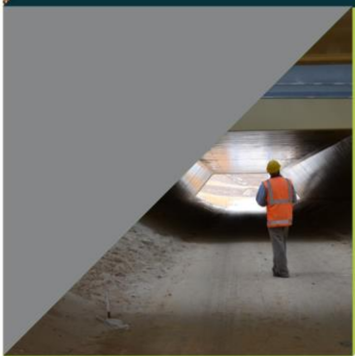
WARRIP
WESTERN AUSTRALIAN ROAD RESEARCH AND INNOVATION PROGRAM

Investigation of Tonkin Highway, Reid Highway & Kwinana Freeway Trial Sections



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AN INITIATIVE BY:

THE GOVERNMENT OF WESTERN AUSTRALIA

mainroads WESTERN AUSTRALIA

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Investigation of Tonkin Highway, Reid Highway & Kwinana Freeway Trial Sections

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for Main Roads Western Australia

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SUMMARY

A comprehensive review of selected trial sections on Tonkin Highway, Reid Highway and Kwinana Freeway was undertaken, including:

- design pavement profile and assumptions
- subsurface and climatic conditions
- construction data
- post-construction monitoring
- traffic history analysis
- performance data including historic Benkelman beam (BB), Falling Weight Deflectometer (FWD), roughness and rutting data.

Following the in-depth review of data collected of nine trial sections across the three sites, which all comprise thin asphalt surfacing (≤ 60 mm) and either a bitumen-stabilised limestone (BSL) or crushed rock base (CRB) basecourse, overlying a limestone subbase and sand subgrade – and a review of the procedures outlined in both Engineering Road Note 9 and Austroads Guide to Pavement Technology: Part 2 – two areas of influence as the mechanism for the better-than-expected performance were identified:

1. the applicability of the mechanistic method for the design of asphalt fatigue for thin surfacings (≤ 60 mm)
2. the conservativeness of the presumptive values assigned to both unbound granular and subgrade materials used in the initial mechanistic pavement design.

The findings of the investigation were as follows:

- The current 5 year design period for less heavily-trafficked roads may be eliminated and higher predicted asphalt fatigue lives could be provided across all design traffic loadings.
- Amendments to the Austroads design methods need to be developed which better reflect the structural contribution of crushed limestone subbase.
- Refinement of the presumptive sand subgrade moduli to reflect strength qualities available in Perth is required.

Further investigation of these observations through the analysis of other sections of road with available performance data should be undertaken as the data available for this project is not considered to be enough to warrant immediate changes to the current method for determining the fatigue life of thin asphalt surfacings. However, MRWA may consider that this project has provided sufficient evidence to justify the implementation of these recommendations.

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1 INTRODUCTION

Austroads (previously the National Association of Australian State Road Authorities) established ARRB Project 357, *Field Trials of Pavement Structures* (Sharp, Butkus, Bruce, Cocks & Potter 1987), in the late 1970s. One element of the project included the design, construction and monitoring of 12 trial pavements along the Tonkin Highway. The principal aim of the project was to define the behaviour of flexible pavement layers (mainly asphalt and unbound granular) relative to the structural design parameters and/or granular equivalencies from detailed laboratory testing and in situ measurements during construction and under service conditions.

Out of the 12 trial sections along the Tonkin Highway, three were constructed using materials typical of Perth's flexible granular pavements with thin (≤ 60 mm) surfacings. These typical materials include crushed rock base (CRB) or bitumen-stabilised limestone (BSL) as basecourse, limestone subbase and sand subgrade. As part of the overall trial, sections were designed to fail after two/three years in-service. However, after approximately 35 years of trafficking and without any major overlays or rehabilitation being required, the performance of these three trial sections continues to be satisfactory.

In addition to the Tonkin Highway trials, nine other sections were constructed along the Reid Highway in West Swan between 1995 and 1996. Similarly to the Tonkin Highway trials, three of the Reid Highway trials comprise the same typical profile of thin asphalt with a CRB or BSL base, over a limestone subbase and sand subgrade. These Reid Highway trials have further demonstrated the sound performance of these pavement systems after 20 years in-service.

As part of the new Perth to Bunbury Highway upgrade in 2009, 15 trial sections were constructed along the southbound carriageway of the Kwinana freeway in Karnup. Again, three of the 15 sections of the trial comprise the typical materials aforementioned; however, these trials represent the youngest of the trial pavement systems which have also been exposed to high annual traffic loadings early in their lives.

With the continuing performance not only of these trial pavements, but also of the majority of metropolitan granular pavements, Main Roads Western Australia (MRWA) proposed that further investigation of the better-than-expected performance is warranted, as this may lead to reduced conservatism and improved value-for-money outcomes from the current pavement design procedure for granular pavement with thin asphalt surfacings.

A comprehensive data review of the selected trial sections was undertaken, including the collation of all available information pertaining to the trial sections of interest. This included:

- design pavement profile and assumptions
- subsurface and climatic conditions
- construction data
- post-construction monitoring
- traffic history
- performance data, including historic Benkelman beam (BB), Falling Weight Deflectometer (FWD), and roughness and rutting data.

Further to the data review, field investigations were undertaken at both sites to confirm the pavement profile and to collect bulk samples for laboratory testing. FWD testing in both the outer wheelpath (OWP) and between the wheelpaths (BWP) was also undertaken. This data was subsequently used in EFROMD3 modulus back-calculation analyses to determine in-service modulus values for the granular and subgrade materials.

A review of the procedures outlined in both *Engineering Road Note 9* (ERN9) (MRWA 2013a) and the *Austroads Guide to Pavement Technology: Part 2* (AGPT02) (Austroads 2012), suggested two areas of influence as the mechanism for the better-than-expected performance exhibited by flexible pavements with thin surfacing:

1. the applicability of the mechanistic method for the design of asphalt fatigue for thin surfacings (≤ 60 mm)
2. the conservativeness of the presumptive values assigned to both unbound granular and subgrade materials as used in the initial mechanistic pavement design.

This report presents the result of the investigations, including a comparison of in-service and predicted performance and recommendations for follow-up work. A summary of the data collected and the results of elastic layer and back-calculation analyses are presented in a series of appendices.

2 CURRENT DESIGN SYSTEM

2.1 Introduction

Current practice for the design of flexible pavements with thin asphalt or bituminous surfacings primarily relies on the empirical design procedure to determine the minimum thickness of the granular, select fill and stabilised subgrade layers which form the pavement structure, over the subgrade. This minimum thickness is dependent on the subgrade design California Bearing Ratio (CBR) in addition to the design traffic loading over a 40 year design period (see Section 8.3 of Austroads 2012).

According to the MRWA (2013) design supplement, ERN9, the subgrade design CBR should be limited to a maximum of 15%, even when a layer of selected material with high soaked CBR has been imported and placed below the subgrade surface and even if the outcome of laboratory assessment indicates a higher value. Typically, a maximum value of 12% in the case of Perth sands is accepted due to the familiarity and historical performance of the material as a subgrade in WA.

The 3/5th base rule or Clause 1.4 of ERN9, is used in conjunction with the empirical method to further calculate the discrete thicknesses of the base and subbase layers for input into the mechanistic procedure. It states that the top three sub-layers of the granular pavement with a thin surfacing must be constructed from basecourse material (MRWA 2013a). This clause was introduced as a way of ensuring that the base layer of the pavement system had sufficient thickness to ensure adequate modulus development. In the case when the top three sublayers exceed 250 mm, the basecourse thickness can be limited to 250 mm (MRWA 2013a).

Following the use of the empirical method to determine a minimum pavement thickness, the mechanistic method is used to assess the fatigue of the asphalt surfacing. For pavements with a nominal asphalt thickness of 60 mm or less, the minimum asphalt fatigue life can be limited to 15 years. However, based on historic performance of thin surfacings on granular pavements of certain material configurations, Clause 1.2(c) was introduced in 2013 which allowed for a reduced fatigue design life of 5 years given all criteria are met. These criteria include:

- CRB or BSL basecourse
- limestone subbase
- well-drained sand subgrade
- 40 year design traffic less than 3×10^7 ESAs.

The traffic limit placed on the use of Clause 1.2(c) is based on the performance of various sections of the Leach Highway which, at that time, was one of the few heavily-trafficked metropolitan roads which had sections approaching 40 years of in-service life and were comprised of well-performing thin bituminous surfacings over either CRB or untreated limestone and sand subgrades. An analysis of the traffic data demonstrated that most of these older sections had reached a level of traffic loading close to or just below 3×10^7 ESAs over the 40 years in-service life.

Prior to 2007, ERN9 did not require mechanistic design for asphalt fatigue to be undertaken; the empirical method would determine the required cover thickness, and a standard surfacing was specified. The use of the mechanistic method for the design of all pavements with thin asphalt surfacings was introduced to reduce the risks associated with increased axle loads and traffic volumes. The introduction of this method also included a 10 mm increase in the nominal asphalt thickness, to reflect construction variability, when modelling thin asphalt pavements using the mechanistic procedure.

2.2 Thin Asphalt Fatigue Life

When using the mechanistic procedure to analyse the fatigue of thin asphalt pavements, the results can be highly variable depending on the material properties assumed by the designer. Furthermore, large increases in granular thickness provide only minor increases in asphalt fatigue life.

Considering the current design procedure and parameters used for the mechanistic design of thin asphalt pavements which conform to the criteria set out in Clause 1.2(c), Figure 2.1 and Figure 2.2 demonstrate the sensitivities and limitations of the mechanistic output.

The granular and asphalt design moduli are presented in Table 2.1 and Table 2.2 respectively. As aforementioned, the 3/5th rule means that layers 4 and 5 of the mechanistic sub-layering process (as per AGPT02) represent the subbase material. It is therefore expected that the top of the 4th layer will have a modulus near to this value.

Table 2.1: Typical pavement design moduli recommended by MRWA (ERN9) and AGPT02 (Austroads 2012)

Material	Modulus (MPa)
Base	500/600
Limestone subbase	250
Sand subgrade	120

Table 2.2: Typical design moduli for dense-graded asphalt (DGA) thin asphalt pavements recommended by ERN9 (MRWA 2013a) and AGPT02 (2012) for various speeds

Material	Posted speed (km/h)	Measured modulus[1] (MPa)	Air voids (%)	Temp. (°C)	In situ V_{air} (%)	V_{bit} (%)	WMAPT (°C)	HV design speed (km/h)	Design modulus (MPa)
10 mm/170 bit Perth DGA	110	5,000	5	25	8.8	11.8	29	100	2,820
	100							90	2,720
	90							80	2,600
	80							70	2,480
	70							60	2,340

1 Indirect tensile modulus measure for a mix with 5% air voids at a temperature of 25°C and a rise time of 40 ms.

As outlined in ERN9, the maximum mean normal stress and minimum octahedral shear stress limits used for determining the vertical modulus at the top sublayer of unbound base materials – using repeated load triaxial testing (RLTT) – is 240 kPa and 120 kPa respectively (MRWA 2013a).

2.2.1 Granular Thickness and Modulus

Figure 2.1 illustrates pavement thickness requirements for various design ESAs and granular moduli at heavy vehicle design speeds (HVS) of 60 km/h and 90 km/h along urban freeways and highways. According to ERN9, for thin asphalt pavements these HVS correspond to posted speed limits of 70 km/h and 100 km/h respectively which is typical of travel speed along urban freeways and highways in the Perth metropolitan area.

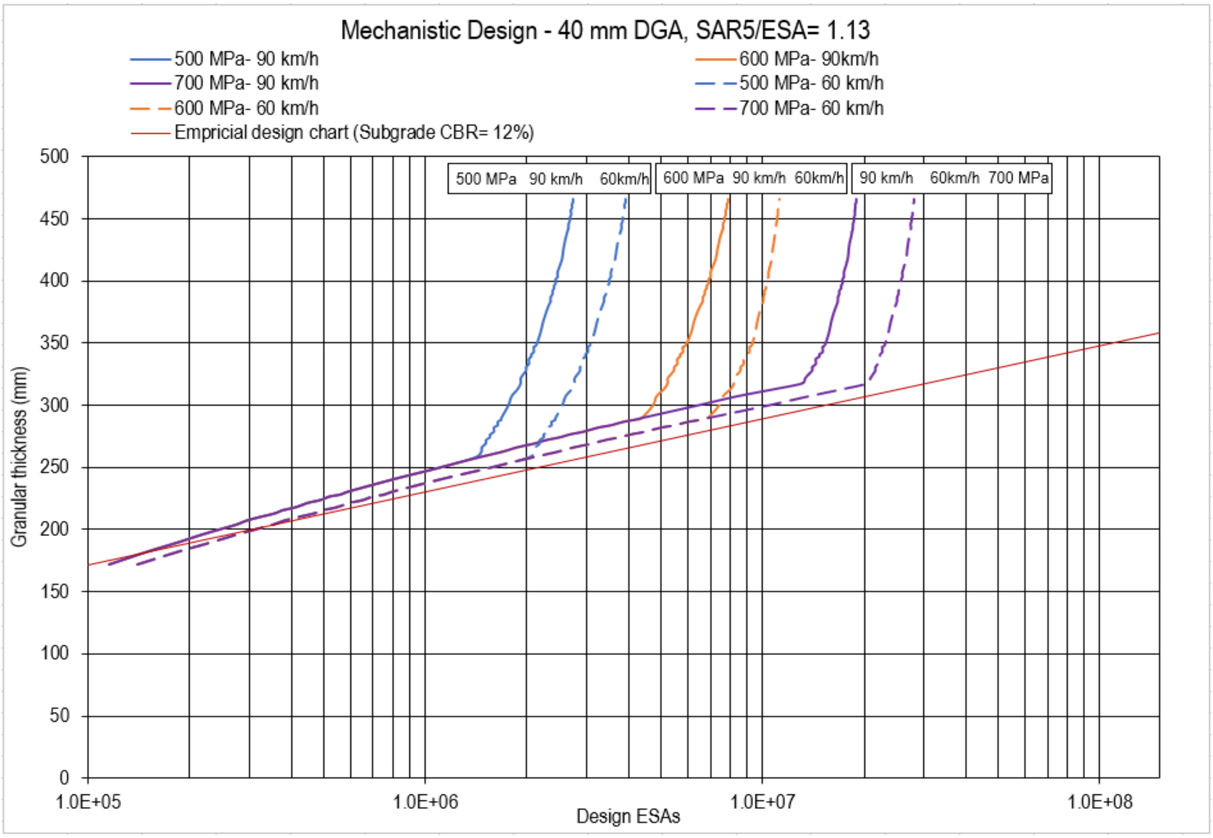
It can be seen from Figure 2.1 that a large increase in the thickness of the granular layer does not result in a large increase in the asphalt fatigue life, i.e. for 500 MPa and a 200 mm increase in layer thickness from 244 mm, the fatigue life increases from 1.5 x 10^6 ESAs to

2.7 x 10^6 ESAs. This small increase in allowable loading with a relatively large increase in granular thickness is an apparent limitation associated with the mechanistic design of thin asphalt pavements.

It is also one of the reasons why the reduced fatigue design life (ERN9 Clause 1.2 (c)) would have been introduced for the design of thin asphalt surfacings as it would be impossible to not only meet the required design traffic, but the pavement thicknesses would be extremely uneconomical. This would result in granular pavements with a 30 mm design thickness of DGA surfacing being unsuitable for any project with a design life greater than 1.0 x 10^6 ESAs.

Furthermore, an increase in the modulus of the granular material from 500 MPa to 700 MPa corresponds to a 10-fold increase in the asphalt fatigue life, i.e. for a thickness of granular material of 350 mm, the fatigue life increases from 2.0 x 10^6 ESAs to 1.5 x 10^7 ESAs. This demonstrates the sensitivity of the method to the modulus of the granular material selected for analysis.

Figure 2.1: Design examples for various granular base moduli and heavy vehicle design speeds (subgrade CBR= 12%)

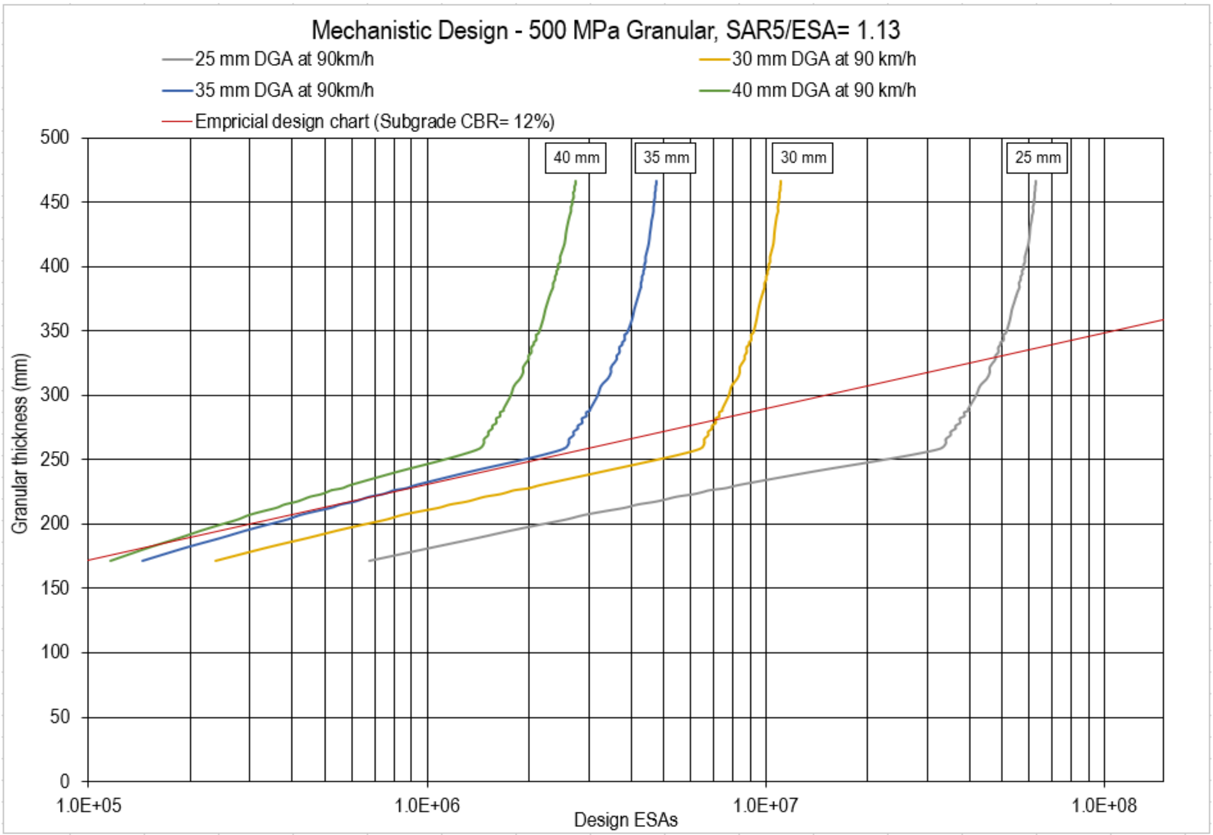


2.2.2 Variation in Asphalt Thickness

Examples of the variation in allowable traffic loading with the thickness of thin asphalt surfacing at HVS of 90 km/h and a standard design granular modulus of 500 MPa are shown in Figure 2.2. As aforementioned, MRWA introduced a 10 mm addition to the nominal asphalt thickness when modelling using the mechanistic procedure. This 10 mm addition is to account for construction variations.

The output demonstrates the high sensitivity of the mechanistic procedure to the thickness of a thin asphalt surfacing. By modelling a 40 mm thick asphalt surfacing rather than the nominal 30 mm, the asphalt fatigue life is reduced by a factor of 10 (i.e. 10^7 to 10^6).

Figure 2.2: Variation in allowable traffic loading with asphalt thickness (subgrade CBR= 12%)



2.3 Areas of Investigation

By considering the current design system and the various outcomes from the mechanistic design of thin asphalt surfacings, it is clear that not only is the mechanistic procedure highly sensitive to granular modulus and asphalt thickness, it also presents limitations on the allowable loading output which can be obtained when modelling thin asphalt surfacings. These limitations, combined with the conservative nature of current design values for material characterisation, result in the output of the mechanistic procedure being conservative and not representative of what is observed within a pavement structure in service.

However, MRWA considers the inclusion of the mechanistic check for asphalt fatigue an integral part of reducing the risk associated with the performance of these pavements. Therefore, MRWA is interested in modifying the design method to more closely reflect field performance. Accordingly, the design method changes were investigated:

- consideration of a new asphalt fatigue design approach which considers both a short- (first year) and long-term (15 years) asphalt fatigue life using the current mechanistic procedure
- possible increase in granular modulus for base materials for use in long-term analysis
- possible increase in granular modulus for limestone subbase material for use in long-term analysis
- possible increase in the maximum subgrade CBR design value above 15%

- change in elastic characterisation of granular materials.

It is hoped that these adjustments will ensure the mechanistic procedure will better reflect the in situ pavement response to load, and therefore better predict the fatigue characteristics of thin asphalt surfacings.

An increase of the limiting traffic loading (3×10^7 ESA) assigned to Clause 1.2(c) was also investigated via data collated from the Tonkin and Reid Highway trial sections, in addition to other similar sections along the same routes.

3 TONKIN HIGHWAY

3.1 Overview

The 12 Tonkin Highway trial sections are located between Kelvin Road and Gosnells Road East between chainages 21 520 and 22 990 m. The test sections include both lanes in the southbound direction which has a posted speed limit of 100 km/h. The start and end chainages and corresponding lengths of each trial section are shown in Table 3.1. The granular pavements materials (where applicable) are also shown.

Table 3.1: Details of Tonkin Highway trial sections

<table>
<tr><th rowspan="2">Trial section</th><th rowspan="2">Start chainage (m)</th><th rowspan="2">End chainage (m)</th><th rowspan="2">Length (m)</th><th colspan="3">Material type</th></tr>
<tr><th>Basecourse</th><th>Subbase</th><th>Subgrade</th></tr>
<tr><td>1</td><td>21 520</td><td>21 600</td><td>80</td><td>2% BSL</td><td rowspan="8">Crushed limestone</td><td rowspan="8">White sand</td></tr>
<tr><td>2</td><td>21 600</td><td>21 720</td><td>120</td><td>2% BSL</td></tr>
<tr><td>3</td><td>21 720</td><td>21 840</td><td>120</td><td>2% BSL</td></tr>
<tr><td>4</td><td>21 840</td><td>21 940</td><td>100</td><td>2% BSL</td></tr>
<tr><td>5</td><td>21 940</td><td>22 040</td><td>100</td><td>2% CSL</td></tr>
<tr><td>6</td><td>22 040</td><td>22 140</td><td>100</td><td>CRB</td></tr>
<tr><td>7</td><td>22 140</td><td>22 280</td><td>140</td><td>CFS</td></tr>
<tr><td>8</td><td>22 280</td><td>22 380</td><td>100</td><td>Crushed limestone</td></tr>
<tr><td>9[(1)]</td><td>22 380</td><td>22 530</td><td>150</td><td>–</td><td>–</td><td rowspan="4">Yellow sand</td></tr>
<tr><td>10</td><td>22 530</td><td>22 700</td><td>170</td><td>CRB</td><td>CRB</td></tr>
<tr><td>11[(1)]</td><td>22 700</td><td>22 800</td><td>100</td><td>–</td><td>–</td></tr>
<tr><td>12</td><td>22 800</td><td>22 900</td><td>100</td><td>CRB</td><td>CRB</td></tr>
</table>

1 Sections 9 and 11 comprise full depth asphalt pavements overlying sand subgrade. No granular materials present.

Notes:

- BSL: bitumen-stabilised limestone
- CSL: cement-stabilised limestone
- CRB: crushed rock base
- CFS: crushed ground granulated blast furnace slag

Source: Butkus & Bruce (1982a Part 1).

The trial sections were constructed in 1980 and opened to traffic in early 1981. All construction and laboratory details were included in a series of internal technical Main Roads reports (Butkus & Bruce 1982a-g, Parts 1-7) which were subsequently summarised in an ARRB internal report (Sharp et al. 1987). These reports collectively include details such as section chainage, design material profiles, as-constructed material profiles, basic laboratory analysis of base, subbase, subgrade and asphalt materials, construction QA test results, and after-construction monitoring data including Benkelman beam data.

3.2 Sections of Interest

Three trial sections were chosen for further investigation from the Tonkin Highway trial. Each of these sections of interest comprised a thin asphalt surfacing (≤ 60 mm nominal thickness), a crushed limestone subbase, and a sand subgrade. As per ERN 9 Clause 1.2(c), the base material of these sections was either crushed rock base (CRB) or bitumen-stabilised (2%) limestone (BSL).

The composition of each section as detailed in the construction reports is presented in Table 3.2. An identification number has been assigned to each section of interest with a prefix to differentiate between trial locations.

Table 3.2: Details of Tonkin Highway sections of interest and pavement profiles

Identification number	Layer	Material	Design thickness (mm)	As constructed mean thickness (mm)
T2	Asphalt	10 mm open-graded asphalt (OGA) Class 320 bitumen	30	39
		10 mm dense-graded asphalt (DGA) Class 170 bitumen	30	46
	Basecourse	2% BSL	75	66
	Subbase	Crushed limestone	225	231
	Subgrade	White sand	–	–
T4	Asphalt	10 mm DGA, Class 170 bitumen	30	42
	Basecourse	2% BSL	75	60
	Subbase	Crushed limestone	225	238
	Subgrade	White sand	–	–
T6	Asphalt	10 mm DGA, Class 170 bitumen	30	39
	Basecourse	CRB	75	77
	Subbase	Crushed limestone	225	221
	Subgrade	White sand	–	–

Source: Butkus & Bruce (1982a Part 1).

3.2.1 Subsurface Conditions

The 1:250 000 Environmental Geological Map series produced by the Geological Survey of Western Australia Pinjarra sheet (Geological Survey of Western Australia 1980) indicates the natural subsurface conditions below the trial pavement systems to include Bassendean sands at T2 and T4. Thin Bassendean sands over Guildford formation clays are inferred at T6. Guildford clays are typically of low plasticity and can also show marginal swell potential ($0.5<I_{ss}<3$). They are often stiff to hard in consistency, increasing in strength when dry.

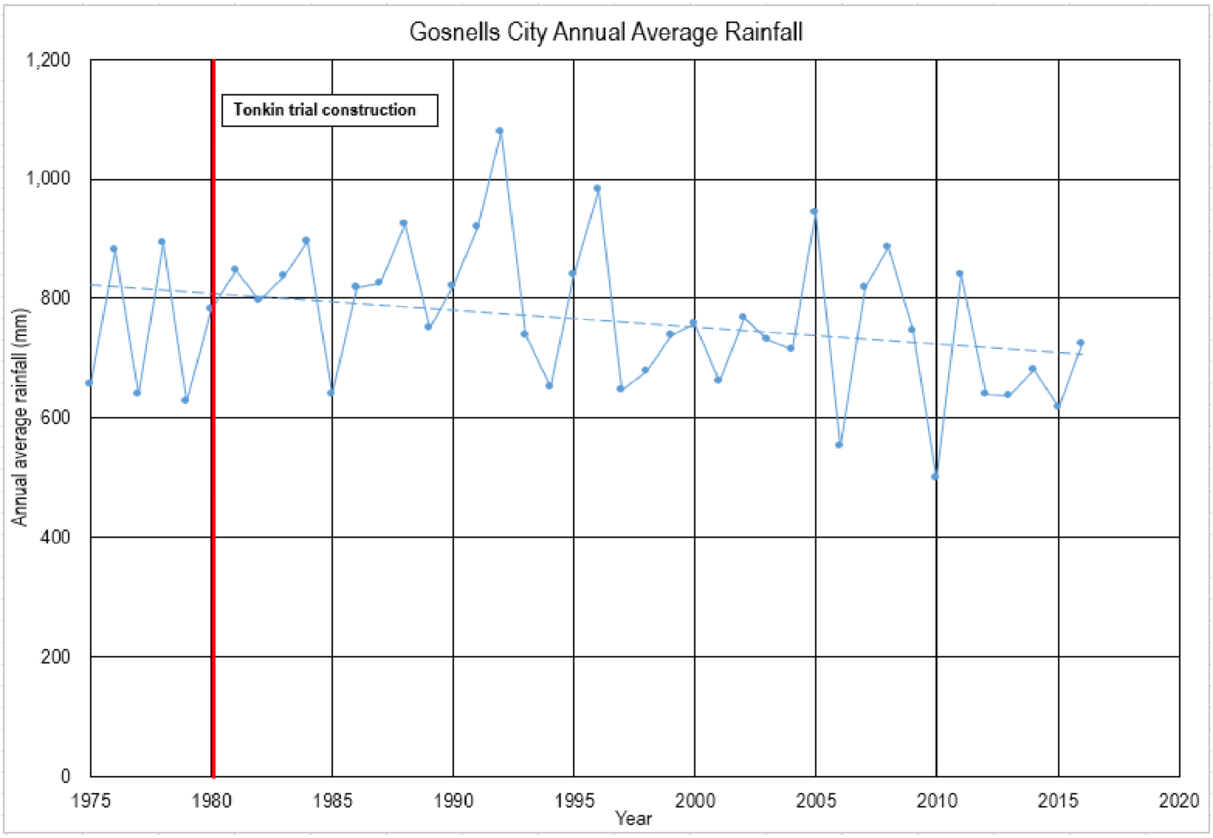
Localised iron-cementation is often encountered within the Bassendean sand system and the Guildford formation. This iron cementation, which can vary in thickness up to a maximum of 4 m, is caused by seasonal fluctuations of the water-table. These pockets of cementation are common at the interface of Bassendean sands and Guildford formation clays due to the inherent nature of water to perch on the clayey surface during wetter months; it tends to evaporate when temperatures rise. This indurated material is often referred to locally as Coffee Rock and can easily cause refusal of a 20 tonne hydraulic excavator. Larger excavators and rock breakers have been widely used, with comparatively slow excavation productivity. Test procedures used to identify areas at risk usually include (Hillman, Cocks & Ameratunga 2003):

- Standard Penetrometer Test (blow counts in excess of 30 counts)
- Electric Friction Cone Penetrometer or CPT (cone resistances of greater than 20 MPa in sands and greater than 5 MPa in high friction ratio clays)
- Borehole core (Point Load Index $Is_{(50)}$ > 0.03 MPa).

3.2.2 Climate Data

The annual average rainfall from the Gosnells City weather station, which is in close vicinity to the Tonkin Highway trial sections, was collated to demonstrate the climatic history during the in-service life of the pavements. Data from five year prior to construction through to 2016 obtained from the Bureau of Meteorology (BOM 2013) is presented in Figure 3.1. The plot demonstrates a clear downward trend of annual average rainfall for this location.

Figure 3.1: Tonkin Highway historic annual average rainfall data



Source: BOM 2013.

3.3 Construction Data

3.3.1 Construction Notes

It was noted during construction that the white sand was difficult to compact; some sections were accepted after reworking even though they were still marginally outside the required specification (Butkus & Bruce 1982a).

As detailed in the Tonkin Highway construction report, sections T2 and T4 were located on embankments constructed of grey and black poorly-graded sands from a separate borrow pit in Canningvale. Section T6, however, was located in a shallow cut which intersected the clayey-gravel natural ground. This unsatisfactory subgrade material was excavated to a depth of 500 mm and replaced with the white subgrade sand (Butkus & Bruce 1982a).

The crushed limestone subbase was sourced from a quarry in Fremantle, whilst the limestone to produce the BSL was sourced from a quarry in Neerabup (Butkus & Bruce 1982c). The CRB was supplied from the Readymix quarry in Gosnells (Butkus & Bruce 1982d)

The subbase limestone had a calcium carbonate content of 66.8% (Butkus & Bruce 1982c) and the BSL limestone 63.8% which were both higher than the minimum required of 60%. The bitumen content of the BSL was measured at an average of 1.6% which was lower than the specified amount of 2% (Butkus & Bruce 1982d).

3.3.2 Material Properties

Basic material testing was undertaken on both the granular and asphalt materials before construction to obtain design values.

Granular materials and subgrade

The material properties of the granular materials and the sand subgrade are shown in Table 3.3 (particle size distribution (PSD)) and Table 3.4 (other results).

Table 3.3: Tonkin Highway – mean particle size distribution (granular materials)

Sieve size (mm)	% Passing			
	2% BSL	CRB	Crushed limestone	White sand
19.0	100	100	100	–
9.0	–	82	86	–
4.75	80	49	78	–
2.36	–	35	73	100
1.18	68	26	70	100
0.60	–	19	63	92
0.425	–	16	52	66
0.300	–	14	38	35
0.150	–	10	17	5
0.075	–	7	13	1
0.0135	–	3	9	1

Source: Butkus & Bruce (1982b-d, Part 2-4).

Table 3.4: Tonkin Highway – results of laboratory testing (granular materials)

Material purpose	Material	Linear shrinkage (%)	Liquid limit (%)	Plastic limit (%)	CBR (%)	MDD (t/m³)	OMC (%)
Basecourse	2% BSL (T2, T4)	–	N/O	NP	80(1)	1.84	9.2
	CRB (T6)	0.5	N/O	NP	82(2)	2.37	6.3
Subbase	Crushed limestone	0	N/O	NP	95(3)	2.00	9.3
Subgrade	White sand	0	N/O	NP	17(4)	1.79	15.8

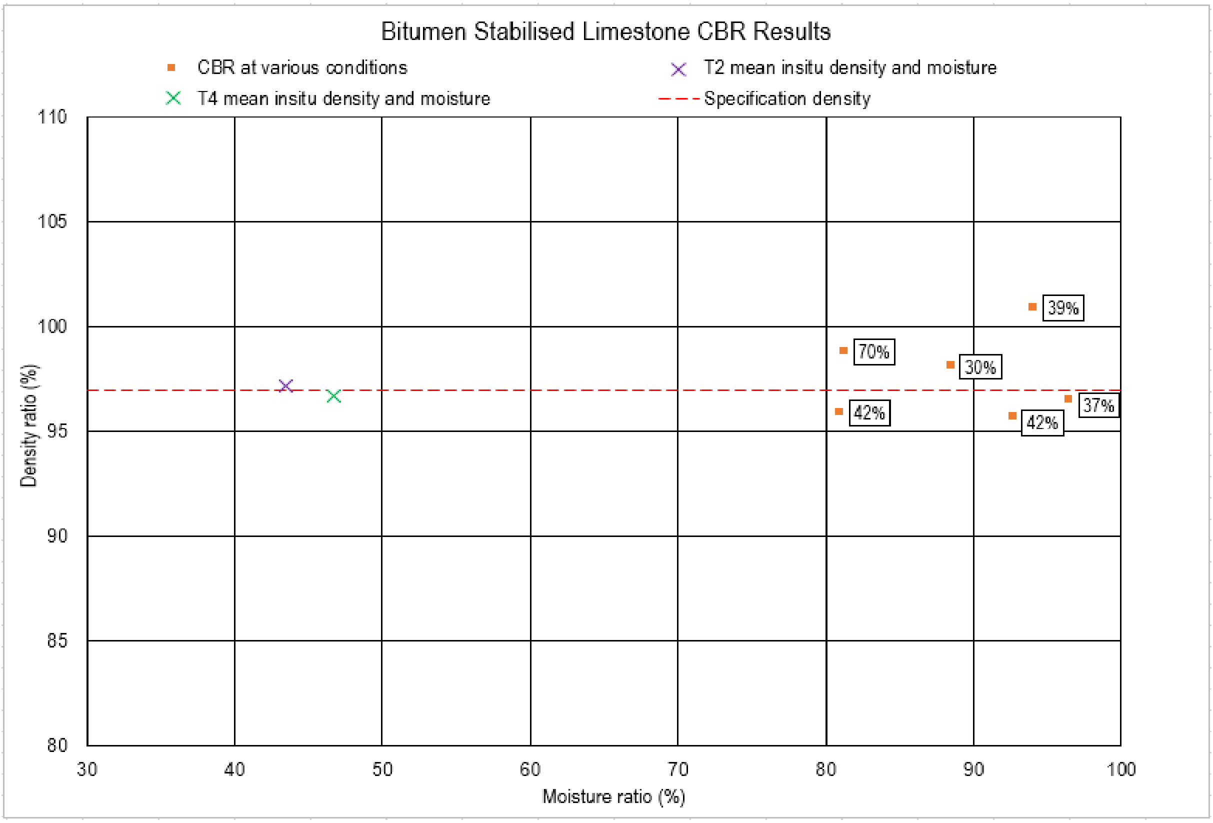
1 Mean CBR conditions: 61% OMC & 98% MMDD with 4.5 kg surcharge, 9 samples.
2 Mean CBR conditions: 78% OMC & 91% MMDD with 4.5 kg surcharge, 4 samples.
3 Mean CBR conditions: 60% OMC & 92% MMDD with 4.5 kg surcharge, 1 sample.
4 Mean CBR conditions: 74% OMC & 93% MMDD with 13.5 kg surcharge.

Notes:
- N/O – not obtainable.
- NP – non-plastic.
- MMDD – Modified maximum dry density.

Source: Butkus & Bruce (1982b-d, Part 2-4).

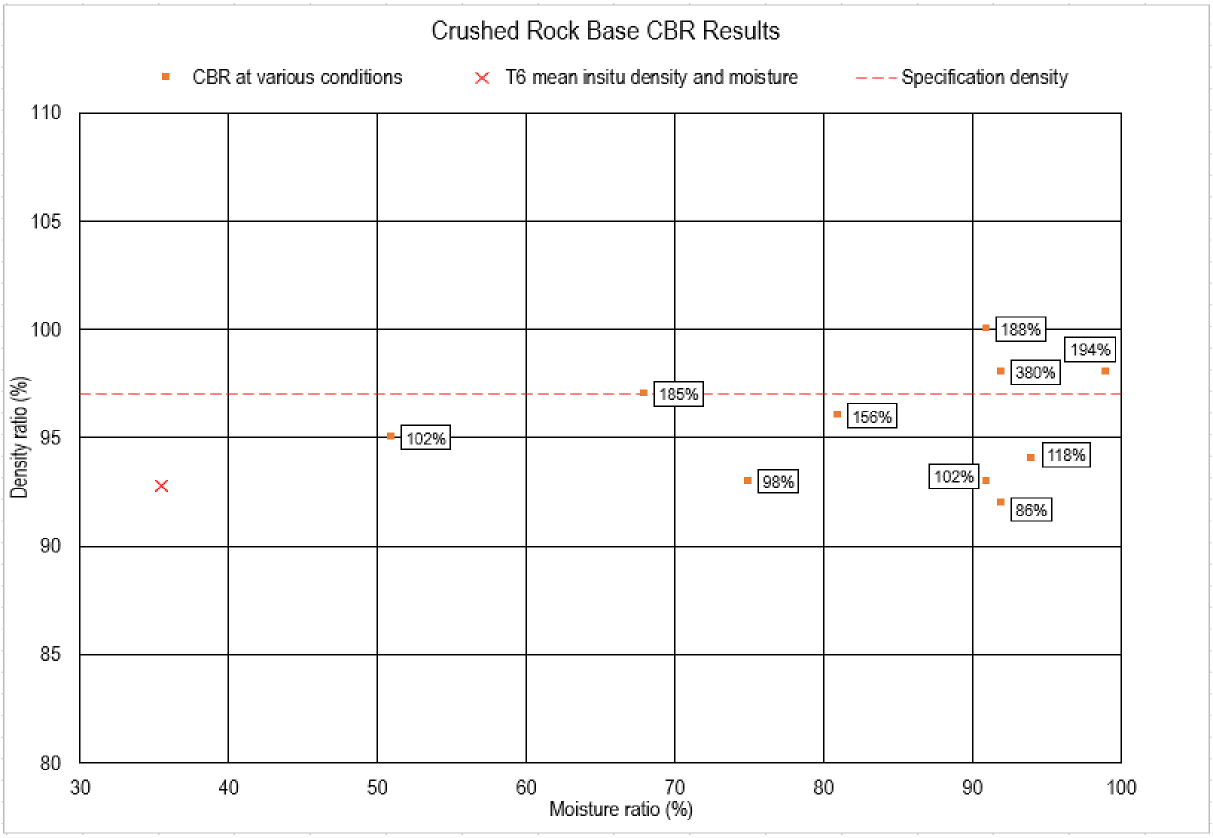
In addition to the CBR testing conducted on samples taken during construction and at conditions close to the specification density and moisture limits, laboratory unsoaked CBR testing was also conducted on the same bulk samples at various moisture and density conditions for the base materials and subgrade sand. These results are plotted in Figure 3.2, Figure 3.3 and Figure 3.4.

Figure 3.2: CBR of bitumen stabilised limestone at various conditions



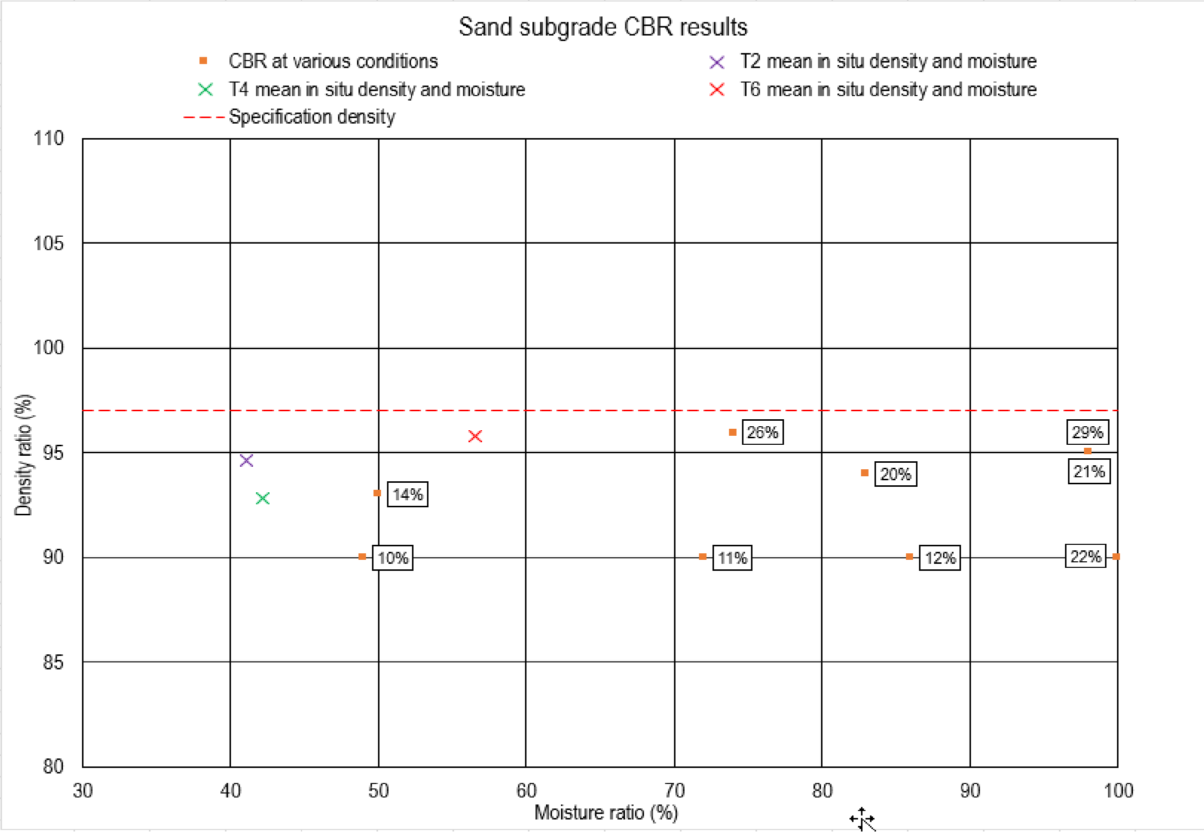
Source: Butkus & Bruce (1982d, Part 4).

Figure 3.3: CBR of crushed rock base at various conditions



Source: Butkus & Bruce (1982d, Part 4).

Figure 3.4: CBR of sand subgrade at various conditions



Source: Butkus & Bruce (1982b, Part 2).

Asphalt

The properties of the asphalt are shown in Table 3.5.

Table 3.5: Tonkin Highway – mean values of laboratory testing results (asphalt)

Asphalt type	% Actual fines (<0.075 mm)	Bitumen content (% volume, Vb)	Maximum density (t/m³)	Air voids (%)
10 mm DGA, Class 170	6.3	13.5	2.46	3.5
10 mm OGA ,Class 320	3.8	13.9	2.49	19.5

Source: Butkus & Bruce (1982e, Part 5).

3.3.3 In situ Density Testing

The density construction specifications for the Tonkin Highway trial sections are presented in Table 3.6. No dryback specification was provided for the trials.

Table 3.6: Tonkin Highway – density specifications

ID	Material	Minimum dry density ratio (% MMDD)
T2	2% BSL	97
T4		
T6	CRB	97
T2	Limestone subbase	96
T4		
T6		
T2	White sand subgrade	97

ID	Material	Minimum dry density ratio (% MMDD)
T4	*Cont...*	*Cont...*
T6		

Source: Butkus & Bruce (1982a-e).

The in situ dry density and moisture content data obtained for each section is shown in Table 3.7. The values in bold italics are below the density specification detailed in Table 3.6.

Table 3.7: Tonkin Highway – mean dry density and moisture content at construction

ID	Material	No. of tests	MDD (t/m3)	OMC (%)	Mean dry density (t/m3)	Mean moisture content (%)	Mean dry density ratio (%)	Mean moisture ratio (%)
T2	2% BSL	8	1.89	9.2	1.84	4.0	97.2	43.5
T4		6			1.83	4.2	***96.7***	46.7
T6	CRB	24	2.37	6.2	2.20	2.2	***92.8***	35.5
T2	Limestone subbase	8	2.00	9.3	1.94	5.5	96.7	59.1
T4		6			1.89	5.8	***94.5***	62.4
T6		2			1.87	6.7	***93.1***	72.0
T2	White sand Subgrade	2	1.79	15.8	1.69	6.5	***94.6***	41.1
T4		4			1.66	6.7	***92.8***	42.2
T6		6			1.713	8.9	***95.8***	56.5

Source: Butkus & Bruce (1982b-d, Part 2-4).

The in situ density results demonstrate that the mean dry density of the sand subgrade was lower than the specified density (Table 3.6) at all locations. The in situ density of the subgrade was, on average, at least 2.6% less than the specified minimum value. This reflected the difficulty of compaction as detailed in the construction notes. The in situ densities in Section T6 were low for both the limestone subbase and the CRB. The level of compaction of the base in Section T4 was acceptable; however the subbase density was also a little below the specified minimum. The compaction of both the subbase and base in Section T2 closely matched the specified minimum.

The moisture ratios in Sections T2 and T4 were similar for all materials; however, the moisture ratios in Section T6 were higher. This can be explained by the fact that Section T6 was located within a cut while Sections T2 and T4 were located on well-drained embankments. However, it is unknown how long after construction moisture sampling was undertaken. This would influence the above results.

3.4 Pavement Maintenance

It is important to identify any maintenance/rehabilitation conducted on the trial pavements as this would influence the overall performance of the pavements. Pavement and surface detail data was extracted from MRWA's corporate Integrated Road Information System (IRIS) which documents any historic structural changes or major resurfacing works that have been undertaken.

Pavement detail data for the Tonkin Highway was extracted from the IRIS database on 26 June 2016. This data indicated that all the sections had undergone an application of a two-coat sprayed seal surfacing with a 14 mm and 7 mm granite aggregates in addition to the application of a GRS. This seal was applied to Sections 1 to 3 and 6 to 8 in 2011. The remaining sections were treated in 2013.

There is no record of prior resurfacing works on these sections. The addition of a GRS at the 2011/2013 reseal works may indicate a high amount of cracking was present and that this was in fact the first surface maintenance works on the trial sections. In high crack situations, the GRS is used to stop moisture entry into the lower parts of the pavement profile. This would infer that the fatigue life of the surfacings at these trials to be in the range of 20 to 30 years and at a cumulative traffic level of approximately 1.0 x 10^7 to 2.0 x 10^7 ESAs.

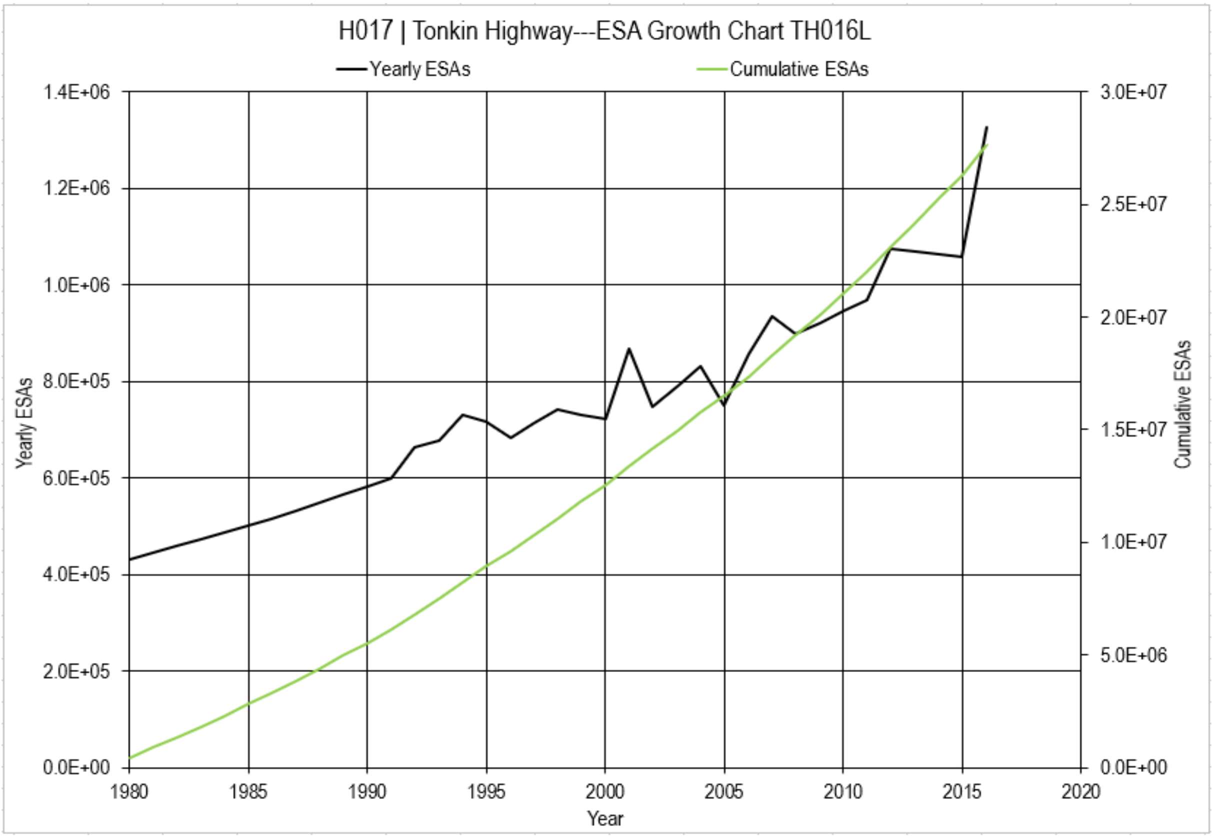
3.5 Traffic Loading

3.5.1 Cumulative Traffic Loading

Tonkin Highway traffic data from 1980 to 2016 was extracted from the MRWA IRIS database on 23 June 2016. The trial sections fall within the Tonkin Highway traffic section designated TH16L.

The cumulative number of equivalent standard axles (ESAs) to 2016 were estimated using the macro-enabled spreadsheet supplied by MRWA, together with the most up-to-date IRIS data. The yearly ESAs and the cumulative ESAs for the TH16L traffic section for 1980 to 2016 inclusive are presented in Figure 3.5.

Figure 3.5: Yearly ESAs and cumulative ESAs for section TH16L



Source: Extracted from IRIS database, June 2016.

3.5.2 Design Traffic

The 40 year design traffic loading for the Tonkin Highway trials sections was 1 x 10^7 ESAs (Sharp et. al. 1987). Other data relating to the design traffic, such as assumed growth rate etc., was not reported or was unavailable. According to the measured traffic data, this design traffic was surpassed at the end of 1997, or 17 years after construction.

3.5.3 Predicted Traffic Loading Over 40 Year Design Period

The average annual growth rate for this section between the years 1991 and 2016 was calculated as 2.8%. The forecast traffic at the end of a 40 year period (2020) was estimated to be 3.2 x 10^7 ESAs.

Traffic data was extracted for other sections of the Tonkin Highway which had similar pavement profiles and thin asphalt surfacings. Figure 3.6 shows the cumulative traffic in addition to the pavement age. The traffic data for the older pavements between approximately 5 SLK and 25 SLK has been averaged in Table 3.8. Included is a prediction of the 40 year cumulative traffic loading which was calculated based on a standard annual growth rate of 3%.

Figure 3.6: Tonkin Highway – traffic data for entire road length

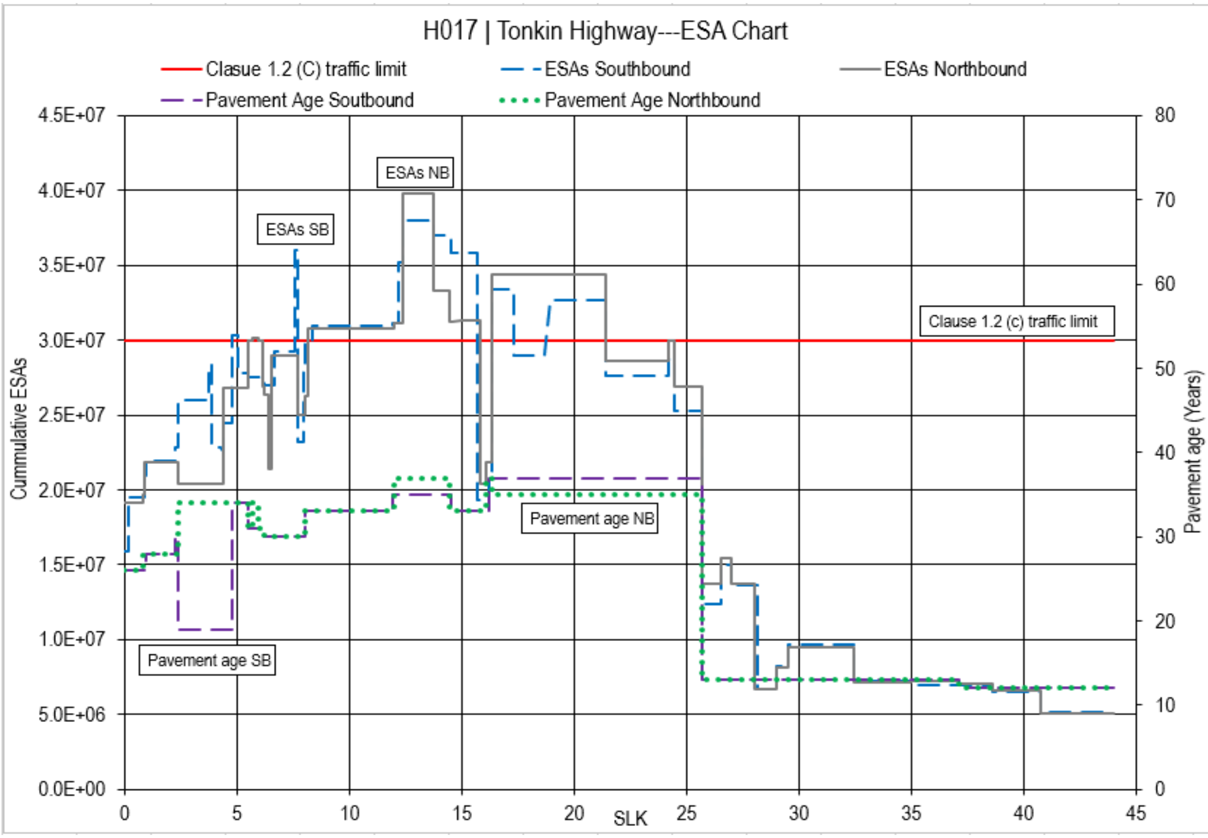


Table 3.8: Tonkin Highway – average traffic data of older sections (5 SLK to 25 SLK)

Carriageway	Southbound	Northbound
Average pavement age (years)	33	33
Average first year traffic (ESAs)	4.0 x 10^5	3.5 x 10^5
Average cumulative traffic (ESAs)	2.9 x 10^7	2.8 x 10^7
Predicted 40 year cumulative traffic (ESAs)	4.0 x 10^7	4.0 x 10^7

The traffic limit specified for the use of Clause 1.2(c) (3 x 10^7 ESA) has also been included in Figure 3.6. With the assumed 3% annual growth rate, the 40 year predicted traffic for the older sections of the Tonkin Highway exceeded the current limit.

3.5.4 Initial Traffic Loading

A similar approach was taken to determine the first year traffic statistics. The data for the Tonkin Highway is shown in Table 3.9. These values were calculated considering both the southbound and northbound carriageways together in addition to all sections of road, not just the older sections.

Table 3.9: Tonkin Highway – first year traffic data of all sections (0 SLK to 44 SLK)

Traffic data	H017
Current pavement age (years)	12 – 37
Average 1st year traffic (ESAs)	4.7×10^5
Lowest 1st year traffic (ESAs)	3.8×10^4
Highest 1st year traffic (ESAs)	1.1×10^6

3.6 Performance Monitoring

3.6.1 Dynamic Cone Penetrometer Testing of Subgrade

Dynamic cone penetrometer (DCP) testing was undertaken on the subgrade material over a nine year monitoring period between 1981 and 1990. The tests were conducted via a core hole drilled through the pavement profile. The results are presented in Table 3.10.

Table 3.10: Results of Dynamic Cone Penetrometer testing of subgrade

ID	Result	Feb-81	Aug-81	Mar-82	Oct-82	Oct-84	Oct-86	Nov-88	Oct-90
T2	mm/blow	5.0	9.1	3.2	4.3	4.4	4.0	3.6	4.1
	CBR (%)	50	25	>50					
T4	mm/blow	6.7	4.9	2.6	3.8	3.7	3.6	2.7	2.5
	CBR (%)	36	>50						
T6	mm/blow	5.6	4.0	2.7	3.3	4.2	4.0	2.1	2.4
	CBR (%)	45	>50						

Source: Butkus (1991).

3.6.2 Moisture Content

Long-term monitoring of the moisture content of each of the pavement layers was conducted from the time the trial sections were constructed in September 1980 through until October 1990. This data is presented in Table 3.11 and Figure 3.7, which also includes the rainfall data for the three months prior to the sampling date. Data for the samples taken in the 2016 field investigation (discussed further in Section 3.7) have also been included.

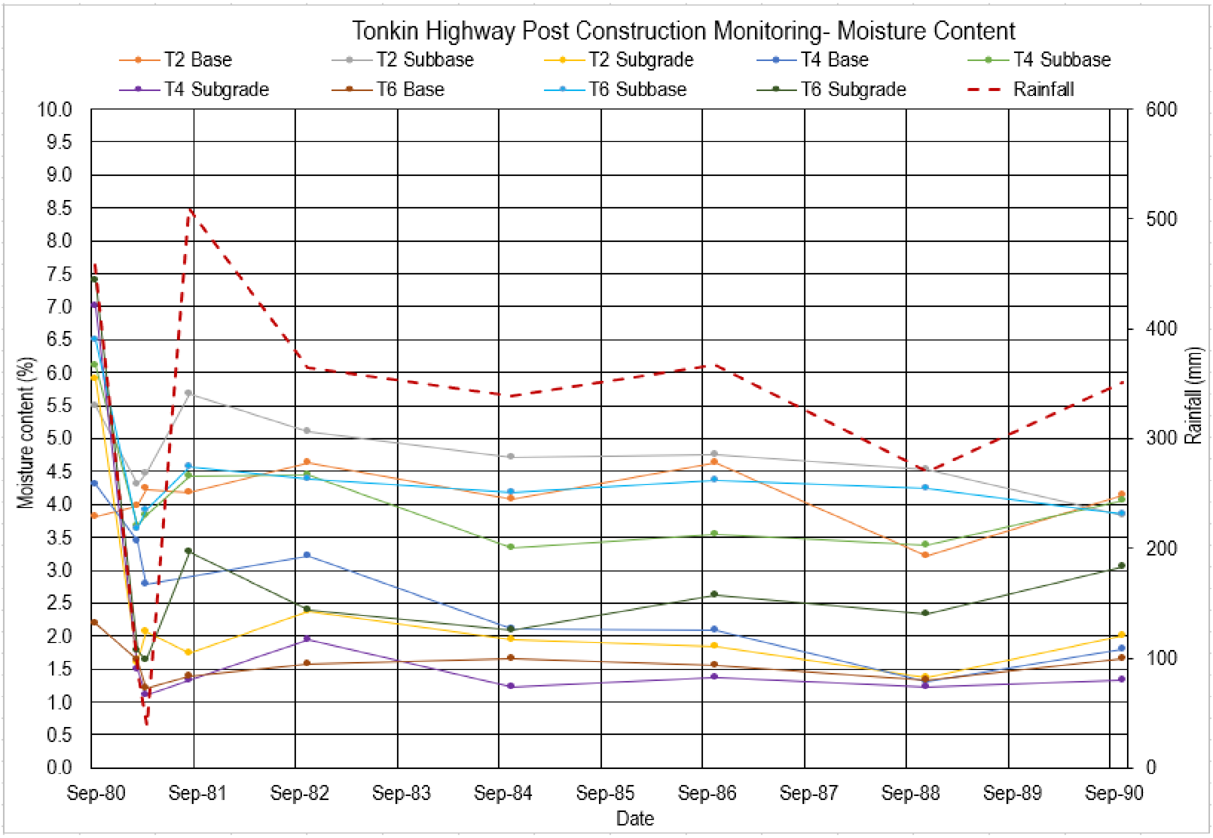
It can be seen from Figure 3.7 that there is a downward trend in the moisture content data of all three sections, indicating that the drainage, even in the cut area of Section T6, is continuing to perform well. This may also be attributed to the downward trend in annual average rainfall which would be expected to induce lower groundwater levels, and have a lesser influence on the pavement performance. All layers follow a similar trend to the rainfall in the three months prior to sampling; this may demonstrate the effect of moisture ingress through the unsealed shoulders.

Table 3.11: Tonkin Highway – moisture content data

ID	Material	Moisture content (%)(1)									
		Sep-80	Feb-81	Aug-81	Mar-82	Oct-82	Oct-84	Oct-86	Nov-88	Oct-90	Sep-16(2)
T2	BSL	3.8	4.0	4.2	4.2	4.6	4.1	4.6	3.2	4.1	5.2
	Limestone	5.5	4.3	5.7	4.5	5.1	4.7	4.8	4.5	3.8	5.3
	Sand	5.9	1.6	1.7	2.1	2.4	2.0	1.8	1.4	2.0	1.4
T4	BSL	4.3	3.4	-	2.8	3.2	2.1	2.1	1.3	1.8	1.6
	Limestone	6.1	3.7	4.4	3.8	4.5	3.3	3.6	3.4	4.1	3.5
	Sand	7.0	1.5	1.3	1.1	2.0	1.2	1.4	1.2	1.3	0.9
T6	CRB	2.2	1.6	1.4	1.2	1.6	1.7	1.6	1.3	1.7	2.1
	Limestone	6.5	3.6	4.6	3.9	4.4	4.2	4.4	4.2	3.9	3.8
	Sand	7.4	1.8	3.3	1.6	2.4	2.1	2.6	2.3	3.1	1.2
Rainfall (mm) (3)		458	84	510	39	364	339	367	270	351	375

1 Samples taken between 1.2-2.25 m transverse chainage. Result is from one test per section (Butkus 1991).
2 September 2016 data not included in Figure 3.7.
3 Rainfall is the total of the three months preceding the test date. Data from Gosnells City, station number 9106 (BOM 2013).

Figure 3.7: Tonkin Highway – results of moisture content monitoring: 1980 to 1990



Source: Butkus (1991) & BOM (2013).

The CRB in Section T6 had the smallest cumulative variation in moisture content over the initial 10 year monitoring period. This was closely followed by the subgrades in Section T2 and T4. This is probably due to these sections being constructed on top of an embankment. The largest cumulative variation was seen in the subgrade of Section T6 which is probably due to this section being located within a cut. The largest single variation (not including the change after construction) was also in the subgrade in Section T6 - 1.6 % between August and March 1981. The average moisture variation between each test date, for all pavement layers and sections, was approximately 0.5%.

Taking into consideration the results obtained in 2016, the BSL base in Section T2 and the subgrade in Section T6 show a continuing variation of moisture content. As previously discussed this is expected in the cut area of Section T6. The variation in Section T2 may be due to the greater depth of the base layer as this would subsequently reduce the effect of evaporation.

3.6.3 Deflection and Curvature

A review of all historic deflection and curvature data was undertaken to enable a preliminary performance analysis of the sections of interest. This included collation of all available data to date of the trial sections to identify unusual or unexpected trends in the deflection and curvature progression which may relate to events such as resurfacings or profile alterations, and also any out-of-the-ordinary performance trends.

The details of the reviewed deflection data for the Tonkin Highway sections are provided in Table 3.12.

