East West Rail Phase 2

Pavement Assessment Report for Oxfordshire Council

EWR Alliance

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Document History

PROJECT NUMBER: 133735			DOCUMENT REF: 133735_RW-EWR-XX-XX-RP-CH-000041			
B01	For LHA Approval	Z. Ahmed	W. Zou	M. Wright	J. Baldock	15/11/19
Revision	**Purpose Description**	**Originated**	**Checked**	**Reviewed**	**Approved**	**Date**

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Executive Summary

This report describes the development of a pavement treatment implementation strategy in preparation for East West Rail Phase 2 (EWR2) construction works within Oxfordshire. This process is made up of four main stages: pavement surveys; construction traffic data assessments; pavement condition assessments; pavement treatment recommendations. The report describes the methodology, constraints and assumptions for each of these stages.

A numerical summary of the results of the proposed pavement implementation strategy is included in Table 1 and Figure 1 below. Detailed results of the proposed pavement implementation strategy have been included in Appendix G and Appendix H.

Table 1 Proposed pavement treatment areas (m^2)

Estimated Treatment Area (m^2)		
No Treatment	**100mm Inlay/ Overlay**	**250mm Full Depth Reconstruction**
83,428 (90.8%) †	5,821 (6.3%)	2,622 (2.9%)

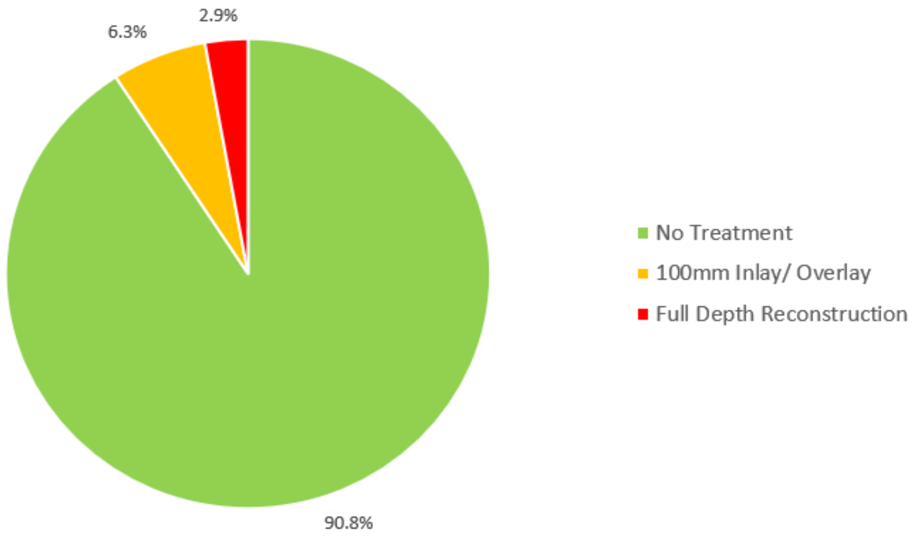

Figure 1 Proposed pavement treatments area (in percentage)

1. Introduction

1.1.1. East West Rail Phase 2 (EWR2) has been proposed to improve the rail links between Bicester-Bletchley-Bedford and Aylesbury-Claydon Junction. In order to construct EWR2, there will be a requirement to deliver material and remove waste or transport it to other sites during the construction phase. A significant proportion of construction generated traffic will be via the existing local road network which was not originally designed to be exposed to the heavy traffic expected to be generated by EWR2. This presents a number of risks to EWR2 and associated stakeholders, which include but are not limited to:

- Roads may wear at a higher rate than their current rate or they may suffer failure as a result of excessive loading;
- The construction traffic might not be able to access the sites as a result of any failures; and
- The public may be inconvenienced due to poor or failing roads.

1.1.2. EWR2 philosophy of approach is to act early in order to avoid delay during works to EWR2 and to local residents and road users. This is the key reasoning for undertaking advanced maintenance works.

1.1.3. Therefore, there is a need to define a survey methodology to accurately assess the current (pre-construction) condition. To help inform the methodology and potential risks, an initial overview assessment of the construction traffic and construction route pavement condition has been undertaken. The pavement condition surveys comprised of a Video and Ground Penetrating Radar (GPR) survey. The objective of these initial surveys was to provide an indication of the pavement construction and to identify surface defects in order to:

- Identify those lengths (sections of the routes) that might be at risk of premature failure during the construction phase;
- Provide a factual record of the surface condition to enable deterioration that takes place during construction to be tracked and quantified; and
- Minimise the risk of premature failure during construction. This includes identifying where early intervention could take place during the construction phase to reduce the likelihood of failure during construction.

1.1.4. This report has been prepared to establish the level of EWR2 construction trafficking and to provide a baseline condition of pavements within the EWR2 construction route network where the overseeing authority is Oxfordshire County Council. The report also provides an initial treatment recommendations where early intervention could be beneficial to reduce the likelihood of failure during construction for target price budgetary purposes for the Oxfordshire County Council network only. This report has also been submitted for approval to comply with an element of planning condition 14 of the Transport and Works Act Order (TWAO).

1.1.5. The construction route network and pavement survey approaches are described in Section 2 of this report. In Section 3, the pavement traffic loading generated from EWR2 construction works is assessed. In Section 4, the pavement assessment methodology (budgetary purpose) to assess the pavement condition based on available video and GPR survey information is presented. The analysis and results of the survey data available are presented in Section 5. The initial pavement treatment methodology and recommendations for budgetary purpose is presented in Section 6. The conclusion and recommendations are presented in Section 7 of the report.

2. Survey Network and Pavement Survey Methodology

2.1. Survey Network

2.1.1. Within the EWR2 construction route network 85 pavement links have been selected by EWR2 for a network level pavement condition assessment. The majority of these links are classified as “HGV/LGV Construction Access Route” according to the survey extent shapefile provided. These “HGV/LGV Construction Access Routes” are sections of highway which may potentially be used by Heavy Goods Vehicles (HGVs) and Large Goods Vehicles (LGVs) to access the EWR2 construction works.

2.1.2. In Oxfordshire, there are 9 pavement links, including links 23, 24, 25, 30 (from chainage 0 to 2100), 83, 102, 103, 104 and 225. Pavement links 24, 83, 103 and 104 represent the trunk road sections of the A4421 and B4100. These were excluded in the original 85 pavement survey links selected by EWR Alliance in 2018; however, at the request of Oxfordshire County Council on 28th March 2019, these four links have been included in this report.

2.1.3. 1 link has been excluded from the pavement assessment. This is as per the pavement treatment methodology outlined in Figure 15. See Appendix B for further details.

2.1.4. The total length of all 9 routes is 9.47 lane-km for the non-trunk routes and 19.60 lane-km for trunk routes. Their details are presented in Appendix A of this report and is shown in Figure 2.

Figure 2 EWR2 Survey Network Located in Oxfordshire

2.2. Pavement Survey Methodologies

2.2.1. The pavement surveys for the network level assessment included a driven video and GPR survey. This rapidly provided pavement construction and surface condition information prior to intrusive assessment such as coring. Further details on the survey methodology is provided in the sections below.

Visual Condition / Inventory Video Survey

2.2.2. Traditionally visual condition surveys are undertaken by a survey team who would walk the network and record defects in the road (e.g. cracking, crazing, surface defectiveness, etc.) and highway inventory items (e.g. carriageway edge details, road widths, etc.). A video survey is a much safer way to collect this information as it allows the defects and inventory of the existing road to be established digitally and without the need to send surveyors out on foot.

2.2.3. With up to 8 digital video cameras mounted on a light commercial vehicle, the high-resolution images of pavement defects can be captured from varied directions (frontwards, backwards, downwards, etc.) at traffic speed (0-70 mph). All data is stored digitally and then processed and packaged in bespoke client specified software for in-depth analysis and interpretation. Accurate in-frame measurements are facilitated by way of measurement calibrations carried out at the start and end of each day survey to ensure the consistency.

2.2.4. Due to the collection speed, no traffic management is required and there is less disruption to the road users and lower health and safety risks for the surveyors. Additionally, because all pavement defects are captured in terms of images stored digitally, it is convenient for all parties to re-visit this data to ensure the accuracy and consistency of the defect records.

Ground Penetrating Radar (GPR)

2.2.5. Ground Penetrating Radar (GPR) is a non-destructive tool that can be used to obtain information about the thickness and material details within a pavement structure. It uses radio waves to obtain thickness and material details within the pavement, as illustrated in Figure 3 below.

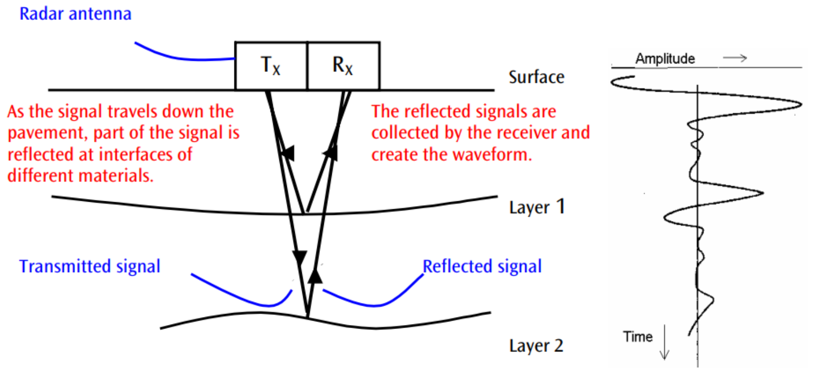

Figure 3 Example of Radar Signals at Pavement Interfaces

2.2.6. As per the requirement of clause 6.33 in Design Manual for Roads and Bridges (DMRB) HD 29/08, cores must be taken following the initial analysis of the GPR data when changes in construction and layer thicknesses have been identified and located. Coring must be carried out in areas where the material appears to be homogeneous in both quality and thickness. The details of GPR calibration process against the cores, where appropriate, are described in Annex 6B in DMRB HD 29/08.

2.3. Impulse Geophysics Data Collection and Processing

2.3.1. In August 2018, Impulse Geophysics undertook video and GPR survey of the 85-pavement links within the whole EWR2 network.

