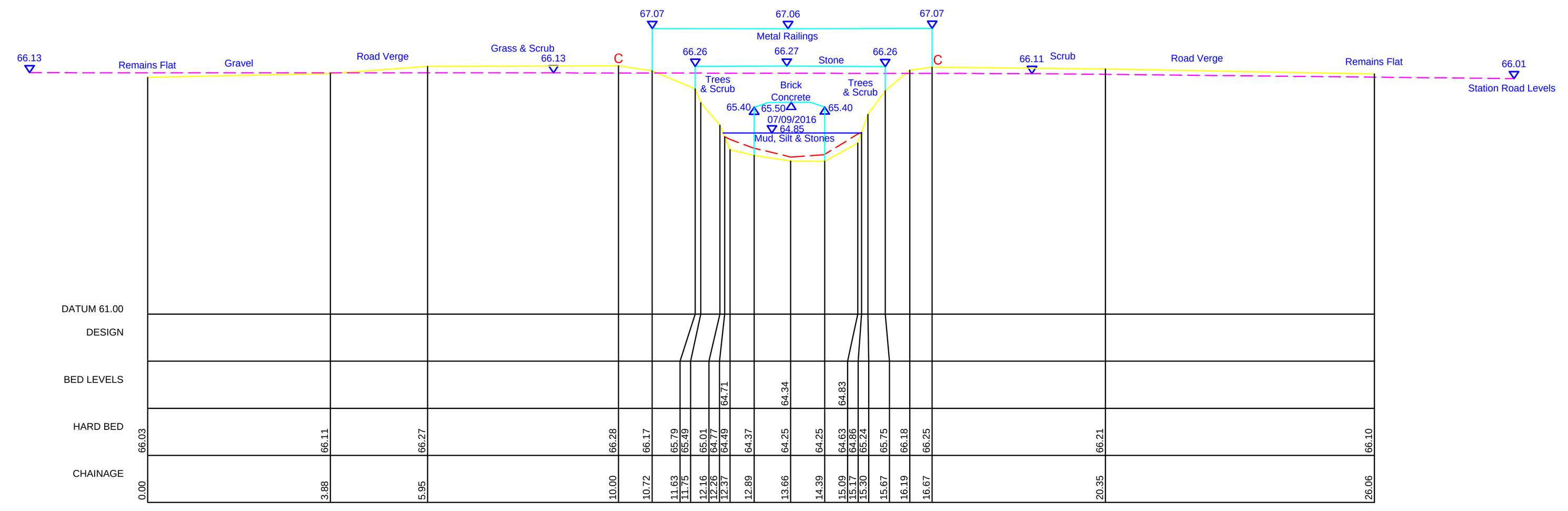
HARD BED (DETERMINED BY PROBING)

C BANK CREST

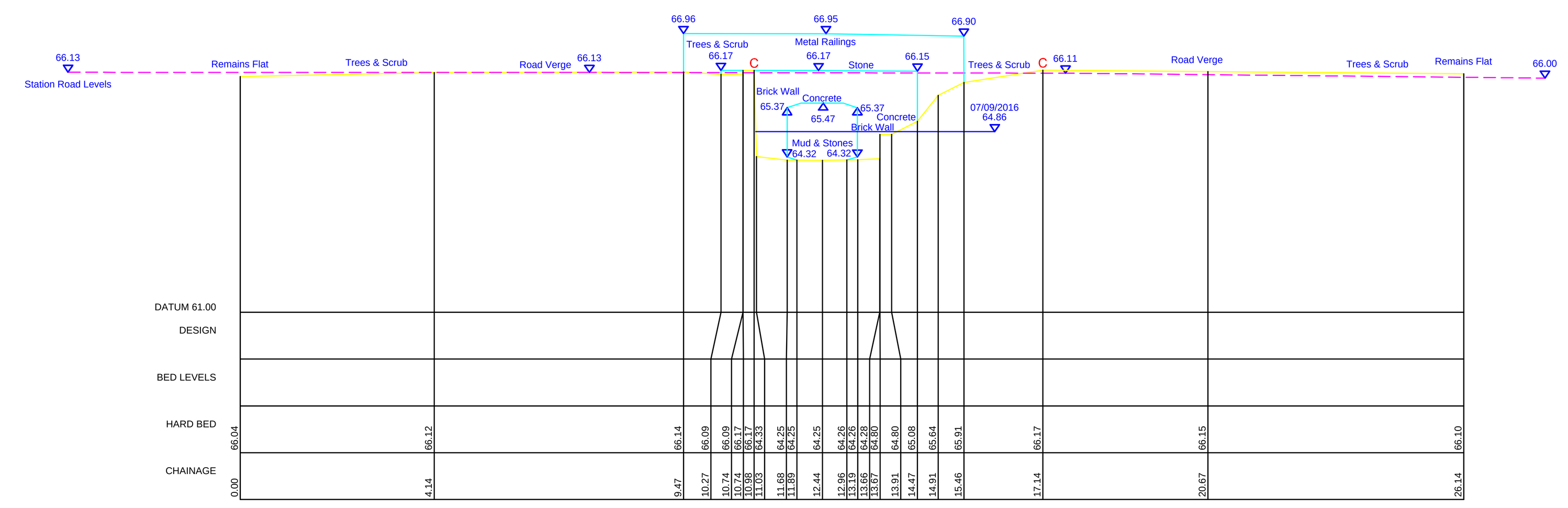
KEY TO LONGITUDINAL SECTION ONLY:

LEFT BANK CREST
RIGHT BANK CREST
VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY "C" ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS

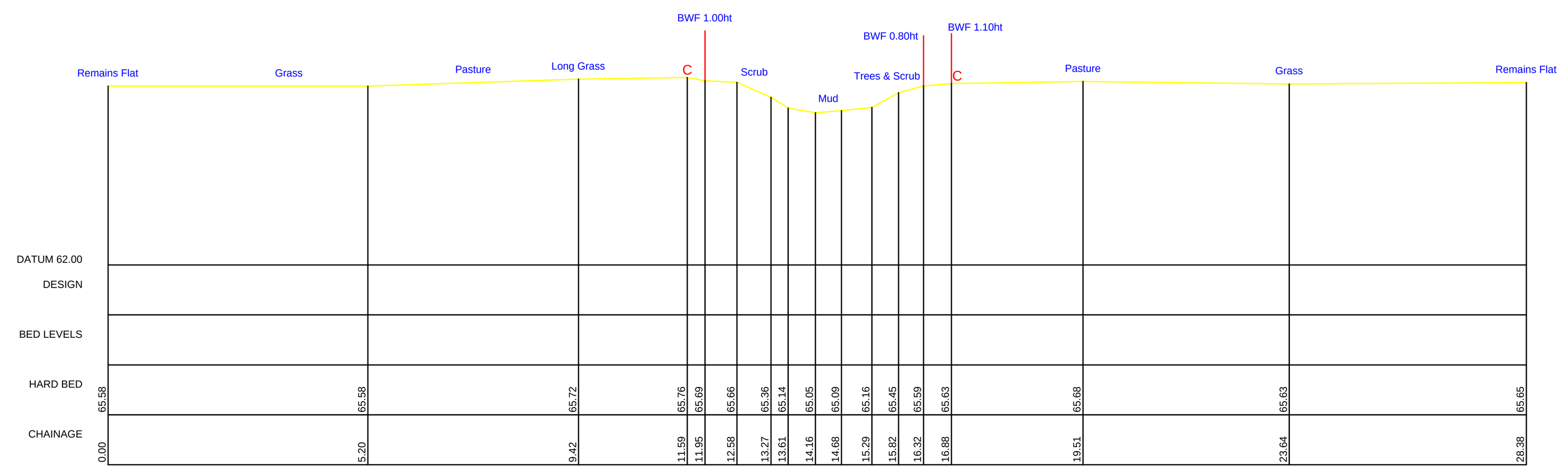
SURVEY LEGEND



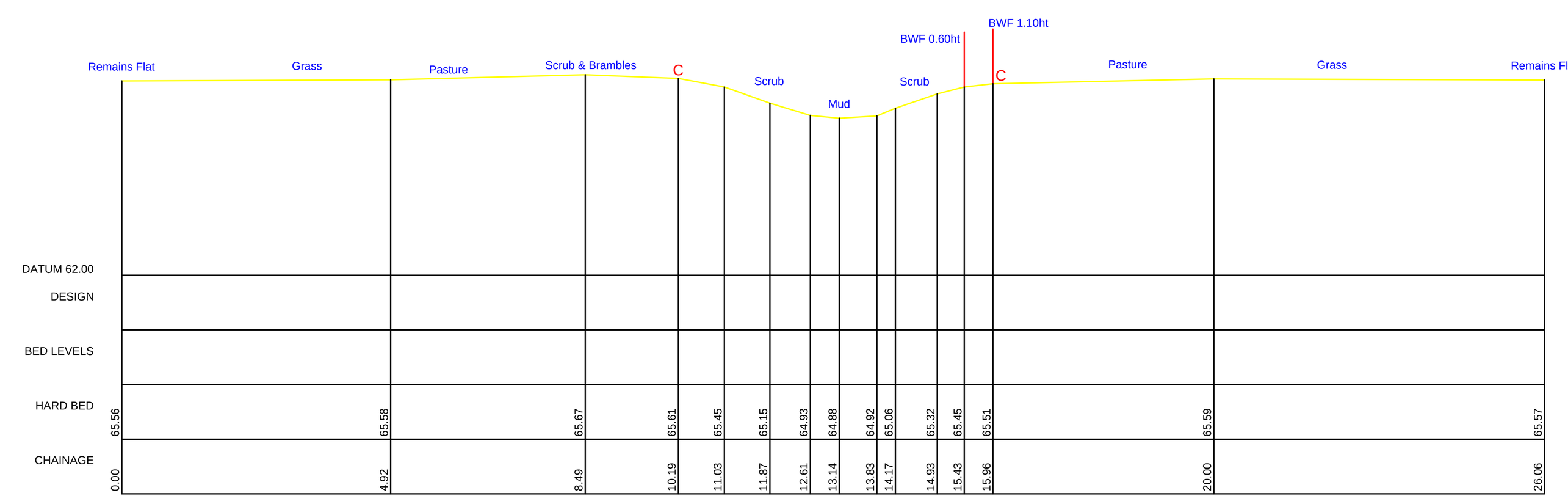
LAUN01_1903
461669.85mE 223311.07mN Brg 235
Culvert Exit
Tunnel Length = 7.97m



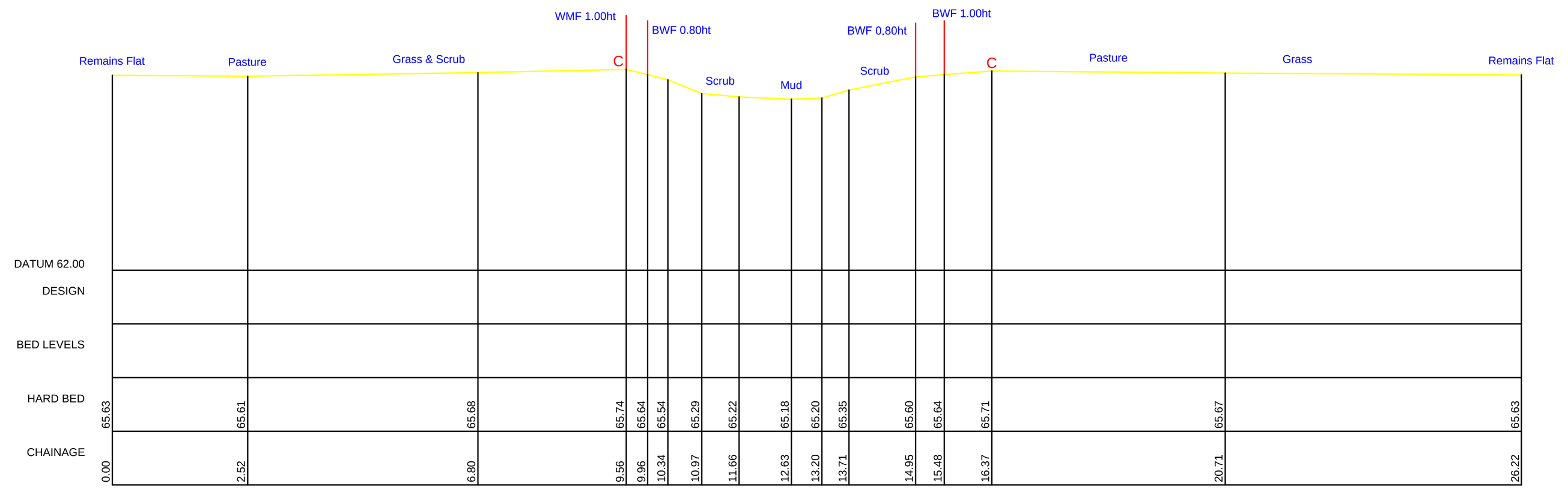
LAUN01_1911
461664.24mE 223316.93mN Brg 234
Culvert Entrance
Tunnel Length = 7.97m



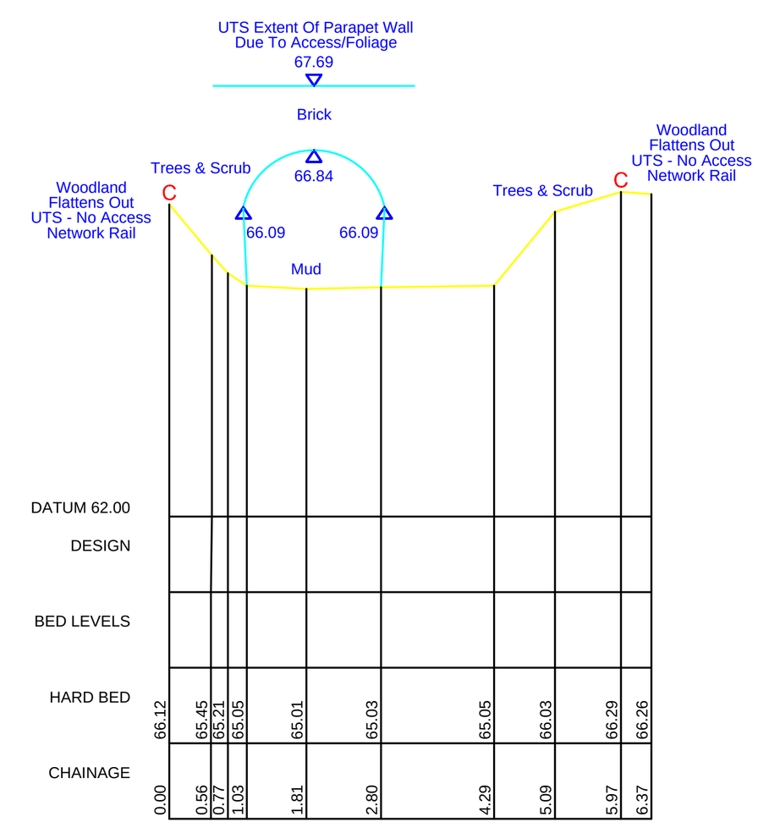
LAUN01_1998
461613.93mE 223387.33mN Brg 236
Open Channel



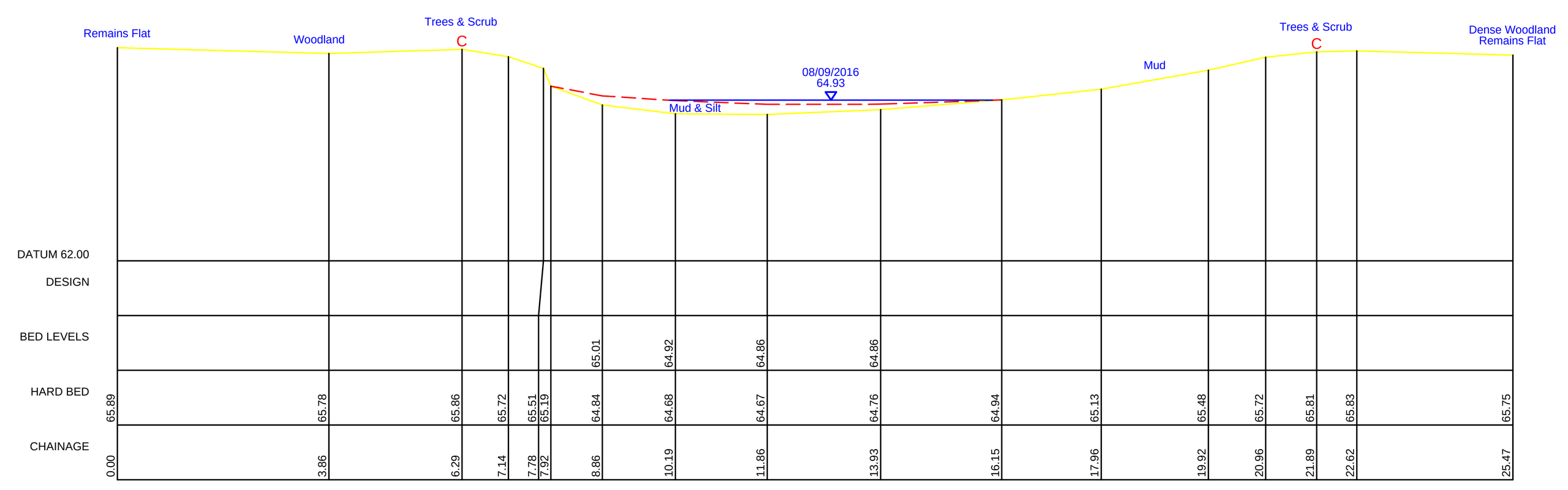
LAUN01_1941
461646.81mE 223342.29mN Brg 232
Open Channel



LAUN01_2052
461572.79mE 223430.86mN Brg 209
Open Channel



LAUN01_2094
461542.03mE 223450.19mN Brg 251
Railway Culvert Entrance
Tunnel Length = 20.46m



LAUN01_2103
461547.13mE 223460.7mN Brg 253
Open Channel

REV.	NOTES	DWN	DATE

ISO 9001 REGISTERED FIRM Certificate Number: GB 6562

MEMBERS OF THE SURVEY ASSOCIATION

ISO 14001 REGISTERED FIRM Certificate Number: GB 11414

Notes:

GRID AND LEVELS RELATE TO OS ACTIVE NETWORK
A REPORT HAS BEEN PRODUCED FOR THIS SURVEY

Control Used:
E5-461772-223450 SP 6177 2345 66.522m

LAND AND ENGINEERING SURVEYORS

MALTBY LAND SURVEYS LTD
2 QUEENS ROAD
HAYWARDS HEATH
WEST SUSSEX
RH16 1EB

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Fax: 01444 417 697
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WebSite: http://www.maltbysurveys.com

SURVEYED	DW	EWR ALLIANCE
DRAWN	DW	
CHECKED	RAM	
		SCALE
		1:100 (A0 Sheet)

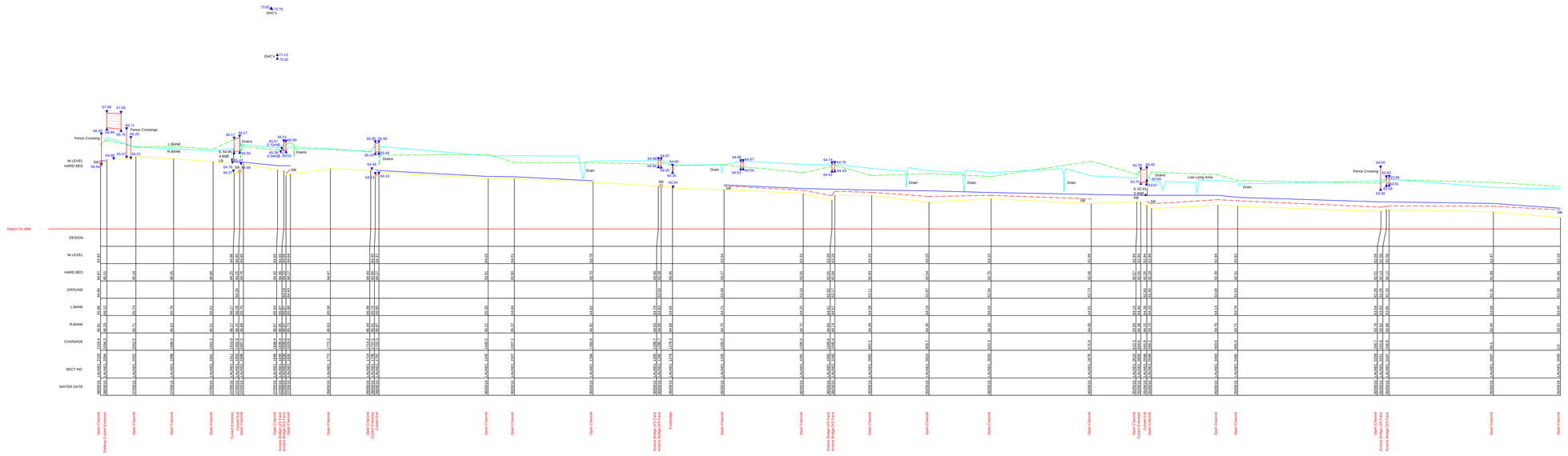
LAUNTON BROOK & TRIBUTARIES

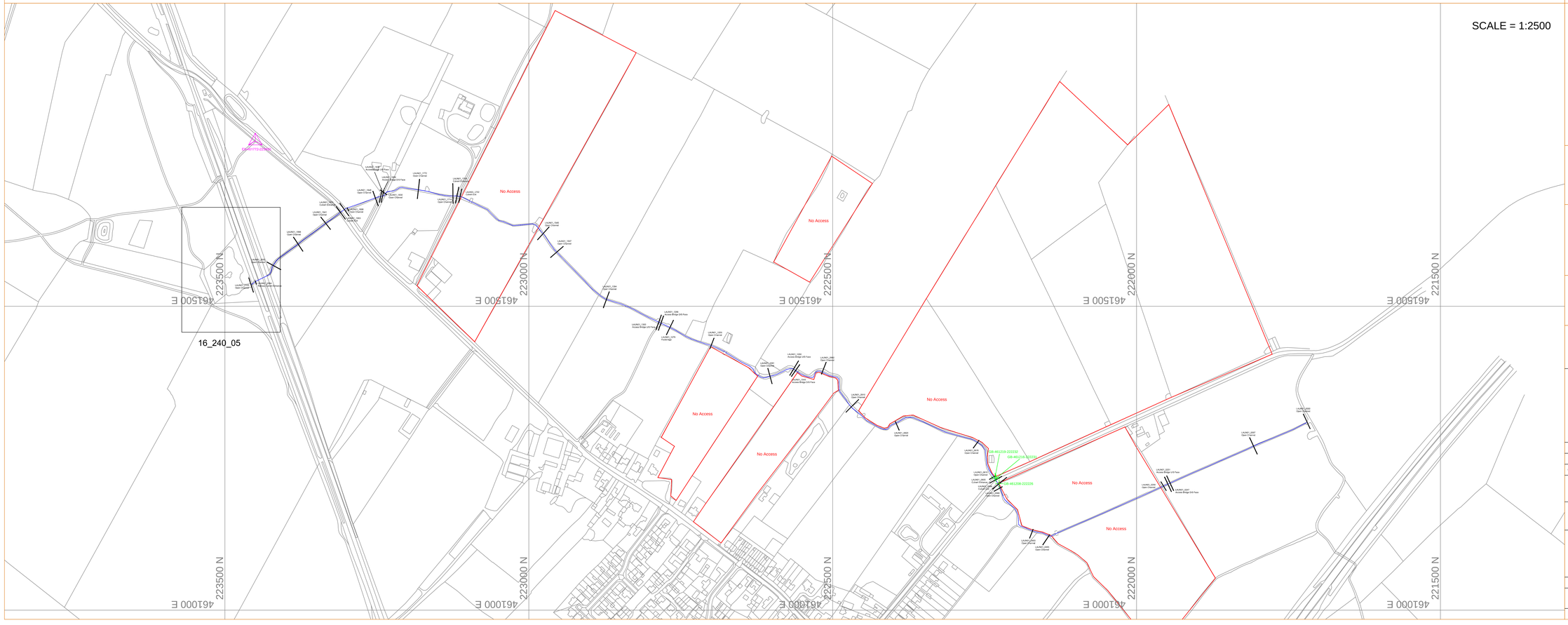
LAUNTON BROOK (LAUN01)
CROSS SECTIONS
LAUN01_1903 TO LAUN01_2103

Job No	Rev	Drawing Number
16_240		16_240_03

Date : SEPTEMBER 2016

SCALE = 1:2500 H, 1:100 V





KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C — BANK CREST

KEY TO LONGITUDINAL SECTION ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

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

- GAUGE BOARD LOCATIONS

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PMF	POST & MIRE FENCE
AM	AIR VALVE	FM	FLOW METER MARKER	PO	POLLARD OAK
B	BOLLARD	FL	FLOOR LEVEL	RE	ROCKING EYE
BB	BELOW BEACON	FP	FENCE POST	RSJ	ROLLED STEEL JOIST
BF	BOTTOM OF	FW	FOUL WATER MANHOLE	RWP	RAIN WATER PIPE
BH	BOREHOLE	G	GULLY	RWP	RAINWATER PIPE
BL	BED LEVEL	GB	GAUGEBOARD	SC	STOP COCK
BOK	BOTTOM OF KERB	GF	GROUND LEVEL	SF	SLEEPER FENCE
BS	BUS STOP	GP	GATE POST	SI	SIGNAGE
BW	BENCH MARK	GM	GAS MARKER	SL	SLOPE LEVEL
BW	BENCH MARK	GV	GAS VALVE	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
CF	CHAIN LINK MESH FENCE	IF	IRON RAILING FENCE	STN	STAN POST
CL	COVER LEVEL	IH	HYDRANTION POINT	SV	SLUICE VALVE
CLF	CONCRETE FENCE	KF	KERB FACE (FLAT)	TF	TIMBER POST RAIL
CSMC	CONCRETE	KG	KERB INLET GULLY	TMP	TWEEP WIRE FENCE
CP	CONCRETE POST	LB	LETTER BOX	TOB	TOP OF BANK MARK
CPF	CONCRETE POST FENCE	LD	LEVEL DATUM	TSB	TEMPORARY BALL BOLT/POST
CR	CHILD RACK	LP	LAMP POST	TC	TELCOM CABINET
CS	CLOSE TO MANHOLE	MB	MOORING BOLLARD	TL	TELEGRAPH LINE
CU	CULVERT	MF	MISCELLANEOUS FENCING	TM	TERMINALS LARGE
DI	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DK	DROP KERB	MP	MARKER POST	TP	TELEGRAPH POLE
DP	DUMPY	MT	MOORING POLE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MWF	METAL RAILING FENCE	TRE	TIMBER RUBBING STRIP
DW	DRAIN WATER	NB	NOTICE BOARD	TS	TRAFFIC SIGNAL
DWB	DOG WASTE BIN	NB	NOTICE BOARD	TUR	TUBULAR STEEL RAILING
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	US	UPSTREAM
EB	ELECTRIC BOX	OS	ORDNANCE SURVEY	VP	VENT PIPE & SURVEY
ECF	ELECTRIC CABLE FENCE	OS	ORDNANCE SURVEY	WL	WATER LEVEL/WATER LINE
EDP	ELECTRICITY CABLE PIT	OTR	OPEN STEEL RAILINGS	WM	WATER METER
EM	ELECTRICITY MANHOLE	P	POLE	WMF	WOODEN MIRE FENCE
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ES	ELECTRICITY TRANSMISSION LINE	PO	POST	WT	WATER TANK
FB	FLOWER BED	PRF	POST & RAIL FENCE	YC	YARD CULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

Location Plan Orientation

GRID

REV.	NOTES	DWN	DATE

ISO 9001 REGISTERED FIRM — Certificate Number: GB 6562

MEMBERS OF THE SURVEY ASSOCIATION

ISO 14001 REGISTERED FIRM — Certificate Number: GB 11414

Notes:

GRID AND LEVELS RELATE TO OS ACTIVE NETWORK
A REPORT HAS BEEN PRODUCED FOR THIS SURVEY

Control Used:
E5-461772-223450 SP 6177 2345 66.522m

LAND AND ENGINEERING SURVEYORS

MALTBY LAND SURVEYS LTD
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WebSite: http://www.maltbysurveys.com