Table 3.12: Tonkin Highway – details of deflection data sources

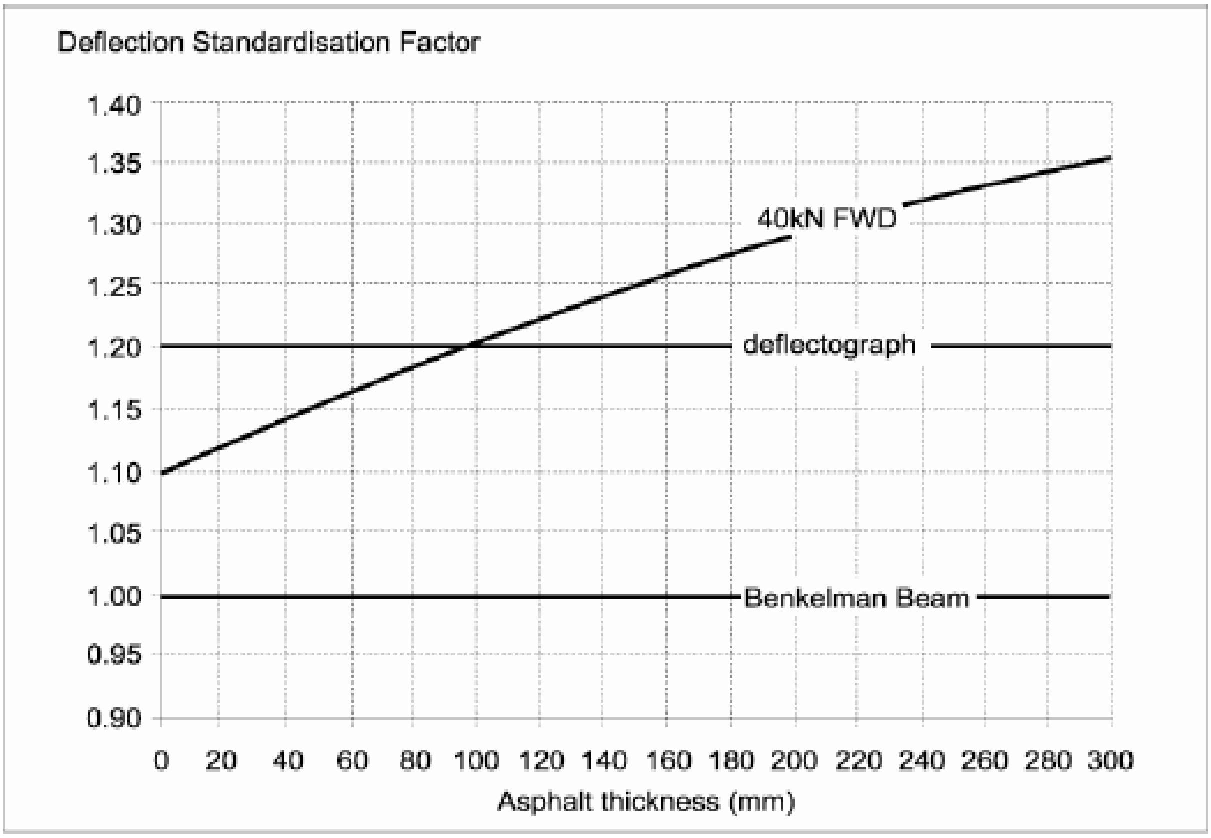
Test data source	Test date	Test details	Method
Material Report No 91/13 M (Butkus 1991)	March 1982 to October 1990	Southbound, left lane, OWP and IWP	BB
15 FWD 469/2 (Main Roads Western Australia 2016a)	December 2015	Southbound, left lane, OWP	FWD
16 FWD 513/1-16/1 (Main Roads Western Australia 2016b-e)	September 2016	Southbound, left lane & right lane, OWP & IWP	

Correction of deflection data

Before 2006, the only deflection data available for the Tonkin and Reid Highway sections was those measured using a Benkelman Beam (BB). After 2006, Falling Weight Deflectometer (FWD) testing was used.

To enable a comparison of historic BB data with the more recent FWD deflection data, the FWD maximum deflection were converted to the equivalent BB maximum deflection. Figure 6.3 of Austroads (2011) (Figure 3.8) was used to calculate the BB equivalent deflection from the FWD results.

Figure 3.8: Deflection standardisation factors



Source: Figure 6.3 of Austroads (2011).

Similarly to the maximum deflection data, the curvature data obtained from BB testing was converted to the equivalent FWD curvature using Figure 6.4 of Austroads (2011) (see Figure 3.9). The curvature is simply the gradient of the deflection bowl; it is calculated using Equation 1. These converted values were then corrected to correspond to a stress of 700 kPa.

$$Curv. = \boldsymbol{D}_{\boldsymbol{0}_{@700\,kPa}} - \boldsymbol{D}_{\boldsymbol{200}_{@700\,kPa}} \qquad 1$$

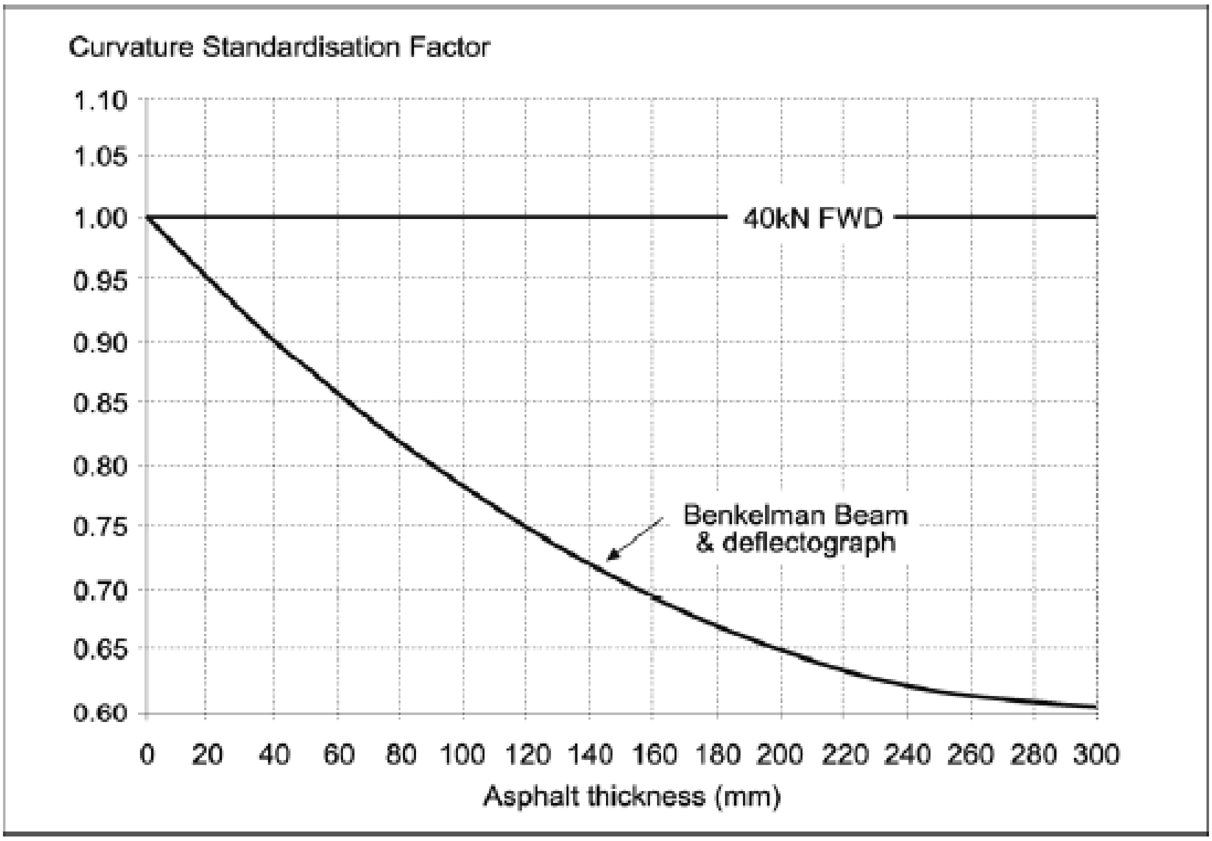
where

$Curv.$	=	curvature of deflection bowl ($D_0 - D_{200}$)
D_0	=	deflection at centre of test corrected to a stress of 700 kPa and 29 °C
D_{200}	=	deflection at 200 mm from centre of test corrected to a stress of 700 kPa and 29 °C

Deflection results

A summary of the Tonkin Highway mean deflection data is presented in Table 3.13 . This data has been corrected from the measurement temperature to the Weighted Mean Annual Pavement Temperature (WMAPT) (29°C for Perth). Also included is the BB equivalent deflection calculated from the 2015 and 2016 FWD data. Cumulative ESAs have also been included. The most recent FWD data for the Tonkin Highway sections is presented in Appendix A.

Figure 3.9: Curvature standardisation factors



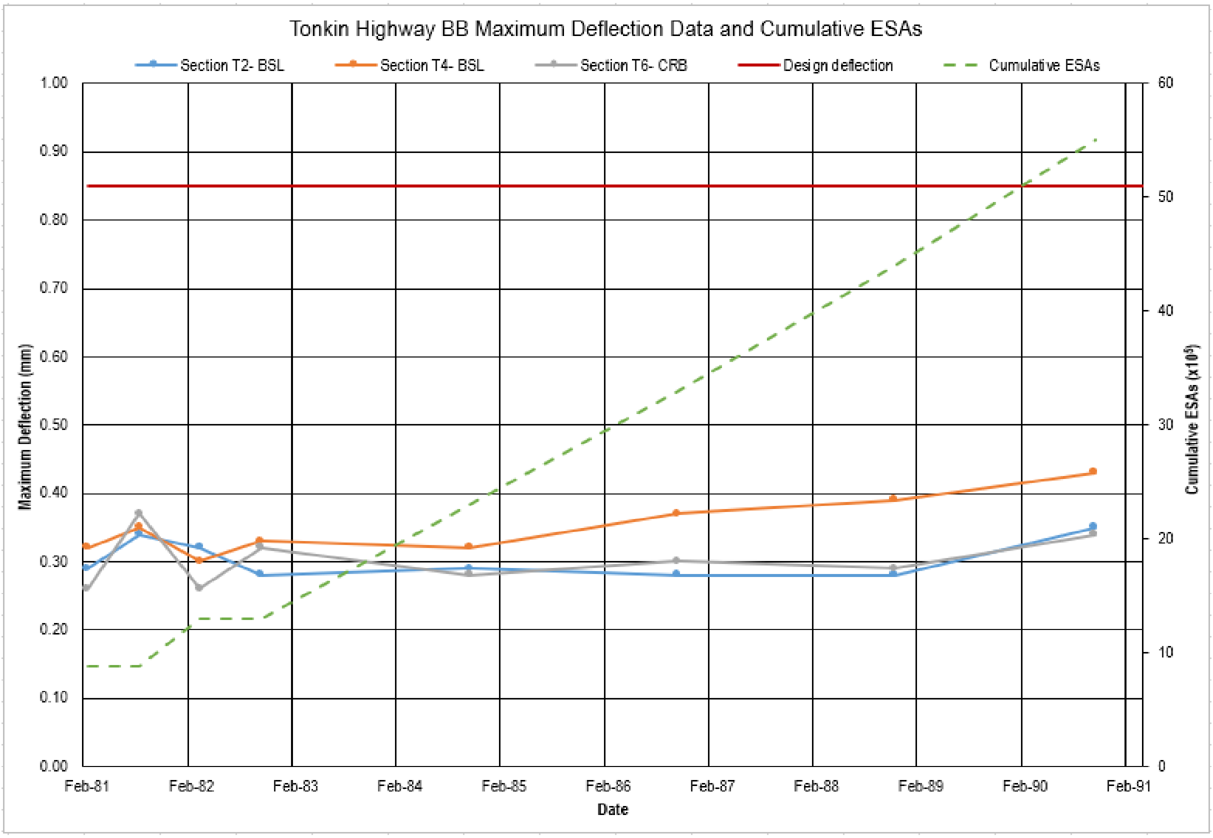
Source: Figure 6.4 of Austroads (2011).

Table 3.13: Tonkin Highway – mean maximum deflection, outer lane, OWP

ID	Basecourse material	Maximum deflection (mm)[1]								BB values estimated from FWD maximum deflections	
		Benkelman beam									
		Feb 1981	Aug 1981	Mar 1982	Oct 1982	Oct 1884	Oct 1986	Nov 1988	Oct 1990	Dec 2015	Sep 2016
T2	BSL	0.29	0.34	0.32	0.28	0.29	0.28	0.28	0.35	0.28	0.36
T4	BSL	0.32	0.35	0.30	0.33	0.32	0.37	0.39	0.43	0.30	0.40
T6	CRB	0.26	0.37	0.26	0.32	0.28	0.30	0.29	0.34	0.29	0.34
Cumulative ESAs (x 10^5)		8.8		13		23	33	44	55	263	276

1 BB and FWD maximum deflection data from outer lane, OWP only.

Figure 3.10: Tonkin Highway – BB mean maximum deflection, outer lane, OWP



Curvature Results

Table 3.14 summarises the Tonkin Highway FWD curvature data at a contact stress of 700 kPa and temperature of 29 °C. MRDAS-derived curvature data from BB measurements was only available for October 1990 and has been corrected to FWD curvatures as per Figure 3.9. Cumulative ESAs have also been included. The most recent FWD curvature data for the Tonkin Highway sections is also presented in Appendix A.

Table 3.14: Tonkin Highway – summary of curvature data, outer lane, OWP

ID	Basecourse material	Curvature (mm)(1)		
		MRDAS derived from BB measurements	FWD	
		Oct 1990	Dec 2015	Sep 2016
T2	BSL	–	0.08	0.16
T4	BSL	0.03	0.08	0.20
T6	CRB	0.09	0.11	0.15
Cumulative ESAs (x 10^5)		8.8	263	276

1 BB and FWD curvature data from left lane, OWP only.

Results of FWD investigation in 2016

The mean deflection and curvature data for the three Tonkin Highway sections of interest measured during the stage 2 investigation are shown in Table 3.15 and Table 3.16. The mean values have been calculated as an average over the entire trial section length using data collected at 5 m test intervals. The raw FWD data from the stage 2 field investigation of the Tonkin Highway is presented in Appendix A.

Table 3.15: Tonkin Highway – stage 2 investigation: mean maximum deflection, southbound lanes

ID	Basecourse material	Maximum deflection (mm)			
		Outer Lane		Inner Lane	
		OWP	BWP	BWP	OWP
T2	BSL	0.38	0.33	0.35	0.34
T4	BSL	0.44	0.33	0.42	0.44
T6	CRB	0.37	0.36	0.33	0.38

Table 3.16: Tonkin Highway – stage 2 investigation: mean curvature summary, southbound lanes

ID	Basecourse material	Curvature (mm)			
		Outer Lane		Inner Lane	
		OWP	BWP	BWP	OWP
T2	BSL	0.16	0.12	0.12	0.10
T4	BSL	0.20	0.09	0.12	0.13
T6	CRB	0.15	0.15	0.13	0.14

Deflection values were typically lower BWP than those in the OWP. Deflection values in the inner lane OWP were similar to those in the outer lane OWP for all sections while the curvature values in the inner lane OWP were typically smaller than those in the outer lane OWP. The outer lane had the highest average differential between the OWP and BWP deflection and curvature measurements.

Table 3.17: Tonkin Highway – comparison of 2015 FWD and 2016 FWD data (outer lane, OWP)

ID	Basecourse material	Maximum deflection (mm)		Curvature (mm)	
		2015 (1)	2016	2015 (1)	2016
T2	BSL	0.30	0.38	0.08	0.16
T4	BSL	0.34	0.44	0.08	0.20
T6	CRB	0.32	0.37	0.11	0.15

1 2015 FWD data collected at 10 m intervals.

A comparison of the FWD data collected in 2015 with that collected during the stage 2 investigation for the outer lane OWP showed that the deflection and curvature for all sections increased over the 9 months between the tests.

Trends in deflection and curvature

The curvature data was insufficient to enable a performance trend to be identified. However, the following three similar phases of performance can be noted from the deflection data from the Tonkin Highway trial sections independent of the base material:

- Phase 1: before opening to traffic to end of first year:
  - deflection tended to increase just above the initial pre-traffic measurement for all sections
- Phase 2: end of first year to around the end of the fifth year:
  - deflection of all sections shows little change compared to the initial pre-traffic measurements
- Phase 3: end of fifth year to end of ninth year:
  - deflection shows continuing increase for all sections and starts to exceed initial measurement.

3.6.4 Roughness Data

A comparison of the longitudinal profile (roughness) over the service life of the Tonkin Highway trial sections was also conducted. The details of the roughness data reviewed is presented in Table 3.18.

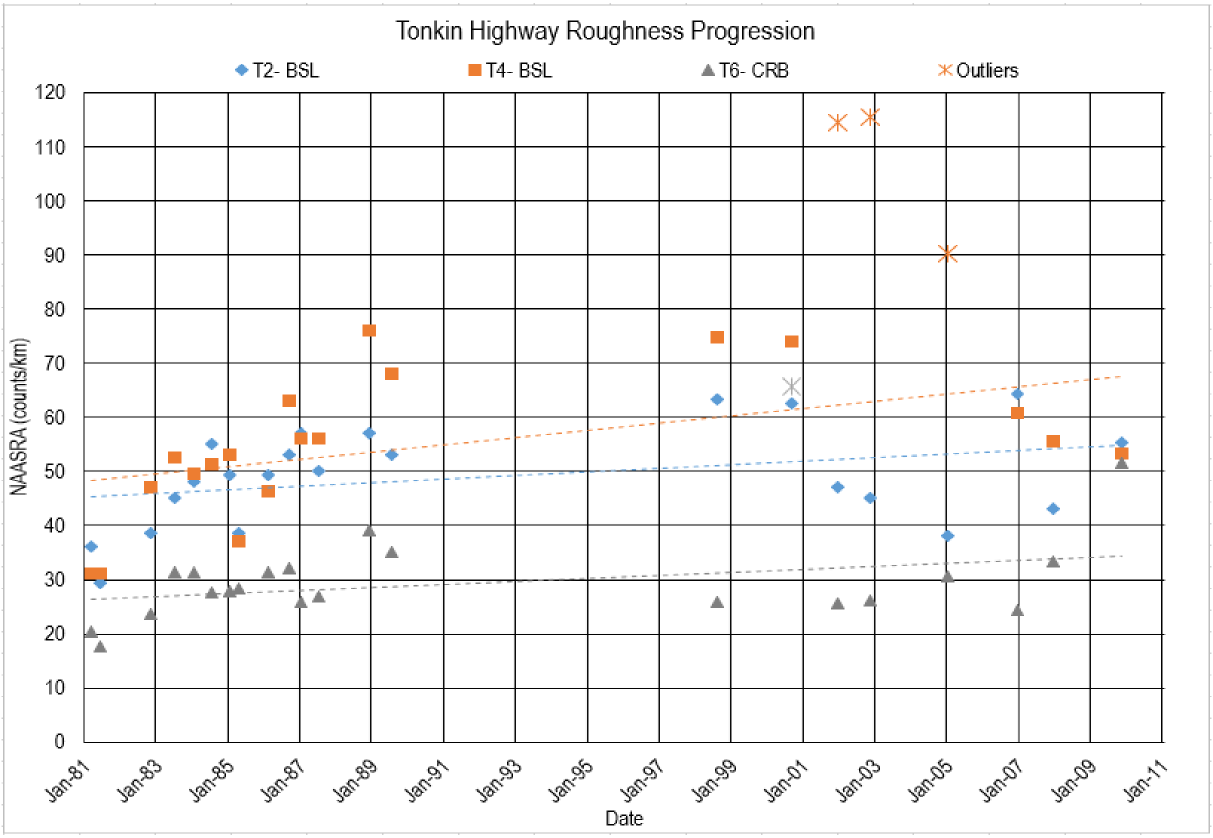
Table 3.18: Tonkin Highway – details of roughness data sources

Test data source	Test date	Results format
Tonkin Highway Test Sections – Monitoring Data Report (Butkus 1991)	9 test data sets between March 1981 and July 1989	NAASRA (counts on left, middle and right part of left lane)
IRIS data (extracted on 23 June 2016)	August 1998, September 2000, December 2001, November 2002, January 2005, December 2006, December 2007 & November 2009	NAASRA lane count

NAASRA counts for each trial section for the left, middle and right part of the left lane were also extracted from IRIS; the three readings were averaged to obtain a single roughness value for each trial section. The roughness progression of the sections of interest over time are shown in Figure 3.11. Outlying values have been plotted but have not been included in the roughness progression trends.

Section T6 showed the lowest roughness counts followed by Section T2 and Section T4 respectively. The rates of roughness progression of Section T2 and Section T6 were similar, while Section 4 showed a larger increase of roughness over time. All three trial sections have performed satisfactorily and the roughness is well below the intervention level of 110 counts/km (excluding outlying counts).

Figure 3.11: Tonkin Highway – roughness progression data



3.6.5 Rutting Data

Rutting data for the Tonkin Highway sections was extracted from IRIS. It included a mean value of rutting using a 2 m straight edge for both the IWP and OWP. The average rut depths for each section are presented in Table 3.19 and Figure 3.12 and Figure 3.13.

The lowest average rutting of approximately 3 mm was in the OWP of Section T4 followed by Sections T2 and T6 (4 mm). Section T6 had the largest differential of approximately 4 mm when comparing the OWP and IWP measurements. The rutting in the IWP was consistently higher than that in the OWP for all sections.

The graphical representation of the rut development over time suggests that the first four data sets represent outlying results. Thereafter the rutting progression increases for each section as expected. It is also understood that the automated laser method used for rut depth measurements changed in 2013 in conjunction with a change in the award of the data collection contract. This may also explain discrepancies in the data collected in 2012 and 2015.

After the resurfacing of Sections T2 and T6 in 2011, the rut depth in these two sections decreased with the exception of the OWP in Section T6 which continued to increase.

Table 3.19: Tonkin Highway – average rut value for each section (2 m straight edge)

Test year	Section T2		Section T4		Section T6	
	Average OWP rut depth (mm)	Average IWP rut depth (mm)	Average OWP rut depth (mm)	Average IWP rut depth (mm)	Average OWP rut depth (mm)	Average IWP rut depth (mm)
Feb-99	3.9	4.7	4.7	6.9	4.2	6.9
Sep-00	3.3	4.8	3.4	7.3	3.2	6.5
Dec-06	2.2	6.8	2.1	4.2	1.7	9.1
Dec-07	4.6	5.4	1.3	3.0	5.5	8.5
Dec-08	3.0	6.8	1.5	2.9	2.1	9.1
Nov-09	5.9	5.4	1.6	2.7	3.4	7.9
Nov-12	5.7	4.6	1.6	2.3	4.9	6.9
Jan-15	4.6	4.7	3.3	3.4	4.6	6.1

Figure 3.12: Tonkin Highway – rutting data OWP (2 m straight edge)

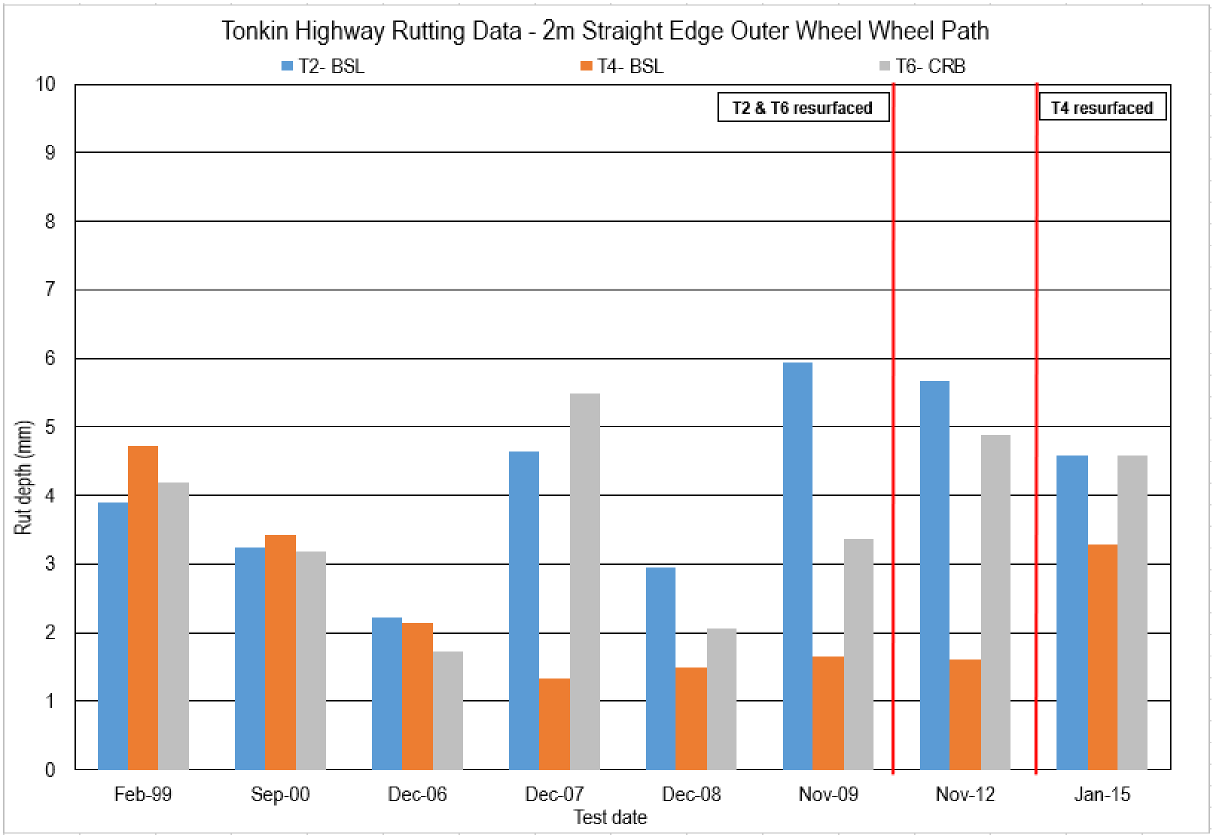
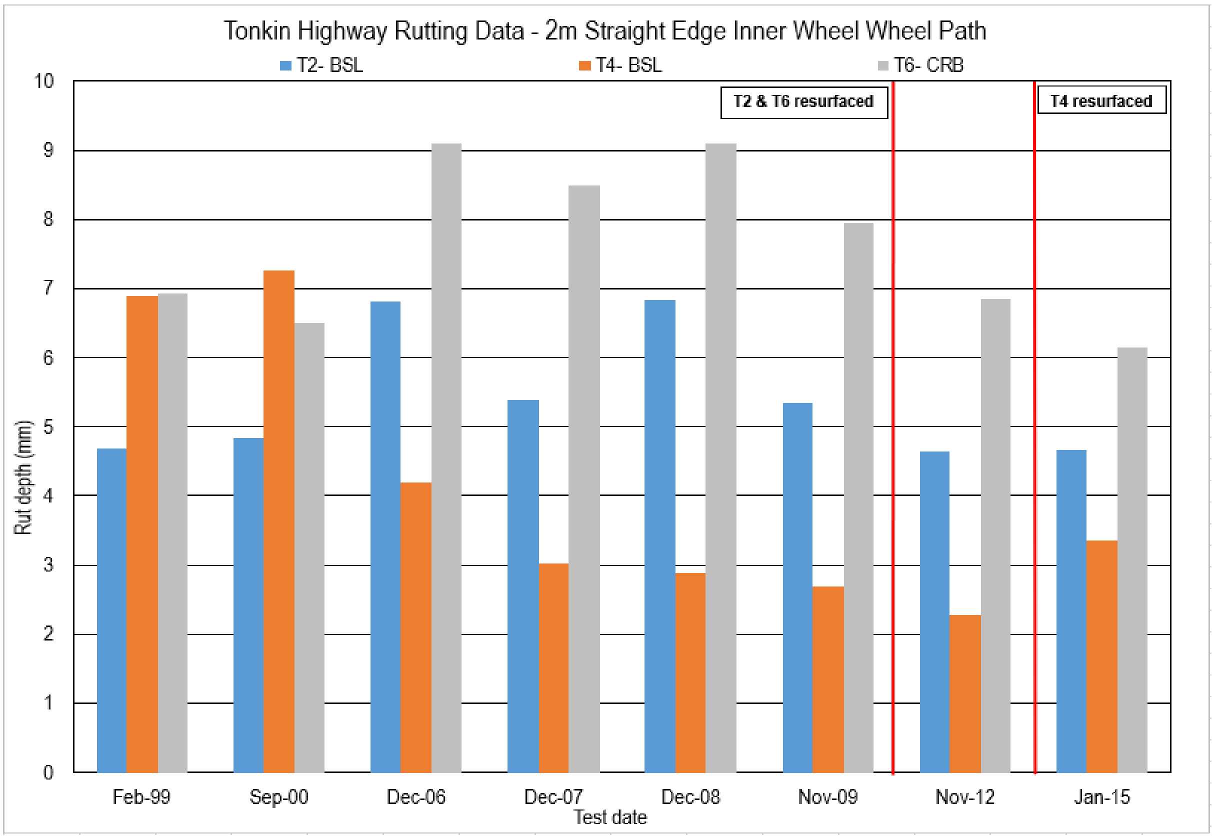


Figure 3.13: Tonkin Highway – rutting data IWP (2 m straight edge)



3.7 Field Investigation

3.7.1 *Introduction*

A field investigation was undertaken in late September 2016 in order to confirm the pavement configurations, measure FWD deflections and sample granular and subgrade materials for laboratory testing.

Field work included the following:

- FWD testing at 5 m intervals along the southbound carriageway. Testing was undertaken in both the OWP and BWP of the left lane and in the OWP and BWP of the right lane. The results are discussed in Section 3.6.3.
- Coring of the asphalt surfacing BWP at 10 m spacings to measure thickness.
- Excavation of a test pit in the OWP at the middle chainage of each test section to measure base and subbase thicknesses and check the upper basecourse condition.
- Nuclear density and moisture content testing of the base and subbase granular layers.
- Bulk sampling of granular materials and subgrade for laboratory testing.

Photographs from the field investigation are provided in Appendix A.

3.7.2 *Asphalt Coring and Profile Measurements*

Mechanical coring of the asphalt layers was undertaken at 10 m intervals along the trial sections to confirm the current surfacing thickness. The maximum and minimum thickness for each section of interest is shown in Table 3.20. The test certificates and summary tables are included in Appendix A.

Table 3.20: Tonkin Highway – Thicknesses of asphalt surfacing

ID	Minimum thickness (mm)	Maximum thickness (mm)	Mean thickness (mm)
T2	41	78	73
T4	60	91	72
T6	33	45	38

Notes:
- Excludes seal thickness of 10 mm.
- Cores taken from BWP.

Table 3.21 lists the measured base and subbase thicknesses at three test pits located in the OWP.

Table 3.21: Tonkin Highway – thickness of base and subbase

Material	Mean thickness (mm)		
	Section T2	Section T4	Section T6
Base	65	60	65
Subbase	250	250	230

3.7.3 Field Density and Moisture Content

The results of the in situ dry density and moisture content testing are shown in Table 3.2.

Table 3.22: Tonkin Highway – results of dry density and moisture content testing

ID	Material	Moisture content (%)	In situ dry density ratio (% MMDD) in 2016 (%)	Mean in situ dry density ratio (% MMDD) at construction (%)
T2	BSL	5.2	101.4	97.2
T4		1.6	102.5	96.7
T6	CRB	6.1	93.7 (1)	92.8
T2	Limestone (2)	5.3	99.0	96.7
T4		3.5	95.5	94.5
T6		3.8	98.4	93.1

1 Poor test surface may affect results.
2 Using combined MDD relationship for Sections T2 & T4.

3.7.4 Laboratory Testing

Details of the laboratory testing undertaken on the bulk samples recovered from the excavated test pits are shown in Table 3.23. The test certificates and summary tables are given in Appendix A.

Table 3.23: Tonkin Highway – bulk sample laboratory test schedule

ID	Material purpose	Material	Moisture	PSD	Consistency Limits	Density moisture relationship	CBR	In situ nuclear density (t/m^3)
T2	Basecourse	BSL	✓	✓	✓	✓(1)	✓(1)	✓
	Subbase	Limestone	✓	✓	✓	✓(2)	✓(2)	✓
	Subgrade	Sand	✓	✓	✓	✓	✓	
T4	Basecourse	BSL	✓	✓	✓	✓(1)	✓(1)	✓
	Subbase	Limestone	✓	✓	✓		✓	✓
	Subgrade	Sand	✓	✓	✓	✓		
T6	Basecourse	CRB	✓	✓	✓	✓		✓
	Subbase	Limestone	✓	✓	✓	✓(2)	✓(2)	✓
	Subgrade	Sand	✓	✓	✓	✓	✓	

1 Section 2 and Section 4 BSL sample combined for density moisture curve & CBR.
2 Section 2 and Section 6 limestone combined for density & moisture curve & CBR.

From the results of the testing the following observations were made:

- The in situ density of the materials was similar to that at construction with the exception of the limestone subbase in Section T6 and the BSL base at both T2 and T4.
- The particle size distributions (PSD) of the CRB and BSL had become slightly finer overall.
- The PSD of the limestone subbase had become slightly finer in the gravel and sand portion of the material. The proportions of material below 0.3 mm size had remained the same.
- The CBR of the sand subgrade was 20%.

4 REID HIGHWAY

4.1 Overview

The nine Reid Highway trial sections are located between West Swan Road and Bennett Brook Bridge in West Swan. Sections 1 to 3 are located east of Lord Street between chainages 19 700 and 19 980 m, whilst Sections 4 to 9 are located west of Lord Street between chainages 18 420 m and 19 000 m. The test sections include a single lane in both the east and west direction with a posted speed limit of 90 km/h. The start and end chainages and corresponding lengths of each trial section are shown in Table 4.1. The granular pavement materials are also shown.

Table 4.1: Details of trial sections: Reid Highway

Trial section	Start chainage (m)	End chainage (m)	Length (m)	Materials		
				Base	Subbase	Subgrade
1	19 890	19 980	90	2% HCTCRB	Crushed limestone	White sand
2	19 800	19 890	90	2% BSL		
3	19 700	19 800	100	CRB		
4	18 880	19 000	120	CRB		
5	18 790	18 880	90	1% HCTCRB		
6	18 700	18 790	90	2% HCTCRB		
7	18 600	18 700	100	0.75% GGBFS stabilised CRB		
8	18 500	18 600	100	2% GGBFS stabilised limestone		
9	18 420	18 500	80	LIMUD		

1 HCTCRB: Hydrate cement-treated crushed rock base.
2 GGBFS: Ground granulated blast furnace slag.
3 LIMUD: Lime putty-stabilised limestone.
Source: Butkus (2004).

Construction of the trial sections was undertaken between October 1995 and April 1996, and the road was opened to traffic in December 1996 (Butkus 2004). All construction and laboratory details are included in a series of internal technical Main Roads reports (Butkus 2004). These reports collectively include details such as section chainage, design material profiles, as-constructed material profiles, basic laboratory analysis of base, subbase and subgrade materials, construction QA test results and after-construction monitoring data including the results of Benkelman beam testing.

The thickness of asphalt at each section was not individually reported as the initial surfacing was a two-coat primerseal. However, the test sections were subsequently surfaced with a nominal 30 mm thick size 10 mm DGA asphalt for shape correction and opened to traffic in December 1996. The actual asphalt thickness was noted to vary between 44 mm and 65 mm.

4.2 Sections of Interest

The composition of each section of interest as detailed in the construction report is presented in Table 4.2. A section identification number was assigned to each section of interest with a prefix to differentiate between trial locations.

Table 4.2: Sections of interest – pavement and profiles: Reid Highway

Identification number	Layer	Material	Design thickness (mm)	As constructed mean thickness (mm)
R2	Base	2% BSL	100	113
	Subbase	Crushed limestone	230	271
	Subgrade	White sand	–	–
R3	Base	CRB	100	90
	Subbase	Crushed limestone	230	259
	Subgrade	White sand	–	–
R4	Base	CRB	200	211
	Subbase	Crushed limestone	130	133
	Subgrade	White sand	–	–

Source: Butkus (2004).

4.2.1 Subsurface Conditions

The 1:250 000 Environmental Geological Map series produced by the Geological Survey of Western Australia Pinjarra sheet (Geological Survey of Western Australia 1980) indicates that the natural subsurface material below the trial pavements was Bassendean sand.

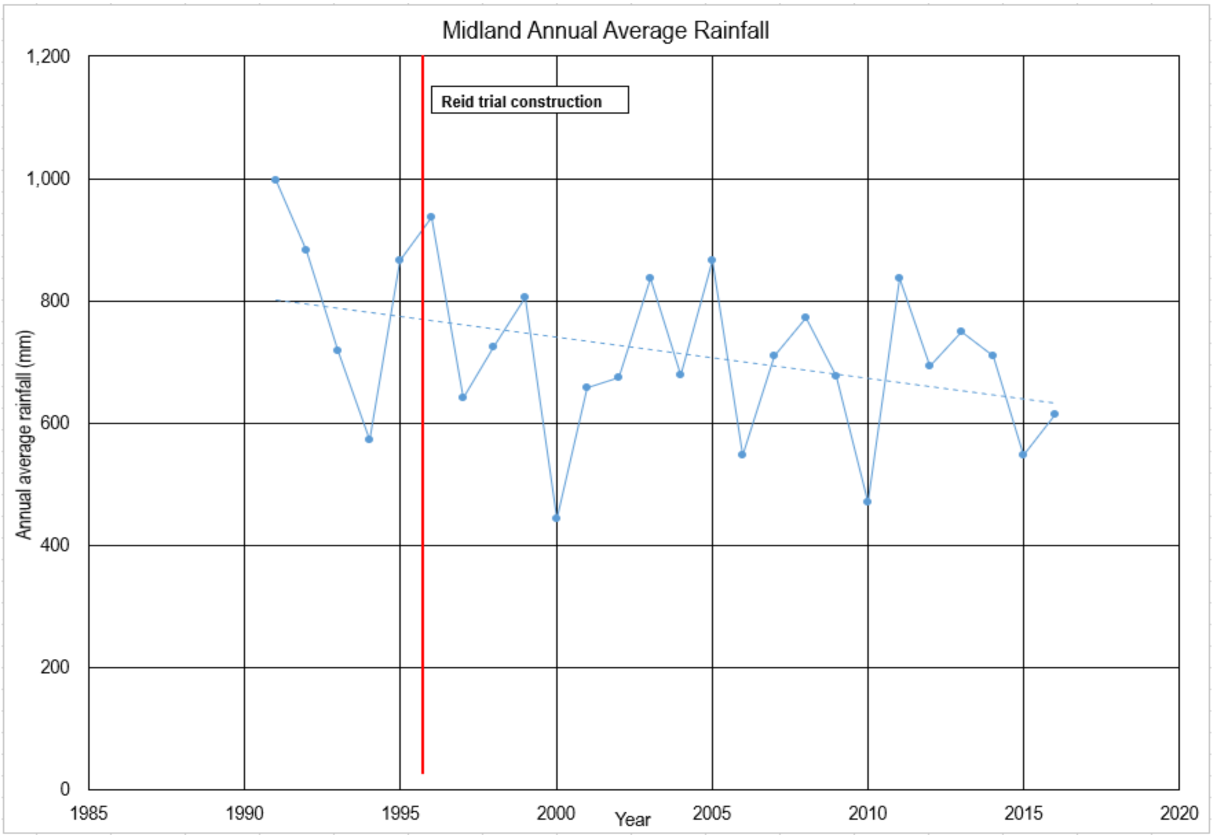
A large geotechnical investigation of the proposed Reid Highway between Beechboro Road and Great Norther highway was undertaken by MRWA in May 1990 (Lee-Goh & Marchant 1991). A hand auger borehole log located in the location of sections R2 and R3 also indicated the subsurface material was Bassendean sands to at least a depth of 1 metre.

Hand auger holes in the vicinity of R4 indicated that the subsurface material west of Lord Street was thin Bassendean sand overlying clayey sands of the Guildford formation at depths below approximately 1 metre below ground level. The clayey sands had a fines content over 10%, a liquid limit of over 27% and a plasticity index (PI) of over 15%. The Linear Shrinkage (LS) also varied from 2% to 5% and the in situ moisture content was high at 12% to 14%.

4.2.2 Climate Data

The annual average rainfall was obtained from the Midland weather station, which is in close vicinity to the Reid Highway trial sections. Data from five years prior to construction through to 2016 is presented in Figure 4.1. The plot demonstrates a clear downward trend of annual average rainfall for this location.

Figure 4.1: Reid Highway – historic annual average rainfall data



Source: BOM (2013).

4.3 Construction Data

4.3.1 Construction Notes

The top 300 mm of the in situ material was removed, geofabric was placed and an embankment of sand fill, generally at least 1 m thick, was constructed from imported yellow non-plastic Bassendean sand. A design subgrade CBR of 12% was assigned to the embankment material (Butkus 2004).

The subbase material and the limestone for the BSL were sourced from the same quarry in Neerabup. The CRB was sourced from the Readymix Quarry in Gosnells (Butkus 2004).

The CRB conformed to the MRWA Specification 501 (MRWA 2012a) and was typical of material used throughout the metro area. The calcium carbonate content of the limestone used in the BSL in Section R2 was 69.9% which met the minimum specified value of 60%. The bitumen content of the BSL varied, with an average of approximately 1.9% which did not quite meet the specification of 2% (Butkus 2004).

4.3.2 Material Properties

Material testing of the granular materials was undertaken prior to construction and the results were as follows.

Granular materials and subgrade

The material properties of the granular materials and the sand subgrade are shown in Table 4.3 and Table 4.4.

Table 4.3: Reid Highway – Particle Size Distribution – granular materials (CRB)

Sieve size (mm)	% Passing
19	100
13.2	91
9	76
4.75	55
2.36	40
1.18	30
0.6	22
0.425	19
0.3	16
0.15	12
0.075	9
0.0135	5

Source: Butkus (2004).

Table 4.4: Reid Highway –mean values of laboratory testing results – granular materials

Material purpose	Material	Test Conditions		Resilient modulus(1) (MPa)	Mean MDD (t/m^3)	Mean OMC (%)
		% MDD	% OMC			
Basecourse	2% BSL	96.1	74.0	286	1.85	10.7
	CRB	97.4	69.6	186	2.30	5.4
Subbase	Crushed limestone	93.6	80.4	185	1.94	9.8
Subgrade	White sand	–	–	–	1.81	12.5

1 RLT testing conducted at 50 kPa confining stress 300 kPa deviator stress after 3000 cycles.
Source: Butkus (2004).

Asphalt

The trial sections were originally surfaced with a two-coat emulsion primerseal with 10 mm and 5 mm aggregate respectively. No data regarding the asphalt surfacing, which was later placed for profile correction, was available. The only information provided was that the asphalt surfacing was a 10 mm DGA which ranged in thickness from 30 mm to 50 mm.

4.3.3 Density Testing

The construction specifications for the minimum dry density ratio and dryback are presented in Table 4.5. Full material specifications are reported in Appendix B.

The measured in situ dry density and moisture content data are listed in Table 4.6. The values in bold italics are below the specifications detailed in Table 4.5.

The mean dry density of all the materials in all sections was well above the target density with the exception of the subbase in Section R3, which was marginally lower than the target. The dryback in the CRB at Section R4 was close to specification but slightly wet.

Table 4.5: Reid Highway – density and dryback specifications

ID	Material	Minimum dry density ratio (% MMDD)	Dryback (% of OMC)
R2	2% BSL	96	85
R3	CRB	98	60
R4			

ID	Material	Minimum dry density ratio (% MMDD)	Dryback (% of OMC)
R2	Limestone subbase	94	Not specified
R3			
R4			
R2	White sand subgrade	96	Not specified
R3			
R4			

Source: Butkus 2004.

Table 4.6: Reid Highway – mean in situ nuclear density and moisture content at construction

ID	Material	No. of tests	MDD (t/m^3)	OMC (%)	Mean dry density (t/m^3)	Mean moisture content (%)	Mean dry density ratio (%)	Mean moisture ratio (%)
R2	2% BSL	9	1.85	10.7	1.85	8.8	99.9	82.2
R3	CRB	9	2.30	5.4	2.34	2.7	101.5	50.0
R4		4	2.31	5.3	2.31	3.4	100.0	***64.2***
R2	Limestone subbase	2	1.96	9.5	1.90	2.2	96.8	23.2
R3		1			1.83	3.1	***93.4***	32.6
R4		3	1.92	10.1	1.84	8.4	96.1	83.2
R2	White sand subgrade	2	1.81	9.9	1.85	9.6	102.3	97.0
R3		5	1.80	12.1	1.82	5.5	100.1	45.2
R4		3	1.81	13.0	1.81	4.6	100.2	35.1

Source: Butkus (2004).

4.4 Pavement Maintenance

Pavement detail data for the Reid Highway was extracted from IRIS on 26 June 2016. This data indicates that the cross-section of Sections 4 to 7 was changed in 2014 as part of the upgrade and widening of the Reid Highway and Lord Street intersection. These changes included the removal of the existing asphalt surfacing and approximately 100 mm of the existing granular basecourse prior to the installation of a full depth asphalt pavement. As Section R4 was modified, only data prior to 2014 has been considered in this study.

Sections R2 an R3 have not been strengthened or resurfaced since construction in 1996.

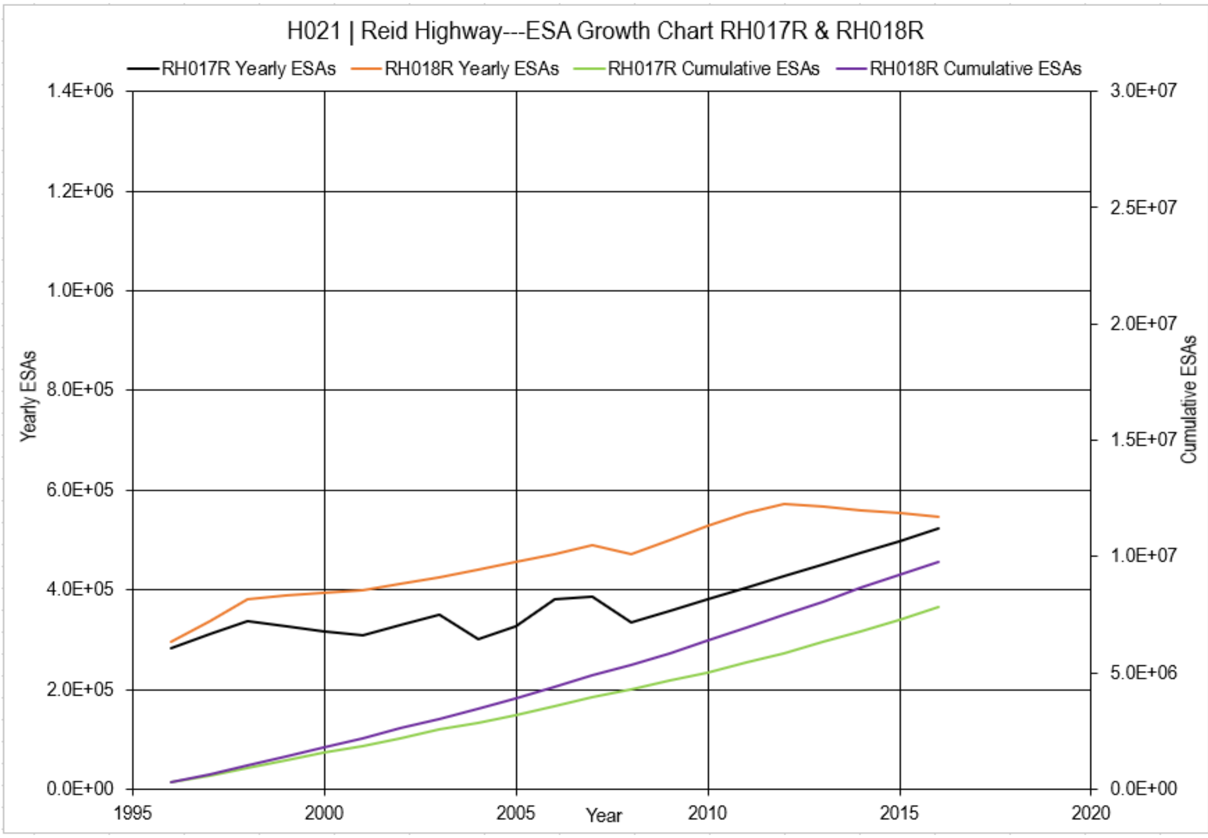
4.5 Traffic Loading

4.5.1 Cumulative Traffic Loading

Westbound Reid Highway traffic data from 1996 to 2016 was extracted from the IRIS database on 23 June 2016. The westbound trial Sections R2 and R3 fall within the traffic designation RH18R whilst R4 falls within RH17R.

The cumulative ESAs to 2016 were estimated using the macro-enabled spreadsheet provided by MRWA in conjunction with the most up-to-date IRIS data. The yearly ESAs and the cumulative ESAs for the RH17R and RH18R traffic sections for the years 1996 to 2016 inclusive are shown in Figure 4.2.

Figure 4.2: Reid Highway – Yearly ESAs and cumulative ESAs for Sections RH17R and RH18R



Source: IRIS database 2016.

4.5.2 Design Traffic

The 40 year design traffic for the Reid Highway trials sections was 3.5 x 10^7 ESAs (Butkus 2004). Other data relating to the design traffic such as the assumed growth rate were not detailed.

4.5.3 Predicted Traffic Loading Over 40 Year Design Period

An average annual growth rate of the RH18R section between the years 1996 and 2016 was 3.1%. The forecast traffic at the end of a 40 year period in 2036 was estimated to be 2.5 x 10^7 ESAs.

Traffic data was also extracted for other sections of the Reid Highway which have similar pavement profiles, including thin asphalt surfacings and the cumulative traffic and pavement age are shown in Figure 4.3. The traffic data for the older pavements, located between chainages approximately 5 SLK and 20 SLK, are reported in Table 4.7. A prediction of the 40 year cumulative traffic, which was calculated based on a standard 3% annual growth rate, is also shown in the Table 4.7.

Figure 4.3: Traffic data: Reid Highway

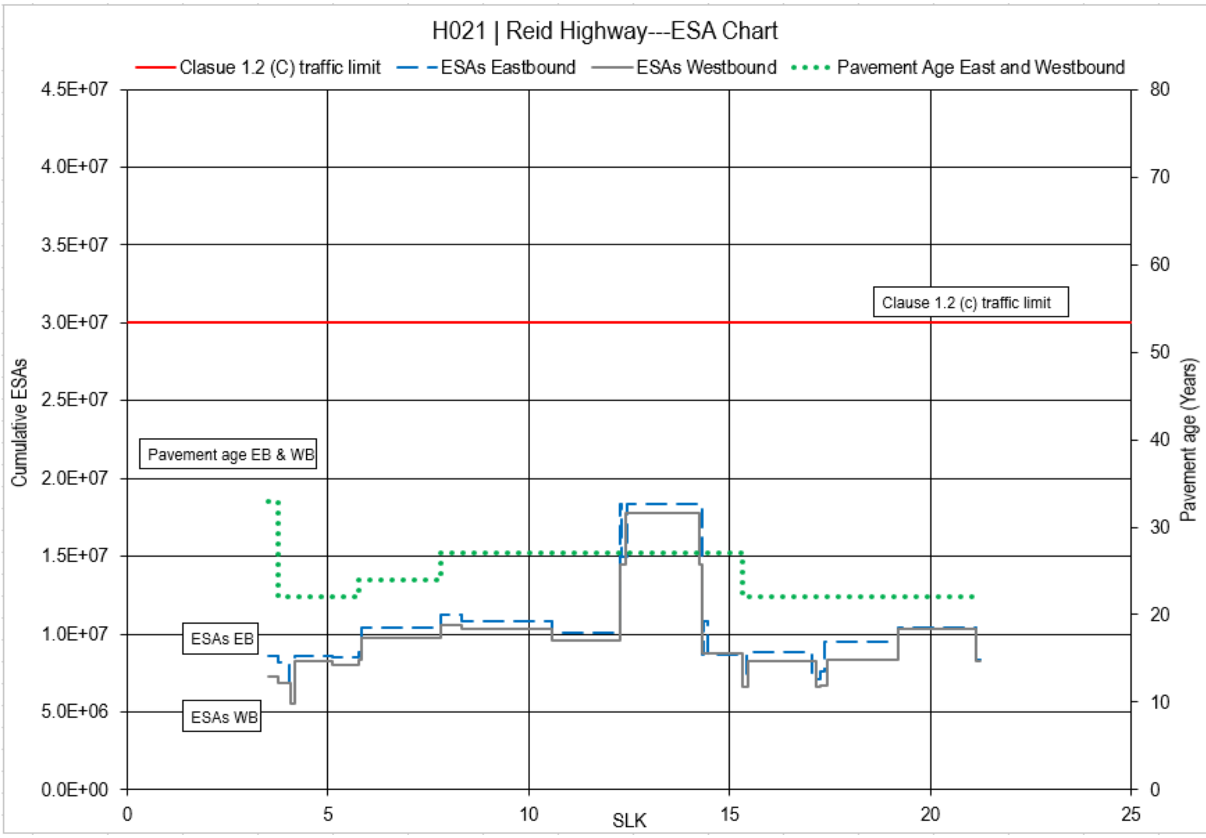


Table 4.7: Reid Highway – Average traffic data – older sections

Traffic data	Eastbound	Westbound
Average pavement age (years)	25	24
Average 1st year traffic (ESAs)	2.1×10^5	2.1×10^5
Average cumulative traffic(ESAs)	1.0×10^7	9.3×10^6
Predicted 40 year cumulative traffic (ESAs)	2.0×10^7	2.0×10^7

The traffic limit specified for the use of Clause 1.2(c) (3×10^7 ESA) has also been included in Figure 4.3. Assuming an annual growth rate of 3%, the 40 year predicted traffic for the older sections of Reid Highway does not exceed the current limit. However, some of these pavements are fairly young (eight years) and the prediction of the 40 year traffic may not be reliable. The data should be reviewed in 10 years time to better predict 40 year traffic.

4.5.4 Initial Traffic Loading

A similar approach was taken to determine the traffic in the first year. These values, shown in Table 4.8, were calculated considering both the left and right carriageways together in addition to all sections of road, not just the older sections.

Table 4.8: Reid Highway Reid Highway – traffic data in first year, all sections (chainage SLK to 24 SLK)

Traffic data	H021
Current pavement age (years)	8 – 33
Average 1st year traffic (ESAs)	2.3×10^5

Traffic data	H021
Lowest 1st year traffic (ESAs)	1.5×10^4
Highest 1st year traffic (ESAs)	5.0×10^5

4.6 Performance Monitoring

4.6.1 Clegg Impact Hammer

Testing was undertaken on the surface of the basecourse using the Clegg Impact Hammer both after construction and before the pavements were opened to traffic. The testing was conducted before the asphalt surfacing was placed. The results of this testing are shown in Table 4.9. All of the measured values were above the minimum specified Clegg Impact Value (CIV) of 45.

Table 4.9: Results of Clegg Impact Hammer testing –pre-traffic

Section ID	Material	CIV	
		Jun-96	Sep-96
R2	BSL	70	63
R3	CRB	56	53
R4	CRB	47	58

Source: Butkus 2004.

4.6.2 Moisture Content

Long-term monitoring of the moisture content of each of the pavement layers was conducted from the time of the trial pavements were constructed in June 1996 until November 2003. This data is presented in Table 4.10 and Figure 4.4; rainfall data for the three months prior to the sampling date is also provided. Samples taken in the 2016 field investigation (discussed further in Section 4.7) have also been included.

Table 4.10: Reid Highway – results of moisture content testing

ID	Material	Moisture content (%) (1)								
		Jun-96	Sep-96	May-97	Oct-97	Jan-99	Dec-99	Nov-03	Nov-06(2)	Sep-16(3)
R2	BSL	3.9	3.8	3.8	3.6	4.1	4.0	3.8	4.3	4.5
	Limestone	4.6	4.8	4.7	5.0	5.2	5.3	6.1	–	5.7
	Sand	–	–	–	–	2.8	2.8	3.4	–	3.6
R3	CRB	2.2	–	2.7	2.1	2.6	2.1	2.3	2.5	3.2
	Limestone	3.4	4.4	4.0	4.3	4.6	4.6	4.9	–	5.8
	Sand	–	–	–	–	3.2	2.7	2.9	–	3.3
R4	CRB	3.2	3.2	3.0	2.7	3.1	2.8	2.8	2.7	–
	Limestone	4.6	5.3	4.6	–	4.1	4.3	4.1	–	–
	Sand	–	–	–	–	3.0	2.8	2.5	–	–
Rainfall (mm) (4)		93.4	93	568	57	322	72	194	274	259

1 Samples taken at transverse chainage of 2 meters. Result is an average from multiple tests per section from both WB and EB lanes (Butkus 2004).

2 November 2006 data from Harris & Lockwood (2009).

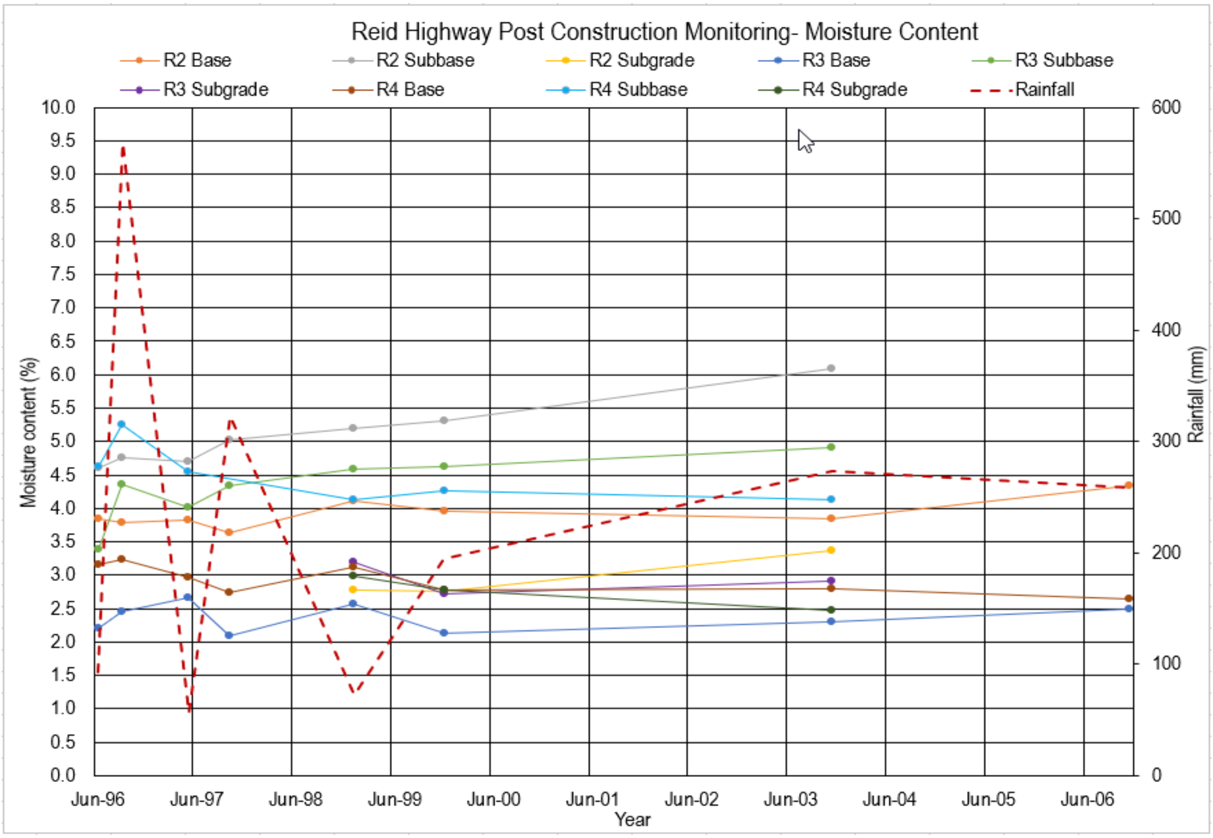
3 September 2016 data not included in Figure 4.4

4 Rainfall is the total of the three months preceding the test date. Data from Midland, station number 9025 (BOM 2013).

The data in Figure 4.4 indicates that the moisture content in all the layers of the pavements was reasonably constant. Unlike the Tonkin Highway sections, the Reid Highway pavement layers do not seem to follow a similar trend in terms of the total rainfall. This may be due to the inclusion of geofabric and embankment of sand fill at least 1 m thick underlying the placed subgrade.

The results for the subgrade in all the sections shows that the variation in moisture content over the initial seven years of monitoring was small. This indicates that the drainage conditions are good, and the groundwater is not influencing the performance of the sections. The largest single variation (not including the change after construction) was in the subbase in Section R4: 0.7 % between September 1996 and May 1997. The average moisture variation between each test date, for all pavement layers and sections, was approximately 0.3%.

Figure 4.4: Reid Highway – results of moisture content monitoring – 1996 to 2008



Source: Butkus (2004), Harris and Lockwood (2009), BOM (2013).

4.6.3 Deflection and Curvature

A review of all historic deflection and curvature data was undertaken to enable a preliminary performance analysis of the trial sections. The performance data for Section R4 collected after 2014 has not been included due to the alteration of the pavement profile.

The details of the reviewed deflection data for the Reid Highway trial sections are shown in Table 4.11.

Table 4.11: Reid Highway – Details of deflection data sources

Data source	Test date	Test details	Method
Materials Report 2009/5 M (Harris & Lockwood 2009)	October 1996 to December 2008	Eastbound and westbound lanes, OWP & IWP	BB
06 FWD 46/1 and 51/1 (MRWA 2006)	November 2006	Eastbound and westbound lanes, OWP	FWD
D00001A (Western Geotechnics Group (WGG) 2007)	March 2007	Eastbound lanes, OWP	
07 FWD 79/1 (MRWA 2007)	March 2007	Westbound lanes, OWP	
08 FWD 190/1 (MRWA 2008)	December 2008	Eastbound and westbound lanes, OWP	
11 FWD 337/1 (MRWA 2011a)	November 2011		
16 FWD 491/3 (MRWA 2016f)	June 2016		
17 FWD 550/1 and 551/1 (MRWA 2017a & MRWA 2017b)	May 2017	Westbound lane, OWP & IWP	

Deflection results

A summary of the mean deflection data in the westbound direction is presented in Table 4.12 and Table 4.13. No temperature data was available when the BB data was collected. Table 4.13 includes the BB equivalent deflection calculated from the FWD data which was corrected from the measurement temperature to the WMAPT (29°C for Perth). Cumulative ESAs have also been included. The most recent FWD deflection data for the Reid Highway sections is also presented in Appendix B.

Table 4.12: Reid Highway – Summary of maximum BB deflections, westbound, OWP

ID	Basecourse material	Maximum deflection (mm)(1)								
		Oct-96	Dec-96	Jun-97	Nov-97	Nov-98	Dec-99	Sep-00	Oct-01	Nov-03
R2	BSL	0.447	0.410	0.310	0.391	0.372	0.359	0.426	0.431	0.380
R3	CRB	0.399	0.377	0.265	0.444	0.406	0.390	0.448	0.412	0.371
Cumulative ESAs (x 10^5)(2)		0	3.0	6.3		10	14	18	22	30
R4	CRB	0.544	0.452	0.286	0.402	0.398	0.247	0.339	0.336	0.270
Cumulative ESAs (x 10^5)(2)		0	3.0	5.9		9.3	13	16	19	23

1 BB maximum deflection data for westbound, OWP.
2 Cumulative ESA values represent the westbound traffic.

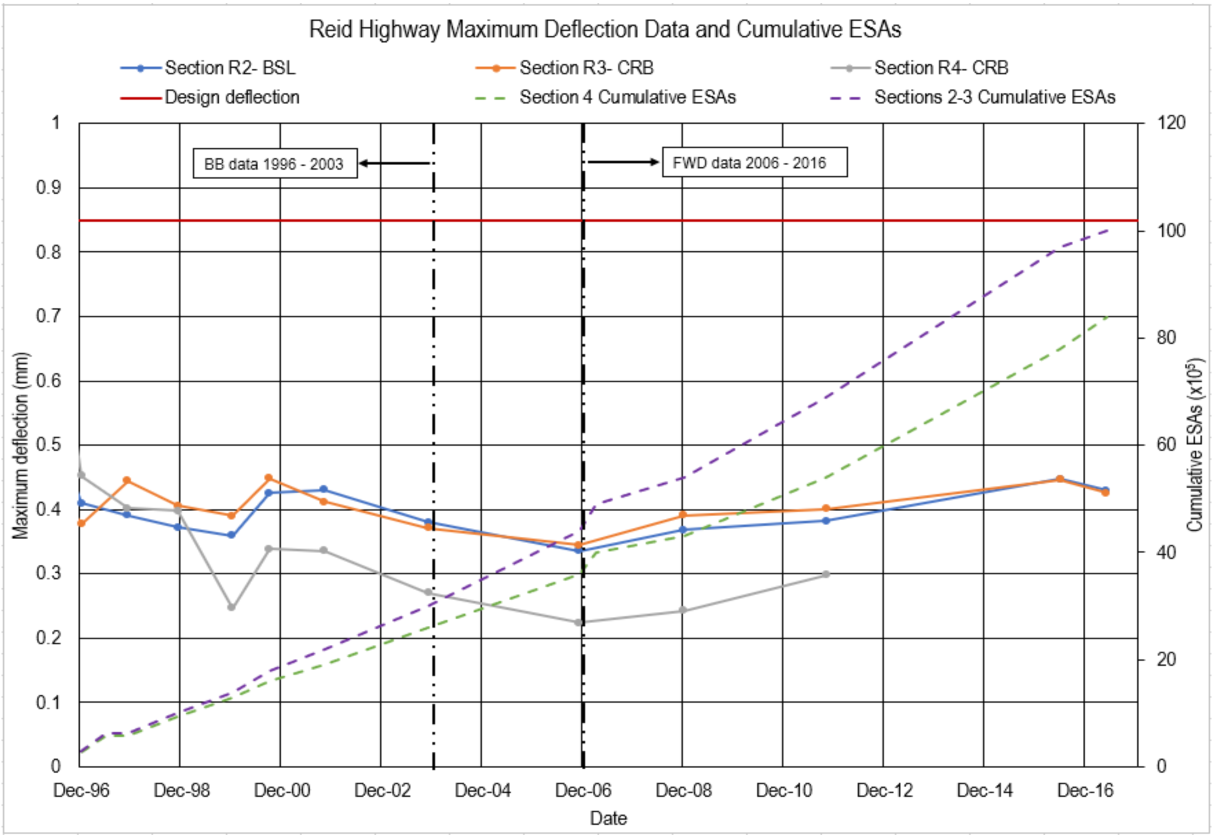
Table 4.13: Reid Highway – maximum BB deflections estimated from FWD maximum deflections, westbound, OWP

ID	Basecourse material	BB equivalent maximum deflection (mm)(1)					
		Nov-06	Mar-07	Dec-08	Oct-11	Jun-16	May-17
R2	BSL	0.34	0.34	0.37	0.38	0.45	0.43
R3	CRB	0.34	0.34	0.39	0.40	0.45	0.43
Cumulative ESAs (x 10^5)(2)		44	49	54	69	97	100
R4	CRB	0.22	0.16	0.24	0.30	N/A	N/A
Cumulative ESAs (x 10^5)(2)		36	40	43	54	78	84

1 FWD maximum deflection data for westbound, OWP.
2 Cumulative ESA values represent the westbound traffic.

The deflection data for each of the three sections is presented in Figure 4.5. Discrete data sets taken in June 1997 and March 2007 were excluded from the graph as they represented outlying values.

