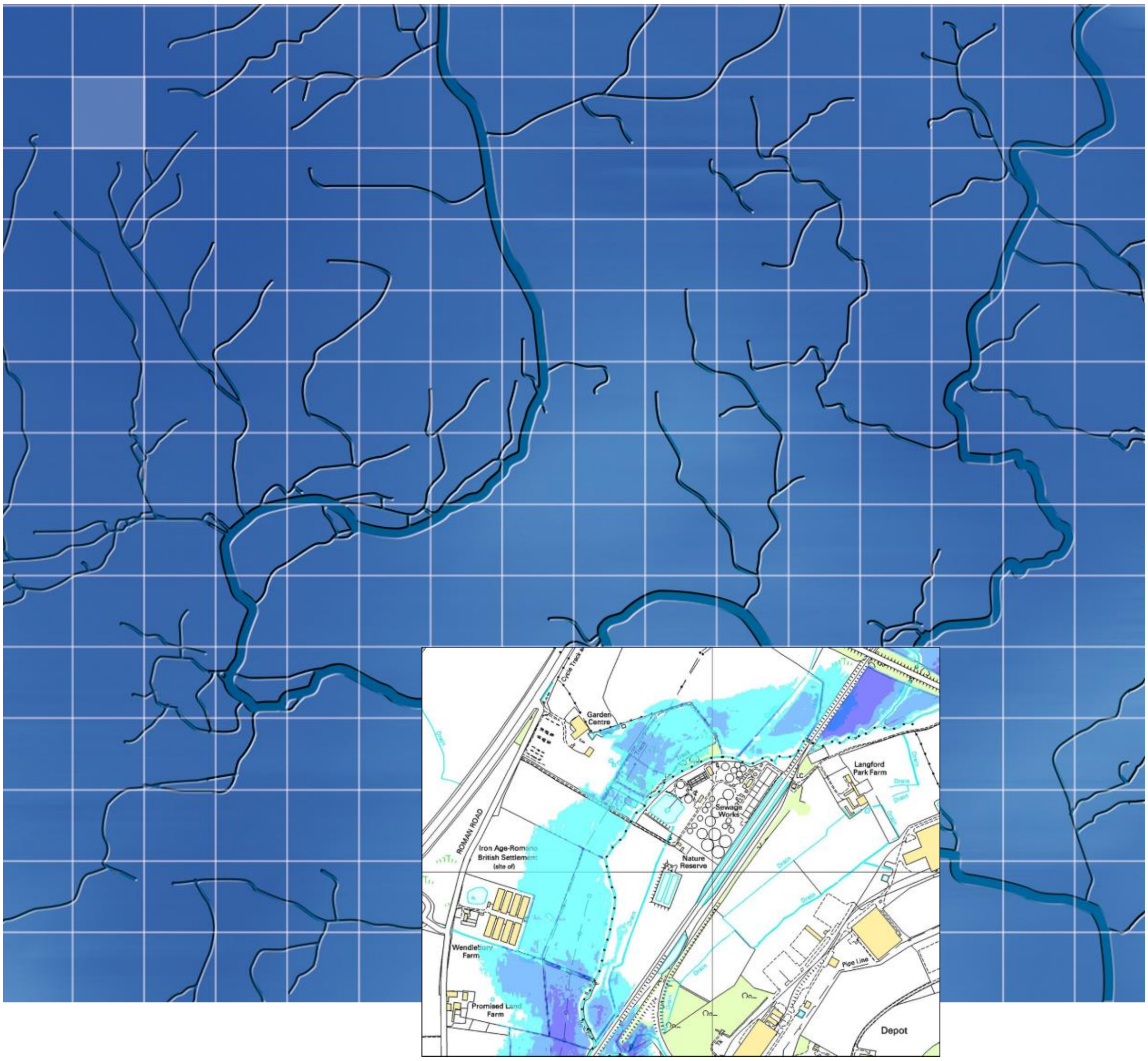
Network Rail and Chiltern Railways

January 2014

EWR-P1-Level 3 FRA: MOD Sidings (East and Central)



Wallingford HydroSolutions Limited

Network Rail

EWR P1 - Level 3 FRA: MOD Sidings (East and Central)

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For and on behalf of Wallingford HydroSolutions Ltd.

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Approved by P. Blackman
Position *Technical Director*

Date **January 2014**

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Contents

1 Introduction

1.1 Background

Environmental Resources Management (ERM) and Wallingford HydroSolutions Ltd. (WHS) completed a Level 2 Flood Risk Assessment (FRA) in 2009 (including a revision in July 2010), together with a Technical Paper[1] outlining potential flood storage mitigation requirements for the proposed Chiltern Railways Bicester to Oxford improvement scheme in support of an application for an Order under the Transport and Works Act 1992 (TWA) by Chiltern Railways (CRCL). The TWA Order was granted by the Secretary of State for Transport in October 2012. This gives statutory powers to authorise the East West Rail Phase 1 (EWR P1) project, comprising the redevelopment and operation of the railway between Oxford and Bicester. The project seeks to introduce a new, fast service between London and Oxford.

The Level 2 FRA was conducted in accordance with Planning Policy Statement 25: Development and Flood Risk (PPS25), and its Practice Guide companion. The Level 2 FRA document highlighted a number of locations along the railway corridor where proposed developments lie within Flood Zones 2 or 3 and could potentially have impacts upon the incidence of local flooding. The report identified a number of assessment points (AP's) along the route of the EWR P1 that require further consideration in a Level 3 FRA. The proposed works to the Ministry of Defence (MOD) Sidings considered within this report were not included within this original study having been proposed during 2013 as a result of Ministry of Defence requests.

This report considers proposed works between AP4 and AP5 of the original study as shown on Figure 1. The MOD Sidings development can be split into three geographical units; east, central and west. This report considers those works within the central and eastern work units. Within the eastern works unit the existing rail embankment will be widened to provide a dual track line. As a result of embankment widening surface water drains will be partially in-filled within the central works unit.

As the proposals for the western section are yet to be designed, the FRA for this section will be submitted separately. This is considered a robust approach and one which has been agreed by the Environment Agency. For consistency, the development considered within this report will be referred to simply as the MOD Sidings.

1.2 Scope of Level 3 FRA

This document constitutes a Level 3 Flood Risk Assessment for the proposed works at the MOD Sidings, as required by Planning Conditions 12 of deemed planning permission granted alongside the Order under the Transport and Works Act 1992.

This document also provides the information required by the National Planning Policy Framework (NPPF) and the associated requirements of PPS25.

This FRA document has been commissioned to address the flood risk issues that result from the construction of the MOD Sidings embankment and partial filling of a surface water ditch. The location of the MOD Sidings is shown in Figure 1. As part of the MOD Sidings, the existing railway embankment is to be widened to allow for a dual mainline track, improved connectivity to the MOD

[1] WHS. 2010. Chiltern Railways Bicester to Oxford Improvements Level 2 Flood Risk Assessment

train network and an additional line to the MOD site, the construction of which will require the infilling of a surface water ditch. The purpose of this FRA is to quantify any adverse impacts on flood risk and provide sustainable and effective mitigation where required.

The scope and method of analysis for this FRA have been agreed in discussions with the Environment Agency.