Data Collection

2.3.2. A survey vehicle similar to the one shown Figure 4 was used during the survey. The equipment listed below is mounted on the survey vehicle to allow the video and GPR survey to be undertaken simultaneously with Global Positioning System (GPS) information embedded. The survey vehicle is self-contained and operates at traffic speed without the need for traffic management.

- 1-8 × 4k High Definition (HD) Digital Video Cameras;
- 1-8 × Manfrotto SuperClamps
- 1 × Laptop
- 1 × Trimble Differential GPS (DGPS)
- 1 × Distance Measuring Device
- 1-3 × GPR Antenna + Receiver

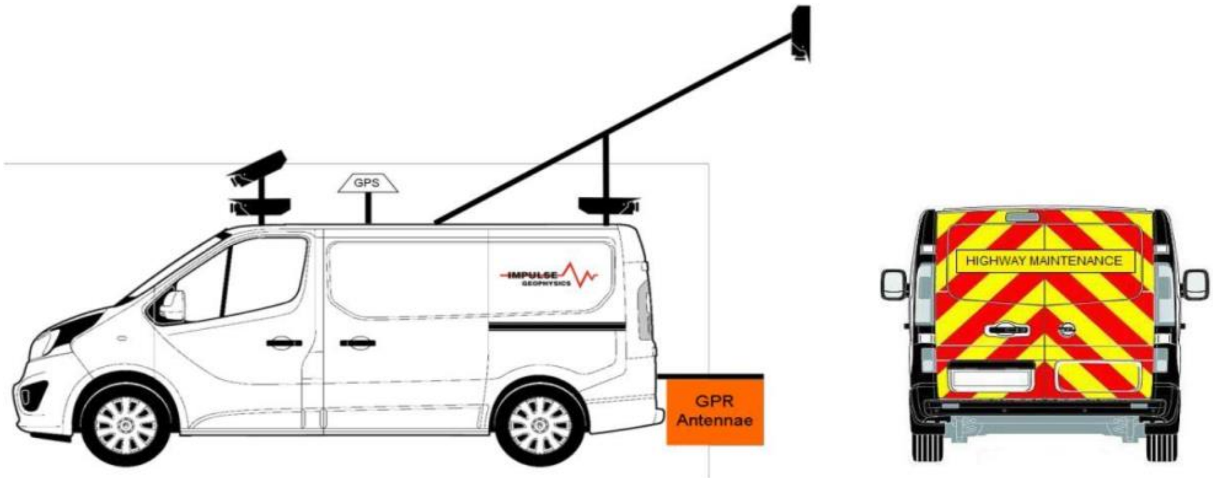

Figure 4 Impulse Geophysics Survey Vehicle

Data Processing

2.3.3. During the collection of the GPR information, an impulse radar auto-calibration was undertaken simultaneously. The Common Depth Point (CDP) method has been adopted in the auto-calibration. A radar antenna array has been used to collect data from varying offsets (illustrated in Figure 5). By analysing the data from each antenna pair, the radar signal velocity of the material can be found and, thus, obtain the depth. However, it must be noted that cores are still required for the confirmation of pavement depth and accurate identification of the material types.

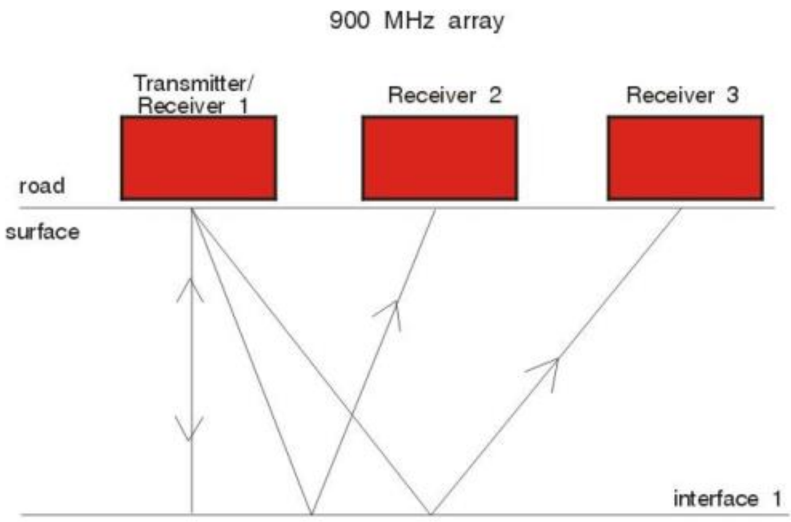

Figure 5 Auto-Calibration Method: Common Depth Point (CDP)

2.3.4. The 4k HD video tracks of the pavement surface, collected by the survey vehicle was process and the video redacted to comply with General Data Protection Regulations. The video can be viewed in Impulse's Roadshow software (as illustrated in Figure 6) and the following information can be procured and recorded by data analysts via Roadshow:

1. Inventory information (e.g. surface type, carriageway width, extent, location, etc.); and
2. Defects information (e.g. defects type, extent, location, etc.)

2.3.5. Both the extent and location were recorded by survey chainage, section chainage and GPS coordinates in the software. The procured records output is in .csv format and used for the pavement condition assessment described in section 3.

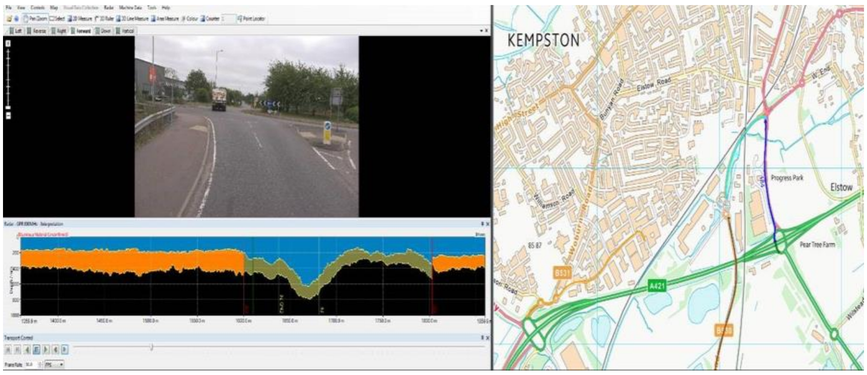

Figure 6 Example of Data Processing Software "Roadshow"

3. Construction Traffic Data Assessment

3.1. Introduction

3.1.1. An assessment of the construction traffic flow data has been undertaken to assess the pavement traffic loading for each construction route. Analysis of the construction traffic data determined the level of traffic expected to be generated by EWR2 and identified the sites with greatest potential risk.

3.2. Traffic Data Sources

3.2.1. Construction traffic flow data has been provided by the EWR2 Alliance, for the purpose of the Traffic and Works Act Application. This included construction trip generation by compound, a construction programme which determined the start dates and durations of construction activity for each compound, local access point and structure, and designated Construction Access Routes that will be used by HGVs.

3.2.2. 2017 baseline traffic data has been generated by traffic surveys from a variety of sources, including:

- Temporary traffic count surveys undertaken as part of the EWR2 Transport Assessment (TA) – primary
- Temporary traffic count surveys undertaken by the relevant local highway authorities – secondary
- Temporary traffic count surveys undertaken by HS2 – secondary
- Highways England permanent count sites along the Strategic Road Network – secondary

3.2.3. 2017 baseline traffic flows were factored to 2020 to account for growth in future background traffic, using TEMPRO growth factors for each local authority area. The assessment year 2020 was selected as this is the time when the Project is predicted to generate the highest number of construction trips across the transport construction study area.

3.2.4. Reasonably Foreseeable Future Projects (RFFPS) have also been considered as part of the baseline, to consider additional traffic generated by local developments in 2020. RFFPs considered included the following:

- Major developments within 500m of the railway line (consisting of more than 10 dwellings, commercial/recreational floorspace over 1,000sqm, or 1ha of land)
- Planning applications granted planning permission or pending determinations since 1st July 2014, reflecting the 3-year period within which granted developments must commence works
- HS2 Phase 1 construction traffic flows

3.2.5. In terms of cumulative traffic flows, data was gathered from Local Authority strategic traffic models. These traffic models account for future year developments and transport schemes across the transport construction study area, many of which will not have been identified in the Project's list of RFFPS. The following models have been consulted:

- Milton Keynes Multi-Modal Model (SATURN)
- Aylesbury Transport Model (VISUM)
- Bicester Transport Model (SATURN)
- Bedford Town Centre Transport Modelling (SATURN)

3.3. Pavement Traffic Assessment

3.3.1. Based on the traffic flow data provided, the commercial vehicle traffic for all 85 construction route links have been assessed in terms of:

- The pavement traffic loading generated by the EWR2 construction commercial vehicle loading for the 5 years construction period;
- The commercial vehicle traffic loading generated by other sources within 5 years construction period, including current authority traffic and HS2 and committed development construction traffic.

3.3.2. The traffic loading has been calculated in accordance with DMRB HD24/06 over the 5-year construction period. A wear factor 3.0 has been assumed for all commercial vehicles in the calculation. This is based on HD24/06 Table 2.3 assuming all commercial vehicles are OGV2 and assuming a maintenance design. This is a conservative assumption.

3.3.3. The total million standard axles (msa) generated from EWR2 was calculated. The percentage of EWR2 traffic loading relative to the total commercial vehicle loading was also generated for each individual pavement link. The data is presented in Table 2 and Appendix B, the data has been broken down as shown in the table so that it can be more easily compared against the flowchart in Figure 15.

Table 2 EWR2 Design Traffic Summary for Pavement Routes within Oxfordshire

EWR2 Commercial Design Traffic/Total Commercial Traffic	Traffic Loading Generated by EWR2 Construction Flow			
	<=0.2msa	0.2msa - 0.5msa	0.5msa-1msa	1msa+
0-25%	1†	1†	2*	0
25-50%	0	0	0	0
50-75%	0	2	0	0
75-100%	0	0	3	0

Notes:

*: Traffic links representing the B4100.