Figure 4.5: Reid Highway – maximum deflection data, westbound, OWP



Curvature results

A summary of the Reid Highway curvature data is presented in Table 4.14 and Table 4.15. The BB curvature data was corrected to 40 kN FWD values as per Figure 3.9. Yearly ESAs have also been included. The most recent FWD curvature data for the Reid Highway sections is also presented in Appendix B.

Table 4.14: Reid Highway – FWD curvatures estimated from BB curvatures, westbound, OWP

ID	Basecourse material	FWD estimated curvature from BB (mm)(1)								
		Oct-96	Dec-96	Jun-97	Nov-97	Nov-98	Dec-99	Sep-00	Oct-01	Nov-03
R2	BSL	0.108	0.105	0.044	0.097	0.071	0.083	0.063	0.064	0.091
R3	CRB	0.085	0.080	0.035	0.088	0.070	0.082	0.054	0.057	0.084
Cumulative ESAs (x 10^5)(2)		0	3.0	6.3		10	14	18	22	30
R4	CRB	0.130	0.090	0.049	0.078	0.061	0.038	0.053	0.044	0.047
Cumulative ESAs (x 10^5)(2)		0	3.0	5.9		9.3	13	16	19	23

1 BB maximum deflection data for westbound, OWP.

2 Cumulative ESA values represent the westbound traffic.

Table 4.15: Reid Highway: summary of FWD curvature, westbound, OWP

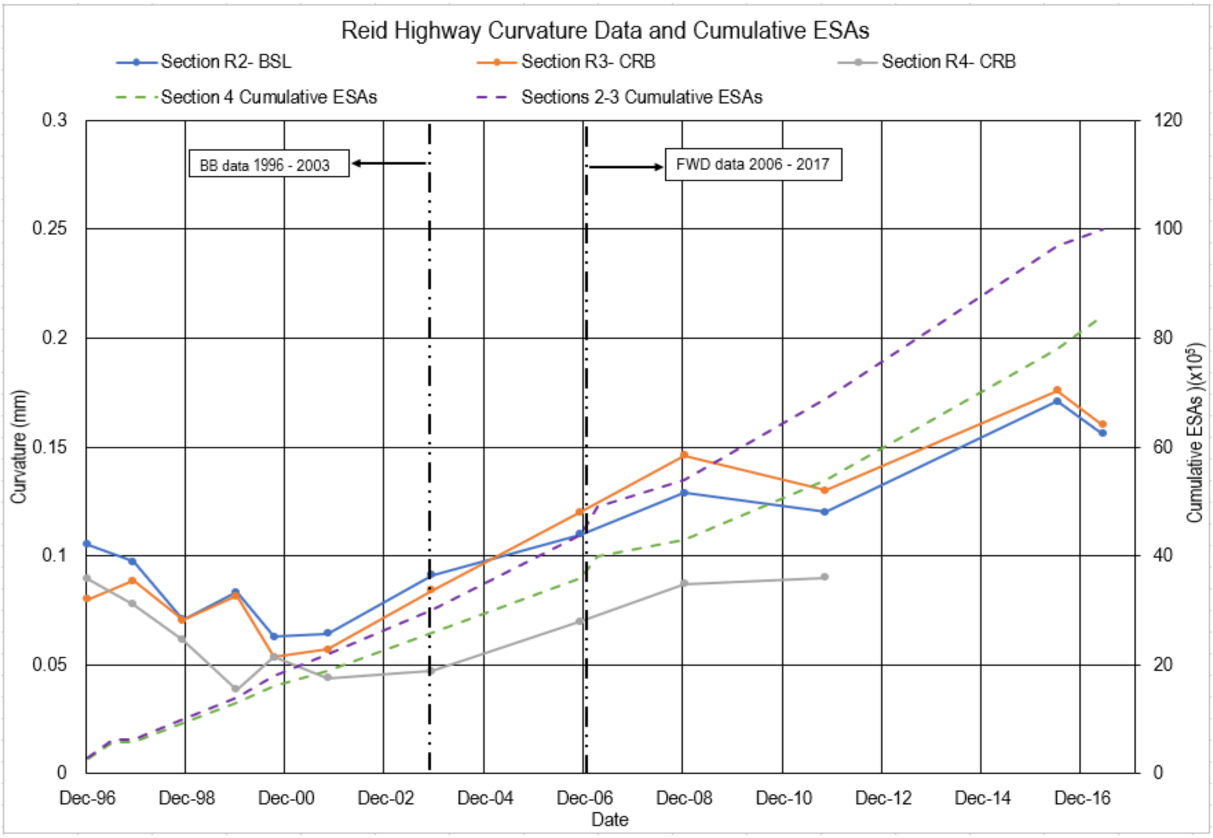
ID	Basecourse material	FWD mean curvature (mm)(1)					
		Nov- 06	Mar- 07	Dec-08	Oct-11	Jun-16	May-17
R2	BSL	0.110	0.110	0.129	0.120	0.171	0.156
R3	CRB	0.120	0.110	0.146	0.130	0.176	0.160
Cumulative ESAs (x 10^5)(2)		44	49	54	69	97	100
R4	CRB	0.070	0.050	0.087	0.090	N/A	N/A
Cumulative ESAs (x 10^5)(2)		36	40	43	54	78	84

1 FWD curvature for westbound, OWP.

2 Cumulative ESA values represent westbound traffic.

The curvature data for each of the three sections is shown in Figure 4.6. The data from June 1997 and March 2007 was excluded from the graph as these values represented outliers.

Figure 4.6: Reid Highway – curvature data, westbound, OWP



Results of FWD investigation in 2017

Table 4.16 and Table 4.17 summarise the stage 2 investigation for the two Reid Highway sections of interest. The mean values have been calculated as an average over the entire trial section length using data collected at 5 m test intervals. The raw FWD data from the stage 2 field investigation is presented in Appendix B.

Table 4.16: Reid Highway stage 2 investigation – summary of mean maximum deflection data

Section ID	Basecourse material	Maximum deflection (mm)	
		OWP	BWP
R2	BSL	0.46	0.42
R3	CRB	0.46	0.41

Table 4.17: Reid Highway stage 2 investigation – summary of mean curvature data

Section ID	Basecourse material	Curvature (mm)	
		OWP	BWP
R2	BSL	0.16	0.14
R3	CRB	0.16	0.14

Deflection values were typically lower BWP than those in the loaded OWP. The differences between the OWP and BWP in both sections were similar.

Table 4.18: Reid Highway – 2016 FWD and 2017 FWD westbound OWP comparison

Section ID	Basecourse material	Maximum deflection (mm)		Curvature (mm)	
		2016 (1)	2017	2016 (1)	2017
R2	BSL	0.48	0.46	0.17	0.14
R3	CRB	0.48	0.46	0.18	0.14

1 2016 FWD data collected at 10 m intervals.

A comparison of the FWD data collected in the westbound OWP in June 2016 with that collected during the stage 2 investigation shows that the deflection and curvature decreased in all sections during the 11 months between testing.

Trends in deflection and curvature data

Similarly to the Tonkin Highway data, discrete performance phases can be noted from the Reid Highway deflection and curvature data that are independent of the base material, but dependent on conformance to 3/5th base rule. It is important to note that, while Section R4 is a conforming section, it has been subject to slightly less traffic compared to Sections R2 and R3 and this may also contribute to the difference in behaviour.

- Phase 1: pre-traffic to end of first year:
  - deflection tends to decrease below initial pre-traffic measurement for all sections
  - curvature decreases below initial pre-traffic measurement for all sections
- Phase 2: end of first year to around end of fifth year:
  - deflection of Section R4, which conforms to 3/5th rule, continues to decrease
  - deflection of remaining non-conforming sections (R2 and R3) shows little change compared to initial pre-traffic measurement
  - curvature continues to decrease but commences to even out toward the end of the phase for all sections

- Phase 3: end of 5th year to end of 15th year:
  - deflection slightly decreases for all sections but commences to even out to initial measurement for non-conforming sections
  - curvature slowly increases and reaches initial values for non-conforming sections
- Phase 4: end of 15th year onwards
  - deflection continues to slowly increase with the deflection in the conforming section still below the initial measurement
  - curvature continues to increase for all sections with conforming section still below the initial measurement.

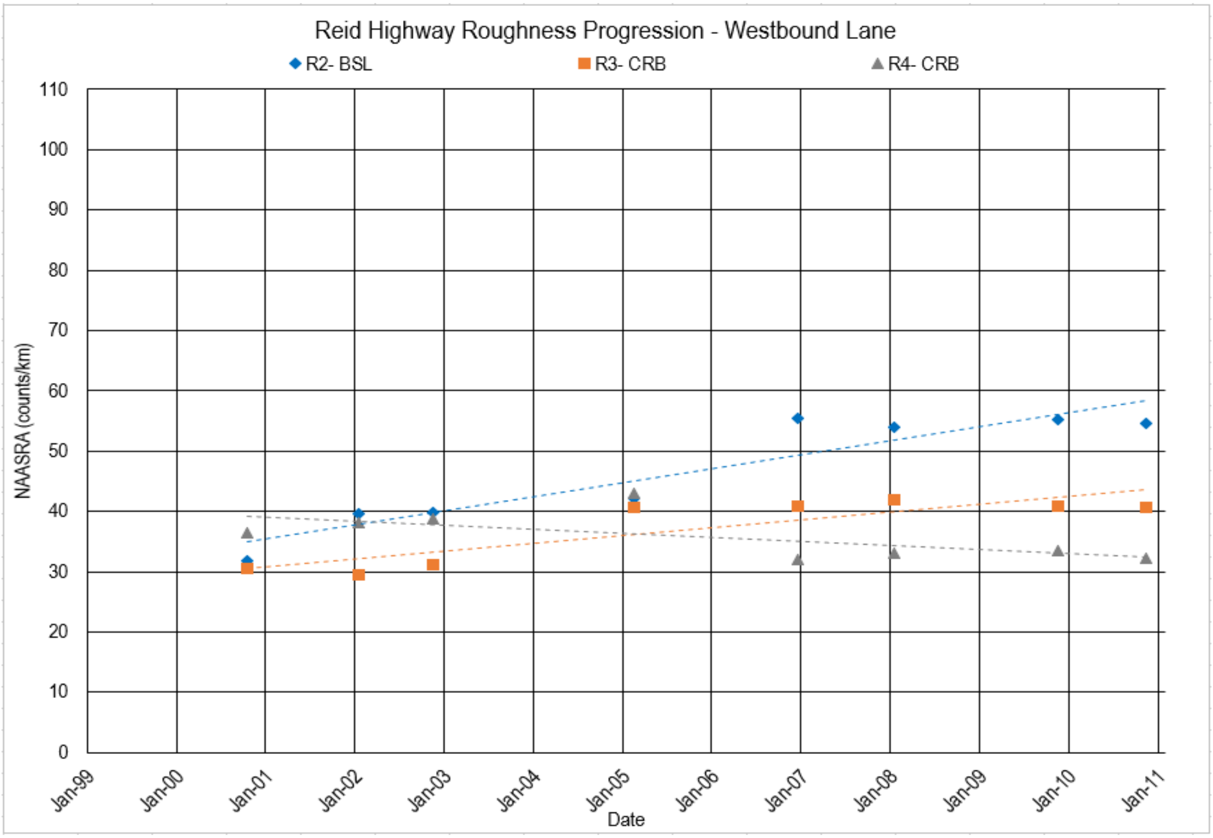
4.6.4 Roughness

A comparison of the longitudinal profile (roughness) over the service life of the trial sections was also conducted. All of the roughness data was extracted from IRIS.

Figure 4.7 shows the roughness progression of the sections of interest over time for the westbound lane. The roughness in the westbound lane has increased in Sections R2 and R3, with the largest increasing trend over the 11 years of data in Section R2. The performance of all three trial sections has been satisfactory, with the roughness well below the intervention level of 110 counts/km.

For both the Tonkin Highway and Reid Highway, the overall roughness and the rate of roughness increase was typically higher at the sections which had BSL as the base material.

Figure 4.7: Reid Highway roughness progression data westbound lane



4.6.5 Rutting

Rutting data for the Reid Highway sections was extracted from IRIS, including a mean value of rutting using a 2 m straight edge in both the IWP and OWP. This data is presented in Figure 4.8 and Figure 4.9, whilst the average rut depths for each section are shown in Table 4.19.

Table 4.19: Reid Highway – average rut value in each section, 2 m straight edge, westbound

Test year	Section R2		Section R3		Section R4	
	Average OWP rut depth (mm)	Average IWP rut depth (mm)	Average OWP rut depth (mm)	Average IWP rut depth (mm)	Average OWP rut depth (mm)	Average IWP rut depth (mm)
Oct-00	1.5	1.4	2.4	1.3	1.6	2.3
Dec-06	1.6	2.3	1.2	3.3	1.5	3.4
Jan-08	1.6	2.4	0.8	3.5	1.4	3.3
Nov-08	1.7	1.7	1.4	2.5	1.5	2.7
Nov-09	1.6	1.5	0.8	2.5	1.5	2.4
Nov-10	1.3	1.5	1.4	2.1	1.4	2.4
Nov-12	2.0	2.8	1.8	3.4	0.9	1.9

The rut depth in the IWP was larger than the OWP for all three sections of interest. Section R2 has the lowest differential of approximately 1 mm between IWP and OWP while both Sections R3 and R4 have a differential of approximately 1.5 mm. Furthermore, for the six years between 2006 and 2012, the rut depth in Sections R2 and R3 has increased by approximately 1 mm in both wheelpaths. Section R4 was the best performing section, with very little increase in rutting over the data collection period.

Figure 4.8: Reid Highway – rutting in OWP, 2 m straight edge, westbound

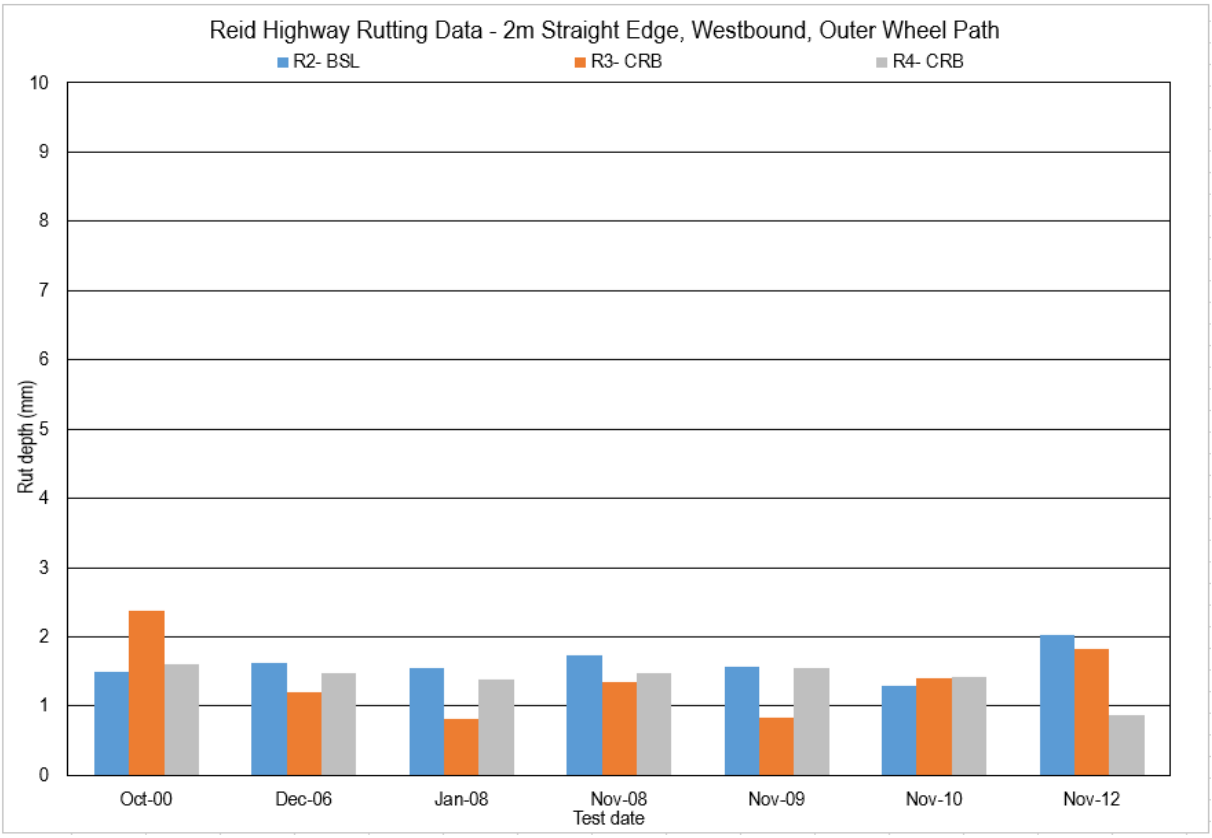
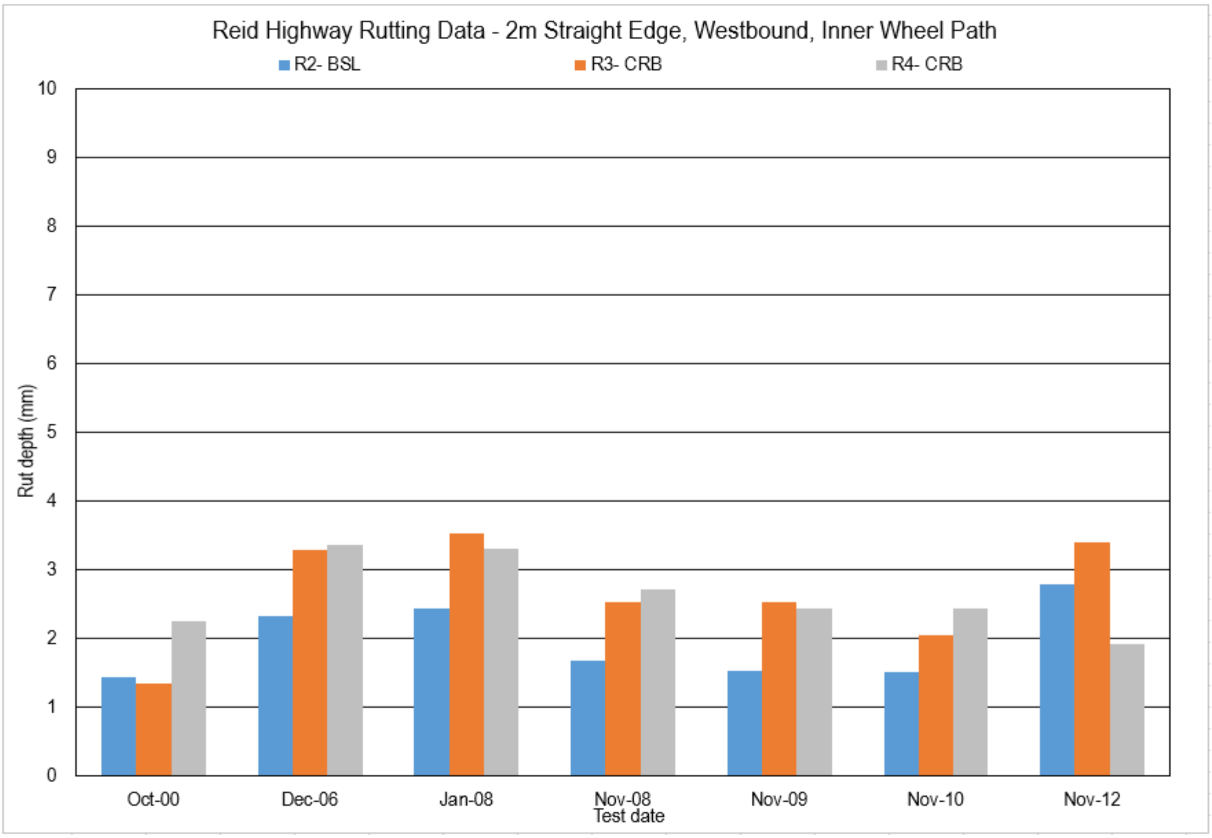


Figure 4.9: Reid Highway – rutting in IWP, 2 m straight edge, westbound



4.7 Field Investigation in 2016

In December 2016, a field investigation was undertaken on Sections R2 and R3 in order to confirm the pavement configurations and to conduct FWD testing and sampling of the granular and subgrade material for characterisation and other laboratory testing. The results of the investigation are reported in the following sections of this report.

The field work included the following:

- coring of asphalt surfacing in BWP at the start, middle and end chainages of each section to confirm thickness
- excavation of a test pit in the OWP at the middle chainage of each test section to measure base and subbase thicknesses and check the upper basecourse condition.
- nuclear density and moisture content testing of the granular layers
- bulk sampling of granular materials and subgrade for laboratory testing.

Photographs from the field investigation are included in Appendix B.

FWD testing was undertaken in May 2017. Testing was conducted in both the OWP and BWP at 5 m intervals along the westbound carriageway.

4.7.1 General Observations

There was no sign of major cracking in the surface of Sections R2 and R3. There was also no sign of cracking or moisture ingress in the CRB and BSL.

4.7.2 Asphalt Coring and Profile Measurements

Mechanical coring of the asphalt layers was undertaken at three locations along each trail section to confirm the current surfacing thickness. The maximum and minimum thickness for each section are shown in Table 4.20. The test certificates and summary tables are included in Appendix B.

Table 4.20: Reid Highway investigation – thickness of asphalt surfacing

ID	Minimum thickness (mm)	Maximum thickness (mm)	Mean thickness (mm)
R2	45	49	47
R3	39	51	45

Notes:
- Includes seal thickness of 10 mm.
- Cores taken from BWP.

The measured base and subbase thicknesses at two test pits located in the OWP are shown in Table 4.21.

Table 4.21: Reid Highway investigation: mean thickness of granular layers

Material	R2 (mm)	R3 (mm)
Base	100	80
Subbase	325	255

4.7.3 Laboratory Testing

The laboratory tests undertaken on the bulk samples recovered from the excavated test pits are detailed in Table 4.22. The test certificates and summary tables are provided in Appendix B.

Table 4.22: Reid Highway investigation – laboratory test schedule of bulk samples

ID	Layer	Material	Moisture	PSD	DCP
R2	Base	BSL	✓	✓	
	Subbase	Limestone	✓		
	Subgrade	Sand	✓	✓	✓
R3	Base	CRB	✓	✓	
	Subbase	Limestone	✓	✓	
	Subgrade	Sand	✓	✓	✓

The following observations are offered:

- the in situ density of the materials was similar to the construction values, with the exception of the CRB in Section R3 which had increased from 2.12 to 2.34 t/m^3
- the PSD of the CRB had become slightly finer in the gravel and sand portion of the material; however, the proportions of material below 0.3 mm in size had remained the same
- the CBR of the sand subgrade in Sections R2 and R3 was between 87% and 114% (inferred from DCP testing).

5 KWINANA FREEWAY

5.1 Overview

The 15 trial sections on the Kwinana Freeway are located between Paganoni Road and Lymon Road; they consist of two lanes in the southbound direction with a posted speed limit of 110 km/h. The start and end chainages and corresponding lengths of each trial section are shown in Table 5.1. The materials in each section are also shown.

Table 5.1: Details of Kwinana Freeway trial sections

Trial section	Start chainage (m)	End chainage (m)	Length (m)	Materials		
				Base	Subbase	Subgrade
1	55 180	55 280	100	2% HCTCRB	Crushed limestone	White sand
2	55 280	55 380	100	CRB		Yellow sand
3	55 380	55480	100	CRB		
4	55 480	55 580	100	Ferricrete		
5	55 580	55 680	100	G1 CRB (<37.5 mm)		
6	55 680	55 780	100	2% HCTCRB GRS(2)		
7	55 780	55 880	100	2% HCTCRB		
8	55 880	55 980	100	2% HCTCRB		
9	55 980	56 080	100	2% HCTCRB		
10	56 080	56 180	100	2% HCTCRB		
11(1)	56 180	56 280	100	–		
12	56 280	56 380	100	BSL		
13	56 380	56 480	100	CRC		
14	56 480	56 580	100	2% HCTCRB		
15(1)	56 580	56 680	100	–		

1 Sections 11 and 15 comprise full depth asphalt pavements overlying crushed limestone subbase. No granular base materials present.

2 HCTCRB GRS: Hydrated cement-treated crushed rock base with a geotextile reinforced seal.

Source: Rehman (2012).

Construction of the trial sections was undertaken in 2009 as part of the New Perth Bunbury Highway (NPBH) project. Details of the construction and laboratory testing are summarised in the MRWA construction and pavement performance evaluation report (Rehman 2012). The road was opened to traffic on 20 September 2009.

5.2 Sections of Interest

Three trial sections were chosen for investigation: namely Sections 2, 3 and 12. Each of these sections comprised a thin asphalt surfacing (approximately 60 mm thick), a crushed limestone subbase and a sand subgrade. As per ERN 9 Clause 1.2(c) the base material was either crushed rock base (CRB) or bitumen-stabilised (2%) limestone (BSL).

The composition of each section as detailed in the construction reports is presented in Table 5.2. An identification number was assigned to each section with a prefix to differentiate between trial locations.

Table 5.2: Kwinana Freeway – sections of interest and pavement profiles

Identification number	Layer	Material	Design thickness (mm)	Mean as-constructed thickness (mm)
K2	Asphalt	OGA	30	65
		DGA	30	
	Base	CRB	125	160
	Subbase	Crushed limestone	255	250
	Subgrade	Yellow sand	–	–
K3	Asphalt	OGA	30	65
		DGA	30	
	Base	CRB	230	255
	Subbase	Crushed limestone	150	160
	Subgrade	Yellow sand	–	–
K12	Asphalt	OGA	30	64
		DGA	30	
	Base	BSL	230	270
	Subbase	Crushed limestone	150	160
	Subgrade	Yellow sand	–	–

Source: Rehman (2012).

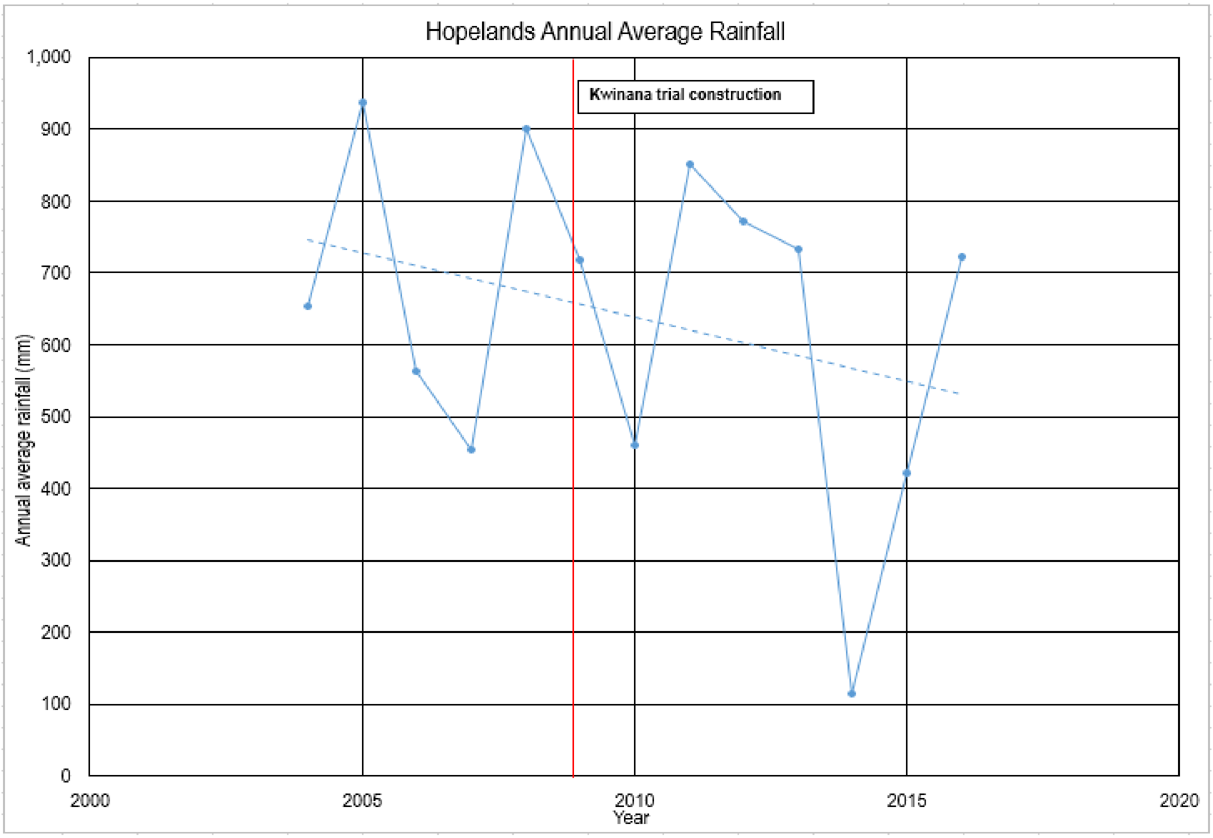
5.2.1 Subsurface Conditions

The 1:250 000 Environmental Geological Map series produced by the Geological Survey of Western Australia Pinjarra sheet (Geological Survey of Western Australia 1980) indicates that the natural subsurface materials below the trial pavements are quartz sands derived from Tamala limestone.

5.2.2 Climate Data

The annual average rainfall from the Hopelands weather station, which is in close vicinity to the Kwinana Freeway trial sections, was collated to demonstrate the climatic history during the in-service life of the pavements. Data from five years prior to construction until 2016 was obtained (BOM 2013) as presented in Figure 5.1. There is a clear downward trend of annual average rainfall at this location.

Figure 5.1: Kwinana Freeway – historic annual average rainfall data



Source: BOM (2013).

5.3 Construction Data

5.3.1 Construction Notes

The subbase material and the limestone for the BSL were sourced from the same quarry in Spearwood. The CRB was sourced from the Readymix Quarry in Gosnells (Rehman 2012). The CRB conformed to the MRWA specification and is typical of material used throughout the metro area. The average calcium carbonate content of the limestone was 82.9% which met the minimum specified value of 60%. The bitumen content of the BSL varied between 2.1% and 2.3% which did not quite meet the specification of 2.0%-2.2% (Rehman 2012).

5.3.2 Material Properties

The results of testing of the granular materials undertaken before construction are presented in Table 5.4 and Table 5.5 . Full material specifications were also available and these are included in Appendix C.

Table 5.3: Kwinana Freeway – mean particle size distribution (granular materials)

Sieve size (mm)	% Passing			
	2% BSL	CRB	Crushed limestone	White sand
105	–	–	100	–
75	–	–	98	–
53	–	–	93	–
37.5	–	–	84	–
26.5	–	–	77	–
19.0	100	100	71	–
13.2	–	97	–	–
9.5	–	71	64	–
6.7	80	–	–	–
4.75	75	52	57	–
2.36	–	39	51	100
1.18	60	28	–	100
0.6	–	20		78
0.425	–	16	34	45
0.3	31	13		23
0.15	–	10	–	7
0.075	7	8	8	4
0.0135	–	–	5	3

Source: Rehman (2012).

Table 5.4: Kwinana Freeway – mean values of laboratory testing results (granular materials)

Material purpose	Material	Linear shrinkage (%)	Liquid limit (%)	Plastic limit (%)	CBR (%)	MDD (t/m³)	OMC (%)
Basecourse	CRB	0.4	–	–	270	2.29	5.3
Subbase	Limestone	0	–	–	80	1.891	11.7
Subgrade	Sand	0	N/O	NP	17	1.714	14.0

Source: Rehman (2012).

5.3.3 RLT Testing – Granular and Subgrade Materials

The RLT testing of the CRB and limestone subbase materials used in the construction of trial sections was carried out by MRWA at their Materials Engineering Branch (MEB) laboratory. Further testing was undertaken on the BSL, limestone subbase and sand subgrade material by ARRB as part of a project conducted under the Western Australia Pavement Asset Research Centre (WAPARC) (Jameson et al. 2017).

The mean normal stresses and octahedral shear stresses used in the testing were 240 kPa and 120 kPa for the base level materials and 94 kPa and 30 kPa for the subbase level materials respectively. The stress states for the subbase are indicative of their lower location in the pavement compared to the basecourse. The sand subgrade was also tested at 83 kPa mean normal stress and 25 kPa octahedral shear stress.

Testing was carried out on 100 mm and 150 mm samples of the base, subbase and subgrade materials at the minimum specified conditions as per the specifications (see Section 5.3). The modulus values were calculated according to the relationships given in

Austroads (2011). The results are summarised in Table 5.5 while the full data set is included in Appendix C.

Table 5.5: Kwinana Freeway – summary of RLT testing of granular and subgrade materials

Material	Stress conditions (kPa)	Curing period (days)	Mean density ratio at test (%)	Mean moisture ratio at test (%)	Mean modulus (MPa)
CRB(1)	94/30	28	99.1	58.9	460
	240/120	28	99.1	58.9	705
BSL(2)	94/30	29	100.2	51.7	414
		74	100.3	51.6	529
	Average		***100.3***	***51.7***	***472***
	240/120	29	100.2	51.7	647
		74	100.3	51.6	810
	Average		***100.3***	***51.7***	***729***
Limestone(1)	94/30	28	94.3	75.9	451
		180	94.3	74.9	459
		365	94.1	72.0	472
		730	94.2	73.7	437
	Average		***94.2***	***74.1***	***455***
	240/120	28	94.3	75.9	607
		180	94.3	74.9	620
		365	94.1	72.0	607
		730	94.2	73.7	589
	Average		***94.2***	***74.1***	***606***
Limestone(2)	94/30	28	100.0	38.5	926
		90	99.7	38.1	913
	Average		***99.9***	***38.3***	***920***
	240/120	28	100.0	38.5	1202
		90	99.7	38.1	1264
	Average		***99.9***	***38.3***	***1233***
Sand(2)	83/25	7	96.4	17.1	379
		28	96.6	17.5	317
	Average		***96.5***	***17.3***	***348***
	94/30	7	96.4	17.1	386
		28	96.6	17.5	324
	Average		***96.5***	***17.3***	***355***
	240/120	7	96.4	17.1	443
		28	96.6	17.5	381
	Average		***96.5***	***17.3***	***412***

1 Samples tested by MRWA at MEB laboratory (Rehman 2013).
2 Samples tested by ARRB as part of WAPARC project (Jameson et al. 2017).

5.4 Density Testing

The density at construction and dryback specifications are presented in Table 5.6. Full material specifications are included in Appendix C.

Table 5.6: Kwinana Freeway – density and dryback specifications

ID	Material	Minimum dry density ratio (% MMDD)	Dryback (% of OMC)
K2	CRB	98	60
K3			
K12	2% BSL	96	85
K2	Limestone subbase	94	85
K3			
K12			
K2	Sand subgrade	96	Not specified
K3			
K12			

Source: Rehman (2012).

The measured in situ dry density and moisture data obtained for each of the sections of interest is reported in Table 5.7. There were no values below the density and dryback specifications detailed in Table 5.6.

Table 5.7: Kwinana Freeway – mean dry density and moisture content at construction

Material	Section ID	No. of tests	MDD (t/m^3)	OMC (%)	Mean dry density (t/m^3)	Mean moisture content (%)	Mean dry density ratio (%)	Mean moisture ratio (%)
CRB	K2	9	2.31	5.2	2.31	2.8	100.0	53.0
	K3	9			2.30	2.9	99.6	54.8
2% BSL	K12	9	1.89	10.2	1.89	5.2	100.3	51.3
Limestone subbase	K2	3	1.91	11.3	1.88	3.3	98.7	29.5
	K3	2			1.89	4.4	98.7	38.5
	K12	6	1.87	12.1	1.86	6.0	99.3	50.0
Sand subgrade	K2	1	1.70	11.9	1.64	2.6	96.4	21.8
	K3	6			1.64	2.5	96.4	21.3
	K12	6	1.76	14.5	1.74	4.0	99.2	27.1

Source: Rehman (2012).

5.5 Pavement Maintenance

It is important to identify any changes to the trial pavements as these changes may have an influence on the overall performance of the pavements. Pavement and surface detail data was also extracted from IRIS which documents any historic structural changes or major resurfacing works that have been undertaken on a pavement.

Pavement detail data was extracted from IRIS on 23 March 2017. This data indicates that none of the Kwinana Freeway trials have been altered or resurfaced since construction in 2009.

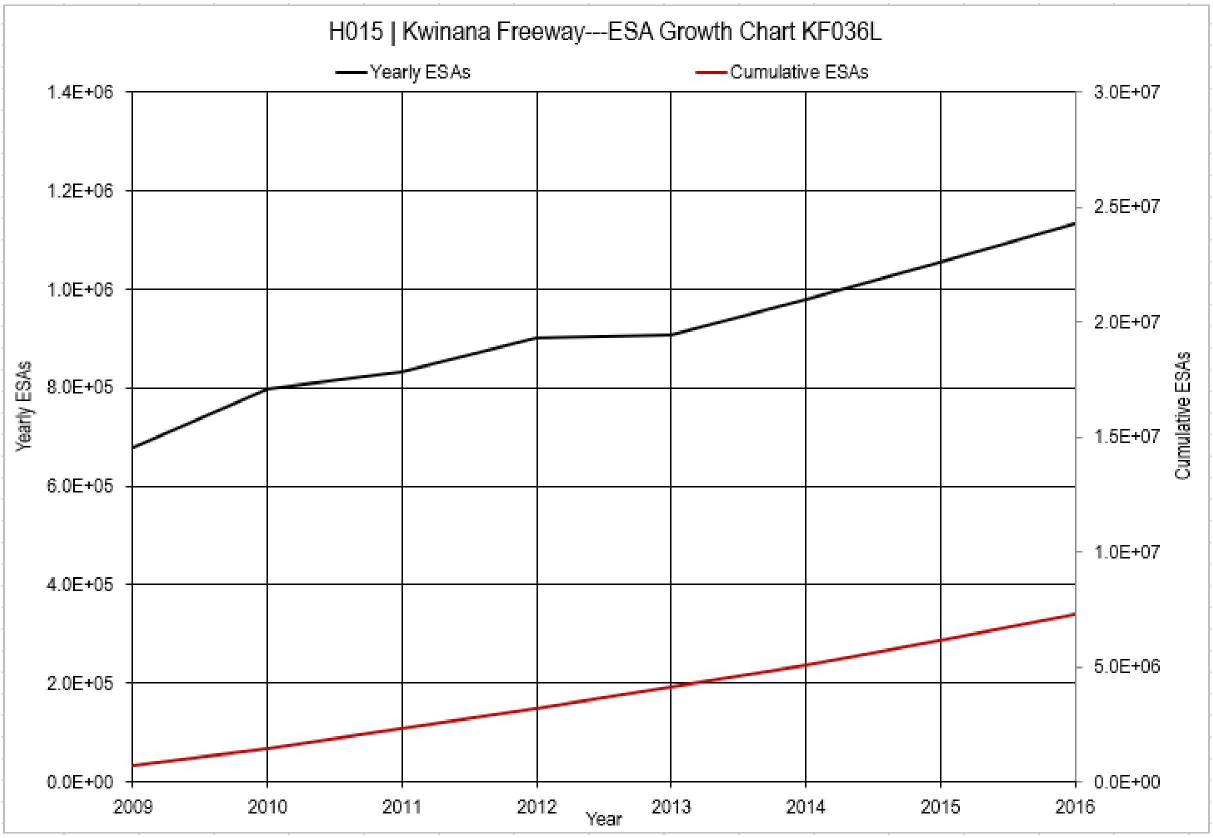
5.6 Traffic Loading

5.6.1 Cumulative Traffic Loading

The southbound Kwinana Freeway traffic data from 2009 to 2016 was also extracted from the IRIS database. The trial sections fall within the Kwinana Freeway traffic section designated KF36L.

The cumulative ESAs were estimated using a macro-enabled spreadsheet supplied by MRWA, together with the most up-to-date IRIS data. Both the yearly ESAs and the cumulative ESAs for the KF36L traffic section for the years 2009 to 2016 inclusive are presented in Figure 5.2.

Figure 5.2: Kwinana Freeway – yearly ESAs and cumulative ESAs (Section KF36L)



Source: IRIS database (2016).

5.6.2 Design Traffic

The 40 year design traffic for the Kwinana Freeway trial sections was 2.2 x 10^8 ESAs (Rehman 2012). Other data relating to the design traffic, such as the assumed growth rate, was not detailed.

5.6.3 Predicted Traffic Loading Over 40 Year Design Period

The average annual growth rate between the years of 2009 and 2014 for this section of the Kwinana Freeway was 7.6%. The forecast traffic at the end of a 40 year period (2049) was estimated to be 1.7 x 10^8 ESAs.

Data for other sections of the Kwinana Freeway which have similar numbers of lanes, pavement profiles, thin asphalt surfacings and traffic data was extracted. The cumulative traffic and pavement age data is shown in Figure 5.3. The average traffic data for the older pavements between chainages of approximately 10 SLK and 30 SLK are shown in Table 5.8, including a prediction of the 40 year cumulative traffic which was calculated based on a standard 3% annual growth rate.

Figure 5.3: Kwinana Freeway – traffic data for entire road length

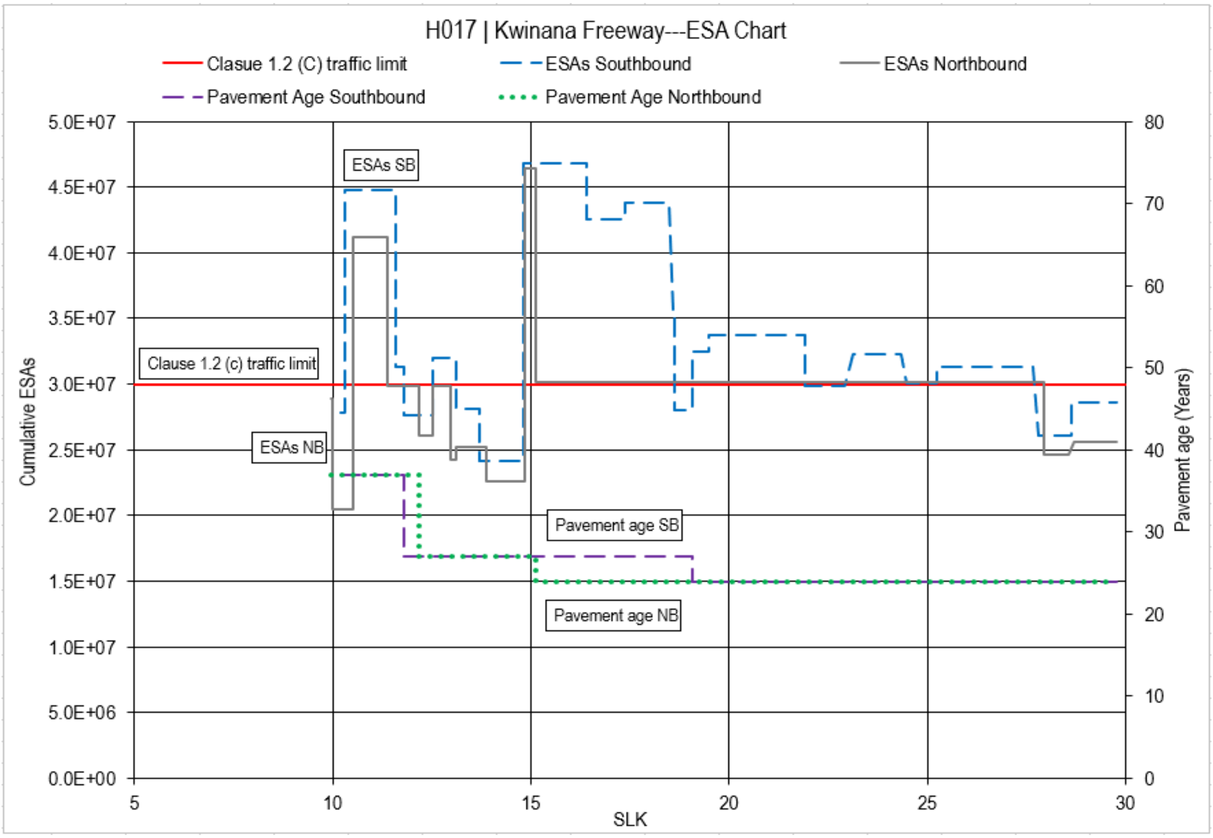


Table 5.8: Kwinana Freeway – average traffic data of older sections (chainage 10 SLK to 30 SLK)

Carriageway	Southbound	Westbound
Average pavement age (Years)	27	29
Average 1st year traffic (ESAs)	5.6×10^5	4.1×10^5
Average cumulative traffic(ESAs)	3.3×10^7	2.9×10^7
Predicted 40 year cumulative traffic (ESAs)	6.0×10^7	5.5×10^7

The traffic limit specified for the use of Clause 1.2(c) (3×10^7 ESA) has also been included in Figure 5.3. With the assumed 3% annual growth rate the 40 year predicted traffic for the older sections of Kwinana Freeway exceed the current limit.

5.6.1 Initial Traffic Loading

A similar approach was taken to determine the first year traffic statistics. Table 5.9 details this data for the Kwinana Freeway. These values were calculated considering both the southbound and northbound carriageways in addition to all sections of road, not just the older sections.

Table 5.9: Kwinana Freeway – traffic data of all sections, first year (1 SLK to 72 SLK)

Carriageway	H015
Current pavement age (years)	9 – 43
Average 1st year traffic (ESAs)	6.5×10^5
Lowest 1st year traffic (ESAs)	1.5×10^5
Highest 1st year traffic (ESAs)	1.3×10^6

5.7 Performance Monitoring

5.7.1 Deflection and Curvature

A review of all historic deflection and curvature data was undertaken to enable a preliminary performance analysis of the trial sections. The details of the reviewed deflection data for the Kwinana Freeway trial sections are given in Table 5.10.

Table 5.10: Kwinana Freeway – details of deflection data collection

Test data source	Test date	Test details	Method
09 FWD 257/1 (MRWA 2009)	September 2009	Before traffic, southbound, outer lane, OWP	FWD
10 FWD 308/1 9 (MRWA 2010)	September 2010	Southbound, outer lane, OWP	
11 FWD 326/1 (MRWA 2011b)	March 2011		
11 FWD 336/1 (MRWA 2011c)	October 2011		
12 FWD 371/1 (MRWA 2012b)	October 2012		
13 FWD 392/1 (MRWA 2013b)	October 2013		
14 FWD 405 (MRWA 2014)	April 2014		
15 FWD 443/1 & 15 FWD 444/1 (MRWA 2015a)	March 2015		
15 FWD 461/2 & 15 FWD 462/2 (MRWA 2015b)	October 2015		
16 FWD 480/3 (MRWA 2016g)	March 2016		
16 FWD 517/1-2 (MRWA 2016h)	October 2016		

Deflection results

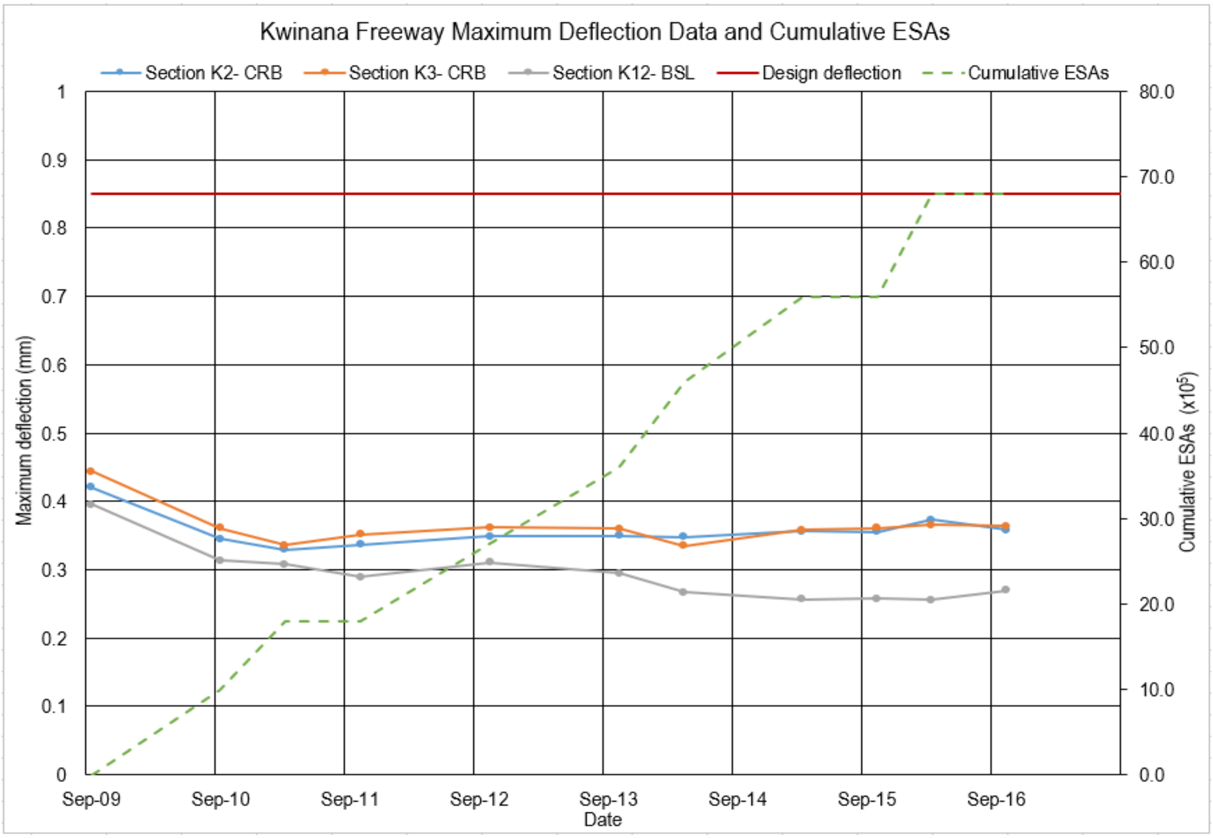
The FWD deflection data for the Kwinana Freeway sections is presented in Appendix C.

A summary of the mean deflection data is presented in Table 5.11. The FWD data was corrected from the temperature at measurement to the WMAPT (29°C for Perth). Cumulative ESAs have also been included.

Table 5.11: Kwinana Freeway – summary of maximum deflections, outer lane, OWP

ID	Basecourse material	Maximum deflection (mm)										
		Sep-09	Sep-10	Mar-11	Oct-11	Oct-12	Oct-13	Apr-14	Mar-15	Oct-15	Mar-16	Oct-16
K2	CRB	0.42	0.35	0.33	0.34	0.35	0.35	0.35	0.36	0.36	0.37	0.36
K3	CRB	0.44	0.36	0.34	0.35	0.36	0.36	0.34	0.36	0.36	0.37	0.36
K12	BSL	0.40	0.31	0.31	0.29	0.31	0.30	0.27	0.26	0.26	0.26	0.27
Cumulative ESAs (x 10^5)		0	10	18		27	36	46	56		68	

Figure 5.4: Kwiana Freeway – maximum deflection data, outer lane, OWP



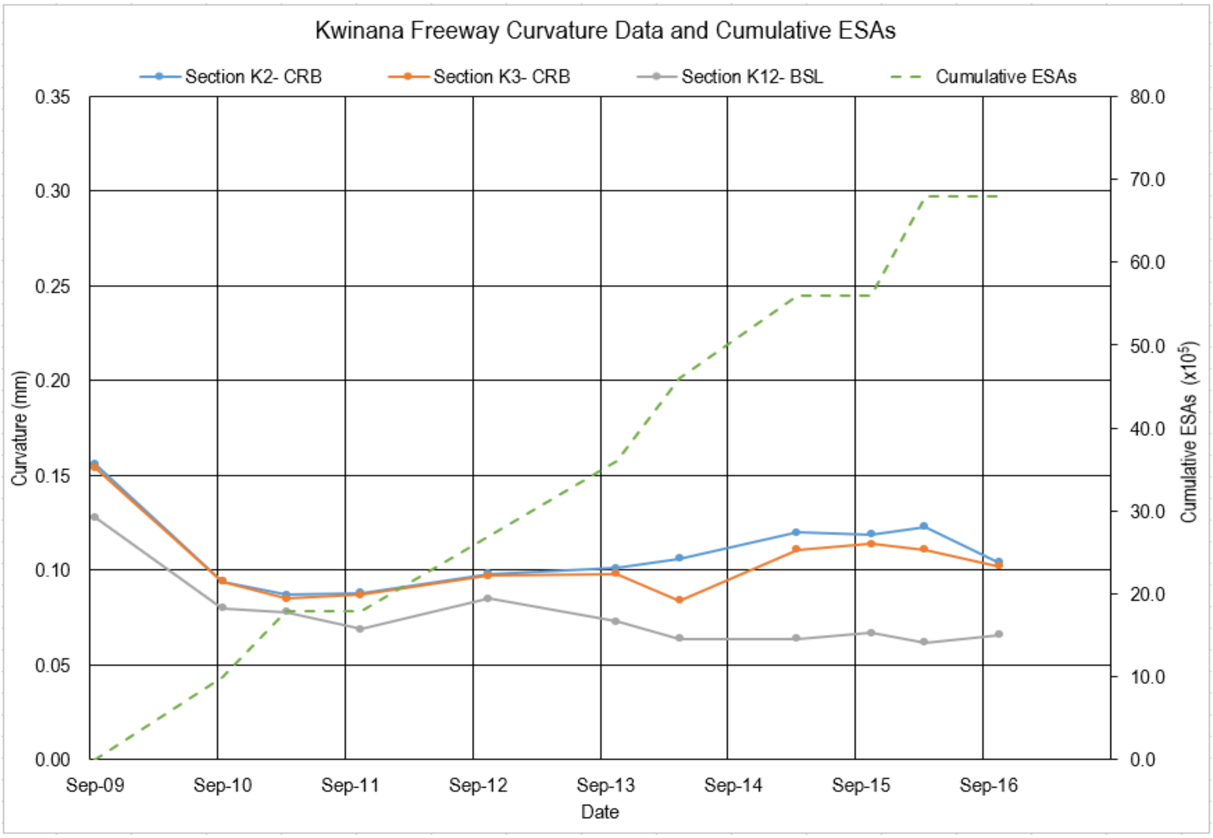
Curvature results

The FWD curvature data for these sections is presented in Appendix C. A summary of the curvature data is presented in Table 5.12.

Table 5.12: Kwinana Freeway – summary of FWD curvature data, outer lane, OWP

ID	Basecourse material	Curvature (mm)										
		Sep-09	Sep-10	Mar-11	Oct-11	Oct-12	Oct-13	Apr-14	Mar-15	Oct-15	Mar-16	Oct-16
K2	CRB	0.16	0.09	0.09	0.09	0.10	0.10	0.11	0.12	0.12	0.12	0.10
K3	CRB	0.15	0.09	0.09	0.09	0.10	0.10	0.08	0.11	0.11	0.11	0.10
K12	BSL	0.13	0.08	0.08	0.07	0.09	0.07	0.06	0.06	0.07	0.06	0.07
Cumulative ESAs (x 10^5)		0	10	18		27	36	46	56		68	

Figure 5.5: Kwiana Freeway – curvature data, outer lane, OWP



Trends in deflection and curvature

Similarly to the Tonkin and Reid Highway data, discrete similar phases can be noted from the Kwinana Freeway deflection and curvature data independent of the base material, but dependent on conformance to 3/5th base rule.

- Phase 1: pre-traffic to end of first year:
  - deflection decreases below initial pre-traffic measurement for all sections
  - curvature decreases below initial pre-traffic measurement for all sections.
- Phase 2: end of first year to around end of fifth year:
  - deflection of sections conforming to 3/5th rule (K3 and K12) continues to show a decreasing trend

— deflection of remaining non-conforming section (K2) shows little change

— curvature continues to decrease but starts to even out toward end of phase for all sections.

- Phase 3: end of fifth year to end of seventh year (most recent data):

— deflection is steady and still below initial measurement for all sections

— curvature slowly increases but still below initial measurements for all sections.

5.7.2 *Roughness Data*

Only one standard data set was available for the Kwinana Freeway trial sections; it was extracted from IRIS. This data is illustrated in Figure 5.6. A second data set which was collected during the trial of the Traffic Speed Deflectometer (TSD) conducted in late 2016 is also shown.

The data presented represents the roughness measured pre-traffic and at a pavement age and a cumulative traffic of approximately seven years and 7.3×10^6 ESAs respectively. Initially all sections had a similar NAASRA roughness count of between 16 and 20 counts/km. After the seven year period the roughness has increased in all sections with Section K2 showing the largest increase of approximately 20 counts/km. Sections K3 and K12 had a similar increase of approximately 4 counts/km. It should be noted that these two data sets were collected using slightly different methods and therefore the trends shown in the graph below may not be fully representative of in-service behaviour.

Figure 5.6: Kwinana Freeway – trends in roughness data

5.7.3 *Rutting Data*

Rutting data for the Kwinana Freeway sections was extracted from IRIS, including a mean value of rutting using a 2 m straight edge for both the IWP and the OWP. This data is presented in Figure 5.7 and Figure 5.8. Average rut depths for each section are presented in Table 5.13.

Table 5.13: Kwinana Freeway – average rut value for each section (2 m straight edge)

Test year	Section K2		Section K3		Section K12	
	Average OWP rut depth (mm)	Average IWP rut depth (mm)	Average OWP rut depth (mm)	Average IWP rut depth (mm)	Average OWP rut depth (mm)	Average IWP rut depth (mm)
Nov-09	2.1	0.9	2.3	1.0	1.5	2.3
Nov-10	2.8	3.0	3.1	3.3	2.3	3.5
Dec-14	1.7	3.7	2.6	3.7	1.6	4.7

The data demonstrates that the rut depth in the IWP was larger than the OWP for all three sections of interest. Section K3 had the lowest differential between the IWP and OWP of approximately 1 mm while Sections K2 and K12 had slightly higher differentials of approximately 1.2 and 1.7 mm respectively.

There was very little change in the rutting in the OWP over the five year monitoring period. Conversely, the rutting in the IWP increased by an average of approximately 2.0 mm between 2009 and 2010, and 1 mm average between 2010 and 2014 values.

In terms of the IWP data, Section K2 was the best performing section with the lowest rut depth values. The rutting in Section K3 was very similar to Section K2, but overall slightly higher. The worst performing section, in terms of rutting, was Section K12; however, the deflection and curvature values were the lowest of the three sections.

Figure 5.7: Kwinana Freeway – rutting in the OWP (2 m straight edge)

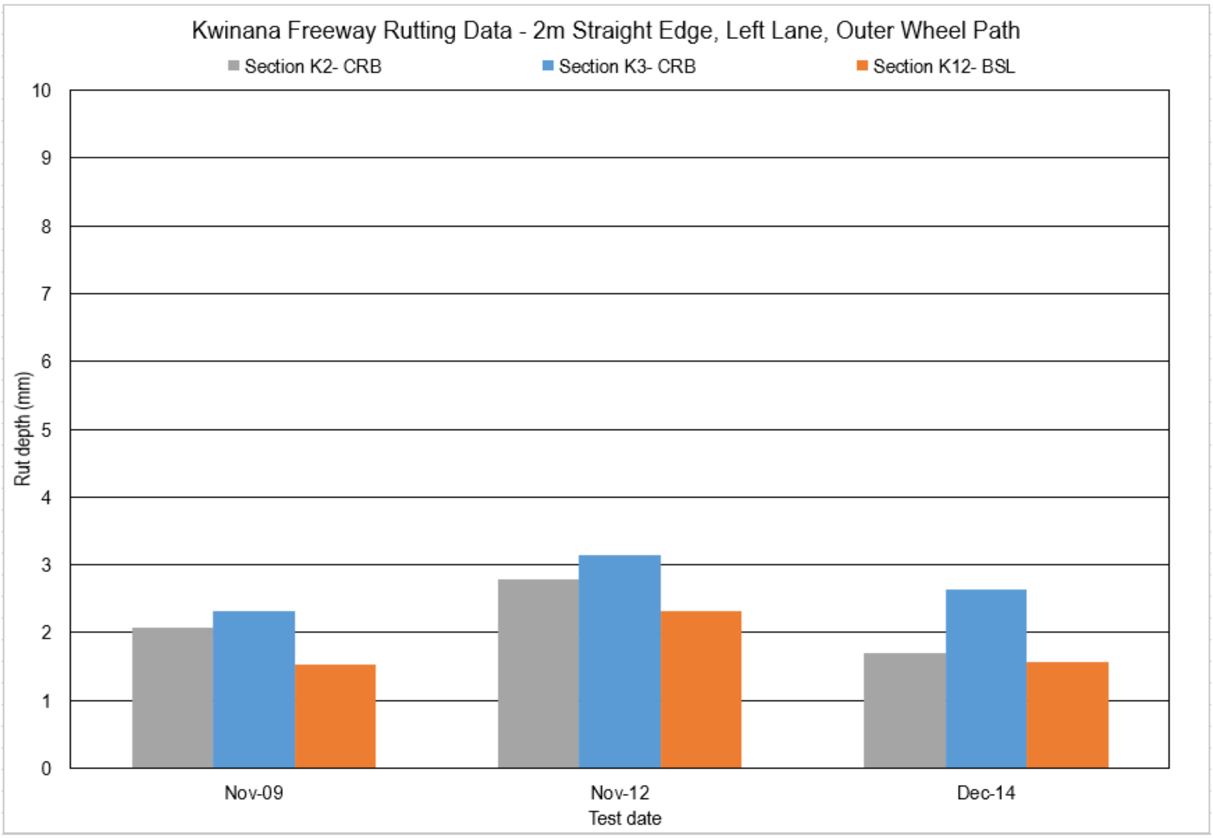
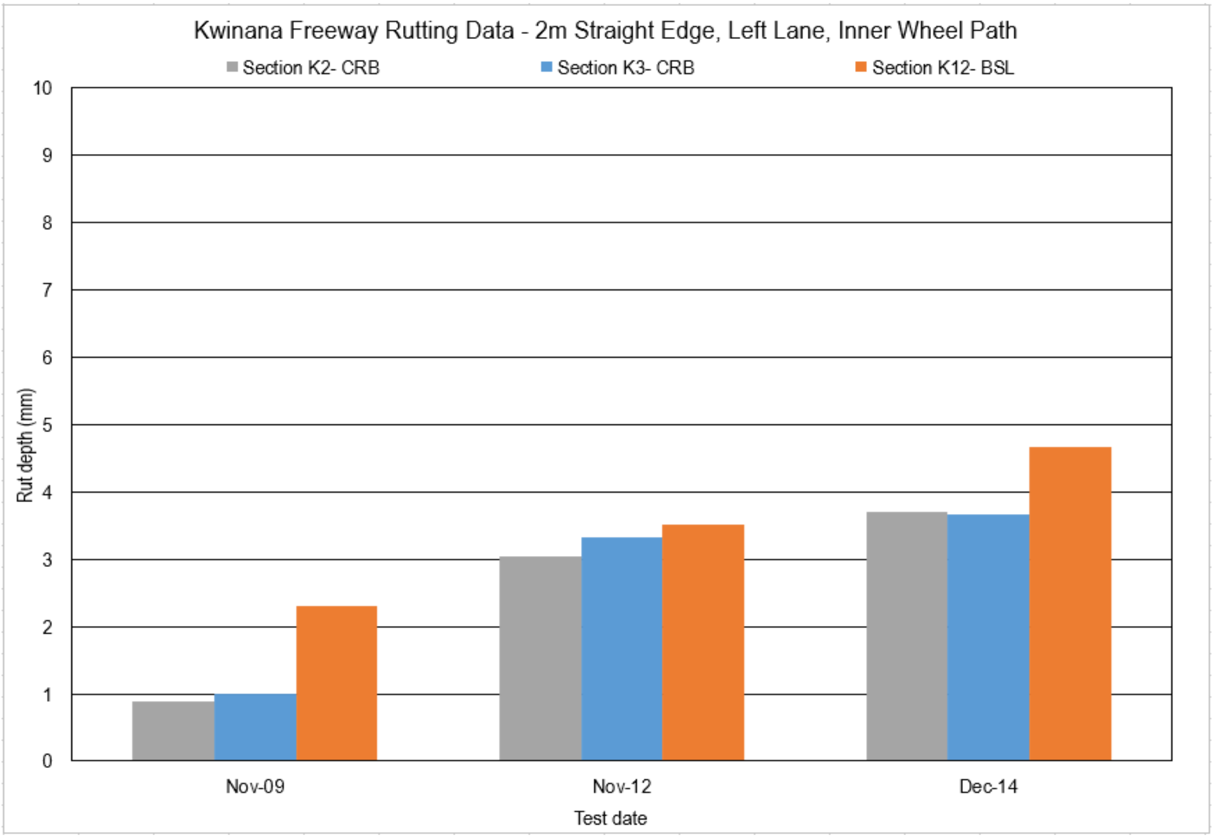


Figure 5.8: Kwinana Freeway – rutting in the IWP (2 m straight edge)



6 COMPARISON OF IN-SERVICE AND PREDICTED PERFORMANCE

6.1 Introduction

To enable a comparison between the actual and predicted performance, the allowable traffic loadings were calculated using the layer thicknesses measured during the field investigation and the presumptive modulus values in ERN9 (MRWA 2013a) and AGTPT02 (Austroads 2012). In order to replicate the original design, the assumptions that are commonly used by MRWA during the design phase of a pavement were used (see Section 6.2). The design procedure detailed in AGTPT02 was used to replicate the original design, not the updated method outlined in the 2017 version of AGPT02.