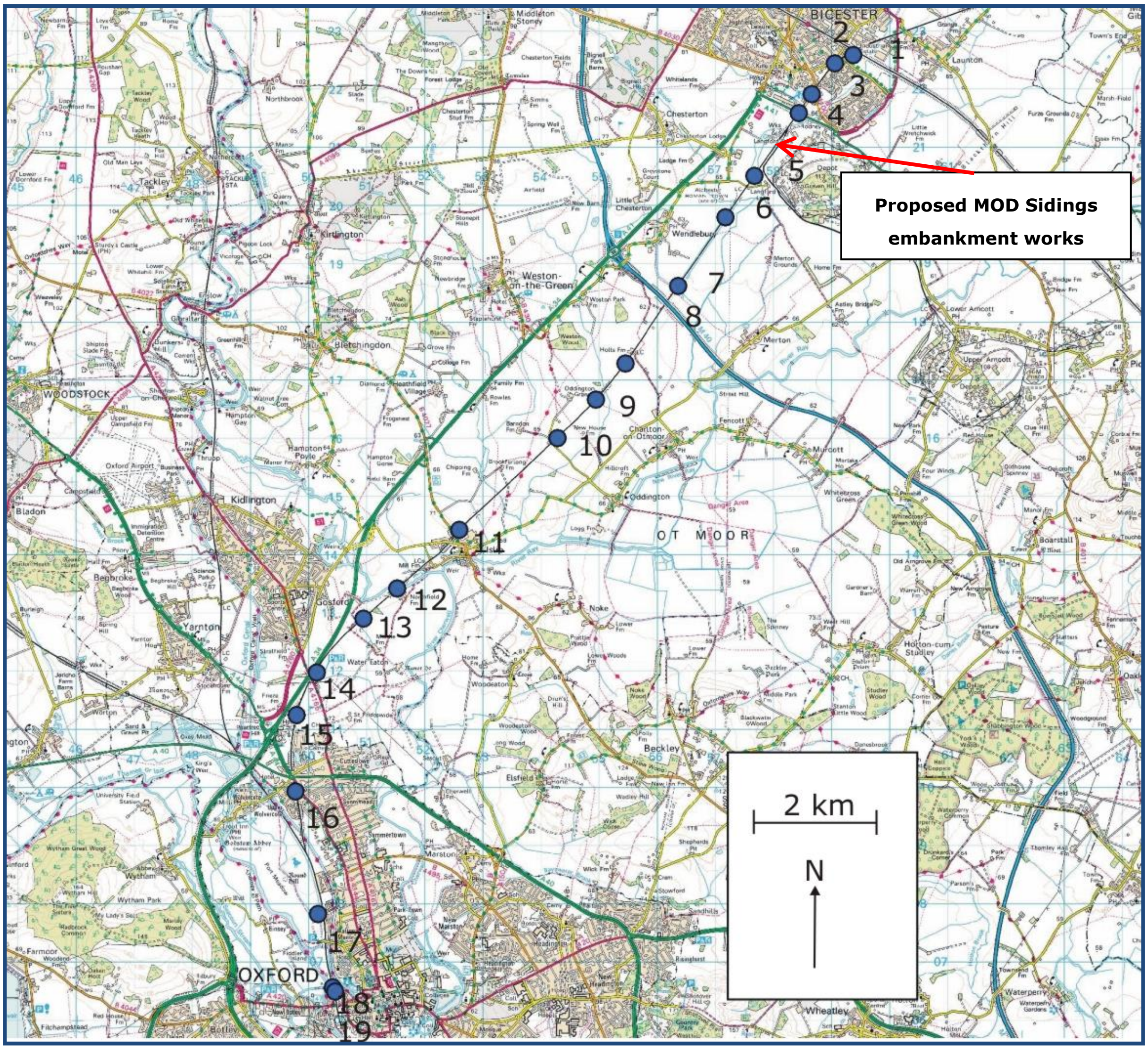

Figure 1 – Scheme Overview Showing Assessment Points.

2 Site Description

2.1 Overview

EWR P1 is a major package of infrastructure investments including the dualing of the line between Bicester town and Oxford North Junction.

This site specific Level 3 FRA considers works between Assessment Points 4 and 5 – MOD Sidings, and considers both the eastern and central work units of this development. As outlined within section 1.1 the proposals for the western section are yet to be designed as such the FRA for this section will be submitted separately. The proposed MOD Sidings works involve the widening of the existing embankment. The widening is required to allow for a dual track mainline, and improved rail connection to the MOD site to the east. As part of this work, two surface water ditches will be partially filled. Figure 1 provides an overview of the MOD Sidings scheme, with Figure 3 showing the location of the proposed MOD embankment widening (East) and Figure 4 shows the location of the surface water ditches which will be partially filled (Central).

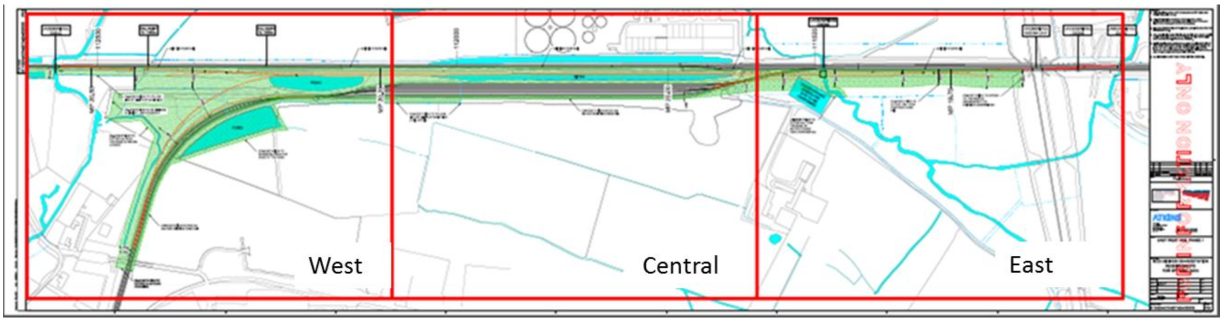

Figure 2 – MOD Sidings Development Scheme, Geographical Zones.

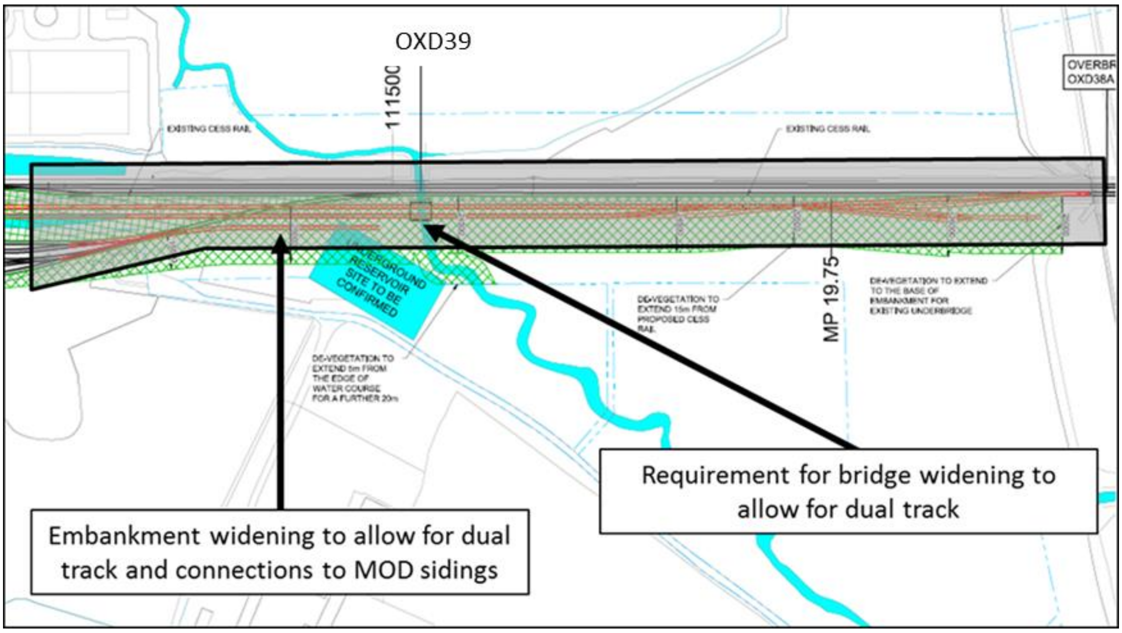

Figure 3 – MOD Sidings Embankment Widening Location Plan (East).

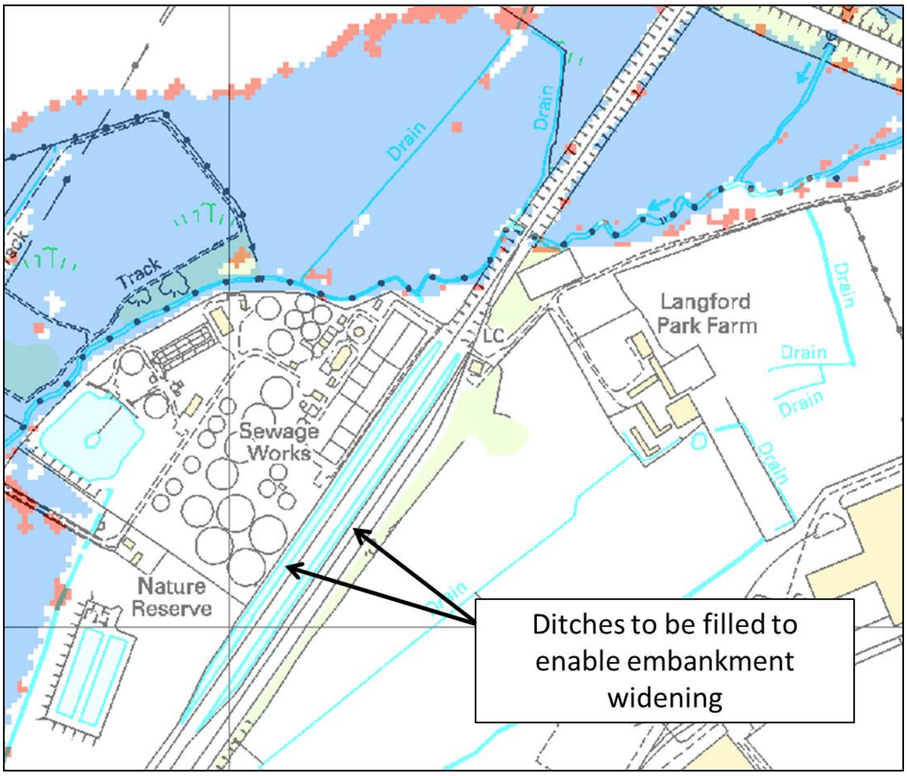

Figure 4 – 1 in 100 Year plus Climate Change and 1 in 1000 Year Flood Outline highlighted in relation to the ditch which will be partially filled (Central). Flood modelling results taken from the existing EA hydraulic model, undertaken by Peter Brett Associates.

2.2 Description of the Proposed Works

2.2.1 Embankment Widening

As stated previously, embankment widening is proposed along this section of the Bicester to Oxford line. This widening is required to allow the main line to be dual track, and allow a new connection to the MOD site. The embankment will be widened on both the north and south side.