†: Traffic links representing the A4421

3.3.4. The analysis in

3.3.5. Table 2 and Appendix B demonstrates that:

- The traffic generated by EWR2 within the 5-year construction period are less than 1.0 msa for all 5-pavement links;
- 3 links have an EWR2 commercial vehicle traffic loading of between 0.5msa-1msa over the 5-year period, accounting for 75-100% of all commercial vehicle loading in those routes;
- 2 links have an EWR2 commercial vehicle traffic loading between 0.2msa-0.5msa and equates to 50-75% of all commercial vehicle loading in those routes;
- 4 links represent the A4421 and B4100 and the corresponding traffic for these links are less than 25% of all commercial vehicle loading in those routes.

Overall, it was concluded that the EWR2 construction traffic in Oxfordshire is variable on a link by link basis but is all between 0.2msa and 1.0 msa over a 5-year period.

4. Pavement Condition Assessment Methodology

4.1.1. In order to assess the condition of the network in advance of EWR2 construction, a Stage 1 pavement assessment methodology has been established in this report. The methodology has the following primary objectives:

- To provide an indication of the pre-construction condition of the network;
- To identify those lengths (sections of the routes) that might be at risk of premature failure during the construction or may have already failed. Therefore, appropriate inventions may need to be undertaken before exposure to heavy vehicles (pre-construction strengthening); and
- To provide a factual record to track and quantify the deterioration that takes places during construction, which could be used to determine whether the defects being observed result from the EWR2 construction or not.

4.1.2. The overall pavement condition of the EWR2 network has been determined by combining surface and structural condition indicators as outlined in this Chapter.

4.2. Surface Condition Assessment

4.2.1. A surface condition assessment has been undertaken to assess the overall surface defects to determine the pre-construction pavement surface condition. This enables appropriate maintenance works to be identified and undertaken before and / or during construction.

4.2.2. To identify the sections that might be at risk of premature failure and to obtain an indication of pavement condition across the network, the risk categories illustrated in Table 3 have been adopted.

Table 3 Pavement Surface Condition Risk Categories

Sound (Green)	Limited Risk (Amber)	At Risk (Red)
Sound and not likely to require a surface maintenance intervention	Adequate but could potentially require a maintenance intervention	Likely to be inadequate and may fail due to EWR2 construction traffic

4.2.3. The Surface Condition Index calculation is based on the defects observed from the video survey which were considered in terms of:

- Road edge condition (for bituminous pavements only); and
- Road visual condition.

4.2.4. The video data was analysed in accordance with UK Pavement Management Systems (UKPMS) Course Visual Inspection (CVI) user manual. Aspects of the analysis, such as the Edge Indicator Calculation, have been undertaken in accordance with UKPMS Detailed Visual Inspection (DVI) user manual.

4.2.5. The following types of defects observed from the video survey have been selected to calculate the road edge and visual conditions:

Flexible Pavements

Road Edge Condition

- Edge Deterioration Severity 1(Minor) at Left Edge (BLE1);
- Edge Deterioration Severity 2(Major) at Left Edge (BLE2);
- Edge Deterioration Severity 1(Minor) at Right Edge (BRE1); and
- Edge Deterioration Severity 2(Major) at Right Edge (BRE2).

Road Visual Condition

- Wheel Track Cracking (BCRW);
- Major Area Cracking (BCHJ);
- Major Fatting (BFAJ);
- Major Surface Defectiveness (BFEJ);
- Pothole (BPHO);
- Major Transverse Crack (BTCK); and
- Subsidence (BSES).

Rigid Pavements

Road Visual Condition

- Concrete Defective Seal (Transverse) (NDFS);
- Concrete Defective Seal (Longitudinal) (NDLS);
- Concrete Joint Defectiveness (Transverse) (NFLT);
- Concrete Joint Defectiveness (Longitudinal) (NJDF);
- Concrete Surface Defectiveness (NSCR);
- Concrete Settlement (NSTM); and
- Concrete Cracking (NCRA).

Block Paving

Road Visual Condition

- Block Paving Major Block Deterioration (KSBD).

4.2.6. The visual condition assessment and edge condition assessment were combined to obtain a single Surface Condition Index. The details of the proposed calculation approach used are described in Appendix C.1 of this report.

4.3. Structural Condition Assessment

4.3.1. The structural condition assessment of the road pavement is used to indicate whether the pavement is structurally adequate and / or is capable of carrying significant levels of Heavy Goods Vehicles (HGV).

4.3.2. To identify sections that may be at risk of premature structural failure four risk categories, as illustrated in Table 4, have been adopted. These have been used to obtain an indication of pavement structural condition across the network.

Table 4 Pavement Structural Condition Risk Categories

Sound (Green)	Limited Risk (Amber)	Potential Risk (High Amber)	At Risk (Red)
Structurally sound and not likely to require structural maintenance intervention.	Structure is likely to be adequate but may require maintenance intervention.	Structure may be inadequate and may require maintenance intervention.	Structurally inadequate - design thickness is insufficient by current design standards or there are extensive structural defects present.

4.3.3. The structural condition assessment is made up by combining the pavement construction and the structural defects calculation as presented in Appendix C.5.3. 1.1.1.1.1C.5.3C.5.3

Pavement Construction Threshold

4.3.4. The existing pavement construction thickness forms a key part of the structural condition assessment. This is based on the principal that a designed pavement construction of significant thickness will be able to support the anticipated commercial vehicle traffic and be less susceptible to structural deterioration. In contrast, a thin pavement will be unable to spread the pavement loading and will be highly susceptible to damage under commercial vehicle trafficking.

4.3.5. Pavement construction thickness thresholds have therefore been established to enable the risk of applying EWR2 construction traffic to pavement be assessed.

4.3.6. Where a fully flexible pavement is greater than 270mm or a rigid pavement is above 250mm the pavement has been assessed to be “Sound” and likely to be able to support the EWR2 construction traffic. This threshold was selected based on HD 26/06 on a typical design traffic of 9msa over the 5-year construction period. This was selected as a conservative approach based on the maximum potential EWR2 traffic and existing commercial vehicle traffic.

4.3.7. Where the pavement construction thickness is below 200mm, the pavement is considered to be “Potential Risk” or at “At Risk” (depending on the level of structural defects present) under EWR2 construction traffic. A value of 200mm is the minimum pavement thickness defined in HD 26/06 for flexible pavements for a design traffic level of 1msa and any trafficking above this level is likely to cause significant structural damage. Where the flexible construction thickness is less than 150mm, the section is automatically classified as “At Risk”.

Structural Defects Calculation

4.3.8. The following structural defects were extracted from the available video survey and used to calculate the Structural Condition Index. The codes for these defects have been taken from UKPMS DVI user manual. These defect types have been selected for use in the structural defects calculation as they are more accurate indicators of structural soundness compared to other defect types.

Flexible Pavement

- Rutting (BRUT);
- Wheel Track Cracking (BCRW);
- Major Area Cracking (BCHJ); and
- Subsidence (BSES).

Rigid Pavement

- Concrete Settlement (NSTM);
- Concrete Cracking (NCRA);
- Concrete Joint Defectiveness (Longitudinal) (NJDF); and
- Concrete Joint Defectiveness (Transverse) (NFLT).

4.3.9. The assessment based on the construction thickness and defects records have been combined to obtain the corresponding Structural Condition Index. The details of the initial calculation approaches are described in Appendix C in this report.

Overall Assessment

4.3.10. The structural condition assessment is made up by combining the pavement construction and the structural defects calculation as outlined below.

Flexible Pavement

- Where construction thickness (the bound material layer thickness) is greater than 270mm, the pavement will be categorised as “Sound” in current stage;
- Where construction thickness is between 200mm and 270mm, the pavement will be categorised as “Limited Risk” if the structural defects percentage is less than 40%; otherwise, it will be classified as “Potential Risk”;
- Where construction thickness is between 150mm and 200mm, the pavement will be categorised as “Potential Risk” if the structural defects percentage is less than 40%; otherwise, it will be classified as “At Risk”; and
- Where construction thickness is less than 150mm, the route/ section will be classified as “At Risk”.

Rigid Pavement

- Where construction thickness (the bound material layer thickness) is greater than 250mm, the pavement will be categorised as “Sound” in current stage;
- Where construction thickness is between 200mm and 250mm, the pavement will be categorised as “Limited Risk” if the identified structural defectiveness is less than 40%, otherwise, it will be classified as “Potential Risk”; and
- Where construction thickness is less than 200mm, the route/ section will be classified as “At Risk”.

4.4. Overall Road Pavement Condition Risk Indicator

4.4.1. A matrix approach to determining the overall indicator of pavement risk has been adopted which makes use of the Surface and Structural Condition Indexes described above and is shown in Figure 7.