6.2 Current Design System

6.2.1 Predicted Allowable Traffic Loading

The allowable traffic loadings, in terms of asphalt fatigue, were predicted in accordance with ERN9 except that the mean measured layer thicknesses were used rather than the design thicknesses with allowance for construction tolerances. Appendix D lists the input data, including the design moduli calculated as per ERN9.

As per the design requirements of ERN9, a 95% reliability is required for design using the mechanistic procedure. This level of reliability represents the assumption that 19 out of 20 pavements will exceed the design traffic loading.

Table 6.1: Predicted allowable traffic loading – original design

Section ID and base material	Design granular modulus (MPa)[(1)]	Nominal surfacing design thickness[(2)] (mm)	Allowable traffic loading at 95% reliability (ESA))	Pavement age at allowable loading in relation to asphalt fatigue	Mean allowable traffic loading (ESA)	Pavement age at mean predicted asphalt fatigue life
T2 (BSL)	500	60	1.0×10^6	2	6.0×10^6	11
T4 (BSL)	500	30	1.7×10^6	3	1.0×10^7	17
T6 (CRB)	600	30	4.4×10^6	8	2.6×10^7	35
R2 (BSL)	500	30	2.6×10^6	7	1.6×10^7	31
R3 (CRB)	600	30	6.4×10^6	15	3.8×10^7	40+
R4 (CRB)	***600***	***30***	***6.3×10^6***	***17***	***3.8×10^7***	***40+***
K2 (CRB)	600	60	2.5×10^6	2	1.5×10^7	12
K3 (CRB)	***600***	***60***	***2.5×10^6***	***2***	***1.5×10^7***	***12***
K12 (BSL)	***500***	***60***	***1.5×10^6***	***1***	***9.0×10^6***	***8***

1 Design granular modulus as per ERN9.

2 Mechanistic analysis includes additional 10 mm construction tolerance as per ERN9 Clause 1.8.

Notes:

- Sections in bold italics indicate conforming 3/5th sections.
- Subgrade design modulus of 120 MPa.

The mean asphalt fatigue life is a better way of comparing the design output with the actual observed pavement performance. The mean fatigue life can be calculated by multiplying the 95% reliability allowable traffic loading by a factor of 6. Both the 95% reliability allowable traffic loadings and the mean allowable traffic loadings are shown in Table 6.1, along with the age of the pavement when the cumulative loading is predicted to exceed the allowable loading (observed performance).

Table 6.2 details the ratios of cumulative traffic to date and the predicted mean asphalt fatigue allowable loading for each section.

Table 6.2: Ratio of cumulative traffic to date and mean fatigue life

Location	Cumulative traffic: end of 2016 (ESAs)	Section and base material	Mean allowable ESAs	Ratio of cumulative traffic to date and mean fatigue life
Tonkin Highway	2.8×10^7	T2 (BSL)	6.0×10^6	4.67
		T4 (BSL)	1.0×10^7	2.75
		T6 (CRB)	2.6×10^7	1.06
Reid Highway	1.0×10^7	R2 (BSL)	1.6×10^7	0.64
		R3 (CRB)	3.8×10^7	0.26
	8.0×10^6	R4 (CRB)	3.8×10^7	0.21
Kwinana Freeway	6.4×10^6	K2 (CRB)	1.5×10^7	0.43
		K3 (CRB)	1.5×10^7	0.43
		K12 (BSL)	9.0×10^6	0.71

With the exception of Tonkin Highway sections, which have all exceeded the calculated mean fatigue life, the other sections have consumed, in most cases, less than half of the calculated mean fatigue life. It is therefore not surprising that widespread cracking and fatigue has not been observed.

6.2.2 Comparison of Predicted and Measured Deflection Bowls

Figure 6.1 and Figure 6.2 show the 95% measured deflection bowls a month before the Kwinana Freeway was opened to traffic and after the first year of traffic. Also shown are the predicted bowls using CIRCLY with a reliability level of 95%, ERN9 presumptive moduli, and as constructed layer thicknesses.

The results suggest that the predicted deflections are considerably higher than the measured deflections even with a higher subgrade design modulus of 150 MPa.

Figure 6.1: Comparison of predicted and measured deflection bowls – Kwinana Freeway CRB

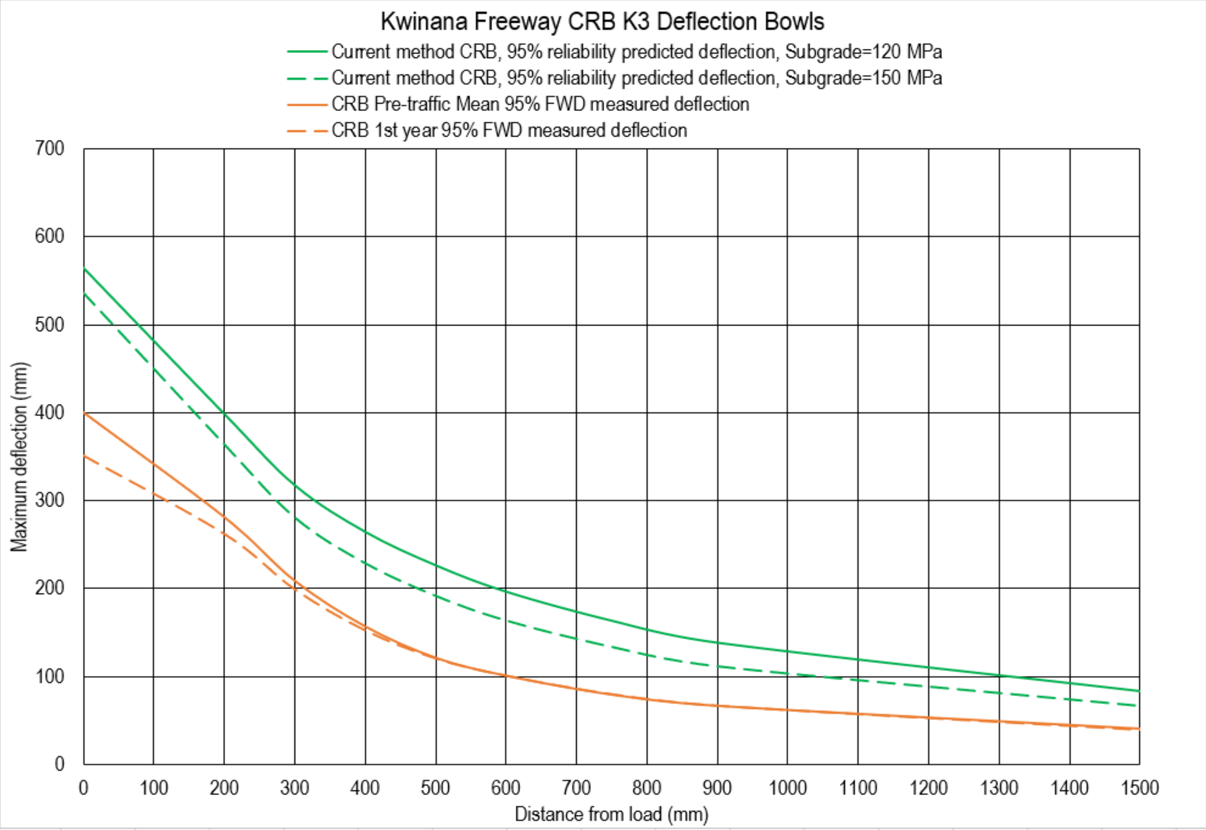
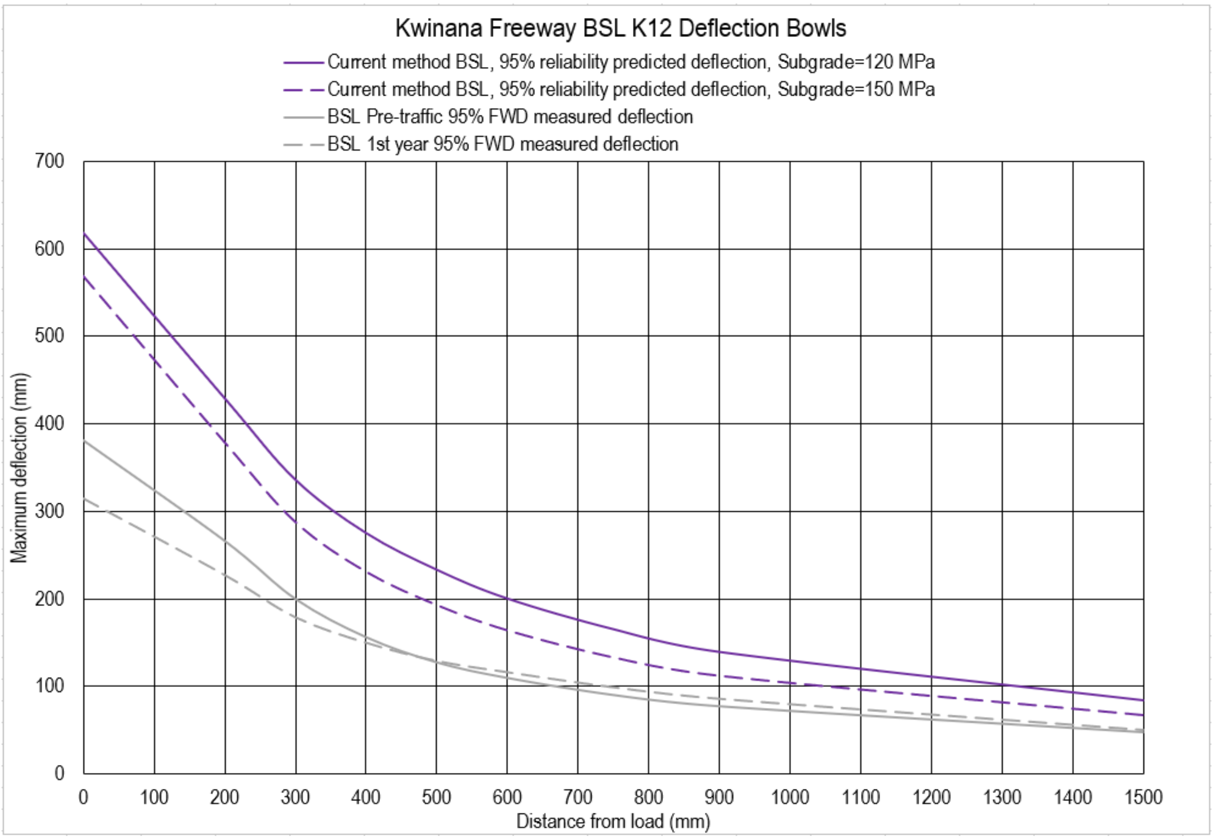


Figure 6.2: Comparison of predicted and measured deflection bowls – Kwinana Freeway BSL



6.2.3 Design Thickness versus Measured Thickness

As already discussed, the allowable traffic loadings reported in Section 6.2.1 were calculated using the mean measured layer thicknesses for the granular material combined with the design thickness for the asphalt surfacing.

Table 6.3 compares the predicted allowable loadings calculated in Section 6.2.1 with those calculated using mean constructed thicknesses for both granular and asphalt materials. This analysis underlines the very high sensitivity of asphalt fatigue life to the constructed asphalt thickness.

Table 6.3: Predicted allowable loadings: design thickness versus measured thickness

Location	Section and base material	Allowable ESAs (95% reliability)	
		Design thickness	Mean constructed thickness
Tonkin Highway	T2 (BSL)	1.0×10^6	1.6×10^6
	T4 (BSL)	1.7×10^6	2.3×10^6
	T6 (CRB)	4.4×10^6	2.0×10^6
Reid Highway	R2 (BSL)	2.6×10^6	1.5×10^6
	R3 (CRB)	6.4×10^6	2.9×10^6
	R4 (CRB)	6.3×10^6	3.0×10^6
Kwinana Freeway	K2 (CRB)	2.5×10^6	2.1×10^6
	K3 (CRB)	2.5×10^6	2.1×10^6
	K12 (BSL)	1.5×10^6	1.2×10^6

6.3 Back-Calculation of Modulus

6.3.1 Method

A linear elastic analysis program which back calculates layer moduli from deflection measurements (EFROMD3) was used in conjunction with the results of the most recent FWD investigation undertaken during the field investigation at both the Tonkin and Reid Highways. FWD testing was undertaken at 5 m intervals along both the OWP and BWP. The most recent FWD data from the Kwinana Freeway was also used for back-calculation input. The Kwinana Freeway FWD testing was undertaken at larger 10 m intervals along both the OWP and BWP.

Back-calculation of modulus was subsequently undertaken; it considered the as-constructed thicknesses of each pavement layer in addition to other construction considerations such as material type, subgrade thickness, embankment data and subsurface conditions. Detailed documentation regarding the methodology used in the EFROMD3 analyses is presented in Appendix E along with input data and output of results.

The base and subbase thicknesses were combined and divided into five equal sublayers as per the mechanistic procedure in Austroads 2012. As the Tonkin Highway sections had a very thin base, EFROMD3 analyses were also undertaken where the base and subbase were modelled separately and the subbase divided into five equal sublayers. Comparison of the EFROMD3 output demonstrated very similar results for both methods.

Due to the modification of the Reid Highway intersection in 2014, Section R4 was not included in the most recent field investigation and therefore back-calculation could not be undertaken. However, Section R4 has been included in the modulus timeline investigation discussed in Section 6.3.3.

It is important to note that Sections K3 and K12 of the Kwinana Freeway and Section R4 of the Reid Highway represent pavement systems which have a granular profile which conforms to the ERN9 3/5th rule. For these pavements, the ERN9 subbase design stresses (MRWA 2013a) are applicable for moduli determined from RLT testing. All remaining sections do not conform to this rule and the subbase was closer to the surface. In such cases, the ERN9 subbase design stresses underestimate the moduli of the limestone subbase.

6.3.2 Results

Representative layer moduli obtained from analysing the back-calculated moduli are presented in Table 6.4, Table 6.5 and Table 6.6. The values chosen to calculate these representative moduli were those at test chainages with high deflections/curvatures and low back-calculation errors, a method which is detailed in AGPT05, *Appendix E* (Austroads 2011). The equivalent stiffness method (Odemark 1949) was used to calculate the discrete base and subbase moduli from the values estimated for the five sublayers.

Table 6.4: Representative back-calculated modulus, southbound lane: Tonkin Highway

Section	Base	Location	Thickness of surfacing (mm)	Back-calculated modulus (MPa)			
				Asphalt	Base	Limestone	Subgrade
T2	BSL	OWP	75	5 000	510	360	280
			88	8 080	500	340	280
			Average		***505***	***350***	***280***
		BWP	75	4 520	620	520	280
			88	2 870	830	500	300
			Average		***725***	***510***	***290***
T4	BSL	OWP	65	7 490	1050	430	180
			101	3 150	880	410	190
			Average		***965***	***420***	***185***
		BWP	65	9 450	1150	520	170
			101	6 150	600	530	180
			Average		***875***	***525***	***175***
T6	CRB	OWP	43	9 800	660	430	190
			55	7 820	590	330	185
			Average		***625***	***380***	***190***
		BWP	43	8 220	830	324	210
			55	6 680	675	370	210
			Average		***750***	***350***	***210***

Table 6.5: Representative back-calculated modulus, westbound lane: Reid Highway

Section	Base	Location	Thickness of surfacing (mm)	Back-calculated modulus (MPa)			
				Asphalt	Base	Limestone	Subgrade
R2	BSL	OWP	45	10 300	480	270	220
			49	9 150	420	280	220
			Average		***450***	***275***	***220***
		BWP	45	11 235	710	230	225
			49	10 180	650	230	225
			Average		***680***	***230***	***225***
R3	CRB	OWP	39	14 430	730	290	220
			51	9 480	470	250	220

Section	Base	Location	Thickness of surfacing (mm)	Back-calculated modulus (MPa)			
				Asphalt	Base	Limestone	Subgrade
			Average		***570***	***255***	***220***
		BWP	39	13 350	800	270	220
			51	10 095	620	240	220
			Average		***710***	***255***	***220***

Table 6.6: Representative back-calculated modulus, southbound lane: Kwinana Freeway

Section	Base	Location	Thickness of surfacing (mm)	Back-calculated modulus (MPa)			
				Asphalt	Base	Limestone	Subgrade
K2	CRB	OWP	65	8510	450	200	250
K3	CRB		65	7480	400	160	310
K12	BSL		64	5200	870	490	220

The moduli of the sand subgrade exceeded 150 MPa and were well in excess of the ERN9 design modulus of 120 MPa. The white sand subgrade at both the Tonkin and Reid Highways had an average moduli of approximately 220 MPa whilst the yellow sand at the Kwinana Freeway was typically higher at approximately 240 MPa.

The back-calculated moduli of the granular materials at Tonkin and Reid Highway were also typically greater than the presumptive design values given by ERN9 and Austroads (see Table 2.1). The moduli of the BSL and CRB were both typically around 700 MPa with the highest values of each in the range of 1,000 MPa and 800 MPa respectively. The limestone was typically around 350 MPa with the highest values reaching 500 MPa.

The limited back-calculation results from the Kwinana Freeway produced lower moduli for the CRB and limestone materials. The BSL moduli was higher than the design value at approximately 870 MPa, which is similar to the results from the Tonkin and Reid Highways. The Kwinana Freeway FWD data used for back-calculation was collected at a much earlier stage of the pavement in-service life and subsequently at a significantly lower cumulative traffic level. This may explain the lower values produced by EFROMD3.

These results suggest that there is potential to improve the ERN9 design method as discussed in Section 7, and also suggests that granular pavement materials exhibit a short-term and long-term strength based on pavement age and cumulative traffic loading.

6.3.3 Variation of Modulus with Time/Loading

Granular pavement materials may undergo a shakedown period when exposed to repeated cyclic loads. Additionally some materials may cure with time in situ. To assess the variation in modulus with time/loading, back-calculation using the same methodology as that in Appendix E, was undertaken using historic FWD data collected at the Kwinana Freeway and Reid Highway sections. The Tonkin Highway was not considered for this part of the study due to the lack of historic FWD data sets. For the Reid Highway sections, the largest measured surfacing thickness was chosen for timeline analysis as this represented the worst case.

Kwinana Freeway

The FWD results from the OWP of the Kwinana Freeway trial sections from pre-traffic in 2009 through to 2016 were analysed. Data from 2014 was omitted as it was taken outside of September/October collection months and may have a seasonal variation element. The development of modulus with increased time/loading is shown in Figure 6.3,

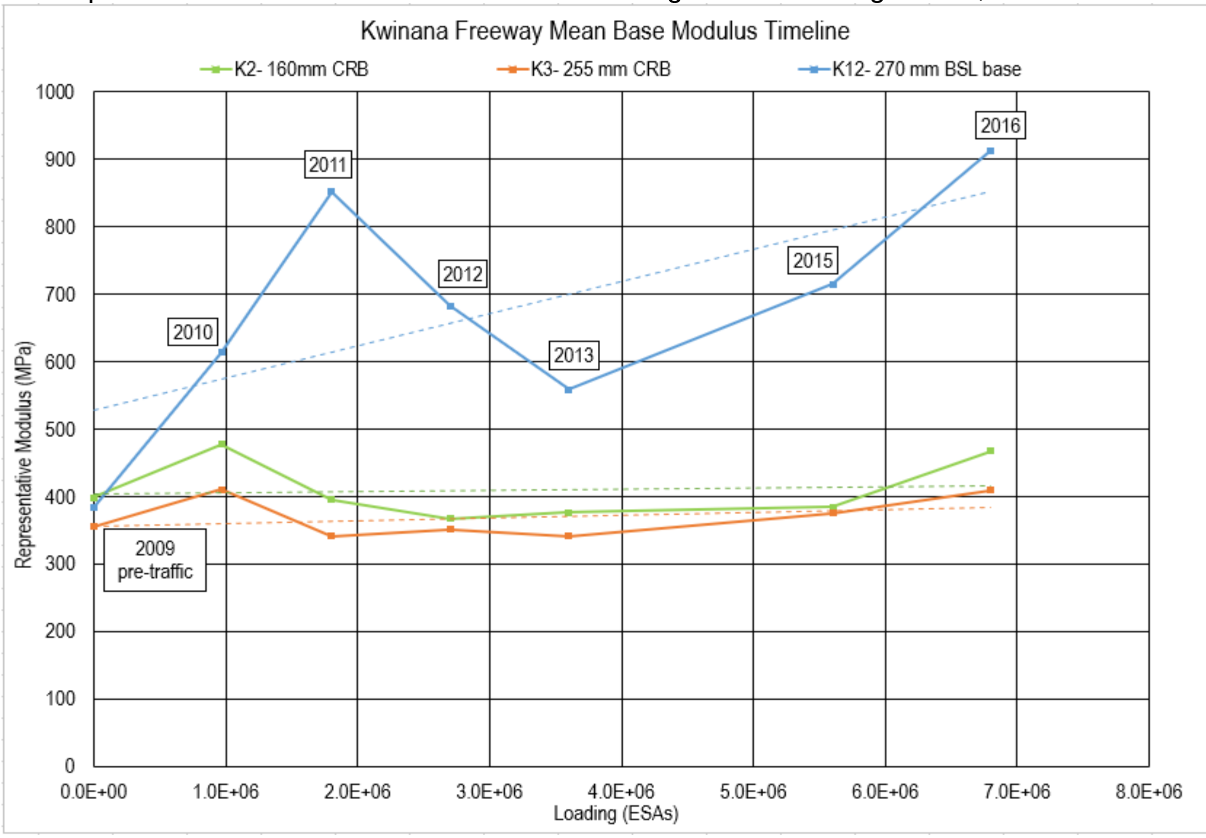


Figure 6.4 and Figure 6.5. For all materials an increase in modulus can be seen between the 2009 data taken a few days before opening to traffic and September 2010, a year later. Similarly to the deflection and curvature data, the modulus timeline at the Kwinana Freeway trials demonstrated three similar phases of performance:

- Phase 1: pre-traffic to end of the first year:
  - modulus of all granular material increases, with the K12 BSL and subbase materials having the largest increase
- Phase 2: end of the first year to around the end of the fifth year:
  - modulus of BSL continues to increase but starts to even off toward the end of the phase
  - modulus of the CRB in Sections K2 and K3 drops to value below the initial pre-traffic strength
  - modulus of the limestone subbase increases in all sections
- Phase 3: end of the fifth year to the end of the seventh year (most recent data)
  - modulus of all bases continues to increase
  - modulus of subbase continues to increase.

The subgrade moduli for all sections showed small variability with an overall slight increase with loading.

Figure 6.3: Development of mean base modulus with time/ loading: Kwinana Freeway

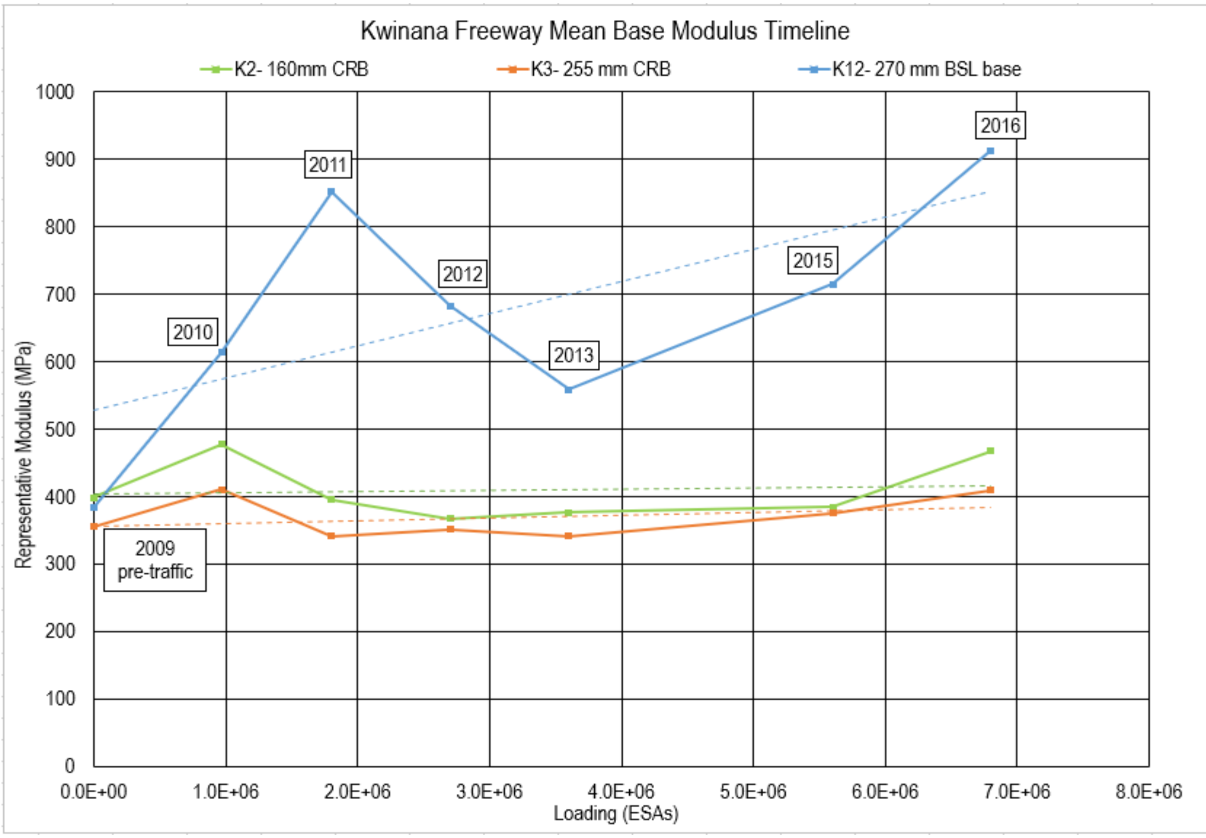


Figure 6.4: Development of mean subbase modulus with time/ loading: Kwinana Freeway

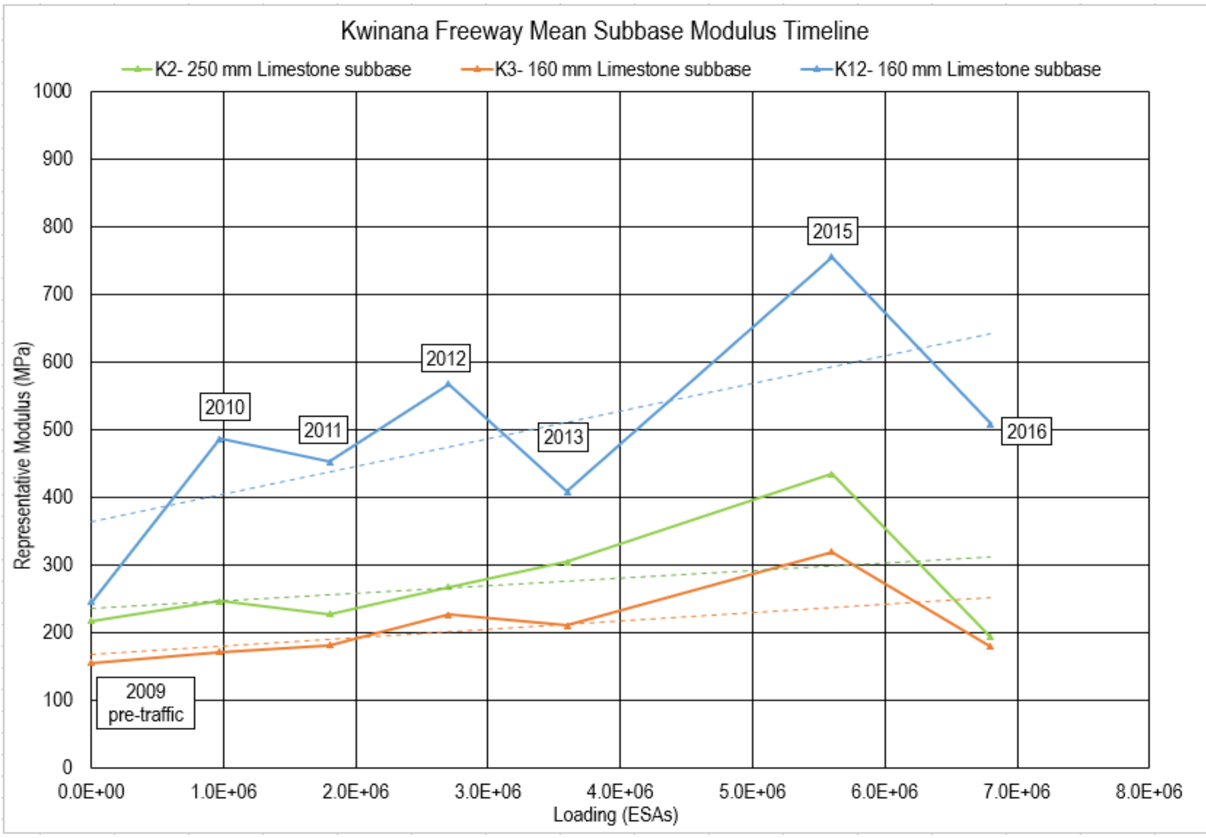
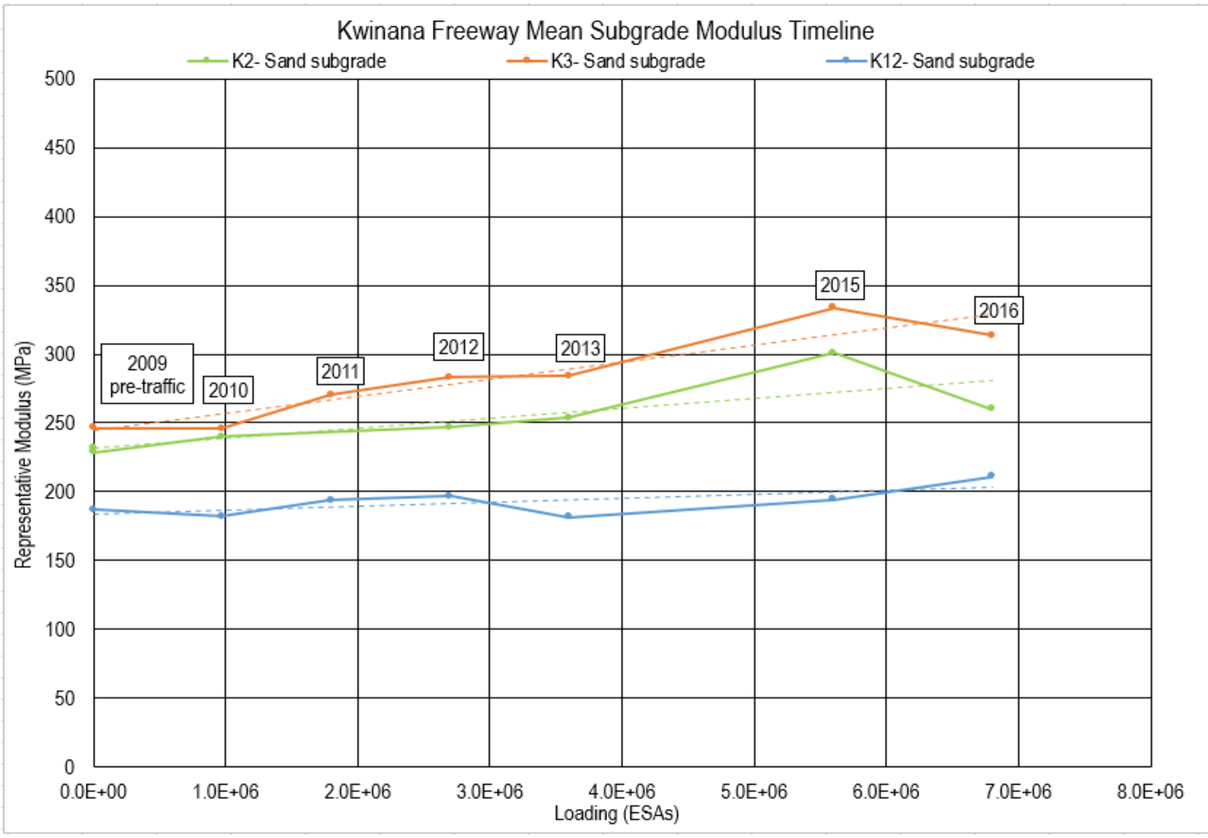


Figure 6.5: Development of mean subgrade modulus with time/loading: Kwinana Freeway



Reid Highway

The FWD results in the OWP of the Reid Highway trial sections from 2006, 2007, 2008, 2011, 2016 and 2017 were analysed. Data from 2007 was omitted for Section R3 and R4 due to data discrepancies. Collection months of the data vary, with measurements in 2006, 2008 and 2011 taken in November to December, and the remaining taken in March to May. This variation may cause seasonal variations in the data. The 2017 data was collected at 10 m spacings to better match the historic data sets. Section R4 only includes data collected in 2006, 2007, 2008 and 2011 due to the modifications of the section in 2014.

The variation in mean moduli with time/loading is shown in Figure 6.6, Figure 6.7 and Figure 6.8.

The earliest FWD data set used for the timeline modelling was 2006 which represents a pavement age of 10 years, or toward the end of the long-term strength profile. The fact that there was no pre-traffic modulus data made it difficult to set the short-term modulus value and therefore assess the two design phases. However, if the RLT modulus results (see Table 4.4) are used as a rough indication of the initial pre-traffic modulus, it may be inferred that the long-term moduli are greater than the initial values. All sections showed minor variability in subgrade modulus.

Figure 6.6: Development of mean base modulus with time/loading: Reid Highway

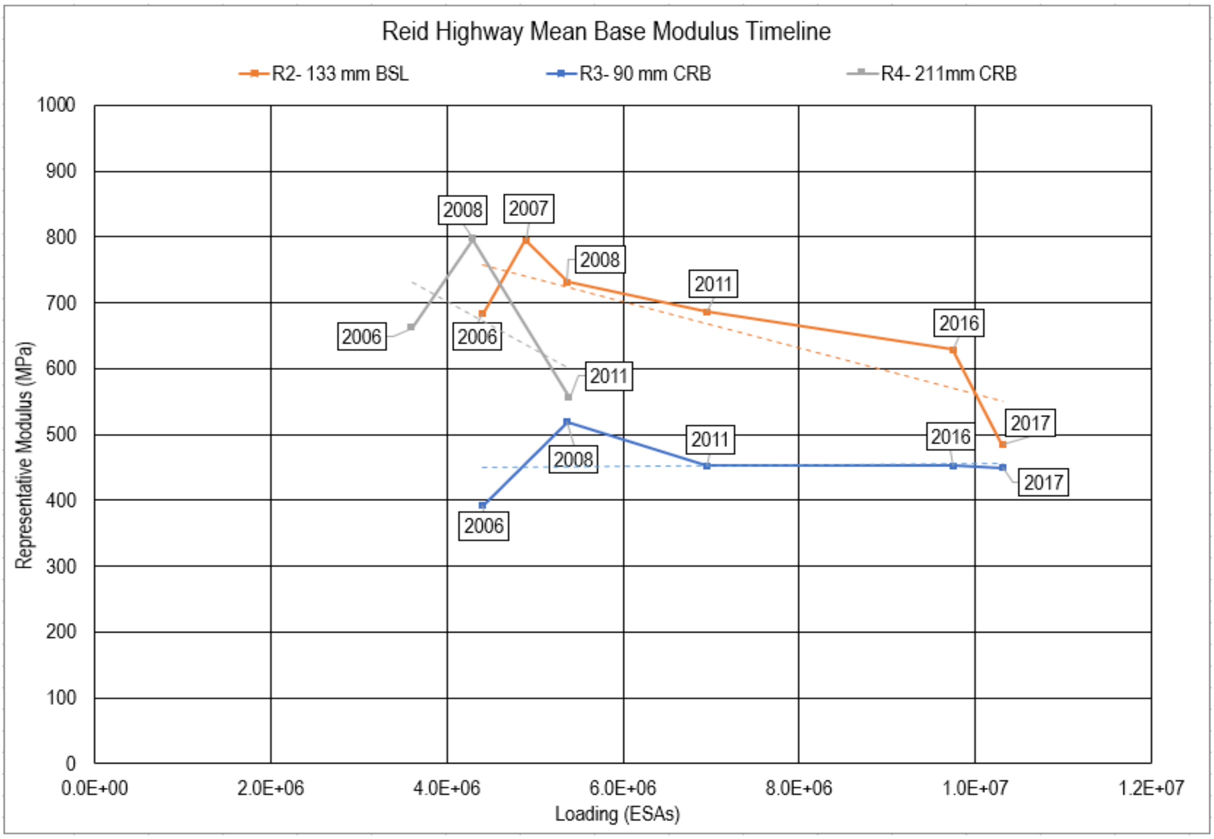


Figure 6.7: Development of mean base modulus with time/loading: Reid Highway

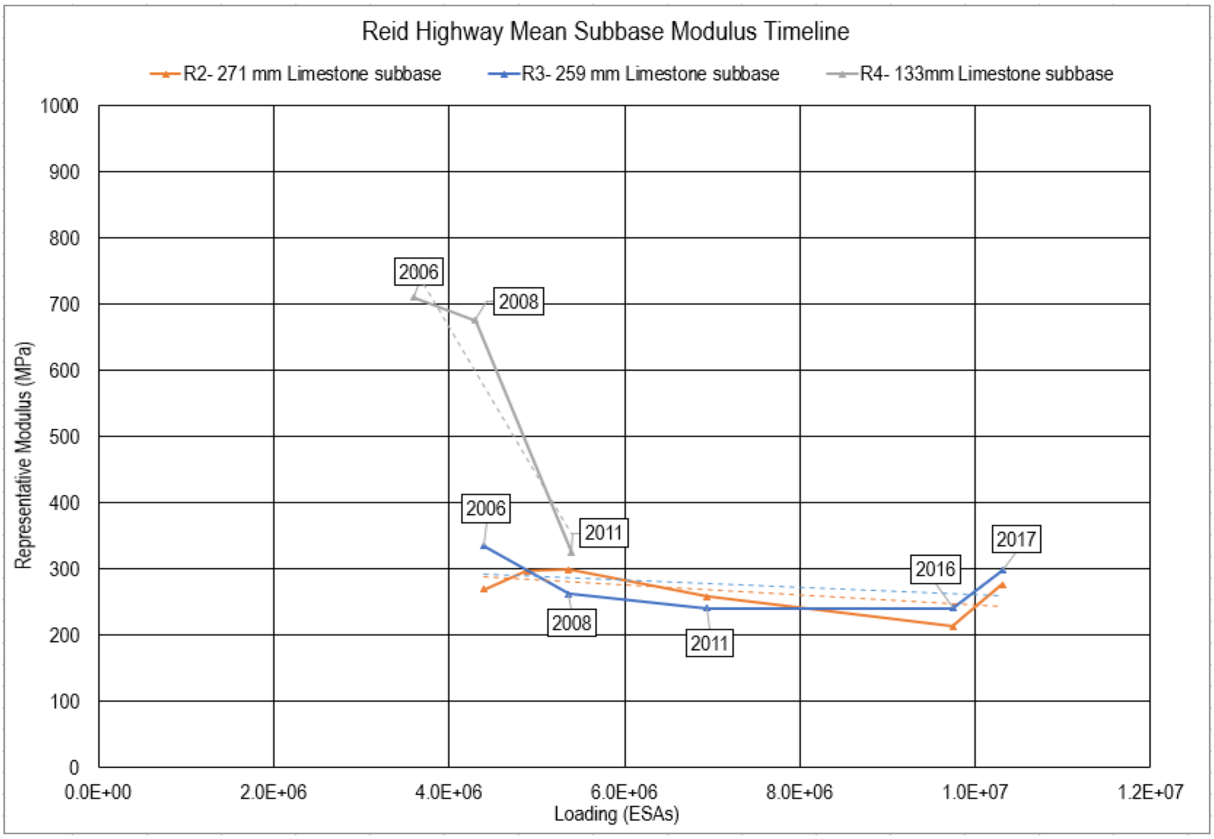
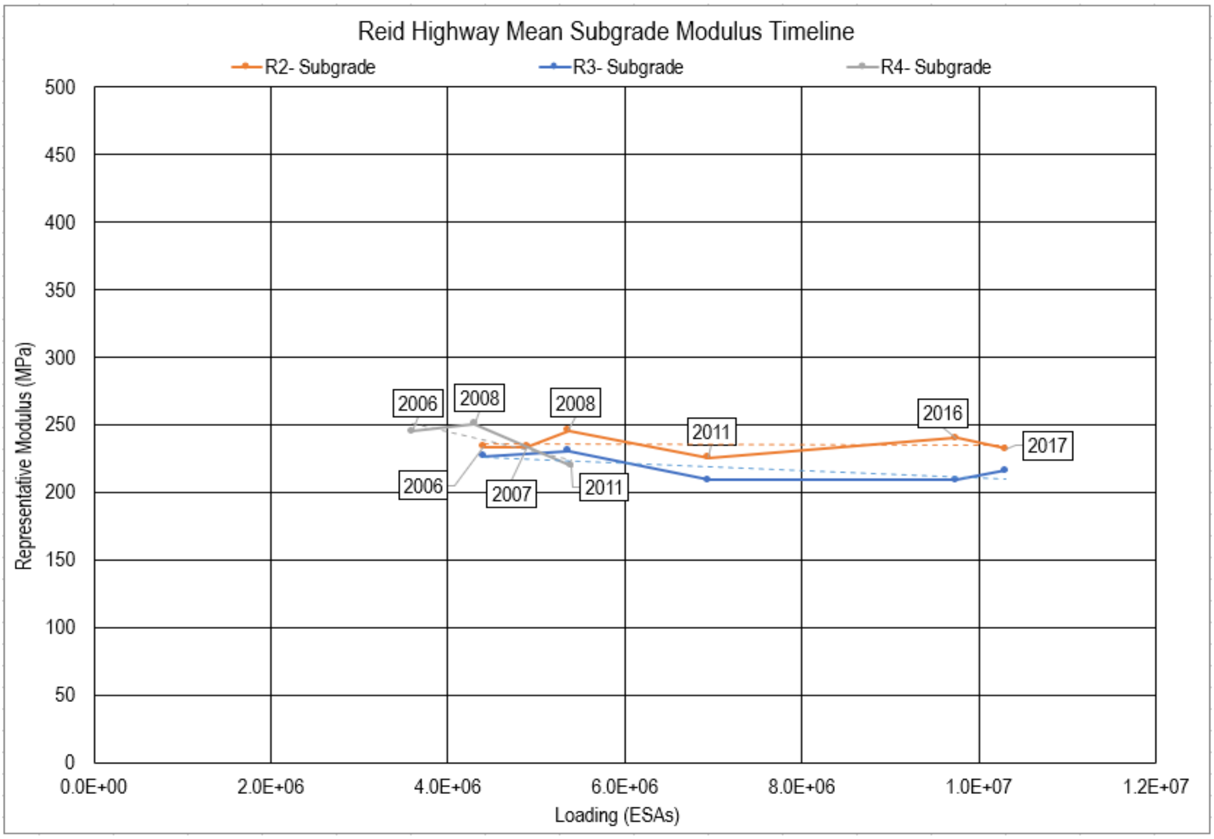


Figure 6.8: Development of mean subgrade modulus with increased loading: Reid Highway



6.4 Summary

From the analysis and review of the trial section pavements, the following observations regarding the current use of the mechanistic procedure for thin surfacings can be made:

- In terms of the in-service performance of discrete sections (Table 6.2):
  - Tonkin Highway BSL, Section T2, which has an inferred fatigue life of at least 20 years: the predicted mean fatigue life is likely an underestimate of the observed performance.
  - Tonkin Highway BSL, Section T4, which has an inferred fatigue life of at least 20 years: the predicted mean fatigue life is likely an underestimate of the observed performance.
  - Tonkin Highway CRB, Section T6, which has an inferred fatigue life of at least 20 years: the predicted mean fatigue life is consistent with the observed performance.
  - Both Reid Highway Sections R2 (BSL) and R3 (CRB), which are yet to be resurfaced and are showing no signs of surfacing fatigue: this is consistent with the predicted mean fatigue lives.
  - Kwinana Freeway CRB Sections K2 and K3, which are yet to be resurfaced and are showing no signs of surfacing fatigue: this is consistent with the predicted mean fatigue; and
  - According to Table 6.1, the cumulative traffic for BSL Section K12 in 2015 was equal the predicted mean fatigue life. As this section remains crack free, this adds to the case that the current ERN9 design methods underestimate thin asphalt fatigue lives of Perth BSL pavements.

- Considering the deflection and curvature trends:
  - Within the standard thin asphalt fatigue design period of 15 years, there are three similar phases of performance behaviour:
    - Phase 1 (pre-traffic to end of 1st year): pavement system strengthens with the application of the first year of traffic. The initial pre-traffic strength represents the worst case design scenario for this phase.
    - Phase 2 (end of first year to around end of fifth year): pavement systems continue to strengthen and eventually even out.
    - Phase 3 (end of fifth year to end of fifteenth year): pavements continue to strengthen.
  - Beyond the standard 15 year fatigue design period pavement systems show a continuing decrease in strength.
- Considering the back-calculated moduli results:
  - The CRB modulus tends to stabilise with time while the BSL and limestone continue to show a slow increase in strength. This may be attributable to the bitumen in the BSL and the calcium carbonate in the limestone allowing the material to gain a small amount of tensile strength.
  - The subgrade modulus does not change much over the in-service life of the pavement given the overlying granular is performing satisfactorily.

All of these observations suggest that:

- The design modulus for the BSL could be increased based on:
    - In-service observations in which BSL has demonstrated equal or better performance to the CRB
    - EFROMD3 back analysis and measured FWD deflection bowls
    - ongoing good performance of trial sections.
- The design modulus for the CRB could be increased based on:
    - the results of RLT testing conducted at base confinement stress levels
    - EFROMD3 back-analysis and measured FWD deflection bowls
    - ongoing good performance of the trial sections.
- The design modulus of the limestone subbase could be increased based on:
    - the results of RLT testing conducted at subbase confinement stress levels in addition to the outcomes of the finite element pavement design modelling project (Jameson et al. 2017)
    - EFROMD3 back-analysis
    - ongoing good performance of trial sections
- The design moduli for the sand subgrades could be increased based on:
    - various CBR results, both current and historic
    - the results of RLT testing conducted at various confinement stress levels in addition to the outcomes of the finite element pavement design modelling project (Jameson et al. 2017)
    - EFROMD3 back analysis and measured FWD deflection bowls

  - ongoing good performance of trial sections.

- A short-term (first year) and long-term (15 years) strength phase has been identified which may be modelled in two stages:
  - The short-term asphalt fatigue can be modelled using the current mechanistic procedure and current granular design moduli as this represents a conservative method to model the most detrimental loading period.
  - The long-term asphalt fatigue may be modelled using the same procedure but with a change in the characterisation of the granular base and subbase layers. This change in the characterisation would ensure that the model can better recognise the higher strength and contribution of the limestone subbase layer.

7 SUMMARY AND RECOMMENDATIONS

This collation and review of nine MRWA trial sections has enabled observations of the current ERN9 design method to be made in addition to exploring the mechanisms behind the ongoing better-than-expected performance of these sections. These observations have been based on three separate trial locations with varying traffic levels, climatic characteristics, subsurface geology, pavement material sources, year of construction, and specification conformance. All have shown similar performance trends throughout their in-service life.

Fatigue cracking of the thin asphalt surfacing has not been observed at either the Tonkin Highway, Reid Highway or Kwinana Freeway trial sites. For each trial section, the cumulative traffic loading to date was compared to the predicted allowable traffic loading. The predicted lives were the mean asphalt fatigue lives rather than the lives with 95% reliability commonly used in design. The mean fatigue life is approximately six times the 95% fatigue life. The predicted mean or best estimate of the allowable loading is most suitable for comparison against the observed performance.

It was determined that, for all but three trial sections, the cumulative traffic loadings were less than the mean predicted fatigue lives.

In situ base, subbase and subgrade moduli were back-calculated from measured surface deflections. The moduli of the sand subgrade exceeded 150 MPa and were well in excess of the ERN9 design modulus of 120 MPa. In addition, the moduli of the limestone subbase were greater than 250 MPa. These findings are supported by the outcomes of a Finite Element Pavement Design Model study (Jameson et al. 2017) in which layer moduli were estimated from the laboratory testing of samples from the Kwinana Freeway trials. A new method of elastic characterisation is needed to more appropriately reflect the structural contribution of the sand subgrade/limestone subbase to the fatigue performance of thin asphalt surfacings. Such a change to the elastic characterisation may enable the restoration of a 15 year design traffic loading for thin asphalt fatigue across all traffic loadings.

Deflection and curvature testing has also demonstrated similar performance phases throughout the in-service life of the pavements. These apparent phases could be the basis of a revised design methodology which considers both a short- and long-term design, with a first year traffic limit and annual average growth rate.

The 40 year predicted traffic levels at the Tonkin and Reid highway were calculated to be 3.2×10^7 and 2.8×10^7 ESAs respectively. These traffic levels are close to the current specified limit of 3.0×10^7 ESAs for Clause 1.2(c) and therefore do not warrant an increase in this traffic criteria.

The 40 year predicted traffic level at the Kwinana Freeway trials was calculated to be 1.7×10^8 ESAs but these pavements are only seven years old. Ongoing monitoring of these sections should be undertaken to ensure performance trends continue as expected and may warrant an increase in the traffic criteria.

Further investigation of these observations through the analysis of other sections of road with available performance data should be undertaken as the data available through this project is not considered to be enough to warrant immediate changes to the current method for determining the fatigue life of thin asphalt surfacings. Sections which were not constructed as part of pavement trials may also provide vital insight into the applicability of these observations in conjunction with pavements constructed to a more representative, standard quality level.

It is recommended that MRWA consider the findings presented in this report in relation to the revision of the ERN9 design procedures for thin asphalt-surfaced granular pavements. These findings, together with those of the WAPARC Finite Element Pavement Model project, would enable consideration to be given to:

- whether there is sufficient evidence to amend ERN9 to provide higher predicted asphalt fatigue across all design traffic loading; this may enable the current 5 year design period for less heavily-trafficked roads to be eliminated
- developing amendments to the Austroads design methods which better reflect the structural contribution of crushed limestone subbase
- refining the presumptive sand subgrade moduli to reflect varying qualities available in Perth.

To allow further investigation of the above recommendations, historic performance and observational data, similar to that used in this report, for various Perth metropolitan granular pavements with thin asphalt surfacings, will be required. Examples of the type of data required include (but are not limited to) the following:

- Design documentation and original design assumptions
- Subsurface conditions and climatic data
- Construction reports and corresponding as constructed pavement data
- Pavement material laboratory test data
- Pavement maintenance and resurfacing history
- Measured traffic data
- Historic and current FWD data
- Other condition data such as roughness, rutting, cracking etc.

It is suggested that identification and collation of this data, where available, be undertaken as a preliminary task to ensure further investigation will be supported by sufficient data and evidence.

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APPENDIX A TONKIN HIGHWAY DATA

A.1 Historic Performance Data

Table A 1: Benkelmen Beam deflection results

Test date	Trial ID	Deflection, OWP (mm)	Deflection, IWP (mm)	Mean deflection, combined wheel paths (mm)
Feb-81	T2	0.273	0.291	0.282
	T4	0.296	0.316	0.306
	T6	0.265	0.256	0.260
Aug-81	T2	0.353	0.338	0.346
	T4	0.402	0.347	0.374
	T6	0.358	0.369	0.363
Mar-92	T2	0.220	0.320	0.270
	T4	0.256	0.30	0.278
	T6	0.289	0.256	0.272
Oct-82	T2	0.338	0.275	0.308
	T4	0.380	0.333	0.357
	T6	0.351	0.316	0.333
Oct-84	T2	0.283	0.293	0.289
	T4	0.354	0.324	0.337
	T6	0.267	0.277	0.271
Oct-86	T2	0.303	0.278	0.289
	T4	0.376	0.369	0.372
	T6	0.298	0.304	0.301

Notes:

- OWP- Outer wheel path
- IWP- Inner wheel path

Source: Butkus 1991

Table A 2: Falling weight deflectometer, 2015 Report No. 15 FWD 469/2 (MRWA 2016a)

Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2004 Correction to 29C					
																Deflection (mm)	Curvature (mm)	Deflection Facto	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
21600	2	SB	12/12/2015	60	24	696	263	216	153	117	93	75	60	50	28	0.265	0.047	1.030	0.272		1.088	0.051	
21611	2	SB	12/12/2015	60	24	682	256	192	143	113	95	83	67	58	35	0.263	0.066	1.027	0.270		1.081	0.071	
21622	2	SB	12/12/2015	60	24	694	303	223	156	120	97	80	68	55	33	0.306	0.081	1.026	0.314		1.079	0.087	
21633	2	SB	12/12/2015	60	24	695	261	190	146	114	96	81	66	55	33	0.263	0.072	1.028	0.270		1.083	0.077	
21644	2	SB	12/12/2015	60	25	696	272	206	139	98	82	69	48	45	26	0.274	0.066	1.025	0.280		1.075	0.071	
21655	2	SB	12/12/2015	60	25	698	284	199	149	112	88	76	61	52	30	0.285	0.085	1.025	0.292		1.073	0.091	
21666	2	SB	12/12/2015	60	25	696	275	188	139	104	83	71	55	47	27	0.277	0.088	1.021	0.282		1.062	0.093	
21677	2	SB	12/12/2015	60	26	699	291	189	134	106	75	67	52	46	25	0.291	0.102	1.017	0.296		1.051	0.107	
21688	2	SB	12/12/2015	60	25	694	287	209	152	113	87	74	60	48	29	0.289	0.079	1.020	0.295		1.058	0.083	
21699	2	SB	12/12/2015	60	24	691	320	223	153	118	95	79	68	50	28	0.324	0.098	1.032	0.334	***0.291***	1.094	0.108	***0.084***
21840	4	SB	12/12/2015	30	23	694	310	242	201	172	151	133	112	99	61	0.313	0.069	1.018	0.318		1.040	0.071	
21849	4	SB	12/12/2015	30	22	700	315	235	182	152	130	117	98	85	54	0.315	0.080	1.020	0.321		1.044	0.083	
21858	4	SB	12/12/2015	30	22	687	342	272	212	176	150	127	104	87	58	0.348	0.071	1.021	0.356		1.047	0.075	
21867	4	SB	12/12/2015	30	25	689	313	237	189	155	131	116	98	86	56	0.318	0.077	1.012	0.322		1.026	0.079	
21876	4	SB	12/12/2015	30	23	687	313	221	170	138	120	104	87	79	47	0.319	0.094	1.018	0.325		1.040	0.097	
21884	4	SB	12/12/2015	30	22	689	284	223	169	133	116	102	89	81	55	0.289	0.062	1.021	0.295		1.047	0.065	
21893	4	SB	12/12/2015	30	22	692	368	262	196	154	129	112	89	76	49	0.372	0.107	1.019	0.379		1.041	0.112	
21902	4	SB	12/12/2015	30	23	692	335	253	195	161	134	115	93	78	45	0.339	0.083	1.017	0.345		1.037	0.086	
21911	4	SB	12/12/2015	30	26	693	334	257	204	169	140	118	98	83	51	0.337	0.078	1.008	0.340		1.018	0.079	
21920	4	SB	12/12/2015	30	26	691	358	283	225	186	156	132	108	92	54	0.363	0.076	1.008	0.366	***0.337***	1.018	0.077	***0.083***
22040	6	SB	12/12/2015	30	23	699	381	265	187	136	104	80	59	48	23	0.382	0.116	1.017	0.388		1.038	0.121	
22049	6	SB	12/12/2015	30	23	696	362	272	187	130	92	68	47	35	14	0.364	0.091	1.016	0.370		1.035	0.094	
22058	6	SB	12/12/2015	30	25	703	299	183	108	63	35	24	19	16	11	0.298	0.116	1.011	0.301		1.024	0.118	
22067	6	SB	12/12/2015	30	23	695	265	166	96	54	31	23	19	17	11	0.267	0.100	1.017	0.271		1.037	0.103	
22076	6	SB	12/12/2015	30	23	686	313	209	128	79	49	32	22	16	8	0.319	0.106	1.017	0.325		1.037	0.110	
22084	6	SB	12/12/2015	30	28	682	263	176	101	61	39	30	23	18	13	0.270	0.089	1.003	0.271		1.006	0.090	
22093	6	SB	12/12/2015	30	28	684	293	188	112	68	46	35	29	23	14	0.300	0.107	1.001	0.300		1.003	0.108	
22102	6	SB	12/12/2015	30	26	697	292	191	117	73	48	34	24	20	13	0.293	0.101	1.009	0.296		1.019	0.103	
22111	6	SB	12/12/2015	30	28	702	316	202	117	73	47	36	27	22	12	0.315	0.114	1.003	0.316		1.006	0.114	
22120	6	SB	12/12/2015	30	27	695	377	257	164	110	76	56	37	26	11	0.380	0.121	1.006	0.382	***0.322***	1.013	0.122	***0.108***

Table A 3: Average rut depth

Test date	Trial ID	Chainage start (km)	Chainage end (km)	3 m straight edge rut (mm)		2 m straight edge rut (mm)	
				OWP	IWP	OWP	IWP
Feb-99	T2	21.60	21.62	3.2	3.8	3.2	3.7
		21.62	21.64	5.3	4.4	5.3	4.4
		21.64	21.66	3.5	5.6	3.5	5.6
		21.66	21.68	3.8	4.1	3.8	4.1
		21.68	21.70	3.6	5.2	3.5	5.1
		21.70	21.72	4.0	5.2	4.0	5.2
	T4	21.84	21.86	5.6	9.0	4.6	7.6
		21.86	21.88	6.5	12.0	4.4	9.5
		21.88	21.90	4.3	7.3	3.5	6.2
		21.90	21.92	6.5	6.7	5.6	5.2
		21.92	21.94	7.8	9.5	5.5	6.0
	T6	22.04	22.06	5.7	9.6	5.1	8.9
		22.06	22.08	4.0	7.7	3.8	7.6
		22.08	22.10	3.8	5.8	3.8	5.8
		22.10	22.12	3.9	6.4	3.9	6.4
		22.12	22.14	4.3	5.9	4.3	5.9
Sep-00	T2	21.60	21.62	3.2	5.0	3.2	5.0
		21.62	21.64	3.0	5.7	2.9	5.6
		21.64	21.66	2.6	5.3	2.4	5.1
		21.66	21.68	3.0	5.5	2.8	5.1
		21.68	21.70	3.6	4.7	3.4	4.5
		21.70	21.72	4.9	3.7	4.8	3.7
	T4	21.84	21.86	6.3	12.2	2.9	9.3
		21.86	21.88	6.5	12.3	2.6	8.9
		21.88	21.90	3.8	7.6	2.4	6.0
		21.90	21.92	6.6	8.5	4.1	5.7
		21.92	21.94	8.5	10.4	5.1	6.4
	T6	22.04	22.06	5.1	10.5	3.8	9.0
		22.06	22.08	3.1	6.2	2.9	6.0
		22.08	22.10	3.3	5.5	3.3	5.5
		22.10	22.12	3.1	6.1	3.1	6.1
		22.12	22.14	2.8	5.9	2.8	5.9
Dec-06	T2	21.60	21.62	0.9	5.0	0.9	5.0
		21.62	21.64	2.4	6.9	2.4	6.8
		21.64	21.66	2.7	8.0	2.7	7.9
		21.66	21.68	2.5	7.2	2.5	7.1
		21.68	21.70	2.2	7.0	2.2	6.8
		21.70	21.72	2.6	7.4	2.6	7.3

Test date	Trial ID	Chainage start (km)	Chainage end (km)	3 m straight edge rut (mm)		2 m straight edge rut (mm)	
				OWP	IWP	OWP	IWP
Cont…	T4	21.84	21.86	2.8	9.3	2.7	8.2
		21.86	21.88	4.3	4.0	3.3	3.2
		21.88	21.90	2.3	3.7	2.0	3.0
		21.90	21.92	1.6	3.9	1.6	3.5
		21.92	21.94	1.1	3.2	1.1	3.1
	T6	22.04	22.06	1.1	6.7	1.1	6.4
		22.06	22.08	1.8	12.5	1.8	11.7
		22.08	22.10	1.8	9.9	1.8	9.8
		22.10	22.12	1.9	8.1	1.9	8.1
		22.12	22.14	2.0	9.6	2.0	9.5
Dec-07	T2	21.61	21.63	5.1	7.3	5.1	7.3
		21.63	21.65	3.4	7.2	3.4	7.2
		21.65	21.67	4.0	4.4	4.0	4.3
		21.67	21.69	4.5	4.4	4.5	4.4
		21.69	21.71	5.5	4.4	5.5	4.4
		21.71	21.73	5.4	4.7	5.3	4.7
	T4	21.85	21.87	2.2	3.7	2.0	3.1
		21.87	21.89	1.5	3.1	1.5	3.1
		21.89	21.91	1.1	2.8	1.1	2.8
		21.91	21.93	0.9	3.4	0.9	3.3
		21.93	21.95	1.2	2.9	1.2	2.8
	T6	22.05	22.07	4.7	8.6	4.7	8.5
		22.07	22.09	5.9	7.4	5.9	7.4
		22.09	22.11	6.5	8.7	6.5	8.7
		22.11	22.13	5.2	7.8	5.2	7.8
		22.13	22.15	5.1	10.1	5.1	10.1
Dec-08	T2	21.61	21.63	2.7	9.3	2.7	9.2
		21.63	21.65	2.7	5.9	2.7	5.8
		21.65	21.67	2.1	5.5	2.1	5.3
		21.67	21.69	2.6	6.1	2.6	6.1
		21.69	21.71	4.5	6.7	4.5	6.7
		21.71	21.73	3.1	8.2	3.1	7.9
	T4	21.85	21.87	1.8	3.4	1.8	3.2
		21.87	21.89	1.5	3.7	1.5	3.5
		21.89	21.91	1.4	3.1	1.4	3.1
		21.91	21.93	1.1	2.7	1.1	2.6
		21.93	21.95	1.7	2.2	1.6	2
	T6	22.05	22.07	2.7	8.2	2.7	8.2
		22.07	22.09	2.3	9.1	2.3	9.0