2.2.2 Drainage Ditch Infilling

As part of the MOD Sidings embankment widening, two ditches will be in filled. The location of these ditches is shown in Figure 4. The ditches are located on both the north and south of the east west rail line, and are approximately 400m in length. During site investigation by Atkins, these ditches were found to be dry, and there was no evidence to suggest that these perform a significant drainage function. It is likely that these ditches were created as borrow pits during the original embankment construction in the 19th century.

3 Flood Risk Impacts

3.1 Data Sources Used and Proposed Methodology

This section outlines the methodology used in undertaking the flood impact assessment for the embankment widening work at the MOD Sidings. This involves an assessment of the floodplain storage volume lost as a result of embankment widening and includes recommendations for mitigation measures to provide compensatory floodplain storage. The Bicester hydraulic model[2] has been approved for use for this study by the Environment Agency (EA) and has been updated with more up to date floodplain topography and updated to reflect best modelling practices. The methodology, parameters and working assumptions, together with the results and recommendations for mitigation are all described in the following sections. An outline of the procedure used to calculate floodplain storage loss is presented below:

- Calculation of the predicted flood level adjacent to the proposed MOD Sidings embankment widening using the updated Bicester model[3].

- Calculation of the subsequent flood storage volumes lost as a result of the embankment widening works. This uses detailed earthworks design sections provided by Atkins[4] to assess volumes of floodplain lost.

- Assessment of the potential for level for level storage within the current Limits of Deviation boundary (LOD).

- If this is not possible:

[2] PBA. 2009. Bicester Hydraulic Model.
[3] WHS. 2013. MOD Sidings Hydraulic Model.
[4] Atkins. 2013. Provided detailed earthworks section of the MOD sidings embankment works in AutoCAD format.

- Provision of compensatory floodplain storage on a volume for volume basis, with an element of over compensation.

The approach used in this assessment has been discussed and agreed with the EA.

A number of data sources have been used in the current assessment, which include:

- Detailed earthwork cross sections[4] of the proposed MOD embankment located within the 1 in 100 year (plus an allowance for climate change) flood zone at 20m centres.
- LiDAR data have been purchased through Geomatics Group. This has a 2m resolution, with a vertical accuracy of +/- 0.15 m;
- The Scheme Boundary, this boundary incorporates land within the Limits of Deviation (LOD) and those areas of the Limits of Land to be Acquired and Used (LLAU) where Chiltern Railways has the legal powers to install flood mitigation, without further land acquisition.
- Hydraulic modelling outputs from an updated version of the EA Bicester Model[2] are used to delineate the inundation area and obtain design flood levels for the 1:100 year (plus climate change allowance) event. The original model was developed for Strategic Flood Risk Assessment (SFRA) purposes. WHS has undertaken work to upgrade the existing model with more up to date topographic data and a finer resolution 2D grid to facilitate modelling of the proposed works. Further details of the modelling undertaken are found in Appendix 1.

3.2 Predicted Flood Level

As previously stated, the current EA Bicester hydraulic model was updated with current topographical data and a finer resolution 2D grid. A review of the hydrology was also undertaken to generate an input boundary to the model. A fuller description of the changes made to the model is provided in Appendix 1.

The hydraulic model confirms that maximum 1 in 100 year plus climate change flood levels are significantly different on either side of the embankment. This is as a result of pooling behind the embankment on the southern side due to raised banks upstream, with the existing embankment forming a barrier to conveyance. This leads to a ponding effect upstream of the embankment resulting in elevated levels when compared to downstream.

Flood levels also vary with distance from the watercourse on both the north and south side of the embankment. On the southern side flood levels increase with distance from the Langford Brook. To the north, flood levels marginally decrease with distance from the watercourse as might be expected as a number of drainage channels operate in this location causing a marginal reduction in level. Figure 5 summarises the flood levels on either side of the embankment. The average maximum flood level on the northern side is predicted to be 65.12mAOD whilst on the southern side this is higher at 65.81mAOD. Both of these levels are comparable to the original EA hydraulic model levels of 65.17mAOD and 65.79mAOD respectively. This shows that the model is relatively insensitive to the adjustments made to the 2D domain.

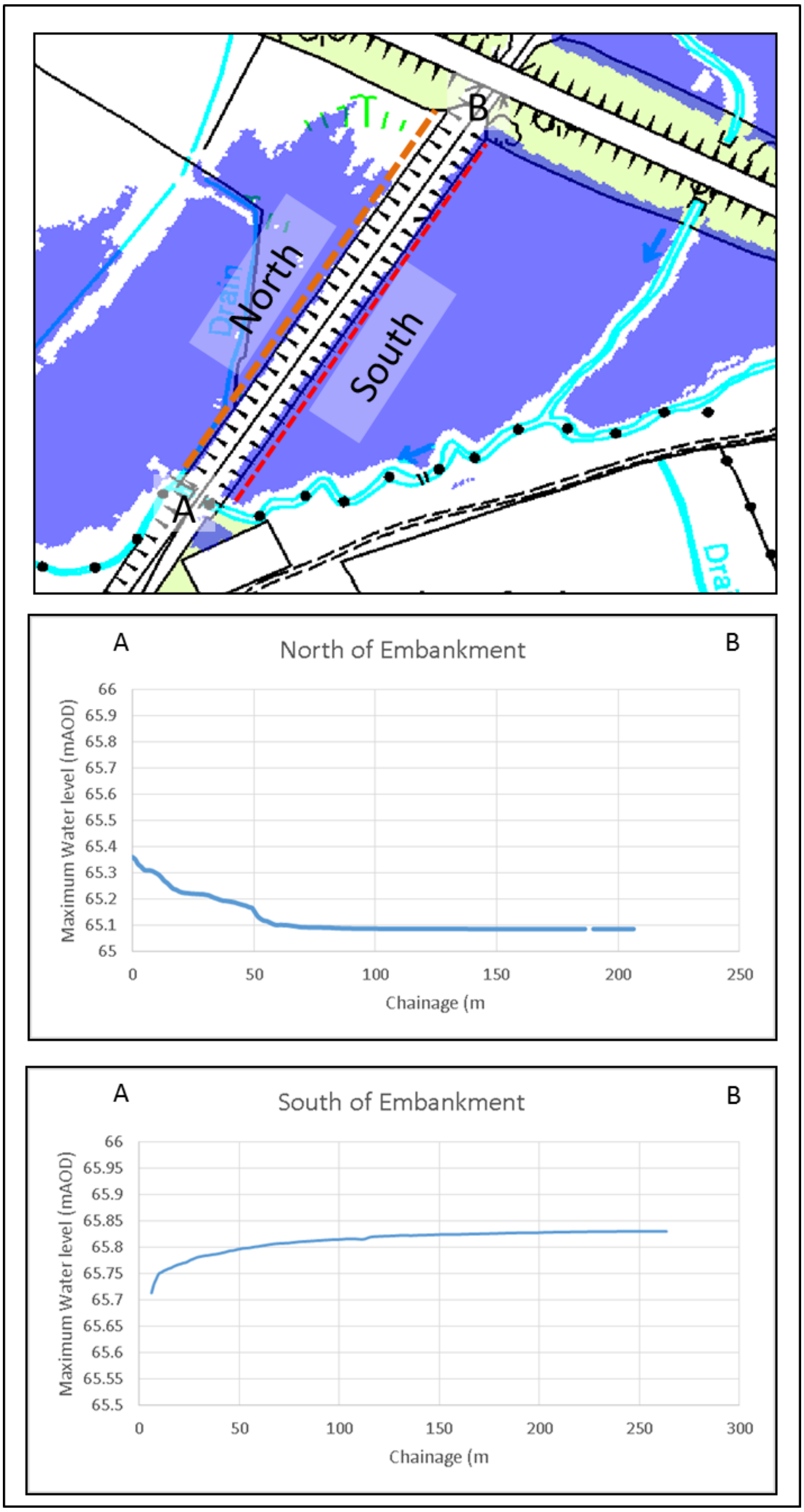

Figure 5 – Summary of Flood Level Change Along the Embankment, on both the north and south side for the 1 in 100 year plus climate change event.

3.3 Design Iterations

Throughout the design process Network Rail and the designers Atkins have actively considered flood risk as a key design consideration. As such, the proposed design has gone through a number of iterations to allow for the impacts on flood risk and loss of storage to be considered in detail. The initial design considered full embankment widening as highlighted within Figure 6. An initial desktop study of the impacts of this design undertaken by WHS[5] predicted this would result in approximately 2000m^3 of flood storage being removed. As a result, further design iterations were undertaken in order to achieve a reduced impact on the flood plain storage in this area. Following a series of discussions about ways of reducing the width of the embankment footprint, a reinforced concrete wall design on the southern side was proposed. This design has significantly reduced the width of the proposed embankment and will therefore have a reduced impact on the floodplain storage volumes. Figure 7 highlights the proposed final design.