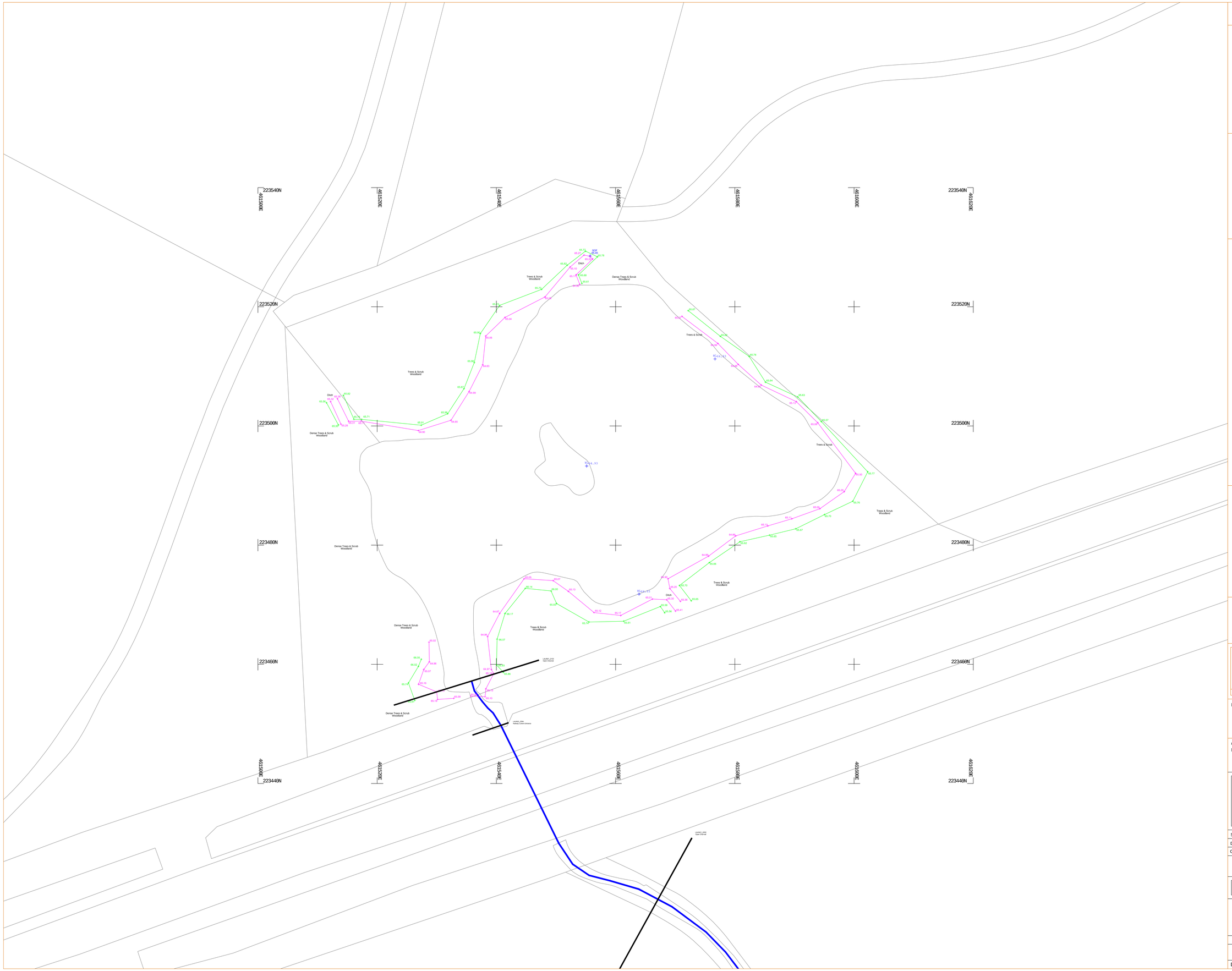
SURVEYED	DW	EWR ALLIANCE
DRAWN	DW	
CHECKED	RAM	SCALE
		AS SHOWN (A0 Sheet)

LAUNTON BROOK & TRIBUTARIES

LAUNTON BROOK (LAUN01)
LONG SECTION & LOCATION PLAN
LAUN01_0000 TO LAUN01_2103

Job No	Rev	Drawing Number
16_240		16_240_04

Date : SEPTEMBER 2016



KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C — BANK CREST

KEY TO LONGITUDINAL SECTION ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

(VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY "C" ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS)

- GAUGE BOARD LOCATIONS

SURVEY LEGEND

AB	AIR BRICK	FH	FIRE HYDRANT	PWF	POST & WIRE FENCE
B	BOLLARD	FM	FLOOD MEASUREMENT MARKER	RE	RODDING EYE
BB	BELOW BEACON	FL	FLOOR LEVEL	RS	ROODING SYP
BF	BOREHOLE	FP	FENCE POST	RSJ	ROLLED STEEL JOIST
BH	BOREHOLE	FW	FOUL WATER MANHOLE	RWP	RAINWATER PIPE
BL	BED LEVEL	G	GULLY	RWP	RAINWATER PIPE
BOK	BOTTOM OF KERB	GB	GAUGEBOARD	SC	STOP COCK
BS	BUS STOP	GF	GROUND LEVEL	SF	SLEEPER FENCE
BW	BENCH MARK	GP	GATE POST	SK	SOAKAWAY
BW	BENCH MARK	GM	GAS MARKER	SL	SLOPE LEVEL
BWF	BARBED WIRE FENCE	GV	GAS VALVE	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
CBF	CLOSE BOARDED FENCE	IF	IRON RAILING FENCE	STN	STAY NET
CL	COVER LEVEL	IP	HYDRANTION POINT	SV	SLUICE VALVE
CL	COVER LEVEL	IW	HYDRANTION WATER	SW	SURFACE WATER PIPE
CONC	CONCRETE FENCE	KG	KERB INLET GULLY	SWF	SHEEP WIRE FENCE
CP	CONCRETE POST	LB	LETTER BOX	TBM	TEMPORARY BENCH MARK
CP	CONCRETE POST	LD	LEVEL DOT	TCB	TOPOGRAPHIC CELL BOLT/POST
CR	CYCLE RACK	LP	LAMP POST	TC	TELECOM CABINET
CV	CHAMBER V. MANHOLE	M	MOORING BOLLARD	TF	TIMBER FENCE
CUL	CULVERT	MF	MISCELLANEOUS FENCING	TK	TRAFFICKED LOAD
DK	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DP	DOWN PIPE	MP	MARKER POST	TP	TELEGRAPH POLE BOX
DS	DOMESTIC	MT	MOORING POLE	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MTF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
DW	DOOR WAY	NB	NOTICE BOARD	TS	TRAFFIC SIGN
DWB	DOG WASTE BIN	NB	NOTICE BOARD	TUR	TUBULAR STEEL RAILING
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	US	UPSTREAM
EB	ELECTRIC BOX	OB	OBSERVATION BOX	VE	VALVE ON SURVEY
ECF	ELECTRIC CABLE FENCE	OS	ORDNANCE SURVEY	WL	WATER LEVEL/WATER LINE
EOP	ELECTRICITY CABLE PIT	OTR	OPEN STEEL RAILINGS	WM	WATER METER
EP	ELECTRICITY POLE	P	PIPE	WP	WOODEN POST
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRIC LINE/TRANSMISSION LINE	PO	POST	WT	WATER TANK
FB	FLOWER BED	PRF	POST & RAIL FENCE	YC	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

Location Plan Orientation

GRID

REV.	NOTES	DWN	DATE

ISO 9001 REGISTERED FIRM — Certificate Number: GB 6562

MEMBERS OF THE SURVEY ASSOCIATION

ISO 14001 REGISTERED FIRM — Certificate Number: GB 11414

Notes:

GRID AND LEVELS RELATE TO OS ACTIVE NETWORK
A REPORT HAS BEEN PRODUCED FOR THIS SURVEY

Control Used:
E5-461772-223450 SP 6177 2345 66.522m

LAND AND ENGINEERING SURVEYORS

MALTBY LAND SURVEYS LTD
2 QUEENS ROAD
HAYWARDS HEATH
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Tel: 01444 416 246
Fax: 01444 417 697
E-Mail: mail@maltbysurveys.com
WebSite: http://www.maltbysurveys.com

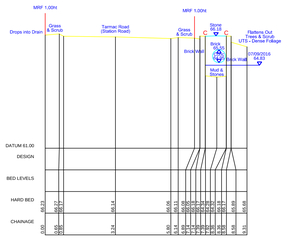
SURVEYED	DW	EWR ALLIANCE
DRAWN	DW	
CHECKED	RAM	SCALE
		1:200 (A0 Sheet)

LAUNTON BROOK & TRIBUTARIES

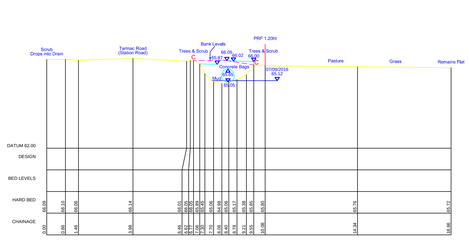
LAUNTON BROOK (LAUN01) TOPOGRAPHIC SURVEY POND LEVELS

Job No	Rev	Drawing Number
16_240		16_240_05

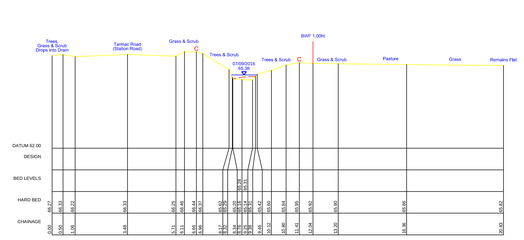
Date : SEPTEMBER 2016



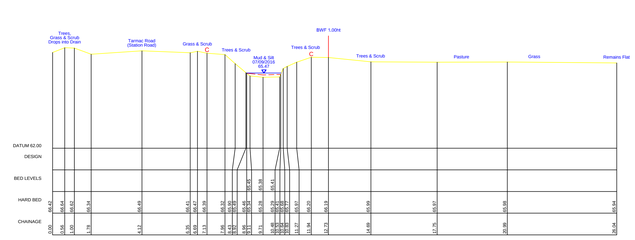
TRIB01_0001
461659.76mE 223304.57mN Brg 324
Culvert Exit
Tunnel Length = 20.18m



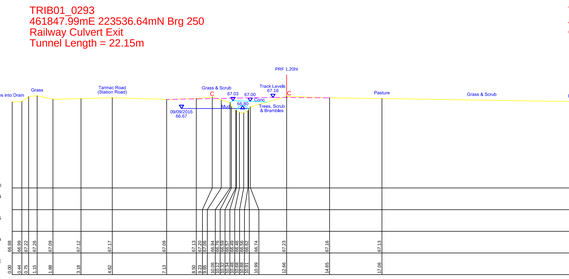
TRIB01_0021
461676.04mE 223318.06mN Brg 317
Culvert Entrance
Tunnel Length = 20.18m



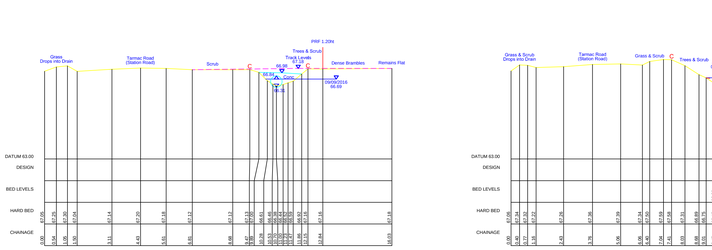
TRIB01_0068
461707.37mE 223355.87mN Brg 302
Open Channel



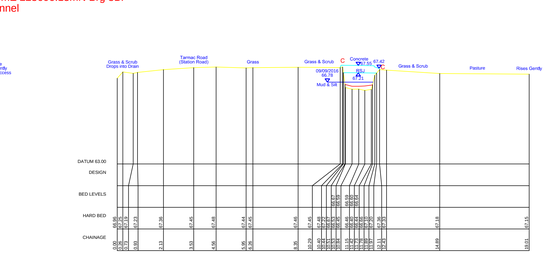
TRIB01_0102
461728.28mE 223380.5mN Brg 310
Open Channel



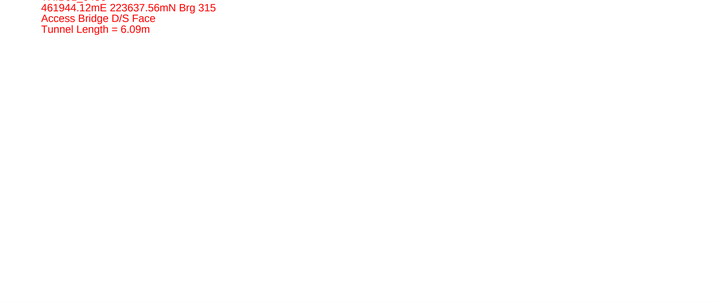
TRIB01_0156
461761.49mE 223423.41mN Brg 311
Open Channel



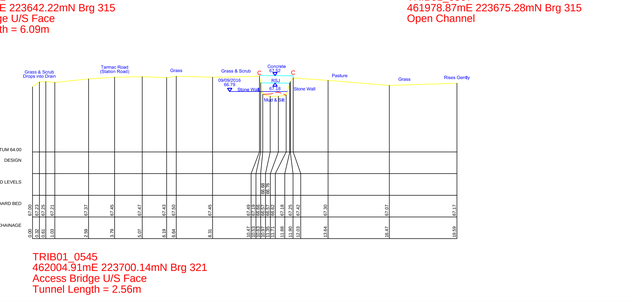
TRIB01_0180
461777.12mE 223440.52mN Brg 315
Access Bridge D/S Face
Tunnel Length = 4.53m



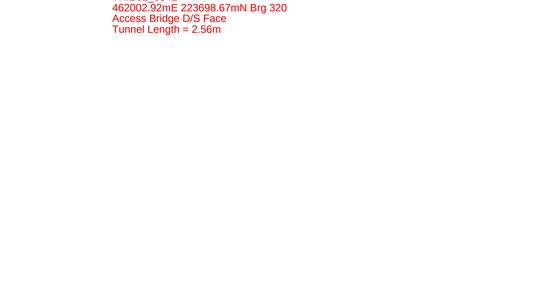
TRIB01_0184
461780.25mE 223443.98mN Brg 314
Access Bridge U/S Face
Tunnel Length = 4.53m



TRIB01_0210
461796.87mE 223464.34mN Brg 308
Open Channel



TRIB01_0259
461833.46mE 223499.01mN Brg 306
Open Channel



TRIB01_0286
461845.86mE 223522.17mN Brg 307
Open Channel

TRIB01_0293
461847.99mE 223536.64mN Brg 250
Railway Culvert Exit
Tunnel Length = 22.15m

TRIB01_0376
461892.66mE 223578.15mN Brg 313
Open Channel

TRIB01_0413
461913.87mE 223606.13mN Brg 317
Open Channel

TRIB01_0456
461944.12mE 223637.56mN Brg 315
Access Bridge D/S Face
Tunnel Length = 6.09m

TRIB01_0462
461948.26mE 223642.22mN Brg 315
Access Bridge U/S Face
Tunnel Length = 6.09m

TRIB01_0507
461978.87mE 223675.28mN Brg 315
Open Channel

TRIB01_0542
462002.92mE 223698.67mN Brg 320
Access Bridge D/S Face
Tunnel Length = 2.56m

TRIB01_0545
462004.91mE 223700.14mN Brg 321
Access Bridge U/S Face
Tunnel Length = 2.56m

KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C BANK CREST

KEY TO LONGITUDINAL SECTION ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

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

SURVEY LEGEND

AB	AIR BRICK	Fh	FIRE HYDRANT	PMP	POST & WIRE FENCE
AP	AIR VALVE	FHW	FIRE HYDRANT MARKER	RE	RIGHT ELSE
BB	BRICK BASE	FP	FLAG POLE	RG	ROAD GULLY
BE	BELOW BEACON	FS	FENCE POST	RSJ	ROLLED STEEL JOIST
BSY	BOUNDARY	FWM	FULL WATER MARKER	RTM	RETAINING WALL
BT	BRICK TRAP	G	GATE	SBW	SOFT BOTTOM WEIR
BL	BED LEVEL	GB	GRASSBANK	SC	STOP VALVE
BRK	BRICKWORK	GI	GROUND LEVEL	SHP	SOAKAWAY PIT
BS	BACK SIGHT	GM	GAS MARKER	SP	STOP POST
BM	BENCH MARK	GV	GAS VALVE	SL	SLOPE LEVEL
BWF	BARBED WIRE FENCE	HC	HEDGE CUTTING	SMH	STORM SEWER MANHOLE
BWP	BARBED WIRE POST	IC	INSPECTION CHAMBER	SWP	SHEET METAL PILING
CF	CLOSE BOARDED FENCE	IL	INVERT LEVEL	SW	SOIL VENT
CHF	CHAIN LINK/MESH FENCE	IP	IRON RAILING FENCE	TK	TANK
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	SV	SLUICE VALVE
CLF	CLEAR LIGHT FENCE	KB	KERB BOTTOM	TBM	TEMPORARY BENCH MARK
CONC	CONCRETE POST	KS	KERB SET/ SILLS	TBP	TEMPORARY BENCH MARK POST
CP	CONCRETE POST	LB	LEFT BANK	TBW	TEMPORARY BENCH MARK WALL
CPF	CONCRETE POST & PANEL FENCE	LP	LAMP POST	TC	TELECOM CABINET
CR	CREST WEIR	LV	LAMP VENT	TEL	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
DE	DEAD END	MF	MESH & METAL FENCING	TP	TELEGRAPH POLE
DH	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DOWN PIPE	MP	MARKER POST	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MRF	METAL RAILING FENCE	TRE	TIMBER RUBBING STRIP
DS	DOWNSTREAM	MS	MILE STONE	TS	TREE STUMP
DWB	DRY STONE WALL	NB	NATIONAL BOARD	UB	UNDER SIDE RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	UC	UPSTREAM
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	UTL	UNABLE TO SURVEY
EF	ELECTRIC FENCE	OP	OPEN STEEL RAILINGS	W	WATER / SEWERAGE LINE
EOF	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WA	WATER METER
EMH	ELECTRICITY MANHOLE	PILE	PILE	WMF	WIRE MESH FENCE
ES	ELECTRICITY POLE	PO	PARKING BOX	WP	WOODEN POST
EX	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	POST	POST	WV	WATER VALVE
FB	FLOWER BED	PSV	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

REV.	NOTES	DWN	DATE

ISO 9001 REGISTERED FIRM
Certificate Number: GB 6562

MEMBERS OF THE SURVEY ASSOCIATION

ISO 14001 REGISTERED FIRM
Certificate Number: GB 11414

Notes:

GRID AND LEVELS RELATE TO OS ACTIVE NETWORK
A REPORT HAS BEEN PRODUCED FOR THIS SURVEY

Control Used:
E5-461772-223450 SP 6177 2345 66.522m

LAND AND ENGINEERING SURVEYORS

MALTBY LAND SURVEYS LTD
2 QUEENS ROAD
HAYWARDS HEATH
WEST SUSSEX
RH16 1EB
Tel: 01444 416 246
Fax: 01444 417 697
E-Mail: mail@maltbysurveys.com
WebSite: http://www.maltbysurveys.com

SURVEYED	DW
DRAWN	DW
CHECKED	RAM

EWR ALLIANCE

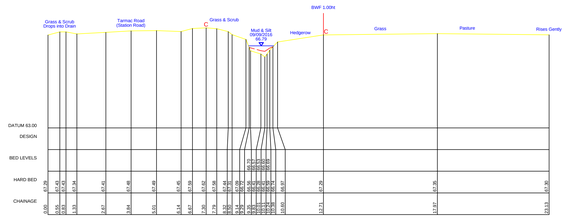
SCALE
1:100 (A0 Sheet)

LAUNTON BROOK & TRIBUTARIES

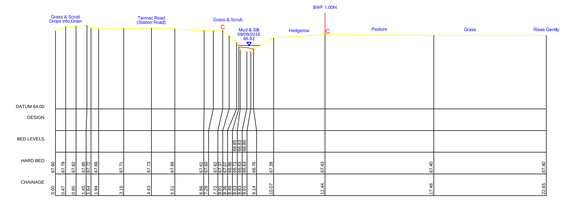
LAUNTON BROOK TRIBUTARY (TRIB01)
CROSS SECTIONS
TRIB01_0001 TO TRIB01_0545

Job No	Rev	Drawing Number
16_240		16_240_06

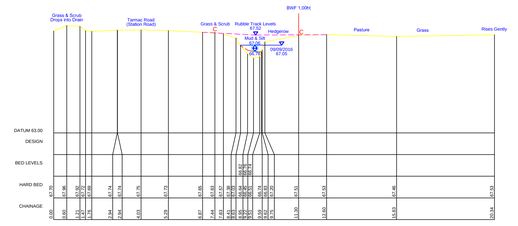
Date : SEPTEMBER 2016



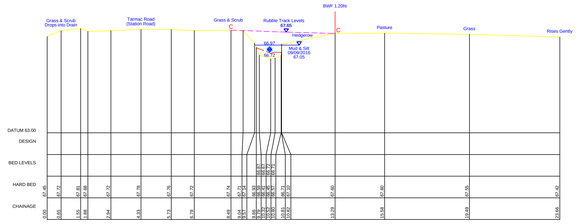
TRIB01_0563
462018.92mE 223709.96mN Brg 329
Open Channel



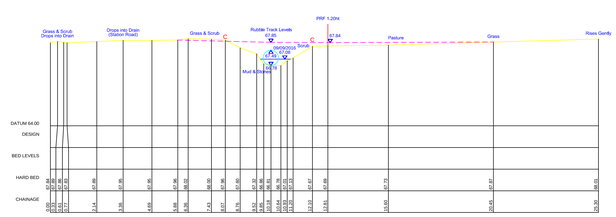
TRIB01_0613
462060.96mE 223740.19mN Brg 321
Open Channel



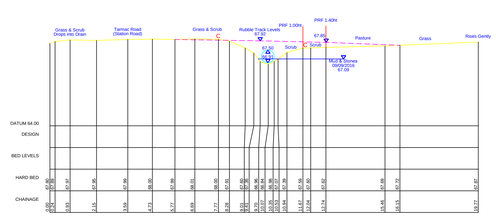
TRIB01_0657
462091.13mE 223773.57mN Brg 306
Access Bridge D/S Face
Tunnel Length = 11.42m



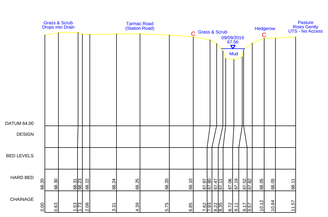
TRIB01_0668
462098.36mE 223782.17mN Brg 308
Access Bridge U/S Face
Tunnel Length = 11.42m



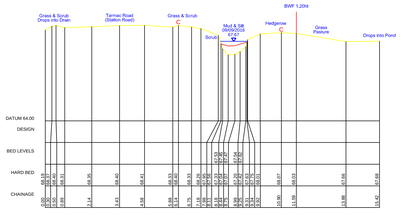
TRIB01_0697
462115.03mE 223805.12mN Brg 311
Access Bridge D/S Face
Tunnel Length = 5.96m



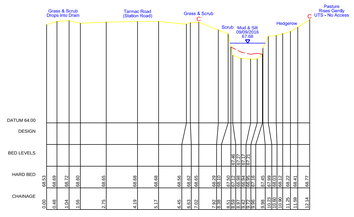
TRIB01_0703
462119.06mE 223810.24mN Brg 308
Access Bridge U/S Face
Tunnel Length = 5.96m



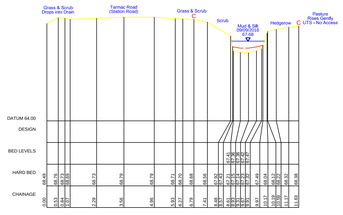
TRIB01_0763
462154.18mE 223859.98mN Brg 299
Open Channel



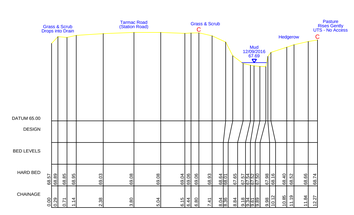
TRIB01_0814
462175.18mE 223906.9mN Brg 297
Open Channel



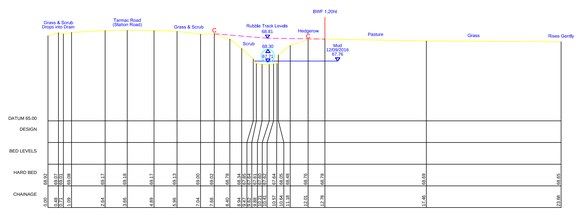
TRIB01_0847
462191.8mE 223933.5mN Brg 307
Open Channel



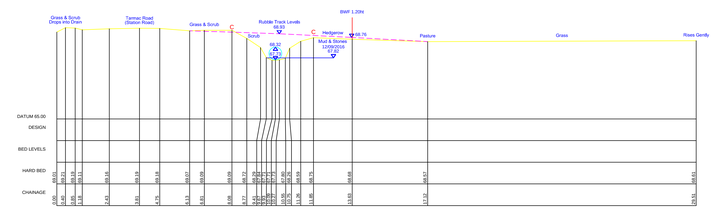
TRIB01_0897
462223.73mE 223970.01mN Brg 316
Open Channel



TRIB01_0948
462263.33mE 223998.27mN Brg 329
Open Channel



TRIB01_0986
462296.12mE 224012.16mN Brg 346
Access Bridge D/S Face
Tunnel Length = 9.72m



TRIB01_0996
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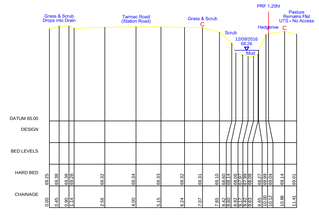
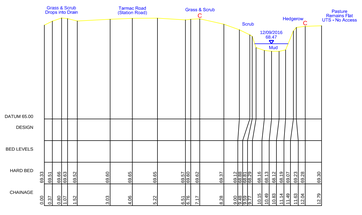
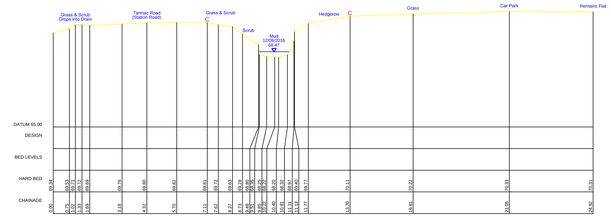
Access Bridge U/S Face
Tunnel Length = 9.72m



TRIB01_1049
462355.94mE 224041.13mN Brg 313
Open Channel



TRIB01_1099
462393.18mE 224069.58mN Brg 330
Open Channel



TRIB01_1148
462436.75mE 224090.76mN Brg 335
Open Channel

KEY TO SECTIONS:

WATER LEVEL

VISIBLE BED (TOP OF SILT) AND GROUND

HARD BED (DETERMINED BY PROBING)

C BANK CREST

KEY TO LONGITUDINAL SECTION ONLY:

LEFT BANK CREST
RIGHT BANK CREST
} VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY "C" ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS

SURVEY LEGEND

AB	AIR BRICK	Fh	FIRE HYDRANT	PMF	POST & MINE FENCE
AV	AIR VALV	FHW	FIRE HYDRANT MARKER	RE	RIGHT EDGE
BB	BRICK BASE	FL	FLOOD LIGHT	RG	RIDGE TILE
BE	BELGIUM BEACON	FP	FENCE POST	RSJ	ROLLED STEEL JOIST
BEY	BOUNDARY	FWH	FOUL WATER MANHOLE	RTW	RETAINING WALL
BH	BORE HOLE	G	GULLY	SAT	SATELLITE DISH
BL	BED LEVEL	GB	GRASSBANK	SC	STOP VALV
BRK	BRICKWORK	GL	GROUND LEVEL	SHP	SOAKAWAY PIT
BS	BUS STOP	GP	GUARD POST	SP	SIGNAL POST
BW	BENCH MARK	GV	GAS MARKER	SL	SLOPE LEVEL
CB	CONCRETE BASE	HW	HEDGEROW	SMH	STORM SEWER MANHOLE
CMF	CHANNEL MINE FENCE	IC	INSPECTION CHAMBER	SMP	SHEET METAL PILING
COF	CLOSE BOARDED FENCE	IP	IRON PEG	SP	SIGN POST
CPF	CONCRETE POST & PANEL FENCE	IR	IRON RAILING FENCE	STA	STAKE
CL	COVER LEVEL	IWF	INTERWOVEN FENCE	SV	SLUICE VALVE
CLF	CHAIN LINK FENCE	KO	KERB OPPOSITE	TBM	TEMPORARY BENCH MARK
CONC	CONCRETE	KS	KERB SPLIT / GULLY	TBP	TEMPORARY BENCH MARK POST
CP	CONCRETE POST	LB	LEFT BANK	TCM	TEMPORARY CONTROL MONUMENT
CPF	CONCRETE POST & PANEL FENCE	LP	LAMP POST	TCP	TEMPORARY CONTROL BOLT/POST
CR	CRECE BRICK	LV	LAMP VENT	TEL	TELECOM CABINET
CTV	CABLE T.V. MANHOLE	MB	MOORING BOLLARD	TMH	TELECOM MANHOLE
DE	DRIP EDGE	MF	MESH & CONCRETE POSTS FENCING	TP	TELEGRAPH POLE
DH	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DL	DECK LEVEL	MKR	MARKER	TLB	TRAFFIC LIGHT BOX
DP	DRAIN PIPE	MP	MARKER POST	TP	TELEGRAPH POLE
DPC	DAMP PROOF COURSE	MPF	METAL PAILING FENCE	TRS	TIMBER RUBBING STRIP
DS	DOWNSTREAM	MS	MILE STONE	TS	TREE STUMP
DWB	DRY STONE WALL	NB	NATIONAL BOARD	TSR	TIMBER STEEL RAILINGS
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	US	UPSTREAM
EB	ELECTRICITY BOX	OHC	OVERHEAD CABLE	UTS	UNABLE TO SURVEY
EF	ELECTRICITY CABLE FENCE	OHL	OVERHEAD LINE	VC	VERTICAL CURVATURE LINE
EOF	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WA	WATER METER
EMH	ELECTRICITY MANHOLE	PILE	PILE	WMF	WIRE MESH FENCE
EP	ELECTRICITY POLE	PM	PARKING METER	WP	WOODEN POST
ES	SWITCHING BOX	PW	PARKING BOX	WPR	WOODEN POST & RAIL FENCE
ETL	ELECTRICITY TRANSMISSION LINE	PO	POST	WV	WATER VALVE
FB	FLOWERBED	PV	POST & RAIL FENCE	YG	YARD GULLY
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

REV.	NOTES	DWN	DATE

ISO 9001 REGISTERED FIRM
Certificate Number: GB 6562

MEMBERS OF THE SURVEY ASSOCIATION

ISO 14001 REGISTERED FIRM
Certificate Number: GB 11414

Notes:

GRID AND LEVELS RELATE TO OS ACTIVE NETWORK
A REPORT HAS BEEN PRODUCED FOR THIS SURVEY

Control Used:
E5-461772-223450 SP 6177 2345 66.522m

LAND AND ENGINEERING SURVEYORS

MALTBY LAND SURVEYS LTD
2 QUEENS ROAD
HAYWARDS HEATH
WEST SUSSEX
RH16 1EB
Tel: 01444 416 246
Fax: 01444 417 697
E-Mail: mail@maltbysurveys.com
WebSite: http://www.maltbysurveys.com

SURVEYED	DW	EWR ALLIANCE
DRAWN	DW	
CHECKED	RAM	
		SCALE
		1:100 (A0 Sheet)

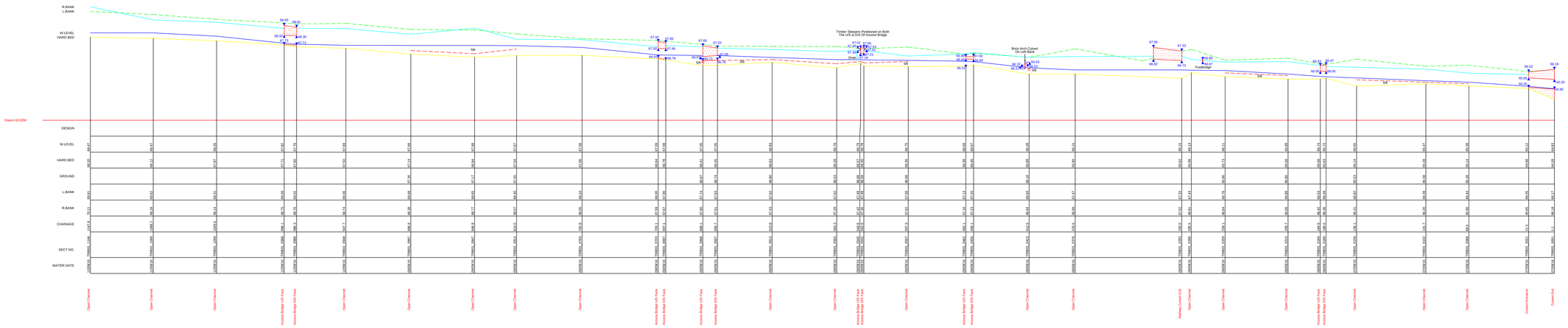
LAUNTON BROOK & TRIBUTARIES

LAUNTON BROOK TRIBUTARY (TRIB01)
CROSS SECTIONS
TRIB01_0563 TO TRIB01_1148

Job No	Rev	Drawing Number
16_240		16_240_07

Date : SEPTEMBER 2016

SCALE = 1:1250 H, 1:100 V



KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C — BANK CREST

KEY TO LONGITUDINAL SECTION ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

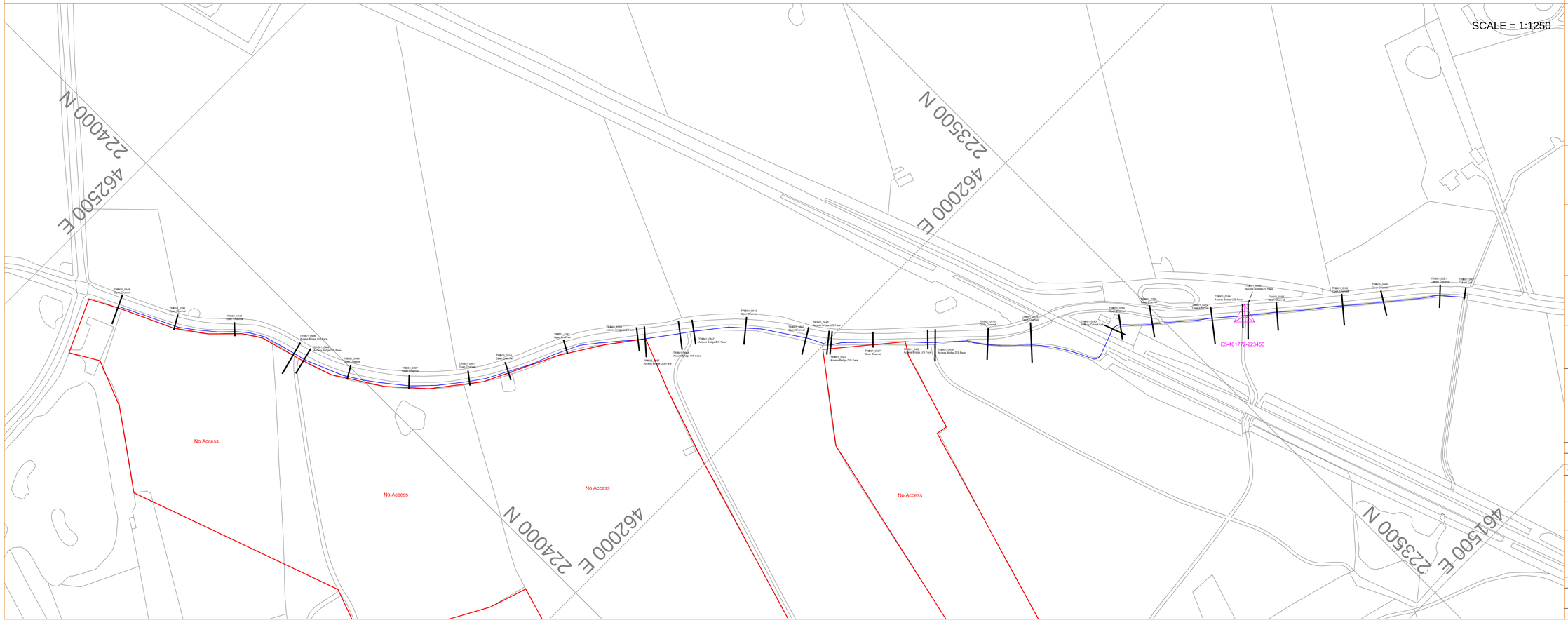
} VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'C' ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS

- GAUGE BOARD LOCATIONS

SURVEY LEGEND

AB	AIR BRICK	Fh	FIRE HYDRANT	PMF	POST & MRE FENCE
AM	AIR METER	FM	FLOOD MARKER	PO	POLE OUTAGE
B	BOLLARD	FL	FLOOR LEVEL	RE	ROADING EP
BB	BELOW BEACON	FP	FENCE POST	RSJ	ROLLED STEEL JOIST
BF	BOREHOLE	FW	FOUL WATER MANHOLE	RWP	RAINWATER PIPE
BH	BOREHOLE	G	GULLY	RWS	RUNNINGS PITS
BL	BED LEVEL	GB	GAUGEBOARD	SC	STOP COCK
BMK	BENCH MARK	GE	GROUND LEVEL	SF	SLEEPER FOOT
BS	BOX SOCK	GP	GATE POST	SI	SIGNAGE
BW	BENCH WARK	GW	GAS MARKER	SL	SLOPE LEVEL
CB	CATCH PIT	HC	HEDGE CUT	SMH	SURFACE WATER MANHOLE
BWF	BARBED WIRE FENCE	IC	INSPECTION CHAMBER	SWP	SWEET METAL PILING
CBF	CLOSE BOARDED FENCE	IP	INVERT LEVEL	SWS	SIGN POST
CF	CHAIN LINK MESH FENCE	IW	INSPECTION WELL	STN	STAY NUT
CL	COVER LEVEL	IF	INTERMEDIATE FENCE	SV	SLUICE VALVE
CMC	CONCRETE FENCE	KC	KERB CUT	TH	TELEPHONE PIPE
CONC	CONCRETE	KD	KERB INLET GULLY	UMP	SHEEP WIRE FENCE
COV	COVER LEVEL	LB	LIGHT BEAM	UMW	UNDERGROUND WIRE
CP	CONCRETE POST	LD	LETTER BOX	TSB	TELEPHONE BALL BUTPOST
CR	CHILD RACK	LP	LAMP POST	TC	TELCOM CABINET
CV	CHILD VALVE	LV	LOCKABLE BOLLARD	TL	TELEPHONE LINE
CULV	CULVERT MANHOLE	MF	MISCELLANEOUS FENCING	TRL	TRAFFICALLY LIGHT
DK	DROP KERB	MH	MANHOLE	TL	TRAFFIC LIGHT
DP	DOWN PIPE	MP	MARKER POST	TP	TELEGRAPH POLE
DS	DOWNSTAY	MT	MOORING POLE	TV	TELEVISION POLE
DPC	DAMP PROOF COURSE	MWF	METAL RAILING FENCE	TRS	TIMBER RUBBING STRIP
EM	ELECTRIC METER	NB	NOTICE BOARD	TS	TRAFFIC SIGNAL
ENB	END NOSE BIN	NB	NOTICE BOARD	TUB	TUBULAR STEEL RAILING
EA	ENVIRONMENT AGENCY	NRA	NATIONAL RIVERS AUTHORITY	US	UPSTREAM
EB	ELECTRIC BOX	OS	ORDNANCE SURVEY	VP	VENT PIPE & SURVEY
ECF	ELECTRIC CABLE FENCE	OS	ORDNANCE SURVEY	WL	WATER LEVEL/WATER LINE
EOP	ELECTRICITY CABLE PIT	OSR	OPEN STEEL RAILINGS	WM	WATER METER
EP	ELECTRICITY POLE	P	PILLAR	WMF	WOODEN MRE FENCE
EP	ELECTRICITY POLE	PB	PILLAR BOX	WP	WOODEN POST
ER	EARTHING ROD	PM	PARKING METER	WPR	WOODEN POST & RAIL FENCE
ET	ELECTRICITY TRANSMISSION LINE	PO	POLE	WS	WATER STOP
FB	FLOWER BED	PSF	POST & RAIL FENCE	YO	YARD VOLUT
FBR	FOOTBRIDGE	PTM	PARKING TICKET MACHINE		

SCALE = 1:1250



Location Plan Orientation

REV.	NOTES	DWN	DATE

ISO 9001 REGISTERED FIRM — Certificate Number: GB 6562

MEMBERS OF THE SURVEY ASSOCIATION

ISO 14001 REGISTERED FIRM — Certificate Number: GB 11414

Notes:

GRID AND LEVELS RELATE TO OS ACTIVE NETWORK
A REPORT HAS BEEN PRODUCED FOR THIS SURVEY

Control Used:
E5-461772-223450 SP 6177 2345 66.522m

LAND AND ENGINEERING SURVEYORS

MALTBY LAND SURVEYS LTD
2 QUEENS ROAD
HAYWARDS HEATH
WEST SUSSEX
RH16 1EB
Tel: 01444 416 246
Fax: 01444 417 697
E-Mail: mail@maltbysurveys.com
WebSite: http://www.maltbysurveys.com

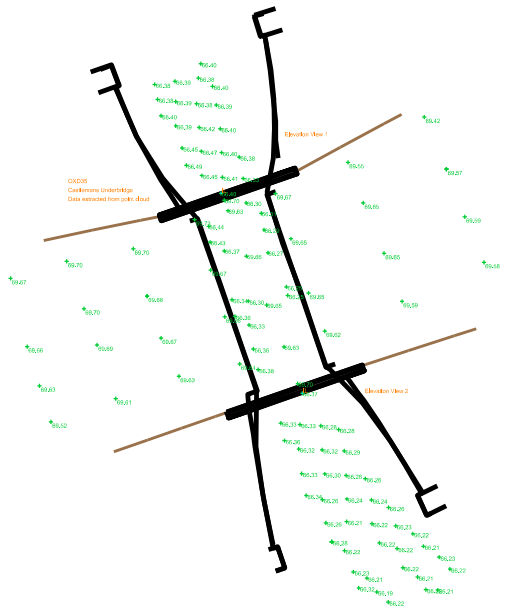
SURVEYED	DW	EWR ALLIANCE
DRAWN	DW	
CHECKED	RAM	
		SCALE
		AS SHOWN (A0 Sheet)

LAUNTON BROOK & TRIBUTARIES

LAUNTON BROOK TRIBUTARY (TRIB01)
LONG SECTION & LOCATION PLAN
TRIB01_0001 TO TRIB01_1148

Job No	Rev	Drawing Number
16_240		16_240_08

Date : SEPTEMBER 2016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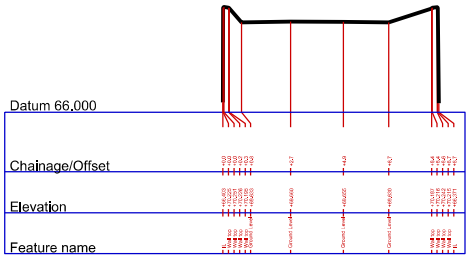
Elevation View 2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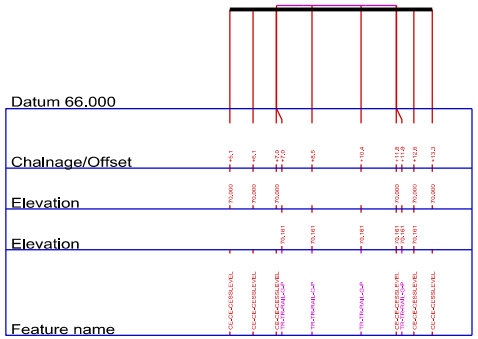
Chainage/Offset
Elevation
Feature name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Elevation
Elevation
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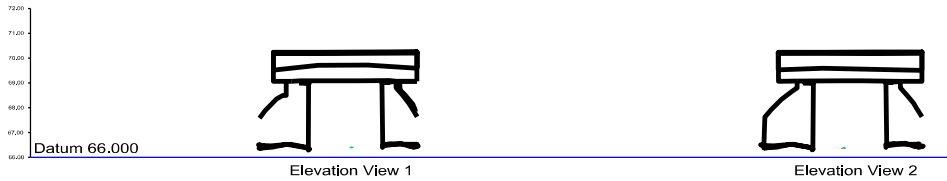
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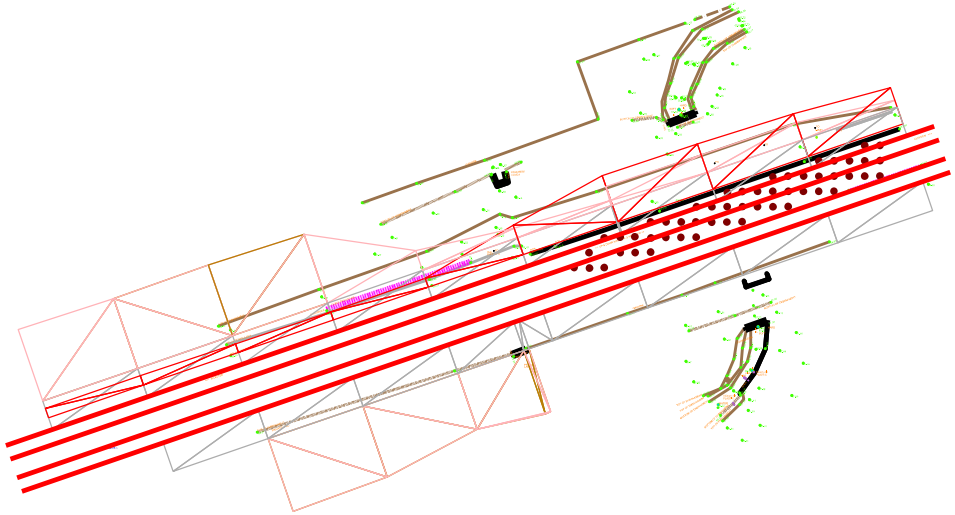
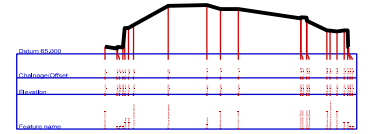
68.20
67.00
66.00
Datum 66.000
Elevation View 1
Elevation View 2

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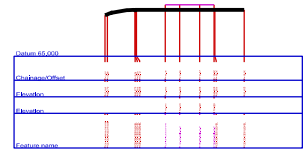
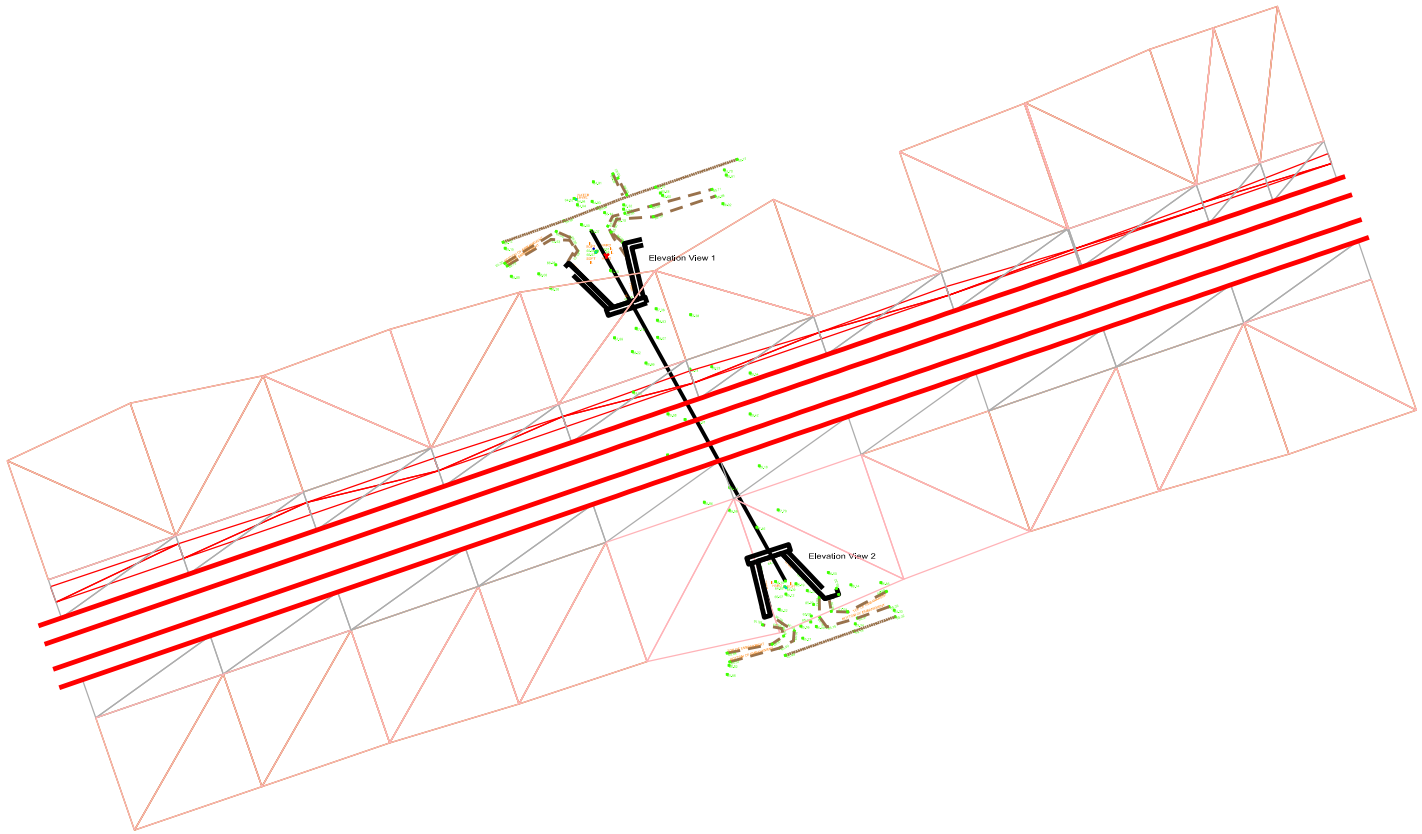
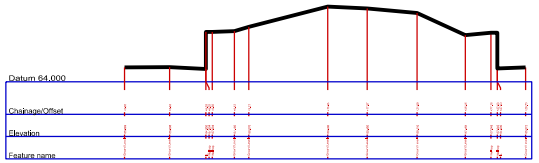
Chainage/Offset
Elevation
Feature name


Datum 65.000
Chainage/Offset
Elevation
Elevation
Feature name

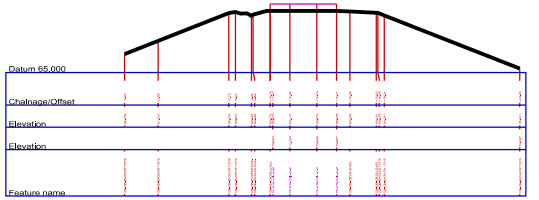

Elevation View 1
Elevation View 2
Datum 65.000



Culvert C170660 Existing Levels Section



Culvert C170660 Design Levels Section



Appendix D. Launton Brook Model Update

Appendix D

Launton Brook Hydraulic Model Improvements

Contents

Tables

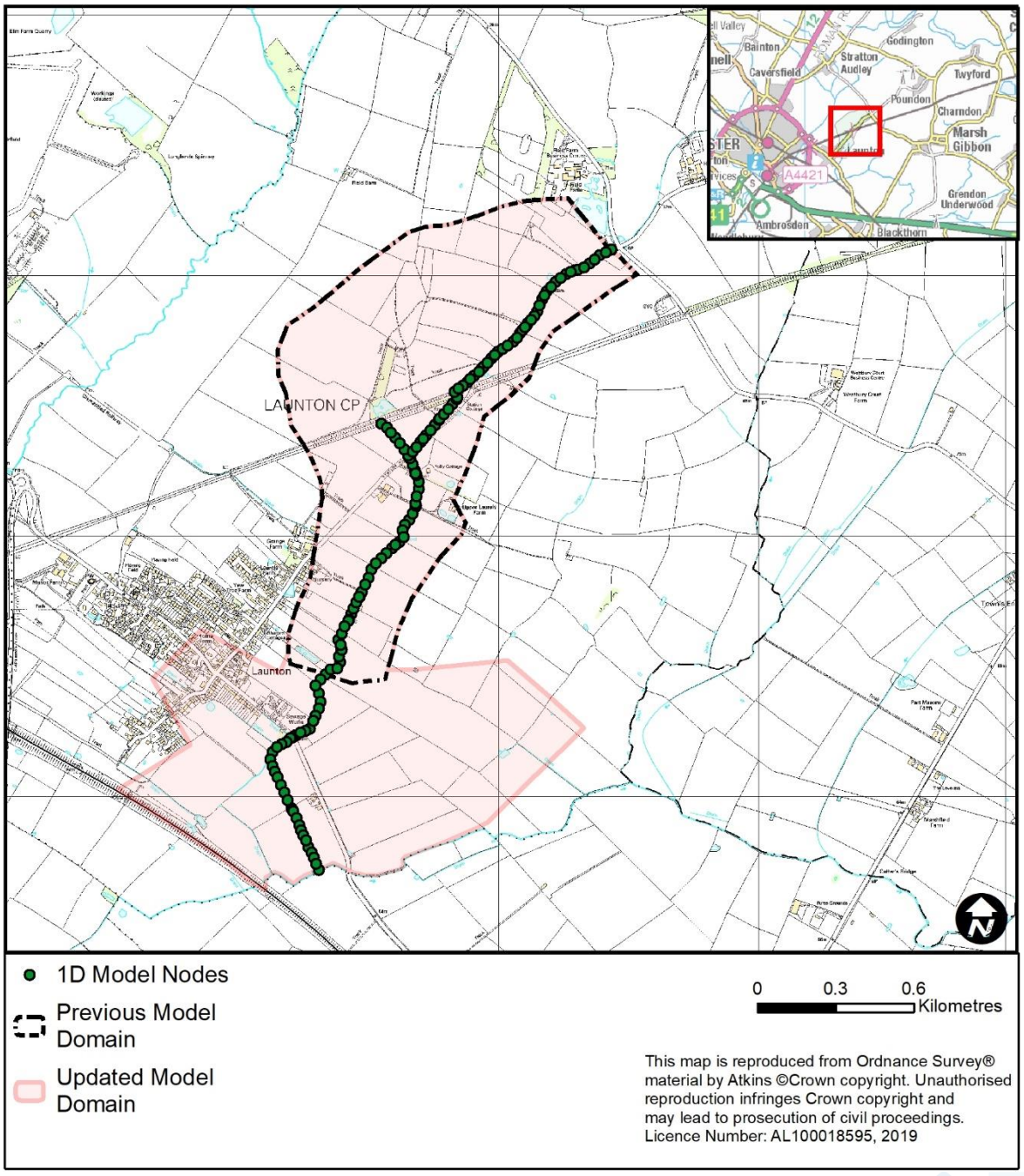
Figures

1. Introduction

This Appendix documents the hydraulic model updates, improvements and checks undertaken for the Launton Brook hydraulic model (extent shown below) in response to the Environment Agency review comments (EWR_Launton Brook Review_Response_ATK_V002.xls) received on 23rd June 2020.

The objective of the modelling is to assess the potential impact of the proposed EWR2 works, and size and design the CFSA required to compensate for floodplain losses.

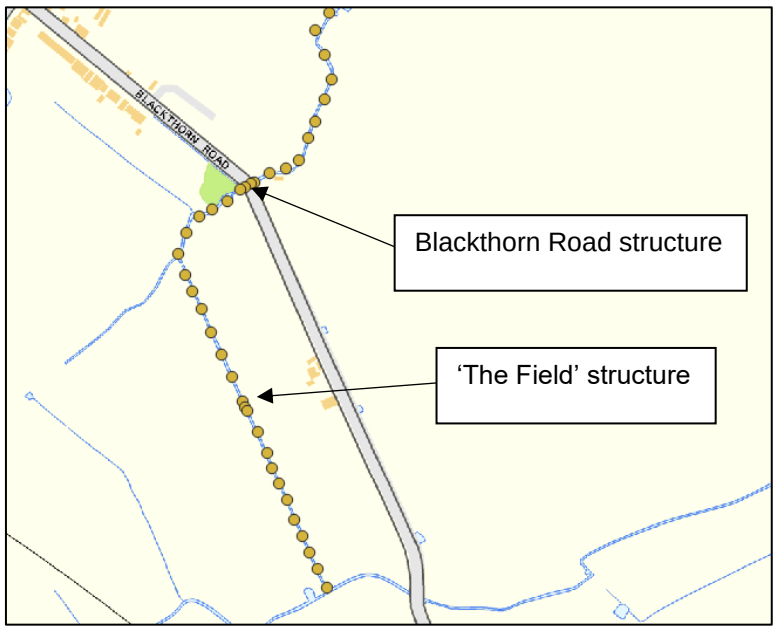
Figure 1-1 Launton Brook model domain



2. Hydraulic model improvements

This section sets out the improvements made to the hydraulic model in response to the Environment Agency review comments. The table below sets out the key improvements made to the model.