Test date	Trial ID	Chainage start (km)	Chainage end (km)	3 m straight edge rut (mm)		2 m straight edge rut (mm)	
				OWP	IWP	OWP	IWP
Cont…	*Cont…*	22.09	22.11	2.0	8.8	2.0	8.8
		22.11	22.13	1.8	9.5	1.8	9.5
		22.13	22.15	1.5	10.0	1.5	10
Nov-09	T2	21.61	21.63	7.8	7.8	7.8	7.7
		21.63	21.65	4.9	7.9	4.9	7.8
		21.65	21.67	4.2	4.0	4.2	4.0
		21.67	21.69	4.4	4.2	4.4	4.2
		21.69	21.71	6.4	3.8	6.4	3.8
		21.71	21.73	7.9	4.6	7.9	4.6
	T4	21.85	21.87	2.8	3.0	2.4	2.6
		21.87	21.89	1.8	2.7	1.8	2.7
		21.89	21.91	1.3	2.4	1.3	2.4
		21.91	21.93	1.3	3.2	1.3	3.2
		21.93	21.95	1.4	2.5	1.4	2.5
	T6	22.05	22.07	2.8	9.4	2.8	9.4
		22.07	22.09	2.8	7.1	2.8	7.1
		22.09	22.11	4.1	6.4	4.1	6.4
		22.11	22.13	3.4	7.7	3.4	7.7
		22.13	22.15	3.7	9.1	3.7	9.1
Nov-12	T2	21.60	21.62	-	-	6.2	5.3
		21.62	21.64	-	-	5.8	5.9
		21.64	21.66	-	-	5.8	6.1
		21.66	21.68	-	-	4.8	3.2
		21.68	21.70	-	-	5.8	3.5
		21.70	21.72	-	-	5.6	3.8
	T4	21.84	21.86	-	-	3.1	2.4
		21.86	21.88	-	-	1.6	1.9
		21.88	21.90	-	-	1.1	2.0
		21.90	21.92	-	-	0.9	2.4
		21.92	21.94	-	-	1.3	2.7
	T6	22.04	22.06	-	-	5.5	8.2
		22.06	22.08	-	-	4.6	6.5
		22.08	22.10	-	-	4.9	6
		22.10	22.12	-	-	4.7	6.4
		22.12	22.14	-	-	4.7	7.2
Jan-15	T2	21.60	21.62	-	-	4.0	5.5
		21.62	21.64	-	-	4.5	6.4
		21.64	21.66	-	-	5.4	6.3
		21.66	21.68	-	-	4.9	2.9

Test date	Trial ID	Chainage start (km)	Chainage end (km)	3 m straight edge rut (mm)		2 m straight edge rut (mm)	
				OWP	IWP	OWP	IWP
Cont…	*Cont…*	21.68	21.70	-	-	4.7	3.4
		21.70	21.72	-	-	4.0	3.5
	T4	21.84	21.86	-	-	3.7	3.0
		21.86	21.88	-	-	3.5	3.8
		21.88	21.90	-	-	3.2	4.2
		21.90	21.92	-	-	3.3	2.9
		21.92	21.94	-	-	2.7	2.9
	T6	22.04	22.06	-	-	4.7	7.9
		22.06	22.08	-	-	3.8	5.3
		22.08	22.10	-	-	4.5	4.8
		22.10	22.12	-	-	5.5	6.5
		22.12	22.14	-	-	4.4	6.2

Notes:

- OWP- Outer wheel path
- IWP- Inner wheel path

Source: IRIS 26/6/16

Table A 4: NAASRA road roughness meter results

Test date	Trial ID	Test Speed (km/h)	NAASRA Counts/km			
			Left lane	Centre lane	Right lane	Mean value
Mar-81	T2	50	34	34	40	36
	T4	50	31	31	31	31
	T6	50	23	15	23	20
Jun-81	T2	50	27	27	34	29
	T4	50	31	31	31	31
	T6	50	15	15	23	18
Nov-82	T2	70	44	36	36	39
	T4	70	47	47	47	47
	T6	70	25	25	21	24
Jul-83	T2	80	44	47	44	45
	T4	80	50	54	54	53
	T6	80	33	33	28	31
Jan-84	T2	70	48	48	48	48
	T4	70	51	55	43	50
	T6	70	30	34	30	31
Jul-84	T2	80	47	47	71	55
	T4	80	50	54	50	51
	T6	80	26	26	31	28
Jan-85	T2	70	54	47	47	49
	T4	70	53	57	49	53
	T6	70	28	28	28	28

Test date	Trial ID	Test Speed (km/h)	NAASRA Counts/km			
			Left lane	Centre lane	Right lane	Mean value
Apr-85	T2	50	41	34	41	39
	T4	50	38	35	38	37
	T6	50	23	31	31	28
Feb-86	T2	70	44	44	60	49
	T4	70	43	48	48	46
	T6	70	33	33	28	31
Sep-86	T2	70	52	52	56	53
	T4	70	63	68	58	63
	T6	70	34	34	29	32
Jan-87	T2	80	66	41	64	57
	T4	80	69	52	48	56
	T6	80	39	18	22	26
Jul-87	T2	80	48	48	55	50
	T4	80	55	55	59	56
	T6	80	31	27	23	27
Dec-88	T2	80	62	58	50	57
	T4	80	83	78	68	76
	T6	80	44	44	29	39
Jul-89	T2	80	54	54	50	53
	T4	80	64	72	67	68
	T6	80	40	35	30	35
Aug-98	T2	-	-	-	-	63
	T4	-	-	-	-	75
	T6	-	-	-	-	69
Sep-00	T2	-	-	-	-	63
	T4	-	-	-	-	74
	T6	-	-	-	-	66
Dec-01	T2	-	-	-	-	47
	T4	-	-	-	-	26
	T6	-	-	-	-	115
Nov-02	T2	-	-	-	-	45
	T4	-	-	-	-	26
	T6	-	-	-	-	115
Jan-05	T2	-	-	-	-	38
	T4	-	-	-	-	31
	T6	-	-	-	-	90
Dec-06	T2	-	-	-	-	64
	T4	-	-	-	-	61
	T6	-	-	-	-	24

Test date	Trial ID	Test Speed (km/h)	NAASRA Counts/km			
			Left lane	Centre lane	Right lane	Mean value
Dec-07	T2	-	-	-	-	43
	T4	-	-	-	-	56
	T6	-	-	-	-	33
Nov-09	T2	-	-	-	-	55
	T4	-	-	-	-	53
	T6	-	-	-	-	52

Notes:
- OWP- Outer wheel path
- IWP- Inner wheel path

Source: Butkus 1991

Stage 2 Investigation

A.1.1 2016 FWD Data

Table A 5: Falling weight deflectometer, left lane left wheel paths Report No. 16 FWD 514/1 (MRWA 2016c)

Station (km)	Trial Section	Direction	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction: Deflection (mm)	Normalised to 700 kPa No Temp Correction: Curvature (mm)	Normalised to 700 kPa Austroads 2008 Correction to 29°C: Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
21.605	2	SB	9.2	75	694	314	205	157	124	99	80	66	53	30	0.316	0.109	1.135	0.359		1.544	0.169	
21.610	2	SB	9.3	75	690	318	203	159	120	95	78	66	53	30	0.323	0.117	1.137	0.367		1.545	0.181	
21.615	2	SB	9.0	80	694	337	224	163	126	100	83	70	54	35	0.340	0.114	1.139	0.388		1.580	0.180	
21.620	2	SB	9.1	80	696	345	248	180	135	105	87	71	57	34	0.347	0.098	1.141	0.396		1.582	0.155	
21.625	2	SB	9.1	85	699	306	209	164	123	106	86	71	61	38	0.307	0.098	1.147	0.352		1.621	0.158	
21.635	2	SB	9.2	85	690	353	241	176	134	109	89	75	63	37	0.358	0.114	1.149	0.411		1.622	0.184	
21.640	2	SB	9.1	85	691	334	220	164	126	100	80	64	54	34	0.339	0.116	1.147	0.389		1.621	0.187	
21.645	2	SB	9.1	85	696	297	212	166	128	104	86	74	60	36	0.298	0.085	1.147	0.342		1.621	0.137	
21.650	2	SB	9.1	80	692	332	243	178	124	100	83	70	56	34	0.336	0.090	1.141	0.383		1.582	0.142	
21.655	2	SB	9.0	80	688	305	213	152	121	93	78	67	54	33	0.310	0.094	1.139	0.353		1.580	0.149	
21.660	2	SB	9.1	80	690	302	210	158	118	96	81	64	54	32	0.306	0.093	1.141	0.349		1.582	0.147	
21.665	2	SB	9.2	80	692	324	251	165	126	97	83	70	58	33	0.328	0.074	1.142	0.374		1.583	0.117	
21.670	2	SB	9.1	86	687	321	222	165	123	100	73	65	55	33	0.327	0.100	1.149	0.375		1.629	0.163	
21.675	2	SB	9.2	86	694	341	245	171	132	103	87	72	57	33	0.344	0.097	1.150	0.396		1.630	0.158	
21.680	2	SB	9.2	85	696	316	206	161	118	99	80	67	55	32	0.318	0.111	1.149	0.365		1.622	0.180	
21.685	2	SB	9.1	85	686	316	216	155	119	98	79	64	52	31	0.323	0.102	1.147	0.370		1.621	0.166	
21.690	2	SB	9.1	87	686	324	234	159	118	93	74	59	46	28	0.331	0.093	1.150	0.381		1.637	0.151	
21.695	2	SB	9.0	87	688	312	225	167	125	96	76	64	51	28	0.317	0.088	1.148	0.364		1.635	0.144	
21.700	2	SB	9.1	88	689	309	213	168	130	101	83	70	56	32	0.314	0.098	1.151	0.362		1.645	0.160	
21.705	2	SB	9.4	88	685	391	239	174	132	107	86	71	58	34	0.400	0.156	1.156	0.462		1.647	0.257	
21.710	2	SB	9.3	81	675	365	256	196	149	121	99	84	68	39	0.379	0.113	1.145	0.434		1.592	0.180	
21.715	2	SB	9.1	81	683	333	238	178	138	111	87	74	59	35	0.342	0.098	1.142	0.390		1.590	0.155	
21.720	2	SB	8.8	85	690	312	224	166	124	104	87	73	61	38	0.316	0.089	1.141	0.361	*0.379*	1.615	0.144	*0.164*
21.845	4	SB	8.7	65	700	337	265	226	175	148	125	109	97	60	0.337	0.071	1.117	0.376		1.462	0.104	
21.850	4	SB	8.8	70	701	389	290	236	192	163	139	121	101	63	0.389	0.099	1.124	0.437		1.500	0.148	
21.855	4	SB	9.0	80	698	357	283	230	185	155	126	108	89	52	0.358	0.074	1.139	0.407		1.580	0.116	
21.860	4	SB	8.9	80	701	383	286	227	183	148	125	105	87	52	0.382	0.097	1.137	0.435		1.578	0.153	
21.865	4	SB	8.7	86	701	356	276	208	155	127	103	91	78	50	0.355	0.079	1.140	0.405		1.620	0.128	
21.870	4	SB	8.7	86	702	454	315	245	190	153	129	111	94	60	0.452	0.138	1.140	0.516		1.620	0.223	
21.875	4	SB	9.0	65	699	271	205	171	142	120	101	87	74	48	0.271	0.066	1.122	0.304		1.468	0.097	
21.880	4	SB	8.7	65	700	343	271	213	164	131	111	94	79	49	0.343	0.071	1.117	0.383		1.462	0.104	
21.885	4	SB	8.8	75	700	325	249	196	156	129	107	92	77	48	0.325	0.076	1.128	0.367		1.536	0.116	
21.890	4	SB	9.7	75	698	333	237	182	143	117	100	87	72	44	0.334	0.097	1.141	0.381		1.546	0.149	
21.895	4	SB	9.4	78	700	259	186	152	126	107	94	82	68	41	0.259	0.073	1.142	0.295		1.569	0.114	
21.900	4	SB	9.2	78	704	354	269	217	179	152	130	113	94	52	0.352	0.085	1.139	0.401		1.567	0.133	

Station (km)	Trial Section	Lane	Surface Temp (ºC)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
21.905	4	SB	8.9	65	699	311	238	192	155	132	111	95	79	40	0.311	0.072	1.121	0.349		1.466	0.106	
21.910	4	SB	8.8	65	701	354	268	213	170	140	115	101	83	45	0.353	0.086	1.119	0.395		1.464	0.125	
21.915	4	SB	8.7	86	700	330	253	201	162	135	110	91	76	40	0.330	0.077	1.140	0.376		1.620	0.124	
21.920	4	SB	9.0	86	700	322	242	194	154	126	104	88	72	42	0.322	0.080	1.147	0.369		1.627	0.130	
21.925	4	SB	9.2	97	700	1054	245	202	163	135	112	94	78	44	1.054	0.809	1.165	1.228		1.717	1.389	
21.930	4	SB	8.8	97	701	373	272	223	176	145	122	103	84	49	0.373	0.101	1.157	0.431		1.709	0.173	
21.935	4	SB	9.1	101	697	334	256	210	174	147	125	107	89	51	0.335	0.078	1.168	0.392		1.745	0.136	
21.940	4	SB	8.9	101	702	404	295	247	174	137	113	97	79	48	0.402	0.109	1.164	0.468	***0.436***	1.741	0.189	***0.198***
22.045	6	SB	9.0	53	697	408	281	194	151	119	94	77	62	31	0.410	0.128	1.111	0.455		1.381	0.176	
22.050	6	SB	9.1	53	699	385	306	228	162	119	93	77	60	28	0.385	0.079	1.112	0.428		1.382	0.109	
22.055	6	SB	9.1	55	701	370	257	188	141	104	84	63	47	20	0.370	0.113	1.114	0.412		1.397	0.158	
22.060	6	SB	9.2	55	700	321	220	151	107	77	59	45	35	17	0.321	0.101	1.115	0.358		1.397	0.141	
22.065	6	SB	8.9	50	698	389	268	181	117	85	61	43	30	15	0.390	0.121	1.106	0.432		1.358	0.165	
22.070	6	SB	9.0	50	702	303	193	116	63	45	34	25	18	12	0.302	0.109	1.108	0.334		1.359	0.149	
22.075	6	SB	9.0	45	699	249	159	92	43	25	13	16	15	11	0.250	0.091	1.094	0.273		1.307	0.119	
22.080	6	SB	9.1	45	699	268	169	92	51	29	22	19	18	10	0.268	0.099	1.095	0.293		1.308	0.130	
22.085	6	SB	9.1	44	701	279	170	97	59	32	24	21	18	12	0.278	0.109	1.092	0.304		1.298	0.141	
22.090	6	SB	8.6	44	703	329	218	143	87	57	38	25	19	10	0.328	0.111	1.086	0.356		1.291	0.143	
22.095	6	SB	8.9	43	702	285	212	140	87	55	37	24	16	10	0.284	0.072	1.088	0.309		1.285	0.093	
22.100	6	SB	8.6	43	701	305	189	123	80	52	39	30	24	13	0.305	0.116	1.084	0.330		1.281	0.149	
22.105	6	SB	9.0	45	697	289	198	124	80	55	38	31	25	15	0.290	0.091	1.094	0.317		1.307	0.119	
22.110	6	SB	8.9	45	703	317	172	113	73	51	40	34	26	16	0.315	0.144	1.093	0.344		1.306	0.188	
22.115	6	SB	9.1	50	701	339	244	151	96	64	47	33	26	13	0.338	0.094	1.109	0.375		1.360	0.128	
22.120	6	SB	9.0	50	698	340	230	151	89	52	39	29	22	12	0.341	0.110	1.108	0.378		1.359	0.150	
22.125	6	SB	9.0	47	698	330	211	133	81	50	38	31	24	12	0.331	0.119	1.100	0.364		1.328	0.158	
22.130	6	SB	9.1	47	704	371	257	163	100	68	48	34	25	12	0.369	0.113	1.101	0.406		1.329	0.151	
22.135	6	SB	9.2	47	702	424	291	191	123	84	57	39	27	12	0.423	0.133	1.102	0.466		1.330	0.177	
22.140	6	SB	9.1	45	701	412	276	176	109	74	52	34	24	13	0.411	0.135	1.095	0.450	***0.369***	1.308	0.177	***0.146***

Table A 6: Falling weight deflectometer, left lane between wheel path Report No. 16 FWD 513/1 (MRWA 2016b)

															Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Direction	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
21.605	2	SB	13.3	75	699	284	214	170	132	107	87	71	57	31	0.285	0.070	1.129	0.322		1.450	0.102	
21.610	2	SB	12.8	75	700	280	221	170	133	107	81	61	54	32	0.280	0.060	1.134	0.317		1.468	0.087	
21.615	2	SB	12.9	80	700	293	221	169	134	109	90	75	59	34	0.293	0.072	1.140	0.334		1.497	0.109	
21.620	2	SB	12.9	80	699	295	224	172	132	112	86	76	65	35	0.295	0.071	1.140	0.336		1.497	0.107	
21.625	2	SB	12.8	85	702	289	217	172	133	112	92	77	64	38	0.289	0.072	1.148	0.331		1.533	0.111	
21.630	2	SB	12.9	85	702	331	234	176	132	107	85	70	59	35	0.330	0.097	1.147	0.379		1.529	0.149	
21.635	2	SB	12.9	85	702	367	247	185	134	109	90	77	62	39	0.366	0.120	1.147	0.420		1.529	0.183	
21.640	2	SB	12.9	85	698	312	222	166	128	98	80	69	58	37	0.312	0.090	1.147	0.358		1.529	0.138	
21.645	2	SB	12.7	80	700	252	201	158	126	103	86	72	60	36	0.252	0.051	1.141	0.288		1.505	0.077	
21.650	2	SB	12.6	80	700	266	213	168	133	106	87	71	58	36	0.266	0.053	1.142	0.303		1.508	0.080	
21.655	2	SB	12.8	80	699	271	202	156	120	97	79	66	54	33	0.272	0.069	1.141	0.310		1.501	0.104	
21.660	2	SB	12.7	80	696	291	194	148	115	95	79	66	55	33	0.293	0.098	1.141	0.334		1.505	0.148	
21.665	2	SB	12.7	86	698	281	201	161	122	100	83	67	55	32	0.282	0.080	1.150	0.324		1.544	0.123	
21.670	2	SB	12.6	86	699	271	207	162	123	104	80	68	59	32	0.272	0.064	1.151	0.313		1.548	0.100	
21.675	2	SB	12.4	85	699	279	201	159	124	100	83	68	54	32	0.279	0.078	1.151	0.322		1.549	0.121	
21.680	2	SB	12.6	85	698	268	200	156	122	99	80	66	53	33	0.269	0.069	1.149	0.309		1.541	0.106	
21.685	2	SB	12.5	87	697	327	212	165	122	99	78	64	55	29	0.328	0.115	1.153	0.378		1.559	0.180	
21.690	2	SB	12.7	87	699	271	200	156	121	98	79	64	51	30	0.271	0.071	1.151	0.313		1.550	0.110	
21.695	2	SB	12.5	88	700	254	200	158	121	100	80	65	52	30	0.254	0.055	1.154	0.294		1.565	0.085	
21.700	2	SB	12.7	88	701	280	211	166	127	104	86	70	60	33	0.279	0.068	1.153	0.322		1.557	0.106	
21.705	2	SB	12.6	81	695	305	210	166	134	113	89	76	67	35	0.307	0.096	1.144	0.351		1.515	0.145	
21.710	2	SB	12.8	81	698	274	219	177	137	119	91	84	71	38	0.275	0.056	1.142	0.314		1.507	0.084	
21.715	2	SB	12.6	85	701	314	225	172	138	107	81	73	62	38	0.313	0.089	1.149	0.360		1.541	0.137	
21.720	2	SB	12.3	85	699	262	187	147	123	108	86	78	61	39	0.262	0.075	1.152	0.302	*0.331*	1.553	0.117	*0.117*
21.845	4	SB	12.0	65	698	331	261	214	176	146	129	110	95	59	0.332	0.070	1.128	0.375		1.428	0.100	
21.850	4	SB	11.9	70	703	293	238	202	170	152	133	116	102	62	0.292	0.055	1.134	0.331		1.465	0.080	
21.855	4	SB	12.5	80	699	330	246	208	170	147	123	106	91	56	0.330	0.083	1.143	0.377		1.512	0.126	
21.860	4	SB	12.2	80	700	318	246	196	159	137	118	102	86	55	0.318	0.072	1.145	0.364		1.523	0.110	
21.865	4	SB	12.2	86	702	319	254	206	173	142	118	106	98	56	0.318	0.065	1.154	0.367		1.564	0.102	
21.870	4	SB	12.2	86	704	330	266	219	178	148	128	109	93	57	0.328	0.064	1.154	0.379		1.564	0.100	
21.875	4	SB	12.2	65	695	294	218	176	136	119	107	88	88	51	0.296	0.076	1.127	0.333		1.423	0.108	
21.880	4	SB	12.1	65	701	278	236	197	160	147	120	103	91	53	0.277	0.042	1.127	0.313		1.426	0.059	
21.885	4	SB	12.5	75	702	314	234	190	159	135	110	99	86	53	0.313	0.079	1.136	0.355		1.479	0.117	
21.890	4	SB	12.3	75	702	278	199	164	135	117	101	89	75	48	0.277	0.078	1.137	0.315		1.486	0.116	
21.895	4	SB	12.2	78	705	220	179	150	130	114	100	91	78	53	0.218	0.041	1.142	0.249		1.510	0.061	

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
21.900	4	SB	12.4	78	697	240	203	174	150	133	117	104	88	54	0.241	0.037	1.141	0.275		1.502	0.056	
21.905	4	SB	12.2	65	705	288	232	192	159	138	120	104	88	58	0.286	0.056	1.127	0.322		1.423	0.080	
21.910	4	SB	12.7	65	696	259	242	196	165	146	123	102	87	51	0.261	0.018	1.123	0.293		1.408	0.025	
21.915	4	SB	12.3	86	703	272	210	173	142	122	102	91	76	45	0.271	0.062	1.153	0.313		1.560	0.097	
21.920	4	SB	12.5	86	700	270	214	178	151	129	113	98	82	49	0.270	0.056	1.151	0.311		1.552	0.086	
21.925	4	SB	12.4	97	703	292	224	187	152	139	112	102	86	47	0.291	0.068	1.168	0.340		1.630	0.110	
21.930	4	SB	12.2	97	705	285	223	196	166	147	126	110	98	53	0.283	0.062	1.169	0.331		1.639	0.102	
21.935	4	SB	12.1	101	705	282	223	187	159	139	122	106	89	54	0.280	0.059	1.176	0.329		1.670	0.099	
21.940	4	SB	12.2	101	700	354	268	216	177	149	127	109	90	54	0.354	0.086	1.175	0.416	***0.334***	1.665	0.144	***0.094***
22.045	6	SB	11.2	53	693	384	278	207	154	121	96	79	63	32	0.388	0.107	1.117	0.433		1.365	0.146	
22.050	6	SB	11.2	53	693	385	276	200	146	108	93	71	53	26	0.388	0.110	1.117	0.434		1.365	0.150	
22.055	6	SB	11.3	55	697	330	210	148	108	81	63	51	39	19	0.332	0.120	1.119	0.371		1.377	0.166	
22.060	6	SB	10.6	55	697	281	183	125	86	62	46	35	26	12	0.282	0.099	1.121	0.316		1.390	0.137	
22.065	6	SB	11.0	50	695	294	219	139	90	58	42	31	20	11	0.296	0.076	1.115	0.330		1.347	0.102	
22.070	6	SB	11.2	50	698	255	164	94	59	36	25	19	15	10	0.256	0.091	1.114	0.285		1.344	0.123	
22.075	6	SB	10.5	45	692	230	150	93	55	35	26	21	15	11	0.233	0.081	1.101	0.256		1.304	0.105	
22.080	6	SB	11.3	45	694	253	160	96	58	38	27	22	18	11	0.255	0.094	1.100	0.281		1.293	0.121	
22.085	6	SB	11.1	44	694	249	161	101	64	42	32	24	19	11	0.251	0.089	1.098	0.276		1.286	0.115	
22.090	6	SB	11.2	44	695	303	214	131	82	49	33	22	16	10	0.305	0.089	1.098	0.335		1.284	0.115	
22.095	6	SB	11.5	43	692	280	168	102	63	42	31	25	20	13	0.284	0.113	1.094	0.310		1.270	0.144	
22.100	6	SB	10.9	43	696	278	164	101	63	43	32	26	21	13	0.279	0.114	1.095	0.306		1.279	0.146	
22.105	6	SB	11.0	45	693	291	189	115	73	49	36	30	24	14	0.294	0.103	1.101	0.324		1.297	0.134	
22.110	6	SB	11.4	45	689	324	212	124	80	57	44	37	29	16	0.330	0.115	1.100	0.362		1.291	0.148	
22.115	6	SB	11.1	50	696	337	236	141	86	54	38	28	22	12	0.339	0.102	1.114	0.378		1.346	0.137	
22.120	6	SB	11.3	50	691	346	211	130	72	51	38	30	23	12	0.350	0.136	1.114	0.390		1.342	0.183	
22.125	6	SB	11.3	47	696	345	228	149	97	68	49	38	29	14	0.347	0.118	1.106	0.384		1.312	0.155	
22.130	6	SB	11.2	47	693	428	254	164	107	74	53	38	27	12	0.432	0.175	1.106	0.478		1.314	0.230	
22.135	6	SB	11.4	47	691	439	280	182	122	85	59	43	30	12	0.445	0.161	1.105	0.491		1.311	0.211	
22.140	6	SB	11.3	45	693	425	276	178	114	79	55	40	29	12	0.430	0.151	1.100	0.473	***0.361***	1.293	0.195	***0.148***

Table A 7: Falling weight deflectometer, right lane right wheel path Report No. 16 FWD 516/1 (MRWA 2016e)

Station (km)	Trial Section	Direction	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
21.605	2	SB	12.2	75	691	286	228	187	152	125	102	85	68	37	0.290	0.058	1.138	0.329		1.489	0.087	
21.610	2	SB	12.2	75	700	280	228	187	154	128	105	88	71	41	0.280	0.051	1.138	0.318		1.489	0.077	
21.615	2	SB	11.9	80	700	284	218	177	143	116	94	77	61	36	0.284	0.066	1.147	0.325		1.534	0.101	
21.620	2	SB	11.9	80	691	299	228	184	148	120	99	81	65	39	0.302	0.071	1.147	0.347		1.534	0.109	
21.625	2	SB	11.9	85	695	316	243	196	157	127	104	86	68	41	0.319	0.074	1.154	0.368		1.569	0.116	
21.630	2	SB	11.8	85	696	310	242	200	160	132	109	91	74	44	0.312	0.068	1.155	0.360		1.572	0.107	
21.635	2	SB	11.7	85	698	310	240	194	158	131	110	93	77	45	0.311	0.070	1.156	0.360		1.576	0.111	
21.640	2	SB	11.7	85	699	288	226	186	149	124	103	87	72	42	0.288	0.061	1.156	0.333		1.576	0.097	
21.645	2	SB	11.9	80	699	323	255	148	118	101	86	74	61	37	0.324	0.068	1.147	0.371		1.534	0.104	
21.650	2	SB	11.8	80	698	290	224	185	151	127	107	90	73	44	0.291	0.066	1.148	0.334		1.537	0.102	
21.655	2	SB	11.8	80	696	299	228	183	145	120	98	82	68	40	0.301	0.072	1.148	0.345		1.537	0.110	
21.660	2	SB	11.8	80	693	275	216	179	146	123	101	85	69	41	0.278	0.060	1.148	0.319		1.537	0.092	
21.665	2	SB	12.1	86	698	314	231	186	148	120	96	80	65	38	0.315	0.083	1.154	0.364		1.568	0.131	
21.670	2	SB	11.8	86	704	279	219	180	145	120	100	84	69	37	0.278	0.059	1.156	0.321		1.579	0.094	
21.675	2	SB	11.6	85	701	307	232	187	152	124	102	85	68	40	0.307	0.075	1.156	0.355		1.579	0.119	
21.680	2	SB	11.3	85	698	278	216	174	140	114	93	77	63	36	0.279	0.063	1.157	0.323		1.590	0.100	
21.685	2	SB	11.5	87	701	289	217	174	138	113	91	77	61	36	0.288	0.071	1.159	0.334		1.597	0.114	
21.690	2	SB	11.7	87	697	286	220	175	137	112	92	77	62	34	0.287	0.067	1.158	0.333		1.590	0.106	
21.695	2	SB	11.5	88	701	270	217	180	144	118	99	82	66	39	0.270	0.052	1.161	0.313		1.604	0.084	
21.700	2	SB	11.7	88	707	269	214	181	150	127	107	90	74	42	0.266	0.054	1.160	0.309		1.597	0.087	
21.705	2	SB	11.7	81	701	280	226	187	152	125	103	86	68	39	0.280	0.054	1.150	0.322		1.548	0.084	
21.710	2	SB	12.0	81	701	294	233	189	151	126	104	87	71	44	0.294	0.061	1.148	0.337		1.537	0.094	
21.715	2	SB	11.4	85	700	279	220	181	150	127	108	93	77	47	0.279	0.059	1.157	0.323		1.586	0.094	
21.720	2	SB	11.2	85	701	284	222	180	146	123	102	89	75	47	0.284	0.062	1.158	0.329	*0.336*	1.593	0.099	*0.101*
21.845	4	SB	10.6	65	700	428	335	281	231	195	166	145	122	75	0.428	0.093	1.138	0.487		1.502	0.139	
21.850	4	SB	10.4	70	701	429	338	278	226	191	161	139	115	70	0.429	0.091	1.151	0.494		1.567	0.143	
21.855	4	SB	10.8	80	702	416	318	256	209	175	148	128	108	68	0.415	0.098	1.151	0.478		1.567	0.154	
21.860	4	SB	10.8	80	701	394	314	260	215	183	156	136	113	70	0.394	0.080	1.160	0.457		1.624	0.131	
21.865	4	SB	10.3	86	704	413	335	277	228	193	164	142	118	71	0.410	0.077	1.160	0.476		1.609	0.124	
21.870	4	SB	10.9	86	699	376	292	243	200	168	144	125	105	66	0.377	0.084	1.132	0.427		1.464	0.123	
21.875	4	SB	10.5	65	696	358	289	241	200	169	143	124	104	63	0.360	0.070	1.132	0.408		1.462	0.102	
21.880	4	SB	10.6	65	702	365	282	232	190	160	135	117	100	61	0.364	0.083	1.144	0.417		1.530	0.127	
21.885	4	SB	10.8	75	700	343	265	214	177	147	126	111	93	60	0.343	0.078	1.144	0.392		1.536	0.120	
21.890	4	SB	10.5	75	699	359	265	220	180	151	129	112	94	57	0.360	0.094	1.148	0.413		1.564	0.148	
21.895	4	SB	10.2	78	701	342	276	237	201	177	153	133	111	66	0.341	0.066	1.148	0.392		1.561	0.102	

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction: Deflection (mm)	Normalised to 700 kPa No Temp Correction: Curvature (mm)	Normalised to 700 kPa Austroads 2008 Correction to 29°C: Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
21.900	4	SB	10.4	78	705	371	302	251	209	179	151	131	110	65	0.369	0.069	1.129	0.416		1.472	0.102	
21.905	4	SB	9.6	65	697	336	283	240	202	177	150	129	108	64	0.338	0.054	1.132	0.382		1.467	0.079	
21.910	4	SB	10.3	65	699	343	281	238	200	173	149	128	105	63	0.343	0.062	1.160	0.398		1.620	0.100	
21.915	4	SB	10.5	86	700	377	310	253	208	176	150	129	106	65	0.377	0.067	1.160	0.437		1.624	0.108	
21.920	4	SB	10.3	86	702	378	300	258	216	186	159	140	116	69	0.377	0.077	1.176	0.443		1.705	0.131	
21.925	4	SB	10.4	97	697	420	322	262	216	184	159	138	115	69	0.422	0.098	1.176	0.496		1.700	0.167	
21.930	4	SB	10.6	97	701	362	290	249	217	187	156	134	115	68	0.362	0.072	1.181	0.427		1.735	0.124	
21.935	4	SB	10.4	101	700	401	310	252	212	174	153	135	106	63	0.401	0.090	1.181	0.474		1.735	0.157	
21.940	4	SB	10.4	101	702	384	308	252	206	171	145	124	103	62	0.383	0.075	1.182	0.452	***0.438***	1.726	0.130	***0.126***
22.045	6	SB	10.1	53	701	314	224	149	105	75	59	49	38	22	0.314	0.091	1.118	0.351		1.381	0.125	
22.050	6	SB	10.3	53	702	349	226	157	111	81	61	49	37	19	0.348	0.123	1.119	0.390		1.379	0.170	
22.055	6	SB	9.9	55	704	313	232	158	109	76	55	41	30	15	0.311	0.081	1.120	0.348		1.397	0.113	
22.060	6	SB	9.8	55	704	330	239	164	110	77	55	39	29	13	0.329	0.091	1.119	0.368		1.398	0.127	
22.065	6	SB	10.1	50	699	353	239	162	109	74	52	36	26	12	0.353	0.114	1.115	0.394		1.359	0.155	
22.070	6	SB	9.8	50	703	335	223	151	103	72	51	37	26	13	0.333	0.111	1.114	0.371		1.361	0.152	
22.075	6	SB	10.2	45	702	317	215	143	96	67	47	34	24	12	0.316	0.102	1.101	0.348		1.307	0.133	
22.080	6	SB	10.1	45	701	354	232	159	106	79	56	40	29	16	0.354	0.122	1.101	0.389		1.307	0.160	
22.085	6	SB	10.1	44	701	327	242	161	105	70	49	35	25	13	0.327	0.086	1.098	0.359		1.297	0.111	
22.090	6	SB	9.4	44	685	340	226	154	100	68	48	42	25	14	0.348	0.116	1.095	0.381		1.299	0.151	
22.095	6	SB	10.1	43	702	344	230	152	103	72	51	36	25	12	0.343	0.113	1.095	0.375		1.287	0.146	
22.100	6	SB	10.0	43	702	338	236	160	107	75	54	38	27	13	0.337	0.101	1.095	0.369		1.287	0.130	
22.105	6	SB	9.1	45	700	347	243	162	109	74	54	39	28	13	0.347	0.105	1.095	0.380		1.308	0.137	
22.110	6	SB	10.3	45	702	359	239	159	109	77	54	39	28	12	0.358	0.119	1.101	0.394		1.306	0.156	
22.115	6	SB	10.0	50	700	357	238	163	111	76	54	39	28	13	0.357	0.118	1.115	0.397		1.360	0.161	
22.120	6	SB	10.1	50	702	330	226	154	102	72	53	37	26	12	0.329	0.104	1.115	0.366		1.359	0.141	
22.125	6	SB	9.9	47	695	347	229	152	101	73	53	39	28	13	0.349	0.118	1.106	0.386		1.329	0.157	
22.130	6	SB	10.2	47	701	384	263	167	110	76	54	39	27	13	0.383	0.120	1.107	0.424		1.327	0.160	
22.135	6	SB	10.2	45	698	380	253	170	113	77	54	39	27	12	0.381	0.127	1.101	0.420		1.307	0.166	
22.140	6	SB	10.0	45	701	330	258	188	132	93	64	45	32	15	0.329	0.071	1.101	0.362	***0.379***	1.308	0.093	***0.142***

Table A 8: Falling weight deflectometer, right lane between wheel paths Report No. 16 FWD 515/1 (MRWA 2016d)

															Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Direction	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
21.605	2	SB	11.5	75	702	294	228	186	146	119	97	80	64	36	0.293	0.067	1.142	0.335		1.511	0.101	
21.610	2	SB	11.4	75	700	288	223	182	146	120	98	81	65	37	0.288	0.065	1.142	0.329		1.514	0.099	
21.615	2	SB	11.2	80	698	281	219	177	142	114	93	76	61	36	0.282	0.062	1.150	0.324		1.556	0.097	
21.620	2	SB	11.1	80	706	312	235	188	149	121	97	81	65	39	0.309	0.076	1.151	0.355		1.559	0.118	
21.625	2	SB	11.2	85	702	320	244	194	153	122	98	80	64	38	0.319	0.076	1.158	0.370		1.593	0.120	
21.630	2	SB	10.9	85	701	329	244	199	158	131	109	87	74	42	0.329	0.085	1.159	0.381		1.602	0.136	
21.635	2	SB	11.0	85	703	332	234	189	151	125	103	86	70	42	0.331	0.098	1.158	0.383		1.599	0.157	
21.640	2	SB	10.9	85	699	308	235	190	156	125	103	85	71	41	0.309	0.074	1.159	0.358		1.602	0.118	
21.645	2	SB	11.1	80	704	321	238	190	147	120	96	74	60	36	0.319	0.083	1.151	0.368		1.559	0.130	
21.650	2	SB	11.4	80	696	272	214	175	139	114	97	81	67	40	0.273	0.058	1.150	0.314		1.550	0.090	
21.655	2	SB	11.3	80	702	299	225	180	144	115	95	80	65	39	0.298	0.073	1.150	0.343		1.553	0.114	
21.660	2	SB	11.0	80	698	294	231	186	148	120	98	81	66	39	0.295	0.063	1.151	0.339		1.562	0.098	
21.665	2	SB	11.3	86	699	302	234	185	148	119	96	79	63	37	0.303	0.069	1.159	0.351		1.597	0.110	
21.670	2	SB	11.1	86	701	287	223	180	144	118	97	80	66	36	0.287	0.065	1.160	0.333		1.603	0.103	
21.675	2	SB	10.7	85	698	304	222	179	140	119	96	78	63	36	0.304	0.082	1.159	0.353		1.607	0.131	
21.680	2	SB	10.6	85	698	301	224	179	141	115	91	74	60	34	0.301	0.077	1.159	0.349		1.610	0.124	
21.685	2	SB	10.8	87	702	300	233	184	145	115	92	75	59	34	0.300	0.067	1.162	0.348		1.619	0.109	
21.690	2	SB	10.8	87	699	290	219	175	141	115	93	75	57	32	0.290	0.071	1.162	0.337		1.619	0.114	
21.695	2	SB	10.7	88	700	285	213	173	139	113	93	76	62	35	0.285	0.072	1.163	0.331		1.630	0.117	
21.700	2	SB	11.2	88	698	276	213	175	142	121	100	84	69	39	0.276	0.063	1.162	0.321		1.615	0.102	
21.705	2	SB	10.6	81	700	305	238	180	148	127	98	87	75	39	0.305	0.068	1.153	0.352		1.579	0.107	
21.710	2	SB	10.7	81	701	281	213	177	143	119	100	83	66	41	0.280	0.068	1.153	0.323		1.577	0.107	
21.715	2	SB	10.6	85	697	308	221	183	147	124	105	89	75	45	0.309	0.087	1.159	0.358		1.610	0.140	
21.720	2	SB	10.7	85	702	287	216	174	141	117	96	82	69	42	0.286	0.071	1.159	0.332	*0.345*	1.607	0.115	*0.115*
21.845	4	SB	10.6	70	702	365	310	262	221	187	161	140	118	72	0.364	0.055	1.138	0.414		1.498	0.083	
21.850	4	SB	11.6	80	700	383	302	257	214	185	158	138	115	69	0.383	0.081	1.149	0.440		1.544	0.125	
21.855	4	SB	11.2	80	694	432	307	243	193	160	138	121	102	66	0.435	0.125	1.150	0.501		1.556	0.195	
21.860	4	SB	10.8	86	697	370	301	252	206	177	151	133	113	70	0.371	0.069	1.160	0.431		1.612	0.112	
21.865	4	SB	11.1	86	698	410	323	263	211	176	148	129	109	69	0.411	0.087	1.160	0.477		1.603	0.140	
21.870	4	SB	11.1	65	699	371	284	236	196	167	142	124	105	66	0.371	0.087	1.132	0.420		1.452	0.126	
21.875	4	SB	11.2	65	693	354	275	228	189	160	137	119	99	61	0.358	0.080	1.131	0.405		1.449	0.116	
21.880	4	SB	11.5	75	691	335	266	219	187	156	133	117	97	61	0.339	0.069	1.142	0.387		1.511	0.105	
21.885	4	SB	11.2	75	699	360	268	216	175	148	128	112	94	59	0.361	0.093	1.143	0.413		1.520	0.141	
21.890	4	SB	11.1	78	695	275	224	185	156	134	115	100	83	52	0.277	0.052	1.148	0.318		1.545	0.081	
21.895	4	SB	11.0	78	696	304	255	221	190	164	144	127	108	66	0.305	0.049	1.148	0.350		1.547	0.075	

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction Deflection (mm)	Normalised to 700 kPa No Temp Correction Curvature (mm)	Normalised to 700 kPa Austroads 2008 Correction to 29°C Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
21.900	4	SB	10.9	65	698	381	303	252	205	176	148	129	109	64	0.382	0.078	1.132	0.433		1.456	0.114	
21.905	4	SB	10.9	65	701	335	285	240	200	171	146	127	108	67	0.334	0.050	1.132	0.378		1.456	0.073	
21.910	4	SB	11.3	86	699	322	254	222	190	162	141	125	103	63	0.322	0.068	1.159	0.374		1.597	0.109	
21.915	4	SB	10.9	86	705	374	303	252	206	174	148	127	104	63	0.371	0.070	1.160	0.430		1.609	0.113	
21.920	4	SB	10.7	97	699	402	307	252	212	183	156	136	115	70	0.403	0.096	1.176	0.474		1.697	0.162	
21.925	4	SB	10.7	97	702	405	320	264	220	188	163	144	119	71	0.404	0.084	1.176	0.475		1.697	0.143	
21.930	4	SB	10.7	101	699	325	275	238	205	183	157	138	119	68	0.326	0.050	1.182	0.385		1.726	0.087	
21.935	4	SB	11.0	101	699	392	310	255	208	175	147	127	107	63	0.393	0.082	1.181	0.464		1.716	0.141	
21.940	4	SB	10.9	101	696	360	309	258	213	179	149	126	102	60	0.362	0.051	1.182	0.427	*0.420*	1.719	0.088	*0.116*
22.045	6	SB	10.5	53	700	317	225	164	119	95	77	64	50	24	0.317	0.092	1.119	0.354		1.377	0.126	
22.050	6	SB	10.6	53	701	217	150	101	70	52	41	32	25	12	0.217	0.067	1.119	0.243		1.375	0.093	
22.055	6	SB	10.1	55	709	183	122	81	56	41	31	23	20	10	0.181	0.061	1.120	0.203		1.396	0.084	
22.060	6	SB	10.6	55	698	288	185	125	84	60	43	33	25	11	0.289	0.103	1.121	0.324		1.390	0.144	
22.065	6	SB	10.8	50	696	307	198	137	97	69	50	38	26	12	0.309	0.110	1.115	0.344		1.351	0.148	
22.070	6	SB	11.0	50	700	294	203	139	95	66	49	38	27	12	0.294	0.091	1.115	0.327		1.347	0.122	
22.075	6	SB	10.5	45	703	289	196	129	88	61	44	33	24	12	0.287	0.093	1.101	0.316		1.304	0.121	
22.080	6	SB	11.3	45	700	298	200	133	92	64	47	35	25	13	0.298	0.098	1.100	0.327		1.293	0.126	
22.085	6	SB	10.8	44	706	288	189	127	84	58	41	31	22	12	0.285	0.098	1.098	0.313		1.290	0.126	
22.090	6	SB	10.5	44	702	299	204	136	94	66	47	35	24	11	0.299	0.095	1.098	0.328		1.293	0.123	
22.095	6	SB	10.0	43	697	289	195	132	90	67	49	36	26	12	0.290	0.094	1.095	0.317		1.287	0.121	
22.100	6	SB	10.6	43	698	296	196	123	81	78	42	53	34	16	0.297	0.100	1.096	0.325		1.282	0.128	
22.105	6	SB	10.1	45	698	346	204	140	95	67	49	36	27	13	0.347	0.143	1.101	0.382		1.307	0.187	
22.110	6	SB	10.6	45	701	333	219	144	98	66	50	34	24	13	0.333	0.114	1.101	0.366		1.303	0.149	
22.115	6	SB	10.0	50	705	332	231	158	110	79	58	43	31	13	0.329	0.100	1.115	0.367		1.360	0.137	
22.120	6	SB	10.5	50	697	328	216	142	98	70	52	38	28	13	0.329	0.112	1.115	0.367		1.355	0.151	
22.125	6	SB	10.1	47	693	341	235	158	106	76	55	41	30	13	0.345	0.108	1.106	0.381		1.328	0.143	
22.130	6	SB	10.0	47	702	347	265	172	114	81	58	42	31	13	0.346	0.082	1.106	0.383		1.329	0.109	
22.140	6	SB	9.9	45	702	285	174	138	106	81	59	39	25	15	0.285	0.111	1.100	0.313	*0.331*	1.309	0.145	*0.131*

A.1.2 Photographs

Figure A 1: Surface of BSL base layer at T2

Figure A 2: T2 granular profile and subgrade surface

Figure A 3: Surface of BSL base layer at T4

Figure A 4: T4 granular profile and subgrade surface

Figure A 5: Surface of CRB base layer at T6

Figure A 6: T6 granular profile and subgrade surface

A.1.3 Test Certificates

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LAYER THICKNESS REPORT

Sampling Method: WA 701.1 Sheet 1 of 3

Report No. 16 S6314/1 Ref. No. Not Applicable Field No. Not Applicable

Date of Test 3/10/2016 Project/Contract/Job No. Tonkin Hwy Trials WARRIP

Date Sampled (Moisture Content) Not Applicable Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Gosnells

Road Tonkin Highway

Section Tonkin Highway Southbound Section 2 SLK 21.600-21.720

Present/Proposed Use Pavement

Test Methods WA 705.1

Core No	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
70	21.605	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 35	25
				Dense Grade Asphalt	35 - 75	40
				Bitumen Stabilised Limestone		
71	21.615	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 40	30
				Dense Grade Asphalt	40 - 80	40
				Bitumen Stabilised Limestone		
72	21.625	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 45	35
				Dense Grade Asphalt	45 - 85	40
				Bitumen Stabilised Limestone		
	21.635	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 45	35
				Dense Grade Asphalt	45 - 85	40
				Bitumen Stabilised Limestone		

Comments/Distribution
Trim 16/5005
Reports
H Asadi

Approved Signatory

Name Jared Symcox
Function Technical Officer Materials
Date 7/10/2016

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LAYER THICKNESS REPORT

Sampling Method: WA 701.1 Sheet 2 of 3

Report No. 16 S6314/1 Ref. No. Not Applicable Field No. Not Applicable

Date of Test 3/10/2016 Project/Contract/Job No. Tonkin Hwy Trials WARRIP

Date Sampled (Moisture Content) Not Applicable Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Gosnells

Road Tonkin Highway

Section Tonkin Highway Southbound Section 2 SLK 21.600-21.720

Present/Proposed Use Pavement

Test Methods WA 705.1

Core No.	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
74	21.635	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 49	39
				Dense Grade Asphalt	49 - 80	31
				Bitumen Stabilised Asphalt		
75	21.655	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 50	40
				Dense Grade Asphalt	50 - 80	30
				Bitumen Stabilised Asphalt		
76	21.665	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 51	41
				Dense Grade Asphalt	51 - 86	35
				Bitumen Stabilised Asphalt		
77	21.675	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 53	43
				Dense Grade Asphalt	53 - 85	32
				Bitumen Stabilised Asphalt		

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LAYER THICKNESS REPORT

Sampling Method: WA 701.1 Sheet 3 of 3

Report No. 16 S6314/1 Ref. No. Not Applicable Field No. Not Applicable

Date of Test 3/10/2016 Project/Contract/Job No. Tonkin Hwy Trials WARRIP

Date Sampled (Moisture Content) Not Applicable Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Gosnells

Road Tonkin Highway

Section Tonkin Highway Southbound Section 2 SLK 21.600-21.720

Present/Proposed Use Pavement

Test Methods WA 705.1

Core No	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
78	21.685	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 55	45
				Dense Grade Asphalt	55 - 87	32
				Bitumen Stabilised Limestone		
79	21.695	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 53	43
				Dense Grade Asphalt	53 - 88	35
				Bitumen Stabilised Limestone		
80	21.705	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 50	40
				Dense Grade Asphalt	50 - 81	31
				Bitumen Stabilised Limestone		
81	21.715	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 55	45
				Dense Grade Asphalt	55 - 85	30
				Bitumen Stabilised Limestone		

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LAYER THICKNESS REPORT

Sampling Method: WA 701.1 Sheet 1 / 3

Report No. 16 S6316 / 1 Ref. No. Not Applicable Field No. Not Applicable

Date of Test 3/10/2016 Project/Contract/Job No. Tonkin Hwy Trials WARRIP

Date Sampled (Moisture Content) Not Applicable Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Gosnells

Road Tonkin Highway

Section Tonkin Highway Southbound Section 4. SLK 21.840 - 21.940

Present/Proposed Use Pavement

Test Methods WA 705.1

Core No	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
82	21.845	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 55	45
				Dense Grade Asphalt	55 - 70	15
				Bitumen Stabilised Limestone		
83	21.855	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 70	60
				Dense Grade Asphalt	70 - 80	10
				Bitumen Stabilised Limestone		
84	21.865	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 55	45
				Dense Grade Asphalt	55 - 86	31
				Bitumen Stabilised Limestone		
85	21.875	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 50	40
				Dense Grade Asphalt	50 - 65	15
				Bitumen Stabilised Limestone		

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LAYER THICKNESS REPORT

Sampling Method: WA 701.1 Sheet 2 / 3

Report No. 16 S6316 / 1 Ref. No. Not Applicable Field No. Not Applicable

Date of Test 3/10/2016 Project/Contract/Job No. Tonkin Hwy Trials WARRIP

Date Sampled (Moisture Content) Not Applicable Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Gosnells

Road Tonkin Highway

Section Tonkin Highway Southbound Section 4. SLK 21.840 - 21.940

Present/Proposed Use Pavement

Test Methods WA 705.1

Core No.	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
86	21.885	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 55	45
				Dense Grade Asphalt	55 - 75	20
				Bitumen Stabilised Limestone		
87	21.895	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 55	45
				Dense Grade Asphalt	55 - 78	23
				Bitumen Stabilised Limestone		
88	21.905	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 65	55
				Dense Grade Asphalt	Unobtainable	
				Bitumen Stabilised Limestone		
89	21.915	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 56	46
				Dense Grade Asphalt	56 - 86	30
				Bitumen Stabilised Limestone		

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LAYER THICKNESS REPORT

Sampling Method: WA 701.1 Sheet 3 / 3

Report No. 16 S6316 / 1 Ref. No. Not Applicable Field No. Not Applicable

Date of Test 3/10/2016 Project/Contract/Job No. Tonkin Hwy Trials WARRIP

Date Sampled (Moisture Content) Not Applicable Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Gosnells

Road Tonkin Highway

Section Tonkin Highway Southbound Section 4, SLK 21.840 - 21.940

Present/Proposed Use Pavement

Test Methods WA 705.1

Core No.	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
90	21.925	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 62	52
				Dense Grade Asphalt	62 - 97	35
				Bitumen Stabilised Limestone		
91	21.935	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 46	36
				Dense Grade Asphalt	46 - 101	55
				Bitumen Stabilised Limestone		

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LAYER THICKNESS REPORT

Sampling Method: WA 701.1 — Sheet 1 / 2

Report No. 16 S6318 / 1 — Ref. No. Not Applicable — Field No. Not Applicable

Date of Test 3/10/2016 — Project/Contract/Job No. Tonkin Hwy Trials WARRIP

Date Sampled (Moisture Content) Not Applicable — Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Gosnells

Road Tonkin Highway

Section Tonkin Highway Southbound Section 6. SLK 22.040 - 22.140

Present/Proposed Use Pavement

Test Methods WA 705.1

Core No	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
92	22.045	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 53	43
				Limestone		
93	22.055	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 55	45
				Crushed Road Base		
94	22.065	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 50	40
				Crushed Road Base		
95	22.075	BWP	R2	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 45	35
				Crushed Road Base		
96	22.085	BWP	R1	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 44	34
				Crushed Road Base		

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Approved Signatory
Name Jared Symcox
Function Technical Officer Materials
Date 7/10/2016

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LAYER THICKNESS REPORT

Sampling Method: WA 701.1 Sheet 2 / 2

Report No. 16 S6318 / 1 Ref. No. Not Applicable Field No. Not Applicable

Date of Test 3/10/2016 Project/Contract/Job No. Tonkin Hwy Trials WARRIP

Date Sampled (Moisture Content) Not Applicable Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Gosnells

Road Tonkin Highway

Section Tonkin Highway Southbound Section 6. SLK 22.040 - 22.140

Present/Proposed Use Pavement

Test Methods WA 705.1

Core No.	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
97	22.095	BWP	R1	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 43	33
				Crushed Road Base		
98	22.105	BWP	R1	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 45	35
				Crushed Road Base		
99	22.115	BWP	R1	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 50	40
				Crushed Road Base		
100	22.125	BWP	R1	Seal	0 - 10	10
				Dense Grade Asphalt	10 - 47	37
				Crushed Road Base		

Comments/Distribution
Trim 16/5005
Reports
H Asadi

Approved Signatory
Name Jared Symcox
Function Technical Officer Materials
Date 7/10/2016

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MOISTURE CONTENT TEST REPORT

Sheet 1 of 3

Report No. 16M467-475 / 2 Reference No. Not Applicable Field No. Not Applicable
Date/s of Test 5/10/2016 Project No. Not Applicable
Date Sampled 12/09/2016 Date Received 12/09/2016
Local Govt Authority
Road Tonkin Highway
Location Tonkin Highway Trail Investigation SLK 21.520-22.900(PRP16040-WARRIP 1611)
Present Use Existing Highway
Test Methods: WA 110.1 Soil and Granular Pavement Material Moisture Content: Convection Oven Method
Sampling Method: WA 100.1 Sampling Procedures for Soil and Manufactured Granular Materials

Sample Numbers	Longitudinal Chainage (m)	Transverse (m)	Material Type	Moisture Content (%)	Depth (mm)			
467	21.621		Subbase Limestone	5.3	from	150	to	400
468	21.621		Subgrade Sand	1.4	from	405+	to	
469	21.868		Subbase Limestone	3.5	from	150	to	400
470	21.868		Subgrade Sand	0.9	from	400+	to	
471	22.069		Basecourse CRB	2.1	from	70	to	135
472	22.069		Subbase Limestone	3.8	from	135	to	365
473	22.069		Subgrade Sand	1.2	from	365	to	700
474	21.621		Basecourse BSL	5.2	from	90	to	155
475	21.868		Basecourse BSL	1.6	from	90	to	150

Comments/Distribution:
TRIM File No. 16/5005
Reports
Zia Rice (PE) Australian Road Research Board

Approved Signatory
Name P. Brittan
Function Project Officer
Date 18/04/2017

Document:71/05/110.1 Issue:17/09/2015 TRIM:D14#628363

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SOIL CLASSIFICATION TEST REPORT

Sheet 2 of 3

Report No.	16M467-475/1	Field No. Not Applicable	Project No. Not Applicable
Date Sampled	12/09/2016	Date/s Tested	6/10/2016
Local Govt Authority	City Of Gosnells		
Road	Tonkin Highway		
Location	Tonkin Highway Trail Investigation SLK 21.520-22.900(PRP16040-WARRIP 1611)		

Sample No.	16M467	16M468	16M469	16M470
Reference No.				
Depth, (mm)	150-400	405+	150-400	400+
Sample Location	Section 2 SLK 21.621	Section 2 SLK 21.621	Section 4 SLK 21.868	Section 4 SLK 21.868
Field Description	Limestone	Sand	Limestone	Sand
Present Use	Subbase	Subgrade	Subbase	Subgrade
PSD WA 115.1	**Sampling Method:** WA 100.1			
Percent Retained on Sieve Size 37.50 mm	1	0	2	0
Sieve Size (mm)	**% Passing**	**% Passing**	**% Passing**	**% Passing**
125.00	100	100	100	100
106.00	100	100	100	100
75.00	100	100	100	100
53.00	100	100	100	100
37.50	99	100	98	100
26.50	96	100	92	100
19.00	89	100	89	100
13.20	82	100	84	99
9.50	78	100	80	99
6.70	71	100	75	99
4.75	67	99	72	99
2.36	60	99	66	98
1.18	57	99	61	98
0.600	50	89	55	82
0.425	42	64	46	52
0.300	32	31	31	22
0.150	17	4	16	3
0.075	12	1	12	1
0.0135	7	1	9	1
LL WA 120.2 (%)	Not Obtainable	Not Obtainable	Not Obtainable	Not Obtainable
PL WA 121.1 (%)	Non Plastic	Non Plastic	Non Plastic	Non Plastic
PI WA 122.1 (%)	Non Plastic	Non Plastic	Non Plastic	Non Plastic
LS WA 123.1 (%)	0.0 at MC 18.4%	0.4 at MC 25.5%	0.4 at MC 17.8%	0.0 at MC 22.5%
GROUP SYMBOL (AS 1726 App A Sect A2)	SM	SP	SM	SP

Comments / Distribution *MC - moisture content

TRIM File No. 16/505

Reports

Zia Rice (PE) Australian Road Research Board

Approved Signatory

Name P.Brittan

Function Project Officer

Date 18/04/2017

Document:71/05/115.1 Issue:17/09/2015 D14#628373

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SOIL CLASSIFICATION TEST REPORT

Sheet 3 of 3

Report No.	16M467-475 / 2	Field No.	Not Applicable	Project No.	Not Applicable
Date Sampled	12/09/2016	Date/s Tested		6/10/2016	
Local Govt Authority	City Of Gosnells				
Road	Tonkin Highway				
Location	Tonkin Highway Trail Investigation SLK 21.520-22.900(PRP16040-WARRIP 1611)				

Sample No.	16M471	16M472	16M473	
Reference No.				
Depth, (mm)	70-135	135-365	365-700	
Sample Location	Section 6 SLK 22.069	Section 6 SLK 22.069	Section 6 SLK 22.069	
Field Description	CRB	Limestone	Sand	
Present Use	Basecourse	Subbase	Subgrade	
PSD WA 115.1	**Sampling Method:** WA 100.1			
Percent Retained on Sieve Size 37.50 mm	0	7	0	
Sieve Size (mm)	**% Passing**	**% Passing**	**% Passing**	
125.00	100	100	100	-
106.00	100	100	100	-
75.00	100	100	100	-
53.00	100	95	100	-
37.50	100	93	100	-
26.50	100	90	100	-
19.00	100	85	100	-
13.20	89	79	100	-
9.50	75	75	100	-
6.70	62	71	100	-
4.75	53	67	100	-
2.36	40	61	99	-
1.18	29	57	99	-
0.600	22	50	86	-
0.425	19	41	55	-
0.300	16	29	22	-
0.150	11	14	2	-
0.075	8	11	0	-
0.0135	6	8	0	-
LL WA 120.2 (%)	20.0	Not Obtainable	Not Obtainable	-
PL WA 121.1 (%)	Non Plastic	Non Plastic	Non Plastic	-
PI WA 122.1 (%)	Non Plastic	Non Plastic	Non Plastic	-
LS WA 123.1 (%)	0.4	0.0 at MC 19.2%	0.0 at MC 21.7%	-
GROUP SYMBOL (AS 1726 App A Sect A2)	GW-GM	SP-SM	SP	

Comments / Distribution *MC - moisture content
TRIM File No.16/5005
Reports
Zia Rice (PE) Australian Road Research Board

Approved Signatory
Name P.Brittan
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CALIFORNIA BEARING RATIO OF REMOULDED SPECIMENS TEST REPORT

WA 141.1 Sampling Method: WA 100.1 Sheet 1 of 3

Report No.	16M467-475 / 1	Reference No.	Not Applicable	Field No.	Not Applicable
Date Sampled	12/09/2016	Date Received	12/09/2016	Date/s of Test	24/02/2017

Local Govt Authority

Road: Tonkin Highway Trial Investigation SLK 21.520 - 22.900 (PRP16040-WARRIP 1611)

Location: Section 2 SLK 21.621 / Section 6 SLK 22.069

Present Use: Subgrade

Project No. — Depth: See Notes mm

Field Description: Sand Subgrade

Sample No.		16M468	16M473
Condition		Unsoaked	Unsoaked
% Retained 19 mm Sieve WA 115.1	%	Visually all passing	Visually all passing
Material Retained 19 mm Sieve (Excluded/Replaced)		Excluded	Excluded
Maximum Dry Density	t/m³	1.71	1.73
Optimum Moisture Content	%	14.5	14.5
Test Conditions of Specimen			
Surcharging of Specimen	kg	13.50	13.50
Compactive Effort Used in Moulding Specimen			
Blows, layers, kg hammer		11 / 5 / 2.7	15 / 5 / 2.7
Test Results			
Dry Density			
Specimen at Compaction	t/m³	1.62	1.64
Dry Density Ratio			
Specimen at Compaction	%	95.0	94.5
Moisture Content			
Specimen at Compaction	%	11.0	11.2
Top 30 mm Layer of Specimen After Penetration	%	8.8	8.5
Remainder of Specimen After Penetration	%	10.8	10.0
Moisture Ratio			
Specimen at Compaction	%	77.0	76.5
Top 30 mm Layer of Specimen After Penetration	%	61.5	58.0
Remainder of Specimen After Penetration	%	75.5	68.5
California Bearing Ratio	%	**20**	**20**
Penetration	mm	**5.0**	**5.0**

Comments / Distribution
TRIM File No. 16/5005
Zia Rice (PE) Austrailian Road Reasearch Board
16M468 405mm+
16M473 335-700mm

Approved Signatory
Name P.Brittan
Function Project Officer
Date 18/04/2017

Document:71/05/141.1 Issue:27/08/2015 TRIM:D14#628396

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Dry Density/Moisture Content Relationship Test Report

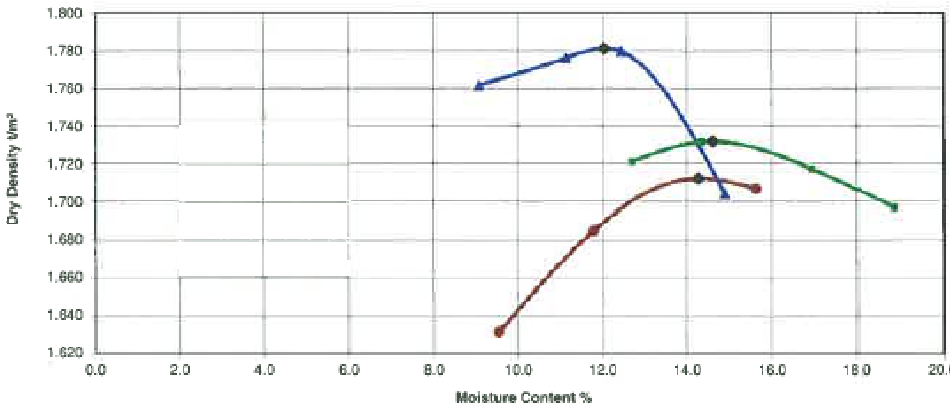
Sampling Method: WA 100.1 Sheet 2 of 3

Report No.	16M467-475 / 1	Reference No.	Not Applicable	Field No.	Not Applicable
Date Sampled	12/09/2016	Date Received	12/09/2016	Date/s of Test	29/11/2016
Present Use	Existing Higway			Project No.	
Local Govt Authority	City of Gosnells				
Road	Tonkin Highway				
Section	Tonkin Highway Trial Investigation SLK 21.520 - 22.900 (PRP16040-WARRIP 1611)				

Sample No.	Location	Depth (mm)	Curing Period (Days) Water	Curing Period (Hrs) Stabiliser	Stabiliser Added %
16M468	16M468 Section 2 SLK 21.621	405+	Field	-	-
16M473	Section 6 SLK 22.069	365-700	Field	-	-
16M474/475	Section 2 SLK 21.621/Section 4 SLK 21.868	90-155	1.00	-	-

Moisture Content ☑ WA 110.1 ☐ WA 110.2 Stabiliser Used: Not Applicable

Field Description: Subgrade Sand&Basecourse BSL



Sample Number		16M468	16M473	16M474/475
Test Method		WA 133.1	WA 133.1	WA 133.1
Maximum Dry Density t/m³		1.712	1.732	1.781
Optimum Moisture Content %		14.3	14.6	12.0
Percentage Retained %	37.5 mm	0	0	0
Percentage Retained %	19.0 mm	0	0	1

Comments / Distribution
TRIM File No. 16/5005
Zia Rice (PE) Australian Road Research Board

Approved Signatory

Name: P.Brittan
Function: Project Officer
Date: 18/04/2017

Document:71/05/132.1 Issue:16/09/2015 TRIM:D14#628388

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Dry Density/Moisture Content Relationship Test Report

Sampling Method: WA 100.1 Sheet 3 of 3

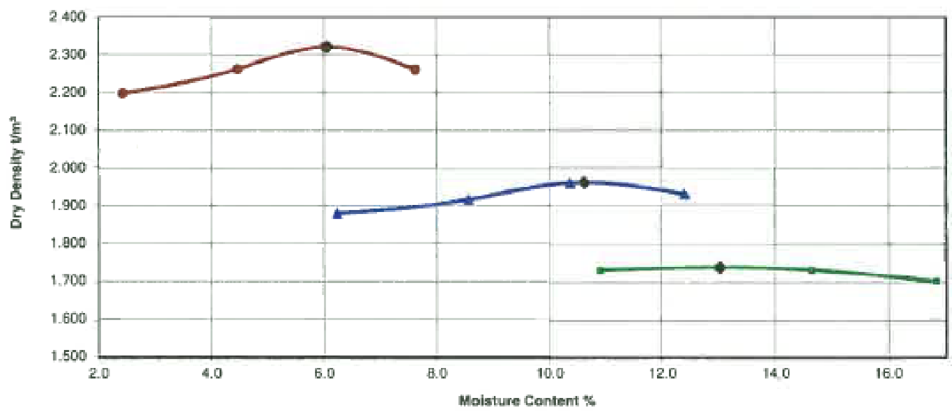
Report No.	16M467-475	Reference No.	Not Applicable	Field No.	Not Applicable
Date Sampled	12/09/2016	Date Received	12/09/2016	Date/s of Test	29/11/2016
Present Use	Existing Road			Project No.	
Local Govt Authority	City of Gosnells				
Road	Tonkin Highway				
Section	Section 6 SLK 21.520-22.900				

Sample No.	Location	Depth (mm)	Curing Period (Days) Water	Curing Period (Hrs) Stabiliser	Stabiliser Added %
16M471	Section 6 SLK 22.069	70-135	Field	-	-
16M470	Section 4 SLK 21.868	400+	Field	-	-
16M467/472	Section 2 SLK 21.621/Section 6 SLK 22.069	135-400	Field	-	-

Moisture Content ☑ WA 110.1 ☐ WA 110.2 Stabiliser Used: Not Applicable

Field Description: 16M471 Basecourse CRB, 16M470 Subgrade Sand, 16M467 / 472 Subbase Limestone

DD / MC Relationship



Sample Number		16M471 ●	16M470 ■	16M467/472 ▲
Test Method		WA 133.1	WA 133.1	WA 133.1
Maximum Dry Density t/m³		2.320	1.739	1.960
Optimum Moisture Content %		6.1	13.0	10.6
Percentage Retained %	37.5 mm	0	0% visually all passing	3
Percentage Retained %	19.0 mm	0	0% visually all passing	12

Comments / Distribution
TRIM File No. 16/5005
Zia Rice (PE) Austrailian Road Reasearch Board

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CALIFORNIA BEARING RATIO OF REMOULDED SPECIMENS TEST REPORT

WA 141.1 Sampling Method: WA 100.1 Sheet 1 of 1

Report No.	17M050-051 / 1	Reference No.	Not Applicable	Field No.	Not Applicable
Date Sampled	12/09/2016	Date Received	12/09/2016	Date/s of Test	24/02/2017
Local Govt Authority					
Road	Tonkin Highway Trial Investigation SLK 21.520 - 22.900 (PRP16040-WARRIP 1611)				
Location					
Present Use	See Field Description				
Project No.		Depth	Various	mm	
Field Description	17M050 Limestone Subbase, 17M051 BSL				

Sample No.		17M050	17M051
Condition		Unsoaked	Unsoaked
% Retained 19 mm Sieve WA 115.1	%	12	1
Material Retained 19 mm Sieve (Excluded/Replaced)		Excluded	Excluded
Maximum Dry Density	t/m³	1.96	1.78
Optimum Moisture Content	%	10.5	12.0
Test Conditions of Specimen			
Surcharging of Specimen	kg	4.50	4.50
Compactive Effort Used in Moulding Specimen			
Blows, layers, kg hammer		18 / 5 / 4.9	17 / 5 / 2.7
Test Results			
Dry Density			
Specimen at Compaction	t/m³	1.86	1.69
Dry Density Ratio			
Specimen at Compaction	%	95.0	95.0
Moisture Content			
Specimen at Compaction	%	8.6	9.7
Top 30 mm Layer of Specimen After Penetration	%	7.4	8.5
Remainder of Specimen After Penetration	%	8.1	9.1
Moisture Ratio			
Specimen at Compaction	%	81.0	80.5
Top 30 mm Layer of Specimen After Penetration	%	69.5	70.5
Remainder of Specimen After Penetration	%	76.5	75.5
California Bearing Ratio	%	**80**	**35**
Penetration	mm	**5.0**	**5.0**

Comments / Distribution
TRIM File No. 17/3 and 16/5005
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See Report 16M467-475 for combined MDD Results used for CBR density and OMC values

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Document:71/05/141.1 Issue:27/08/2015 TRIM:D14#628396

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A.1.1 Summary of Laboratory Testing

Table A 9: Tonkin Highway investigation: BSL test results

ID	Material	Moisture (%)	LS (%)	LL (%)	PL (%)	MDD (t/m^3) (1)	OMC (%)	CBR (%)	In situ nuclear density (t/m3)	Mean in situ density at construction (t/m3)
T2	BSL	5.2	0	NA	NP	1.78	12.0	35(2)	1.81	1.84
T4		1.6	0	NA	NP				1.83	1.83

1 Section 2 and Section 4 BSL sample combined for density moisture curve, and CBR

2 CBR conducted @ 95% SMDD and 80.5% OMC

Table A 10: Tonkin Highway investigation: BSL PSD

Sieve size (mm)	% Passing			
	T2	T4	Mean PSD	Mean PSD from construction report
26.5	100	100	100	–
19.0	99	98	99	100
13.2	94	94	94	–
9.50	92	92	92	–
6.70	89	89	89	–
4.75	85	86	86	80
2.36	79	80	80	–
1.18	74	75	74	68
0.600	63	64	64	–
0.300	43	44	44	–
0.150	13	13	13	–
0.075	3	4	4	–

Table A 11: Tonkin Highway investigation: CRB test results

ID	Material	Moisture content (%)	LS (%)	LL (%)	PL (%)	MDD (t/m^3) (1)	OMC (%)	CBR (%)	In situ nuclear density (t/m3)	Mean in situ density at construction (t/m3)
T6	CRB	2.1	0.4	20	NP	2.32	6.1	–	2.20	2.20

Table A 12: Tonkin Highway investigation: CRB PSD

Sieve size (mm)	% Passing	
	T6	Mean PSD from construction report
19.0	100	100
13.2	89	–
9.5	75	82
6.70	62	–
4.75	53	49
2.36	40	35
1.18	29	26
0.600	22	19
0.425	19	16
0.300	16	14
0.150	11	10
0.075	8	7
0.0135	6	3

Table A 13: Tonkin Highway investigation: limestone subbase test results

ID	Material	Moisture content (%)	LS (%)	LL (%)	PL (%)	MDD (t/m^3) (1)	OMC (%)	CBR (%)	In situ nuclear density (t/m3)	Mean in situ density at construction (t/m3)
T2	Limestone	5.3	0	NA	NP	1.96	10.5	80	1.94	1.94
T4		3.5	0.4	NA	NP	-	-	-	1.87	1.89
T6		3.8	0	NA	NP	1.96	10.5	80	1.93	1.87

1 Section 2 and Section 6 limestone combined for density and moisture curve and CBR.
2 CBR conducted @ 95% MMDD and 81% of OMC.