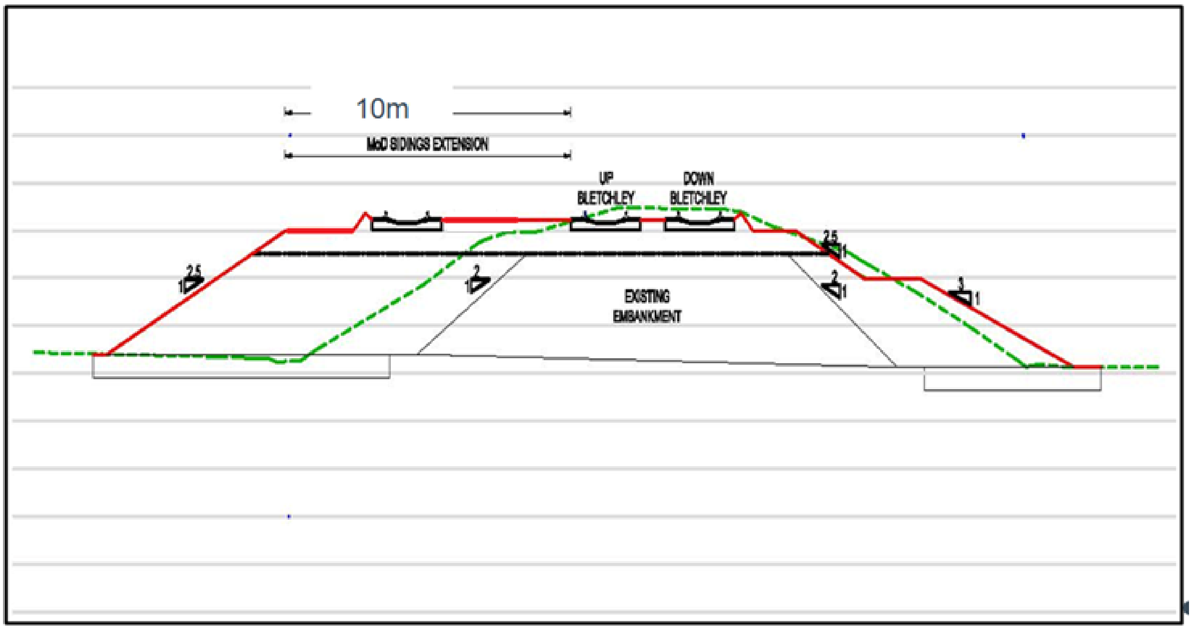

Figure 6 – Proposed Embankment Widening at the MOD Sidings (based on Atkins 2013. Technical Note 45)

[5] WHS. 2013. EWR P1 – MOD Sidings Flood Risk Desk Top Study.

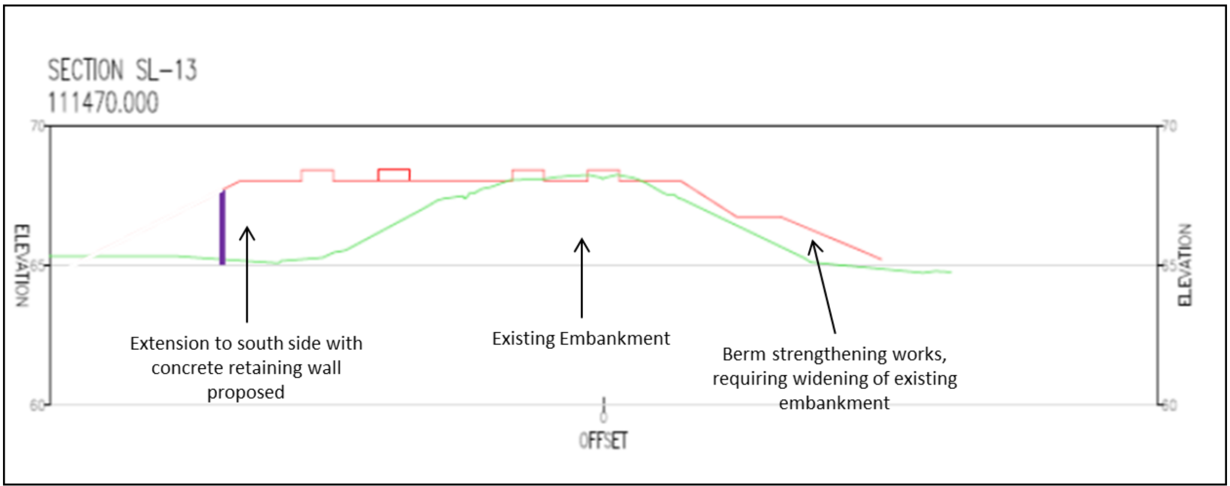

Figure 7 – Proposed Embankment Widening at the MOD Sidings (based on Atkins 2013. Technical Note 45)

3.4 Floodplain Storage Loss Analysis

The volume of floodplain storage lost as a result of the embankment widening work has been calculated to inform the design of any compensatory storage provision that is required to ensure flood risk is effectively managed. The loss of floodplain storage volume has been calculated with the aid of AutoCAD design software. The method adopted is outlined below:

- Atkins has provided detailed earthworks sections[4] at between 10-20 metre centres along the MOD Sidings embankment. For each cross section, the area of floodplain lost has been determined by plotting the predicted flood level onto the embankment design sections and calculating the area of floodplain lost – noting the ground level at the cross section. See Figure 8 for a typical earthworks cross section of the embankment widening work and Figure 9 for details of how the cross-sectional area lost under the Q100+CC flood event has been calculated.

- This process is repeated for all earthwork sections that lie within the 1 in 100 year (plus an allowance for climate change) flood inundation area along the length of the MOD Sidings embankment.

- The final stage is to calculate the total volume lost. This is achieved by multiplying the measured cross-sectional area within each depth band by the associated chainage (i.e. 20m centres) over the total length of the MOD Sidings (both north and south) to give the total storage volume lost.

Table 1 provides a summary of the volumes of floodplain storage predicted to be lost / gained as a result of the proposed works at 200mm level bandings at each cross section. The total storage volume lost to the MOD Sidings embankment widening is 340m^3.

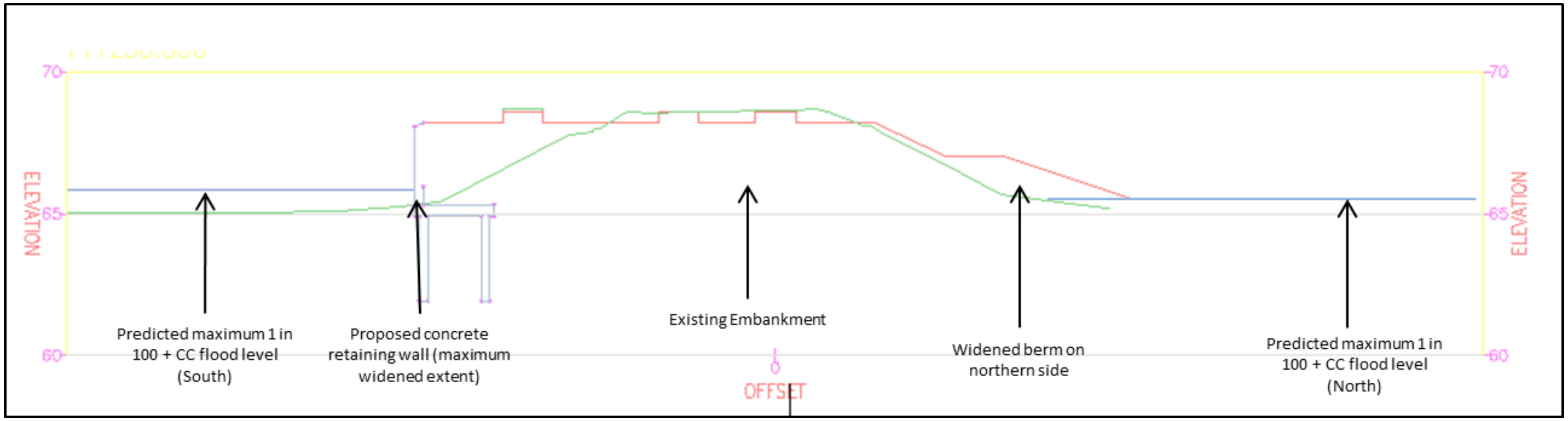

Figure 8 – Typical Design Cross Section at MOD Sidings, showing the proposed concrete retaining wall on the south side, and extended berm to north.

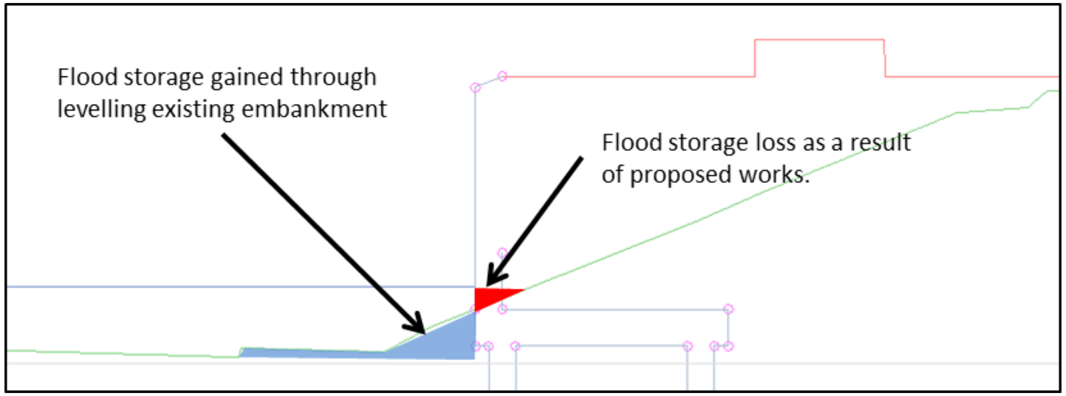

Figure 9 – Example of Calculation Method for Flood Storage Loss / Gain at each Cross-section along the MOD Embankment.