Table 2-1 Hydraulic model improvements

No.	Description
1	**Review Item No. 4.5**
	The 1D in-channel model was extended, and the downstream boundary moved approximately 1km downstream. The extension utilised the (EWR Alliance) 2016 survey of the Launton Brook. • The Blackthorn Road structure was modelled using two parallel rectangular orifice units. The rectangular opening is a simplification of the openings. However, there is a significant drop in bed level across the structure and this approach was adopted to improve stability and the invert/obvert levels and opening areas are as surveyed. • The small access bridge at 'The Field' was modelled using a USBPR bridge unit. • Overtopping at the Blackthorn Road and 'The Field' structures, was represented using 1D spill units. The weir coefficients were determined based on the characteristics of the bridge deck. Where railings, or other obstructions, were present, a lower (0.8) value was used. The existing normal depth downstream boundary approach (using the bed gradient between the two upstream nodes) was retained and connected to the new downstream cross section.
	 **Figure 2-1 Model extension structures**
2	**Review Item No. 4.5 and 9.2**

No.	Description
	The active 2D domain was extended downstream to provide a dynamic 2D floodplain link for the extended 1D domain. The 2D domain was linked to the 1D using HX lines with bank top z-lines applied using the same approach as the existing model (as surveyed at 1D sections and interpolated between nodes). The 2D domain was also extended where necessary to avoid glass walling during the most extreme (1% annual chance event plus 70% climate change) modelled event. The existing HQ 2D downstream boundary was moved and the gradient ('b' parameter) reduced to 0.002 (from 0.01) to reflect the shallower floodplain gradient at the new boundary location.
3	The 2D HX 'a' parameter was increased from the default "0" to reflect characteristics of the channel banks and energy losses expected at the interface between 1D (in-channel) and 2D (floodplain) flows as the water is forced to change direction and magnitude. Values are set globally to 0.2, to reflect naturally vegetated channel banks. Although this improves the hydraulic behaviour of water at these locations, the flows across the HX line are relatively minor compared with those within the 1D channel and the effect of the additional energy loss will be minor.
4	**Review Item No. 7.8**
	The representation of buildings has been changed to include a nominal 300mm threshold and use a flow constriction (90% blockage), as opposed to raised Manning's n, to reflect the building interior. This approach provides refined hydraulics where the 2D model resolution is more detailed and able to capture the building footprint.
5	**Review Item No. 10.1, 10.2 and 10.4**
	The model now utilises the 0.2m resolution EWR2 project LiDAR.
6	**Review Item No. 6.1 and 11.1**
	The model timesteps have been adjusted: 2D: 1 sec, 1D: 0.5 sec.
7	**Review Item No. 9.1, 10.1 and 10.2**
	Additional survey was collected in July 2020 at the three culverts/underpasses beneath the current railway line. This was compared against the current representation to validate the 2016 survey and the model updated where no previous survey data was available. Specifically, structure OXD35, the underpass between Launton Brook and the tributary culverts, which was based on LiDAR only, was updated based on the recent survey.
8	**Review Item No. 9.1 and 11.2**
	The Initial Water Level (IWL) at the wetland/pond, to the north of the railway line at the upstream extent of the surveyed Launton Brook, was initially modelled as 65.3mAOD. It was not clear from the WSP model reporting why this value was chosen. The IWL was adjusted to 64.93mAOD to reflect the water level as surveyed in 2016. This value was checked and confirmed against the July 2020 survey. A sensitivity test was carried out on this value (raised to 65.4mAOD and removed).
9	**Review Item No. 6.3**

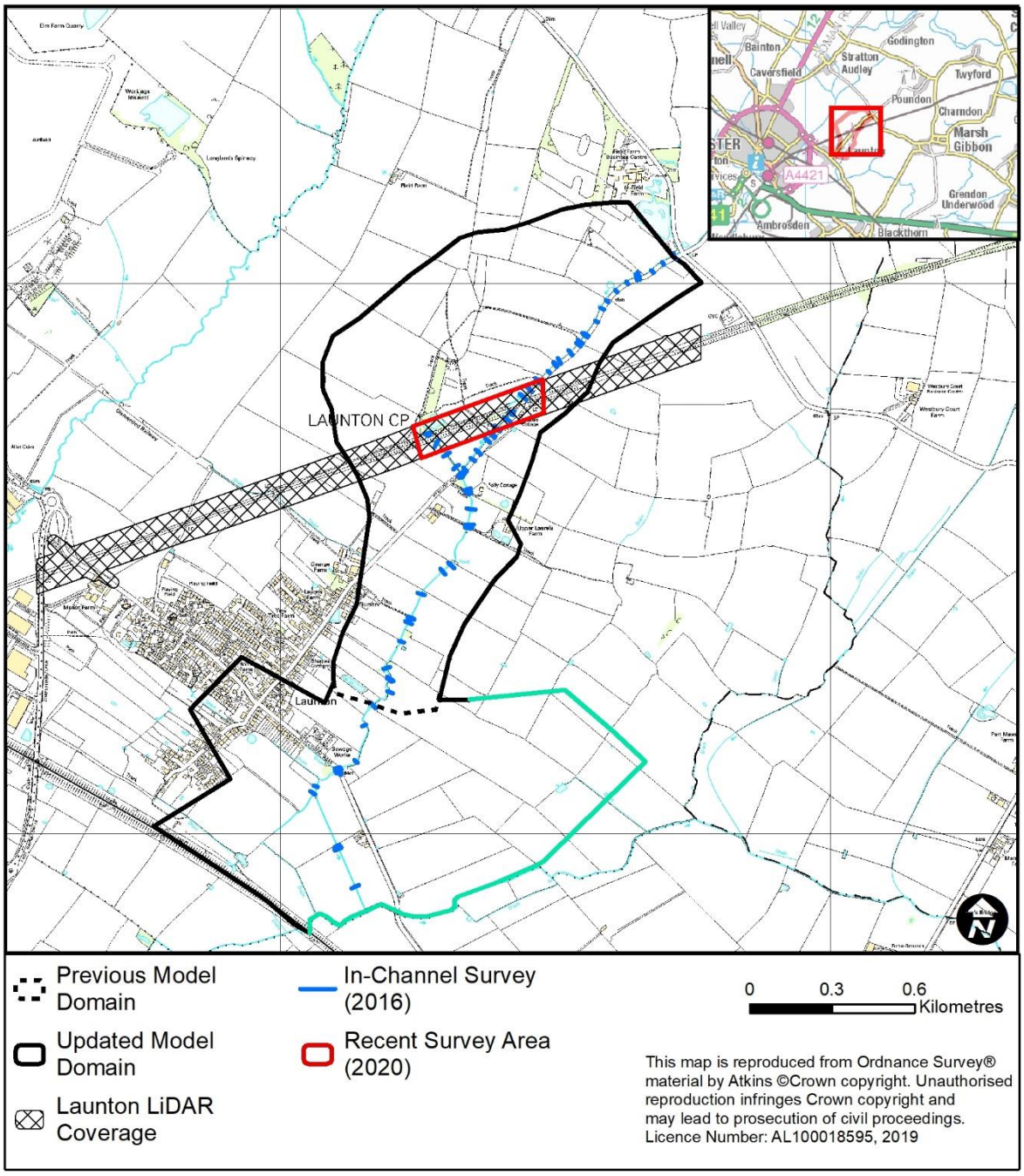
No.	Description
	The model dflood value (5m) was reduced to the default value (3m).
10	**Review Item No. 12.2**
	The Flood Modeller .gxy has been updated and is consistent between baseline and scheme simulations where there are matching node labels.
11	**Review Item No. 13.1 and 14.3**
	The deactivated areas were adjusted to remove warnings at model start-up.
12	**Review Item No. 16.1, 16.2, 16.3 and 17.10**
	The following sensitivity tests were carried out: • Downstream boundary +/- 50% • Flow +/- 20% • Manning's n +/- 20% • Blockage of key structures (50% blockage at C170352 and C170660) • Raising timestep (this was applied to all model runs) • Reducing dflood to default (if dflood can be reduced, this will be applied to all model runs) • Pond arrangement, sensitivity to removal of IWL and raising to previously modelled level (~+0.3m) • OXD35 Castlemans Underbridge – 50% blockage • LAUN01_0605 – Blackthorn Road structure – 50% blockage
13	**Review Item No. 3.2**
	Confirmation of modelling approaches against survey: • Structures (opening dimensions, inverts and soffits) • Cross sections (section geometry)
14	**Review Item No. 14.1**
	The 2D model cumulative mass error has improved for the 1% annual chance event plus climate change 70% (largest modelled event) and is within the recommended limits of +/- 1%. The 2D model dVol results indicate a smooth transfer of flow volume between the 1D and 2D domains. Please see Figure 2-6.
15	The 1D initial conditions have been adjusted and minimum flows adjusted: • LAU_LAT – 0.08m³/s (was 0.05m³/s) • TRI01_1148 – 0.02m³/s (was 0.05m³/s) • Sweetner02 – 0.05m³/s (additional)
16	Model simulations updated to latest version of TUFLOW (2020-AB)
17	**Review Item No. 2.1 and 4.2**
	All required return periods simulated (50%, 5%, 1%, 1% plus climate change 70% and 0.1% annual chance events).

The subsequent sections provide further detail of the updates and checks made.

Topographic survey

Figure 2-2 shows the locations of the surveyed cross sections, additional survey collated to improve confidence in the model, and the 0.2m EWR2 project LiDAR.

Figure 2-2 Topographic survey data and extended 2D domain



Additional survey was collected in July 2020 at the three culverts/underpasses beneath the current railway line (Figure 2-3).

Figure 2-3 Railway culvert locations

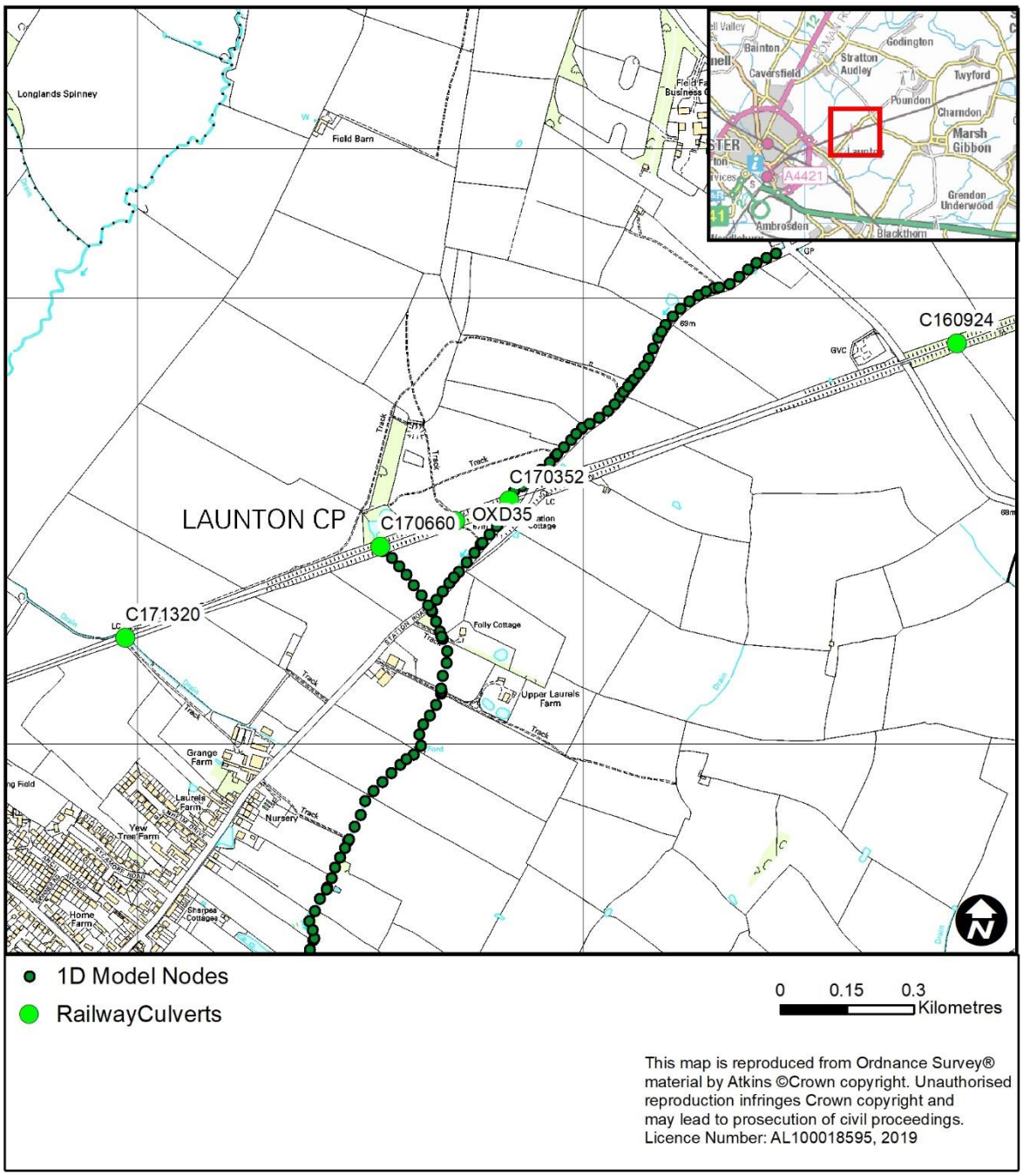


Table 2-2: Survey and Modelling comparisons at key structures

<table>
<tr><th>Survey site</th><th colspan="4">Actions</th></tr>
<tr><td>C170660
(Launton Brook: RailTunn1, ESTRY)</td><td colspan="4">The topographic surveys were reviewed and differences between the surveys were minimal, thus no changes were made from the 2016 model structure representation.</td></tr>
<tr><td>C170352
(Tributary: TRI01_0315, FM)</td><td colspan="4">The topographic surveys were reviewed and differences between the surveys were minimal, thus no changes were made from the 2016 model structure representation.</td></tr>
<tr><td rowspan="5">OXD35 Castlemans Underbridge
(underpass, ESTRY)</td><td colspan="4">Previous modelling was based on estimated dimensions from available LIDAR and not from any available survey. This was found to overestimate the capacity of the structure. The structure width and height were reduced, and upstream and downstream invert levels were raised in line with the recent survey. Loss and roughness coefficients are unchanged.</td></tr>
<tr><td></td><td>2016 Maltby (mAOD)</td><td>Previous modelling (mAOD)</td><td>2020 EWR updated modelling (mAOD)</td></tr>
<tr><td>Upstream invert</td><td>Not surveyed</td><td>66.185</td><td>66.40</td></tr>
<tr><td>Downstream invert</td><td>Not surveyed</td><td>66.185</td><td>66.37</td></tr>
<tr><td>Width</td><td>Not surveyed</td><td>4.5</td><td>3.03</td></tr>
<tr><td>Height</td><td>Not surveyed</td><td>3.1</td><td>2.59</td></tr>
</table>

Downstream extension

Table 2-3: Modelling improvements - Extension of downstream reach

Cross sections:

The following updates were made to the extension in-channel domain:

- Manning's n values for the in-channel and immediate floodplain remain consistent with the upstream reach. Based on aerial imagery and survey photos, there is little change in channel/floodplain characteristics upstream and downstream of the original downstream boundary.
- Panel markers are added where there is a change in channel morphology and where there is a change in Manning's n.
- Left-right bank markers are added to each cross section to improve the plotting of cross sections in Flood Modeller.
- Channel cross-sections are trimmed to the extent of the deactivated 2D domain.
- Interpolates added between river sections so that node spacing is consistent with wider model.

Structures:

Two structures were added to the model downstream extension:

- LAU01_0605. Twin pipe structure beneath Blackthorn Road. Road culverts modelled as twin parallel orifice units due to difference in bed elevation either side of road to improve stability. Overtopping of structure was modelled in 1D, using a spill unit, with a lowered weir coefficient (0.8) to represent obstructions (railings and vegetation) across road.

- LAU01_0251. Farm access crossing at ‘The Field’. Crossing modelling as USBPR bridge unit with overtopping represented in 1D using a spill unit. Weir coefficient lowered to 0.8 to represent obstruction (railings, fence posts and vegetation) across bridge deck.

Long section:

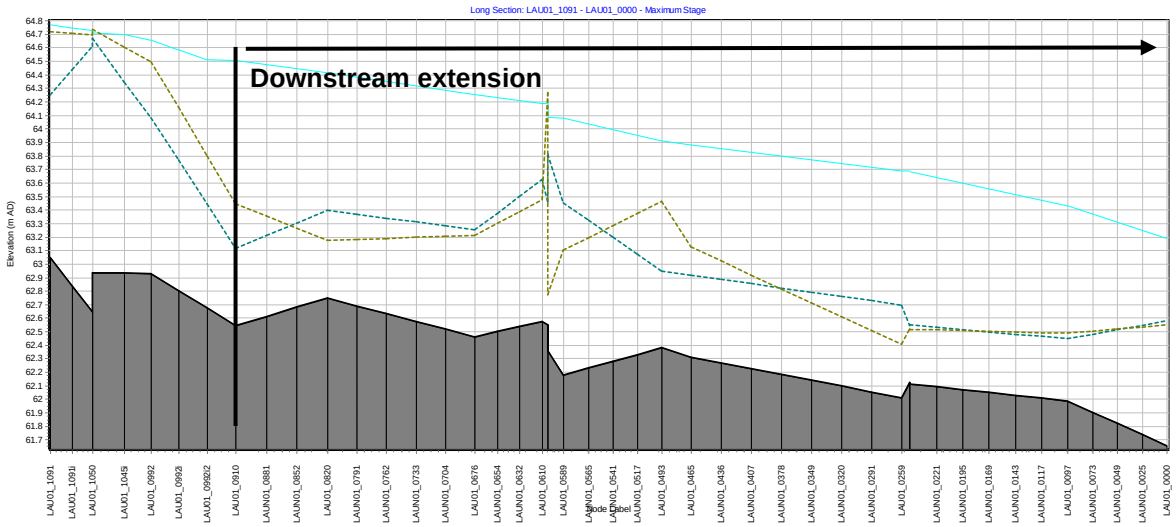


Figure 2-4 Downstream extension long section

The long section indicates that the downstream reach of the model continues at a similar gradient. However, the drop in bed level at the Blackthorn Road culvert is significant and results in a drop in water level across the structure, particularly at lower return periods.

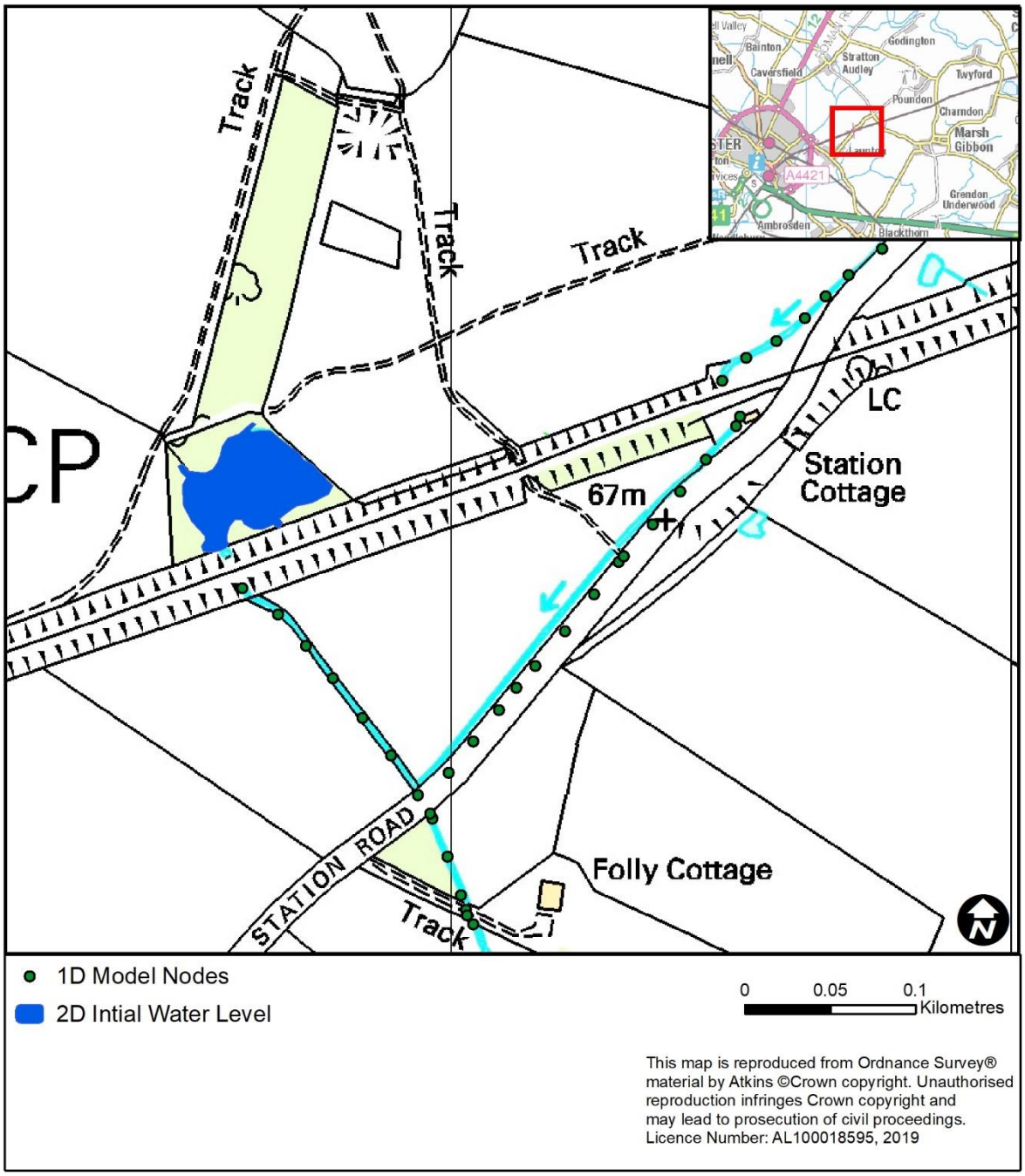
Boundaries:

- **1D**: The existing normal depth downstream boundary approach, using the bed gradient between the two upstream nodes, was retained.
- **2D**: The existing HQ 2D downstream boundary was moved and the gradient ('b' parameter) reduced to 0.002 (from 0.01) to reflect the shallower floodplain gradient at the new boundary.
- **1D-2D links**: The 2D domain was linked to the 1D using HX lines with bank top z-lines applied using the same approach as the existing model (as surveyed at 1D sections and interpolated between nodes). The 2D HX 'a' parameter was increased from the default "0" to reflect characteristics of the channel banks and energy losses expected at the interface between 1D (in-channel) and 2D (floodplain) flows as the water is forced to change direction and magnitude. Values are set globally to 0.2, to reflect naturally vegetated channel banks.

Initial Water Level

The IWL at the wetland/pond to the north of the railway line at the upstream extent of the surveyed Launton Brook, was initially modelled as 65.3mAOD. It was not clear from the WSP-PB model reporting why this value was chosen. The IWL was adjusted to 64.9mAOD to reflect the water level as surveyed in 2016. This value was checked and confirmed against the July 2020 survey.

Figure 2-5: Initial Water Level Location



Checks against survey

The original survey data has been checked against the sections, structures and spills to ensure they are represented correctly. Some minor changes have been made (description can be found in the .dat file comments) so that cross sections are representative of the channel reach based on the survey.

Manning's n roughness

The model roughness values were derived from the original model, as described in the 2016 report. With additional photographic information to confirm the approach, the roughness values were considered to be representative.

A +/-20% Manning's n sensitivity has been undertaken changing both floodplain and in-channel roughness values. The changes in 1D water level are shown below.

Table 2-4: Reported changes in water level based on changes in manning's n

	Minus 20% Manning's n (change in water level, m)	**Plus 20% Manning's n (change in water level, m)**
Average	-0.02	+0.02
Median	-0.03	+0.02

The Manning's values for the 2D model domain have been updated using Ordnance Survey MasterMap data in line with updating the model's resolution to 2m. Building representation has been updated following the Environment Agency review in line with recommended approaches.

What roughness values have been used?

Channel and floodplain roughness were represented within the model by using Manning's *n* values for roughness. Values were chosen with reference to standard values and using site visit photographs and judgement.

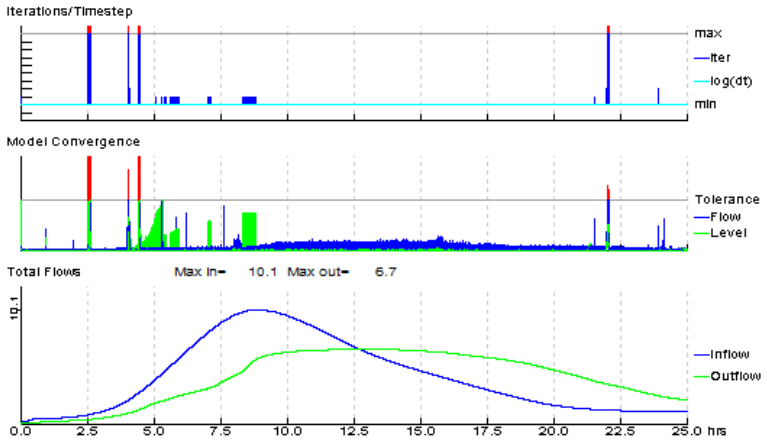
FMP	Manning's n or Colebrook-White k (mm)
Launton Brook in-channel	n = 0.045 (0.05 in overgrown areas)
Tributary in channel	n = 0.045 (0.05 in overgrown areas)
Channel edges/banks	n = 0.065 (0.07 in overgrown areas)
Concrete culverts	n= 0.013
Plastic pipes	n = 0.024
TUFLOW	**Manning's n**
Buildings	0.3
Inland water	0.035
Railway surfaces (natural and manmade)	0.035
Roads	0.02
General surface (natural)	0.05

Model performance

The figures below show the model performance plots.