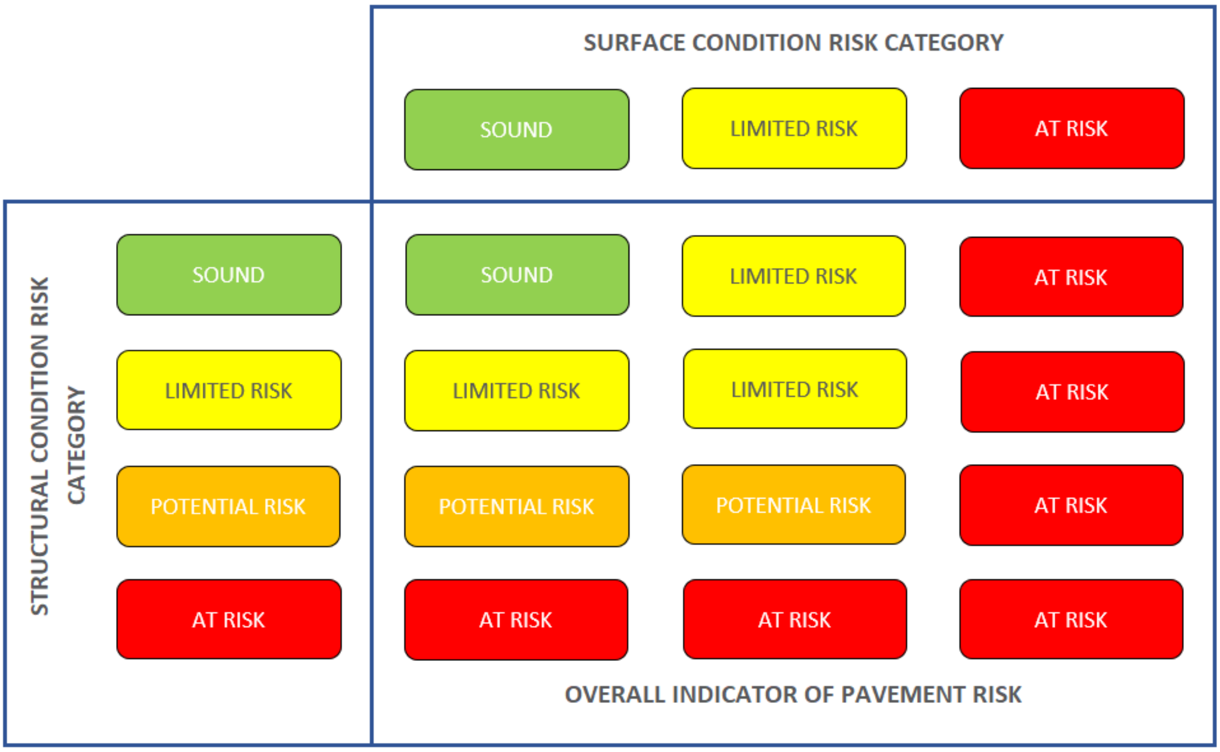

Figure 7 Calculation of Overall Indicator of Pavement Risk

5. Pavement Condition Assessment

5.1. Pavement Survey Coverage

5.1.1. The analysis of the survey coverage for the 5 non-trunk roads (links 23, 25, 30, 102 and 225) is presented in Table 5 for both video and GPR survey.

Table 5 Pavement Survey Coverage within Oxfordshire

Total Lane Length (lane-km)	Video Survey Coverage		GPR Survey Coverage	
	Surveyed Length (lane-km)	Survey Coverage (%)	Surveyed Length (lane-km)	Survey Coverage (%)
9.55	9.46	99.1%	9.46	99.1%

5.1.2. The data shows that a high level of survey coverage for both the video survey and GPR survey has been achieved for the selected non-trunk roads. In total, the video survey and GPR survey information has been received for 44 links. Survey information (both video and GPR data) is only missing for pavement link 225 (the only haul road link within Oxfordshire) and this is due to no man-made road identified in survey.

5.1.3. Of the original 9 links, 1 has been excluded from the pavement assessment. This is as per the pavement treatment methodology outlined in Figure 15. See Appendix B for further details.

5.2. Pavement Survey Data Analysis

GPR Survey Data Analysis

5.2.1. The construction thickness is extracted from the incoming GPR data. Confirmation and calibration through coring is still required to confirm the pavement thickness and for the accurate identification of the material types interpreted from the GPR data.

5.2.2. The summary of the pavement type information interpreted from partially calibrated GPR data is presented in Table 6 and graphically in Figure 8.

Table 6 Summary of Pavement Type within EWR2 Network in Oxfordshire

Pavement Type	Flexible Pavement	GPR Data Missing
Lane length (lane-km)	9.46	0.09

Figure 8 Pavement Type Identified from GPR Data

5.2.3. The uncalibrated data demonstrates:

- All surveyed pavement links are identified as flexible pavement construction due to the existence of bituminous material identified in the GPR survey; and
- Only 0.09 lane-km within the network in Oxfordshire cannot be determined due to the missing of GPR survey. This is associated with link 225, which is the haul road as illustrated in Table A-1.
- The analysis excludes links 24, 83, 103 and 104, which are located in trunk roads A4421 and B4100.

5.2.4. A summary of the pavement thickness information, as per the proposed thickness threshold in section 4.3, is presented in Table 7 and graphically in Figure 9.

Table 7 Summary of Flexible Pavement Construction Thickness* within EWR2 Network

Construction Thickness Category†	Pavement Construction* Thickness Range	Flexible Pavement Lane Length (lane-km)
Pavement has sufficient construction thickness†	>=270mm	4.36
Pavement is likely to have sufficient construction thickness†	200mm to 270mm	2.41
Pavement may have insufficient construction thickness†	150mm to 200mm	1.80
Pavement has insufficient construction thickness†	<150mm	0.89
No Thickness Information	-	0.09††

Note:

*: Pavement Construction thickness in this report refers to the total thickness of bound materials identified in available GPR data. For flexible pavement, construction thickness includes all bituminous and cementitious layers' thickness. For rigid pavement, it includes all cementitious layers' thickness.

†: The pavement construction thicknesses are categorised in accordance with the expected traffic during EWR2 construction phase.

††: Links 24, 83, 103 and 104 are excluded from the analysis.

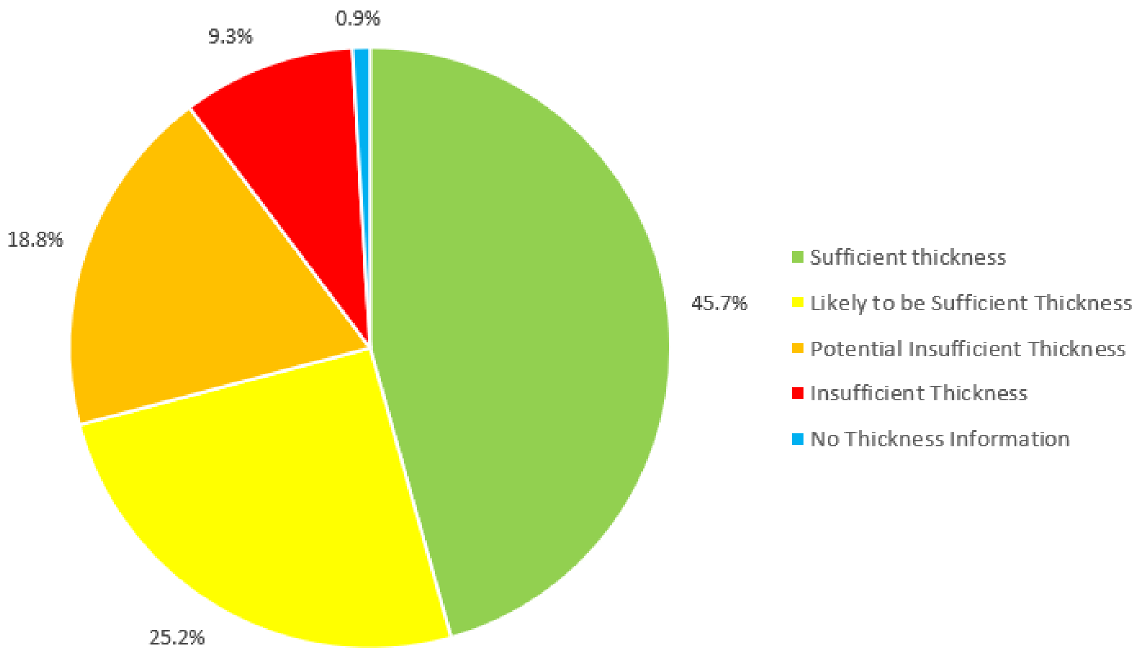

Figure 9 Pavement Thickness Range Identified from GPR Data

5.2.5. The data demonstrates that for the non-trunk roads of EWR2 network within Oxfordshire:

- 45.7% of the sections within the network have a minimum of 270mm of bound material for flexible pavement. This represents 4.36 lane-km that can be considered structurally adequate with regards to the expected construction traffic, as stated in section 3.3;
- 25.2% of the sections identified from the GPR thickness data have a bound material layer thickness between 200mm to 270mm. This equates to 2.41 lane-km of pavement can be considered structurally adequate;
- 18.8% of the sections have been identified as flexible pavement with a thickness between 150mm to 200mm. This is below the structural thickness requirement stated in HD 26/06 for 1msa.;
- 9.3% of the sections are indicated by GPR data to have a bound layer thickness below 150mm, which will present a risk if subjected to significant commercial traffic; and
- The remaining approximately 0.9% of sections have no thickness information due to no GPR survey.

Video Survey Data Analysis

5.2.6. Based on the video Impulse's Roadshow software, the pavement defects, as listed in Section 4.2.5, and the carriageway inventory information have been captured in terms of pavement link ID, defective type (code), location/ chainage, width, lane information, etc.

5.2.7. The identified pavement defects are illustrated in Table 8 below in terms of the defective area (m2). The area calculation approach details are stated in Appendix C in this report.

- Major Surface Defectiveness (BFEJ) is the most common defect identified in the video survey, which comprises approximately 42.1% of identified defects in area;
- Wheel Track Cracking (BCRW), Major Area Cracking (BCHJ) and Major Fatting (BFAJ) are also three of the main defectives observed in the video survey, comprising approximately 15.8%, 12.2% and 20.2% of identified defects in area, respectively;
- Approximately 271m2 Edge Deterioration has been identified in the video survey, representing 8.8% of identified defects in area. With 201 out of 271 m2 Edge Deterioration is rated as "Severity 2" (Major) defectiveness; and
- Pothole (BPHO) and Major Transverse Crack (BTCK) is also recorded in the video survey; however, they only comprise less than 1% of identified defects in area.

Table 8 Identified Defective Area (m^2) in Video Survey Data

Pavement Defect	Defect Code	Total Areas Identified (m^2)	Total Areas Identified (%)
Edge Deterioration Severity 1(Minor) at Left Edge	BLE1	34	1.1%
Edge Deterioration Severity 2(Major) at Left Edge	BLE2	149	4.9%
Edge Deterioration Severity 1(Minor) at Right Edge	BRE1	35	1.2%
Edge Deterioration Severity 2(Major) at Right Edge	BRE2	52	1.7%
Rutting	BRUT	0	0.0%
Wheel Track Cracking	BCRW	486	15.8%
Major Area Cracking	BCHJ	375	12.2%
Major Fatting	BFAJ	621	20.2%
Major Surface Defectiveness	BFEJ	1,292	42.1%
Pothole	BPHO	24	0.8%
Major Transverse Crack	BTCK	1	0.0%
Subsidence	BSES	0	0.0%
Concrete Defective Seal (Transverse)	NDFS	0	0.0%
Concrete Defective Seal (Longitudinal)	NDLS	0	0.0%
Concrete Joint Defectiveness (Transverse)	NFLT	0	0.0%
Concrete Joint Defectiveness (Longitudinal)	NJDF	0	0.0%
Concrete Surface Defectiveness	NSCR	0	0.0%
Concrete Settlement	NSTM	0	0.0%
Concrete Cracking	NCRA	0	0.0%
Total		**3,071***	**100%**

* The defects can occur simultaneously, therefore the defect area may not be the same as the proposed treatment area.