Table 1 – Floodplain Storage Volume Loss / Gain at each Design Cross-section at 200mm Level Bands (Note: a negative value shows storage gained)

Volume loss by level band											
		Level Band (mAOD)									
Section	Embankment Face	65.8 to 65.6	65.6 to 65.4	65.4 to 65.2	65.2 to 65.0	65.0 to 64.8	64.8 to 64.6	64.6 to 64.4	64.4 to 64.2	64.2 to 64.0	64.0 to 63.8
21	N	-	-	-	-	-	-	-	-	-	-
	S	-	4.32	12.10	5.02	-	-	-	-	-	-
19	N	-	-	-	-	-	-	-	-	-	-
	S	-	2.75	4.68	-	-	-	-	-	-	-
17	N	-	-	-	-	-	-	-	-	-	-
	S	-	4.82	15.10	13.46	3.35	-	-	-	-	-
16	N	-	-	-	-	-	-	-	-	-	-
	S	-	2.90	9.07	8.44	8.17	5.40	3.61	2.64	1.66	0.57
15	N	-	-	-	-	-	-	-	-	-	-
	S	3.16	4.39	3.78	1.96	-	-	-	-	-	-
13	N	-	-	3.30	9.58	3.74	-	-	-	-	-
	S	10.50	14.42	11.66	2.27	-	-	-	-	-	-
12	N	-	-	1.55	13.33	4.08	-	-	-	-	-
	S	18.58	19.33	14.51	5.62	-	-	-	-	-	-
11	N	-	-	-	11.61	5.10	-	-	-	-	-
	S	10.18	8.72	5.46	0.33	-	-	-	-	-	-
10	N	-	-	-	7.31	4.71	-	-	-	-	-
	S	5.46	3.02	0.89	-1.33	-	-	-	-	-	-
9	N	-	-	-	5.46	5.09	-	-	-	-	-
	S	5.51	3.48	1.72	-1.82	-	-	-	-	-	-
8	N	-	-	-	7.17	4.57	-	-	-	-	-
	S	5.15	2.86	1.23	-1.20	-	-	-	-	-	-
7	N	-	-	-	6.54	4.15	-	-	-	-	-
	S	6.34	3.74	1.70	-0.34	-	-	-	-	-	-
6	N	-	-	-	4.44	2.16	-	-	-	-	-
	S	0.68	-1.32	-3.18	-4.96	-	-	-	-	-	-
5	N	-	-	-	-	-	-	-	-	-	-
	S	-0.88	-2.88	-5.31	-13.74	-	-	-	-	-	-
4	N	-	-	-	-	-	-	-	-	-	-
	S	-0.32	-2.33	-5.12	-9.92	-	-	-	-	-	-
3	N	-	-	-	-	-	-	-	-	-	-
	S	1.34	-0.99	-2.76	-1.22	-	-	-	-	-	-
2	N	-	-	-	-	-	-	-	-	-	-
	S	6.96	4.40	-0.76	-5.26	-	-	-	-	-	-
1	N	-	-	-	-	-	-	-	-	-	-
	S	7.80	4.28	-4.63	-3.23	-	-	-	-	-	-
Totals		**80.47**	**75.91**	**64.99**	**59.52**	**45.13**	**5.40**	**3.61**	**2.64**	**1.66**	**0.57**
									Sum of Totals		**339.88**

3.5 Viability of Level for Level Storage

The EA has confirmed that level for level storage is considered preferential when providing compensatory storage. The total volume of floodplain storage lost is 340m^3 as summarised above and is lost between a level of 63.8mAOD (lowest ground level) and 65.83mAOD (maximum predicted flood level).

An assessment of the availability of suitable land to provide the compensatory storage has been undertaken in the vicinity of the site. Throughout the process of identifying suitable locations for storage there are a number of key factors that have been considered that include:

- Storage is to be provided within the LOD boundary, as close as possible to the point of impact.
- Ensuring compensatory storage areas can be hydraulically connected to the floodplain.
- Identifying areas that can provide the required storage on a level for level basis.

Review of the levels and areas available locally within the LOD boundary indicate that insufficient area is available to provide level for level storage.

Outside of the LOD boundary, the area identified within Figure 10 has an area of 5,000m^2, indicating that this area has the potential to provide the level for level compensatory storage. Ground levels could be reduced on the left bank of the Langford Brook in order to accommodate some of the flood storage required. However this will impact a significant length of river corridor. Further consideration would also need to be given to impacts on the access track to Langford Park Farm.

As this area is outside the current LOD boundary, Chiltern Railways and Network Rail have no direct control over the land and therefore obtaining the necessary land agreements will not be possible within the project timescales.

In addition, this area is identified for use as compensatory storage as part of a residential development upstream and it is very unlikely that agreement could be secured for the use of this land.

As a result of this assessment the provision of level for level storage is not considered viable at this site.

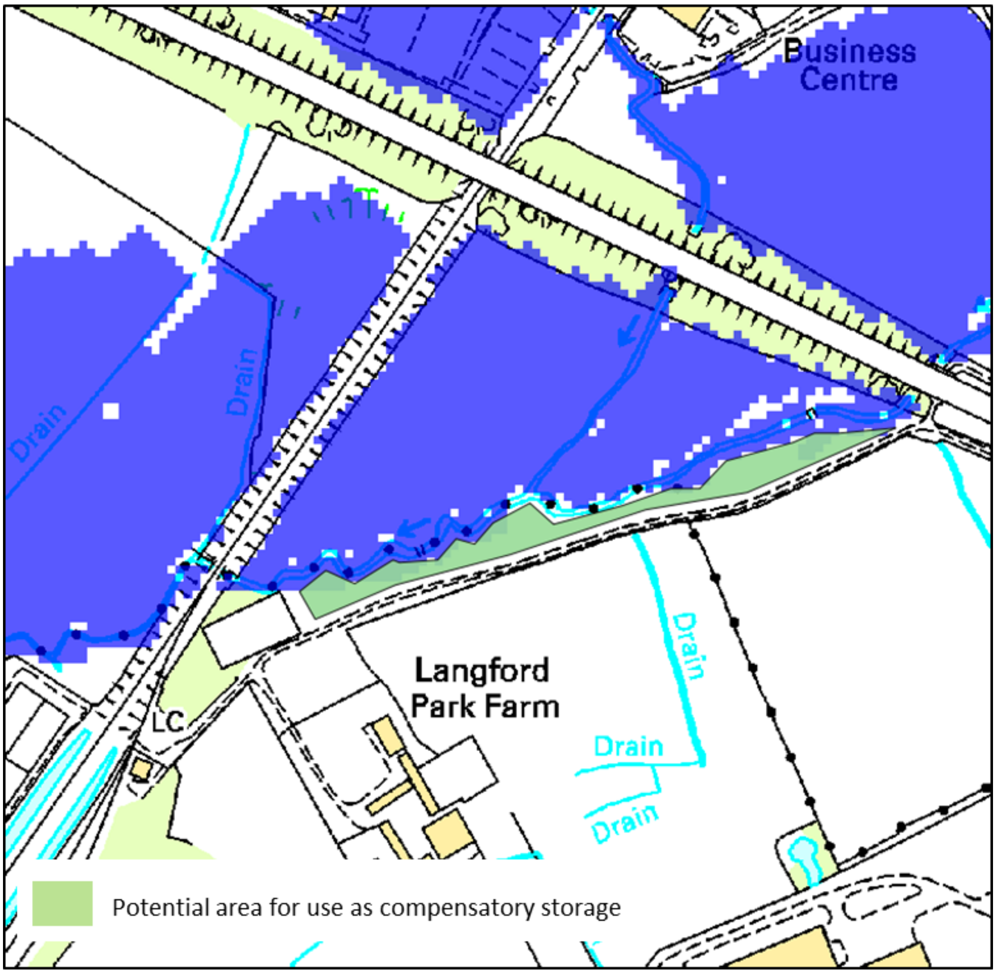

Figure 10 – Potential Area for Level for Level Flood Compensation Works, to the north of MOD Sidings

3.6 Volume for volume compensatory storage

As a result of the findings of the level for level analysis, volume for volume compensatory storage is considered to be the more viable option. This will be achieved through the provision of a shallow swale located adjacent to the A41 embankment to the east of the MOD embankment. The proposed location of the swale is shown in Figure 11. A swale immediately adjacent to the proposed railway embankment is not possible due to the presence of an existing Thames Water sewer. Although the proposed swale location is outside of the LOD boundary, the highways authority owns the land and is in the process of transferring land ownership to Network Rail. Although not the preferred EA method of compensation a significant degree of overcompensation could be provided.

The proposed swale would allow the provision of the required 700m^3 of storage and will have a trapezoidal shape. This is double the area of storage lost as a result of the development. The depth of the swale will be between 0.5m and 1m in depth. The swale will be connected to the watercourse via an open outfall. The outfall invert will be approximately 400mm above the river bed. The proposed design for the swale is provided within Appendix 4 of this report.