Figure 2-6 Summary of model performance

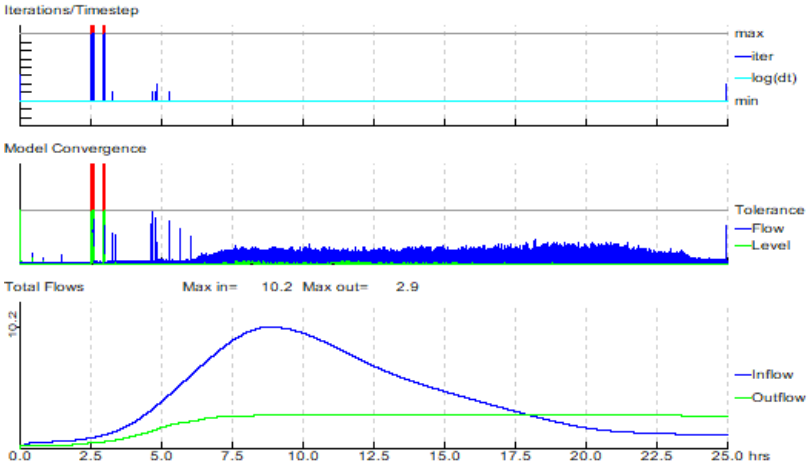
Previous model:



Datafile: ...\FMP\DAT\LAUN01_HARD_V33.DAT
Results: ...\FMP\RESULTS\LAUNTON_V33_B_Q0100CC70_FMP .zzl
Ran at 18:50:45 on 04/12/2016
Ended at 08:03:06 on 05/12/2016
Start Time: 0.000 hrs
End Time: 25.010 hrs
Timestep: 0.2 secs

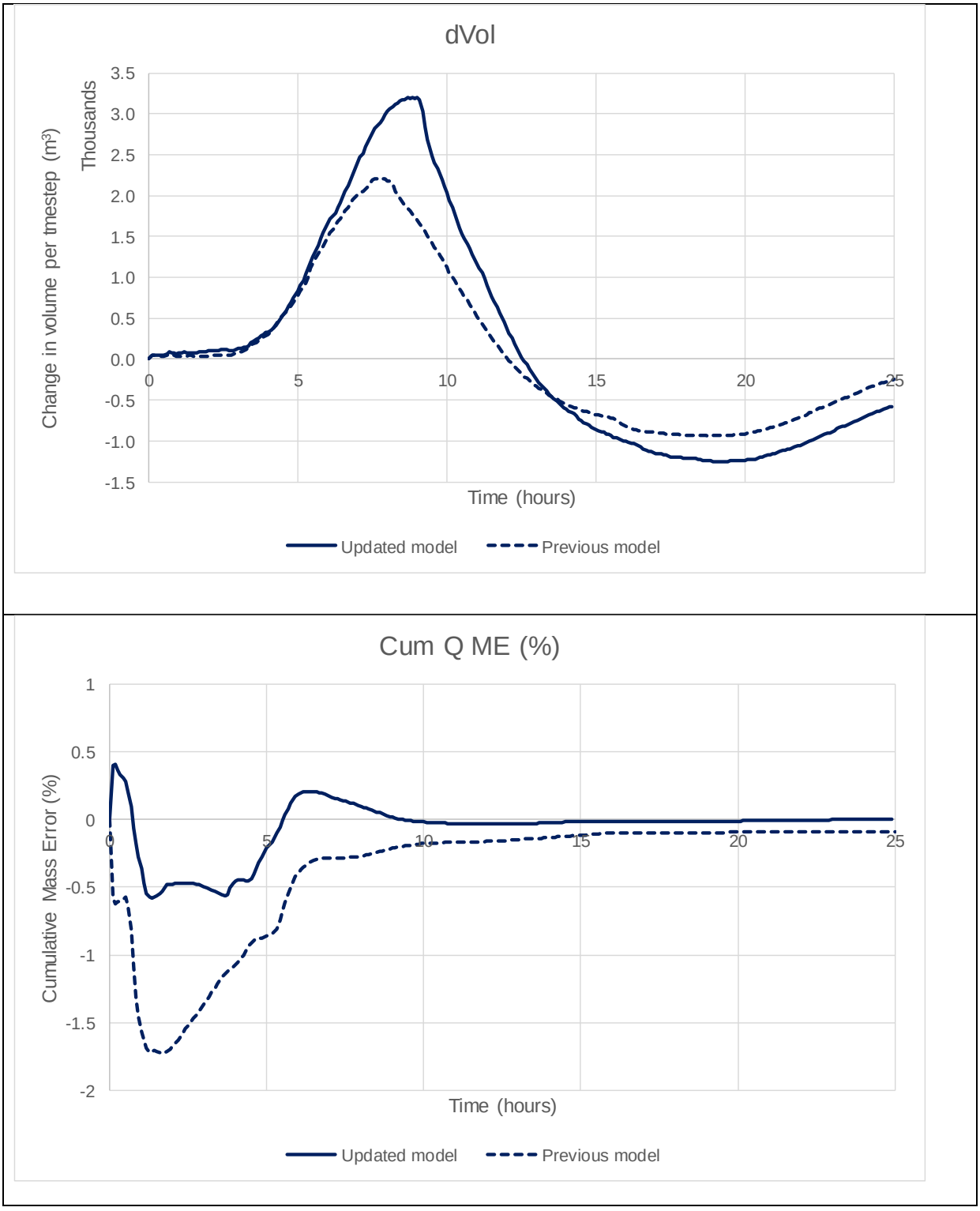
Current Model Time: 25.01 hrs
Percent Complete: 100 %

Updated model:



Datafile: ...\EAST_WEST_RAIL_FMP\DAT\LAUN_BL_003.DAT
Results: ...\ief\..\RESULTS\LAUNTON_BLN_Q0100CC70_V10.zzl
Ran at 22:44:49 on 08/08/2020
Ended at 12:28:10 on 09/08/2020
Start Time: 0.000 hrs
End Time: 25.000 hrs
Timestep: 0.5 secs

Current Model Time: 25.00 hrs
Percent Complete: 100 %



The figures above present a summary of model performance and stability:

- The Flood Modeller run summary indicates largely acceptable model convergence throughout the model run and smooth inflow and outflow hydrographs. Instances of non-convergence occur when the

soffit level of the access culvert adjacent to Station Road (TRI01_0184) is surcharged, there is a chance in mode at the unit and a rapid change in local water level.

- The dVol plot indicates a smooth transfer of water between the 1D and 2D domains.

The Cumulative Volume Mass Error plot indicates acceptable mass error (less than +/- 1%) for the duration of the model run. The plot also indicates an improvement compared to the previous model for Launton Brook, where the mass balance peak exceeded -1.5%.

3. Sensitivity testing

A range of sensitivity tests on the improved baseline model were undertaken to test the potential impact of uncertainties in the model; the table below lists out the sensitivity tests completed for the 1% annual chance event. These sensitivity tests were agreed with the Environment Agency.

These tests indicate minimal model sensitivity for the main areas of interest at the EWR2 crossings, embankment and overbridge to key model variables, demonstrating that the scheme designs (culvert liners, CFSA and river realignment) are robust.

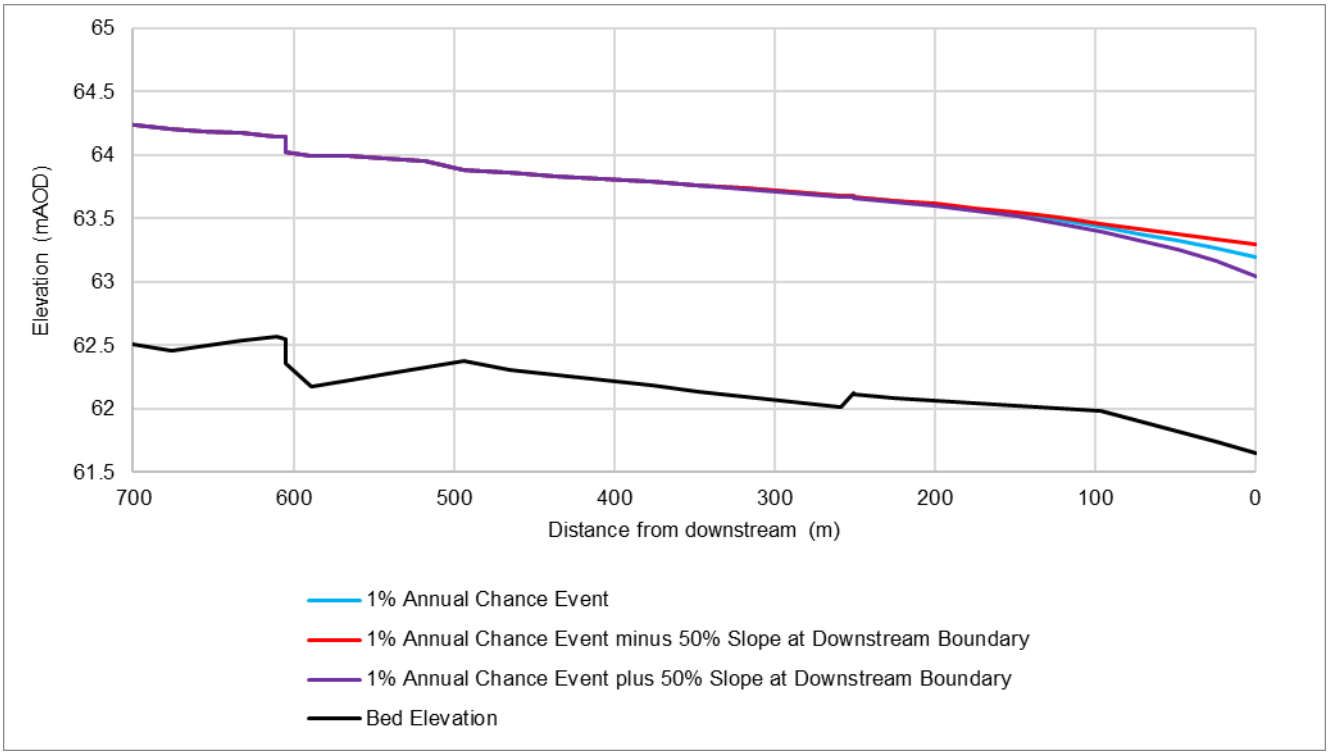
Table 3-1 Sensitivity Tests

Sensitivity Test Description	**Scenario name: (Launton_2m_~*s1*~_010.tcf)**
Downstream boundary +/- 50%	*PlusDS* | *MinusDS*
Flow +/- 20%	*PlusFlow* | *MinusFlow*
Manning's n +/- 20%	*PlusMannings* | *MinusMannings*
Blockage of key structures (50% blockage) at: • C170352 • C170660 • OXD35 (Castlemans Underbridge) • LAUN01_0605	*C170352BL* | *C170660BL* | *LAU0605BL* | *OXD35BL*
Pond arrangement, sensitivity to removal of iwl and raising to previously modelled level (~+0.3m)	*RaisedIWL* | *RemovedIWL*

Downstream boundary

Figure 3-1 below details the model sensitivity towards changes in downstream boundary slope (+/- 50%). These changes have been applied to the 1% annual chance event, and demonstrate minimal, localised impacts only, indicating only minor model sensitivity.

Figure 3-1 Sensitivity to changes in downstream boundary (+/-50%)



The 1D and 2D downstream boundary conditions, represented by a normal depth gradient, were adjusted by +/-50%. Figure 3-1 indicates that the sensitivity of the model to changes in downstream boundary is limited to the downstream 250m of the model. The upstream limit is approximately the location of the structure at 'The Fields'. There are localised changes in flooded area as a result of the change in downstream water level, however, is no reported increase in flood risk to any key receptors.

Flow

The figure below shows the model sensitivity to changes in flow (+/- 20%). These changes have been applied to the 1% annual chance event.

Figure 3-2 Sensitivity to changes in flow (+/-20%)

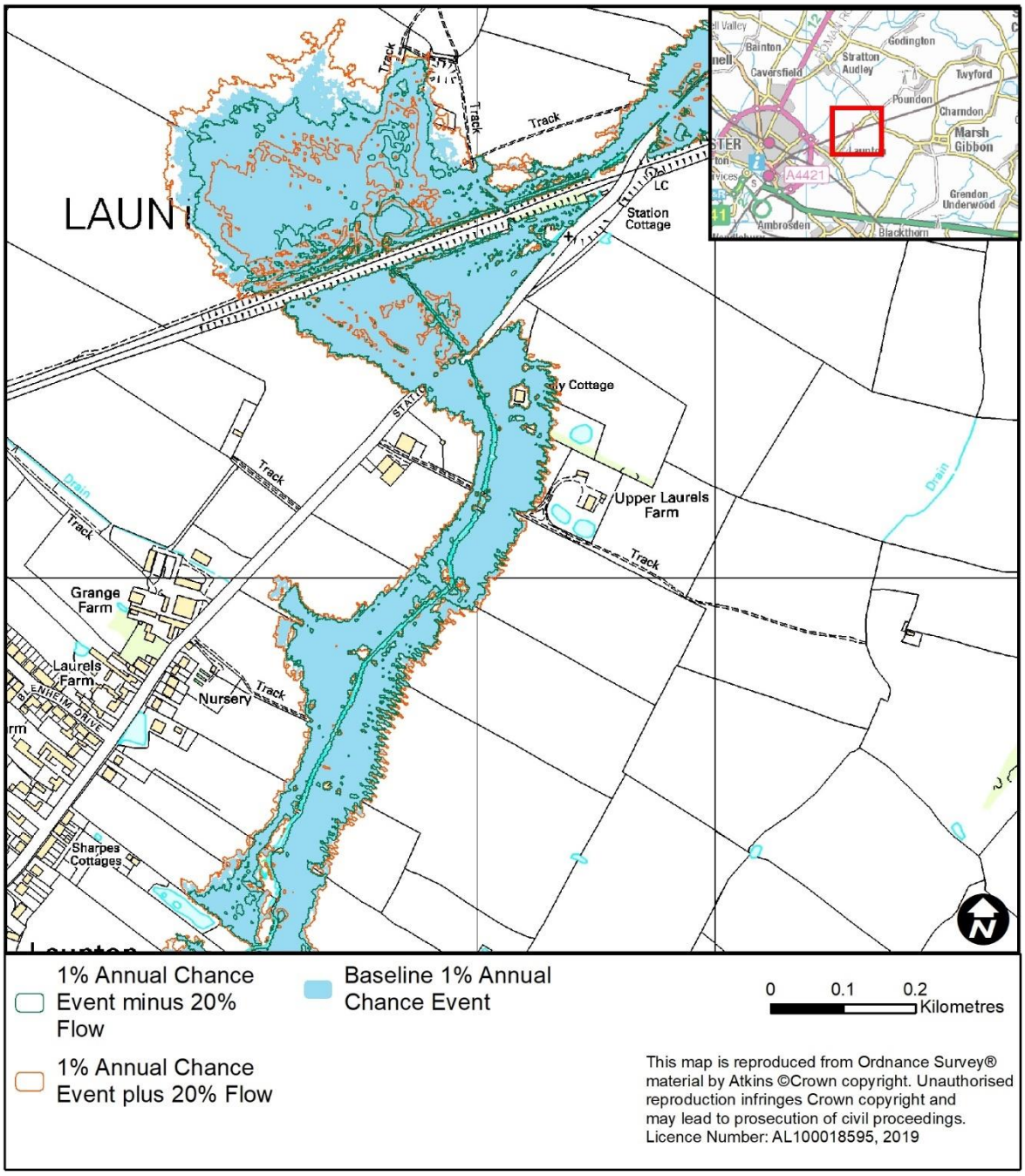


Table 3-2: Reported changes in water level based on changes in flow

	Minus 20% Flow (change in water level, m)	Plus 20% Flow (change in water level, m)
Average	-0.03	+0.02
Median	-0.03	+0.02

The model demonstrates that results are sensitive to flow in the pond area upstream of the railway embankment near structure C170660. This area of the catchment is flat and the capacity of C170660 is exceeded at the 1% annual chance event, which causes water to accumulate behind the embankment, levels to rise and the overall flood extent to increase. Elsewhere, the model results indicate an average change in 1D water level of less than 0.03m with increase/decrease in flow. This results in isolated changes in flood extents within unoccupied, rural grassland but no change in the level of risk posed to property.

Manning's n

The figure below shows the model sensitivity to changes in Mannings roughness (+/- 20%). These changes have been applied to the 1% annual chance event.

Figure 3-3 Sensitivity to changes in Manning's n (+/-20%)

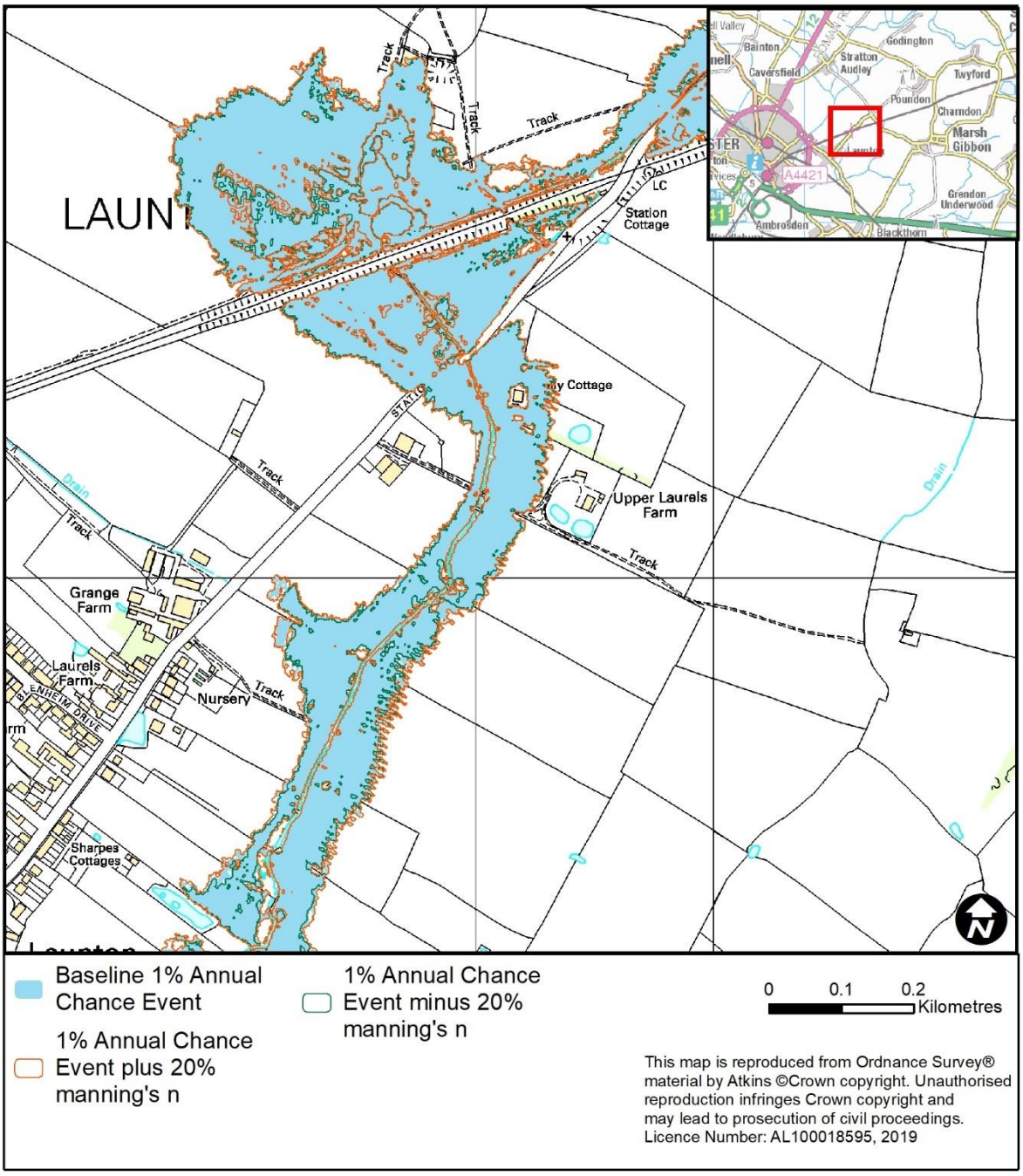


Table 3-3: Reported changes in water level based on changes in manning's n

	Minus 20% Manning's n (change in water level, m)	Plus 20% Manning's n (change in water level, m)
Average	-0.02	+0.02
Median	-0.03	+0.02

The model indicates relatively low sensitivity to changes in Manning's n. The average change in 1D water level is less than 0.03m. This results in isolated changes in flood extents within unoccupied, rural grassland but no change in the level of risk posed to property.

Structure blockage (50%)

The figure below shows the model sensitivity to blockage of key structures by 50% of culverts C170660 and C170352. These changes have been applied to the 1% annual chance event.

Figure 3-4 Sensitivity to 50% blockage at C170352

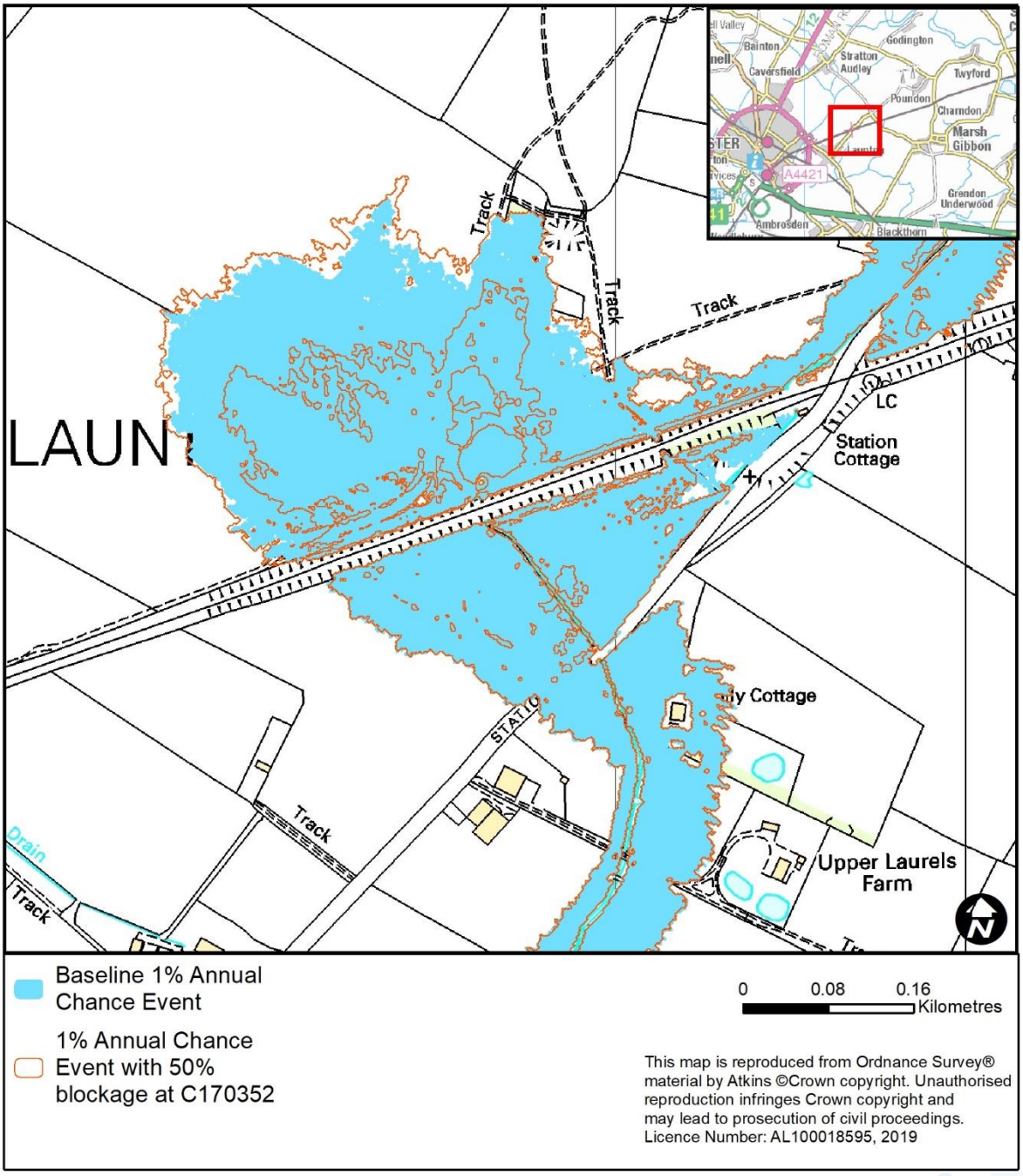


Table 3-4: Reported model result changes based on 50% blockage applied at key structures

C170352 **(Tributary: TRI01_0315, FM)**	Blockage at C170352 causes an increase in flood extent upstream of the railway embankment. By blocking the culvert at the tributary, a greater volume of water is forced into this lowland area. Small changes are also observed further upstream, adjacent to the Launton Brook tributary. More water is held in the floodplains adjacent to the watercourse as the blockage causes water to spill out of bank locally, but the impact is minimal. Small changes are also seen downstream of the railway, as the volume of water discharging through C170352 is reduced. However, any changes are isolated and occur within unoccupied, rural grassland and no change in the level of risk posed to property.
C170660 **(Launton Brook: RailTunn1, ESTRY)**	Blockage at the Launton Brook culvert C170660 results in raising of water levels upstream of the railway embankment and an increase in flooded area adjacent to the Launton Brook tributary. The extent of the change is less significant than a blockage at C170352, because water in this area can still discharge by OXD35 and there isn't the additional volume of water from the tributary watercourse. Small changes are also seen downstream of the railway, as the volume of water discharging through C170660 is reduced. However, any changes are minor and isolated within unoccupied, rural grassland but no change in the level of risk posed to property.
OXD35 (Castlemans Underbridge) **(underpass, ESTRY)**	Blockage at the underbridge OXD35 inhibits the drainage from the upstream side of EWR2 and results in an increase in flooded area upstream of the railway embankment within the area containing the pond, and adjacent to the Launton Brook tributary. The impacts are similar to blockage at C170352, but much less significant. Water can still discharge via C170660. Any changes in flood extents are minor and located within unoccupied, rural grassland. There is no change in the level of risk posed to property.
LAUN01_0605 **(Blackthorn Road, FM)**	Blockage at Blackthorn Road results in water spilling out of bank of Launton Brook earlier within the reach immediately (<100m) upstream, particularly on the right bank. Further (up to 250m) upstream, although the point at which water spills out of bank is roughly the same compared to the baseline, water levels rise faster, causing greater volume of water to spill out of bank earlier. However, due to the flat open floodplains and water easily/frequently spilling out of bank in this location, the difference in maximum water level at the structure compared to the baseline is just +0.08m and the overall increase in flooded area is minor and restricted to unoccupied land and doesn't affect the onset of flooding to property.

Pond arrangement

The model indicates some sensitivity to changing the IWL at the wetland/pond upstream of the Launton Brook railway culvert (C170660). By removing the IWL, flooded area upstream of the railway is reduced. Flooded area upstream of the railway is increased with raising the IWL. However, any changes are negligible and isolated to individual pixels on the extremes of the modelled flood extents. Similar differences are also seen downstream of the railway. Any change in depth upstream of the railway are less than 0.01m, or outside of the recommended accuracy of the model.

Summary

Table 3-5 summarises the peak water level between the baseline condition and various sensitivity tests at key areas of interest along the EWR2 route. The results indicate almost no impacts across these key locations, with changes in design flow having the most effect on peak water levels. Blockage tests

indicate only a localised impact. These results demonstrate the robustness in both the model and designs for the EWR2 scheme.

Table 3-5 Sensitivity test results comparisons

Scenario	1% annual chance event Peak Water Level (mAOD)			
	EWR2 CFSA (TRI01_0507)	Upstream of EWR2 embankment at C170660	Upstream of EWR2 embankment (TRI01_0315)	Station Road, downstream of EWR2 (LAU01_1903)
Baseline	67.50	66.36	67.12	66.05
Roughness +20%	67.52	66.37	67.12	66.07
Roughness -20%	67.48	66.34	67.12	66.03
Design flow +20%	67.53	66.47	67.15	66.08
Design flow -20%	67.47	66.24	67.08	66.02
Downstream boundary +50%	67.50	66.36	67.12	66.05
Downstream boundary -50%	67.50	66.36	67.12	66.05
C170352 blockage	67.50	66.44	67.17	66.04
C170660 blockage	67.50	66.36	67.12	66.05
OXD35 (Castlemans Underbridge) blockage	67.50	66.37	67.12	66.05
LAUN01_0605 blockage	67.50	66.36	67.12	66.05
Removed IWL	67.50	66.36	67.12	66.05
Raised IWL	67.50	66.36	67.12	66.05

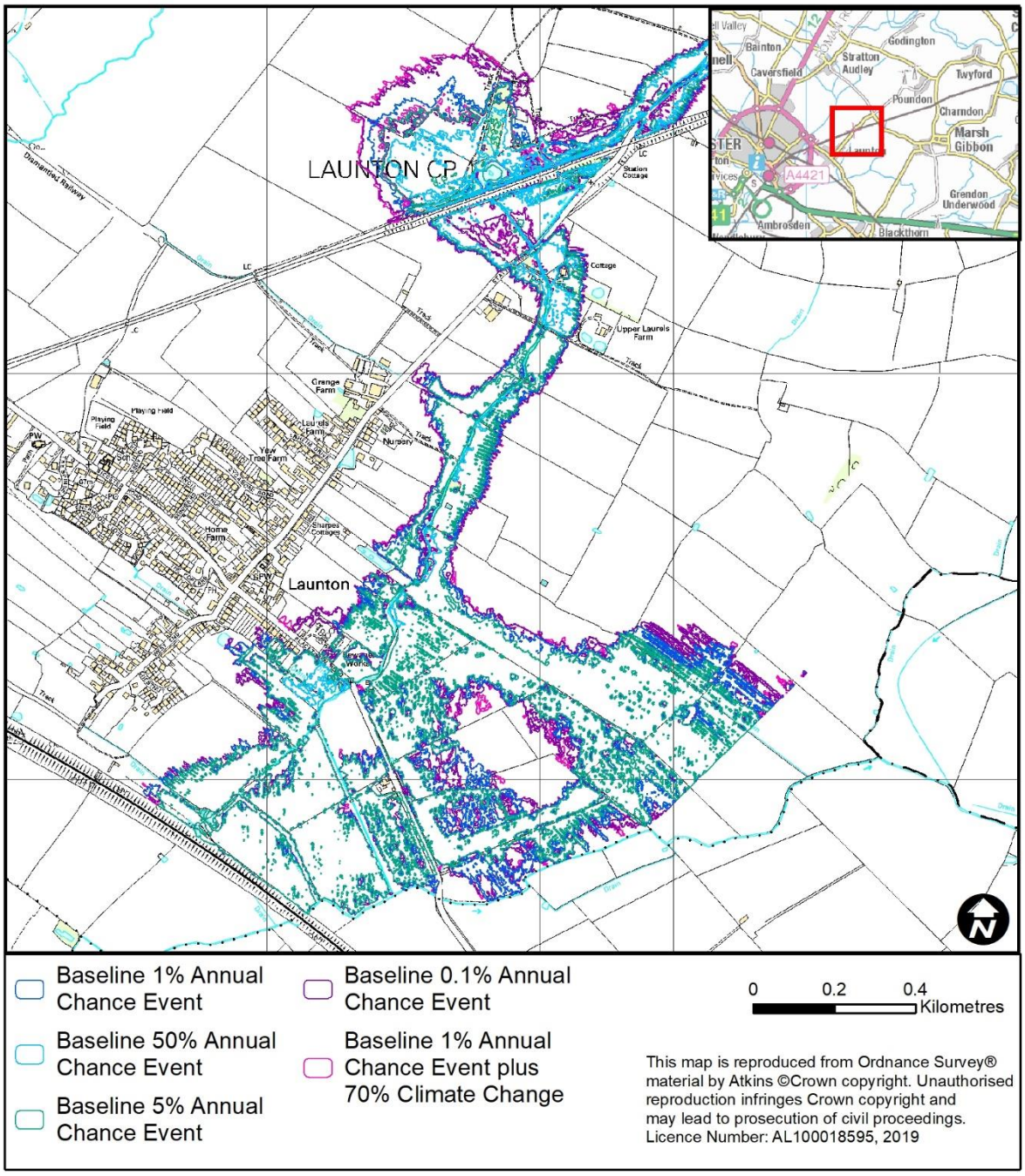
4. Comparison of results and scenarios

WSP-PB Baseline (2016) and Updated Baseline (2020)

There are minor differences shown between the 2016 WSP-PB model and 2020 updated model, however these are primarily due to the adoption of the new EWR2 LiDAR and extension of the downstream reach made as part of the model improvements. The general trends remain broadly consistent with the previous model, although absolute levels have increased slightly over the previous baseline, due in part to a more robust representation of the EWR2 railway embankment in the baseline model. This representation utilises recently commissioned EWR2 survey data in addition to the LiDAR data used in previous model versions.