Table A 14: Tonkin Highway investigation: Limestone subbase PSD

Sieve size (mm)	% Passing				
	T2	T4	T6	Mean PSD	Mean PSD from construction report
75.0	100	100	100	100	100
53.0	100	100	95	98	100
37.5	99	98	93	97	100
26.5	96	92	90	93	100
19.0	89	89	85	88	100
13.2	82	84	79	82	-
9.6	78	80	75	78	86
6.7	71	75	71	72	-
4.75	67	72	67	69	78
2.36	60	66	61	62	73
1.18	57	61	57	58	70
0.600	50	55	50	52	63
0.425	42	46	41	43	52
0.300	32	31	29	31	38
0.150	17	16	14	16	17
0.075	12	12	11	12	13
0.0135	7	9	8	8	9

Table A 15: Tonkin Highway investigation: Subgrade test results

ID	Material	Moisture (%)	LS (%)	LL (%)	PL (%)	MDD (t/m^3) (1)	OMC (%)	CBR (%)
T2	Sand	1.4	0.4	NA	NP	1.712	14.3	20
T4		0.9	0	NA	NP	1.739	13.0	–
T6		1.2	0	NA	NP	1.732	14.6	20

1 Section 2 and Section 4 BSL sample combined for density moisture curve, and CBR.
2 CBR conducted @ 95% SMDD and 77% OMC.

Table A 16: Tonkin Highway investigation: Sand subgrade PSD

Sieve size (mm)	% Passing				
	T2	T4	T6	Mean PSD	Mean PSD from construction report
19.0	100	100	100	100	100
9.5	100	99	100	100	100
6.70	100	99	100	100	100
4.75	99	99	100	99	100
2.36	99	98	99	99	100
1.18	99	98	99	99	100
0.600	89	82	86	86	92
0.425	64	52	55	57	66
0.300	31	22	22	25	35
0.150	4	3	2	3	5
0.075	1	1	0	1	1
0.0135	1	1	0	1	1

APPENDIX B REID HIGHWAY DATA

B.1.1 Construction Specifications

SPECIFICATION FOR CRUSHED ROCK BASE

General

All crushed rock base shall be quarried granite only. The crushed rock base shall consist of a uniformly blended mixture of coarse and fine aggregate.

Coarse aggregate (retained 4.75mm sieve) shall consist of clean, hard, durable, angular fragments or rock produced by crushing sound unweathered rock and shall not include materials which break up when alternately wetted and dried.

Fine aggregate (passing 4.75mm sieve) shall consist of crushed rock fragments or a mixture of crushed rock fragments with natural sand. Crushed rock fine aggregate from each source shall, except as to size, comply with all the provisions specified for coarse aggregate.

Crushed Rock Base

The mixture of fine and coarse aggregate forming the rock base shall be free from vegetable matter, lumps of clay, overburden, or any other deleterious matter.

The crushed rock base shall meet the following requirements when tested in accordance with MRWA Test Method WA 115.1. The grading of material passing the 19.0 sieve shall vary from coarse to fine in a uniform and consistent manner. It shall not be subject to extreme or near extreme percentages of gradation represented by the maximum and minimum limits for the various sieve sizes, and shall conform as closely as possible to the required target grading.

	Requirement	MRWA Test Method
Particle Size Distribution	As per Table 1	WA 115.12
Flakiness Index	30% maximum	WA 216.1
Los Angeles Abrasion Value	35% maximum	WA 220.1
Maximum Dry Compressive Strength	1700 kPa minimum	WA 140.1
California Bearing Ratio (Soaked 4 days)	100% minimum	WA 141.1
Liquid Limit (Cone Penetrometer)	25% maximum	WA 120.1
Linear Shrinkage	0.4% minimum 2.0% maximum	WA 123.1

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AS Sieve	% Passing by Mass Target Grading	Specified Grading Limits
26.5mm		100
19.0mm	100	95 - 100
13.2mm	82	70 - 90
9.5mm	70	60 - 80
4.75mm	50	40 - 60
2.36mm	38	30 - 45
1.18mm	25	20 - 35
600um	19	13 - 27
425um	17	11 - 23
300um	13	8 - 20
150um	10	5 - 14
75um	8	5 - 11

Table 1
Particle Size Distribution Crushed Rock Base

The Dust Ratio defined as the ratio of the percentage passing by mass the 75um sieve to the percentage passing by mass the 425um sieve, shall be within the range of 0.35 to 0.6.

Stockpiling and Moisture Content

Crushed rock base shall be pre-wet to within -1% and +2% of the optimum moisture content as determined by MRWA Test Method WA 133.1. The moisture content shall be determined in accordance with MRWA Test Method WA 110.1.

Crushed rock base shall be thoroughly mixed with water using a pugmill to produce a homogeneous product suitable for placement into final position.

Where an order is requested by the Superintendent for a specific moisture content, the crushed rock base shall be pre-wet to within -1% and +1% of the requested moisture content. The Contractor shall provide suitable cover for a days production where the material mixed at or below optimum moisture content would be affected by inclement weather in the stockpile.

SPECIFICATION FOR BITUMEN STABILISED LIMESTONE

GENERAL

Bitumen stabilised limestone shall be produced by the addition of bitumen emulsion to crushed limestone material. The limestone shall be obtained from a conforming rock source and shall be free of sand, roots and other foreign material. All materials used in the production of bitumen stabilised limestone shall be approved by the Superintendent prior to the start of the mixing process.

The bitumen emulsion used to modify the limestone shall comply with the requirements of Australian Standard 1160, "Bitumen Emulsion for Construction and Maintenance of Pavements", for Grade ASS emulsion. The emulsifier used in the manufacture of the emulsion shall be Vinsol resin. The bitumen used in the manufacture of the emulsion shall be grade ASS/50 bitumen conforming to AS 2008, "Residual Bitumen for Pavements. Tenderers shall nominate the source of supply of bitumen emulsion with their tender. Sources of supply shall not be changed without the approval of the Superintendent in writing. The Contractor shall make arrangements for the Superintendent to sample the emulsion or any of its components at any time during normal working hours. These arrangements shall include a means of identifying lots of emulsion or the component material which will be used in the Works.

Any water added before or during the mixing process shall contain a wetting agent approved by the Superintendent and added at the appropriate rate.

Production Process

Tenderers shall describe with their tender the process they propose to use to produce bitumen stabilised limestone. Acceptance of a tender shall imply approval of the nominated production process which shall not be changed without written approval of the Superintendent.

The mixing process shall produce a homogeneous mixture of limestone, bitumen and water in which the bitumen is uniformly distributed in the form of a thin film covering the particles of the crushed limestone. Mixing shall be carried out as either a batch or continuous process in an approved plant.

This plant shall include measuring equipment which will determine the mass of bitumen emulsion added to an known mass of crushed limestone at all stages of the mixing process. The Superintendent's approval of the Contractor's plant will be conditional on this equipment being capable of determining the mass of bitumen emulsion added to within plus or minus 10% of the specified amount.

Surfacing Requirements

The compacted and approved bitumen stabilised limestone base shall be surfaced according to the relevant specification for stone and binder application rate.

Bitumen Content

The residual bitumen content of the stabilised limestone shall be determined by Main Roads Test Method WA 730.1 and shall have a residual bitumen content of not less than 2% and not more than 3%.

Bitumen Dispersion

Compliance of any lot with this requirement shall be based on the results of the assessment of 3 samples randomly selected from the lot being assessed and tested in accordance with Main Roads WA 717.1. All results should generally have a dispersion of Class 1, however the Superintendent may agree to accept the material if one of the three samples has a dispersion of Class 2.

Particle Size Distribution

The particle size distribution of the bitumen stabilised limestone after mixing and delivery shall be determined in accordance with Main Roads test Method WA 730.1 and shall comply with the limits detailed below:

AS Sieve	Percentage Passing by Mass
26.5mm	100
19.0mm	90 - 100
4.75mm	60 - 90
1.18mm	35 - 75

Los Angeles Value

The Los Angeles Value of the crushed limestone shall be determined using Main Roads Test Method WA 220.1, with columns E, F or G in Table 1 modified as follows:

- Test portion shall be half of that required.
- Use only four balls for test.
- Number of revolutions shall be 250.

The Los Angeles value as determined above shall be 20% min and 60% max.

Calcium Carbonate Content

The calcium carbonate content shall be determined using Main Roads Test Method WA 915.1, and shall be 60% minimum by weight.

Stockpiling and Moisture Content

The stabilised limestone shall be stockpiled for at least three days before delivery to the site. The moisture content of the mixture shall be determined using Main Roads Test Method WA 110.1 and shall have a moisture content of not less than 7% and not greater than 14% by weight. Sampling shall occur immediately prior to delivery and be sampled in the truck using Main Roads Test Method 100.1. If a specific moisture content is ordered by the Superintendent, the stabilised limestone shall be pre- wet to within ± 2% of this ordered moisture content.

CONSTRUCTION ISSUES

Sub-base Dryback Requirements

Basecourse construction shall not commence until the sub-base has dried back such that the Characteristic Moisture Content is less then 85% of the Optimum Moisture Content as determined by MRWA Test Method 133.1 "Dry Density/Moisture Content Relationship: Modified Compaction".

The Characteristic Moisture Content (Mc) is defined by the expression:

Mc = m + 0.5 s

Where m = average of 6 sample moisture content determinations

s = is the standard deviation of the 6 sample moisture content determinations on the lot being assessed, calculated using the following relationship and reported to the nearest 0.1.

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{(n-1)}}$$

Where; x_i is an individual result

$\bar{x}$ is the mean of n results

n is the number of results from one lot

Surface Finish

The finished basecourse shall be in a uniformly bound condition with no evidence of layering or disintegration. The finished surface shall be dense, even textured, tightly bound, and suitable to receive bituminous surfacing. The finished surface shall be maintained in its conforming condition until the application of bituminous surfacing.

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- **Density**

Bitumen stabilised limestone basecourse shall be compacted to a Characteristic Dry Density ratio of 96% or greater.

- **Basecourse Dryback**

Bituminous surfacing of the section shall not commence until he basecourse has dried such that the characteristic moisture content is less than 85% of the Optimum Moisture Content as determined by Main Roads Test Method WA 133.1 "Dry Density/Moisture Content Relationship: Modified Compaction".

SPECIFICATION FOR PLANT CRUSHED LIMESTONE

General

The limestone shall be obtained from a conforming rock source and shall be free of sand, roots, and other foreign material. The limestone shall be free of large elongated or flaky material after passing the 26.5 mm sieve.

Particle Size Distribution

The particle size distribution of the crushed limestone shall comply with the limits detailed below:

AS Sieve	Percentage Passing by Mass
26.5mm	100
19.0mm	90 - 100
4.75mm	60 - 90
1.18mm	35 - 75

Los Angeles Value

The Los Angeles Value of the crushed limestone shall be determined using Main Roads Test Method WA 220.1, with columns E, F or G in Table 1 modified as follows:

- Test portion shall be half of that required.
- Use only four balls for test.
- Number of revolutions shall be 250.

The Los Angeles value as determined above shall be 20% min and 60% max.

Calcium Carbonate Content

The calcium carbonate content shall be determined using Main Roads Test Method WA 915.1, and shall be 60% minimum by weight.

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B.2 Historic Performance Data

Table B 1: Falling weight deflectometer, 2006 Report No. 06 FWD 46/1 and 51/1 (MRWA 2006)

																Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2004 Correction to 29C					
Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Factor	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
11.355	2	EB	26/11/2006	46	30.8	715	402	277	190	133	102	85	71	63	41	0.39	0.12	0.99	0.39		0.98	0.12	
11.365	2	EB	26/11/2006	46	30.8	714	435	282	185	127	96	81	67	60	41	0.43	0.15	0.99	0.43		0.98	0.15	
11.375	2	EB	26/11/2006	46	30.8	713	426	271	179	122	94	79	66	59	40	0.42	0.15	0.99	0.42		0.98	0.15	
11.385	2	EB	26/11/2006	46	30.8	715	423	260	171	118	92	79	67	59	38	0.41	0.16	0.99	0.41		0.98	0.16	
11.395	2	EB	26/11/2006	46	30.8	714	410	266	175	122	95	81	68	59	38	0.40	0.14	0.99	0.40		0.98	0.14	
11.405	2	EB	26/11/2006	46	30.8	716	389	253	168	116	89	75	61	53	33	0.38	0.13	0.99	0.38		0.98	0.13	
11.415	2	EB	26/11/2006	46	30.8	715	396	262	174	119	91	75	60	50	32	0.39	0.13	0.99	0.39		0.98	0.13	
11.425	2	EB	26/11/2006	46	30.8	714	369	231	148	96	72	59	51	47	35	0.36	0.14	0.99	0.36		0.98	0.14	
11.435	2	EB	26/11/2006	46	30.8	721	340	225	153	110	91	80	72	67	47	0.33	0.11	0.99	0.33		0.98	0.11	
11.445	2	EB	26/11/2006	46	30.6	711	429	274	184	129	100	83	70	63	41	0.42	0.15	0.99	0.42	***0.39***	0.98	0.15	***0.14***
11.455	3	EB	26/11/2006	53	30.6	712	350	232	169	125	98	82	67	59	39	0.34	0.12	0.99	0.34		0.98	0.12	
11.465	3	EB	26/11/2006	53	30.6	708	344	241	175	133	105	87	69	62	39	0.34	0.10	0.99	0.34		0.98	0.10	
11.475	3	EB	26/11/2006	53	30.6	715	335	233	172	131	104	87	69	58	35	0.33	0.10	0.99	0.33		0.98	0.10	
11.485	3	EB	26/11/2006	53	30.6	713	355	242	173	129	100	82	65	54	32	0.35	0.11	0.99	0.35		0.98	0.11	
11.495	3	EB	26/11/2006	53	30.6	714	368	245	181	136	108	90	72	63	39	0.36	0.12	0.99	0.36		0.98	0.12	
11.505	3	EB	26/11/2006	53	30.6	711	361	252	183	138	109	91	73	62	40	0.36	0.11	0.99	0.36		0.98	0.11	
11.515	3	EB	26/11/2006	53	30.6	712	397	269	192	144	115	96	78	67	44	0.39	0.13	0.99	0.39		0.98	0.13	
11.525	3	EB	26/11/2006	53	30.6	713	374	258	188	139	111	93	75	66	42	0.37	0.11	0.99	0.37		0.98	0.11	
11.535	3	EB	26/11/2006	53	30.6	709	352	240	177	136	110	93	75	65	42	0.35	0.11	0.99	0.35	***0.35***	0.98	0.11	***0.11***
10.585	4	EB	19/11/2006	44	30.6	719	405	269	182	133	107	91	75	64	40	0.39	0.13	0.99	0.39		0.98	0.13	
10.595	4	EB	19/11/2006	44	30.6	723	343	235	170	132	110	97	81	69	42	0.33	0.10	0.99	0.33		0.98	0.10	
10.605	4	EB	19/11/2006	44	30.6	722	320	223	159	124	103	90	76	66	42	0.31	0.09	0.99	0.31		0.98	0.09	
10.615	4	EB	19/11/2006	44	30.6	724	364	246	169	124	100	85	71	61	40	0.35	0.11	0.99	0.35		0.98	0.11	
10.625	4	EB	19/11/2006	44	30.6	720	389	171	124	100	85	69	61	39	0	0.13	0.13	0.99	0.13		0.98	0.13	
10.635	4	EB	19/11/2006	44	30.6	719	359	243	170	129	106	90	75	64	40	0.35	0.11	0.99	0.35		0.98	0.11	
10.645	4	EB	19/11/2006	44	30.6	712	343	239	172	130	108	93	77	66	41	0.34	0.10	0.99	0.34		0.98	0.10	
10.655	4	EB	19/11/2006	44	30.6	717	345	241	170	129	106	92	76	65	43	0.34	0.10	0.99	0.34		0.98	0.10	
10.665	4	EB	19/11/2006	44	30.6	716	345	235	165	129	108	94	78	67	43	0.34	0.11	0.99	0.34		0.98	0.11	
10.675	4	EB	19/11/2006	44	30.6	715	363	242	173	136	113	99	82	71	44	0.36	0.12	0.99	0.36		0.98	0.12	
10.685	4	EB	19/11/2006	44	30.6	713	466	280	197	150	122	106	87	75	44	0.40	0.12	0.99	0.40		0.98	0.12	
10.695	4	EB	19/11/2006	44	30.6	709	486	294	207	157	125	106	85	72	41	0.43	0.14	0.99	0.43	***0.34***	0.98	0.14	***0.11***

Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2004 Correction to 29C					
																Deflection (mm)	Curvature (mm)	Deflection Factor	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
11.535	2	WB	26/11/2006	46	41.6	715	337	233	175	137	112	96	80	70	45	0.33	0.1	0.96	0.32		0.88	0.09	
11.525	2	WB	26/11/2006	46	41.6	706	359	247	183	141	114	97	80	70	45	0.36	0.11	0.96	0.34		0.88	0.10	
11.515	2	WB	26/11/2006	46	41.6	703	401	269	196	149	119	100	82	72	46	0.4	0.13	0.96	0.38		0.88	0.12	
11.505	2	WB	26/11/2006	46	41.6	708	386	256	181	134	107	90	73	64	42	0.38	0.13	0.96	0.36		0.88	0.12	
11.495	2	WB	26/11/2006	46	41.6	705	382	254	188	143	116	97	79	68	40	0.38	0.13	0.96	0.36		0.88	0.12	
11.485	2	WB	26/11/2006	46	41.6	706	367	243	177	134	108	91	74	63	37	0.36	0.12	0.96	0.34		0.88	0.11	
11.475	2	WB	26/11/2006	46	41.6	709	365	252	190	146	118	100	79	68	42	0.36	0.11	0.96	0.34		0.88	0.10	
11.465	2	WB	26/11/2006	46	41.6	713	406	269	195	147	116	97	78	68	43	0.4	0.13	0.96	0.38		0.88	0.12	
11.455	2	WB	26/11/2006	46	41.6	710	390	260	186	140	111	92	74	64	43	0.38	0.13	0.96	0.36	***0.36***	0.88	0.12	***0.11***
11.445	3	WB	26/11/2006	53	40.4	707	434	285	194	145	118	102	84	73	47	0.43	0.15	0.96	0.41		0.89	0.13	
11.435	3	WB	26/11/2006	53	40.4	710	374	252	176	133	112	100	87	78	55	0.37	0.12	0.96	0.36		0.89	0.11	
11.425	3	WB	26/11/2006	53	40.4	709	374	232	149	105	85	74	63	56	38	0.37	0.14	0.96	0.36		0.89	0.13	
11.415	3	WB	26/11/2006	53	40.4	716	339	222	148	108	90	79	68	61	42	0.33	0.11	0.96	0.32		0.89	0.10	
11.405	3	WB	26/11/2006	53	40.4	716	364	250	174	126	102	89	75	66	44	0.36	0.11	0.96	0.35		0.89	0.10	
11.395	3	WB	26/11/2006	53	40.4	714	379	241	165	121	99	86	75	67	44	0.37	0.14	0.96	0.36		0.89	0.13	
11.385	3	WB	26/11/2006	53	40.4	712	432	279	187	133	106	90	76	67	44	0.42	0.15	0.96	0.40		0.89	0.13	
11.375	3	WB	26/11/2006	53	40.4	710	402	255	166	119	98	85	73	65	43	0.4	0.15	0.96	0.38		0.89	0.13	
11.365	3	WB	26/11/2006	53	40.4	713	407	268	178	124	98	84	71	67	42	0.4	0.14	0.96	0.38		0.89	0.13	
11.355	3	WB	26/11/2006	53	40.4	708	422	268	175	126	100	86	73	65	44	0.42	0.15	0.96	0.40	***0.37***	0.89	0.13	***0.12***
10.695	4	WB	26/11/2006	44	47.5	708	214	169	130	105	89	78	66	57	37	0.21	0.04	0.94	0.20		0.85	0.03	
10.685	4	WB	26/11/2006	44	47.5	709	228	169	128	105	93	82	72	66	44	0.23	0.06	0.94	0.22		0.85	0.05	
10.676	4	WB	26/11/2006	44	47.5	714	229	165	125	95	86	79	70	64	44	0.22	0.06	0.94	0.21		0.85	0.05	
10.665	4	WB	26/11/2006	44	47.5	718	277	185	137	110	93	83	71	62	41	0.27	0.09	0.94	0.25		0.85	0.08	
10.655	4	WB	26/11/2006	44	47.5	718	261	171	126	100	85	75	65	57	39	0.25	0.09	0.94	0.24		0.85	0.08	
10.845	4	WB	26/11/2006	44	47.5	713	245	160	118	93	80	70	61	54	37	0.24	0.08	0.94	0.23		0.85	0.07	
10.635	4	WB	26/11/2006	44	47.5	722	245	166	122	97	82	72	63	56	39	0.24	0.08	0.94	0.23		0.85	0.07	
10.625	4	WB	26/11/2006	44	47.5	720	248	162	116	91	78	69	60	54	37	0.24	0.08	0.94	0.23		0.85	0.07	
10.615	4	WB	26/11/2006	44	47.5	714	230	153	111	90	79	70	61	55	39	0.23	0.08	0.94	0.22		0.85	0.07	
10.605	4	WB	26/11/2006	44	47.5	718	288	194	140	109	91	78	66	60	40	0.28	0.09	0.94	0.26		0.85	0.08	
10.595	4	WB	26/11/2006	44	47.5	717	333	223	157	118	96	82	69	61	40	0.33	0.11	0.94	0.31		0.85	0.09	
10.585	4	WB	26/11/2006	44	47.5	711	376	238	159	117	94	81	69	61	41	0.37	0.14	0.94	0.35	***0.24***	0.85	0.12	***0.07***

Table B 2: Falling weight deflectometer, 2007 Report No. D00001A (WGEOG 2007)

Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2004 Correction to 29C					
																Deflection (mm)	Curvature (mm)	Deflection Factor	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
11.535	2	EB	18/03/2007	53	28.0	701	387	241	188	143	105	75	57	-	-	0.39	0.15	1.00	0.39		1.01	0.15	
11.525	2	EB	18/03/2007	53	28.0	701	402	247	190	143	103	72	65	-	-	0.40	0.16	1.00	0.40		1.01	0.16	
11.515	2	EB	18/03/2007	53	28.0	699	455	286	218	158	112	71	64	-	-	0.46	0.17	1.00	0.46		1.01	0.17	
11.505	2	EB	18/03/2007	53	28.0	700	459	254	185	136	86	54	25	-	-	0.46	0.21	1.00	0.46		1.01	0.21	
11.495	2	EB	18/03/2007	53	28.0	699	429	257	192	143	99	63	58	-	-	0.43	0.17	1.00	0.43		1.01	0.17	
11.485	2	EB	18/03/2007	53	28.0	698	412	242	183	137	97	59	59	-	-	0.41	0.17	1.00	0.41		1.01	0.17	
11.475	2	EB	18/03/2007	53	28.0	702	409	256	203	152	105	75	56	-	-	0.41	0.15	1.00	0.41		1.01	0.15	
11.465	2	EB	18/03/2007	53	28.0	699	449	274	209	152	104	66	59	-	-	0.45	0.18	1.00	0.45		1.01	0.18	
11.455	2	EB	18/03/2007	53	28.0	698	439	269	203	146	98	64	63	-	-	0.44	0.17	1.00	0.44	***0.43***	1.01	0.17	***0.17***
11.445	3	EB	18/03/2007	46	22.5	699	472	275	200	153	113	77	65	-	-	0.47	0.20	1.03	0.49		1.09	0.22	
11.435	3	EB	18/03/2007	46	28.5	701	372	233	175	134	110	82	68	-	-	0.37	0.14	1.00	0.37		1.01	0.14	
11.425	3	EB	18/03/2007	46	28.5	697	383	213	153	116	88	58	57	-	-	0.39	0.17	1.00	0.39		1.01	0.17	
11.415	3	EB	18/03/2007	46	28.5	700	327	176	130	102	73	53	51	-	-	0.33	0.15	1.00	0.33		1.01	0.15	
11.405	3	EB	18/03/2007	46	28.5	701	351	217	156	120	93	56	33	-	-	0.35	0.13	1.00	0.35		1.01	0.13	
11.395	3	EB	18/03/2007	46	28.5	700	459	241	173	136	96	60	41	-	-	0.46	0.22	1.00	0.46		1.01	0.22	
11.385	3	EB	18/03/2007	46	28.5	702	438	253	181	136	101	68	61	-	-	0.44	0.18	1.00	0.44		1.01	0.19	
11.375	3	EB	18/03/2007	46	28.5	703	415	236	166	126	96	69	60	-	-	0.41	0.18	1.00	0.41		1.01	0.18	
11.365	3	EB	18/03/2007	46	28.5	700	429	255	185	126	92	67	55	-	-	0.43	0.17	1.00	0.43		1.01	0.18	
11.355	3	EB	18/03/2007	46	28.5	700	451	270	193	136	98	73	60	-	-	0.45	0.18	1.00	0.45	***0.41***	1.01	0.18	***0.18***
10.69	4	EB	18/03/2007	44	36.5	698	165	99	78	69	55	35	30	-	-	0.17	0.07	0.97	0.16		0.92	0.06	
10.68	4	EB	18/03/2007	44	36.5	698	171	101	83	71	61	43	29	-	-	0.17	0.07	0.97	0.17		0.92	0.06	
10.67	4	EB	18/03/2007	44	36.5	703	175	92	72	68	59	44	44	-	-	0.17	0.08	0.97	0.17		0.92	0.08	
10.66	4	EB	18/03/2007	44	36.5	699	195	97	78	71	61	37	36	-	-	0.20	0.10	0.97	0.19		0.92	0.09	
10.65	4	EB	18/03/2007	44	36.5	702	176	91	71	63	52	41	39	-	-	0.18	0.09	0.97	0.17		0.92	0.08	
10.64	4	EB	18/03/2007	44	36.5	698	192	101	73	65	56	38	20	-	-	0.19	0.09	0.97	0.19		0.92	0.08	
10.63	4	EB	18/03/2007	44	36.5	700	193	100	72	70	53	44	44	-	-	0.19	0.09	0.97	0.19		0.92	0.09	
10.62	4	EB	18/03/2007	44	36.5	700	187	98	72	62	54	39	36	-	-	0.19	0.09	0.97	0.18		0.92	0.08	
10.61	4	EB	18/03/2007	44	36.5	700	164	86	68	60	51	37	25	-	-	0.16	0.08	0.97	0.16		0.92	0.07	
10.6	4	EB	18/03/2007	44	36.5	702	223	126	99	73	61	45	44	-	-	0.22	0.10	0.97	0.22		0.92	0.09	
10.59	4	EB	18/03/2007	44	36.5	700	323	154	110	89	67	46	43	-	-	0.32	0.17	0.97	0.31		0.92	0.16	
10.58	4	EB	18/03/2007	44	36.5	700	317	166	117	86	69	47	28	-	-	0.32	0.15	0.97	0.31	***0.20***	0.92	0.14	***0.09***

Table B 3: Falling weight deflectometer, 2007 Report No. 07 FWD 79/1 (MRWA 2007)

Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa		Normalised to 700 kPa					
																No Temp Correction		Austroads 2004 Correction to 29C					
																Deflection (mm)	Curvature (mm)	Deflection Factor	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
11.535	2	WB	18/03/2007	46	25.8	712	333	244	187	149	122	104	85	73	44	0.33	0.09	1.02	0.34		1.04	0.09	
11.525	2	WB	18/03/2007	46	25.8	710	348	253	194	152	124	105	86	77	45	0.34	0.09	1.02	0.35		1.04	0.09	
11.515	2	WB	18/03/2007	46	25.8	704	406	288	218	169	135	113	90	77	47	0.40	0.12	1.02	0.41		1.04	0.13	
11.505	2	WB	18/03/2007	46	25.8	706	379	263	192	146	114	94	75	65	40	0.38	0.11	1.02	0.39		1.04	0.11	
11.495	2	WB	18/03/2007	46	25.8	710	376	265	203	158	127	106	85	74	41	0.37	0.11	1.02	0.38		1.04	0.11	
11.485	2	WB	18/03/2007	46	25.8	713	369	255	190	148	119	99	80	68	41	0.36	0.11	1.02	0.37		1.04	0.11	
11.475	2	WB	18/03/2007	46	25.8	704	360	260	203	160	130	109	87	74	39	0.36	0.10	1.02	0.37		1.04	0.10	
11.465	2	WB	18/03/2007	46	25.8	705	395	281	211	163	130	107	85	74	43	0.39	0.11	1.02	0.40		1.04	0.11	
11.455	2	WB	18/03/2007	46	25.8	712	392	274	206	157	124	103	82	69	47	0.39	0.12	1.02	0.40	***0.37***	1.04	0.13	***0.11***
11.445	3	WB	18/03/2007	53	27.3	703	430	294	212	163	134	116	96	83	52	0.43	0.14	1.01	0.43		1.02	0.14	
11.435	3	WB	18/03/2007	53	27.3	715	345	250	. 187	149	125	110	94	83	55	0.34	0.09	1.01	0.34		1.02	0.09	
11.425	3	WB	18/03/2007	53	27.3	713	336	229	162	124	105	92	78	69	43	0.33	0.11	1.01	0.33		1.02	0.11	
11.415	3	WB	18/03/2007	53	27.3	712	280	194	139	106	89	79	67	61	41	0.27	0.08	1.01	0.27		1.02	0.08	
11.405	3	WB	18/03/2007	53	27.3	718	315	229	171	132	108	94	78	69	43	0.31	0.08	1.01	0.31		1.02	0.08	
11.395	3	WB	18/03/2007	53	27.3	715	343	244	177	136	110	95	80	72	45	0.34	0.10	1.01	0.34		1.02	0.10	
11.385	3	WB	18/03/2007	53	27.3	713	381	265	192	143	116	100	84	72	47	0.37	0.11	1.01	0.37		1.02	0.11	
11.375	3	WB	18/03/2007	53	27.3	712	373	254	178	133	109	95	80	72	43	0.37	0.12	1.01	0.37		1.02	0.12	
11.365	3	WB	18/03/2007	53	27.3	709	386	271	194	141	111	94	78	67	41	0.38	0.11	1.01	0.38		1.02	0.11	
11.355	3	WB	18/03/2007	53	27.3	697	403	275	189	138	111	95	80	70	47	0.40	0.13	1.01	0.40	***0.36***	1.02	0.13	***0.11***
10.690	4	WB	18/03/2007	44	34.0	718	147	106	86	74	66	60	52	47	32	0.14	0.04	0.98	0.14		0.95	0.04	
10.680	4	WB	18/03/2007	44	34.0	720	153	104	86	75	68	62	56	52	38	0.15	0.05	0.98	0.15		0.95	0.05	
10.670	4	WB	18/03/2007	44	34.0	718	147	102	78	65	61	58	52	49	36	0.14	0.04	0.98	0.14		0.95	0.04	
10.660	4	WB	18/03/2007	44	34.0	722	154	103	82	70	64	59	53	49	35	0.15	0.05	0.98	0.15		0.95	0.05	
10.650	4	WB	18/03/2007	44	34.0	725	153	99	78	67	60	55	50	46	34	0.15	0.05	0.98	0.15		0.95	0.05	
10.640	4	WB	18/03/2007	44	34.0	722	156	103	80	67	60	55	49	45	33	0.15	0.05	0.98	0.15		0.95	0.05	
10.630	4	WB	18/03/2007	44	34.0	727	151	104	81	68	60	55	50	47	35	0.15	0.05	0.98	0.15		0.95	0.05	
10.620	4	WB	18/03/2007	44	34.0	722	151	95	45	64	57	52	47	43	32	0.15	0.05	0.98	0.15		0.95	0.05	
10.610	4	WB	18/03/2007	44	34.0	728	150	98	46	65	59	54	49	45	34	0.14	0.05	0.98	0.14		0.95	0.05	
10.600	4	WB	18/03/2007	44	34.0	730	191	126	97	81	71	65	56	51	35	0.18	0.06	0.98	0.18		0.95	0.06	
10.590	4	WB	18/03/2007	44	34.7	729	266	174	122	93	75	66	57	52	36	0.26	0.09	0.98	0.25		0.94	0.08	
10.580	4	WB	18/03/2007	44	34.7	724	290	192	132	96	78	68	59	54	38	0.28	0.10	0.98	0.27	***0.17***	0.94	0.09	***0.05***

Table B 4: Falling weight deflectometer, 2008 Report No. 08 FWD 190/1 (MRWA 2008)

Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2004 Correction to 29C					
																Deflection (mm)	Curvature (mm)	Deflection Factor	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
11.450	2	EB	7/12/2008	46	35.7	705	420	279	202	150	116	97	77	66	43	0.417	0.141	0.968	0.404		0.925	0.130	
11.460	2	EB	7/12/2008	46	35.9	698	395	268	198	151	119	100	81	68	42	0.396	0.127	0.967	0.383		0.923	0.118	
11.470	2	EB	7/12/2008	46	36.0	707	391	264	195	147	116	94	74	61	35	0.387	0.125	0.966	0.374		0.922	0.115	
11.480	2	EB	7/12/2008	46	36.4	704	409	272	199	150	119	99	78	67	39	0.407	0.137	0.965	0.393		0.919	0.126	
11.490	2	EB	7/12/2008	46	36.4	700	408	271	200	153	120	99	79	67	41	0.408	0.137	0.965	0.393		0.919	0.126	
11.500	2	EB	7/12/2008	46	36.8	702	421	280	206	159	128	107	86	72	43	0.420	0.140	0.963	0.404		0.915	0.128	
11.510	2	EB	7/12/2008	46	36.9	701	464	296	212	157	124	104	85	73	45	0.463	0.167	0.962	0.446		0.914	0.153	
11.520	2	EB	7/12/2008	46	36.8	698	432	290	215	165	133	109	91	76	45	0.433	0.142	0.963	0.417		0.915	0.130	
11.530	2	EB	7/12/2008	46	36.8	701	408	274	206	159	129	109	89	76	47	0.407	0.134	0.963	0.392		0.915	0.122	
11.540	2	EB	7/12/2008	46	36.8	700	475	308	209	150	116	100	84	74	46	0.475	0.167	0.961	0.456	***0.406***	0.907	0.151	***0.130***
11.350	3	EB	7/12/2008	53	34.2	703	442	297	201	142	112	88	70	63	39	0.440	0.144	0.970	0.427		0.927	0.133	
11.360	3	EB	7/12/2008	53	34.2	700	467	301	201	143	109	91	75	65	40	0.467	0.166	0.970	0.453		0.927	0.154	
11.370	3	EB	7/12/2008	53	34.8	696	470	314	204	141	105	87	72	63	39	0.472	0.157	0.967	0.457		0.920	0.145	
11.380	3	EB	7/12/2008	53	34.7	703	468	312	213	149	114	95	79	69	43	0.466	0.156	0.968	0.451		0.921	0.143	
11.390	3	EB	7/12/2008	53	34.4	704	487	309	205	142	109	92	77	66	40	0.484	0.177	0.969	0.469		0.925	0.163	
11.400	3	EB	7/12/2008	53	34.3	706	467	300	199	140	106	87	71	61	35	0.463	0.165	0.970	0.449		0.926	0.153	
11.410	3	EB	7/12/2008	53	34.6	704	481	316	209	146	110	90	72	61	36	0.478	0.164	0.968	0.463		0.922	0.152	
11.420	3	EB	7/12/2008	53	34.6	705	432	286	185	123	89	71	57	50	34	0.429	0.146	0.968	0.415		0.922	0.134	
11.430	3	EB	7/12/2008	53	34.8	706	404	251	165	115	93	83	76	71	51	0.400	0.152	0.967	0.387		0.920	0.140	
11.440	3	EB	7/12/2008	53	34.8	706	512	320	212	149	115	95	79	69	44	0.508	0.191	0.967	0.491	***0.446***	0.920	0.175	***0.149***
10.590	4	EB	7/12/2008	44	22.9	699	360	254	179	138	110	93	77	67	40	0.360	0.106	1.028	0.370		1.073	0.114	
10.600	4	EB	7/12/2008	44	23.2	696	344	243	176	135	110	94	78	67	42	0.346	0.102	1.026	0.355		1.069	0.109	
10.610	4	EB	7/12/2008	44	23.7	698	378	261	182	136	107	89	72	62	39	0.379	0.117	1.024	0.388		1.062	0.124	
10.620	4	EB	7/12/2008	44	23.4	698	389	265	182	134	105	87	70	60	38	0.390	0.124	1.025	0.400		1.066	0.132	
10.630	4	EB	7/12/2008	44	23.7	698	337	238	173	133	108	92	76	65	41	0.338	0.100	1.024	0.346		1.062	0.106	
10.640	4	EB	7/12/2008	44	23.9	698	356	248	179	134	107	90	73	62	39	0.357	0.108	1.023	0.365		1.059	0.115	
10.650	4	EB	7/12/2008	44	30.9	706	351	239	173	136	113	97	82	70	45	0.348	0.111	0.990	0.344		0.977	0.109	
10.660	4	EB	7/12/2008	44	31.8	703	359	243	177	138	114	100	83	71	45	0.357	0.116	0.986	0.352		0.967	0.112	
10.670	4	EB	7/12/2008	44	32.3	699	402	278	200	155	126	107	88	75	47	0.402	0.124	0.984	0.396		0.962	0.119	
10.680	4	EB	7/12/2008	44	31.4	699	468	311	219	169	135	114	92	77	43	0.468	0.157	0.988	0.463		0.972	0.153	
10.690	4	EB	7/12/2008	44	32.1	703	433	281	198	152	122	103	84	71	39	0.432	0.152	0.985	0.425		0.964	0.146	
10.700	4	EB	7/12/2008	44	31.7	700	427	285	215	168	134	113	89	74	41	0.427	0.141	0.987	0.421	***0.385***	0.969	0.137	***0.123***

Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa		Normalised to 700 kPa					
																No Temp Correction		Austroads 2004 Correction to 29C					
																Deflection (mm)	Curvature (mm)	Deflection Factor	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
11.540	2	WB	14/12/2008	46	21.9	704	352	241	185	145	118	100	81	69	43	0.350	0.111	1.037	0.364		1.103	0.122	
11.533	2	WB	14/12/2008	46	22.2	708	332	233	180	143	118	100	82	71	44	0.329	0.098	1.033	0.339		1.089	0.107	
11.523	2	WB	14/12/2008	46	21.9	701	412	284	208	158	125	105	85	73	45	0.411	0.128	1.035	0.426		1.093	0.140	
11.513	2	WB	14/12/2008	46	21.7	706	401	269	200	153	121	99	79	67	41	0.398	0.131	1.036	0.412		1.097	0.144	
11.503	2	WB	14/12/2008	46	22.0	704	444	299	213	165	131	108	84	71	43	0.442	0.144	1.034	0.457		1.092	0.158	
11.493	2	WB	14/12/2008	46	21.7	706	366	259	198	153	122	101	80	67	40	0.362	0.106	1.036	0.376		1.097	0.116	
11.483	2	WB	14/12/2008	46	21.6	702	395	278	210	163	131	109	86	71	40	0.394	0.117	1.037	0.408		1.098	0.128	
11.473	2	WB	14/12/2008	46	21.5	699	378	268	204	157	124	102	81	67	40	0.378	0.110	1.037	0.392		1.100	0.121	
11.463	2	WB	14/12/2008	46	21.7	702	366	252	190	147	118	99	79	68	44	0.365	0.113	1.036	0.378		1.097	0.124	
11.453	2	WB	14/12/2008	46	21.4	700	383	267	203	155	123	101	80	67	43	0.383	0.116	1.038	0.398	***0.395***	1.102	0.128	***0.129***
11.442	3	WB	14/12/2008	53	22.3	700	391	261	180	133	109	96	82	72	47	0.391	0.130	1.037	0.406		1.105	0.144	
11.432	3	WB	14/12/2008	53	22.5	702	362	248	178	132	107	92	78	69	47	0.361	0.114	1.036	0.374		1.101	0.126	
11.422	3	WB	14/12/2008	53	22.6	704	368	245	170	123	98	84	69	59	39	0.366	0.122	1.035	0.379		1.099	0.135	
11.412	3	WB	14/12/2008	53	22.8	700	361	245	173	129	104	89	74	63	40	0.361	0.116	1.034	0.374		1.095	0.127	
11.402	3	WB	14/12/2008	53	22.5	704	395	268	188	138	109	93	77	67	42	0.393	0.127	1.036	0.407		1.101	0.139	
11.392	3	WB	14/12/2008	53	22.7	701	403	278	194	144	114	96	80	69	43	0.402	0.125	1.034	0.416		1.097	0.137	
11.382	3	WB	14/12/2008	53	23.0	702	447	300	206	145	113	95	77	66	41	0.446	0.147	1.033	0.461		1.092	0.161	
11.372	3	WB	14/12/2008	53	23.3	697	426	282	196	141	108	90	74	64	41	0.427	0.144	1.031	0.441		1.086	0.157	
11.362	3	WB	14/12/2008	53	22.9	693	453	308	216	155	117	97	79	67	43	0.458	0.147	1.033	0.473		1.094	0.160	
11.352	3	WB	14/12/2008	53	22.9	694	456	299	204	148	112	93	77	67	42	0.460	0.159	1.033	0.475	***0.420***	1.094	0.174	***0.146***
10.700	4	WB	14/12/2008	44	27.7	702	284	189	143	117	101	89	77	68	43	0.283	0.094	1.005	0.285		1.014	0.096	
10.690	4	WB	14/12/2008	44	27.1	709	252	171	129	105	89	78	66	57	35	0.249	0.080	1.008	0.250		1.020	0.081	
10.680	4	WB	14/12/2008	44	27.0	706	220	154	121	107	92	81	73	67	46	0.219	0.066	1.008	0.220		1.021	0.067	
10.670	4	WB	14/12/2008	44	26.8	700	242	164	126	105	91	82	73	65	45	0.242	0.079	1.009	0.245		1.024	0.081	
10.660	4	WB	14/12/2008	44	27.3	698	273	172	130	104	89	80	68	60	38	0.274	0.102	1.007	0.276		1.018	0.104	
10.650	4	WB	14/12/2008	44	26.5	701	274	179	133	106	89	79	67	59	39	0.274	0.094	1.010	0.276		1.027	0.097	
10.640	4	WB	14/12/2008	44	27.3	707	251	169	128	105	88	77	66	58	39	0.248	0.081	1.007	0.250		1.018	0.082	
10.630	4	WB	14/12/2008	44	27.3	701	238	162	121	97	83	73	63	56	38	0.237	0.075	1.007	0.239		1.018	0.077	
10.620	4	WB	14/12/2008	44	27.3	698	251	166	122	98	83	73	62	54	36	0.252	0.085	1.007	0.254		1.018	0.087	
10.610	4	WB	14/12/2008	44	27.5	703	226	149	110	90	82	71	63	57	39	0.225	0.077	1.006	0.226		1.016	0.078	
10.600	4	WB	14/12/2008	44	27.9	700	284	197	142	111	91	79	67	58	39	0.284	0.088	1.005	0.286		1.013	0.089	
10.590	4	WB	14/12/2008	44	27.3	697	322	216	154	118	98	84	71	61	40	0.324	0.107	1.008	0.326	***0.261***	1.021	0.109	***0.087***

Table B 5: Falling weight deflectometer, 2011 Report No. 11 FWD 337/1 (MRWA 2011a)

Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2004 Correction to 29C					
																Deflection (mm)	Curvature (mm)	Deflection Factor	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
19.800	2	EB	1/11/2011	46	28.7	697	490	318	229	165	124	101	83	69	45	0.492	0.173	1.001	0.493		1.003	0.173	
19.810	2	EB	1/11/2011	46	28.3	701	375	271	202	151	118	97	78	64	39	0.375	0.104	1.003	0.376		1.008	0.105	
19.820	2	EB	1/11/2011	46	28.3	698	407	280	205	150	116	95	76	62	36	0.409	0.128	1.003	0.410		1.008	0.129	
19.830	2	EB	1/11/2011	46	28.3	696	397	274	203	154	122	99	81	67	39	0.399	0.124	1.003	0.400		1.008	0.124	
19.840	2	EB	1/11/2011	46	28.3	699	442	302	221	161	126	103	84	70	42	0.443	0.140	1.003	0.444		1.008	0.141	
19.850	2	EB	1/11/2011	46	28.3	700	421	285	205	148	113	93	76	62	40	0.421	0.136	1.003	0.422		1.008	0.137	
19.860	2	EB	1/11/2011	46	28.3	701	461	309	221	161	122	100	82	68	40	0.460	0.151	1.003	0.461		1.008	0.152	
19.870	2	EB	1/11/2011	46	28.3	700	451	312	229	170	134	111	92	76	45	0.451	0.140	1.003	0.453		1.008	0.141	
19.880	2	EB	1/11/2011	46	28.4	700	405	287	216	164	131	110	91	76	45	0.405	0.118	1.002	0.406	*0.429*	1.007	0.119	*0.136*
19.700	3	EB	1/11/2011	49	29.0	702	475	314	214	147	108	86	70	60	38	0.473	0.160	1.000	0.473		1.000	0.160	
19.710	3	EB	1/11/2011	49	29.0	696	463	312	209	143	105	85	70	59	37	0.465	0.151	1.000	0.465		1.000	0.151	
19.720	3	EB	1/11/2011	49	28.9	700	500	325	214	147	111	92	76	65	41	0.500	0.175	1.000	0.500		1.001	0.175	
19.730	3	EB	1/11/2011	49	28.8	698	453	307	212	150	115	96	81	69	42	0.454	0.146	1.001	0.454		1.002	0.146	
19.740	3	EB	1/11/2011	49	29.0	697	477	320	218	150	117	97	81	69	41	0.479	0.157	1.000	0.479		1.000	0.157	
19.750	3	EB	1/11/2011	49	30.0	697	473	314	209	144	109	90	75	64	38	0.475	0.159	0.994	0.472		0.986	0.157	
19.760	3	EB	1/11/2011	49	28.9	698	473	317	214	151	115	94	78	65	38	0.475	0.157	1.000	0.475		1.001	0.157	
19.770	3	EB	1/11/2011	49	28.9	698	451	301	201	134	98	78	64	54	35	0.453	0.151	1.000	0.453		1.001	0.151	
19.780	3	EB	1/11/2011	49	29.0	701	440	282	187	128	100	85	76	68	48	0.440	0.158	1.000	0.440		1.000	0.158	
19.790	3	EB	1/11/2011	49	29.0	699	468	312	210	149	116	98	84	71	44	0.469	0.157	1.000	0.469	*0.468*	1.000	0.157	*0.157*
18.890	4	EB	1/11/2011	44	29.1	699	404	259	187	139	112	95	80	67	42	0.404	0.145	1.000	0.404		0.999	0.144	
18.900	4	EB	1/11/2011	44	29.0	700	353	255	183	133	109	95	81	69	42	0.353	0.098	1.000	0.353		1.000	0.098	
18.910	4	EB	1/11/2011	44	28.7	699	387	265	188	137	109	93	79	67	43	0.388	0.122	1.002	0.388		1.004	0.123	
18.920	4	EB	1/11/2011	44	29.0	699	408	267	181	130	105	88	75	64	41	0.408	0.141	1.000	0.408		1.000	0.141	
18.930	4	EB	1/11/2011	44	29.0	697	414	269	184	134	108	91	75	63	41	0.415	0.146	1.000	0.415		1.000	0.146	
18.940	4	EB	1/11/2011	44	28.9	704	360	257	186	136	111	95	81	68	43	0.358	0.103	1.000	0.358		1.001	0.103	
18.950	4	EB	1/11/2011	44	28.8	703	372	262	187	141	113	97	81	68	42	0.371	0.109	1.001	0.371		1.002	0.110	
18.960	4	EB	1/11/2011	44	29.0	702	370	254	179	137	112	98	84	71	45	0.369	0.116	1.000	0.369		1.000	0.116	
18.970	4	EB	1/11/2011	44	29.1	700	369	270	195	144	119	104	88	72	45	0.369	0.099	0.999	0.369		0.999	0.099	
18.980	4	EB	1/11/2011	44	29.1	697	433	299	215	165	135	117	98	82	49	0.435	0.135	0.999	0.434		0.999	0.135	
18.990	4	EB	1/11/2011	44	29.1	698	480	317	223	167	136	114	96	78	44	0.482	0.164	0.999	0.481		0.999	0.163	
19.000	4	EB	1/11/2011	44	29.0	698	415	294	211	159	126	106	88	71	39	0.416	0.122	1.000	0.416	*0.397*	1.000	0.122	*0.125*

																Normalised to 700 kPa		Normalised to 700 kPa						
																No Temp Correction		Austroads 2004 Correction to 29C						
Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Factor	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
19.885	2	WB	17/10/2011	46	31.6	698	377	268	206	159	128	107	89	74	45	0.378	0.109	0.987	0.373		0.968	0.105	
19.875	2	WB	17/10/2011	46	32.5	700	408	283	213	164	131	109	91	76	45	0.408	0.125	0.982	0.401		0.957	0.120	
19.865	2	WB	17/10/2011	46	32.5	698	427	294	223	168	134	111	92	77	45	0.428	0.133	0.982	0.420		0.957	0.127	
19.855	2	WB	17/10/2011	46	32.4	702	426	301	217	159	124	102	83	69	43	0.425	0.125	0.983	0.418		0.958	0.120	
19.845	2	WB	17/10/2011	46	32.5	698	393	284	212	162	129	107	88	72	42	0.394	0.110	0.982	0.387		0.957	0.105	
19.835	2	WB	17/10/2011	46	32.4	698	414	300	229	176	141	118	95	78	44	0.415	0.115	0.983	0.408		0.958	0.110	
19.825	2	WB	17/10/2011	46	32.4	698	405	286	219	168	134	110	90	74	42	0.406	0.119	0.983	0.399		0.958	0.114	
19.815	2	WB	17/10/2011	46	32.4	699	426	294	219	164	131	108	91	75	47	0.427	0.133	0.983	0.419		0.958	0.127	
19.805	2	WB	17/10/2011	46	32.3	699	436	308	232	170	132	108	87	72	47	0.437	0.128	0.983	0.429	***0.406***	0.960	0.123	***0.117***
19.795	3	WB	17/10/2011	53	31.7	698	433	297	210	155	125	107	91	77	48	0.434	0.136	0.984	0.427		0.959	0.130	
19.785	3	WB	17/10/2011	53	31.9	701	424	287	207	154	125	108	96	83	53	0.423	0.137	0.983	0.416		0.957	0.131	
19.775	3	WB	17/10/2011	53	31.6	700	433	289	195	138	106	89	75	63	40	0.433	0.144	0.985	0.426		0.961	0.138	
19.765	3	WB	17/10/2011	53	31.9	698	394	272	189	138	111	95	81	68	44	0.395	0.122	0.983	0.388		0.957	0.116	
19.755	3	WB	17/10/2011	53	32.1	700	422	301	218	158	123	103	89	75	46	0.422	0.120	0.982	0.414		0.954	0.115	
19.745	3	WB	17/10/2011	53	32.0	700	425	299	212	154	121	103	88	74	46	0.425	0.126	0.982	0.417		0.955	0.120	
19.735	3	WB	17/10/2011	53	31.9	699	476	334	231	167	130	110	93	79	48	0.477	0.142	0.983	0.469		0.957	0.136	
19.725	3	WB	17/10/2011	53	31.9	699	453	312	218	155	122	102	87	73	45	0.453	0.141	0.983	0.445		0.957	0.135	
19.715	3	WB	17/10/2011	53	31.9	699	449	312	219	155	118	99	84	71	45	0.450	0.138	0.983	0.442		0.957	0.132	
19.705	3	WB	17/10/2011	53	31.9	702	455	319	224	159	125	105	91	77	48	0.454	0.135	0.983	0.446	***0.429***	0.957	0.129	***0.128***
18.995	4	WB	17/10/2011	44	32.0	701	331	243	188	150	125	108	91	76	46	0.330	0.087	0.981	0.324		0.950	0.083	
18.985	4	WB	17/10/2011	44	32.4	694	342	245	184	144	118	103	88	74	45	0.345	0.097	0.978	0.337		0.944	0.092	
18.975	4	WB	17/10/2011	44	32.2	696	334	248	186	146	121	105	89	74	45	0.336	0.087	0.980	0.329		0.947	0.083	
18.965	4	WB	17/10/2011	44	31.9	696	315	225	172	136	115	99	86	73	46	0.317	0.091	0.981	0.311		0.952	0.086	
18.955	4	WB	17/10/2011	44	32.2	696	303	218	164	128	106	92	78	66	43	0.304	0.085	0.980	0.298		0.947	0.081	
18.945	4	WB	17/10/2011	44	32.1	697	296	210	156	122	101	88	77	66	42	0.298	0.087	0.980	0.292		0.948	0.082	
18.935	4	WB	17/10/2011	44	32.1	698	303	219	164	128	107	94	81	69	44	0.303	0.084	0.980	0.297		0.948	0.080	
18.925	4	WB	17/10/2011	44	32.2	695	308	221	162	126	105	88	79	66	41	0.310	0.088	0.980	0.304		0.947	0.084	
18.915	4	WB	17/10/2011	44	32.1	695	298	216	161	122	101	87	75	64	42	0.300	0.083	0.978	0.293		0.941	0.078	
18.905	4	WB	17/10/2011	44	32.4	696	288	202	151	119	100	88	78	68	46	0.289	0.086	0.976	0.282		0.936	0.081	
18.895	4	WB	17/10/2011	44	32.1	702	348	243	177	134	109	92	80	68	44	0.347	0.104	0.978	0.339		0.941	0.098	
18.885	4	WB	17/10/2011	44	32.1	698	439	299	213	157	123	101	84	70	45	0.441	0.141	0.978	0.431	***0.320***	0.941	0.133	***0.088***

Table B 6: Falling weight deflectometer, 2016 Report No. 16 FWD 491/3 (MRWA 2016f)

Station (km)	Trial Section ID	Direction	Date	Designed Asphalt Thickness (mm)	Surface Temp	Load (kPa)	Defl. 1 (Micron) 0 mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction: Deflection (mm)	Normalised to 700 kPa No Temp Correction: Curvature (mm)	Normalised to 700 kPa Austroads 2004 Correction to 29C: Deflection Factor	Corrected Deflection	Section Mean	Curvature Factor	Corrected Curvature	Section Mean
19.800	2	EB	27/06/2016	46	10.8	631	375	268	200	150	118	96	80	67	42	0.416	0.120	1.104	0.459		1.310	0.157	
19.810	2	EB	27/06/2016	46	10.9	629	350	251	189	143	113	90	75	61	35	0.389	0.110	1.104	0.429		1.390	0.153	
19.820	2	EB	27/06/2016	46	11.1	637	384	266	196	148	115	92	76	61	34	0.422	0.130	1.103	0.465		1.306	0.170	
19.830	2	EB	27/06/2016	46	11.0	631	363	249	189	144	113	92	76	63	36	0.403	0.127	1.104	0.445		1.307	0.166	
19.840	2	EB	27/06/2016	46	11.0	628	417	292	212	157	122	98	81	66	37	0.465	0.140	1.104	0.513		1.307	0.183	
19.850	2	EB	27/06/2016	46	10.5	635	423	284	203	150	116	93	78	65	41	0.467	0.153	1.104	0.516		1.314	0.201	
19.860	2	EB	27/06/2016	46	10.4	626	442	292	207	152	116	93	77	63	38	0.494	0.167	1.104	0.545		1.315	0.220	
19.870	2	EB	27/06/2016	46	10.8	632	401	282	206	156	123	100	84	68	39	0.445	0.132	1.104	0.491		1.310	0.173	
19.880	2	EB	27/06/2016	46	10.8	622	370	261	196	153	121	100	83	69	39	0.417	0.123	1.104	0.460	***0.483***	1.309	0.161	***0.178***
19.700	3	EB	27/06/2016	53	11.5	635	474	326	226	158	117	92	76	64	38	0.522	0.163	1.116	0.583		1.359	0.222	
19.710	3	EB	27/06/2016	53	11.5	630	470	320	217	154	115	89	73	61	35	0.522	0.167	1.116	0.583		1.359	0.227	
19.720	3	EB	27/06/2016	53	11.5	625	476	319	219	154	114	90	75	62	36	0.533	0.176	1.116	0.595		1.359	0.239	
19.730	3	EB	27/06/2016	53	11.0	627	461	313	219	156	120	95	79	65	37	0.515	0.165	1.118	0.576		1.369	0.226	
19.740	3	EB	27/06/2016	53	11.5	637	474	320	217	157	119	95	79	64	36	0.520	0.168	1.116	0.580		1.359	0.228	
19.750	3	EB	27/06/2016	53	11.4	628	467	301	211	152	114	90	74	60	35	0.521	0.186	1.117	0.582		1.361	0.253	
19.760	3	EB	27/06/2016	53	11.5	632	465	306	214	151	113	88	72	59	35	0.515	0.176	1.116	0.575		1.359	0.239	
19.770	3	EB	27/06/2016	53	11.6	630	447	286	193	133	96	73	60	50	32	0.497	0.179	1.116	0.555		1.357	0.243	
19.780	3	EB	27/06/2016	53	11.5	630	400	255	175	126	97	80	70	62	41	0.444	0.161	1.116	0.496		1.359	0.219	
19.790	3	EB	27/06/2016	53	11.6	633	427	290	201	144	112	91	78	66	40	0.472	0.152	1.116	0.527	***0.565***	1.375	0.209	***0.230***
19.800	2	WB	17/10/2011	46	10.1	626	410	286	196	141	111	90	77	64	40	0.458	0.139	1.104	0.506		1.318	0.183	
19.810	2	WB	17/10/2011	46	9.8	622	371	263	196	146	115	91	76	62	40	0.418	0.122	1.103	0.461		1.319	0.161	
19.820	2	WB	17/10/2011	46	10.2	626	414	293	216	162	125	99	81	64	37	0.463	0.136	1.104	0.511		1.317	0.179	
19.830	2	WB	17/10/2011	46	10.0	631	369	265	197	149	118	96	79	63	34	0.409	0.115	1.103	0.451		1.318	0.152	
19.840	2	WB	17/10/2011	46	9.7	630	361	255	191	141	109	88	71	56	30	0.401	0.118	1.102	0.442		1.320	0.156	
19.850	2	WB	17/10/2011	46	9.8	627	432	298	218	163	126	99	80	64	35	0.482	0.150	1.103	0.532		1.319	0.198	
19.860	2	WB	17/10/2011	46	9.5	632	365	258	188	140	109	87	72	58	35	0.404	0.118	1.101	0.445		1.320	0.156	
19.870	2	WB	17/10/2011	46	9.6	624	433	302	221	168	132	107	89	72	41	0.485	0.147	1.102	0.534		1.351	0.199	
19.880	2	WB	17/10/2011	46	9.7	626	356	250	187	144	115	95	80	66	37	0.398	0.118	1.111	0.442	***0.480***	1.350	0.159	***0.171***
19.700	3	WB	17/10/2011	53	9.7	629	374	269	195	147	116	93	78	65	38	0.416	0.117	1.117	0.465		1.384	0.162	
19.710	3	WB	17/10/2011	53	9.8	625	427	298	214	156	120	97	82	68	41	0.478	0.144	1.117	0.534		1.383	0.199	
19.720	3	WB	17/10/2011	53	9.8	625	391	272	198	146	116	94	80	66	39	0.438	0.133	1.117	0.489		1.383	0.184	
19.730	3	WB	17/10/2011	53	10.3	633	391	269	188	139	110	91	78	65	39	0.432	0.135	1.119	0.483		1.379	0.186	
19.740	3	WB	17/10/2011	53	10.1	624	428	297	214	157	122	99	83	68	40	0.481	0.148	1.118	0.538		1.381	0.204	
19.750	3	WB	17/10/2011	53	10.0	625	419	294	215	156	123	99	83	69	40	0.469	0.140	1.118	0.524		1.382	0.193	
19.760	3	WB	17/10/2011	53	10.0	630	335	251	191	147	117	97	83	68	39	0.373	0.094	1.118	0.417		1.382	0.129	
19.770	3	WB	17/10/2011	53	10.0	632	341	235	171	127	101	85	73	61	38	0.378	0.118	1.118	0.423		1.382	0.163	
19.780	3	WB	17/10/2011	53	10.1	625	373	260	188	141	111	91	77	64	38	0.418	0.127	1.118	0.467		1.381	0.175	
19.790	3	WB	17/10/2011	53	10.1	625	366	256	185	140	112	94	80	65	40	0.409	0.123	1.104	0.452	***0.479***	1.318	0.162	***0.176***