5.3. Surface Condition Risk Category

5.3.1. Based on the methodology described in section 4.2 and the video survey data collected, the analysis of the surface condition risk category is presented in Table 9 below.

Table 9 Indicator of Pavement Surface Condition Risk Rating

Risk Category	At Risk	Limited Risk	Sound	Survey Data Missing*
Length (lane-km)	2.25 (23.6%)	4.55 (47.6%)	2.66 (27.9%)	0.09 (0.9%)

Notes:

*: Links 24, 83, 103 and 104 are excluded from the analysis.

5.3.2. The analysis of the data indicates:

- 23.6% of the network (in length) has a Surface Condition Category of “At Risk”, which represents 2.25 lane-km.
- 47.6% of the network (in length) has been identified as “Potential Risk” for Surface Condition Risk Rating, which represents 4.55 lane-km. Whilst this is currently adequate, surface maintenance intervention may still be required during the construction period.
- 27.9% of the network in length is assigned as “Sound” for the Surface Condition Risk Rating, comprising 2.66 lane-km.
- 0.9% of the network has no video survey data, which represents 0.09 lane-km.

5.3.3. Detailed maps of showing the surface condition risk category throughout the EWR2 construction is shown in Appendix D.

5.3.4. The analysis excludes links 24, 83, 103 and 104, which are located in trunk roads A4421 and B4100.

5.4. Structural Condition Risk Category

5.4.1. Based on the methodology described in Section 4.3 and the available video and GPR survey data, the analysis of the structural condition risk category is presented in Table 10.

Table 10 Indicator of Pavement Structural Condition Risk Rating

Risk Category	At Risk	Potential Risk	Limited Risk	Sound	Survey Data Missing*
Length (lane-km)	0.92 (9.6%)	1.78 (18.6%)	2.40 (25.1%)	4.36 (45.7%)	0.09 (0.9%)

Notes:

*: Links 24, 83, 103 and 104 are excluded from the analysis.

5.4.2. The analysis of the data indicates:

- 9.6% of the network (in length) has a Structural Condition Category of “At Risk”. This represents 0.92 lane-km which is likely to be structural inadequate as the pavement thickness indicated is below current design standards;
- 18.6% of the network length has a Structural Condition Category of “Potential Risk”. This represents 1.78 lane-km which may be structurally inadequate due to insufficient construction thickness or significant structural defects;
- 25.1% of the network is identified as “Limited Risk” for Structural Condition Risk Rating. This represents 2.40 lane-km which should be structurally adequate; however, structural maintenance intervention may still be required;
- 45.7% of the network is assigned as “Sound” for the Structural Condition Risk Rating, comprising 4.36 lane-km; and
- The remaining 0.9% of the network in length has no GPR survey data, which represents 0.09 lane-km.

5.4.3. Detailed maps of showing the structural condition risk category throughout the EWR2 construction is shown in Appendix E.

5.4.4. The analysis excludes links 24, 83, 103 and 104, which are located in trunk roads A4421 and B4100.

5.5. Overall Indicator of Pavement Risk

5.5.1. Analysis of the Overall Indicator of Pavement Risk rating is present in Table 11 and Figure 10 below. In addition, the analysis of the Surface Condition Risk Category and Structural Condition Risk Category contribution to the Overall Condition Risk Indicator is presented in Table 12.

Table 11 Overall Indicator of Pavement Risk Rating

Risk Category	At Risk	Potential Risk	Limited Risk	Sound	No Rating
Length (lane-km)	2.93	1.11	4.14	1.28	0.09*

Notes:

*: Links 24, 83, 103 and 104 are excluded from the analysis.

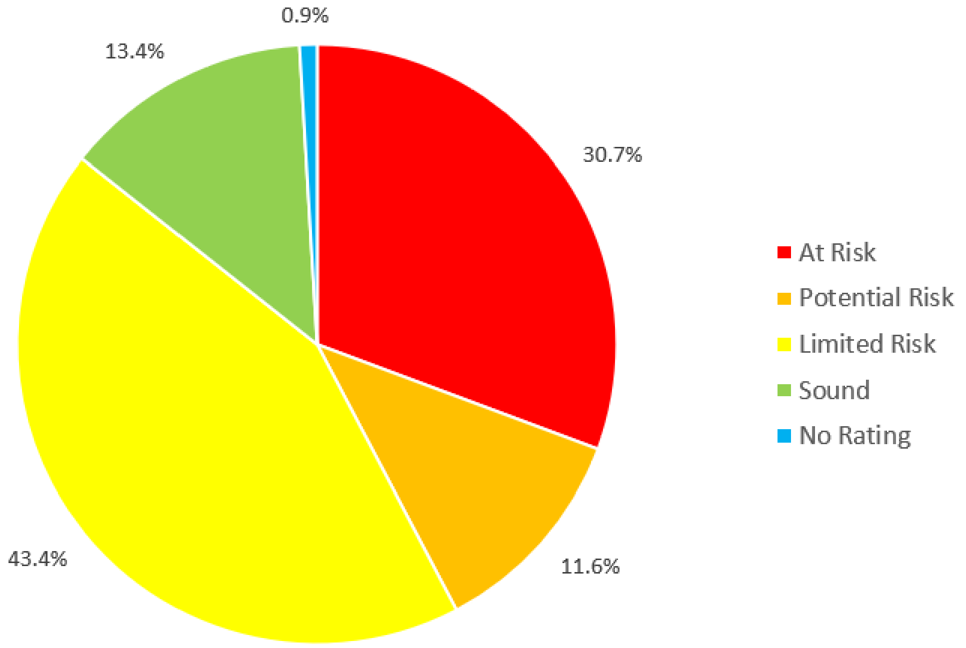

Figure 10 Overall Condition Index Risk (in percentage)

Table 12 Overall Indicator of Pavement Risk Rating

	Provisional† Structural Condition Index Risk				
Surface Condition Index Risk	**Sound**	**Limited Risk**	**Potential Risk**	**At Risk**	**Un-surveyed Length (No Works)**
Sound	1.28 (13.4%)	0.78 (8.2%)	0.42 (4.4%)	0.18 (1.9%)	0.09* (0.9%)
Limited Risk	2.50 (26.2%)	0.86 (9.0%)	0.69 (7.2%)	0.50 (5.2%)	
At Risk	0.58 (6.1%)	0.76 (8.0%)	0.67 (7.0%)	0.24 (2.5%)	

Notes:

*: Links 24, 83, 103 and 104 are excluded from the analysis.

†: This has been labelled as provisional as these values may change once the GPS has been calibrated.

5.5.2. The analysis of the data indicates:

- 30.7% of the network in length has an overall "At Risk" level, which represents 2.93 lane-km.
- 11.6% of the network in length is identified as "Potential Risk" due to the structural condition assessment, which represents approximately 1.11 lane-km;
- 43.4% of the network in length has an overall condition "Limited Risk" level, which represents 4.14 lane-km. In addition, 0.86 lane-km sections have been calculated as "Limited Risk" level by both surface and structural condition assessment;
- 13.4% of the network in length is assigned as "Sound" for the Overall Condition Indicator, comprising 1.28 lane-km; and
- 0.9% of the sections has no rating for the overall risk assessment. This is attributed to the missing GPR and video survey information for 0.09 lane-km sections.

5.5.3. Detailed maps of showing the overall condition risk category throughout the EWR2 construction is shown in Appendix F. The analysis excludes links 24, 83, 103 and 104, which are located in trunk roads A4421 and B4100.

5.5.4. Examples of typical defects of a “At Risk”, “Potential Risk”, “Limited Risk” and “Sound” location for the Overall Pavement Condition Risk Indicator are shown in

5.5.5. Figure 11 to Figure 14.

Figure 11 Overall Indicator of Pavement Risk “At Risk” Condition

Figure 12 Overall Indicator of Pavement Risk “Potential Risk” Condition

Figure 13 Overall Indicator of Pavement Risk “Limited Risk” Condition

Figure 14 Overall Indicator of Pavement Risk “Sound” Condition

6. Pavement Treatments – Implementation Work

6.1. Introduction

6.1.1. The implementation strategy is based on treating the immediate sections which are deemed to be “At Risk”. These treatments will be implemented following verification from calibrated GPS.

6.1.2. The EWR2 philosophy regarding pavement treatment works is to act early, aiming to avoid delaying construction works and local residents/road users. This is the main reason for undertaking advanced maintenance works.

6.1.3. The analysis below determines the extent of pro-active pavement treatment work that is recommended based on the existing pavement condition and traffic loading. This excludes any localised/patching works and any post-construction treatment

6.1.4. The implementation work will be subject to agreement between the EWR2 Alliance and the Local Highway Authority and further refined prior to commencement to finalise scheme extents and account for further deterioration between date of survey and commencement of works.

6.2. Pavement Treatment Methodology

6.2.1. A 3-stage treatment methodology for the initial implementation work, as illustrated in Figure 15, has been developed based on the traffic data, surface condition assessment and structural condition assessment described in sections 3.2, 4.2 and 4.3 respectively.

Stage 1 – Traffic Assessment

6.2.2. The methodology first considers the significance of the EWR2 commercial traffic loading. If the EWR2 commercial traffic loading as presented in Appendix B is greater than 0.2msa over the 5-year construction period or the EWR2 construction traffic accounts for more than 25% of the total commercial vehicle traffic, then the EWR2 traffic is considered to have the potential impact to the pavement condition.

6.2.3. If either of these thresholds are exceeded, then the need to treat the pavement section will be considered.

6.2.4. 8 construction route sections in Oxfordshire exceeded the threshold and are considered for treatment and only 1 trunk road link (link 83) is excluded with regards to the traffic.

Stage 2 - Pavement Assessment

6.2.5. Analysis of the pavement surface condition assessment and structural condition assessment has then been undertaken on a 10m basis to identify the sections which present a risk to the construction programme.