This section compares the 2016 model outputs and the 2020 updated baseline model results. Figure 4-1 details the modelled flood extents for each of the annual chance events (50% to 0.1%).

Figure 4-1 Updated baseline flood outlines



The Launton Brook model indicates that land upstream and downstream of the EWR crossing is susceptible to frequent flooding; at a return period of less than two years. This is driven by exceedance of the structure capacity at C170352 and transfer of water between natural catchments on the northern side of the EWR crossing. This forces more water through C170660 and OXD35. Downstream of Station Road, at the 50% annual chance event, flood water re-enters the channel. Isolated and small areas of flooding are observed further downstream where immediate floodplain levels are lower and channel banks are less well defined.

The model also indicates that large areas of the downstream floodplain are at risk from a flood event less than the 5% annual chance event, driven by the natural south-easterly flow routes in the floodplain. Flood depths are shallow (<0.15-0.20m) and there are no properties affected. However, flooding is observed at the 5% annual chance design event to gardens of properties adjacent to Blackthorn Road.

The updated flood extents were compared against the previous modelling undertaken by WSP-PB in 2016. The flood extents adjacent to the EWR crossing are largely similar for both the 5% and 1% annual chance events. Improvements to the ground model, by adopting the high resolution (0.2m) EWR LiDAR, in this area resulted in small localised changes in flooded area. Downstream of Station Road, there are areas where the flood extents, particularly at the 5% annual chance event, are notably different. This is due to changes in the downstream boundary and inclusion of the structure at Blackthorn Road. This structure causes a backwater effect that raises upstream water levels and creates a shallower water surface longitudinal profile compared to the WSP-PB model. The relative effect of this change is more significant at lower return periods. A sensitivity of 50% blockage at the 1% annual chance event at the structure indicated that the backwater effect is broadly localised (no more than 300m upstream) of the structure. A projection of the backwater effect at the lower order events can be undertaken using the top of banks and top of road levels, providing a very conservative indication of the potential extents of this backwater effect. Even with this conservative approach, the extent of the backwater effect does not reach the proposed EWR2 works.

Figure 4-2 and Figure 4-3 compare the flood extents between the existing 2016 WSP-PB model and the improved 2020 EWR model, for the 5% and 1% annual chance events.

Figure 4-2 Comparison between 2016 and 2020 baseline outlines (5% Annual Chance Event)

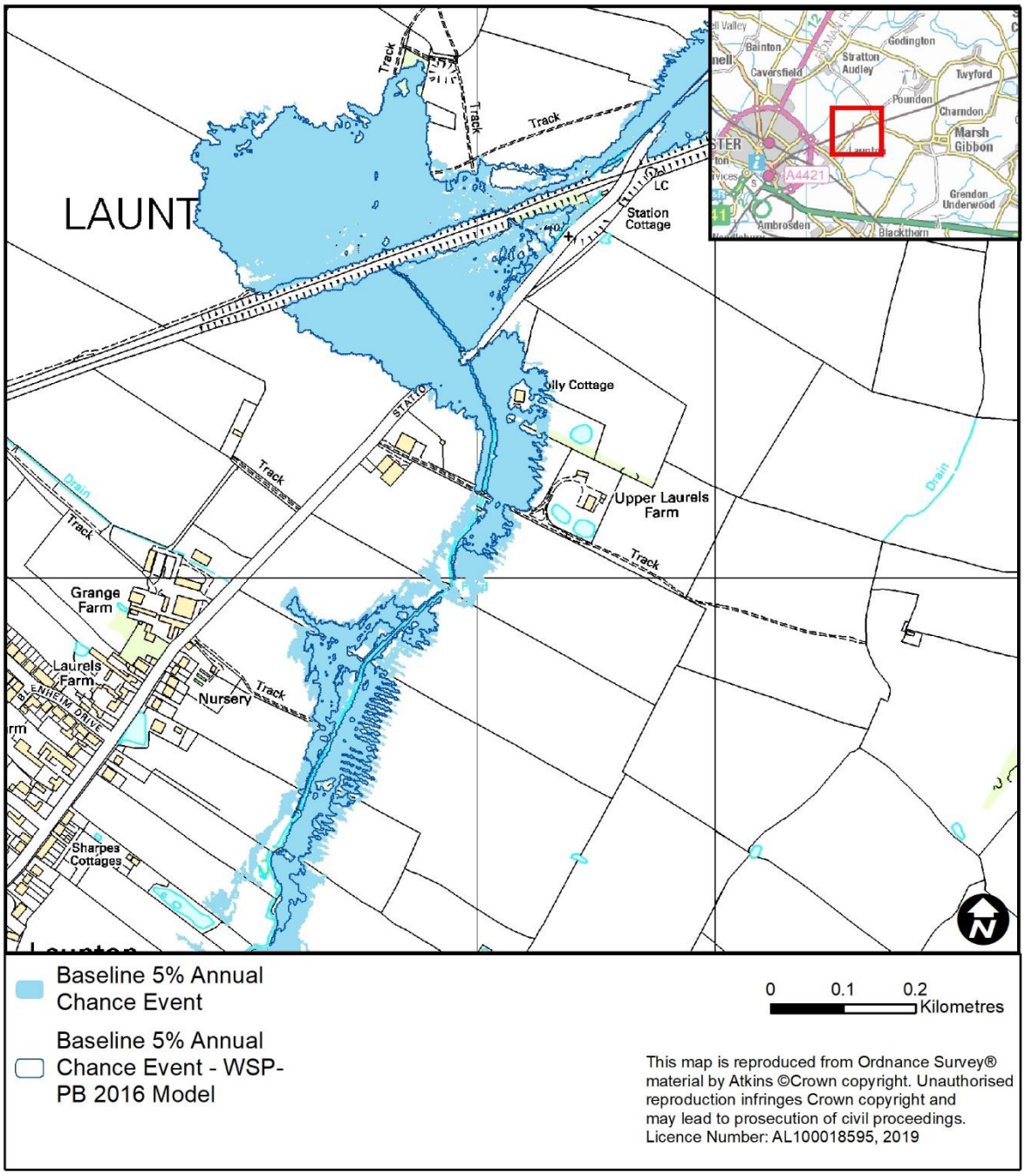
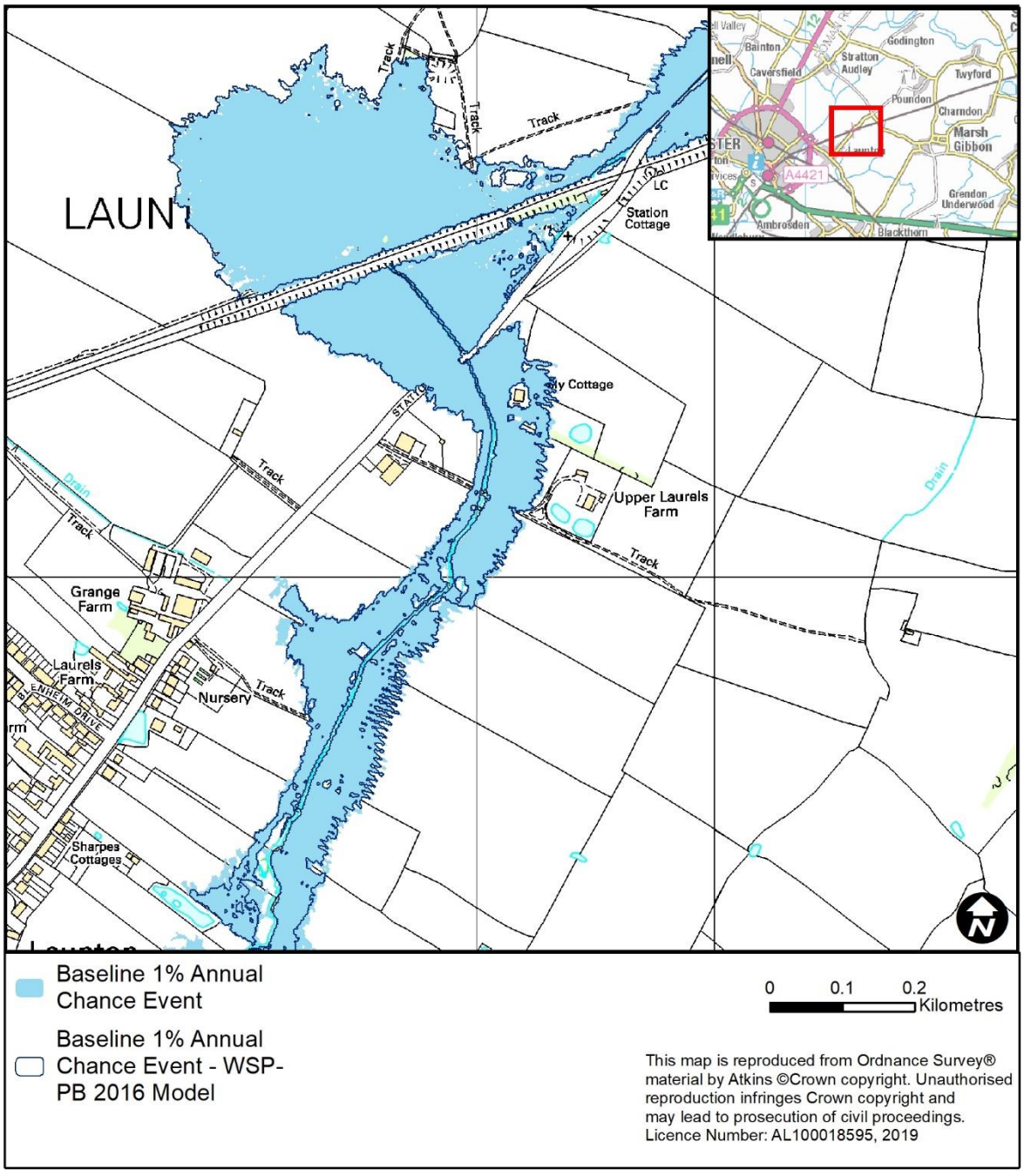


Figure 4-3 Comparison between 2016 and 2020 baseline outlines (1% Annual Chance Event)



The table below compares the differences in peak water levels at key assessment locations for the 1% annual chance event between the WSP/PB (2016) baseline model, and the improved EWR2 (2020) baseline model. The key assessment point locations are shown in Figure 3-3 of the Main Report.

Table 4-1 Comparison of peak water levels between WSP/PB baseline model and updated baseline (1% annual chance event)

Assessment Point	Location Description	1% annual chance event Peak Water Level WSP-PB Baseline (m AOD)	1% annual chance event Peak Water Level Updated Baseline (m AOD)	Difference (m)
1	South of Field Farm.	68.66	68.68	0.02
2	Approximately 200m north east of Station Rd overbridge.	67.49	67.55	0.06
3	Approximately 150m north east of Station Rd overbridge.	67.45	67.51	0.06
4	Approximately 120m north east of Station Rd overbridge.	67.41	67.49	0.08
5	60m north west of the pond, to the west of Station Rd overbridge.	66.39	66.48	0.09
6	Upstream of culvert C170352.	66.79	66.81	0.02
7	Upstream of the underpass beneath the railway line.	66.45	66.54	0.09
8	Upstream of culvert C170660.	66.40	66.48	0.08
9	Downstream of C170352 and the underpass beneath the railway line.	66.47	66.48	0.01
10	Station Road.	66.06	66.07	0.01
11	Approximately 20m west of Folly Cottage.	65.99	66.00	0.01
12	Approximately 70m west of Upper Laurels Farm.	65.89	65.91	0.02
13	Approximately 200m south east of Green Close Nursery.	64.99	65.00	0.01

The table below compares the differences in peak water levels at key assessment locations for the 20% annual chance event between the WSP/PB (2016) baseline model, and the improved EWR (2020) baseline model.

Table 4-2 Comparison of peak water levels between WSP/PB baseline model and updated baseline (20% annual chance event)

Assessment Point	Location Description	20% annual chance event Peak Water Level WSP-PB Baseline (m AOD)	20% annual chance event Peak Water Level Updated Baseline (m AOD)	Difference (m)
1	South of Field Farm.	68.57	68.60	0.03
2	Approximately 200m north east of Station Rd overbridge.	67.43	67.47	0.04
3	Approximately 150m north east of Station Rd overbridge.	67.40	67.45	0.05
4	Approximately 120m north east of Station Rd overbridge.	67.35	67.43	0.08

Assessment Point	Location Description	20% annual chance event Peak Water Level WSP-PB Baseline (m AOD)	20% annual chance event Peak Water Level Updated Baseline (m AOD)	Difference (m)
5	60m north west of the pond, to the west of Station Rd overbridge.	66.20	66.23	0.03
6	Upstream of culvert C170352.	66.97	67.08	0.11
7	Upstream of the underpass beneath the railway line.	66.41	66.48	0.07
8	Upstream of culvert C170660.	66.20	66.20	0.00
9	Downstream of C170352 and the underpass beneath the railway line.	66.45	66.56	0.11
10	Station Road.	66.01	66.05	0.04
11	Approximately 20m west of Folly Cottage.	65.94	65.98	0.04
12	Approximately 70m west of Upper Laurels Farm.	65.82	65.88	0.06
13	Approximately 200m south east of Green Close Nursery.	64.90	64.95	0.05

These tables demonstrate that the improved 2020 model is predicting higher water levels than the 2016 model and is thus a precautionary assessment of flood risk.

With Scheme

Representation in the Hydraulic Model

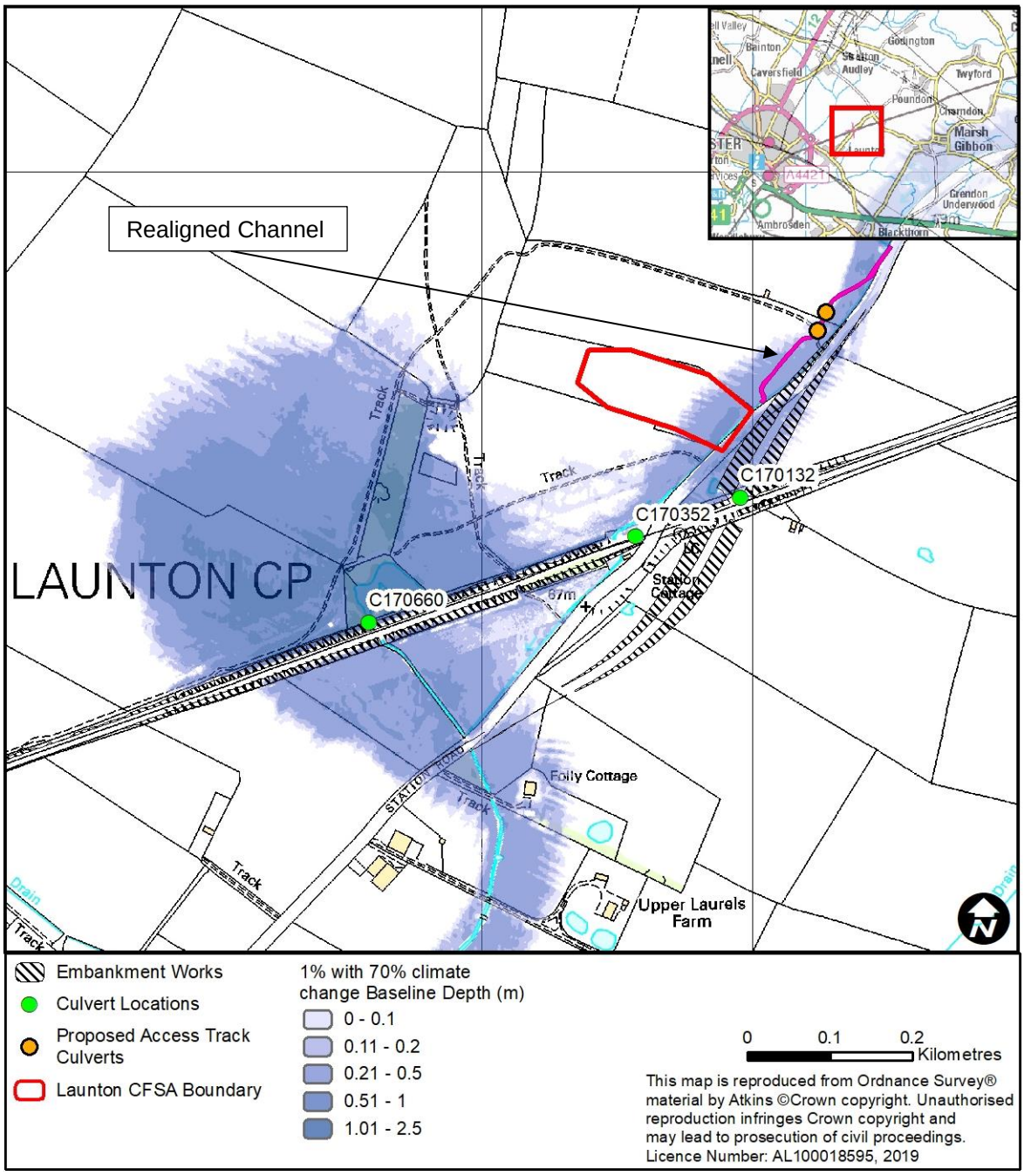
The With Scheme model was used to assess the potential impacts of the proposed works for a range of return period events. The figure below shows the location of the proposed works. Peak water levels were extracted from the model for all assessment points for comparison to the baseline model runs to understand any impact of The Project on flood risk. The With Scheme model was updated with the following changes:

- A new overbridge, OXD34A to the east of the existing overbridge has been added to the Digital Terrain Model (DTM) based on the detailed earthworks design, the road alignment to the north of the railway embankment has been modified to tie in with the new overbridge alignment;
- The model DTM has been modified to include the detailed earthworks design for the railway embankment;
- Culvert C170352 that conveys the Launton Brook beneath the rail embankment adjacent to Station Road is proposed to be rehabilitated with the model amended to represent a 30mm thick liner through the existing arch culvert with invert levels amended accordingly;
- Culvert C170660 is also to be rehabilitated with the model amended to represent the addition of a 50mm thick liner whilst retaining the existing brick arch geometry;
- The Launton Brook river realignment, associated with the proposed overbridge, was included in the 1D and 2D network. The new proposed cross sections were added to the Flood Modeller 1D component, and the spatial re-alignment of the river was altered moving the watercourse slightly to the northwest and lengthing the channel by approximately 15m. The realignment includes two new field access culverts, the sizes of which were based on the existing structures. The upstream 0.6m diameter circular culvert has been replaced with a depressed invert box culvert 1m x 0.65m in order

to tie in with the proposed earthworks and approximately match conveyance, whilst retaining scheme bulidability. 10m downstream the existing 0.25m diameter culvert has been replaced by a 1.2m x 0.6m box culvert, whilst this is larger than the previous culvert it was considered necessary due to blockage risk and buildability issues. Invert levels for both new culverts have been kept in line with the realigned channel gradient;

- A bund with a length of 60m and a crest level of 68.6mAOD has been included to prevent flooding of the eastern side of the overbridge embankment. This bund is over-represented in the model in order to determine its requirements and only approximately 25m of it to a height of 0.35m would be required in a 1% annual chance event with 70% climate change; and
- The CFSA was designed based upon the combined level area relationship described in Section 3 of the Main Report. The existing ground levels across the entire GRIP4 CFSA site were reviewed and the extent further refined, ensuring the CFSA falls outside of existing floodplains but connecting back into the floodplain area to allow flood water to flow from the watercourse freely into the CFSA, and back into the watercourse following the event. This will enable the CFSA to operate without the need for control structures. The CFSA at GRIP5 was represented in the With Scheme hydraulic model by adjusting the DTM.

Figure 4-4 With Scheme Model changes



Results

The peak water levels for the 1% annual chance event (including an allowance for climate change) are presented below for key assessment points for the With Scheme scenario. The key assessment point locations are shown in Figure 3-3 of the Main Report.

Table 4-3 With Scheme Peak Water Levels

No.	Location Description	Peak Water Level (mAOD)			
		Annual Chance Events			
		50%	1%	1%+70%	0.1%
1	South of Field Farm.	68.53	68.67	68.76	68.75
2	Approximately 200m north east of Station Rd overbridge.	67.38	67.53	67.63	67.61
3	Approximately 150m north east of Station Rd overbridge.	67.33	67.50	67.60	67.59
4	Approximately 120m north east of Station Rd overbridge.	67.32	67.49	67.59	67.58
5	60m north west of the pond, to the west of Station Rd overbridge.	66.47	66.79	66.95	66.94
6	Upstream of culvert C170352.	65.98	66.45	66.82	66.76
7	Upstream of the underpass beneath the railway line.	66.42	66.54	66.82	66.76
8	Upstream of culvert C170660.	No Flooding	66.49	66.52	66.50
9	Downstream of C170352 and the underpass beneath the railway line.	65.98	66.45	66.82	66.76
10	Station Road.	65.96	66.09	66.15	66.14
11	Approximately 20m west of Folly Cottage.	65.81	66.01	66.08	66.07
12	Approximately 70m west of Upper Laurels Farm.	No Flooding	65.91	65.97	65.96
13	Approximately 200m south east of Green Close Nursery.	No Flooding	65.01	65.09	65.07
14	Approximately 150m south east of Sharpes Cottages.	No Flooding	64.60	64.70	64.68

The following table compares the differences in peak water levels between the Baseline and With Scheme scenarios. The differences are minimal, with the majority of locations showing no change or an increase of 0.01m. The maximum decrease is 0.04m at assessment points 6, 7 and 9, and the maximum increase is 0.02m at assessment points 8 and 10, suggesting the proposed scheme does not significantly impact on flood risk. No additional receptors are shown to be at flood risk.

Table 4-4 Differences between Baseline and With Scheme model results

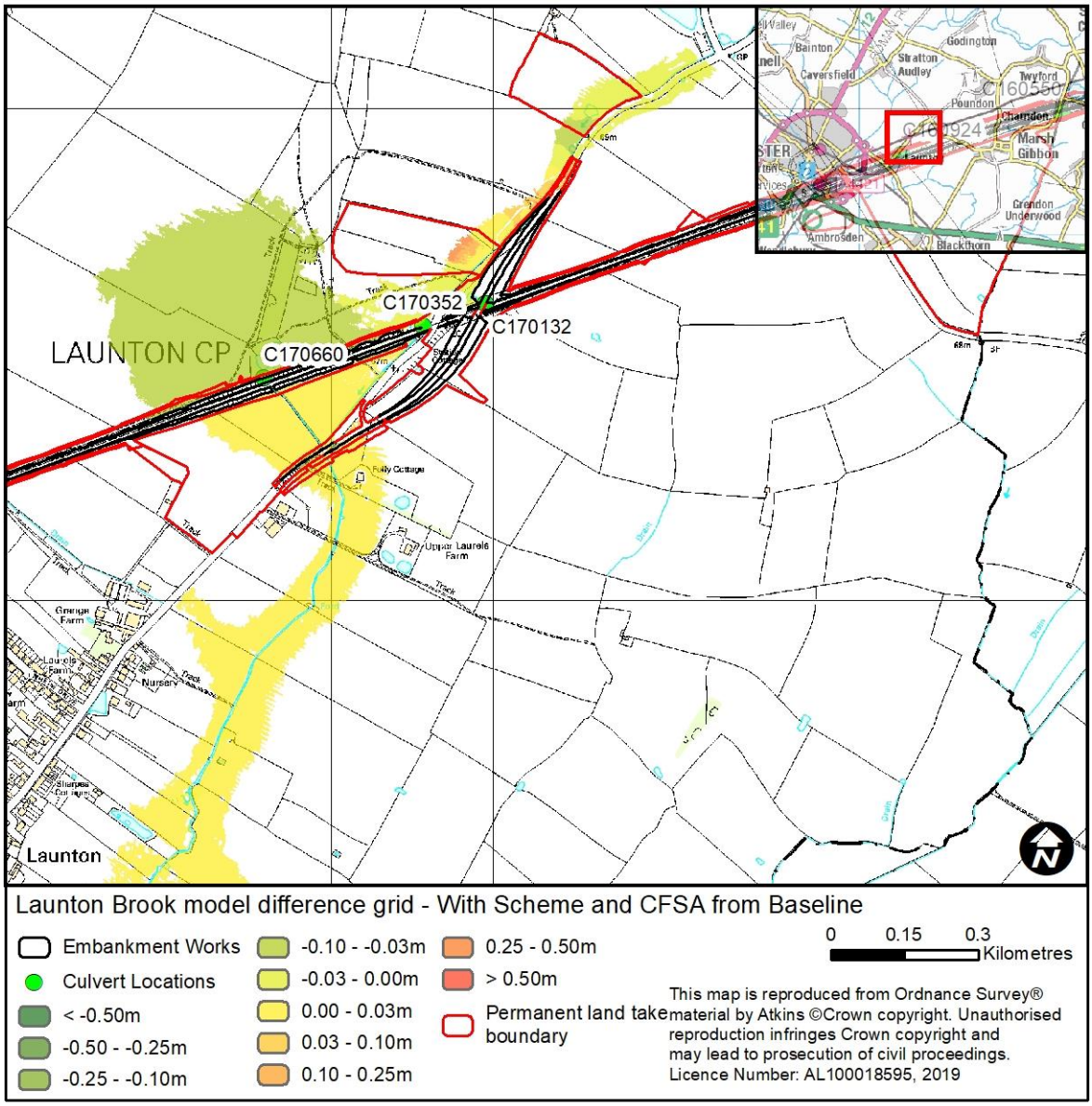
No.	Location Description	Difference in Peak Water Level (m)			
		Annual Chance Events			
		50%	1%	1%+70%	0.1%
1	South of Field Farm.	0.00	-0.01	0.00	0.00
2	Approximately 200m north east of Station Rd overbridge.	-0.02	-0.02	0.00	0.00
3	Approximately 150m north east of Station Rd overbridge.	-0.01	0.00	0.00	0.00
4	Approximately 120m north east of Station Rd overbridge.	-0.01	0.00	0.00	0.00
5	60m north west of the pond, to the west of Station Rd overbridge.	-0.02	-0.02	0.00	0.00
6	Upstream of culvert C170352.	0.00	-0.03	-0.04	-0.04
7	Upstream of the underpass beneath the railway line.	-0.02	0.00	-0.03	-0.04
8	Upstream of culvert C170660.	0.00	0.00	0.02	0.01
9	Downstream of C170352 and the underpass beneath the railway line.	0.00	-0.03	-0.04	-0.04
10	Station Road.	0.01	0.02	0.00	0.00
11	Approximately 20m west of Folly Cottage.	-0.04	0.00	0.01	0.01
12	Approximately 70m west of Upper Laurels Farm.	0.00	0.00	0.01	0.01
13	Approximately 200m south east of Green Close Nursery.	0.00	0.00	0.00	0.01
14	Approximately 150m south east of Sharpes Cottages.	0.00	0.00	0.01	0.01

The peak water level differences between the Baseline and With Scheme including the CFSA can be seen in the figure below, and shows the difference across the modelled reach and shows depth increases in the proposed CFSA and adjacent the new highway overbridge, with increases downstream of EWR2 limited to <0.03m outside of the redline boundary, and up to 0.2m within an isolated area restricted to where earthworks for the new access tracks will change ground levels at the channel realignment.