Table B 7: Average rut depth

Test date	Trial ID	Chainage start (km)	Chainage end (km)	3 m straight edge rut (mm)		2 m straight edge rut (mm)	
				OWP	IWP	OWP	IWP
Jul-99	R2	19.80	19.82	1.5	1.4	1.5	1.4
		19.82	19.84	1.3	2.0	1.3	2.0
		19.84	19.86	1.4	1.6	1.4	1.6
		19.86	19.90	1.3	1.7	1.3	1.7
	R3	19.70	19.72	0.9	2.7	0.9	2.7
		19.72	19.74	1.5	1.3	1.5	1.3
		19.74	19.76	1.3	1.4	1.3	1.4
		19.76	19.78	1.2	1.3	1.2	1.3
		19.78	19.80	1.5	1.2	1.4	1.2
	R4	18.88	18.90	0.7	2.1	0.7	2.1
		18.90	18.92	0.9	2.0	0.9	2.0
		18.92	18.94	0.7	2.5	0.7	2.5
		18.94	18.96	0.7	1.6	0.7	1.6
		18.96	18.98	0.6	2.2	0.6	2.2
		18.98	19.00	1.0	1.6	1.0	1.6
Oct-00	R2	19.81	19.83	1.2	2.6	1.0	2.4
		19.83	19.85	1.6	1.6	1.6	1.6
		19.85	19.87	1.6	2.0	1.6	2.0
		19.87	19.89	2.0	0.8	1.9	0.8
	R3	19.71	19.73	1.0	1.7	1.0	1.7
		19.73	19.75	0.6	1.8	0.6	1.7
		19.75	19.77	0.8	2.6	0.8	2.5
		19.77	19.79	1.1	2.6	1.0	2.4
	R4	18.88	18.90	0.8	2.1	0.8	2.1
		18.90	18.92	1.2	3.2	0.9	2.9
		18.92	18.94	1.2	3.7	1.1	3.5
		18.94	18.96	1.1	4.1	1.0	3.9
		18.96	18.98	0.9	3.6	0.8	3.4
		18.98	19.00	1.1	3.5	1.0	3.3
Dec-06	R2	19.80	19.82	1.3	2.8	1.3	2.8
		19.82	19.84	1.4	3.4	1.4	3.4
		19.84	19.86	2.0	3.1	1.9	3.0
		19.86	19.88	2.0	3.1	2.0	3.1
	R3	19.70	19.72	1.3	3.2	1.3	3.2
		19.72	19.74	1.4	3.5	1.4	3.5
		19.74	19.76	0.9	3.0	0.9	3.0
		19.76	19.78	0.9	3.7	0.9	3.7
		19.78	19.80	1.5	3.7	1.5	3.7

Test date	Trial ID	Chainage start (km)	Chainage end (km)	3 m straight edge rut (mm)		2 m straight edge rut (mm)	
				OWP	IWP	OWP	IWP
Cont…	R4	18.89	18.91	1.3	4.2	1.3	4.2
		18.91	18.93	1.2	3.6	1.2	3.6
		18.93	18.95	1.5	4.0	1.5	4.0
		18.95	18.97	1.2	4.3	1.2	4.3
		18.97	18.99	1.1	4.2	1.1	4.2
Jan-08	R2	19.80	19.82	0.9	3.6	0.9	3.6
		19.82	19.84	1.1	3.0	1.1	2.9
		19.84	19.86	1.4	3.1	1.4	3.1
		19.86	19.88	1.9	2.6	1.9	2.6
	R3	19.70	19.72	0.9	3.6	0.9	3.6
		19.72	19.74	0.7	3.3	0.7	3.3
		19.74	19.76	0.8	3.4	0.8	3.4
		19.76	19.78	0.7	3.7	0.7	3.7
		19.78	19.80	0.9	3.6	0.9	3.5
	R4	18.88	18.90	1.2	4.3	1.2	4.3
		18.90	18.92	1.3	3.5	1.3	3.5
		18.92	18.94	1.4	3.9	1.4	3.8
		18.94	18.96	1.2	4.0	1.2	4.0
		18.96	18.98	1.0	4.1	1.0	4.1
		18.98	19.00	0.9	3.8	0.9	3.8
Nov-08	R2	19.81	19.83	1.1	2.9	1.1	2.9
		19.83	19.85	1.3	2.4	1.3	2.4
		19.85	19.87	1.5	2.7	1.5	2.7
		19.87	19.89	2.1	2.0	2.1	2.0
	R3	19.71	19.73	1.3	2.9	1.3	2.9
		19.73	19.75	1.1	2.5	1.1	2.5
		19.75	19.77	1.3	2.7	1.3	2.7
		19.77	19.79	1.1	3.0	1.1	3.0
	R4	18.89	18.91	1.3	3.9	1.3	3.9
		18.91	18.93	1.3	3.0	1.3	3.0
		18.93	18.95	1.5	3.3	1.5	3.3
		18.95	18.97	1.5	3.7	1.5	3.7
		18.97	18.99	1.2	3.7	1.2	3.7
Nov-09	R2	19.80	19.82	1.5	2.7	1.5	2.7
		19.82	19.84	1.8	2.0	1.8	2.0
		19.84	19.86	1.3	2.7	1.3	2.7
		19.86	19.88	2.3	1.7	2.3	1.7
	R3	19.70	19.72	1.0	2.5	1.0	2.5
		19.72	19.74	0.8	2.4	0.8	2.4

Test date	Trial ID	Chainage start (km)	Chainage end (km)	3 m straight edge rut (mm)		2 m straight edge rut (mm)	
				OWP	IWP	OWP	IWP
Cont…	*Cont…*	19.74	19.76	1.1	2.9	1.1	2.9
		19.76	19.78	1.0	3.2	1.0	3.2
		19.78	19.80	1.1	3.1	1.1	3.1
	R4	18.88	18.90	1.4	3.2	1.4	3.2
		18.90	18.92	1.3	3.2	1.3	3.2
		18.92	18.94	1.3	3.2	1.3	3.2
		18.94	18.96	1.3	3.8	1.3	3.8
		18.96	18.98	1.1	3.3	1.1	3.3
Nov-10	R2	19.80	19.82	1.3	2.2	1.3	2.2
		19.82	19.84	1.5	2.2	1.5	2.2
		19.84	19.86	2.2	2.0	2.2	2.0
		19.86	19.90	2.0	1.8	2.0	1.8
	R3	19.70	19.72	2.0	2.6	2.0	2.6
		19.72	19.74	1.7	2.0	1.7	2.0
		19.74	19.76	1.4	1.9	1.4	1.9
		19.76	19.78	1.3	2.8	1.3	2.8
		19.78	19.80	1.4	3.5	1.4	3.5
	R4	18.88	18.90	1.2	2.9	1.2	2.9
		18.90	18.92	1.3	1.9	1.3	1.9
		18.92	18.94	1.5	2.5	1.5	2.5
		18.94	18.96	1.5	2.6	1.5	2.6
		18.96	18.98	1.3	2.5	1.3	2.5
		18.98	19.00	1.3	2.4	1.3	2.4
Dec-14	R2	19.80	19.82	-	-	1.4	4.3
		19.82	19.84	-	-	1.7	3.5
		19.84	19.86	-	-	1.4	3.4
		19.86	19.90	-	-	1.2	3.0
	R3	19.70	19.72	-	-	1.3	3.4
		19.72	19.74	-	-	1.0	2.5
		19.74	19.76	-	-	1.3	3.3
		19.76	19.78	-	-	1.5	4.1
		19.78	19.80	-	-	1.5	4.1
	R4	18.88	18.90	-	-	2.4	2.9
		18.90	18.92	-	-	2.3	2.2
		18.92	18.94	-	-	2.2	2.8
		18.94	18.96	-	-	2.0	4.7
		18.96	18.98	-	-	2.0	4.0
		18.98	19.00	-	-	1.7	3.2

Source: IRIS 26/6/2016

Table B 8: NAASRA road roughness meter results

Test date	Trial ID	NAASRA Counts/km	
		Eastbound lane	Westbound lane
Jul-99	R2	34.4	-
	R3	43.9	-
	R4	39.1	-
Oct-00	R2	45.3	31.8
	R3	37.4	30.6
	R4	40.1	36.4
Jan-02	R2	46.3	39.7
	R3	37.2	29.6
	R4	40.7	38.1
Nov-02	R2	44.4	39.9
	R3	37.5	31.1
	R4	41.8	38.7
Feb-05	R2	44.9	42.2
	R3	37.6	40.7
	R4	44.1	42.9
Dec-06	R2	47	55.5
	R3	39.9	40.9
	R4	40.3	32.1
Jan-08	R2	48.8	53.9
	R3	41.9	41.9
	R4	38.9	33
Nov-09	R2	46.9	55.2
	R3	40.1	40.9
	R4	42	33.4
Nov-10	R2	46.2	54.7
	R3	38.9	40.7
	R4	39.3	32.2

Source: IRIS 26/6/2016

B.3 Stage 2 Investigation

B.3.1 FWD Data

Table B 9: Falling weight deflectometer, 2017 Report No. 17 FWD 551/1 (MRWA 2017)

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
19.890	2	WB	18.7	49	673	381	271	192	146	118	102	85	72	41	0.396	0.115	1.059	0.420		1.164	0.133	
19.885	2	WB	18.1	46	677	446	303	208	158	126	106	87	73	42	0.461	0.147	1.059	0.488		1.161	0.171	
19.880	2	WB	17.7	46	679	364	261	198	155	127	108	88	74	44	0.375	0.106	1.062	0.398		1.169	0.124	
19.875	2	WB	17.5	46	677	365	264	198	155	126	106	86	73	43	0.378	0.105	1.063	0.402		1.173	0.123	
19.870	2	WB	17.5	46	677	407	284	202	156	125	105	85	71	42	0.421	0.128	1.063	0.448		1.173	0.150	
19.865	2	WB	17.7	46	676	435	297	210	163	130	109	88	73	43	0.451	0.144	1.062	0.479		1.169	0.168	
19.860	2	WB	17.8	46	673	454	309	221	171	135	113	90	74	42	0.472	0.151	1.061	0.501		1.167	0.176	
19.855	2	WB	17.7	46	675	409	285	205	157	126	107	87	73	42	0.424	0.128	1.062	0.450		1.169	0.150	
19.850	2	WB	17.9	46	675	471	317	219	167	132	111	90	76	48	0.488	0.159	1.060	0.518		1.165	0.186	
19.845	2	WB	17.8	46	678	491	345	256	198	161	135	109	91	54	0.507	0.151	1.061	0.538		1.167	0.176	
19.840	2	WB	17.3	46	678	472	316	224	170	134	112	90	73	40	0.488	0.161	1.065	0.519		1.177	0.190	
19.835	2	WB	17.3	46	677	379	273	203	159	125	105	84	70	40	0.392	0.110	1.065	0.418		1.177	0.129	
19.830	2	WB	17.3	46	674	409	266	187	145	117	99	79	63	35	0.425	0.148	1.065	0.452		1.177	0.174	
19.825	2	WB	17.3	46	676	412	283	202	156	125	104	84	69	38	0.426	0.133	1.065	0.454		1.177	0.157	
19.820	2	WB	17.3	46	674	388	278	206	159	127	105	83	68	37	0.403	0.115	1.065	0.429		1.177	0.135	
19.815	2	WB	17.4	46	675	424	300	215	169	134	111	87	72	40	0.440	0.129	1.064	0.468		1.175	0.151	
19.810	2	WB	17.5	46	674	443	301	216	163	128	105	84	69	41	0.460	0.147	1.063	0.489		1.173	0.172	
19.805	2	WB	17.4	46	675	395	278	202	157	123	102	81	69	44	0.410	0.121	1.064	0.436	***0.461***	1.175	0.142	***0.156***
19.800	3	WB	17.4	46	673	415	283	200	151	119	98	78	65	42	0.431	0.137	1.064	0.459		1.175	0.161	
19.795	3	WB	17.3	53	677	419	301	222	168	126	101	80	67	42	0.433	0.122	1.074	0.465		1.212	0.148	
19.790	3	WB	18.3	53	675	413	279	192	146	116	98	81	68	42	0.428	0.139	1.066	0.457		1.188	0.165	
19.785	3	WB	17.8	53	682	370	250	176	137	112	96	80	69	43	0.380	0.123	1.070	0.406		1.200	0.147	
19.780	3	WB	18.0	53	680	391	279	201	155	126	108	90	77	47	0.403	0.115	1.068	0.430		1.195	0.138	
19.775	3	WB	17.9	53	680	352	255	190	149	123	106	89	77	50	0.363	0.100	1.069	0.388		1.198	0.120	
19.770	3	WB	17.8	53	681	402	268	183	140	110	93	77	65	40	0.414	0.138	1.070	0.442		1.200	0.166	
19.765	3	WB	17.9	53	680	386	269	190	143	110	92	76	65	40	0.397	0.120	1.069	0.424		1.198	0.144	
19.760	3	WB	17.6	53	680	329	221	158	125	102	88	73	62	41	0.338	0.111	1.071	0.363		1.205	0.133	
19.755	3	WB	17.8	53	678	332	229	167	133	110	95	80	69	43	0.343	0.107	1.070	0.367		1.200	0.128	
19.750	3	WB	17.3	53	677	353	264	198	154	124	104	86	72	43	0.365	0.092	1.074	0.392		1.212	0.112	
19.745	3	WB	17.3	53	675	397	281	201	156	124	106	88	74	44	0.411	0.120	1.074	0.442		1.212	0.145	
19.740	3	WB	17.2	53	677	495	326	230	171	135	112	92	78	47	0.512	0.175	1.074	0.550		1.214	0.213	
19.735	3	WB	17.5	53	677	457	314	222	167	130	109	89	76	45	0.472	0.148	1.072	0.506		1.207	0.179	
19.730	3	WB	17.5	53	672	474	322	225	166	129	106	86	72	44	0.494	0.159	1.072	0.530		1.207	0.192	
19.725	3	WB	17.3	53	680	478	330	228	167	129	107	87	73	44	0.492	0.152	1.074	0.528		1.212	0.185	
19.720	3	WB	17.7	53	676	424	292	198	147	117	99	83	70	43	0.439	0.136	1.070	0.470		1.202	0.164	
19.715	3	WB	17.7	53	679	425	290	203	152	120	101	83	70	43	0.438	0.138	1.070	0.469		1.202	0.166	
19.710	3	WB	17.3	53	676	450	294	205	154	120	101	82	69	41	0.466	0.161	1.074	0.500		1.212	0.195	
19.705	3	WB	17.3	53	675	456	318	225	168	129	107	85	71	44	0.473	0.143	1.074	0.508		1.212	0.174	
19.700	3	WB	17.7	53	678	464	311	216	160	123	103	83	70	44	0.479	0.157	1.070	0.513	***0.457***	1.202	0.189	***0.160***

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa, No Temp Correction: Deflection (mm)	Normalised to 700 kPa, No Temp Correction: Curvature (mm)	Normalised to 700 kPa, Austroads 2008 Correction to 29°C: Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
19.890	2	WB	17.8	49	678	390	263	186	142	114	96	78	66	39	0.403	0.131	1.066	0.429		1.183	0.155	
19.885	2	WB	16.8	46	676	314	233	179	143	116	99	79	66	39	0.325	0.083	1.068	0.347		1.187	0.099	
19.880	2	WB	16.6	46	679	313	224	176	142	116	100	82	68	40	0.323	0.092	1.070	0.345		1.191	0.109	
19.875	2	WB	16.5	46	682	315	227	177	143	116	99	80	67	38	0.323	0.091	1.070	0.346		1.193	0.108	
19.870	2	WB	16.3	46	677	366	258	191	148	118	99	81	68	40	0.378	0.111	1.072	0.406		1.197	0.133	
19.865	2	WB	16.4	46	680	414	284	207	160	125	104	84	70	41	0.427	0.134	1.071	0.457		1.195	0.161	
19.860	2	WB	16.4	46	679	412	284	213	166	131	108	86	70	40	0.425	0.132	1.071	0.455		1.195	0.158	
19.855	2	WB	16.4	46	676	383	269	197	152	120	101	81	68	41	0.397	0.118	1.071	0.425		1.195	0.141	
19.850	2	WB	16.4	46	677	470	324	237	180	143	117	94	78	47	0.485	0.151	1.071	0.520		1.195	0.180	
19.845	2	WB	16.6	46	676	468	328	246	194	153	126	100	83	47	0.484	0.145	1.070	0.518		1.191	0.172	
19.840	2	WB	16.7	46	678	390	274	199	156	123	103	82	68	37	0.403	0.120	1.069	0.431		1.189	0.143	
19.835	2	WB	16.7	46	679	338	250	191	151	122	103	82	68	39	0.348	0.091	1.069	0.372		1.189	0.108	
19.830	2	WB	16.6	46	677	356	253	190	149	120	101	81	67	38	0.368	0.107	1.070	0.394		1.191	0.127	
19.825	2	WB	16.4	46	677	351	254	191	151	122	102	81	66	36	0.363	0.101	1.071	0.389		1.195	0.121	
19.820	2	WB	16.5	46	678	349	250	190	149	119	99	78	64	35	0.360	0.102	1.070	0.386		1.193	0.122	
19.815	2	WB	16.5	46	675	411	294	216	166	130	107	85	69	39	0.426	0.122	1.070	0.456		1.193	0.146	
19.810	2	WB	16.3	46	676	422	296	219	168	132	107	84	69	41	0.437	0.130	1.072	0.468		1.197	0.156	
19.805	2	WB	16.4	46	678	359	257	192	152	120	100	79	66	41	0.371	0.105	1.071	0.397	*0.419*	1.195	0.126	*0.137*
19.800	3	WB	16.3	46	678	356	260	197	152	119	99	76	63	39	0.368	0.100	1.072	0.394		1.197	0.119	
19.795	3	WB	16.3	53	679	387	296	208	149	111	91	72	61	39	0.399	0.094	1.082	0.431		1.237	0.116	
19.790	3	WB	17.2	53	675	351	243	174	133	108	92	77	66	42	0.364	0.113	1.074	0.391		1.214	0.137	
19.785	3	WB	17.4	53	677	361	249	169	131	106	92	78	67	43	0.373	0.117	1.073	0.401		1.210	0.141	
19.780	3	WB	17.3	53	680	355	251	182	143	119	104	89	77	49	0.366	0.107	1.074	0.392		1.212	0.130	
19.775	3	WB	17.2	53	674	331	243	182	141	116	99	82	70	44	0.343	0.092	1.074	0.369		1.214	0.111	
19.770	3	WB	17.3	53	677	350	241	169	126	98	83	68	58	36	0.361	0.112	1.074	0.388		1.212	0.136	
19.765	3	WB	17.2	53	676	363	251	176	134	107	90	73	62	38	0.376	0.116	1.074	0.404		1.214	0.141	
19.760	3	WB	17.1	53	677	333	233	167	128	104	89	74	64	39	0.344	0.103	1.075	0.370		1.217	0.126	
19.755	3	WB	17.2	53	675	347	244	177	138	111	95	79	66	41	0.360	0.107	1.074	0.387		1.214	0.130	
19.750	3	WB	17.1	53	675	356	255	185	143	115	97	79	67	40	0.369	0.105	1.075	0.397		1.217	0.128	
19.745	3	WB	17.1	53	678	386	275	200	151	120	101	84	71	42	0.399	0.115	1.075	0.429		1.217	0.140	
19.740	3	WB	16.7	53	677	409	285	204	156	124	105	86	73	43	0.423	0.129	1.078	0.456		1.227	0.158	
19.735	3	WB	17.3	53	679	385	276	201	154	122	103	85	72	43	0.397	0.113	1.074	0.426		1.212	0.137	
19.730	3	WB	17.4	53	673	389	277	199	151	120	100	82	69	42	0.404	0.116	1.073	0.434		1.210	0.141	
19.725	3	WB	17.3	53	678	397	277	193	147	115	97	79	66	40	0.410	0.124	1.074	0.440		1.212	0.150	
19.720	3	WB	17.2	53	679	373	262	188	141	111	93	76	64	39	0.384	0.114	1.074	0.413		1.214	0.139	
19.715	3	WB	17.1	53	682	366	260	188	143	114	95	77	65	40	0.376	0.109	1.075	0.404		1.217	0.132	
19.710	3	WB	17.1	53	681	385	271	195	147	113	93	75	64	38	0.396	0.118	1.075	0.426		1.217	0.143	
19.705	3	WB	16.9	53	681	403	278	202	152	119	100	81	68	42	0.414	0.128	1.077	0.446		1.222	0.156	
19.700	3	WB	17.2	53	679	402	280	204	155	122	103	84	72	44	0.415	0.126	1.074	0.445	*0.412*	1.214	0.153	*0.136*

B.3.2 Photographs

Figure B 1: Surface of BSL base layer at R2 (surface water from cutting process)

Figure B 2: R2 granular profile and subgrade surface

Figure B 3: Surface of CRB base layer at R3 (surface water from cutting process)

Figure B 4: R3 granular profile and subgrade surface

Figure B 5: Thin longitudinal crack in R2 OWP westbound

Figure B 6: Thin longitudinal crack in R2 OWP westbound

B.3.3 Test Certificates

mainroads WESTERN AUSTRALIA

ABN: 50 860 676 021

MOISTURE CONTENT TEST REPORT Sheet 1 of 7

Report No. **17 S6489 / 1** Reference No. Not Applicable Field No. Not Applicable

Date/s of Test 13/12/2016 Project No. WARRIP

Date Sampled 11/12/2016 Date Received 12/12/2016

Local Govt Authority City of Swan

Road Reid Hwy Westbound

Location Section 2. SLK 19.890 - 19.800

Present Use Pavement

Test Methods: WA 110.1 Soil and Granular Pavement Material Moisture Content: Convection Oven Method

Sampling Method: WA 100.1 Sampling Procedures for Soil and Manufactured Granular Materials

Sample Numbers	Longitudinal SLK	Transverse (m)	Material Type	Moisture Content (%)	Depth (mm)
S6489	19.845	LWP	Bitumen Stabilised Limestone	**4.5**	from 45 to 95
S6489	19.845	LWP	Limestone	**5.7**	from 145 to 345
S6489	19.845	LWP	Sand	**3.6**	from 470 to 570

Comments/Distribution:
TRIM File No. 16/10252

Approved Signatory
Name Mark Hopgood
Function Project Officer
Date 19/01/2017

Document:71/05/110.1 Issue:21/12/2016 TRIM:D14#628363

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ABN: 50 860 676 021

LAYER THICKNESS REPORT

Sampling Method: WA 701.1 Sheet 2 of 7

Report No. 17 S6489 / 1 Ref. No. Not Applicable Field No. Not Applicable

Date of Test 11/12/2016 Project/Contract/Job No. WARRIP

Date Sampled (Moisture Content) Not Applicable Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Swan

Road Reid Highway Westbound

Section Section 2. SLK 19.890 - 19.800

Present/Proposed Use Pavement

Test Methods WA 705.1 Preparation of Asphalt fot Testing
WA 330.1 Layer Thickness

Core No	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
4	19.885	BWP	Westbound	Dense Grade Asphalt	0 - 47	47
5	19.845	BWP	Westbound	Dense Grade Asphalt	0 - 49	49
6	19.805	BWP	Westbound	Dense Grade Asphalt	0 - 45	45
Section 2	19.845	LWP	Westbound	Dense Grade Asphalt	0 - 45	45
				Bitumen Stabilised Limestone	45 - 145	100
				Limestone	145 - 470	325
				Sand	470 +	

Comments/Distribution
Trim File No. 16/10252

Approved Signatory
Name Mark Hopgood
Function Project Officer
Date 19/01/2017

Document:71/05/330.1A Issue:12/05/2014 TRIM:D14#628264
ACCREDITATION No. 1989 SITE No. 1982

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DENSE GRADED ASPHALT TEST REPORT

Page 3 of 7

Report:	17 S6489 / 1	Contract No:	WARRIP	Field No:	Not Applicable
Date Sampled:	11/12/2016	Date Tested:	11/01/2017	Customer:	Main Roads Western Australia
Road:	Reid Highway	Sample Source:	Not Supplied		
Mix Type:	Bitumen Stabilised Limestone	Lot Number:	Not Applicable		
Sample Location:	Section 2. SLK 19.890 - 19.800				
Sampling Details:	Basecourse				
Sampling Method:	SAMPLING PROCEDURES FOR ASPHALT WA 701.1				
Preparation Method:	PREPARATION OF ASPHALT FOR TESTING WA 705.1				
Sample No.	S6489				
Reference No.	Not Applicable				

BITUMEN CONTENT AND PARTICLE SIZE DISTRIBUTION OF ASPHALT:CENTRIFUGE METHOD WA 730.1

Seive Size mm	% Passing				SPECIFICATION *
26.50mm	100				
19.00mm	100				
13.20mm	98				
9.50mm	97				
6.70mm	95				
4.75mm	93				
2.36mm	87				
1.18mm	81.7				
0.600mm	74.1				
0.300mm	52.7				
0.150mm	19.7				
0.075mm	8.2				
Bitumen Content %	1.7				

MAXIMUM DENSITY : RICE DENSITY WA 732.2

Maximum Density t/m³					

BULK DENSITY AND VOID CONTENT WA 733.1

Bulk Density t/m³					
% Air Voids					
% VMA					
% VFB					

STABILITY AND FLOW : MARSHALL METHOD WA 731.1

TEMPERATURE @ COMPACTION °C					
NUMBER OF BLOWS					
Stability kN					
Flow mm					

COMMENTS/DISTRIBUTION:
REPORTS
16/10252

APPROVED SIGNATORY:
Mark Hopgood (Project Officer)
DATE: 19/01/2017

Document 71/05/730.1 Issue 25/10/2016 TRIM D14#528103

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SOIL CLASSIFICATION TEST REPORT

Sheet 4 of 7

Report No.	17 S6489 / 1	Field No. Not Applicable	Project No. WARRIP
Date Sampled	11/12/2016	Date/s Tested	5/01/2017
Local Govt Authority	City of Swan		
Road	Reid Highway		
Location	Reid Highway Westbound SLK 19.845 Section 2, SLK 19.890 - 19.800		

Sample No.	S6489			
Reference No.	Not Applicable			
Depth, (mm)	470			
Sample Location	19.845 SLK LWP			
Field Description	Sand			
Present Use	Subgrade			
PSD WA 115.1	Sampling Method: WA 100.1			
Percent Retained on Sieve Size 37.50 mm	0			
Sieve Size (mm)	**% Passing**			
125.00	-	-	-	-
106.00	-	-	-	-
75.00	-	-	-	-
53.00	-	-	-	-
37.50	-	-	-	-
26.50	-	-	-	-
19.00	-	-	-	-
13.20	-	-	-	-
9.50	-	-	-	-
6.70	-	-	-	-
4.75	-	-	-	-
2.36	100	-	-	-
1.18	100	-	-	-
0.600	87	-	-	-
0.425	63	-	-	-
0.300	31	-	-	-
0.150	8	-	-	-
0.075	5	-	-	-
0.0135	4	-	-	-
LL WA 120.2 (%)	-	-	-	-
PL WA 121.1 (%)	-	-	-	-
PI WA 122.1 (%)	-	-	-	-
LS WA 123.1 (%)	-	-	-	-
GROUP SYMBOL (AS 1726 App A Sect A2)	Not Applicable			

Comments / Distribution TRIM File No. 16/10252	Approved Signatory Name Mark Hopgoood Function Project Officer Date 19/01/2017

Document:71/05/115.1 Issue:17/09/2015 D14#628373

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FIELD DENSITY TEST REPORT

Page 5 of 7

Report No.	17 S6489 / 1	Ref. No.	Not Applicable	Field No.	Not Applicable
Date Sampled	11/12/2016	Date/s of Test	11/12/2016	Test Depth	50 mm DT
Local Govt. Authority			City of Swan		
Road			Reid Highway Westbound		
Section			Section 2, SLK 19.890 - 19.800		
Project/Contract No.	WARRIP	Present / Proposed Use		Basecourse	
Field Description			Bitumen Stabilised Limestone		

WA 134.1 Dry Density Ratio — MDD Value Used: Mean ☐ Individual ☑

WA 136.1 Moisture Ratio — OMC Value Used: Mean ☐ Individual ☐

Chainage (m)	Transverse (m)	Dry Density (t/m³) *	MDD (t/m³)	R_D %	Moisture Content % **	OMC %	R_W %
19.845	LWP	1.827			4.5		

* Density: WA 324.2 ☑ WA 324.1 ☐ ** Moisture: WA 110.1 ☑ WA 110.2 ☐

Compaction: WA 133.1 ☐ WA 133.2 ☐ WA 132.1 ☐ WA 132.2 ☐

Sample No.	MDD t/m³	OMC %	Sample No.	MDD t/m³	OMC %

Sampling Method: W

Mean MDD	t/m³	Mean OMC	%
Std Dev MDD	t/m³	Std Dev OMC	%

Dry Density Ratio	Mean	%	Moisture Ratio	Mean	%
	Std Dev	%		Std Dev	%
	k Factor			k Factor	
Char. Density ($R_C = R_D - k.s$)		%	Char. Moisture ($R_C = R_W + k.s$)		%
Specification		%	Specification		%

Comments/Distribution
TRIM File No. 16/10252

Approved Signatory

Name Mark Hopgood
Function Project Officer
Date 19/01/2017

Document:71/05/324.2 Issue:07/04/2016 TRIM:D14#628257

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FIELD DENSITY TEST REPORT

Page 6 of 7

Report No.	17 S6489 / 1	Ref. No.	Not Applicable	Field No.	Not Applicable
Date Sampled	11/12/2016	Date/s of Test	11/12/2016	Test Depth	200 mm DT
Local Govt. Authority	City of Swan				
Road	Reid Highway Westbound				
Section	Section 2. SLK 19.890 - 19.800				
Project/Contract No.	WARRIP	Present / Proposed Use	Subbase		
Field Description	Limestone				

WA 134.1 Dry Density Ratio — MDD Value Used: Mean ☐ Individual ☑

WA 136.1 Moisture Ratio — OMC Value Used: Mean ☐ Individual ☐

Chainage (m)	Transverse (m)	Dry Density (t/m³) *	MDD (t/m³)	R_D %	Moisture Content % **	OMC %	R_W %
19.845	LWP	1.920			5.7		

* Density: WA 324.2 ☑ WA 324.1 ☐ ** Moisture: WA 110.1 ☑ WA 110.2 ☐

Compaction: WA 133.1 ☐ WA 133.2 ☐ WA 132.1 ☐ WA 132.2 ☐

Sample No.	MDD t/m³	OMC %	Sample No.	MDD t/m³	OMC %

Sampling Method: W

Mean MDD		t/m³	Mean OMC		%
Std Dev MDD		t/m³	Std Dev OMC		%

Dry Density Ratio	Mean	%	Moisture Ratio	Mean	%
	Std Dev	%		Std Dev	%
	k Factor			k Factor	
Char. Density ($R_C = R_D - k.s$)		%	Char. Moisture ($R_C = R_W + k.s$)		%
Specification		%	Specification		%

Comments/Distribution
TRIM File No. 16/10252

Approved Signatory [signature]
Name: Mark Hopgood
Function: Project Officer
Date: 19/01/2017

Document:71/05/324.2 Issue:07/04/2016 TRIM:D14#628257

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DETERMINATION OF THE PENETRATION RESISTANCE OF SOIL
TEST REPORT

Sheet 7 of 7

Report No.	17 S6489 / 1	Reference No.	Not Applicable	Field No.	Not Applicable
Date Sampled	11/12/2016	Date/s Tested	11/12/2016	Project No.	WARRIP
Local Govt Authority	City Of Swan				
Road	Reid Highway Westbound				
Location	Section 2. SLK 19.890 - 19.800				
Present Use	Pavement Subgrade				
Soil Description	Yellow Sand				

Tested in accordance with test method: AS 1289.6.3.2

Sampling Method:

Moisture Content Method:

Depth below surface at the commencement of penetration: 470 mm

Reduced level of ground surface at test site: Not Applicable R.L.

Location of ground water table, if intersected or known: Unknown

Depth from surface for moisture condition of soil determination	Moisture Content or wet or dry
mm	
mm	
mm	
mm	
mm	

Penetration depth from surface (mm) Start	Finish	Penetration (mm)	Cumulative number of blows (blows)	* Calculated CBR (%)
470	690	220	70	87

Comments / Distribution
* Calculated CBR is not NATA accredited.
TRIM File No. 16/10252

Approved Signatory

Name Mark Hopggod
Function Project Officer
Date 19/01/2017

Document:71/05/1289.6.3.2 Issue:12/05/2014 TRIM:D14#629041

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MOISTURE CONTENT TEST REPORT

Sheet 1 of 8

Report No.	17 S6490 / 1	Reference No.	Not Applicable	Field No.	Not Applicable
Date/s of Test	13/12/2016			Project No.	WARRIP
Date Sampled	11/12/2016	Date Received	12/12/2016		
Local Govt Authority	City of Swan				
Road	Reid Hwy Westbound				
Location	Section 3, SLK 19.800 - 19.700				
Present Use	Pavement				
Test Methods:	WA 110.1 Soil and Granular Pavement Material Moisture Content: Convection Oven Method				
Sampling Method:	WA 100.1 Sampling Procedures for Soil and Manufactured Granular Materials				

Sample Numbers	Longitudinal SLK	Transverse (m)	Material Type	Moisture Content (%)	Depth (mm)
S6490	19.75	LWP	Crushed Rock Base	3.2	from 45 to 95
S6490	19.75	LWP	Limestone	5.8	from 125 to 325
S6490	19.75	LWP	Sand	3.3	from 380 to 480

Comments/Distribution:
TRIM File No. 16/10252

Approved Signatory

Name Mark Hopgood
Function Project Officer
Date 19/01/2017

Document 71/05/110.1 Issue:21/12/2016 TRIM:D14#628363

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LAYER THICKNESS REPORT

Sampling Method: WA 701.1 Sheet 2 of 8

Report No. 17 S6490 / 1 Ref. No. Not Applicable Field No. Not Applicable

Date of Test 11/12/2016 Project/Contract/Job No. WARRIP

Date Sampled (Moisture Content) Not Applicable Date of Test (Moisture Content) Not Applicable

Local Govt Authority City of Swan

Road Reid Highway Westbound

Section Section 3. SLK 19.800 - 19.700

Present/Proposed Use Pavement

Test Methods WA 705.1 Preparation of Asphalt fot Testing
WA 330.1 Layer Thickness

Core No.	Chainage / SLK (m)	Transverse Position (m)	Carriageway / Lane	Material Type	Depth From - To (mm)	Layer Thickness (mm)
7	19.795	BWP	Westbound	Dense Grade Asphalt	0 - 39	39
8	19.750	BWP	Westbound	Dense Grade Asphalt	0 - 47	47
9	19.705	BWP	Westbound	Dense Grade Asphalt	0 - 51	51
Section 3	19.750	LWP	Westbound	Dense Grade Asphalt	0 - 45	45
				Crushed Rock Base	45 - 125	80
				Limestone	125 - 380	255
				Sand	380 +	

Comments/Distribution
TRIM File No. 16/10252

Approved Signatory
Name Mark Hopgood
Function Project Officer
Date 19/01/2017

Document:71/05/330.1A Issue:12/05/2014 TRIM:D14#628264
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SOIL CLASSIFICATION TEST REPORT

Sheet 3 of 8

Report No.	17 S6490 / 1	Field No.	Not Applicable	Project No.	WARRIP
Date Sampled	11/12/2016	Date/s Tested		6/01/2016	
Local Govt Authority	City Of Swan				
Road	Reid Highway				
Location	Reid Highway Westbound SLK 19.750 Section 3. 19.800 - 19.700				

Sample No.	S6490			
Reference No.	Not Applicable			
Depth, (mm)	45			
Sample Location	19.750 SLK LWP			
Field Description	Crushed Rock Base			
Present Use	Basecourse			
PSD WA 115.1	**Sampling Method:** WA 100.1			
Percent Retained on Sieve Size 37.50 mm	0			
Sieve Size (mm)	**% Passing**			
125.00	-	-	-	-
106.00	-	-	-	-
75.00	-	-	-	-
53.00	-	-	-	-
37.50	-	-	-	-
26.50	100	-	-	-
19.00	99	-	-	-
13.20	84	-	-	-
9.50	70	-	-	-
6.70	61	-	-	-
4.75	55	-	-	-
2.36	39	-	-	-
1.18	28	-	-	-
0.600	21	-	-	-
0.425	18	-	-	-
0.300	15	-	-	-
0.150	12	-	-	-
0.075	9	-	-	-
0.0135	5	-	-	-
LL WA 120.2 (%)	-	-	-	-
PL WA 121.1 (%)	-	-	-	-
PI WA 122.1 (%)	-	-	-	-
LS WA 123.1 (%)	-	-	-	-
GROUP SYMBOL (AS 1726 App A Sect A2)				

Comments / Distribution

TRIM File No. 16/10252

Approved Signatory

Name: Mark Hopgood
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Date: 19/01/2017

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SOIL CLASSIFICATION TEST REPORT

Sheet 4 of 8

Report No.	17 S6490 / 1	Field No.	Not Applicable	Project No.	WARRIP
Date Sampled	11/12/2016	Date/s Tested			11/01/2017
Local Govt Authority	City of Swan				
Road	Reid Highway				
Location	Reid Highway Westbound SLK 19.750 Section 3. SLK 19.800 - 19.700				

Sample No.	S6490			
Reference No.	Not Applicable			
Depth, (mm)	125			
Sample Location	19.750 SLK LWP			
Field Description	Limestone			
Present Use	Subbase			
PSD WA 115.1	Sampling Method:	WA 100.1		
Percent Retained on Sieve Size 37.50 mm	3			
Sieve Size (mm)	**% Passing**			
125.00	-	-	-	-
106.00	-	-	-	-
75.00	100	-	-	-
53.00	-	-	-	-
37.50	97	-	-	-
26.50	-	-	-	-
19.00	91	-	-	-
13.20	-	-	-	-
9.50	-	-	-	-
6.70	-	-	-	-
4.75	-	-	-	-
2.36	71	-	-	-
1.18	-	-	-	-
0.600	-	-	-	-
0.425	-	-	-	-
0.300	-	-	-	-
0.150	-	-	-	-
0.075	-	-	-	-
0.0135	-	-	-	-
LL WA 120.2 (%)	-	-	-	-
PL WA 121.1 (%)	-	-	-	-
PI WA 122.1 (%)	-	-	-	-
LS WA 123.1 (%)	-	-	-	-
GROUP SYMBOL (AS 1726 App A Sect A2)	Not Applicable			

Comments / Distribution
TRIM File No. 16/10252

Approved Signatory

Name Mark Hopgood
Function Project Officer
Date 19/01/2017

Document:71/05/115.1 Issue 17/06/2015 D14#628373

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SOIL CLASSIFICATION TEST REPORT

Sheet 5 of 8

Report No.	17 S6490 / 1	Field No.	Not Applicable	Project No.	WARRIP
Date Sampled	11/12/2016	Date/s Tested		5/01/2017	
Local Govt Authority	City of Swan				
Road	Reid Highway				
Location	Reid Highway Westbound SLK 19.750 Section 3. SLK 19.800 - 19.700				

Sample No.	S6490			
Reference No.	Not Applicable			
Depth, (mm)	380			
Sample Location	19.750 SLK LWP			
Field Description	Sand			
Present Use	Subgrade			
PSD WA 115.1	Sampling Method: WA 100.1			
Percent Retained on Sieve Size 37.50 mm	0			
Sieve Size (mm)	**% Passing**			
125.00	-	-	-	-
106.00	-	-	-	-
75.00	-	-	-	-
53.00	-	-	-	-
37.50	-	-	-	-
26.50	-	-	-	-
19.00	-	-	-	-
13.20	-	-	-	-
9.50	-	-	-	-
6.70	-	-	-	-
4.75	-	-	-	-
2.36	100	-	-	-
1.18	100	-	-	-
0.600	87	-	-	-
0.425	61	-	-	-
0.300	30	-	-	-
0.150	9	-	-	-
0.075	6	-	-	-
0.0135	5	-	-	-
LL WA 120.2 (%)	-	-	-	-
PL WA 121.1 (%)	-	-	-	-
PI WA 122.1 (%)	-	-	-	-
LS WA 123.1 (%)	-	-	-	-
GROUP SYMBOL (AS 1726 App A Sect A2)	Not Applicable			

Comments / Distribution TRIM File No. 16/10252	Approved Signatory Name: Mark Hopgoood Function: Project Officer Date: 19/01/2017

Document:71/05/115.1 Issue:17/09/2015 D14#628373

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FIELD DENSITY TEST REPORT

Page 6 of 8

Report No.	17 S6490 / 1	Ref. No.	Not Applicable	Field No.	Not Applicable
Date Sampled	11/12/2016	Date/s of Test	11/12/2016	Test Depth	50 mm DT
Local Govt. Authority	City of Swan				
Road	Reid Highway Westbound				
Section	Section 3, SLK 19.800 - 19.700				
Project/Contract No.	WARRIP	Present / Proposed Use	Basecourse		
Field Description	Crushed Rock Base				

WA 134.1 Dry Density Ratio — MDD Value Used: Mean ☐ Individual ☑

WA 136.1 Moisture Ratio — OMC Value Used: Mean ☐ Individual ☐

Chainage (m)	Transverse (m)	Dry Density (t/m³) *	MDD (t/m³)	R_D %	Moisture Content % **	OMC %	R_W %
19.750	LWP	2.116			3.2		

* Density: WA 324.2 ☑ WA 324.1 ☐ ** Moisture: WA 110.1 ☑ WA 110.2 ☐

Compaction: WA 133.1 ☐ WA 133.2 ☐ WA 132.1 ☐ WA 132.2 ☐

Sample No.	MDD t/m³	OMC %	Sample No.	MDD t/m³	OMC %

Sampling Method: W

Mean MDD		t/m³	Mean OMC		%
Std Dev MDD		t/m³	Std Dev OMC		%

Dry Density Ratio	Mean	%	Moisture Ratio	Mean	%
	Std Dev	%		Std Dev	%
	k Factor			k Factor	
Char. Density ($R_C = R_D - k.s$)		%	Char. Moisture ($R_C = R_W + k.s$)		%
Specification		%	Specification		%

Comments/Distribution
TRIM File No. 16/10252

Approved Signatory
Name: Mark Hopgood
Function: Project Officer
Date: 19/01/2017

Document:71/05/324.2 Issue:07/04/2016 TRIM:D14#628257

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FIELD DENSITY TEST REPORT

Page 7 of 8

Report No.	17 S6490 / 1	Ref. No.	Not Applicable	Field No.	Not Applicable
Date Sampled	11/12/2016	Date/s of Test	11/12/2016	Test Depth	200 mm DT
Local Govt. Authority	City of Swan				
Road	Reid Highway Westbound				
Section	Section 3. SLK 19.800 - 19.700				
Project/Contract No.	WARRIP	Present / Proposed Use	Subbase		
Field Description	Limestone				

WA 134.1 Dry Density Ratio — MDD Value Used: Mean ☐ Individual ☑

WA 136.1 Moisture Ratio — OMC Value Used: Mean ☐ Individual ☐

Chainage (m)	Transverse (m)	Dry Density (t/m³) *	MDD (t/m³)	R_D %	Moisture Content % **	OMC %	R_W %
19.750	LWP	1.888			5.8		

* Density: WA 324.2 ☑ WA 324.1 ☐ ** Moisture: WA 110.1 ☑ WA 110.2 ☐

Compaction: WA 133.1 ☐ WA 133.2 ☐ WA 132.1 ☐ WA 132.2 ☐

Sample No.	MDD t/m³	OMC %	Sample No.	MDD t/m³	OMC %

Sampling Method: W

Mean MDD	t/m³	Mean OMC	%
Std Dev MDD	t/m³	Std Dev OMC	%

Dry Density Ratio	Mean	%	Moisture Ratio	Mean	%
	Std Dev	%		Std Dev	%
	k Factor			k Factor	
Char. Density ($R_C = R_D - k.s$)		%	Char. Moisture ($R_C = R_W + k.s$)		%
Specification		%	Specification		%

Comments/Distribution
TRIM File No. 16/10252

Approved Signatory

Name: Mark Hopgood
Function: Project Officer
Date: 19/01/2017

Document:71/05/324.2 Issue:07/04/2016 TRIM:D14#528257

NATA Accredited for compliance with ISO/IEC 17025 ACCREDITATION No. 1989 SITE No. 1982

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DETERMINATION OF THE PENETRATION RESISTANCE OF SOIL
TEST REPORT

Sheet 8 of 8

Report No. 17 S6490 / 1 Reference No. Not Applicable Field No. Not Applicable
Date Sampled 11/12/2016 Date/s Tested 11/12/2016 Project No. WARRIP
Local Govt Authority City Of Swan
Road Reid Highway Westbound
Location Section 3. SLK 19.800 - 19.700
Present Use Pavement Subgrade
Soil Description Yellow Sand

Tested in accordance with test method: AS 1289.6.3.2
Sampling Method:
Moisture Content Method:

Depth below surface at the commencement of penetration: 380 mm
Reduced level of ground surface at test site: Not Applicable R.L.
Location of ground water table, if intersected or known: Unknown

Depth from surface for moisture condition of soil determination	Moisture Content or wet or dry
mm	
mm	
mm	
mm	
mm	

Penetration depth from surface (mm) Start		Finish	Penetration (mm)	Cumulative number of blows (blows)	* Calculated CBR (%)
380	-	555	175	70	114
	-				
	-				
	-				
	-				
	-				
	-				

Comments / Distribution
* Calculated CBR is not NATA accredited.
TRIM File No. 16/10252

Approved Signatory
Name Mark Hopggod
Function Project Officer
Date 19/01/2017

Document:71/05/1289.6.3.2 Issue:12/05/2014 TRIM:D14#629041

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B.3.4 Summary of Laboratory Testing

Table B 10: Reid Highway investigation: In situ nuclear density and moisture results

ID	Material	Moisture (%)	In situ nuclear density (t/m^3)	Mean in situ density at construction (t/m3)
R2	BSL	4.5	1.83	1.85
	Limestone	5.7	1.92	1.90
	Sand	3.5	–	–
R3	CRB	3.2	2.12	2.34
	Limestone	5.8	1.89	1.83
	Sand	3.3	–	–

Table B 11: Reid Highway investigation: BSL PSD

Sieve size (mm)	% Passing
	R2
26.5	100
19.0	100
13.2	98
9.50	97
6.70	95
4.75	93
2.36	87
1.18	82
0.600	74
0.300	53
0.150	20
0.075	8

Table B 12: Reid Highway investigation: CRB PSD

Sieve size (mm)	% Passing	
	R3	Mean PSD from construction report
26.5	100	–
19.0	99	100
13.2	84	91
9.50	70	–
6.70	61	–
4.75	55	55
2.36	39	40
1.18	28	30
0.600	21	22
0.425	18	19
0.300	15	16
0.150	12	12
0.075	9	9
0.0135	5	5

Table B 13: Reid Highway investigation: limestone subbase PSD

Sieve size (mm)	% Passing
	R3
75.0	100
37.5	97
19.0	91
2.36	71

Table B 14: Reid Highway investigation: in situ subgrade DCP results

ID	Penetration (mm/blow)	Calculated CBR
R2	3.1	87
R3	2.5	114

- CRB calculated as per Clause 3.7.2 ERN9

Table B 15: Reid Highway investigation: Subgrade PSD

Sieve size (mm)	% Passing	
	R2	R3
2.36	100	100
1.18	100	100
0.600	87	87
0.425	63	61
0.300	31	30
0.150	8	9
0.075	5	6
0.0135	4	5

APPENDIX C KWINANA FREEWAY DATA

C.1 Results of RLT Testing of CRB and Limestone Subbase

The results of repeat load triaxial (RLT) testing on the CRB and limestone subbase under various stress conditions are shown in Table C 1 to Table C 4.

Table C 1: RLT modulus: CRB (stress conditions 94/30 kPa, 28 day curing period)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
28 day curing period				
09M276AA	100	99.2	63.6	423
09M276AB	100	99.7	60.3	403
09M276AC	100	99.1	54.5	537
09M276AD	150	99.1	62.1	380
09M276AE	150	98.6	59.6	406
09M276AF	150	99.1	53.4	610
Average		***99.1***	***58.9***	***460***

Table C 2: RLT modulus: CRB (stress conditions 240/120 kPa, 28 day curing period)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
28 day curing period				
09M276AA	100	99.2	63.6	656
09M276AB	100	99.7	60.3	651
09M276AC	100	99.1	54.5	797
09M276AD	150	99.1	62.1	631
09M276AE	150	98.6	59.6	647
09M276AF	150	99.1	53.4	848
Average		***99.1***	***58.9***	***705***

Table C 3: RLT modulus: limestone subbase (stress conditions 94/30 kPa, various curing periods)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
28 day curing period				
09M161AA	100	94.7	91.2	413
09M161AC	100	94.4	73.1	431
09M161AD	100	93.9	62.6	429
09M161BA	150	94.2	88.7	442
09M161BB	150	94.3	81.6	443
09M161BC	150	94.3	71.7	455
09M161BD	150	94.3	61.5	487
09M161CA	100	94.2	92	403
09M161CB	100	94.5	77.8	423
09M161CC	100	94.4	72.3	401
09M161CD	100	94.2	60.9	471
09M161DA	150	94.2	90.9	460
09M161DB	150	94.2	79.4	502
09M161DC	150	94.2	72.5	477

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
28 day curing period				
09M161DD	150	94.0	62.1	523
Average		***94.3***	***75.9***	***451***
180 day curing period				
09M161AE	100	94.8	86.5	408
09M161AF	100	94.3	76.6	392
09M161AG	100	94.3	72.6	410
09M161BE	150	94.2	89.2	452
09M161BF	150	94.4	79.9	418
09M161BG	150	94.2	70.6	449
09M161BH	150	94.1	57.1	563
09M161CE	100	94.2	93.3	414
09M161CF	100	94.2	83	441
09M161CG	100	94.1	70.8	477
09M161CH	100	94.3	59.6	510
09M161DF	150	94.1	78.7	449
09M161DG	150	94.2	72.3	482
09M161DH	150	94.3	57.9	558
Average		***94.3***	***74.9***	***459***
365 day curing period				
09M161AI	100	93.5	89.1	395
09M161AJ	100	94.6	79.9	468
09M161AK	100	94.4	69.8	439
09M161AL	100	94.5	59.7	523
09M161BI	150	94.2	89.6	393
09M161BK	150	94.3	70.5	428
09M161BL	150	94.2	62.5	462
09M161CJ	100	93.5	80	483
09M161CK	100	94.1	71	517
09M161CL	100	94.4	62.4	581
09M161DK	150	93.4	66.5	490
09M161DL	150	93.6	63.4	480
Average		***94.1***	***72.0***	***472***
730 day curing period				
09M161AO	150	94.2	70.5	418
09M161CM	150	94.2	83.4	448
09M161CN	150	94.1	78.8	423
09M161DO	150	94.1	79.1	428
09M161DP	150	94.4	70.4	431
09M161DM	150	94.1	59.7	471
Average		***94.2***	***73.7***	***437***

Table C 4: RLT modulus: limestone subbase (stress conditions 240/120 kPa, various curing periods)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
28 day curing period				
09M161AA	100	94.7	91.2	571
09M161AC	100	94.4	73.1	566
09M161AD	100	93.9	62.6	574
09M161BA	150	94.2	88.7	594
09M161BB	150	94.3	81.6	601
09M161BC	150	94.3	71.7	601
09M161BD	150	94.3	61.5	641
09M161CA	100	94.2	92.0	541
09M161CB	100	94.5	77.8	590
09M161CC	100	94.4	72.3	545
09M161CD	100	94.2	60.9	618
09M161DA	150	94.2	90.9	624
09M161DB	150	94.2	79.4	686
09M161DC	150	94.2	72.5	645
09M161DD	150	94.0	62.1	714
Average		***94.3***	***75.9***	***607***
180 day curing period				
09M161AE	100	94.8	86.5	567
09M161AF	100	94.3	76.6	527
09M161AG	100	94.3	72.6	566
09M161BE	150	94.2	89.2	599
09M161BF	150	94.4	79.9	579
09M161BG	150	94.2	70.6	626
09M161BH	150	94.1	57.1	720
09M161CE	100	94.2	93.3	560
09M161CF	100	94.2	83	596
09M161CG	100	94.1	70.8	636
09M161CH	100	94.3	59.6	682
09M161DF	150	94.1	78.7	625
09M161DG	150	94.2	72.3	652
09M161DH	150	94.3	57.9	751
Average		***94.3***	***74.9***	***620***
365 day curing period				
09M161AI	100	93.5	89.1	517
09M161AJ	100	94.6	79.9	563
09M161AK	100	94.4	69.8	556
09M161AL	100	94.5	59.7	638
09M161BI	150	94.2	89.6	521
09M161BK	150	94.3	70.5	580
09M161BL	150	94.2	62.5	630
09M161CJ	100	93.5	80	575
09M161CK	100	94.1	71	645

09M161CL	100	94.4	62.4	703
09M161DK	150	93.4	66.5	678
09M161DL	150	93.6	63.4	673
Average		***94.1***	***72.0***	***607***
730 day curing period				
09M161AO	150	94.2	70.5	418
09M161CM	150	94.2	83.4	448
09M161CN	150	94.1	78.8	423
09M161DO	150	94.1	79.1	428
09M161DP	150	94.4	70.4	431
09M161DM `	150	94.1	59.7	471
Average		***94.2***	***73.7***	***589***

C.2 Results of RLT Testing of BSL, Limestone Subbase and Sand

The results of RLT testing conducted on the BSL, limestone subbase and sand under a range of test conditions are presented in Table C 5 to Table C 11.

Table C 5: RLT modulus: BSL (stress conditions 94/30 kPa, various curing periods)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
29 day curing period				
09M262A	100	100.2	52.0	430
09M262B	100	100.2	51.3	398
Average		***100.2***	***51.7***	***414***
74 day curing period				
09M262D	100	100.3	51.6	534
09M262F	100	100.3	51.6	524
Average		***100.3***	***51.6***	***529***

Table C 6: RLT modulus: BSL (stress conditions 240/120 kPa, various curing periods)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
29 day curing period				
09M262A	100	100.2	52.0	670
09M262B	100	100.2	51.3	624
Average		***100.2***	***51.7***	***647***
74 day curing period				
09M262D	100	100.3	51.6	797
09M262F	100	100.3	51.6	823
Average		***100.3***	***51.6***	***810***

Table C 7: RLT modulus: limestone subbase (stress conditions 94/30 kPa, various curing periods)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
28 day curing period				
12M7B	100	100.1	35.8	1035
12M7C	100	100.1	36.1	1170
12M7G	100	100.0	42.1	826
12M7I	100	100.1	41.5	849
12M7N	150	99.9	36.6	1070
12M7O	150	100.0	39.1	603
Average		***100.0***	***38.5***	***926***
90 day curing period				
12M7D	100	100.0	35.9	972
12M7J	100	99.9	41.8	906
12M7L	100	100.1	41.7	939
12M7Q	150	99.3	34.4	823
12M7R	150	99.3	34.2	942
12M7T	150	99.4	38.1	893
Average		***99.7***	***37.7***	***913***

Table C 8: RLT modulus: limestone subbase (stress conditions 240/120 kPa, various curing periods)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
28 day curing period				
12M7B	100	100.1	35.8	1385
12M7C	100	100.1	36.1	1310
12M7G	100	100.0	42.1	1056
12M7I	100	100.1	41.5	1164
12M7N	150	99.9	36.6	1456
12M7O	150	100.0	39.1	838
Average		***100.0***	***38.5***	***1202***
90 day curing period				
12M7D	100	100.0	35.9	1500
12M7J	100	99.9	41.8	1224
12M7L	100	100.1	41.7	1281
12M7Q	150	99.3	34.4	1129
12M7R	150	99.3	34.2	1227
12M7T	150	99.4	38.1	1220
Average		***99.7***	***37.7***	***1264***

Table C 9: RLT modulus: sand (stress conditions 83/25 kPa, various curing periods)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
7 day curing period				
12M212	150	96.4	17.1	379
28 day curing period				
12M212	150	96.6	17.5	317

Table C 10: RLT modulus: sand (stress conditions 94/30 kPa, various curing periods)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
7 day curing period				
12M212	150	96.4	17.1	386
28 day curing period				
12M212	150	96.6	17.5	324

Table C 11: RLT modulus: sand (stress conditions 240/120 kPa, various curing periods)

Sample	Specimen diameter (mm)	Tested density ratio (%)	Tested moisture ratio (%)	Modulus (MPa)
7 day curing period				
12M212	150	96.4	17.1	443
28 day curing period				
12M212	150	96.6	17.5	381

C.3 Specifications

WA 324.2	Dry Density and Moisture Content: Nuclear Method
WA 330.1	Layer Thickness: Direct Measurement
WA 717.1	Dispersion of Bitumen in Soil
WA 730.1	Bitumen Content and Particle Size Distribution of Asphalt and Stabilised Soil: Centrifuge Method
WA 910.1	Chlorides and Total Soluble Salts in Soils and Water
WA 915.1	Calcium Carbonate Content

SOUTHERN GATEWAY ALLIANCE
Specifications

Specification 100	GENERAL REQUIREMENTS
Specification 302	EARTHWORKS
Specification 303	PITS AND QUARRIES
Specification 503	BITUMINOUS SURFACING
Specification 504	ASPHALT SURFACING

501.03 DEFINITIONS

1. The following particular definitions shall apply:

a) PAVEMENT LAYER shall be any layer above subgrade and will include shoulders.

b) RETAINED PAVEMENT shall be that portion of existing pavement remaining after removal of the existing seal.

2. Water used in any pavement construction or pavement material manufacture process shall comply with the requirements of Main Roads Western Australia publication 6706-02-133 "Water to be used in Pavement Construction" and shall be free from significant quantities of suspended material, organic matter, oil or acid. ***Water***

501.04 – 501.05 NOT USED

PRODUCTS AND MATERIALS

501.06 GRAVEL SUB-BASE – NOT USED

501.07 CRUSHED LIMESTONE SUB-BASE (FREEWAY HIGHWAY AND LOCAL ROADS)

501.07.01 GENERAL

1. This specification recognises that the limestone from the pits in the southern section (Highway) of the project may be evaluated on different criteria and it may not be possible to achieve the required

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properties according to the Standard 501 Pavements specification. Recommendations based on experience from the South West Region have been included to select limestone for this section of the project, which may be used for the sealed pavements (Described as *Highway or Local Roads* in the specification). Sub base for asphalt pavements should comply with the *Freeway* specification.

2. Research has shown that limestone produced within the envelope to a coarser grading produces a sub base with a higher CBR. Every effort should be made to produce material to the coarser grading.

3. The source material for the supply of crushed limestone shall be free of organic material, clay lumps, cap rock or any other foreign material deleterious to its performance in the pavement.

501.07.02 PARTICLE SIZE DISTRIBUTION – WA 115.1

Particle Size Distribution

1. The material shall comply with the grading limits shown in Table 501.03.

TABLE 501.03 PARTICLE SIZE DISTRIBUTION (CRUSHED LIMESTONE SUB-BASE)

AS Sieve Size (mm)	% Passing by Mass (Note1)	
	Freeway Limits	Highway and Local roads Limits
100	100	100
75	88 - 100	88 - 100
19	55 – 85	55 – 85
2.36	35 – 65	35 – 65
0.425	N/A	10 - 50
0.075	N/A	0 - 20

Note 1 The envelope for this product is very wide based on local and regional experience. Trials conducted on various sites have shown that material crushed to the coarser side of the envelope produces a sub base layer with higher CBR and stiffness. Every effort should be made to achieve the coarser grading.

501.07.03 OTHER ACCEPTANCE LIMITS

Other Acceptance Limits

1. The material shall comply with the grading limits shown in Table 501.04.

TABLE 501.04 OTHER ACCEPTANCE LIMITS (CRUSHED LIMESTONE)

Test	Freeway Limits	Highway Limits	Test method
Los Angeles Abrasion Value of Crushed Limestone	20% Minimum, 60% Maximum		WA 220.2
Calcium Carbonate Content	60% Minimum	See Note 1 and Table 501.05	WA 915.1
Californian Bearing Ratio (Soaked 4 days) at 94% of MDD and 100% of OMC	50% Minimum	60 % Minimum	WA 141.1 (Note2)
Linear Shrinkage (on 0.425mm)	Not greater than 1.0%		WA123.1

Note 1 Lower limits for Calcium Carbonate may be accepted on the highway provided that the MDCS meets the limits indicated in Table 501.05

Note 2: The same percentage of coarse material (passing the 53 mm and retained on the 4.75 mm sieves) in the original field sample is to be maintained in the test sample. Refer to the test method for more details.

TABLE 501.05 CALCIUM CARBONATE CONTENT ($CACO_3$) AND MAXIMUM DRY COMPRESSIVE STRENGTH (MDCS) RELATIONSHIP.

$CaCO_3$ WA 915.1	MDCS WA 140.1
30% - 45%	Not less than 1,500 kPa
45% - 60%	Not less than 1,100 kPa
60% - greater	Not less than 700 kPa

0.075	7	4 - 13
0.0135	4	2 - 9

501.07.03 OTHER ACCEPTANCE LIMITS

1. The material shall comply with the limits shown in Table 501.09 ***Other Acceptance Limits***

TABLE 501.09 OTHER ACCEPTANCE LIMITS (GRAVEL BASECOURSE)

(Suitable for all Minor Secondary Roads as shown on the drawings)

Test	Limits	Test Method
Liquid limit	25.0% Maximum	WA 120.2
Linear Shrinkage	2.0% Maximum	WA 123.1
Maximum Dry Compressive Strength	2.3 MPa Minimum	WA140.1
California Bearing Ratio (Soaked 4 days) at 96% of MDD and 100% of OMC	80% Minimum	WA 141.1

501.09 CRUSHED ROCK BASE BASECOURSE

501.09.01 GENERAL

1. This portion of the specification covers the manufacture of crushed rock base to be used in the pavement as either unmodified (CRB) or modified as Hydrated Crushed Rock base (HCTCRB). There are different requirements for the production of each of the materials.

2. All crushed rock base shall consist of a uniformly blended mixture of coarse and fine aggregate.

3. Coarse aggregate (retained 4.75mm sieve) shall consist of clean, hard, durable, angular fragments of rock produced by crushing sound unweathered rock and shall not include materials which break up when alternately wetted and dried. ***Coarse Aggregate***

4. Fine aggregate (passing 4.75mm sieve) shall consist of crushed rock fragments or a mixture of crushed rock fragments with natural sand or clayey sand. Crushed rock fine aggregate from each source shall, except as to size, comply with all the provisions specified for coarse aggregate. ***Fine Aggregate***

5. See also Clause 501.09.06 for details of the manufacture of Hydrated Cement Treated Crushed Rock Base (HCTCRB). ***HCTCRB***

6. CRB and HCTCRB materials shall be mixed at a central plant and laid by paver. ***Central Plant Mixed and Paver-Laid***

501.09.02 LIMITS OF ACCEPTANCE

1. The mixture of fine and coarse aggregate forming the rock base shall be free from vegetable matter, lumps of clay, overburden, or any other deleterious matter.