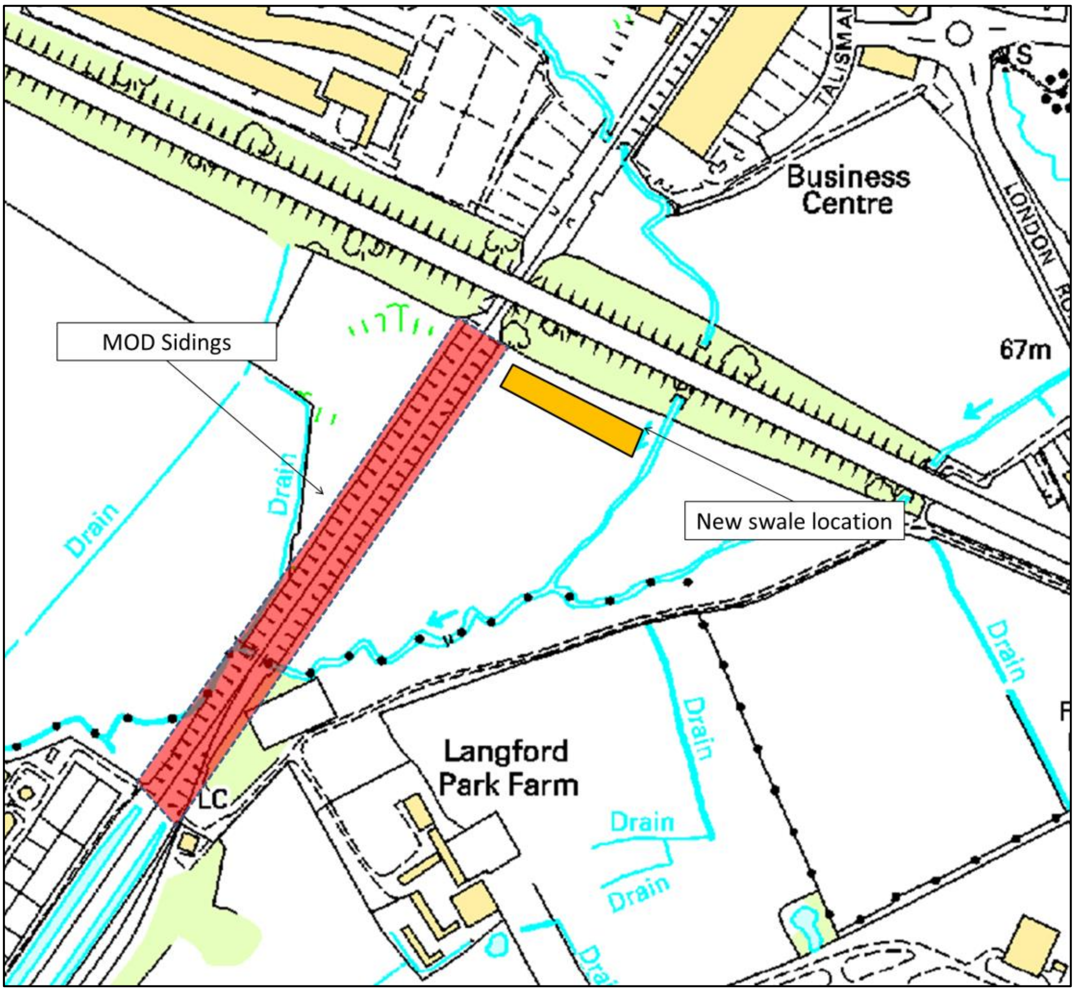

Figure 11 – Approximate Location of Proposed Swale in Relation to the MOD Sidings.

3.7 Modelling Flood Consequence of the Proposed Development

Flood modelling has been undertaken to assess the impacts of the proposed development, including the volume for volume compensatory storage, on flood risk in the surrounding area. Flood impacts have been considered during the 1 in 100 year plus climate change event. This section considers the results of the flood modelling rather than the model construction. For more detail in regards to how the development was modelled refer to Appendix 1.

3.7.1 Impact on 1D (River) Levels

Figure 12, outlines the location of a number of 1D node points located upstream and downstream of the proposed development site. Table 2 presents the predicted change in 1D levels as a result of the development. The maximum increase in flood levels is predicted to be 0.02m. This is localised, with no increase predicted upstream of the A41. As such the proposed development does not cause any significant increase in 1D flood levels.

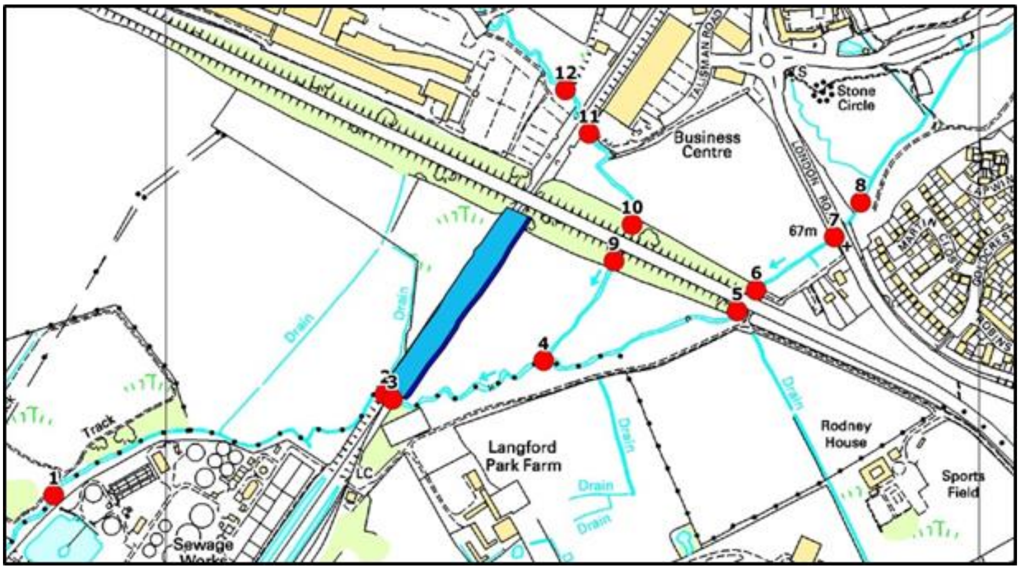

Figure 12 – 1D Assessment Locations (as referenced in Table 2), location of works highlighted with blue shading.

Table 2 – Maximum Predicted Levels Pre and Post Embankment Widening within the 1D Model.

1D Node Point	1 in 100 + CC max level		
	BSC	Swale	Change
1	64.52	64.52	**0.00**
2	65.37	65.39	**0.02**
3	65.37	65.39	**0.02**
4	65.83	65.84	**0.01**
5	66.07	66.08	**0.00**
6	66.14	66.14	**0.00**
7	66.28	66.28	**0.00**
8	66.38	66.38	**0.00**
9	65.87	65.87	**0.01**
10	66.00	66.00	**0.00**
11	66.29	66.29	**0.00**
12	67.02	67.02	**0.00**

3.7.2 Impact on Flood Extent

Analysis of the change in flood extent was undertaken to assess the potential impact of the development. Figure 13 shows the predicted change in flood extent. As shown there is a minimal increase in flood extent immediately downstream of the embankment as a result of the slight increase in 1D levels predicted at this location. This is not considered to be significant.