The increases of up to 0.03m at the 1% annual chance event (including 70% climate change allowance) occur on agricultural land, no properties are at increased flood risk. As can be seen from Table 4-4 the changes in peak water levels at the assessment points across the range of annual chance events is typically no change or +0.01m. It should be noted that differences between the 2016 (WSP-PB) and

2020 baseline models are generally greater than those between the 2020 baseline and With Scheme model.

Figure 4-5 Flood level difference for the 1% (+70% climate change) annual chance event



The following figures compare flow hydrographs at two locations, the first 70m downstream of Station Road near assessment point 11, and the second at assessment point 13, adjacent to Launton Village. The hydrographs demonstrate that the hydrograph shapes are consistent between the Baseline and With Scheme, with limited increases in peak flows at the 1% annual chance and 1% annual chance plus climate change events but decreases at the 50% annual chance event.

Figure 4-6 Comparison of flow hydrographs between Baseline and With Scheme – at assessment point 11

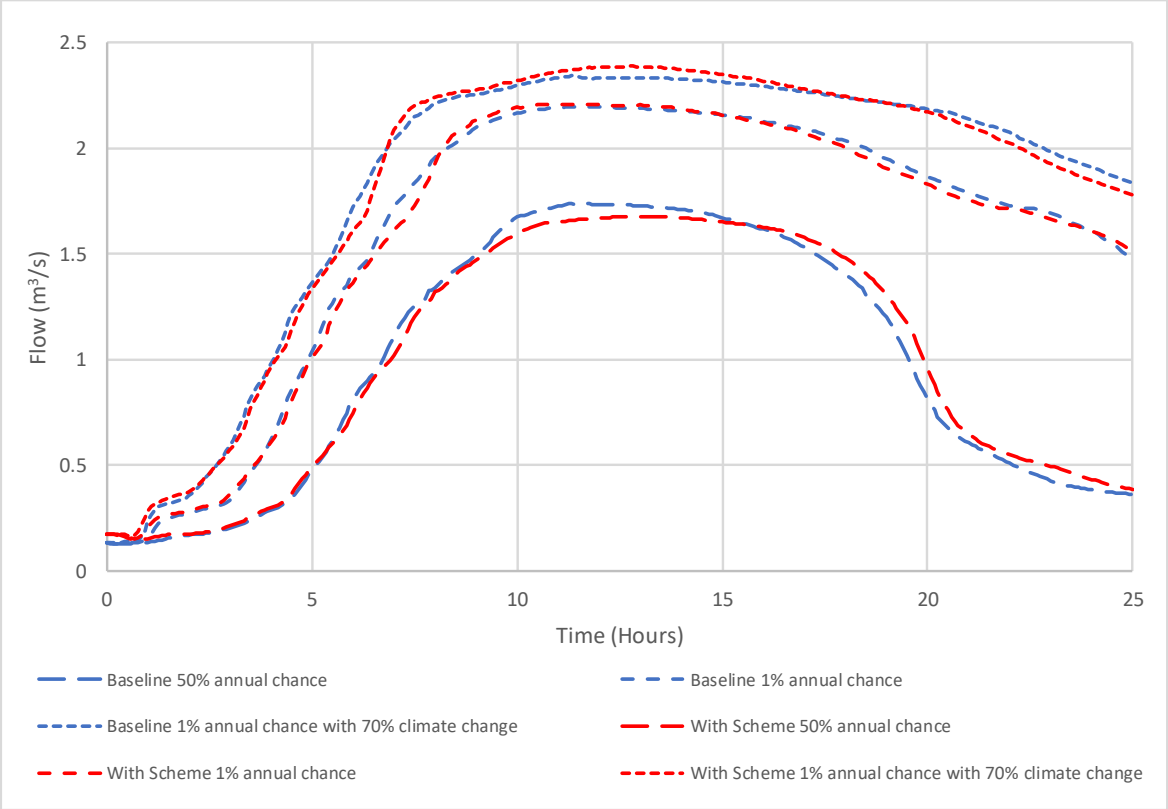
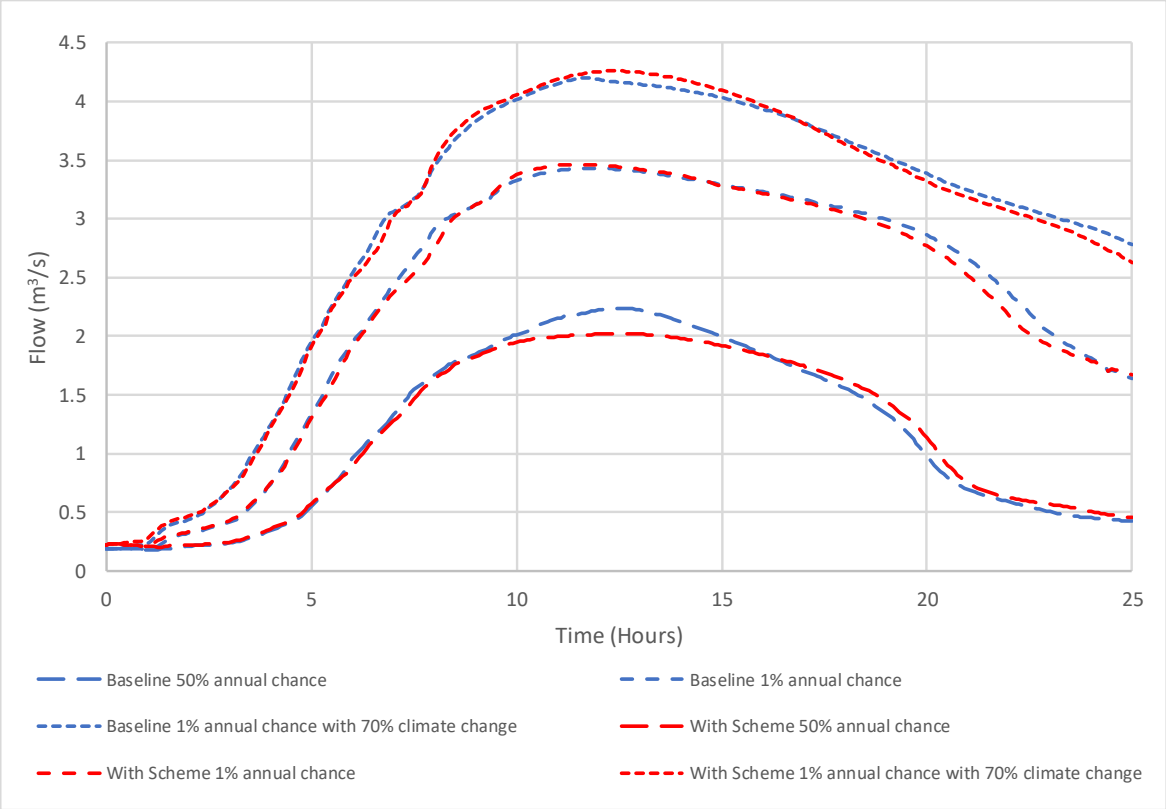


Figure 4-7 Comparison of flow hydrographs between Baseline and With Scheme at assessment Point 13, adjacent to Launton Village



The table below compares the baseline and With Scheme peak flows at the assessment points; this list is reduced from that above as it includes only 1D channel cross sections. The results reflect the scale of change seen in the peak water levels described previously.

Table 4-5: Comparison of Baseline and With Scheme Peak Flows

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	South of Field Farm.	0.69	0.71	0.69	0.71	1.26	1.24
2	Approximately 200m north east of Station Rd overbridge.	0.49	0.58	0.72	0.72	0.81	0.89
3	Approximately 150m north east of Station Rd overbridge.	0.44	0.32	0.79	0.58	0.82	0.69
4	Approximately 120m north east of	0.32	0.32	0.32	0.32	0.32	0.32

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
	Station Rd overbridge.						
6	Upstream of culvert C170352.	1.18	1.19	1.58	1.65	1.74	1.83
9	Downstream of C170352 and the underpass beneath the railway line.	0.93	0.94	1.07	1.08	1.10	1.11
13	Approximately 200m south east of Green Close Nursery.	2.24	2.02	3.43	3.47	4.21	4.26

Inclusion of Station Road overbridge drainage discharges

As a sensitivity test the model included the highway drainage discharge from the proposed OXD34A overbridge (noting the catchment hydrology will already represent the flows from this area). The drainage design for the overbridge limits runoff to existing greenfield runoff rates, which for the 1% annual chance event is a peak discharge of 66l/s for a 240-minute storm duration. The peak discharge was added to the model at the location of the discharge close to Assessment Point 10 for the first 240-minutes of the model run as a precautionary estimate. Due to the small size of the upstream catchment a non-uniform storm is unlikely, and flows should mostly pass through the drainage system prior to the fluvial response.

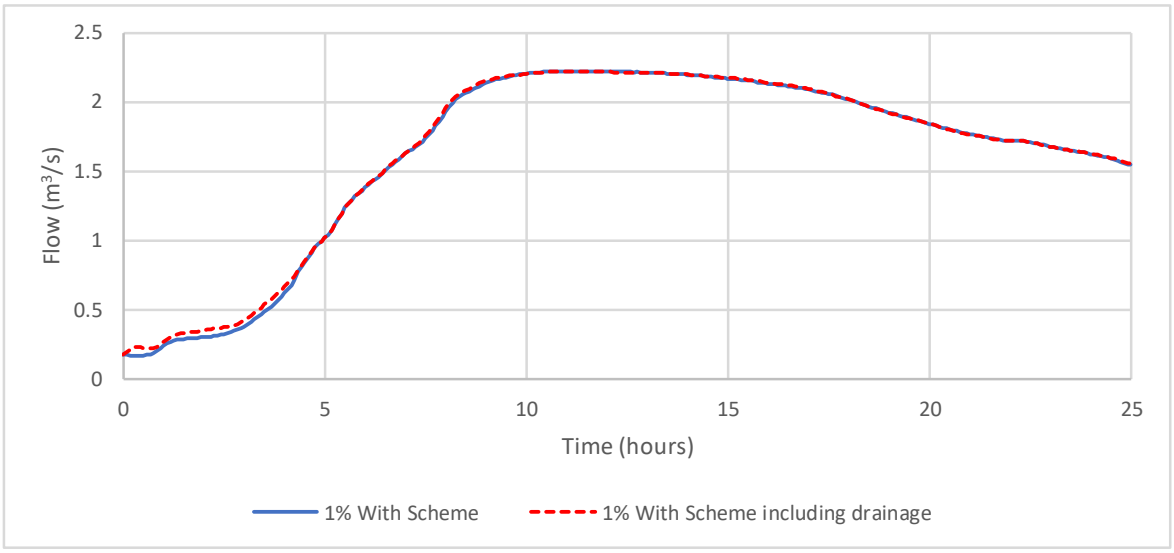
The peak flows for the 1% annual chance event With Scheme scenario including the drainage discharges are shown in Table 4-6 where a small increase in peak flows of 0.01m^3/s can be seen downstream at Assessment Point 13. Figure 4-8 below shows the changes to the hydrograph at Assessment Point 10 due to the inclusion of the drainage flows. The figure shows the majority of the attenuated drainage flows passes prior to the peak and does not impact peaks from the main fluvial event. As a result there is no distinguishable changes in peak water level or extent.

Table 4-6: Highway Drainage Assessment

No.	Location Description	Peak Flow (m^3/s)		
		1% annual chance event		
		Baseline	With Scheme	With drainage discharge
1	South of Field Farm.	0.69	0.71	0.71
2	Approximately 200m north east of Station Rd overbridge.	0.72	0.72	0.72
3	Approximately 150m north east of Station Rd overbridge.	0.79	0.58	0.58
4	Approximately 120m north east of Station Rd overbridge.	0.32	0.32	0.32
6	Upstream of culvert C170352.	1.58	1.65	1.65

No.	Location Description	Peak Flow (m^3/s)		
		1% annual chance event		
		Baseline	With Scheme	With drainage discharge
9	Downstream of C170352 and the underpass beneath the railway line.	1.07	1.08	1.08
13	Approximately 200m south east of Green Close Nursery.	3.43	3.47	3.48

Figure 4-8 Comparison of flow hydrographs between With Scheme and With Scheme including highway drainage at assessment Point 11



Blockage Assessment

The Project Wide FRA has indicated that a blockage assessment is required for culverts C170660 and C170352, and that a quantitative assessment using the hydraulic model was considered necessary. A blockage scenario was assessed for the 1% annual chance event with 50% blockage to both culverts for the With Scheme scenario. The table below compares the results of this blockage assessment, and demonstrates limited changes upstream and downstream of C170352, but with an increase of 0.25m upstream of culvert C170660.

Table 4-7: Blockage Assessment

No.	Location Description	1% annual chance event		
		With Scheme Peak Water Level (mAOD)	With Scheme plus 50% blockage Peak Water Level (mAOD)	Difference (m)
1	Upstream of C170352	67.14	67.17	0.03
2	Downstream of C170352	66.85	66.73	-0.12
3	Upstream of C170660	66.46	66.71	0.25
4	Downstream of C170660	66.12	66.07	-0.06

5. Summary

This Appendix has documented the hydraulic model updates and checks made to the Launton Brook hydrological and hydraulic model in response to the Environment Agency review comments.

The updated 2020 model builds on the 2016 (WSP-PB) model and applies the same hydrology to ensure a precautionary approach is adopted. In terms of the flood risk mechanisms and locations of the out of bank flows, the updated 2020 model is consistent with the 2016 modelling, with extensive flooding predicted in some areas. The model has been improved with more recent topographical data, improved model resolution, and reduced model instabilities and Mass Balance issues. Through extensive sensitivity testing it has been demonstrated that where uncertainties exist, these do not impact on model results or scheme designs.

Appendix E. GRIP5 CFSA Calculation Record

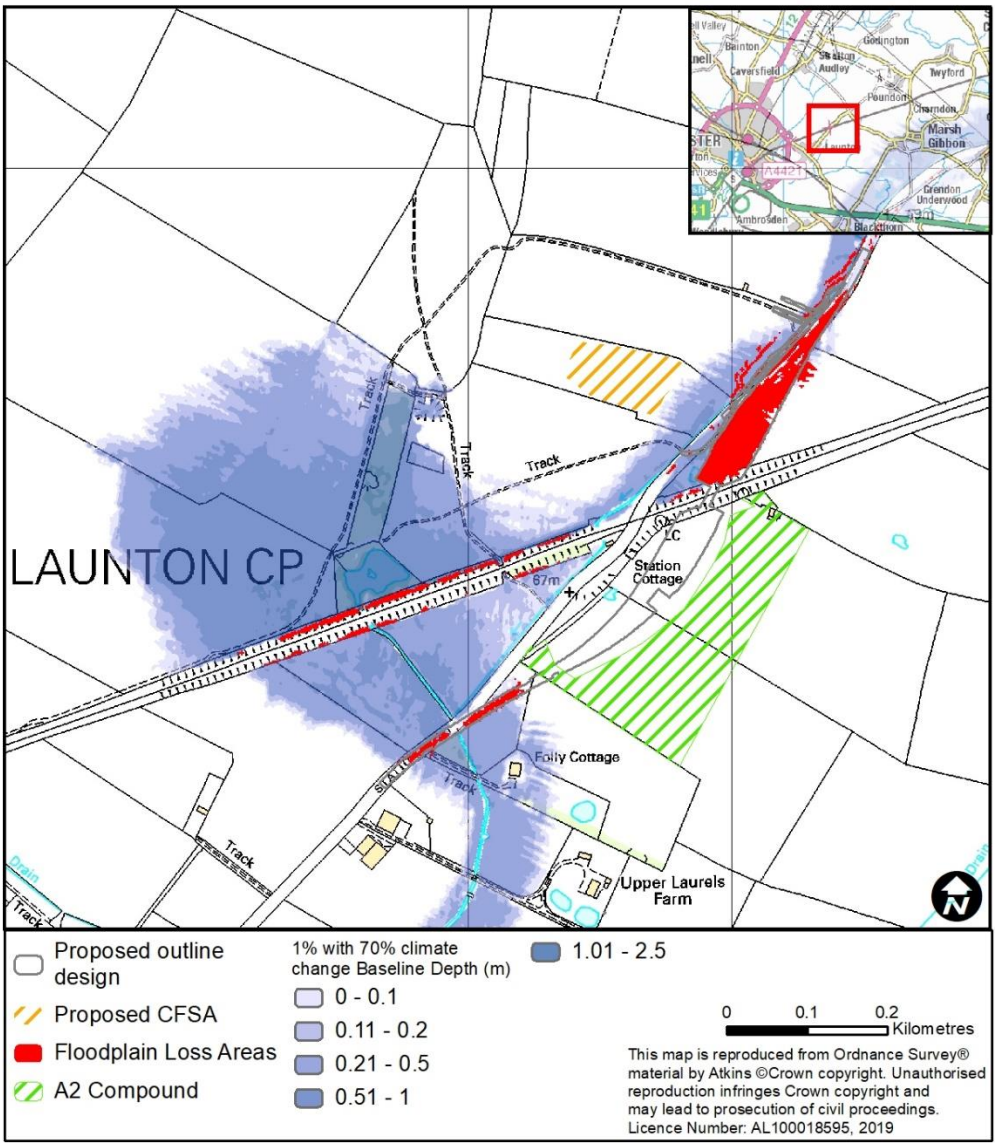
Appendix E: GRIP5 CFSA Calculation Record

This assessment has been undertaken to assess the volume of floodplain losses due to the EWR2 scheme and size the proposed Compensatory Flood Storage Area (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 Launton Brook hydraulic model

Floodplain Losses

The proposed overbridge and railway earthworks have been assessed for floodplain volume losses with a CFSA put forward for the volume losses. The compensation area must provide compensation for all floodplain losses and therefore must be compensated for in full during construction. The volume of floodplain lost during each flood event over-and-above the previous assessed event is listed in the fourth column in the tables below for each 0.2m increment.



Floodplain losses due to proposed earthworks

Annual Chance Event	Total Volume lost (m^3)	Flood level (mAOD)	Volume lost at Increment (m^3)
50%	731	67.34	731
5%	1484	67.45	753
1%	2035	67.51	550
1% + 70% climate change	3141	67.60	1106

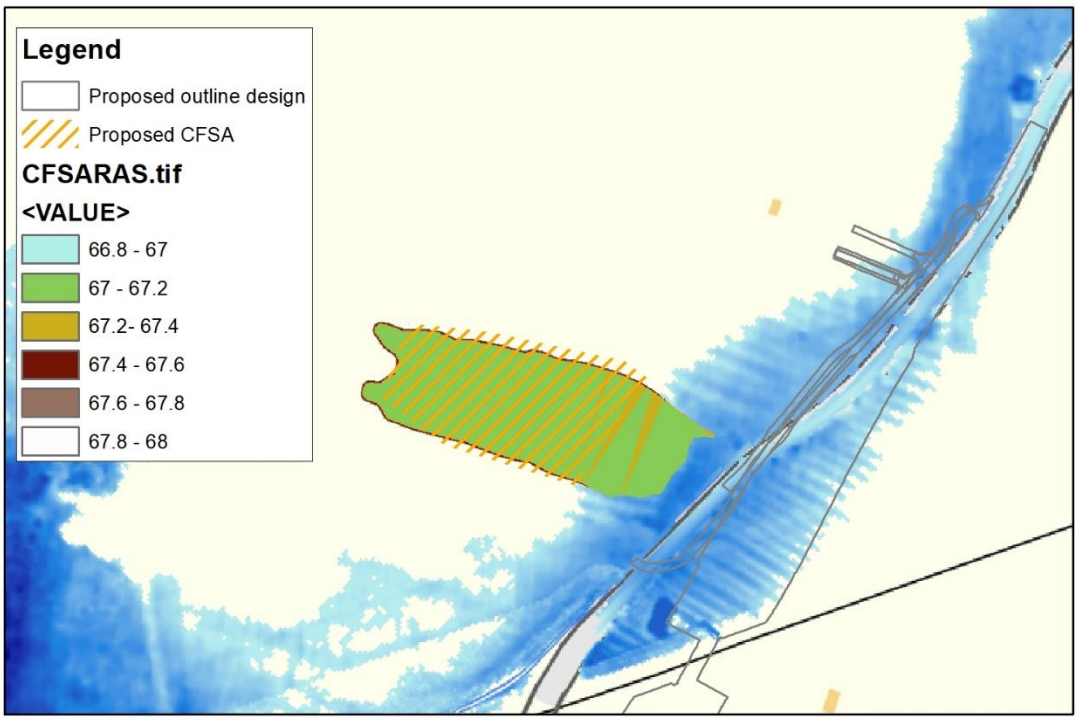
Losses from proposed works (in 200mm bands)

The differences in peak flood levels shown above are too small to construct a viable compensation area at such a fine scale, therefore the total losses have been condensed into three 200mm bands deemed the minimum feasible for construction, as shown in the table below.

From Level (mAOD)	To Level (mAOD)	Total Volume (m^3)	Volume lost at Increment (m^3)
67.14	67.34	731	731
67.34	67.54	2035	1303
67.54	67.74	3141	1106

Compensatory Flood Storage Area (CFSA)

The proposed CFSA has been sized to provide the compensation volumes with the least amount of excavation and is contained within one field boundary.



Proposed CFSA gains

From Level (mAOD)	To Level (mAOD)	Total Volume (m^3)	Volume gained at Increment (m^3)
67.14	67.34	1513	1513
67.34	67.54	3132	1618
67.54	67.74	4774	1643

Appendix F. All Model Results

No.	Node reference	Peak Water level (mAOD)							
		Annual Chance Events							
		50%		1%		1% + 70% Climate change		0.10%	
		Baseline	Scheme	Baseline	Scheme	Baseline	Scheme	Baseline	Scheme
1	LAU01_1045	64.34	64.29	64.62	64.63	64.71	64.71	64.69	64.70
2	LAU01_1045i	64.31	64.26	64.61	64.61	64.70	64.70	64.68	64.69
3	LAU01_0992	64.28	64.23	64.57	64.58	64.65	64.66	64.64	64.64
4	LAU01_0992i	64.26	64.20	64.51	64.51	64.58	64.58	64.56	64.57
5	LAU01_0992i2	64.24	64.18	64.46	64.46	64.51	64.51	64.50	64.50
6	LAU01_0910	64.22	64.17	64.46	64.46	64.50	64.51	64.50	64.50
7	LAU01_1998	65.94	65.96	66.08	66.09	66.15	66.16	66.14	66.14
8	LAU01_1998i	65.94	65.96	66.08	66.09	66.15	66.16	66.14	66.14
9	LAU01_1941	65.94	65.95	66.07	66.09	66.15	66.15	66.14	66.14
10	LAU01_1898	65.87	65.84	66.02	66.03	66.10	66.11	66.09	66.09
11	LAU01_1898i	65.86	65.82	66.02	66.02	66.09	66.10	66.08	66.08
12	LAU01_1848	65.86	65.82	66.01	66.02	66.08	66.09	66.07	66.08
13	LAU01_1839	65.83	65.79	65.99	65.99	66.07	66.08	66.05	66.06
14	LAU01_1839Su	65.83	65.79	65.99	65.99	66.07	66.08	66.05	66.06
15	LAU01_1839Sd	65.72	65.67	65.97	65.98	66.06	66.07	66.04	66.05
16	LAU01_1839Ou	65.83	65.79	65.99	65.99	66.07	66.08	66.05	66.06
17	LAU01_1839Od	65.72	65.67	65.97	65.98	66.06	66.07	66.04	66.05
18	LAU01_1836	65.72	65.67	65.97	65.98	66.06	66.07	66.04	66.05
19	LAU01_1830	65.71	65.65	65.96	65.97	66.04	66.05	66.03	66.04
20	LAU01_1830i	65.68	65.62	65.94	65.94	66.01	66.02	66.00	66.00
21	LAU01_1772	65.65	65.59	65.92	65.92	65.99	65.99	65.97	65.98
22	LAU01_1772i	65.62	65.55	65.91	65.91	65.97	65.98	65.96	65.96
23	LAU01_1714	65.59	65.52	65.89	65.90	65.95	65.96	65.94	65.95
24	LAU01_1708	65.58	65.51	65.87	65.87	65.93	65.93	65.92	65.92
25	LAU01_1708Su	65.58	65.51	65.87	65.87	65.93	65.93	65.92	65.92
26	LAU01_1708Sd	65.42	65.36	65.78	65.78	65.85	65.86	65.84	65.85
27	LAU01_1708Ou	65.58	65.51	65.87	65.87	65.93	65.93	65.92	65.92
28	LAU01_1708Od	65.42	65.36	65.78	65.78	65.85	65.86	65.84	65.85
29	LAU01_1702	65.42	65.36	65.78	65.78	65.85	65.86	65.84	65.85
30	LAU01_1702i	65.37	65.32	65.74	65.74	65.82	65.83	65.80	65.81
31	LAU01_1702i2	65.31	65.26	65.68	65.69	65.77	65.77	65.75	65.76
32	LAU01_1702i3	65.26	65.21	65.62	65.63	65.71	65.71	65.69	65.70
33	LAU01_1702i4	65.21	65.16	65.59	65.59	65.70	65.70	65.68	65.69
34	LAU01_1702i5	65.16	65.11	65.49	65.50	65.59	65.59	65.57	65.58
35	LAU01_1545	65.11	65.06	65.40	65.40	65.48	65.49	65.47	65.48
36	LAU01_1545i	65.07	65.03	65.34	65.34	65.41	65.41	65.39	65.40
37	LAU01_1507	65.05	65.00	65.33	65.33	65.40	65.40	65.38	65.39
38	LAU01_1507i	65.01	64.96	65.28	65.28	65.36	65.36	65.34	65.35
39	LAU01_1507i2	64.97	64.92	65.22	65.22	65.30	65.30	65.28	65.29
40	LAU01_1507i3	64.92	64.88	65.16	65.17	65.24	65.24	65.22	65.23
41	LAU01_1394	64.88	64.84	65.14	65.15	65.22	65.23	65.21	65.21
42	LAU01_1394i	64.84	64.80	65.09	65.10	65.18	65.18	65.16	65.17
43	LAU01_1394i2	64.81	64.77	65.05	65.06	65.13	65.14	65.11	65.12
44	LAU01_1300	64.79	64.75	65.04	65.04	65.11	65.12	65.10	65.10
45	LAU01_1300Ou	64.79	64.75	65.04	65.04	65.11	65.12	65.10	65.10
46	LAU01_1300Od	64.77	64.73	65.01	65.01	65.09	65.09	65.07	65.08
47	LAU01_1300Sd	64.77	64.73	65.01	65.01	65.09	65.09	65.07	65.08
48	LAU01_1296	64.77	64.73	65.01	65.01	65.09	65.09	65.07	65.08
49	LAU01_1279	64.76	64.72	65.01	65.01	65.09	65.09	65.07	65.08
50	LAU01_1279Sd	64.72	64.68	65.00	65.00	65.08	65.08	65.06	65.07
51	LAU01_1278	64.72	64.68	65.00	65.00	65.08	65.08	65.06	65.07