6.2.6. It is proposed to pro-actively treat concurrent sections where the EWR2 construction traffic is deemed to be significant and structural condition is considered to be "At Risk". In addition, it is proposed to treat any sections where the structural condition is deemed to be a "Potential Risk" and the surface condition is "At Risk" as shown below.

Table 13 EWR2 Treatment Rules

Treatment Category	Surface Condition Index	Structural Condition Index
100mm Treatment *Overlay/ partial overlay (if not kerbed and where feasible)/ Inlay if not possible to overlay*	At Risk	Potential Risk
	Sound	At Risk
	Limited Risk	At Risk
250mm Full Depth Reconstruction on Class 2 Foundation *(as required)*	At Risk	At Risk

6.2.7. It is assumed that the pavement treatment will be applied to the full carriageway width. This is proposed based on the existing lane configuration, to minimize the pavement joints and to maximize the potential to overlay the existing pavement.

6.2.8. The treatment rules listed in Table 13 are an initial assessment only. Validation is required following the receipt of core data and subsequently detailed design will be required to define the actual treatment requirements, in conjunction with the Local Highway Authority. The actual sections and treatments will be subject to revision and the treatments described in Table 14 should not be considered a definitive/final treatment programme. However, following a risk-based approach, EWR Alliance, funded by the public purse, will seek to prioritise 'At Risk' areas above 'Limited Risk' areas should the quantum of repairs increase.

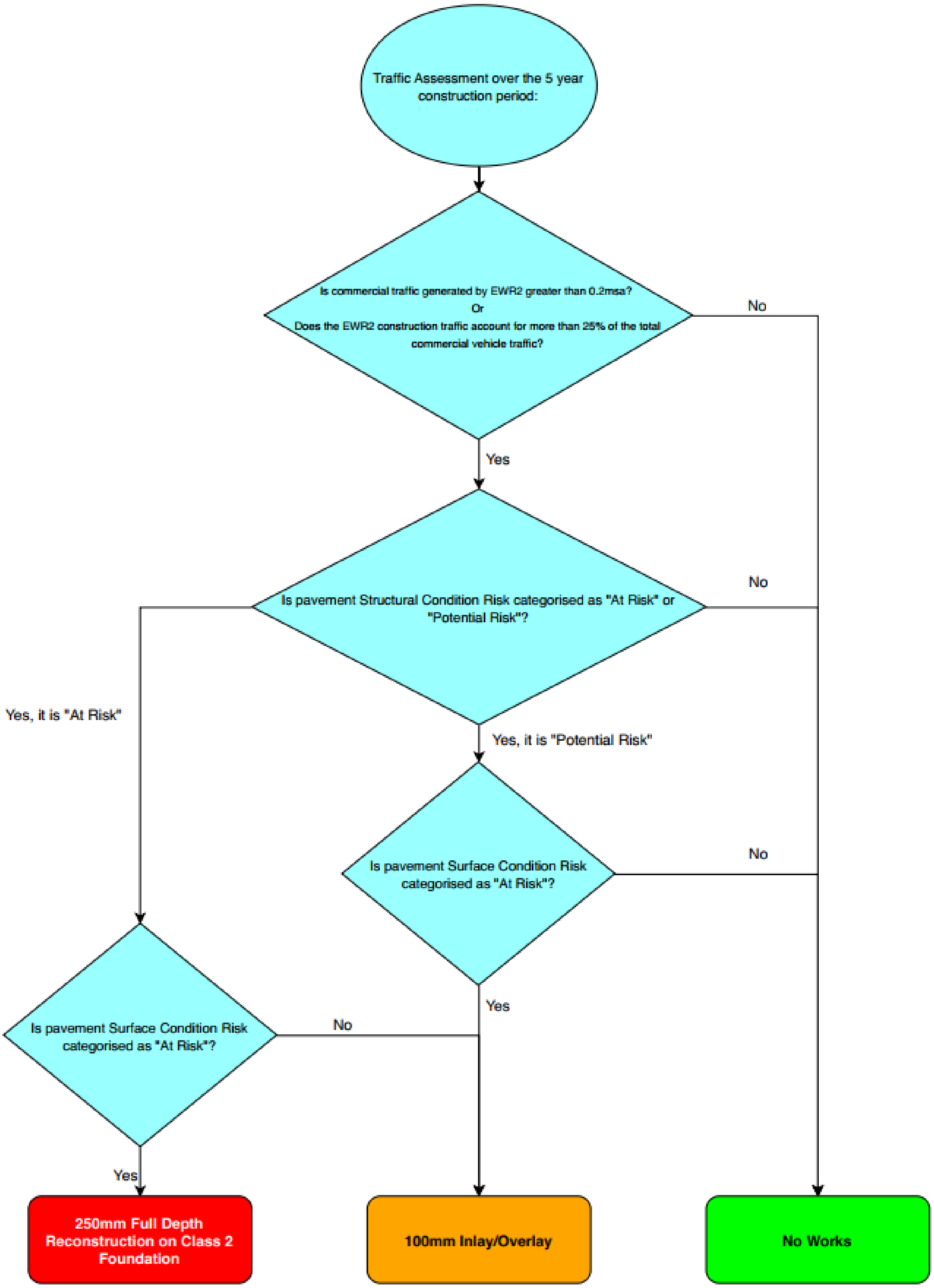

Figure 15 Pavement Treatment Methodology for Stages 1 & 2

Stage 3 Rationalisation

6.2.9. After the proposed pavements treatment in terms of 10m sub-sections, rationalisation has been undertaken to make an operationally efficiency programme. The process for rationalisation has considered:

- The minimum treated length is 15m. If the continuous length of proposed treatments in stage 2 is less than 15m, then the treatment length would be rationalised to achieve 15m, by either connecting with nearby treated sections or upgrade the adjacent sections from “No Treatment” to “Treated”.
- The individual isolated 10m sections, which are deemed to be “At Risk”, would be excluded in the treatments. This will be treated through reactive maintenance as required.
- The proposed treatments within the extent of two passing bays at links 23 and 25 will be rationalised as “Full Depth Reconstruction” to provide sufficient width for construction traffic. This will be applied to a minimum 35m ahead of the stop lines proposed in the passing bay design.
- For trunk road links 24, 103 and 104, EWR2 construction traffic is in a relatively low proportion (<25%) of all commercial vehicles in these routes. In addition, the trunk roads are generally designed and built to support high levels of heavy traffic. Therefore, though no pavement survey information is available in current design stage, “No Treatment” is proposed as pavement treatments for these three links. This is subject to the pavement condition assessment whenever the survey information (GPR, video survey and coring, etc) is available in the future stage.

6.3. Output

6.3.1. All EWR2 Oxfordshire pavement links have been assessed in accordance with the treatment rules described above.

6.3.2. The detailed proposed pavement treatments are issued in terms of spreadsheet table and the kml file. The summary of treatment areas, lengths and widths are listed in Appendix H and the proposed treatment areas for all 4 links (excluding link 225, the EWR2 haul road link within Oxfordshire) are illustrated in Table 14 and Figure 16 below.

Table 14 Proposed pavement treatment areas (m^2)

Estimated Treatment Area (m^2)		
No Treatment	**100mm Inlay/ Overlay**	**250mm Full Depth Reconstruction**
83,428 (90.8%) †	5,821 (6.3%)	2,622 (2.9%)

Notes:

†: The pavement lane width of the pavement links 24, 83, 103 and 104 is assumed to be 3.5m in the calculation of treatment area.

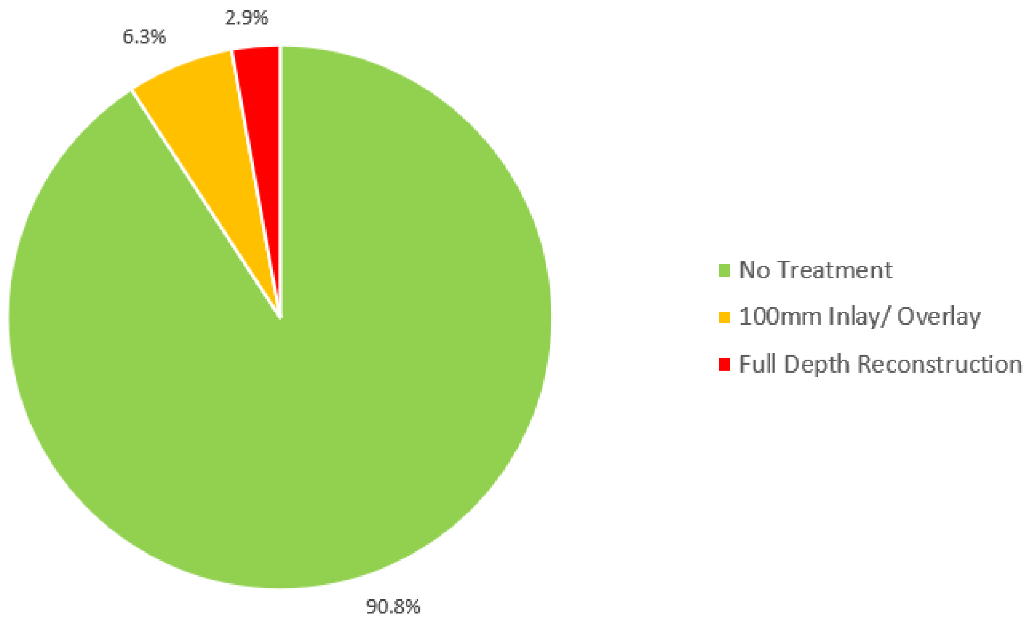

Figure 16 Proposed pavement treatments area (in percentage)

7. Conclusion and Recommendations

7.1. Conclusion

7.1.1. Analysis of the EWR2 construction traffic loading over the construction period has been undertaken. The analysis has concluded EWR2 construction traffic in Oxfordshire is variable on a link by link basis but is generally limited between 0.5msa and 1.0msa loading for all 9 links over a 5-year period.

7.1.2. A pavement survey and condition methodology has been conducted in order to provide an indication of the pre-construction condition of the network and to identify those lengths (sections of the routes) that might be at risk of premature failure during the construction or may have already failed.