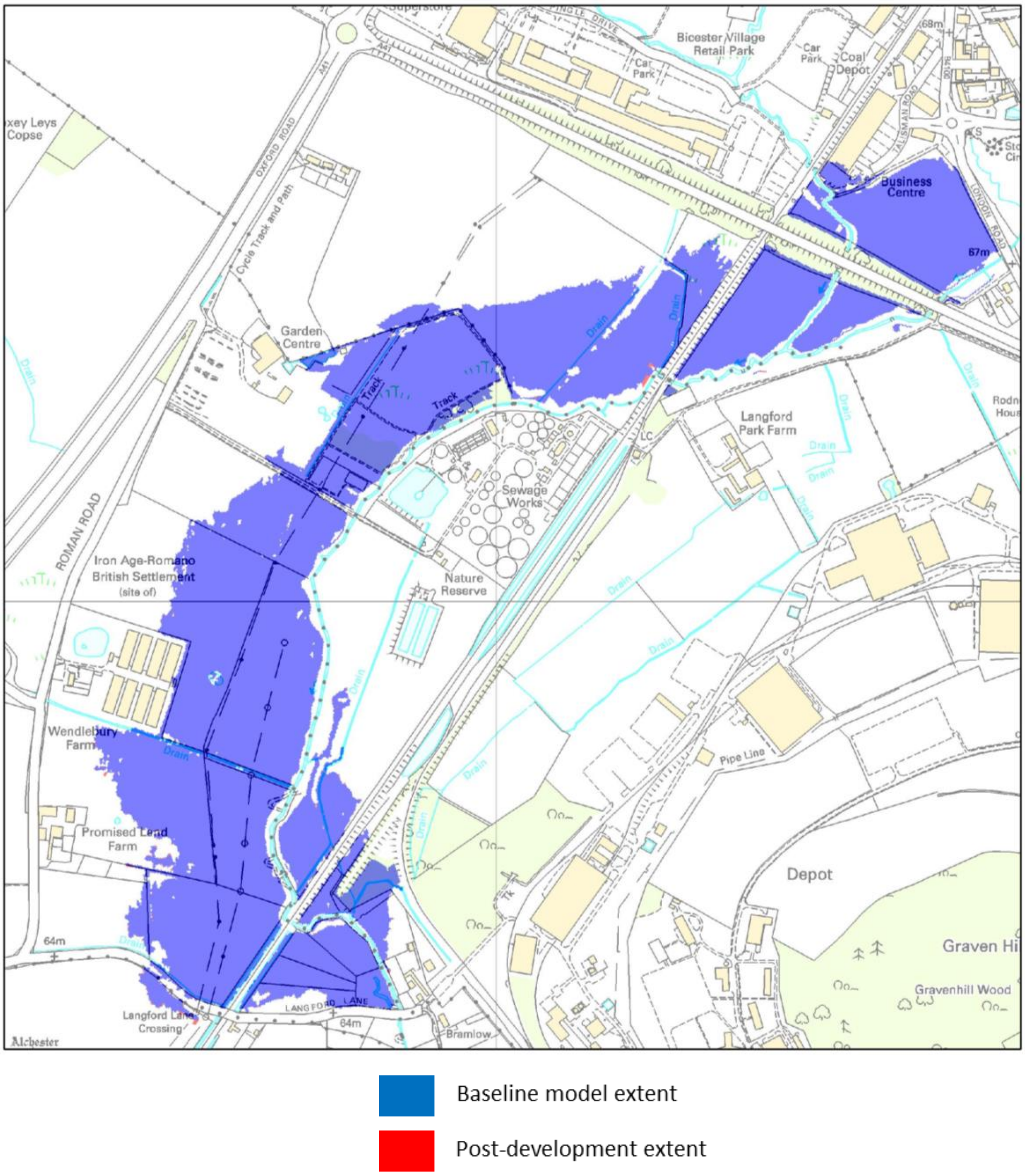

Figure 13 – Predicted Change in Flood Extent as a Result of the Development during the 1 in 100 Year plus Climate Change Event.

3.7.3 Impact on 2D (Floodplain) Levels

Figure 14 outlines the predicted level change across the 2D domain. Figure 15 shows the location of seventy assessment points within the 2D floodplain used within the analysis. As shown in

Table 3, the water levels in the 2D domain increase by a maximum of 0.01m (outside of the location of the swale) and are restricted to rural areas and green fields. There is a small predicted decrease in flood levels immediately downstream of the railway embankment. As such the proposed development is considered to cause no significant increase in flood levels with the provision of the proposed swale.

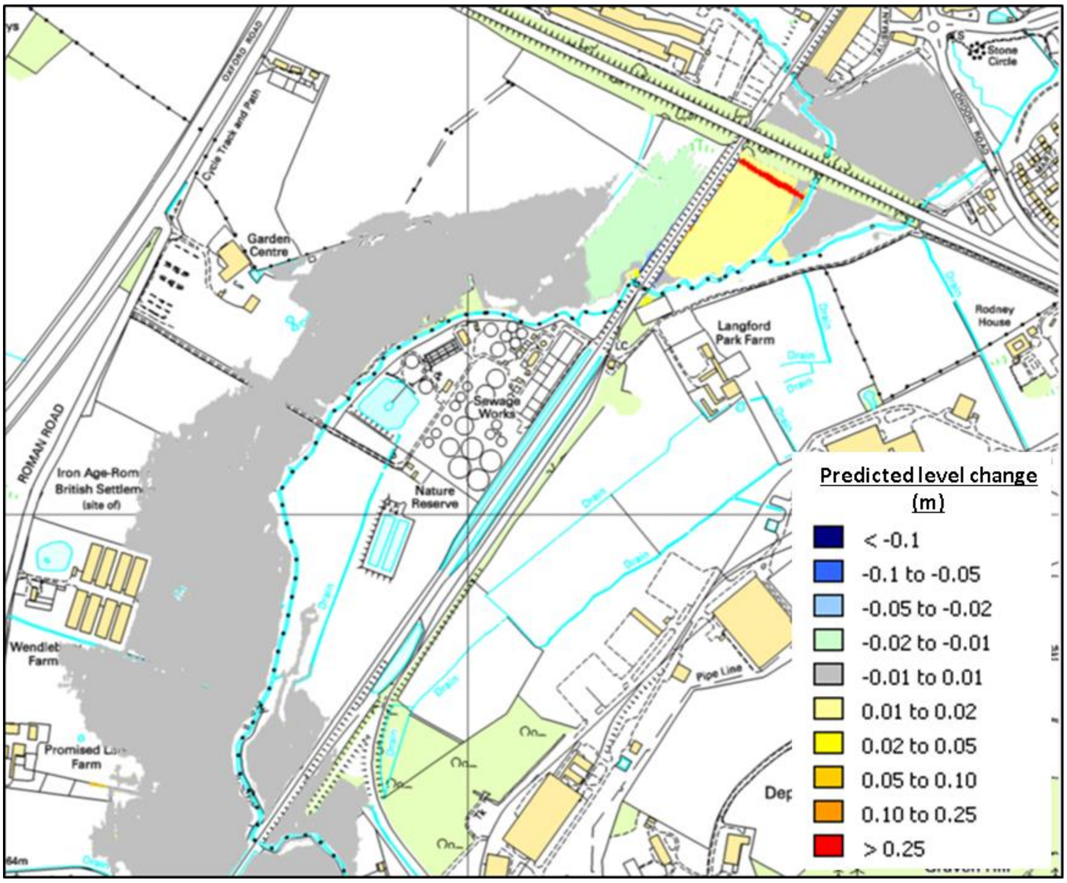

Figure 14 – Predicted Change in Flood Level as a Result of the Development during the 1 in 100 Year plus Climate Change Event.

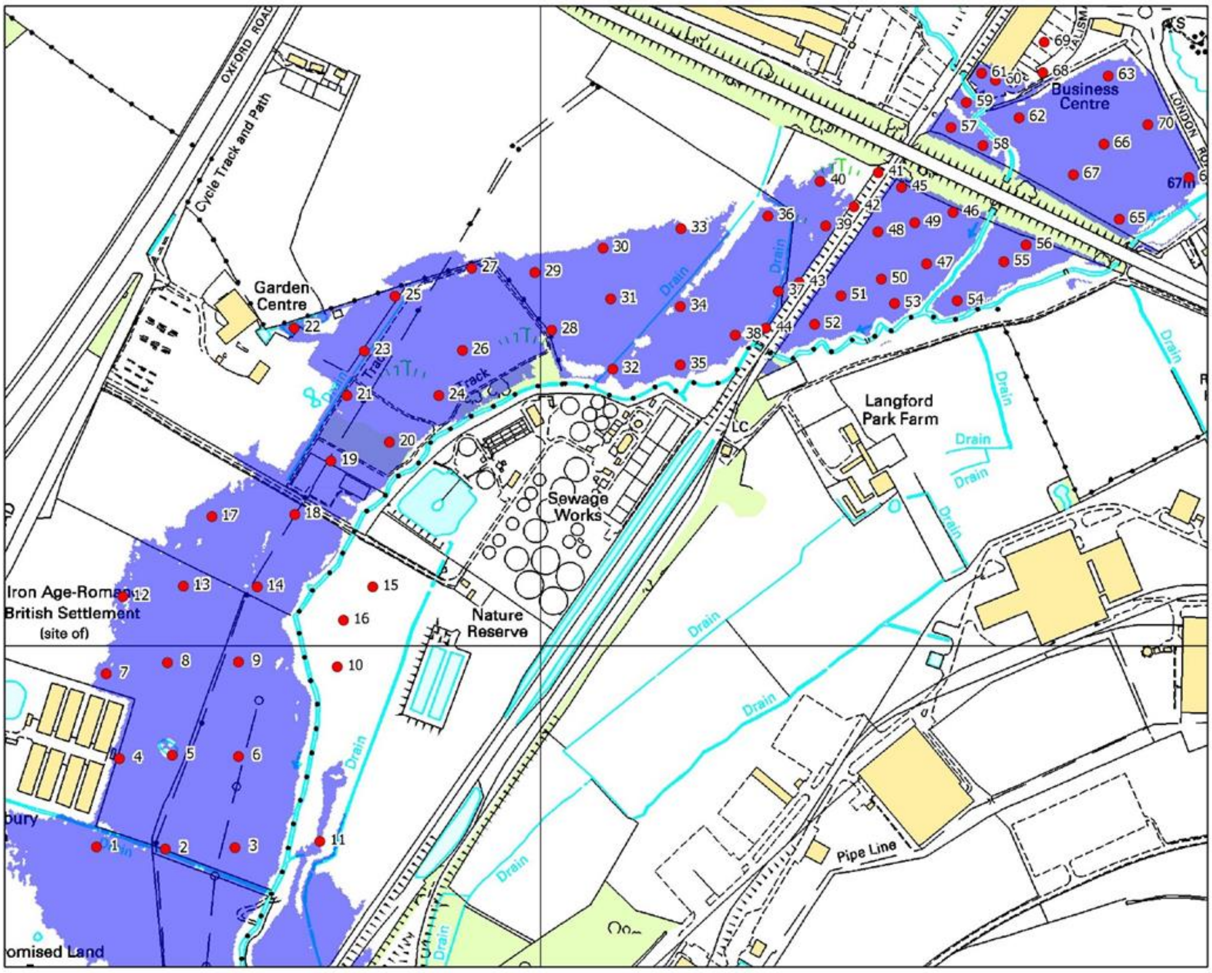

Figure 15 – 2D Comparison Points

Table 3 – Maximum Predicted Levels Pre and Post Embankment Widening within the Floodplain.