No.	Node reference	Peak Water level (mAOD)							
		Annual Chance Events							
		50%		1%		1% + 70% Climate change		0.10%	
		Baseline	Scheme	Baseline	Scheme	Baseline	Scheme	Baseline	Scheme
52	LAU01_1278i	64.68	64.63	64.98	64.98	65.06	65.07	65.05	65.05
53	LAU01_1278i2	64.64	64.60	64.91	64.91	64.99	65.00	64.98	64.98
54	LAU01_1205	64.61	64.56	64.88	64.88	64.96	64.96	64.94	64.95
55	LAU01_1181	64.58	64.53	64.87	64.87	64.95	64.95	64.93	64.94
56	LAU01_1177	64.55	64.50	64.83	64.84	64.92	64.93	64.90	64.91
57	LAU01_1181Sd	64.55	64.50	64.83	64.84	64.92	64.93	64.90	64.91
58	LAU01_1177i	64.50	64.45	64.79	64.80	64.88	64.89	64.87	64.87
59	LAU01_1177i2	64.45	64.40	64.69	64.69	64.78	64.78	64.76	64.77
60	LAU01_1091	64.40	64.34	64.67	64.68	64.77	64.77	64.75	64.76
61	LAU01_1091i	64.38	64.32	64.65	64.66	64.75	64.75	64.73	64.73
62	LAU01_1050	64.37	64.32	64.64	64.65	64.73	64.73	64.71	64.72
63	LAU01_1050Ou	64.37	64.32	64.64	64.65	64.73	64.73	64.71	64.72
64	LAU01_1050Od	64.34	64.29	64.62	64.63	64.71	64.71	64.69	64.70
65	LAU01_2074U	65.94	65.96	66.08	66.10	66.16	66.17	66.15	66.15
66	LAU01_2074i	65.94	65.96	66.08	66.09	66.16	66.16	66.14	66.15
67	LAU01_2074i2	65.94	65.96	66.08	66.09	66.15	66.16	66.14	66.15
68	LAU01_1050Su	64.37	64.32	64.64	64.65	64.73	64.73	64.71	64.72
69	LAU01_1050Sd	64.34	64.29	64.62	64.63	64.71	64.71	64.69	64.70
70	LAU01_1181Ou	64.58	64.53	64.87	64.87	64.95	64.95	64.93	64.94
71	LAU01_1181Su	64.58	64.53	64.87	64.87	64.95	64.95	64.93	64.94
72	LAU01_1181Od	64.55	64.50	64.83	64.84	64.92	64.93	64.90	64.91
73	LAU01_1300Su	64.79	64.75	65.04	65.04	65.11	65.12	65.10	65.10
74	LAU01_1279Ou	64.76	64.72	65.01	65.01	65.09	65.09	65.07	65.08
75	LAU01_1279Su	64.76	64.72	65.01	65.01	65.09	65.09	65.07	65.08
76	LAU01_1279Od	64.72	64.68	65.00	65.00	65.08	65.08	65.06	65.07
77	LAU01_1911	65.93	65.94	66.07	66.08	66.14	66.15	66.13	66.14
78	LAU01_1911Ou	65.93	65.94	66.07	66.08	66.14	66.15	66.13	66.14
79	LAU01_1911Su	65.93	65.94	66.07	66.08	66.14	66.15	66.13	66.14
80	LAU01_1911Sd	65.89	65.87	66.03	66.05	66.11	66.12	66.09	66.11
81	LAU01_1911Od	65.89	65.87	66.03	66.05	66.11	66.12	66.09	66.11
82	LAU01_1903	65.89	65.87	66.03	66.05	66.11	66.12	66.09	66.11
83	TRI01_1148	69.46	69.46	69.85	69.85	69.95	69.95	69.93	69.93
84	TRI01_1148i	69.40	69.40	69.68	69.68	69.80	69.80	69.78	69.78
85	TRI01_1099	69.33	69.33	69.46	69.46	69.49	69.49	69.46	69.46
86	TRI01_1099i	69.25	69.25	69.38	69.38	69.45	69.45	69.43	69.43
87	TRI01_1049	69.10	69.10	69.21	69.21	69.25	69.25	69.24	69.24
88	TRI01_1049i	68.94	68.94	68.97	68.97	69.02	69.02	69.00	69.00
89	TRI01_0996	68.93	68.92	68.97	68.96	69.02	69.02	69.00	69.00
90	TRI01_0996Ou	68.93	68.92	68.97	68.96	69.02	69.02	69.00	69.00
91	TRI01_0996Od	68.48	68.42	68.69	68.67	68.82	68.81	68.80	68.79
92	TRI01_0986	68.48	68.42	68.69	68.67	68.82	68.81	68.80	68.79
93	TRI01_0986i	68.43	68.34	68.68	68.66	68.78	68.78	68.77	68.76
94	TRI01_0948	68.40	68.29	68.67	68.66	68.76	68.76	68.75	68.75
95	TRI01_0948i	68.38	68.24	68.66	68.65	68.75	68.74	68.74	68.73
96	TRI01_0897	68.35	68.19	68.60	68.55	68.66	68.64	68.65	68.63
97	TRI01_0897i	68.33	68.15	68.57	68.45	68.63	68.55	68.63	68.54
98	TRI01_0847	68.32	68.11	68.54	68.36	68.60	68.46	68.60	68.45
99	TRI01_0847i		68.09		68.30		68.40		68.39
100	TRI01_0703	67.98	67.99	68.11	68.12	68.19	68.20	68.18	68.18
101	TRI01_0703Ou	67.98		68.11		68.19		68.18	
102	TRI01_0703Od	67.90		68.05		68.13		68.12	

No.	Node reference	Peak Water level (mAOD)							
		Annual Chance Events							
		50%		1%		1% + 70% Climate change		0.10%	
		Baseline	Scheme	Baseline	Scheme	Baseline	Scheme	Baseline	Scheme
103	TRI01_0697	67.90	67.77	68.05	67.92	68.13	68.03	68.12	68.01
104	TRI01_0697i		67.77		67.91		68.02		68.00
105	TRI01_0668	67.82	67.77	67.93	67.92	68.01	68.03	68.00	68.01
106	TRI01_0668C	67.79	67.65	67.91	67.86	67.98	67.99	67.97	67.96
107	TRI01_0657C	67.71	67.49	67.85	67.78	67.93	67.92	67.92	67.90
108	TRI01_0657	67.71	67.49	67.85	67.78	67.93	67.92	67.92	67.90
109	TRI01_0613		67.40		67.53		67.61		67.59
110	TRI01_0563		67.41		67.53		67.60		67.58
111	TRI01_0545	67.36	67.37	67.52	67.51	67.61	67.59	67.59	67.57
112	TRI01_0542	67.36	67.37	67.52	67.50	67.61	67.58	67.59	67.56
113	TRI01_0542i	67.34	67.35	67.51	67.48	67.60	67.56	67.59	67.54
114	TRI01_0507	67.34	67.33	67.50	67.47	67.60	67.55	67.58	67.53
115	TRI01_0507i	67.32	67.28	67.49	67.40	67.59	67.52	67.58	67.50
116	TRI01_0462	67.32	67.29	67.49	67.42	67.59	67.53	67.58	67.51
117	TRI01_0456	67.29	67.15	67.49	67.42	67.59	67.53	67.58	67.51
118	TRI01_0456i	67.16	67.08	67.43	67.34	67.55	67.46	67.54	67.44
119	TRI01_0413	67.09	67.02	67.38	67.28	67.51	67.41	67.49	67.38
120	TRI01_0413i	67.05	66.97	67.33	67.24	67.46	67.37	67.44	67.35
121	TRI01_0376	67.02	66.93	67.29	67.18	67.42	67.30	67.41	67.28
122	TRI01_0376i	66.99	66.89	67.22	67.15	67.35	67.28	67.33	67.25
123	TRI01_0376i2	66.95	66.83	67.09	67.03	67.14	67.11	67.14	67.10
124	TRI01_0315	66.93	66.81	67.14	67.04	67.23	67.15	67.22	67.13
125	TRI01_0293	66.77	66.74	66.84	66.85	66.86	66.88	66.86	66.87
126	TRI01_0286	66.73	66.69	66.79	66.79	66.81	66.81	66.80	66.80
127	TRI01_0259	66.65	66.62	66.71	66.70	66.72	66.72	66.72	66.71
128	TRI01_0259i	66.60	66.58	66.65	66.64	66.66	66.65	66.66	66.65
129	TRI01_0210	66.55	66.53	66.58	66.56	66.58	66.57	66.58	66.57
130	TRI01_0184	66.54	66.52	66.56	66.55	66.57	66.56	66.57	66.56
131	TRI01_0184Ou	66.54	66.52	66.56	66.55	66.57	66.56	66.57	66.56
132	TRI01_0184Od	66.30	66.24	66.35	66.33	66.37	66.35	66.37	66.35
133	TRI01_0184Su	66.54	66.52	66.56	66.55	66.57	66.56	66.57	66.56
134	TRI01_0184Sd	66.30	66.24	66.35	66.33	66.37	66.35	66.37	66.35
135	TRI01_0180	66.30	66.24	66.35	66.33	66.37	66.35	66.37	66.35
136	TRI01_0156	66.19	66.14	66.25	66.24	66.28	66.28	66.28	66.27
137	TRI01_0156i	66.13	66.08	66.19	66.19	66.23	66.24	66.22	66.22
138	TRI01_0102	66.06	66.03	66.13	66.15	66.18	66.21	66.17	66.19
139	TRI01_0102i	66.03	66.00	66.10	66.13	66.16	66.20	66.15	66.18
140	TRI01_0068	65.99	65.97	66.08	66.12	66.16	66.19	66.14	66.18
141	TRI01_0068i	65.95	65.95	66.07	66.12	66.15	66.19	66.14	66.17
142	TRI01_0021	65.96	65.95	66.08	66.12	66.15	66.19	66.14	66.17
143	TRI01_0021C	65.94	65.94	66.07	66.12	66.15	66.19	66.14	66.17
144	TRI01_0010C	65.93	65.93	66.07	66.11	66.15	66.19	66.13	66.17
145	TRI01_0001C	65.93	65.93	66.07	66.11	66.14	66.18	66.13	66.16
146	TRI01_0001CO	65.93	65.93	66.07	66.11	66.14	66.18	66.13	66.16
147	TRI01_0315Cl	66.93	66.81	67.14	67.04	67.23	67.15	67.22	67.13
148	TRI01_0315C	66.88	66.76	67.03	66.91	67.09	66.97	67.09	66.96
149	TRI01_0304C	66.83	66.75	66.95	66.89	66.99	66.94	66.99	66.93
150	TRI01_0293C	66.77	66.74	66.84	66.85	66.86	66.88	66.86	66.87
151	TRI01_0293CO	66.77	66.74	66.84	66.85	66.86	66.88	66.86	66.87
152	TRI01_0462Ou	67.32	67.29	67.49	67.42	67.59	67.53	67.58	67.51
153	TRI01_0462Od	67.29	67.15	67.49	67.42	67.59	67.53	67.58	67.51

No.	Node reference	Peak Water level (mAOD)							
		Annual Chance Events							
		50%		1%		1% + 70% Climate change		0.10%	
		Baseline	Scheme	Baseline	Scheme	Baseline	Scheme	Baseline	Scheme
154	TRI01_0545Ou	67.36	67.37	67.52	67.51	67.61	67.59	67.59	67.57
155	TRI01_0545Su	67.36	67.37	67.52	67.51	67.61	67.59	67.59	67.57
156	TRI01_0545Od	67.36	67.37	67.52	67.50	67.61	67.58	67.59	67.56
157	TRI01_0545Sd	67.36	67.37	67.52	67.50	67.61	67.58	67.59	67.56
158	Realign_B		68.00		68.14		68.24		68.22
159	Realign_C		67.99		68.13		68.23		68.21
160	Realign_D		67.99		68.11		68.19		68.17
161	Realign_E		67.99		68.12		68.18		68.17

No.	Node reference	Peak Flow (m^3/s)							
		Annual Chance Events							
		50%		1%		1% + 70% Climate change		0.10%	
		Baseline	Scheme	Baseline	Scheme	Baseline	Scheme	Baseline	Scheme
1	LAU01_1045	2.30	2.10	3.83	3.88	4.79	4.83	4.60	4.67
2	LAU01_1045i	2.30	2.10	3.28	3.30	3.77	3.80	3.65	3.69
3	LAU01_0992	2.27	2.10	3.68	3.73	4.56	4.61	4.37	4.44
4	LAU01_0992i	2.30	2.10	4.76	4.82	5.66	5.70	5.49	5.56
5	LAU01_0992i2	2.30	2.10	4.79	4.86	6.02	6.08	5.78	5.87
6	LAU01_0910	2.30	2.10	3.82	3.87	4.91	4.97	4.68	4.77
7	LAU01_1998	0.44	0.50	0.53	0.61	0.61	0.65	0.59	0.63
8	LAU01_1998i	0.46	0.47	0.47	0.53	0.57	0.59	0.55	0.56
9	LAU01_1941	0.68	0.68	0.68	0.66	0.75	0.91	0.73	0.87
10	LAU01_1898	1.55	1.77	1.60	1.94	1.61	1.98	1.62	1.98
11	LAU01_1898i	1.54	1.67	1.59	1.76	1.71	1.97	1.66	1.91
12	LAU01_1848	1.41	1.41	1.50	1.61	1.89	2.04	1.81	1.96
13	LAU01_1839	1.74	1.68	1.92	1.95	2.01	2.06	1.98	2.03
14	LAU01_1839Su	0.21	0.11	1.34	1.36	1.54	1.60	1.51	1.56
15	LAU01_1839Sd	0.21	0.11	1.34	1.36	1.54	1.60	1.51	1.56
16	LAU01_1839Ou	1.60	1.58	1.57	1.58	1.55	1.52	1.55	1.52
17	LAU01_1839Od	1.60	1.58	1.57	1.58	1.55	1.52	1.55	1.52
18	LAU01_1836	1.74	1.68	1.92	1.95	2.01	2.06	1.98	2.03
19	LAU01_1830	1.74	1.68	2.20	2.22	2.34	2.39	2.31	2.35
20	LAU01_1830i	1.75	1.68	2.62	2.66	3.28	3.36	3.17	3.24
21	LAU01_1772	1.92	1.76	2.69	2.73	3.47	3.58	3.34	3.42
22	LAU01_1772i	1.94	1.76	2.50	2.53	3.33	3.45	3.19	3.28
23	LAU01_1714	1.97	1.76	2.64	2.66	3.21	3.31	3.10	3.17
24	LAU01_1708	1.97	1.76	3.56	3.59	4.16	4.25	4.07	4.13
25	LAU01_1708Su	0.09	0.04	2.15	2.18	2.89	2.99	2.76	2.84
26	LAU01_1708Sd	0.09	0.04	2.15	2.18	2.89	2.99	2.76	2.84
27	LAU01_1708Ou	1.88	1.72	1.98	1.98	1.88	1.93	1.94	1.96
28	LAU01_1708Od	1.88	1.72	1.98	1.98	1.88	1.93	1.94	1.96
29	LAU01_1702	1.97	1.76	3.56	3.59	4.16	4.25	4.07	4.13
30	LAU01_1702i	1.97	1.76	3.34	3.35	3.67	3.72	3.61	3.64
31	LAU01_1702i2	2.16	1.95	3.70	3.73	4.13	4.19	4.03	4.08
32	LAU01_1702i3	2.16	1.95	4.03	4.05	4.55	4.61	4.42	4.48
33	LAU01_1702i4	2.16	1.95	3.97	3.99	4.05	4.11	4.04	4.10
34	LAU01_1702i5	2.16	1.95	4.87	4.90	5.61	5.66	5.48	5.54
35	LAU01_1545	2.16	1.95	5.10	5.17	6.06	6.10	5.91	5.98
36	LAU01_1545i	2.16	1.95	5.05	5.12	6.19	6.27	5.99	6.08
37	LAU01_1507	2.11	1.93	4.26	4.31	5.26	5.33	5.07	5.16
38	LAU01_1507i	2.16	1.95	4.17	4.19	4.69	4.74	4.56	4.61
39	LAU01_1507i2	2.16	1.95	4.29	4.33	4.94	4.99	4.82	4.88
40	LAU01_1507i3	2.15	1.95	4.23	4.27	5.05	5.10	4.90	4.97
41	LAU01_1394	2.16	1.95	3.56	3.57	3.96	4.02	3.88	3.92
42	LAU01_1394i	2.24	2.03	3.96	3.99	4.38	4.40	4.31	4.34
43	LAU01_1394i2	2.24	2.03	4.17	4.22	5.01	5.06	4.86	4.92
44	LAU01_1300	2.24	2.02	3.73	3.77	4.58	4.64	4.40	4.48
45	LAU01_1300Ou	2.22	2.02	2.78	2.79	2.80	2.80	2.80	2.80
46	LAU01_1300Od	2.22	2.02	2.78	2.79	2.80	2.80	2.80	2.80
47	LAU01_1300Sd	0.02	0.00	1.40	1.45	2.43	2.50	2.21	2.30
48	LAU01_1296	2.24	2.02	3.74	3.77	4.58	4.64	4.40	4.48
49	LAU01_1279	2.24	2.02	3.43	3.47	4.21	4.26	4.03	4.10
50	LAU01_1279Sd	0.78	0.47	2.68	2.72	3.43	3.49	3.27	3.34
51	LAU01_1278	2.24	2.02	3.43	3.47	4.21	4.26	4.03	4.10

No.	Node reference	Peak Flow (m^3/s)							
		Annual Chance Events							
		50%		1%		1% + 70% Climate change		0.10%	
		Baseline	Scheme	Baseline	Scheme	Baseline	Scheme	Baseline	Scheme
52	LAU01_1278i	2.24	2.02	3.16	3.18	3.72	3.77	3.58	3.64
53	LAU01_1278i2	2.24	2.02	4.52	4.55	5.17	5.21	5.05	5.11
54	LAU01_1205	2.24	2.02	4.21	4.25	4.96	5.01	4.81	4.87
55	LAU01_1181	2.24	2.03	3.49	3.52	4.06	4.12	3.95	4.01
56	LAU01_1177	2.24	2.03	3.49	3.52	4.06	4.12	3.95	4.01
57	LAU01_1181Sd	0.00	0.00	1.15	1.19	1.97	2.01	1.82	1.88
58	LAU01_1177i	2.31	2.10	3.63	3.66	4.19	4.23	4.05	4.11
59	LAU01_1177i2	2.31	2.10	4.76	4.81	5.48	5.52	5.35	5.40
60	LAU01_1091	2.15	2.04	3.42	3.45	3.96	3.99	3.85	3.89
61	LAU01_1091i	2.30	2.10	3.63	3.67	4.30	4.33	4.16	4.21
62	LAU01_1050	2.30	2.10	3.83	3.88	4.79	4.83	4.60	4.67
63	LAU01_1050Ou	2.27	2.10	2.60	2.59	2.61	2.60	2.61	2.60
64	LAU01_1050Od	2.27	2.10	2.60	2.59	2.61	2.60	2.61	2.60
65	LAU01_2074U	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
66	LAU01_2074i	0.58	0.59	0.86	0.88	1.08	1.16	1.07	1.12
67	LAU01_2074i2	0.60	0.61	0.75	0.78	0.87	0.92	0.86	0.89
68	LAU01_1050Su	0.04	0.00	1.41	1.45	2.25	2.30	2.06	2.13
69	LAU01_1050Sd	0.04	0.00	1.41	1.45	2.25	2.30	2.06	2.13
70	LAU01_1181Ou	2.24	2.03	2.64	2.63	2.61	2.63	2.64	2.63
71	LAU01_1181Su	0.00	0.00	1.15	1.19	1.97	2.01	1.82	1.88
72	LAU01_1181Od	2.24	2.03	2.64	2.63	2.61	2.63	2.64	2.63
73	LAU01_1300Su	0.02	0.00	1.40	1.45	2.43	2.50	2.21	2.30
74	LAU01_1279Ou	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
75	LAU01_1279Su	0.78	0.47	2.68	2.72	3.43	3.49	3.27	3.34
76	LAU01_1279Od	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
77	LAU01_1911	1.23	1.57	1.22	1.59	1.28	1.56	1.26	1.57
78	LAU01_1911Ou	1.45	1.70	1.42	1.69	1.39	1.68	1.39	1.69
79	LAU01_1911Su	0.00	0.00	0.00	0.01	0.09	0.11	0.06	0.07
80	LAU01_1911Sd	0.00	0.00	0.00	0.01	0.09	0.11	0.06	0.07
81	LAU01_1911Od	1.45	1.70	1.42	1.69	1.39	1.68	1.39	1.69
82	LAU01_1903	1.45	1.70	1.42	1.69	1.39	1.68	1.39	1.69
83	TRI01_1148	1.56	1.56	4.27	4.27	7.26	7.26	6.71	6.71
84	TRI01_1148i	1.56	1.56	4.24	4.24	5.95	5.96	5.50	5.50
85	TRI01_1099	1.56	1.56	3.97	3.98	5.16	5.15	4.90	4.90
86	TRI01_1099i	1.52	1.52	2.42	2.42	3.11	3.12	2.41	2.44
87	TRI01_1049	1.51	1.51	2.20	2.20	2.56	2.56	2.42	2.42
88	TRI01_1049i	1.51	1.51	2.09	2.09	2.32	2.32	2.26	2.26
89	TRI01_0996	0.67	0.71	0.67	0.71	0.68	0.71	0.68	0.71
90	TRI01_0996Ou	0.67	0.71	0.67	0.71	0.68	0.71	0.68	0.71
91	TRI01_0996Od	0.67	0.71	0.67	0.71	0.68	0.71	0.68	0.71
92	TRI01_0986	0.67	0.71	0.67	0.71	0.68	0.71	0.68	0.71
93	TRI01_0986i	0.69	0.71	0.69	0.71	1.15	1.14	1.03	1.04
94	TRI01_0948	0.69	0.71	0.69	0.71	1.26	1.24	1.10	1.09
95	TRI01_0948i	0.69	0.71	0.69	0.71	1.20	1.15	1.11	1.06
96	TRI01_0897	0.89	0.91	2.05	2.32	2.60	2.81	2.52	2.75
97	TRI01_0897i	0.95	0.97	1.88	2.50	2.24	2.90	2.18	2.86
98	TRI01_0847	0.95	0.97	1.88	2.50	2.20	2.90	2.15	2.86
99	TRI01_0847i		0.97		2.50		2.90		2.86
100	TRI01_0703	0.31		0.32		0.32		0.32	
101	TRI01_0703Ou	0.31		0.32		0.32		0.32	
102	TRI01_0703Od	0.31		0.32		0.32		0.32	

No.	Node reference	Peak Flow (m^3/s)							
		Annual Chance Events							
		50%		1%		1% + 70% Climate change		0.10%	
		Baseline	Scheme	Baseline	Scheme	Baseline	Scheme	Baseline	Scheme
103	TRI01_0697	0.31		0.32		0.32		0.32	
104	TRI01_0668	0.07		0.07		0.07		0.07	
105	TRI01_0668C	0.07		0.07		0.07		0.07	
106	TRI01_0657C	0.07		0.07		0.07		0.07	
107	TRI01_0657	0.07		0.07		0.07		0.07	
108	TRI01_0545	0.49	0.58	0.72	0.72	0.81	0.89	0.81	0.87
109	TRI01_0542	0.49	0.58	0.72	0.72	0.81	0.89	0.81	0.87
110	TRI01_0542i	0.49	0.51	0.71	0.63	0.73	0.70	0.72	0.69
111	TRI01_0507	0.44	0.32	0.79	0.58	0.82	0.69	0.81	0.66
112	TRI01_0507i	0.71	0.68	1.08	0.97	1.12	0.99	1.11	0.99
113	TRI01_0462	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
114	TRI01_0456	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
115	TRI01_0456i	1.45	1.39	1.65	1.65	1.65	1.66	1.65	1.66
116	TRI01_0413	1.50	1.44	2.15	2.15	2.40	2.40	2.36	2.36
117	TRI01_0413i	1.53	1.46	2.73	2.72	3.16	3.16	3.11	3.10
118	TRI01_0376	1.53	1.46	2.93	2.93	3.55	3.55	3.49	3.47
119	TRI01_0376i	1.54	1.46	3.22	3.22	4.03	4.02	3.96	3.94
120	TRI01_0376i2	1.54	1.46	3.53	3.52	4.80	4.80	4.66	4.66
121	TRI01_0315	1.18	1.19	1.58	1.65	1.74	1.83	1.72	1.81
122	TRI01_0293	1.18	1.19	1.58	1.65	1.74	1.83	1.72	1.81
123	TRI01_0286	1.18	1.19	1.58	1.65	1.74	1.83	1.72	1.81
124	TRI01_0259	1.18	1.19	1.50	1.54	1.58	1.69	1.58	1.68
125	TRI01_0259i	1.18	1.19	1.48	1.52	1.55	1.57	1.55	1.57
126	TRI01_0210	1.18	1.19	1.48	1.52	1.55	1.57	1.55	1.57
127	TRI01_0184	0.93	0.94	1.07	1.08	1.10	1.11	1.10	1.11
128	TRI01_0184Ou	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
129	TRI01_0184Od	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
130	TRI01_0184Su	0.48	0.48	0.64	0.66	0.69	0.69	0.68	0.69
131	TRI01_0184Sd	0.48	0.48	0.64	0.66	0.69	0.69	0.68	0.69
132	TRI01_0180	0.93	0.94	1.07	1.08	1.10	1.11	1.10	1.11
133	TRI01_0156	0.98	0.99	1.14	1.16	1.18	1.19	1.18	1.19
134	TRI01_0156i	0.98	0.99	1.14	1.16	1.18	1.19	1.18	1.19
135	TRI01_0102	0.98	0.99	1.14	1.16	1.18	1.19	1.18	1.19
136	TRI01_0102i	0.98	0.99	1.14	1.16	1.18	1.19	1.18	1.19
137	TRI01_0068	0.97	0.98	1.08	1.09	1.10	1.11	1.10	1.11
138	TRI01_0068i	0.86	0.86	0.91	0.92	0.92	0.93	0.92	0.93
139	TRI01_0021	0.48	0.46	0.47	0.44	0.48	0.45	0.46	0.43
140	TRI01_0021C	0.48	0.46	0.47	0.44	0.48	0.45	0.46	0.43
141	TRI01_0010C	0.48	0.46	0.47	0.44	0.48	0.45	0.46	0.43
142	TRI01_0001C	0.48	0.46	0.47	0.44	0.48	0.45	0.46	0.43
143	TRI01_0001CO	0.48	0.46	0.47	0.44	0.48	0.45	0.46	0.43
144	TRI01_0315CI	1.18	1.19	1.58	1.65	1.74	1.83	1.72	1.81
145	TRI01_0315C	1.18	1.19	1.58	1.65	1.74	1.83	1.72	1.81
146	TRI01_0304C	1.18	1.19	1.58	1.65	1.74	1.83	1.72	1.81
147	TRI01_0293C	1.18	1.19	1.58	1.65	1.74	1.83	1.72	1.81
148	TRI01_0293CO	1.18	1.19	1.58	1.65	1.74	1.83	1.72	1.81
149	TRI01_0462Ou	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
150	TRI01_0462Od	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
151	TRI01_0545Ou	0.29	0.30	0.28	0.29	0.29	0.31	0.29	0.29
152	TRI01_0545Su	0.33	0.37	0.59	0.58	0.68	0.78	0.68	0.75
153	TRI01_0545Od	0.29	0.30	0.28	0.29	0.29	0.31	0.29	0.29

No.	Node reference	Peak Flow (m^3/s)							
		Annual Chance Events							
		50%		1%		1% + 70% Climate change		0.10%	
		Baseline	Scheme	Baseline	Scheme	Baseline	Scheme	Baseline	Scheme
154	TRI01_0545Sd	0.33	0.37	0.59	0.58	0.68	0.78	0.68	0.75
155	Realign_B		0.78		1.46		1.92		1.86
156	Realign_C		0.75		1.29		1.66		1.61
157	Realign_D		0.76		1.19		1.51		1.47
158	Realign_E		0.82		1.41		2.01		1.94
159	Realign_H		0.87		2.04		2.81		2.73
160	Realign_I		0.89		1.93		2.64		2.55
161	Realign_J		0.89		1.54		2.07		2.00
162	Realign_K		1.29		2.00		2.41		2.36
163	Realign_L		0.84		1.36		1.74		1.69
164	Realign_M		0.84		1.14		1.45		1.41
165	Realign_N		0.83		0.90		1.06		1.02
166	LAT03	0.11	0.11	0.31	0.31	0.53	0.53	0.49	0.49
167	LAT04	0.11	0.11	0.29	0.29	0.50	0.50	0.46	0.46

EWR Alliance
Floor 2
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