As part of this methodology, a GPR and video survey was carried out by Impulse Geophysics in August 2018. GPR and Video survey information was received for 4 pavement links within Oxfordshire and 5 missing sections have been identified:

- Link 225, which is the haul link and non-paved route within Oxfordshire; and
- Links 24, 83, 103 and 104, which are trunk road links and excluded in the survey lists requested by EWR Alliance in 2018. These four links have been added in this report at the request of Oxfordshire County Council on 28th March 2019.

7.1.3. Analysis of the surface condition for the non-trunk road links indicates:

- 23.6% of the network in length has a Surface Condition Category of “At Risk”, which represents 2.25 lane-km;
- 47.6% of the network in length is identified as “Potential Risk” for Surface Condition Risk Rating, which represents 4.55 lane-km sections is adequate for surface performance requirement; however, surface maintenance intervention may still be required during the construction period;
- 27.9% of the network in length is assigned as “Sound” for the Surface Condition Risk Rating, comprising 2.66 lane-km; and
- 0.9% of the network has no video survey data, which represents 0.09 lane-km.

7.1.4. Analysis of the structural condition for the non-trunk road links indicates:

- 9.6% of the network has a Structural Condition Category of “At Risk”. This represents 0.92 lane-km which is likely to be structural inadequate as the pavement thickness indicated is below current design standards;
- 18.6% of the network length has a Structural Condition Category of “Potential Risk”. This represents 1.78 lane-km which may be structurally inadequate due to insufficient construction thickness or significant structural defects;
- 25.1% of the network is identified as “Limited Risk” for Structural Condition Risk Rating. This represents 2.40 lane-km with an adequate structural performance requirement; however, a structural maintenance intervention may still be required;
- 45.7% of the network is assigned as “Sound” for the Structural Condition Risk Rating, comprises 4.36 lane-km; and
- The remaining 0.9% of the network in length has no GPR survey data, which represents 0.09 lane-km.

7.1.5. It is important to note that the above analysis is based on video and uncalibrated GPR survey. Further pavement investigations will be undertaken to refine the pavement condition assessment, treatment requirements and any future modelling. Currently the pavement condition category is heavily influenced by the pavement thickness threshold defined in the Structural Condition rating.

7.1.6. Based on the pavement assessment results and the calculated design traffic, the pavement treatment rules have been proposed.

7.1.7. Analysis of the proposed pavement treatments indicates:

- 2,622 m^2 area may require a full depth reconstruction, accounting for approximately 2.9% of total areas of all 4 surveyed pavement links;
- 5,821 m^2 area may require 100mm inlay/overlay treatments, accounting for approximately 6.3% of total areas of all 4 surveyed pavement links; and
- The remaining 83,428 m^2 area is proposed to be monitored, including 4 trunk road links located in A4421 and B4100.

7.1.8. It is noted that validation is still required to be undertaken and subsequently detailed design following the pavement investigation will be required to define the actual treatment requirements. The current proposed treatments should not be considered a definitive/final treatment programme.

7.2. Recommendations - Further Pavement Investigation

7.2.1. In order to establish a more accurate overview of the pre-condition and refine the risk ratings and associated treatment requirements the following pavement investigations are to be carried out:

Coring

7.2.2. Coring is an intrusive test undertaken to extract a sample of pavement and record the layer depths and material types. Coring is required to calibrate and validate the GPR survey, as stated in Sections 2.2.6 and 5.2.1. A coring specification has been proposed as defined in the East West Rail Phase 2 GRIP 5 Design Specification Pavement Investigation Specification – Coring Document Number: 133735-EWR-REP-EHW-000044. In total, 217 cores with associated DCP testing are proposed on the construction route network for the whole EWR2 network. The location and cores have been selected based on the construction variability and condition of the sections.

7.2.3. It is proposed that the survey will be conducted network wide to inform the baseline condition.

Appendices

Appendix A. Pavement Links within EWR2 Network

A.1.1 EWR Alliance pavement team has been appointed to assess the pavement condition for 85 pavement links within EWR2 network. The detailed information for those links within Oxfordshire is listed in Table A-1 below.

Table A-1 Pavement Links within EWR2 Network (Oxfordshire)

Id	Classification	Road Name	Length (lane-km)
23	HGV/LGV CONSTRUCTION ACCESS ROUTE	Launton Road	0.81
24	Network/ Trunk Road	B4100	2.92
25	HGV/LGV CONSTRUCTION ACCESS ROUTE	Station Road	1.98
30	HGV/LGV CONSTRUCTION ACCESS ROUTE	Main Street near Poundon	4.2
83	Network/ Trunk Road	A4421	2.31
102	HGV/LGV CONSTRUCTION ACCESS ROUTE	-	2.39
103	Network/ Trunk Road	B4100	8.86
104	Network/ Trunk Road	A4421	5.51
225	HGV/LGV CONSTRUCTION ACCESS ROUTE	Unknown. Junction with Launton Road	0.09

Appendix B. EWR2 Traffic Assessment

Table B-1 Design traffic within EWR2 Network

Link ID	Road Name	Road Feature	EWR2 Construction Traffic (msa)	Total Commercial Traffic (msa)	% Traffic from EWR2	Excluded in pavement assessment?
23	Launton Road	Network	0.77	1.01	76%	No
24	B4100	Network	0.76	3.31	23%	No
25	Station Road	Network	0.77	0.95	82%	No
30	Main Street near Poundon	Network	0.36	0.60	60%	No
83	A4421	Network	0.11	5.94	2%	Yes
102		Network	0.36	0.51	72%	No
103	B4100	Network	0.76	3.78	20%	No
104	A4421	Network	0.36	6.07	6%	No
225	Junction with Launton Road	Haul Road	0.77	0.77	100%	No

B.1.1 Link ID 83 has been excluded from the pavement assessment. This is because the traffic generated by EWR2 is less than 0.2msa at this site and less than 25% of the total commercial vehicle traffic will be caused by EWR2. This is as per the pavement treatment methodology outlined in Figure 15.

Appendix C. EWR2 “Stage 1” Road Pavement Condition Assessment Calculations

C.1 Surface Condition Index

C.1.1 The process for characterising the Surface Condition Index is summarised in the Figure C-17. Detailed calculations for Edge Indicator, VCS Indicator and Surface Condition Index are then presented in the subsequent sub-sections.

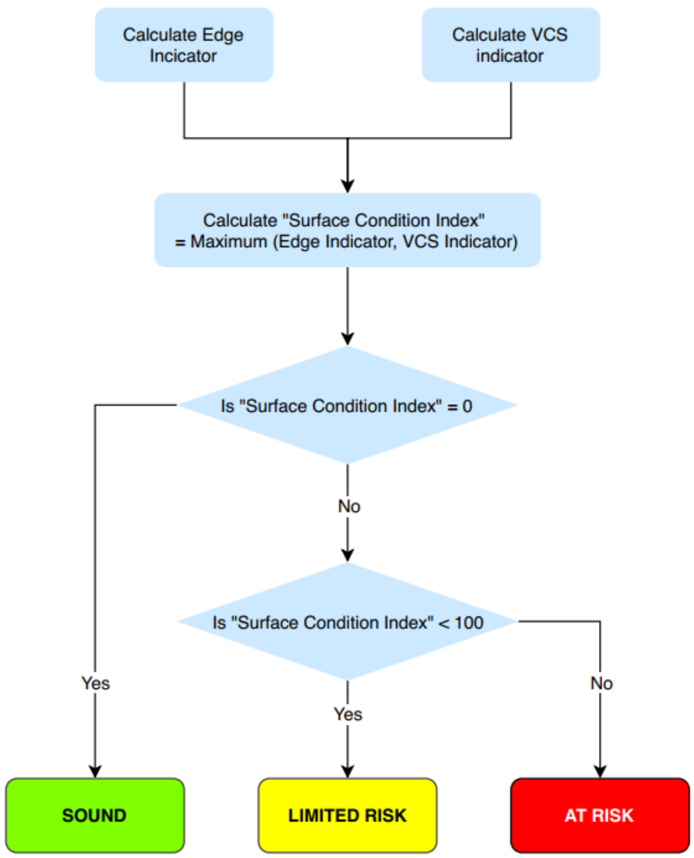

Figure C-17 Calculation of Overall Indicator of Pavement Risk

C.2 Edge Indicator Calculation

C.2.1 The Edge Indicator is calculated using visual survey data at a 10m sub-section level or part sub-section for each cross-section position (XSP). The following parameters are used in the calculation:

Defect	Defect Code
Left Recorded Edge Deterioration Severity 1	BLE1
Left Recorded Edge Deterioration Severity 2	BLE2
Right Recorded Edge Deterioration Severity 1	BRE1
Right Recorded Edge Deterioration Severity 2	BRE2

C.2.2 This is in accordance with UKPMS DVI Manual, which states *"Edge defects can only be recorded where no edge restraint is present (i.e. kerb or channel)".* Therefore, edge indicator has not been calculated when there is an edge restraint present.

C.2.3 The calculation process is as follows:

1. Calculate major edge deterioration:

IF(BLE2+BRE2>0), Edge Indicator $_{\text{Sub-section/XSP}}$ = 100

2. If no major edge deterioration, then review minor edge deterioration:

IF(BLE1+BRE1>0), Edge Indicator $_{\text{Sub-section/XSP}}$ = 50

3. If the above requirements are not met (i.e. BLE2+BRE2+BLE1+BRE1= 0) then:

Edge Indicator $_{\text{Sub-section/XSP}}$ = 0

4. The risk level is then assigned as follows:

Edge Indicator $_{\text{Sub-section/XSP}}$	Risk Level
0	Green – Sound
50	Amber – Limited risk
100	Red – At risk

C.3 Visual Condition Survey Indicator Calculation

C.3.1 The Visual Condition Survey (VCS) Indicator is calculated using data at a 10m sub-section level or part sub-section for each cross-section position.

C.3.2 The calculation process is as follows:

1. The area of the sub-section for each XSP is calculated as follows:

VCS Area $_{\text{Sub-section/XSP}}$ = Length $_{\text{Sub-section/XSP}}$ * Average Width $_{\text{Sub-section/XSP}}$

C.3.3 The length for the sub-section will typically be 10m. For sub-sections where the length is less than 10m then the actual sub-section length is used to ensure the percentage defectiveness is a true reflection of the sub-section.