Maximum 2D water depth (m)				Maximum 2D water depth (m)			
2D Sample Point	1 in 100 year + CC max level (mAOD)			2D Sample Point	1 in 100 year + CC max level (mAOD)		
	Pre	Post	Diff		Pre	Post	Diff
1	0.330	0.333	0.002	36	0.251	0.238	-0.013
2	0.201	0.203	0.002	37	0.441	0.427	-0.014
3	0.281	0.283	0.002	38	0.122	0.111	-0.010
4	0.199	0.200	0.002	39	0.098	0.085	-0.013
5	0.170	0.172	0.002	40	0.059	0.046	-0.013
6	0.224	0.226	0.002	41	-	-	-
7	0.060	0.062	0.002	42	-	-	-
8	0.141	0.141	0.001	43	-	-	-
9	0.075	0.075	0.001	44	0.394	0.135	-0.259
10	-	-	-	45	0.680	1.285	0.605
11	0.164	0.171	0.007	46	0.583	0.596	0.012
12	0.042	0.043	0.000	47	0.501	0.514	0.012
13	0.169	0.170	0.000	48	0.759	0.772	0.013
14	0.095	0.095	0.000	49	0.646	0.659	0.013
15	-	-	-	50	0.724	0.736	0.012
16	-	-	-	51	0.814	0.827	0.013
17	0.093	0.093	0.000	52	0.799	0.812	0.013
18	0.079	0.078	0.000	53	0.582	0.595	0.012
19	0.167	0.167	0.000	54	0.617	0.627	0.010
20	0.261	0.261	0.000	55	0.368	0.376	0.009
21	0.109	0.108	-0.001	56	0.363	0.371	0.008
22	0.416	0.416	-0.001	57	0.425	0.429	0.004
23	0.334	0.333	-0.001	58	0.365	0.369	0.004
24	0.253	0.252	-0.001	59	0.141	0.141	0.000
25	0.024	0.023	-0.001	60	0.572	0.573	0.001
26	0.277	0.276	-0.001	61	0.408	0.409	0.001
27	-	-	-	62	0.230	0.232	0.002
28	0.197	0.196	-0.001	63	0.167	0.169	0.002
29	0.296	0.295	-0.002	64	0.350	0.352	0.002
30	0.144	0.141	-0.003	65	0.562	0.564	0.002
31	0.170	0.167	-0.003	66	0.564	0.567	0.002
32	0.819	0.824	0.005	67	0.533	0.535	0.002
33	0.062	0.057	-0.005	68	-	-	-
34	0.147	0.138	-0.009	69	-	-	-
35	0.199	0.190	-0.009	70	0.533	0.535	0.002

4 Infilling of Surface Water Ditch

4.1 Methodology

This section outlines the methodology used in undertaking the flood impact assessment for the infilling of a surface water ditch as a result of the embankment widening. The flood modelling results were analysed to consider whether the ditches are considered to lie within the flood extent and therefore hydraulically connected to the river. If this is not the case then no compensatory storage would be required. A walk over survey was also undertaken by Atkins to confirm any potential hydraulic connectivity with the main river.

4.2 Analysis

Maximum flood event extents were considered for the 1 in 100 year plus climate change, and 1 in 1000 year events. The results were extracted from the updated hydraulic model (Appendix 1). As shown in Figure 16, the ditches which are required to be partially in filled are not located within the flood extents of either event. No culvert connections or drainage channels from this ditch have been identified by Atkins following their walkover survey, and as such the ditches are not considered to be hydraulically connected to the watercourse or its floodplain.

The evidence also suggests that the ditches do not perform any drainage function as there are no observed connections to or from the ditches and were observed to contain standing water. Figure 17 is a photograph of the northern surface water drainage ditch showing the structure of the drainage ditch raised up above the floodplain. It has been suggested by the designers, Atkins, that the ditches were created as excavations to generate fill material for the railway embankment when it was originally constructed 150 years ago. The proposed works will include the construction of shallow ditches along the alignment of the existing ditches, which will be used to convey Greenfield run-off from the railway embankments.

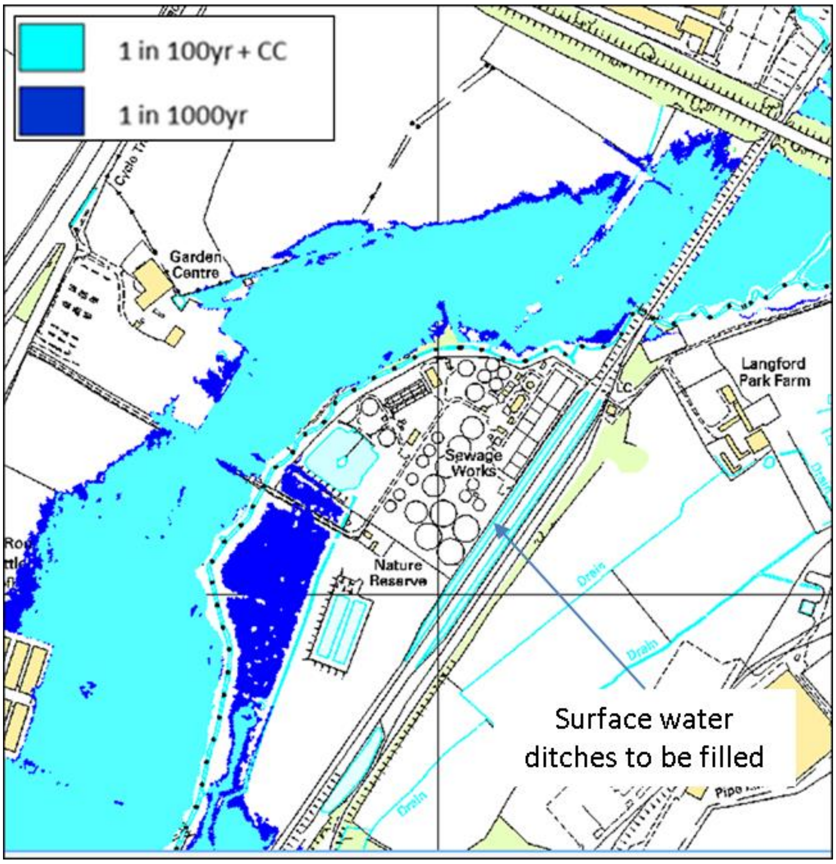

Figure 16 – 1 in 100 Year plus Climate Change and 1 in 1000 Year Flood (outline highlighted in relation to the ditches which will be partially filled). Flood modelling results taken from the WHS updated model based on the existing EA hydraulic model, undertaken by Peter Brett Associates.

Figure 17 – Photograph of the Northern Surface Water Drainage Ditch to be Partially Filled, taken from within the ditch – Atkins, 2013.

4.3 Summary

As the ditches are not hydraulically connected to either the main watercourse or its active floodplain, floodplain compensatory storage is not required. It has been concluded from the surveys that the existing ditches do not perform any significant drainage functions. Shallow ditches will be re-provided along the current ditch alignment as part of the railway line drainage infrastructure.

5 Conclusions

The key conclusions of this FRA are as follows:

- The proposed MOD Sidings embankment widening would lead to a reduction in floodplain storage, initially assessed to be a loss of around 2000m^3, but this has been mitigated down to 340m^3 through the use of retaining structures.

- Due to the ground levels and the flat nature of the catchment, flood storage compensation on a level for level basis cannot be achieved.

- As a result, volume for volume compensation is proposed in the form of a swale. Over compensation to a volume of 700m^3 will be provided.

- Flood modelling has shown that no significant impact is caused with regard to flood risk upstream or downstream of the proposed works.
- The infilling of the ditches in the centre of the proposed development site will not have any impact on flood storage as it is located outside of both the 1 in 100 plus climate change, and 1 in 1000 year flood outline. Although the ditches do not perform any significant drainage function, shallow ditches will be provided along the same alignment to allow for drainage of the railway embankment.

5.1 Future Considerations

A 'Works Approval' is to be submitted separately in due course for the proposed works in this area, under the provisions of Schedule 15 of the TWA Order. Works Approvals will also be required for any temporary works within 16 metres of the Langford Brook or within flood zones 2 and 3.

There are some points that need to be considered by the contractor in relation to the temporary works required during the construction phase of the MOD Sidings embankment widening. These include:

- All compounds, stockpiles and other works will need to be kept outside Flood Zones 2 & 3 and be sited within Flood Zone 1.
- All temporary haul roads within Flood Zones 2 and 3 will need to be kept at grade to avoid any requirement for compensatory flood storage.
- All roads should be constructed with a permeable hard-core or stone surface to avoid increasing the impermeable footprint of the site.

Chiltern Railways and Network Rail will submit applications for the permanent Works Approvals and the Contractor will submit applications for temporary works approvals, where necessary.

Appendix 1 – Updated Hydraulic Modelling

Appendix 2 – Flood Hydrology

Appendix 3 – Proposed Embankment Cross Sections

Note: Flood level shown on designs is for guidance only.

Appendix 4 – Swale Design Sketch