2. The area of defect is calculated for each sub-section/XSP in accordance with the following Table. (where 'Line' represents the length of the defect).

Defect	Defect Code	Attrib.1	Attrib.2	Attrib. 3	Calculation of Defect Area
Bituminous pavement					
Rutting*	BRUT	Line	Width	~	= Line * Width
Pothole	BPHO	Point	~	~	5% of Sub-Section Area per Point
Wheel Track Cracking	BCRW	Line	Width	No. tracks	= Line * Width * No. Tracks
Major Area Cracking	BCHJ	Line	Width	~	= Line * Width
Major Fatting	BFAJ	Line	Width	~	= Line * Width
Major Surface Defectiveness	BFEJ	Line	Width	~	= Line * Width
Major Transverse Crack	BTCK	Point	Width	~	= Width * 0.5
Subsidence	BSES	Line	Width	~	= Line * Width
Concrete pavement					
Concrete Defective Seal Transverse	NDFS	Point	Width	~	= Width * 0.5
Concrete Defective Seal Longitudinal	NDLS	Line	Width	~	= Line * Width
Concrete Joint Defectiveness Transverse	NFLT	Point	Width	~	= Width * 0.5
Concrete Joint Defectiveness Longitudinal	NJDF	Line	Width	~	= Line * Width
Concrete Surface Deterioration	NSCR	Line	Width	~	= Line * Width
Concrete Settlement	NSTM	Line	Width	~	= Line * Width
Concrete Cracking	NCRA	Line	Width	~	= Line * Width
Block paving					
Block Paving Major Block Deterioration	KSBD	Line	Width	~	= Line * Width

Note:

*: Defective area of rutting is not counted in visual condition assessment; however, it will be applied in the structural condition assessment for flexible pavement.

3. The total area for all defects in a sub-section/XSP is calculated by summing all contributing defects shown in the above Table:

$$\text{Total VCS Indicator Defects}_{\text{Sub-section/XSP}} = \sum BPHO + \sum BCRW + \sum BCHJ + \sum BFAJ + \sum BFEJ + \sum BTCK + \sum BSES + \sum NDFS + \sum NDLS + \sum NFLT + \sum NJDF + \sum NSCR + \sum NSTM + \sum NCRA + \sum KSBD$$

4. The percentage defectiveness for each sub-section/XSP is calculated as follows:

$$\text{Percentage Defectiveness}_{\text{Sub-section/XSP}} = (\text{Total VCS Indicator Defects}_{\text{Sub-section/XSP}} / \text{VCS Area}_{\text{Sub-section/XSP}}) \times 100$$

5. The percentage defectiveness is converted to a VCS Indicator and a risk level assigned as per below:

Percentage Defectiveness $_{\text{Sub-section/XSP}}$	**VCS Indicator** $_{\text{Sub-section/XSP}}$	**Risk Level**
0%	0	Green – Sound
>0% and <20%	50	Amber – Limited risk
≥20%	100	Red – At risk

C.3.4 If the sub-section/XSP is un-surveyed, then the Percentage Defectiveness $_{\text{sub-section/XSP}}$ is not calculated and the VCS Indicator left blank with no risk level assigned.

C.4 Surface Condition Index

C.4.1 The Surface Condition Index is calculated at a 10m sub-section level or part sub-section for each XSP as per the following equation:

$$\text{Surface Condition Index}_{\text{Sub-section/XSP}} = \text{Max}(\text{Edge Indicator}_{\text{Sub-section/XSP}}, \text{VCS Indicator}_{\text{Sub-section/XSP}})$$

Surface Condition Index $_{\text{Sub-section/XSP}}$	**Risk Level**
0	Green – Sound
> 0 and < 100	Amber – Limited risk
100	Red – At risk

C.4.2 If the sub-section/XSP is un-surveyed (i.e. no results are available for the Edge Indicator, Shape Indicator and VCS Indicator), then the Surface Condition Index is not calculated and left blank with no risk level assigned.

C.5 Structural Condition Index

C.5.1 The construction thickness (the total thickness of bound layers) identified from the GPR survey is applied in the Structural Condition Index, along with the defective areas of selected deterioration types.

Flexible Pavement Construction

C.5.2 Where the pavement construction is identified as fully flexible or flexible composite, the total thickness of bituminous and cementitious material layers shall be summed together as "Flexible Construction Thickness". Then:

1. Establish if pavement is likely to be long-life:

   IF (Flexible Construction Thickness >270mm) = Green (Sound)

2. Establish if the pavement has reasonable thickness but is displaying significant structural defects:

   IF (Flexible Construction Thickness >=200mm) &
   Percentage Structural Defectiveness $_{\text{Sub-section/XSP}}$ = ((= ∑BRUT+∑BCRW+∑BCHJ+∑BSES/ VCS Area $_{\text{Sub-section/XSP}}$) x 100) >=40% = High Amber (Potential Risk)

3. Establish if the pavement has reasonable thickness and is not displaying significant structural defects:

   IF (Flexible Construction Thickness >=200mm) &
   Percentage Structural Defectiveness $_{\text{Sub-section/XSP}}$ = ((= ∑BRUT+∑BCRW+∑BCHJ+∑BSES/ VCS Area $_{\text{Sub-section/XSP}}$) x 100) <40% = Amber (Limited Risk)

4. Establish if construction thickness is between 150-200mm but is displaying significant structural defects:

   IF (Flexible Construction Thickness <200 & >=150) &
   Percentage Structural Defectiveness $_{\text{Sub-section/XSP}}$ = ((= ∑BRUT+∑BCRW+∑BCHJ+∑BSES/ VCS Area $_{\text{Sub-section/XSP}}$) x 100) >=40% = Red (At Risk)

5. Establish if the pavement has reasonable thickness and is not displaying significant structural defects:

   IF (Flexible Construction Thickness <200 & >=150) &
   Percentage Structural Defectiveness $_{\text{Sub-section/XSP}}$ = ((= ∑BRUT+∑BCRW+∑BCHJ+∑BSES/ VCS Area $_{\text{Sub-section/XSP}}$) x 100) <40% = High Amber (Potential Risk)

6. IF (Construction Thickness <150mm) = Red (At Risk)

Rigid Pavement Construction

C.5.3 Where the pavement construction is identified as concrete pavement, the total thickness of cementitious material layers shall be summed together as "Rigid Construction Thickness". Then:

1. Establish if pavement is likely to be long-life:

   IF (Rigid Construction Thickness >250mm) = Green (Sound)

1. Establish if the pavement has reasonable thickness but is displaying significant structural defects:

   IF (Rigid Construction Thickness >=200mm) &
   Percentage Structural Defectiveness $_{\text{Sub-section/XSP}}$ = ((= ∑NSTM+∑NCRA+∑NJDF+∑NFLT/ VCI Area $_{\text{Sub-section/XSP}}$) x 100) >=40% = High Amber (Potential Risk)

2. Establish if the pavement has reasonable thickness and is not displaying significant structural defects:

   IF (Rigid Construction Thickness >=200mm) &
   Percentage Structural Defectiveness $_{\text{Sub-section/XSP}}$ = ((= ∑NSTM+∑NCRA+∑NJDF+∑NFLT/ / VCI Area $_{\text{Sub-section/XSP}}$) x 100) <40% = Amber (Limited Risk)

3. Establish if insufficient construction thickness:

   IF (Rigid Construction Thickness <200mm) = Red (At Risk)

Appendix D. EWR2 Surface Condition Risk Rating Maps - Oxfordshire

Link 225 is excluded from pavement treatments as it is haul road and no survey (either video or GPR) has been undertaken. Therefore, link 225 is not illustrated in maps below.


N
Legend
At Risk
Limited Risk
Sound
Google earth
© 2018 Google
600 m


Legend
At Risk
Limited Risk
Sound
N
Google Earth
© 2018 Google
200 m

Appendix E. EWR2 Structural Condition Risk Rating Maps - Oxfordshire

Haul Road link 225 has not been shown on the maps due to no video or GPR survey being conducted for that link.


N
Legend
At Risk
Limited Risk
Potential Risk
Sound
Google earth
© 2018 Google
600 m


Legend
At Risk
Limited Risk
Potential At Risk
Sound
N
Google Earth
Compound A2 Launton
© 2018 Google
200 m

Appendix F. EWR2 Overall Condition Risk Rating Maps - Oxfordshire

Haul Road link 225 has not been shown on the maps due to no video or GPR survey being conducted for that link.


Legend
At Risk
Limited Risk
Potential Risk
Sound
N
Google earth
© 2018 Google
600 m


Legend
At Risk
Limited Risk
Potential At Risk
Sound
N
Google Earth
© 2018 Google
200 m

Appendix G. EWR2 Initial Pavement Treatment Maps - Oxfordshire

Haul Road link 225 has not been shown on the maps due to no video or GPR survey being conducted for that link.


Legend
100mm Inlay/Overlay
Full Depth Reconstruction
No Treatment
900 m
N


Legend
100mm Inlay/Overlay
Full Depth Reconstruction
No Treatment
400 m
N

Appendix H. EWR2 Proposed Pavement Treatments

Table H-1 Design traffic within EWR2 Network

Section ID	Indicative Treatment Area (m^2)			Indicative Treatment Length (m)		
	No Treatment	100mm Inlay/ Overlay	Full Depth Reconstruction	No Treatment	100mm Inlay/ Overlay	Full Depth Reconstruction
23	302	1,033	948	80	205	160
24†	10,220	0	0	1,460	0	0
25	2,357	1,870	701	510	370	110
30	6,390	2,918	973	1,270	620	210
83†	8,085	0	0	1,165	0	0
102	5,779	0	0	1,195	0	0
103†	31,010	0	0	4,430	0	0
104†	19,285	0	0	2,755	0	0
Total	**83,428**	**5,821**	**2,622**	**12,855**	**1,195**	**480**

Notes:

†: The lane width of all four trunk road links within Oxfordshire is assumed to be 3.5m in the calculation of indicative treatment area.

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