501.09.03 PARTICLE SIZE DISTRIBUTION

1. The Particle Size Distribution of the material when tested in accordance with Test Method WA 115.1 shall comply with the requirements shown in Table 501.18. The grading of material passing the 37.5mm sieve shall vary from coarse to fine in a uniform and consistent manner. It shall not be subject to extreme or near extreme percentages of gradation represented by the maximum and minimum limits from the various sieve sizes, and shall conform as closely as possible to the specified target grading. ***Particle Size Distribution***

TABLE 501.18 PARTICLE SIZE DISTRIBUTION (CRUSHED ROCK BASE)

AS 1152 Sieve Size (mm)	% Passing by Mass Target Grading	% Passing by Mass
26.5		100
19.0	100	95 – 100
13.2	82	70 – 90
9.5	70	60 – 80
4.75	50	40 – 60
2.36	38	30 – 45
1.18	25	20 – 35
0.600	19	13 – 27
0.425	17	11 – 23
0.300	13	8 – 20
0.150	10	5 – 14
0.075	8	5 – 11

2. The Dust Ratio, defined as the ratio of the percentage passing by mass the 0.075mm sieve to the percentage passing by mass the 0.425mm sieve, shall be within the range 0.35 to 0.60. ***Dust Ratio***

501.09.04 OTHER ACCEPTANCE LIMITS

1. The crushed rock base shall meet other limits as shown in Table 501.19. ***Other Acceptance Limits***

TABLE 501.19 OTHER ACCEPTANCE LIMITS (CRUSHED ROCK BASE)

Test	Freeway Limits (HCTCRB)	Highway Limits (CRB)	Test Method
Liquid Limit (Cone Penetrometer)	25.0% Maximum		WA120.2
Plasticity Index	6.0 % Maximum	5.0% Maximum	WA122.1
Linear Shrinkage	2.0% Maximum 0.4% Minimum	2.0% Maximum	WA123.1
Flakiness Index	30% Maximum		WA216.1
Los Angeles Abrasion Value	35% Maximum		WA 220.1
Maximum Dry Compressive Strength	1.7MPa Minimum		WA 140.1
California Bearing Ratio (Soaked 4 days) at 98% of MDD and 100% of OMC	100% Minimum		WA141.1

501.09.05 MOISTURE CONTENT

1. Crushed rock base shall be thoroughly mixed with water using a pugmill to produce a homogeneous product suitable for placement into final position. ***Mixing***

2. Crushed rock base shall be pre-wet to within 95% to 110% of the Optimum Moisture Content as determined by Test Method WA 133.1. ***Pre-wetting***

501.09.06 HYDRATED CEMENT TREATED CRUSHED ROCK BASE (HCTCRB)

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501.27 DRYBACK REQUIREMENTS

501.27.01 SUBGRADE – NOT USED

501.27.02 SUB-BASE

Sub-Base Dryback

1. Basecourse construction shall not commence until the sub-base has dried back such that the Dryback Characteristic Moisture Content (DMc) is equal to or less than the proportion of Optimum Moisture Content as shown in Annexure 501A as determined by WA 133.1 or 133.2. The Dryback Characteristic Moisture Content shall be determined in accordance with Specification 201 QUALITY SYSTEMS

501.27.03 BASECOURSE

Basecourse Dryback

1. No binder shall be applied to a basecourse lot until it has dried back such that the Dryback Characteristic Moisture Content of both the upper half and lower half of the basecourse layer is less than or equal to the proportion of the Optimum Moisture Content (OMC) as specified in Annexure 501A as determined by WA 133.1 or 133.2. Where no such proportion of OMC is specified in Annexure 501A, the Dryback Characteristic Moisture Content of the basecourse shall be dried back to 85% of OMC. The Dryback Characteristic Moisture Content shall be determined in accordance with Specification 201 QUALITY SYSTEMS.

501.28 SPREADING

501.28.01 GENERAL

1. Each pavement layer worked shall be generally parallel to the finished pavement surface and shall extend the full width of the layer.

501.28.02 SUB-BASE

1. Sub-base shall be worked in compacted layers not greater than 250mm nor less than 100mm. Where less than 100mm is required to be worked the underlaying sub-base shall be scarified to such a depth that the resulting compacted thickness of the layer to be worked is not less than 100mm.

501.28.03 BASECOURSE

1. Basecourse shall be worked in compacted layers not more than 200mm nor less than 100mm compacted thickness. Where less than 100mm is required to be worked the underlying basecourse shall be scarified to such a depth that the resulting compacted thickness of the layer to be worked is not less than 100mm.

2. The respective pre-conditioned mixtures of CRB and HCTCRB shall be spread by mechanical paver on the underlying layer to the required width and to such thickness as will comply with the requirements specified in 501.41 to 501.46 after final compaction. Segregation of the materials shall be avoided and the layer shall be free from pockets of coarse and fine materials. Immediately prior to spreading the CRB or the HCTCRB, the underlying layer shall be moistened and kept moist but not excessively wet. If longitudinal construction joints are necessary, they shall be constructed in the positions to match the permanent longitudinal line markings.

CRB and HCTCRB spread by mechanical paver

501.29 COMPACTION

501.29.01 GENERAL

1. Pavement material shall be spread and compacted to achieve uniformity free from any evidence of segregation.

2. Compaction shall be carried out at a Construction Characteristic Moisture Content (CM_C) within 95% and 110% of the Optimum Moisture Content and a uniform compactive effort applied longitudinally and transversely to the road alignment to achieve the density as specified in Annexure 501A, width, shape, level and surface finish as specified.

501.29.02 HYDRATED CEMENT TREATED CRUSHED ROCK BASE (HCTCRB)

1. HCTCRB basecourse shall be compacted to a Characteristic Dry Density Ratio given in Annexure 501A, or greater. The maximum dry density used in the calculations shall be determined on pre-treated material sampled from the basecourse lots prior to compaction and shall be determined in accordance with Test Method WA 133.1. Pre-treatment shall comprise mixing HCTCRB material at a moisture content dry of OMC in a cement mixer with a bowl of approximately 0.06 cubic metres (2.2 cubic foot) capacity at 28 revolutions per minute for 20 ± 2 minutes.

Density

2. Basecourse dryback prior to bituminous surfacing shall be in accordance with Annexure 501A and shall be based on the OMC determined at Clause 501.29.02.1.

Basecourse Dryback

C.4 Historic Performance Data

Table C 1: Falling weight deflectometer, 2009 Report No. 09 FWD 257/1 (MRWA 2009)

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa, No Temp Correction: Deflection (mm)	Normalised to 700 kPa, No Temp Correction: Curvature (mm)	Normalised to 700 kPa, Austroads 2008 Correction to 29°C: Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	11.8	60	724	386	272	199	149	116	97	79	68	46	0.373	0.110	1.123	0.419		1.400	0.154	
55.30	2	L	11.6	60	728	376	265	198	148	117	97	78	67	45	0.362	0.107	1.124	0.407		1.405	0.150	
55.31	2	L	13.6	60	729	391	270	201	151	119	98	79	68	44	0.376	0.116	1.111	0.417		1.349	0.156	
55.32	2	L	13.5	60	720	399	281	206	153	119	99	80	68	45	0.388	0.115	1.112	0.431		1.352	0.156	
55.33	2	L	13.8	60	725	395	276	203	151	119	99	80	68	44	0.381	0.115	1.109	0.423		1.343	0.154	
55.33	2	L	12.5	60	729	386	268	194	146	114	96	77	66	42	0.371	0.113	1.119	0.415		1.381	0.157	
55.34	2	L	13.0	60	723	385	266	192	143	112	94	75	65	42	0.373	0.115	1.116	0.416		1.367	0.157	
55.35	2	L	13.5	60	723	392	269	198	147	114	95	76	66	41	0.380	0.120	1.112	0.422		1.352	0.162	
55.36	2	L	13.3	60	721	398	278	201	149	115	95	76	65	41	0.386	0.117	1.113	0.430		1.358	0.158	
55.37	2	L	12.9	60	721	392	273	199	147	115	96	78	66	42	0.381	0.115	1.116	0.425	***0.421***	1.370	0.158	***0.156***
55.39	3	L	13.4	60	723	434	305	225	170	131	107	82	69	42	0.420	0.125	1.112	0.467		1.355	0.169	
55.40	3	L	13.0	60	725	419	295	222	166	128	105	82	68	41	0.405	0.120	1.116	0.452		1.367	0.164	
55.41	3	L	13.4	60	728	417	301	222	165	128	104	82	68	41	0.401	0.112	1.112	0.446		1.355	0.152	
55.42	3	L	13.8	60	718	400	285	211	158	122	102	80	67	41	0.390	0.113	1.109	0.433		1.343	0.152	
55.42	3	L	13.9	60	722	408	293	220	165	127	105	82	68	42	0.396	0.111	1.108	0.439		1.340	0.149	
55.43	3	L	14.6	60	720	408	297	225	169	130	107	84	70	42	0.397	0.108	1.103	0.438		1.319	0.143	
55.44	3	L	14.4	60	724	421	305	231	173	134	109	84	70	42	0.407	0.112	1.104	0.449		1.325	0.148	
55.45	3	L	14.4	60	723	422	300	223	167	128	105	81	68	42	0.408	0.118	1.104	0.451		1.325	0.156	
55.46	3	L	13.9	60	728	406	290	215	161	124	102	83	69	41	0.391	0.112	1.108	0.433		1.340	0.150	
55.47	3	L	14.7	60	720	402	279	208	157	121	101	80	67	42	0.390	0.119	1.102	0.430	***0.444***	1.316	0.157	***0.154***
56.29	12	L	21.0	60	719	384	270	202	158	130	113	94	82	55	0.374	0.111	1.049	0.392		1.148	0.127	
56.30	12	L	22.6	60	718	384	271	202	157	129	113	95	83	56	0.374	0.111	1.038	0.388		1.113	0.123	
56.31	12	L	22.7	60	724	401	276	204	160	132	115	96	83	54	0.387	0.121	1.037	0.402		1.110	0.134	
56.32	12	L	22.4	60	724	383	266	200	157	127	110	92	81	53	0.370	0.113	1.039	0.385		1.117	0.127	
56.33	12	L	22.8	60	723	390	270	201	157	129	112	94	82	53	0.378	0.117	1.036	0.391		1.108	0.129	
56.33	12	L	22.6	60	714	394	279	210	164	135	117	98	85	56	0.386	0.113	1.038	0.401		1.113	0.125	
56.34	12	L	22.4	60	718	399	278	210	163	132	113	94	81	51	0.389	0.118	1.039	0.404		1.117	0.131	
56.35	12	L	22.5	60	723	411	284	208	160	130	112	92	79	50	0.398	0.123	1.038	0.413		1.115	0.138	
56.36	12	L	22.3	60	725	380	268	203	157	128	110	90	77	47	0.367	0.108	1.040	0.381		1.119	0.121	
56.37	12	L	21.8	60	721	390	278	208	162	130	112	92	79	49	0.379	0.110	1.043	0.395	***0.395***	1.130	0.124	***0.128***

															Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	25.0	60	715	381	258	184	139	111	96	80	70	47	0.373	0.121	1.022	0.382		1.066	0.129	
55.30	2	L	24.2	60	724	398	271	194	145	115	98	81	71	48	0.384	0.122	1.027	0.395		1.081	0.1323	
55.31	2	L	24.4	60	726	439	289	202	149	115	98	81	70	48	0.423	0.145	1.026	0.434		1.077	0.1559	
55.32	2	L	24.2	60	721	413	275	195	143	115	98	81	70	47	0.401	0.134	1.027	0.412		1.081	0.1445	
55.33	2	L	24.5	60	724	400	271	190	141	111	96	79	68	45	0.387	0.125	1.025	0.397		1.075	0.1347	
55.33	2	L	25.0	60	719	395	264	189	139	111	95	78	68	45	0.384	0.127	1.022	0.393		1.066	0.1354	
55.34	2	L	24.8	60	723	401	267	184	134	106	91	75	65	43	0.388	0.129	1.023	0.397		1.069	0.1383	
55.35	2	L	25.0	60	720	396	259	182	135	107	92	75	64	42	0.385	0.134	1.022	0.394		1.066	0.1425	
55.36	2	L	25.9	60	724	392	266	189	137	109	92	75	64	41	0.379	0.121	1.017	0.385		1.050	0.1272	
55.37	2	L	25.7	60	719	414	275	191	140	109	92	75	64	41	0.403	0.136	1.018	0.410	***0.400***	1.053	0.1429	***0.138***
55.39	3	L	26.7	60	723	445	300	217	160	123	103	80	68	43	0.430	0.140	1.012	0.436		1.036	0.1445	
55.40	3	L	25.8	60	723	455	308	219	160	124	102	80	68	42	0.440	0.142	1.017	0.448		1.051	0.1494	
55.41	3	L	25.7	60	721	435	303	215	156	120	100	80	68	43	0.423	0.129	1.018	0.430		1.053	0.1357	
55.42	3	L	26.3	60	719	443	304	215	158	122	101	81	68	42	0.431	0.136	1.014	0.438		1.043	0.1415	
55.42	3	L	26.1	60	723	430	295	208	153	118	99	80	67	42	0.416	0.131	1.016	0.422		1.046	0.1365	
55.43	3	L	25.9	60	717	425	290	209	153	120	99	79	67	43	0.415	0.131	1.017	0.421		1.050	0.1375	
55.44	3	L	26.1	60	723	438	296	209	152	118	99	80	68	42	0.424	0.138	1.016	0.431		1.046	0.1441	
55.45	3	L	26.4	60	719	442	295	206	150	118	99	79	67	42	0.431	0.144	1.014	0.437		1.041	0.1498	
55.46	3	L	26.6	60	721	430	289	203	151	118	100	80	68	42	0.417	0.136	1.013	0.423		1.038	0.1414	
55.47	3	L	26.7	60	722	431	294	208	152	119	100	80	68	43	0.418	0.133	1.012	0.423	***0.431***	1.036	0.1374	***0.1418***
56.29	12	L	32.0	60	719	427	281	203	158	131	114	96	85	57	0.416	0.142	0.980	0.407		0.948	0.1346	
56.30	12	L	31.7	60	718	433	287	205	160	132	116	97	86	58	0.423	0.143	0.982	0.415		0.953	0.1363	
56.31	12	L	31.4	60	716	430	282	203	156	129	112	94	82	53	0.421	0.145	0.984	0.414		0.958	0.139	
56.32	12	L	32.4	60	721	459	300	213	161	131	114	97	85	57	0.446	0.154	0.978	0.436		0.942	0.1455	
56.33	12	L	31.9	60	713	447	297	210	159	130	114	97	86	56	0.438	0.146	0.981	0.430		0.950	0.1391	
56.33	12	L	31.7	60	718	473	309	219	165	133	115	97	85	55	0.461	0.159	0.982	0.452		0.953	0.1517	
56.34	12	L	31.9	60	716	457	302	210	156	125	107	89	77	49	0.447	0.152	0.981	0.439		0.950	0.1444	
56.35	12	L	32.5	60	717	493	320	222	165	133	115	95	82	52	0.481	0.169	0.977	0.470		0.940	0.1586	
56.36	12	L	32.8	60	720	447	299	211	159	129	111	91	78	49	0.435	0.144	0.975	0.424		0.936	0.1351	
56.37	12	L	32.4	60	714	463	296	211	160	129	112	92	79	50	0.454	0.163	0.978	0.444	***0.433***	0.942	0.1535	***0.14378***

Table C 2: Falling weight deflectometer, 2010 Report No. 10 FWD 308/1 (MRWA 2010)

															Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	26.1	60	696	333	247	188	147	119	101	84	72	46	0.335	0.087	1.010	0.339		1.031	0.089	
55.30	2	L	26.0	60	699	338	249	190	146	117	100	83	71	45	0.338	0.088	1.011	0.342		1.032	0.091	
55.31	2	L	26.3	60	697	344	251	192	148	117	99	81	69	45	0.346	0.094	1.009	0.349		1.027	0.097	
55.32	2	L	26.0	60	698	353	257	197	150	118	100	81	69	45	0.354	0.097	1.011	0.358		1.032	0.100	
55.33	2	L	26.0	60	704	349	256	192	147	117	99	81	69	43	0.347	0.093	1.011	0.351		1.032	0.096	
55.33	2	L	25.9	60	700	343	251	188	143	115	97	78	66	40	0.343	0.092	1.011	0.347		1.034	0.095	
55.34	2	L	25.8	60	703	336	246	188	142	113	95	77	65	40	0.334	0.089	1.012	0.338		1.036	0.092	
55.35	2	L	26.1	60	699	340	247	186	143	112	94	76	65	39	0.340	0.093	1.010	0.343		1.031	0.095	
55.36	2	L	25.9	60	700	334	248	185	141	111	93	75	64	39	0.334	0.086	1.011	0.337		1.034	0.089	
55.37	2	L	26.3	60	702	347	252	186	140	111	94	76	65	40	0.346	0.095	1.009	0.349	***0.345***	1.027	0.097	***0.094***
55.39	3	L	26.5	60	698	354	264	201	154	121	101	80	68	40	0.355	0.090	1.008	0.358		1.024	0.092	
55.40	3	L	26.5	60	704	349	260	197	152	121	101	80	67	41	0.347	0.088	1.008	0.350		1.024	0.090	
55.41	3	L	26.9	60	702	356	267	204	156	122	102	80	66	39	0.355	0.089	1.006	0.357		1.017	0.091	
55.42	3	L	26.1	60	699	361	265	201	152	120	100	79	66	38	0.361	0.096	1.010	0.365		1.031	0.099	
55.42	3	L	26.9	60	702	360	270	210	160	125	104	82	69	40	0.359	0.090	1.006	0.361		1.017	0.091	
55.43	3	L	27.1	60	700	369	269	207	159	125	104	82	68	39	0.369	0.100	1.005	0.370		1.014	0.101	
55.44	3	L	26.9	60	700	357	265	204	156	124	104	81	67	40	0.357	0.092	1.006	0.359		1.017	0.094	
55.45	3	L	26.8	60	697	366	272	206	157	125	103	81	68	40	0.367	0.094	1.006	0.369		1.019	0.095	
55.46	3	L	27.7	60	701	363	271	206	156	124	103	82	68	40	0.363	0.092	1.002	0.363		1.005	0.093	
55.47	3	L	27.0	60	703	358	268	204	156	124	103	82	68	40	0.356	0.090	1.005	0.358	***0.361***	1.016	0.091	***0.094***
56.29	12	L	37.1	60	700	329	238	188	154	133	119	101	89	58	0.329	0.092	0.944	0.311		0.863	0.079	
56.30	12	L	36.1	60	700	315	227	178	150	129	117	101	89	58	0.315	0.089	0.950	0.299		0.875	0.077	
56.31	12	L	36.1	60	703	336	243	189	158	135	121	102	90	56	0.335	0.093	0.950	0.318		0.875	0.081	
56.32	12	L	36.1	60	700	315	230	181	151	130	117	99	87	55	0.315	0.085	0.950	0.299		0.875	0.074	
56.33	12	L	35.7	60	699	319	229	184	153	133	120	102	90	56	0.320	0.090	0.952	0.304		0.880	0.079	
56.33	12	L	34.7	60	701	338	248	198	164	140	126	107	94	58	0.337	0.089	0.957	0.323		0.892	0.080	
56.34	12	L	35.5	60	698	328	235	188	156	135	120	101	88	53	0.329	0.094	0.953	0.314		0.882	0.083	
56.35	12	L	34.8	60	700	349	247	194	161	137	122	102	88	53	0.349	0.102	0.957	0.334		0.891	0.091	
56.36	12	L	35.8	60	704	327	239	190	158	135	119	100	86	50	0.325	0.087	0.951	0.309		0.878	0.077	
56.37	12	L	34.8	60	697	339	248	194	160	136	121	102	87	52	0.340	0.092	0.957	0.325	***0.314***	0.891	0.082	***0.080***

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	23.4	60	699	332	242	188	148	119	102	83	72	46	0.332	0.090	1.027	0.3413		1.080	0.0971	
55.30	2	L	22.8	60	699	325	240	187	147	119	102	83	72	46	0.326	0.085	1.031	0.336		1.092	0.093	
55.31	2	L	22.8	60	697	330	242	187	147	119	102	83	71	45	0.331	0.088	1.031	0.341		1.092	0.096	
55.32	2	L	22.5	60	702	335	247	188	147	120	102	83	72	45	0.334	0.088	1.033	0.345		1.098	0.097	
55.33	2	L	23.0	60	697	327	240	185	145	118	100	81	69	44	0.328	0.087	1.030	0.338		1.088	0.095	
55.33	2	L	22.8	60	703	329	245	190	149	121	102	83	70	43	0.328	0.084	1.031	0.338		1.092	0.091	
55.34	2	L	23.2	60	702	318	235	180	142	114	97	80	68	42	0.317	0.082	1.028	0.326		1.084	0.089	
55.35	2	L	23.1	60	698	327	237	182	141	114	96	78	67	40	0.328	0.090	1.029	0.338		1.086	0.098	
55.36	2	L	23.4	60	698	319	236	183	142	114	97	78	67	40	0.320	0.084	1.027	0.329		1.080	0.090	
55.37	2	L	23.0	60	702	336	244	185	145	115	97	79	66	40	0.335	0.092	1.030	0.345	***0.33765***	1.088	0.100	***0.09467***
55.39	3	L	24.1	60	704	334	248	193	151	122	103	83	70	42	0.332	0.086	1.022	0.340		1.066	0.092	
55.40	3	L	23.4	60	700	333	249	197	153	124	105	84	70	42	0.333	0.084	1.027	0.342		1.080	0.091	
55.41	3	L	23.2	60	697	335	254	198	155	124	104	83	69	40	0.337	0.082	1.028	0.346		1.084	0.089	
55.42	3	L	23.5	60	700	336	252	195	154	124	104	83	69	41	0.336	0.084	1.026	0.345		1.078	0.090	
55.42	3	L	23.6	60	705	330	249	194	152	122	102	82	68	41	0.328	0.080	1.026	0.336		1.076	0.087	
55.43	3	L	24.0	60	697	332	248	192	150	121	102	81	68	40	0.334	0.085	1.023	0.341		1.068	0.091	
55.44	3	L	23.5	60	702	336	250	194	151	121	102	82	69	41	0.335	0.085	1.026	0.343		1.078	0.092	
55.45	3	L	23.9	60	700	333	245	189	147	119	101	81	68	40	0.333	0.088	1.024	0.341		1.070	0.094	
55.46	3	L	24.1	60	697	319	237	184	144	116	99	80	68	40	0.320	0.083	1.022	0.327		1.066	0.088	
55.47	3	L	24.0	60	699	327	244	189	147	120	102	82	69	41	0.328	0.083	1.023	0.335	***0.340***	1.068	0.089	***0.090***
56.29	12	L	29.7	60	695	333	240	189	155	132	116	99	87	57	0.336	0.094	0.988	0.332		0.968	0.091	
56.30	12	L	29.3	60	707	345	251	196	162	137	121	103	90	59	0.342	0.093	0.991	0.339		0.975	0.091	
56.31	12	L	29.1	60	698	351	256	197	159	134	117	99	86	53	0.352	0.095	0.992	0.349		0.979	0.093	
56.32	12	L	29.7	60	696	344	250	195	159	135	119	101	89	57	0.346	0.094	0.988	0.342		0.968	0.091	
56.33	12	L	29.7	60	696	346	252	198	164	139	124	105	91	57	0.348	0.094	0.988	0.344		0.968	0.091	
56.33	12	L	29.7	60	705	361	260	202	164	138	123	104	91	57	0.359	0.100	0.988	0.355		0.968	0.097	
56.34	12	L	29.5	60	708	354	258	198	160	133	115	96	83	50	0.350	0.095	0.989	0.346		0.972	0.092	
56.35	12	L	30.3	60	703	372	264	203	165	139	122	101	88	52	0.370	0.108	0.984	0.364		0.958	0.103	
56.36	12	L	29.8	60	700	342	251	197	158	131	115	96	82	50	0.342	0.092	0.987	0.338		0.966	0.089	
56.37	12	L	29.6	60	702	349	250	194	157	133	116	97	83	50	0.348	0.098	0.989	0.344	***0.34519***	0.970	0.095	***0.093***

Table C 3: Falling weight deflectometer, 2011 Report No. 11 FWD 326/1 (MRWA 2011b)

															Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	28.4	60	700	329	242	182	140	113	97	80	69	44	0.329	0.087	1.003	0.330		1.009	0.088	
55.30	2	L	28.2	60	696	330	244	181	139	111	94	77	66	41	0.331	0.086	1.004	0.333		1.012	0.087	
55.31	2	L	29.8	60	701	335	247	184	140	111	95	77	66	41	0.335	0.088	0.995	0.333		0.985	0.087	
55.32	2	L	29.7	60	698	339	246	183	140	109	92	74	63	39	0.340	0.093	0.995	0.339		0.987	0.092	
55.33	2	L	29.6	60	702	332	248	182	137	108	91	74	63	39	0.331	0.084	0.996	0.330		0.989	0.083	
55.33	2	L	29.4	60	701	333	247	178	134	105	89	71	60	36	0.332	0.086	0.997	0.332		0.992	0.085	
55.34	2	L	29.6	60	701	331	240	175	131	103	87	70	59	35	0.330	0.090	0.996	0.329		0.989	0.089	
55.35	2	L	29.9	60	702	331	241	174	132	104	88	71	60	37	0.330	0.091	0.994	0.328		0.983	0.089	
55.36	2	L	30.0	60	701	313	231	169	128	102	85	69	58	34	0.312	0.081	0.993	0.310		0.982	0.080	
55.37	2	L	29.6	60	699	332	241	175	131	103	86	69	58	35	0.332	0.091	0.996	0.331	***0.329***	0.989	0.090	***0.087***
55.39	3	L	30.4	60	701	339	259	189	143	111	92	72	61	34	0.339	0.080	0.991	0.335		0.974	0.078	
55.40	3	L	30.1	60	697	326	246	185	141	112	92	72	61	35	0.327	0.080	0.992	0.325		0.980	0.078	
55.41	3	L	30.2	60	700	329	248	185	139	110	91	71	59	33	0.329	0.081	0.992	0.326		0.978	0.079	
55.42	3	L	30.2	60	701	334	246	181	137	107	89	69	58	33	0.334	0.088	0.992	0.331		0.978	0.086	
55.42	3	L	30.4	60	702	342	254	185	140	110	92	71	61	33	0.341	0.088	0.991	0.337		0.974	0.085	
55.43	3	L	30.5	60	700	348	259	192	145	115	94	74	61	35	0.348	0.089	0.990	0.345		0.973	0.087	
55.44	3	L	30.4	60	695	345	255	191	143	113	93	73	60	34	0.347	0.091	0.991	0.344		0.974	0.089	
55.45	3	L	30.4	60	704	346	263	195	147	116	95	75	62	35	0.344	0.083	0.991	0.340		0.974	0.080	
55.46	3	L	30.5	60	702	342	248	184	140	110	92	72	61	34	0.341	0.094	0.990	0.338		0.973	0.091	
55.47	3	L	30.7	60	705	350	252	189	144	113	94	75	61	34	0.347	0.097	0.989	0.343	***0.336***	0.969	0.094	***0.085***
56.29	12	L	34.9	60	702	314	228	176	144	125	112	96	84	55	0.313	0.086	0.963	0.301		0.906	0.078	
56.30	12	L	34.7	60	701	310	227	174	144	124	112	96	85	53	0.310	0.083	0.964	0.299		0.908	0.076	
56.31	12	L	34.6	60	697	323	234	180	149	128	113	97	84	52	0.325	0.089	0.965	0.313		0.910	0.081	
56.32	12	L	34.6	60	700	310	228	177	145	124	110	94	82	52	0.310	0.082	0.965	0.299		0.910	0.074	
56.33	12	L	34.6	60	705	319	231	180	150	130	117	100	87	55	0.317	0.088	0.965	0.306		0.910	0.080	
56.33	12	L	34.3	60	698	320	238	187	153	133	119	102	89	57	0.321	0.082	0.966	0.310		0.914	0.075	
56.34	12	L	34.8	60	696	314	229	180	149	127	114	97	84	50	0.316	0.085	0.964	0.305		0.907	0.077	
56.35	12	L	34.7	60	699	335	240	185	152	128	113	96	82	49	0.336	0.095	0.964	0.324		0.908	0.087	
56.36	12	L	34.6	60	703	317	234	182	149	129	112	94	81	48	0.315	0.082	0.965	0.304		0.910	0.075	
56.37	12	L	34.7	60	698	326	239	183	148	127	111	94	81	49	0.327	0.088	0.964	0.316	***0.308***	0.908	0.080	***0.078***

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	29.2	60	700	250	180	136	108	90	80	68	60	39	0.250	0.071	0.999	0.250		0.996	0.070	
55.30	2	L	29.1	60	701	258	187	142	114	95	83	70	61	40	0.257	0.070	0.999	0.257		0.998	0.070	
55.31	2	L	29.8	60	700	267	194	147	116	97	84	70	61	38	0.267	0.073	0.995	0.266		0.985	0.072	
55.32	2	L	29.7	60	700	270	192	145	115	96	84	70	61	38	0.270	0.078	0.995	0.268		0.987	0.077	
55.33	2	L	29.6	60	700	261	186	139	112	93	81	68	59	37	0.261	0.075	0.996	0.260		0.989	0.074	
55.33	2	L	29.7	60	702	263	190	145	115	94	83	69	59	36	0.262	0.072	0.995	0.261		0.987	0.071	
55.34	2	L	29.5	60	699	247	177	134	107	89	78	65	56	35	0.247	0.071	0.997	0.246		0.991	0.070	
55.35	2	L	29.8	60	701	248	176	133	105	86	77	64	55	33	0.248	0.072	0.995	0.246		0.985	0.071	
55.36	2	L	29.7	60	702	241	175	132	102	85	75	63	54	33	0.240	0.066	0.995	0.239		0.987	0.065	
55.37	2	L	29.7	60	702	264	188	141	109	90	78	64	55	33	0.263	0.076	0.995	0.262	***0.256***	0.987	0.075	***0.072***
55.39	3	L	30.2	60	700	251	181	139	110	91	79	66	56	34	0.251	0.069	0.992	0.249		0.978	0.068	
55.40	3	L	30.1	60	699	244	176	133	107	89	78	65	55	34	0.245	0.069	0.992	0.243		0.980	0.067	
55.41	3	L	30.1	60	700	253	178	137	109	90	79	65	55	33	0.253	0.075	0.992	0.251		0.980	0.073	
55.42	3	L	30.2	60	695	249	180	137	108	90	79	66	56	34	0.251	0.070	0.992	0.249		0.978	0.068	
55.42	3	L	30.3	60	706	243	174	132	104	88	76	63	54	32	0.241	0.068	0.991	0.239		0.976	0.067	
55.43	3	L	30.5	60	699	244	176	133	107	89	78	65	56	34	0.244	0.068	0.990	0.242		0.973	0.066	
55.44	3	L	30.2	60	698	242	175	133	105	88	77	64	55	34	0.242	0.067	0.992	0.240		0.978	0.066	
55.45	3	L	30.3	60	699	236	171	129	104	87	76	64	55	33	0.237	0.066	0.991	0.235		0.976	0.064	
55.46	3	L	30.5	60	693	223	163	121	98	83	74	62	54	33	0.225	0.061	0.990	0.223		0.973	0.059	
55.47	3	L	30.5	60	698	234	167	125	102	85	76	63	55	34	0.234	0.067	0.990	0.232	***0.240***	0.973	0.065	***0.066***
56.29	12	L	32.5	60	701	329	229	173	141	121	108	93	82	54	0.328	0.099	0.977	0.321		0.940	0.093	
56.30	12	L	32.4	60	699	323	231	174	141	119	106	91	80	52	0.324	0.093	0.978	0.316		0.942	0.087	
56.31	12	L	32.1	60	697	327	231	175	141	119	105	88	77	49	0.328	0.097	0.980	0.322		0.946	0.092	
56.32	12	L	32.5	60	703	328	233	178	141	121	107	91	80	52	0.326	0.094	0.977	0.319		0.940	0.089	
56.33	12	L	32.6	60	706	338	247	186	149	127	112	94	83	51	0.336	0.091	0.976	0.328		0.939	0.085	
56.33	12	L	32.6	60	705	344	244	185	149	126	112	95	82	51	0.341	0.099	0.976	0.333		0.939	0.093	
56.34	12	L	32.4	60	704	340	241	179	141	118	103	87	75	46	0.338	0.098	0.978	0.330		0.942	0.092	
56.35	12	L	32.7	60	707	348	249	186	149	125	110	92	80	48	0.345	0.099	0.976	0.337		0.937	0.092	
56.36	12	L	32.9	60	701	343	239	177	145	120	103	90	75	45	0.342	0.103	0.975	0.333		0.934	0.097	
56.37	12	L	32.6	60	702	343	243	179	145	123	108	90	77	46	0.342	0.100	0.976	0.334	***0.327***	0.939	0.094	***0.091***

Table C 4: Falling weight deflectometer, 2011 Report No. 11 FWD 336/1 (MRWA 2011c)

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction Deflection (mm)	Normalised to 700 kPa No Temp Correction Curvature (mm)	Normalised to 700 kPa Austroads 2008 Correction to 29°C Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	25.5	60	702	333	237	179	138	114	99	85	73	47	0.332	0.096	1.014	0.337		1.041	0.100	
55.30	2	L	25.5	60	700	324	245	186	140	111	94	79	67	43	0.324	0.080	1.014	0.328		1.041	0.083	
55.31	2	L	25.5	60	701	328	245	184	139	111	92	78	65	42	0.328	0.083	1.014	0.332		1.041	0.086	
55.32	2	L	25.6	60	704	332	252	189	142	111	93	77	63	40	0.331	0.080	1.013	0.335		1.039	0.083	
55.33	2	L	25.8	60	701	347	261	194	144	111	91	75	62	40	0.346	0.085	1.012	0.350		1.036	0.088	
55.33	2	L	25.7	60	698	339	254	192	141	111	91	75	61	39	0.340	0.085	1.013	0.344		1.037	0.089	
55.34	2	L	25.7	60	704	337	251	188	139	109	90	73	60	37	0.335	0.086	1.013	0.340		1.037	0.089	
55.35	2	L	25.4	60	699	328	248	183	136	106	87	71	58	35	0.328	0.080	1.014	0.333		1.043	0.084	
55.36	2	L	25.7	60	699	342	254	189	139	108	89	72	59	35	0.342	0.088	1.013	0.347		1.037	0.091	
55.37	2	L	25.8	60	699	324	242	183	134	105	86	70	58	35	0.324	0.082	1.012	0.328	***0.337***	1.036	0.085	***0.088***
55.39	3	L	26.4	60	701	343	250	187	136	106	86	71	58	35	0.342	0.092	1.009	0.345		1.026	0.094	
55.40	3	L	25.6	60	704	340	256	192	144	111	88	72	59	35	0.338	0.084	1.013	0.343		1.039	0.087	
55.41	3	L	26.5	60	704	332	255	194	143	113	92	74	63	36	0.331	0.077	1.008	0.333		1.024	0.079	
55.42	3	L	26.4	60	699	344	263	200	147	114	92	73	59	34	0.345	0.081	1.009	0.348		1.026	0.083	
55.42	3	L	25.8	60	704	357	270	203	147	114	92	74	60	35	0.355	0.086	1.012	0.359		1.036	0.089	
55.43	3	L	25.9	60	699	354	273	209	152	117	94	75	63	35	0.355	0.082	1.011	0.359		1.034	0.084	
55.44	3	L	26.2	60	703	357	273	207	153	119	97	76	61	35	0.355	0.084	1.010	0.359		1.029	0.086	
55.45	3	L	25.9	60	701	348	266	203	153	117	95	76	61	35	0.348	0.082	1.011	0.352		1.034	0.085	
55.46	3	L	26.2	60	701	368	278	212	156	119	96	77	62	35	0.368	0.090	1.010	0.371		1.029	0.092	
55.47	3	L	25.8	60	702	351	268	200	145	113	95	74	59	35	0.350	0.083	1.012	0.354	***0.352***	1.036	0.086	***0.087***
56.29	12	L	26.4	60	699	158	139	132	119	111	102	93	81	53	0.158	0.019	1.009	0.159		1.026	0.019	
56.30	12	L	26.9	60	699	293	222	179	146	124	109	94	81	52	0.293	0.071	1.006	0.295		1.017	0.072	
56.31	12	L	25.7	60	702	292	218	178	145	124	110	96	81	52	0.291	0.074	1.013	0.294		1.037	0.076	
56.32	12	L	26.2	60	703	306	230	185	150	128	112	96	82	51	0.305	0.075	1.010	0.308		1.029	0.077	
56.33	12	L	26.5	60	703	290	222	179	145	124	108	93	79	50	0.289	0.068	1.008	0.291		1.024	0.070	
56.33	12	L	26.3	60	699	293	226	184	150	129	113	98	84	52	0.294	0.067	1.009	0.296		1.027	0.069	
56.34	12	L	26.5	60	702	308	232	189	155	132	116	100	85	54	0.307	0.076	1.008	0.310		1.024	0.078	
56.35	12	L	26.0	60	701	303	231	187	151	128	112	97	81	49	0.302	0.072	1.011	0.305		1.032	0.074	
56.36	12	L	26.7	60	705	326	244	199	159	135	116	99	83	49	0.324	0.081	1.007	0.326		1.021	0.083	
56.37	12	L	26.5	60	700	298	232	188	153	129	111	95	79	47	0.298	0.066	1.008	0.301	***0.289***	1.024	0.068	***0.069***

															Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	28.1	60	699	314	236	183	141	114	97	82	69	45	0.314	0.078	0.999	0.314		0.998	0.077	
55.30	2	L	28.0	60	701	316	238	184	142	114	96	81	68	44	0.315	0.077	1.000	0.315		1.000	0.077	
55.31	2	L	28.1	60	700	319	239	187	142	114	96	80	67	43	0.319	0.080	0.999	0.319		0.998	0.080	
55.32	2	L	28.5	60	702	333	249	190	143	115	97	81	68	44	0.332	0.083	0.996	0.330		0.990	0.082	
55.33	2	L	28.3	60	696	323	241	188	142	114	95	80	67	42	0.325	0.082	0.998	0.324		0.994	0.082	
55.33	2	L	28.9	60	698	324	244	189	143	114	96	79	66	42	0.325	0.081	0.994	0.323		0.983	0.079	
55.34	2	L	28.8	60	701	316	238	181	138	111	92	77	63	40	0.316	0.078	0.994	0.314		0.985	0.077	
55.35	2	L	28.8	60	701	313	235	180	135	109	91	76	63	39	0.313	0.079	0.994	0.311		0.985	0.078	
55.36	2	L	28.7	60	699	313	236	182	138	110	92	76	62	38	0.313	0.077	0.995	0.312		0.986	0.076	
55.37	2	L	28.6	60	700	329	244	186	140	111	92	76	63	38	0.329	0.084	0.996	0.327	***0.31899***	0.988	0.083	***0.07907***
55.39	3	L	28.5	60	701	321	246	192	148	119	99	81	67	40	0.320	0.074	0.996	0.319		0.990	0.073	
55.40	3	L	28.4	60	701	331	256	200	154	124	103	84	69	41	0.331	0.075	0.997	0.330		0.992	0.075	
55.41	3	L	28.4	60	703	333	257	198	152	122	100	82	67	40	0.331	0.076	0.997	0.331		0.992	0.075	
55.42	3	L	28.3	60	699	332	257	199	152	121	100	82	67	40	0.332	0.075	0.998	0.331		0.994	0.075	
55.42	3	L	28.2	60	703	326	252	193	147	118	99	80	66	39	0.324	0.073	0.999	0.324		0.996	0.073	
55.43	3	L	28.0	60	696	325	251	195	149	119	99	81	66	39	0.327	0.075	1.000	0.327		1.000	0.075	
55.44	3	L	28.2	60	700	326	246	192	148	118	98	80	66	39	0.326	0.080	0.999	0.325		0.996	0.079	
55.45	3	L	28.2	60	702	326	245	189	145	116	97	80	66	39	0.325	0.081	0.999	0.325		0.996	0.080	
55.46	3	L	27.7	60	702	312	240	186	145	116	97	80	66	39	0.311	0.073	1.002	0.312		1.005	0.073	
55.47	3	L	28.3	60	700	319	243	191	146	118	99	82	67	40	0.319	0.076	0.998	0.318	***0.32417***	0.994	0.075	***0.07535***
56.29	12	L	31.3	60	698	324	236	189	152	130	116	101	87	57	0.325	0.088	0.978	0.318		0.941	0.083	
56.30	12	L	31.9	60	699	339	252	197	159	136	120	103	88	58	0.339	0.087	0.974	0.331		0.932	0.081	
56.31	12	L	32.1	60	701	346	254	200	159	134	118	101	85	54	0.345	0.092	0.973	0.336		0.929	0.086	
56.32	12	L	31.7	60	701	350	261	205	163	138	120	103	88	57	0.349	0.089	0.975	0.341		0.935	0.083	
56.33	12	L	31.7	60	698	358	268	213	170	144	125	108	91	58	0.359	0.090	0.975	0.350		0.935	0.084	
56.33	12	L	31.9	60	701	357	261	207	165	141	123	105	90	56	0.357	0.096	0.974	0.347		0.932	0.089	
56.34	12	L	31.8	60	701	347	256	199	157	132	114	97	82	50	0.346	0.091	0.974	0.337		0.934	0.085	
56.35	12	L	31.7	60	701	362	266	211	169	142	124	107	90	55	0.361	0.095	0.975	0.352		0.935	0.089	
56.36	12	L	31.8	60	696	352	261	202	160	132	115	97	80	48	0.354	0.092	0.974	0.345		0.934	0.085	
56.37	12	L	31.3	60	701	360	263	205	163	137	118	101	84	50	0.360	0.097	0.978	0.352	***0.3408***	0.941	0.092	***0.086***

Table C 5: Falling weight deflectometer, 2012 Report No. 11 FWD 371/1 (MRWA 2012b)

															Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	26.2	60	700	335	247	185	141	112	97	80	68	44	0.335	0.088	1.015	0.340		1.044	0.092	
55.30	2	L	25.9	60	701	339	247	183	140	111	94	77	68	43	0.338	0.091	1.017	0.344		1.050	0.096	
55.31	2	L	25.8	60	699	347	253	188	142	113	95	77	67	42	0.347	0.094	1.017	0.353		1.051	0.099	
55.32	2	L	26.0	60	699	353	261	191	141	111	93	74	63	40	0.353	0.092	1.016	0.359		1.048	0.096	
55.33	2	L	25.9	60	700	352	256	191	143	112	93	75	63	40	0.352	0.097	1.017	0.358		1.050	0.101	
55.33	2	L	25.7	60	698	343	250	182	137	105	89	71	59	35	0.344	0.093	1.018	0.350		1.053	0.098	
55.34	2	L	25.8	60	701	338	244	179	133	105	88	70	59	35	0.338	0.094	1.017	0.343		1.051	0.099	
55.35	2	L	25.9	60	696	334	243	180	133	104	88	69	57	35	0.336	0.092	1.017	0.342		1.050	0.096	
55.36	2	L	25.9	60	700	335	242	178	133	105	88	70	59	35	0.335	0.094	1.017	0.341		1.050	0.098	
55.37	2	L	26.5	60	699	358	256	185	136	107	89	71	59	35	0.359	0.102	1.013	0.363	***0.349***	1.039	0.106	***0.098***
55.39	3	L	26.6	60	702	352	261	194	144	111	93	72	60	35	0.351	0.090	1.013	0.355		1.038	0.094	
55.40	3	L	26.3	60	700	344	256	191	143	111	94	72	60	35	0.344	0.088	1.014	0.349		1.043	0.092	
55.41	3	L	25.9	60	700	354	261	193	145	111	92	72	59	34	0.354	0.093	1.017	0.359		1.050	0.097	
55.42	3	L	26.1	60	700	355	259	193	142	110	90	71	59	33	0.355	0.096	1.016	0.361		1.046	0.101	
55.42	3	L	26.2	60	701	369	274	198	149	115	94	73	59	35	0.368	0.094	1.015	0.374		1.044	0.099	
55.43	3	L	26.4	60	701	377	281	208	153	118	97	75	62	36	0.376	0.096	1.014	0.381		1.041	0.100	
55.44	3	L	26.8	60	703	365	270	199	150	115	95	74	61	35	0.364	0.095	1.012	0.368		1.034	0.098	
55.45	3	L	26.7	60	699	366	272	205	152	117	97	73	62	34	0.366	0.094	1.012	0.371		1.036	0.098	
55.46	3	L	26.4	60	700	351	257	189	142	111	92	72	60	34	0.351	0.094	1.014	0.356		1.041	0.098	
55.47	3	L	26.7	60	700	345	257	192	145	112	94	72	60	34	0.345	0.088	1.012	0.349	***0.362***	1.036	0.091	***0.097***
56.29	12	L	29.0	60	702	304	218	177	149	130	116	100	87	55	0.303	0.086	1.000	0.303		1.000	0.086	
56.30	12	L	28.5	60	701	299	218	175	149	130	118	100	88	55	0.299	0.081	1.003	0.300		1.007	0.081	
56.31	12	L	28.6	60	703	315	224	179	151	130	116	98	85	52	0.314	0.091	1.002	0.314		1.006	0.091	
56.32	12	L	28.9	60	697	304	219	174	148	128	114	97	84	53	0.305	0.085	1.001	0.305		1.001	0.085	
56.33	12	L	29.6	60	701	311	227	182	154	135	121	104	91	56	0.310	0.083	0.996	0.309		0.989	0.082	
56.33	12	L	29.2	60	696	314	232	186	156	135	121	102	89	55	0.316	0.082	0.999	0.315		0.996	0.082	
56.34	12	L	29.4	60	700	312	228	183	154	133	118	100	87	51	0.312	0.084	0.997	0.311		0.992	0.083	
56.35	12	L	29.5	60	699	330	239	187	156	133	118	99	85	49	0.330	0.091	0.997	0.329		0.991	0.091	
56.36	12	L	29.4	60	701	307	225	180	152	129	114	96	83	47	0.306	0.082	0.997	0.306		0.992	0.081	
56.37	12	L	29.1	60	701	322	237	188	158	136	121	101	87	51	0.322	0.086	0.999	0.322	***0.311***	0.998	0.085	***0.085***

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	25.5	60	705	315	230	177	137	112	96	80	69	45	0.313	0.084	1.019	0.319		1.057	0.089	
55.30	2	L	25.3	60	699	317	230	175	136	109	94	77	67	44	0.317	0.087	1.020	0.324		1.060	0.092	
55.31	2	L	25.7	60	699	327	237	183	139	110	95	76	68	43	0.328	0.090	1.018	0.333		1.053	0.095	
55.32	2	L	25.8	60	701	332	239	179	137	111	94	78	67	44	0.331	0.093	1.017	0.337		1.051	0.098	
55.33	2	L	25.6	60	698	324	235	178	136	109	93	76	66	42	0.325	0.089	1.018	0.331		1.055	0.094	
55.33	2	L	25.6	60	699	322	235	179	137	109	93	75	65	40	0.322	0.087	1.018	0.328		1.055	0.092	
55.34	2	L	25.5	60	697	309	223	168	129	104	88	72	62	38	0.311	0.086	1.019	0.316		1.057	0.091	
55.35	2	L	25.5	60	699	313	226	170	129	103	87	71	61	37	0.313	0.087	1.019	0.319		1.057	0.092	
55.36	2	L	25.9	60	696	315	229	171	132	105	88	72	61	37	0.317	0.086	1.017	0.322		1.050	0.091	
55.37	2	L	25.3	60	699	328	235	178	134	106	90	72	62	38	0.329	0.093	1.020	0.335	***0.327***	1.060	0.099	***0.093***
55.39	3	L	26.2	60	698	316	231	182	141	112	96	74	66	39	0.317	0.085	1.015	0.321		1.044	0.089	
55.40	3	L	26.2	60	699	328	246	188	147	118	99	80	67	40	0.328	0.082	1.015	0.333		1.044	0.086	
55.41	3	L	26.2	60	697	328	244	187	145	115	97	78	66	40	0.330	0.085	1.015	0.335		1.044	0.089	
55.42	3	L	26.6	60	697	332	245	187	145	116	98	78	66	40	0.334	0.088	1.013	0.338		1.038	0.091	
55.42	3	L	26.2	60	702	322	240	182	142	113	96	77	65	38	0.321	0.082	1.015	0.326		1.044	0.086	
55.43	3	L	26.5	60	699	325	241	184	143	115	97	78	66	39	0.325	0.084	1.013	0.330		1.039	0.087	
55.44	3	L	26.1	60	701	321	238	181	141	113	96	77	65	39	0.321	0.083	1.016	0.326		1.046	0.087	
55.45	3	L	26.4	60	697	318	234	177	138	111	95	77	65	39	0.320	0.084	1.014	0.324		1.041	0.088	
55.46	3	L	26.2	60	702	314	233	180	139	113	97	76	65	37	0.314	0.081	1.015	0.318		1.044	0.085	
55.47	3	L	26.3	60	699	318	235	182	142	115	98	79	67	40	0.319	0.083	1.014	0.323	***0.327***	1.043	0.087	***0.087***
56.29	12	L	29.0	60	703	333	233	181	152	131	118	101	89	58	0.331	0.099	1.000	0.331		1.000	0.099	
56.30	12	L	28.5	60	700	341	243	190	157	136	121	104	92	59	0.341	0.098	1.003	0.341		1.007	0.099	
56.31	12	L	28.5	60	698	344	243	190	154	132	118	100	87	54	0.345	0.101	1.003	0.346		1.007	0.102	
56.32	12	L	28.7	60	698	353	248	194	159	135	120	102	90	58	0.354	0.106	1.002	0.355		1.004	0.106	
56.33	12	L	29.0	60	701	362	256	199	165	142	126	107	94	58	0.361	0.106	1.000	0.361		1.000	0.106	
56.33	12	L	28.8	60	696	354	251	195	161	137	121	102	88	55	0.356	0.103	1.001	0.356		1.003	0.104	
56.34	12	L	28.5	60	698	345	243	187	152	129	114	96	82	50	0.346	0.103	1.003	0.347		1.007	0.103	
56.35	12	L	27.9	60	702	365	248	195	160	137	122	103	89	54	0.364	0.117	1.006	0.366		1.017	0.119	
56.36	12	L	28.6	60	702	355	252	193	157	133	117	97	83	49	0.354	0.103	1.002	0.355		1.006	0.104	
56.37	12	L	28.3	60	702	366	261	204	166	139	121	99	85	50	0.365	0.104	1.004	0.366	***0.353***	1.011	0.105	***0.105***

Table C 6: Falling weight deflectometer, 2013 Report No. 13 FWD 392/1 (MRWA 2013b)

															Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (MIcron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	24.0	60	699	335	246	184	141	114	96	79	68	44	0.336	0.089	1.028	0.345		1.084	0.096	
55.30	2	L	24.8	60	699	334	243	179	138	110	95	76	66	42	0.334	0.092	1.023	0.342		1.069	0.098	
55.31	2	L	24.8	60	699	341	248	185	139	111	93	75	64	41	0.342	0.093	1.023	0.350		1.069	0.100	
55.32	2	L	25.0	60	699	357	259	188	142	110	92	73	63	40	0.358	0.099	1.022	0.366		1.066	0.105	
55.33	2	L	24.8	60	699	349	253	186	140	110	91	73	62	38	0.350	0.096	1.023	0.358		1.069	0.103	
55.33	2	L	25.5	60	700	340	246	176	134	104	88	71	61	37	0.340	0.094	1.019	0.347		1.057	0.100	
55.34	2	L	25.3	60	698	329	235	172	130	101	84	67	57	35	0.330	0.094	1.020	0.337		1.060	0.100	
55.35	2	L	25.1	60	703	335	243	178	135	104	87	69	58	35	0.334	0.092	1.021	0.341		1.064	0.098	
55.36	2	L	25.3	60	701	340	245	180	135	105	87	69	57	34	0.340	0.095	1.020	0.346		1.060	0.101	
55.37	2	L	25.0	60	700	362	256	185	136	105	87	69	57	33	0.362	0.106	1.022	0.370	***0.350***	1.066	0.113	***0.101***
55.39	3	L	25.0	60	703	340	254	188	142	111	91	71	59	35	0.338	0.086	1.022	0.346		1.066	0.092	
55.40	3	L	24.9	60	699	336	251	187	143	112	92	73	60	35	0.336	0.084	1.023	0.344		1.067	0.090	
55.41	3	L	24.9	60	704	353	262	194	146	113	93	72	60	35	0.351	0.090	1.023	0.359		1.067	0.097	
55.42	3	L	25.1	60	697	358	260	188	142	110	89	70	58	33	0.359	0.098	1.021	0.367		1.064	0.105	
55.42	3	L	25.3	60	702	364	270	202	151	115	93	72	59	33	0.363	0.094	1.020	0.370		1.060	0.099	
55.43	3	L	25.6	60	698	366	269	199	151	116	94	73	60	33	0.367	0.098	1.018	0.374		1.055	0.103	
55.44	3	L	25.7	60	701	365	268	200	150	117	95	73	60	34	0.365	0.097	1.018	0.371		1.053	0.103	
55.45	3	L	25.6	60	697	371	270	197	148	115	94	72	59	33	0.373	0.102	1.018	0.380		1.055	0.107	
55.46	3	L	25.5	60	702	340	249	184	140	108	90	70	58	33	0.339	0.091	1.019	0.345		1.057	0.096	
55.47	3	L	25.5	60	702	340	252	189	143	111	92	71	58	32	0.339	0.088	1.019	0.346	***0.360***	1.057	0.093	***0.098***
56.29	12	L	27.4	60	701	282	215	174	149	129	115	99	87	55	0.281	0.067	1.008	0.283		1.025	0.068	
56.30	12	L	27.2	60	701	283	213	174	148	129	115	99	86	55	0.283	0.070	1.009	0.285		1.028	0.072	
56.31	12	L	27.0	60	704	290	216	175	150	129	115	97	84	50	0.289	0.074	1.010	0.292		1.031	0.076	
56.32	12	L	27.0	60	696	269	207	169	144	125	112	95	83	51	0.271	0.062	1.010	0.273		1.031	0.064	
56.33	12	L	26.7	60	701	285	217	179	154	135	121	103	90	55	0.285	0.068	1.012	0.288		1.036	0.071	
56.33	12	L	26.6	60	698	295	224	182	156	135	120	102	89	54	0.296	0.071	1.013	0.300		1.038	0.073	
56.34	12	L	26.8	60	699	305	231	187	156	134	117	97	83	47	0.306	0.075	1.012	0.309		1.034	0.077	
56.35	12	L	26.7	60	698	307	234	186	157	133	117	96	82	47	0.308	0.074	1.012	0.312		1.036	0.076	
56.36	12	L	26.6	60	700	289	219	177	149	129	114	94	81	46	0.289	0.070	1.013	0.293		1.038	0.072	
56.37	12	L	26.6	60	705	309	237	189	159	136	120	100	85	49	0.307	0.072	1.013	0.311	***0.295***	1.038	0.074	***0.073***

															Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	20.8	60	704	316	238	182	144	118	100	82	70	46	0.314	0.078	1.051	0.330		1.152	0.089	
55.30	2	L	20.8	60	703	323	239	184	146	118	99	82	69	44	0.321	0.083	1.051	0.338		1.152	0.096	
55.31	2	L	21.0	60	702	332	249	190	149	120	102	81	71	45	0.331	0.083	1.049	0.347		1.148	0.095	
55.32	2	L	20.9	60	701	343	253	192	147	118	99	80	69	44	0.342	0.089	1.050	0.359		1.150	0.103	
55.33	2	L	20.9	60	701	337	247	188	146	117	99	79	68	43	0.336	0.089	1.050	0.353		1.150	0.103	
55.33	2	L	21.0	60	703	334	245	188	146	116	98	79	68	41	0.332	0.089	1.049	0.349		1.148	0.102	
55.34	2	L	20.9	60	700	320	236	178	139	111	94	75	64	39	0.320	0.084	1.050	0.336		1.150	0.096	
55.35	2	L	21.0	60	703	325	240	183	141	113	95	76	64	39	0.324	0.085	1.049	0.340		1.148	0.097	
55.36	2	L	20.9	60	700	320	240	183	143	115	96	76	64	39	0.320	0.079	1.050	0.335		1.150	0.091	
55.37	2	L	20.9	60	700	323	238	179	137	108	89	68	56	31	0.323	0.085	1.050	0.339	***0.343***	1.150	0.098	***0.097***
55.39	3	L	21.0	60	700	327	247	192	151	121	101	81	67	39	0.327	0.080	1.049	0.343		1.148	0.091	
55.40	3	L	21.0	60	703	338	256	200	156	124	104	82	69	41	0.336	0.082	1.049	0.353		1.148	0.094	
55.41	3	L	21.1	60	704	341	259	198	156	124	103	82	68	41	0.339	0.081	1.048	0.355		1.145	0.093	
55.42	3	L	21.1	60	703	343	259	200	158	124	104	82	69	40	0.341	0.083	1.048	0.358		1.145	0.095	
55.42	3	L	21.1	60	702	334	255	196	152	120	101	80	67	39	0.333	0.079	1.048	0.349		1.145	0.091	
55.43	3	L	21.1	60	700	332	251	195	153	122	101	82	68	41	0.332	0.081	1.048	0.348		1.145	0.093	
55.44	3	L	21.1	60	704	331	252	195	152	122	102	81	68	40	0.329	0.078	1.048	0.345		1.145	0.090	
55.45	3	L	21.0	60	701	329	249	192	150	120	101	81	67	40	0.328	0.079	1.049	0.344		1.148	0.091	
55.46	3	L	21.1	60	700	321	243	190	151	121	102	82	69	42	0.321	0.078	1.048	0.337		1.145	0.090	
55.47	3	L	21.1	60	701	332	250	192	152	125	105	84	70	41	0.332	0.082	1.048	0.348	***0.348***	1.145	0.094	***0.092***
56.29	12	L	23.5	60	702	301	228	184	155	134	119	101	89	56	0.300	0.073	1.032	0.310		1.094	0.080	
56.30	12	L	23.1	60	704	315	237	192	162	139	124	104	92	57	0.313	0.077	1.034	0.324		1.102	0.085	
56.31	12	L	24.0	60	700	314	238	191	160	137	121	101	88	54	0.314	0.076	1.028	0.323		1.084	0.083	
56.32	12	L	24.6	60	703	336	253	201	165	141	124	105	91	57	0.335	0.083	1.025	0.343		1.073	0.089	
56.33	12	L	24.5	60	699	336	256	206	171	146	129	108	94	58	0.337	0.081	1.025	0.345		1.075	0.087	
56.33	12	L	24.3	60	700	332	253	202	169	144	127	107	92	55	0.332	0.079	1.026	0.341		1.079	0.085	
56.34	12	L	24.3	60	701	329	245	194	159	134	118	98	84	50	0.328	0.084	1.026	0.337		1.079	0.090	
56.35	12	L	23.5	60	702	333	248	198	165	142	124	104	89	52	0.332	0.084	1.032	0.342		1.094	0.092	
56.36	12	L	24.6	60	700	340	252	199	162	138	120	99	85	50	0.340	0.088	1.025	0.348		1.073	0.095	
56.37	12	L	24.8	60	701	347	260	205	168	143	124	102	87	51	0.346	0.087	1.023	0.354	***0.337***	1.069	0.093	***0.088***

Table C 7: Falling weight deflectometer, 2014 Report No. 14 FWD 405/1 (MRWA 2014)

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa, No Temp Correction: Deflection (mm)	Normalised to 700 kPa, No Temp Correction: Curvature (mm)	Normalised to 700 kPa, Austroads 2008 Correction to 29°C: Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	31.1	60	702	337	240	179	139	113	97	81	70	45	0.336	0.097	0.986	0.332		0.963	0.093	
55.30	2	L	31.0	60	699	339	244	180	138	112	94	77	66	43	0.339	0.095	0.987	0.335		0.964	0.092	
55.31	2	L	31.5	60	696	345	247	181	138	111	94	77	65	41	0.347	0.098	0.983	0.342		0.956	0.094	
55.32	2	L	31.1	60	703	348	245	177	135	106	88	73	61	39	0.346	0.102	0.986	0.341		0.963	0.098	
55.33	2	L	31.3	60	702	348	247	182	137	107	89	71	61	38	0.347	0.101	0.985	0.342		0.959	0.097	
55.33	2	L	30.8	60	701	352	245	174	132	104	85	68	56	33	0.351	0.107	0.988	0.347		0.968	0.103	
55.34	2	L	31.2	60	698	340	241	170	128	100	82	66	55	33	0.341	0.099	0.985	0.336		0.961	0.095	
55.35	2	L	31.0	60	700	439	242	173	130	102	85	69	57	34	0.439	0.197	0.987	0.433		0.964	0.190	
55.36	2	L	30.9	60	700	334	235	170	129	101	83	67	55	32	0.334	0.099	0.987	0.330		0.966	0.096	
55.37	2	L	31.4	60	700	347	243	175	131	103	85	67	56	33	0.347	0.105	0.984	0.342	***0.348***	0.958	0.100	***0.106***
55.39	3	L	35.9	60	701	340	249	182	136	107	87	68	55	31	0.340	0.091	0.957	0.325		0.893	0.081	
55.40	3	L	36.5	60	700	341	248	181	137	109	89	71	57	33	0.341	0.093	0.954	0.325		0.885	0.082	
55.41	3	L	35.6	60	699	348	251	184	139	108	88	69	57	32	0.349	0.098	0.959	0.335		0.897	0.088	
55.42	3	L	34.4	60	705	353	250	183	137	106	87	69	55	31	0.350	0.102	0.966	0.338		0.913	0.093	
55.42	3	L	35.7	60	697	355	262	189	142	109	89	68	55	30	0.356	0.094	0.959	0.341		0.895	0.084	
55.43	3	L	34.8	60	705	360	265	195	147	114	93	72	57	32	0.358	0.095	0.964	0.345		0.907	0.086	
55.44	3	L	34.7	60	704	355	261	191	146	114	92	71	58	33	0.353	0.094	0.964	0.341		0.908	0.086	
55.45	3	L	34.1	60	706	363	264	197	149	115	93	72	58	31	0.360	0.098	0.968	0.348		0.917	0.090	
55.46	3	L	34.1	60	702	331	253	182	137	107	88	69	56	30	0.330	0.078	0.968	0.319		0.917	0.071	
55.47	3	L	34.6	60	699	343	256	188	144	113	92	73	58	32	0.343	0.087	0.965	0.331	***0.335***	0.910	0.079	***0.084***
56.29	12	L	43.1	60	699	287	211	169	146	128	116	99	87	55	0.287	0.076	0.923	0.265		0.817	0.062	
56.30	12	L	44.7	60	698	277	203	165	143	127	115	99	87	55	0.278	0.074	0.916	0.254		0.803	0.059	
56.31	12	L	44.2	60	703	294	212	168	145	128	115	98	86	52	0.293	0.082	0.918	0.269		0.807	0.066	
56.32	12	L	42.1	60	702	274	197	159	138	122	109	94	82	51	0.273	0.077	0.927	0.253		0.826	0.063	
56.33	12	L	44.4	60	696	286	210	168	145	129	116	99	87	53	0.288	0.077	0.918	0.264		0.805	0.062	
56.33	12	L	43.0	60	700	280	210	169	147	130	117	101	88	54	0.280	0.070	0.923	0.258		0.817	0.057	
56.34	12	L	45.3	60	703	296	216	171	146	128	113	95	82	46	0.295	0.080	0.914	0.270		0.798	0.063	
56.35	12	L	44.1	60	703	304	217	174	147	129	114	95	81	46	0.303	0.087	0.919	0.278		0.808	0.070	
56.36	12	L	44.4	60	699	290	211	166	142	124	110	92	79	45	0.290	0.079	0.918	0.266		0.805	0.064	
56.37	12	L	43.5	60	699	313	227	179	151	131	117	98	84	47	0.313	0.086	0.921	0.289	***0.267***	0.813	0.070	***0.064***

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	26.8	60	696	251	180	137	112	94	83	71	62	40	0.253	0.071	1.012	0.256		1.034	0.074	
55.30	2	L	27.3	60	695	258	186	142	116	97	85	72	61	40	0.260	0.073	1.009	0.263		1.026	0.075	
55.31	2	L	28.2	60	693	279	203	153	124	102	88	73	63	39	0.282	0.077	1.004	0.283		1.012	0.078	
55.32	2	L	28.4	60	693	280	201	151	120	100	86	71	62	39	0.283	0.080	1.003	0.284		1.009	0.081	
55.33	2	L	28.2	60	691	273	196	148	118	98	85	71	60	39	0.277	0.078	1.004	0.278		1.012	0.079	
55.33	2	L	28.0	60	693	271	195	146	118	97	84	70	59	36	0.274	0.077	1.005	0.275		1.015	0.078	
55.34	2	L	28.8	60	694	261	185	139	111	92	80	66	57	34	0.263	0.077	1.001	0.263		1.003	0.077	
55.35	2	L	28.5	60	693	265	191	142	113	94	81	67	57	35	0.268	0.075	1.003	0.268		1.007	0.076	
55.36	2	L	28.6	60	692	264	190	142	114	93	80	66	56	34	0.267	0.075	1.002	0.267		1.006	0.075	
55.37	2	L	28.5	60	695	274	196	145	115	95	82	67	57	34	0.276	0.079	1.003	0.277	***0.271***	1.007	0.080	***0.077***
55.39	3	L	29.3	60	696	256	183	139	111	92	80	66	56	34	0.258	0.074	0.998	0.257		0.994	0.074	
55.40	3	L	29.7	60	690	270	196	149	120	99	85	68	57	34	0.274	0.075	0.995	0.272		0.987	0.074	
55.41	3	L	29.5	60	691	272	201	151	121	99	85	69	58	34	0.275	0.072	0.997	0.274		0.991	0.071	
55.42	3	L	29.4	60	690	276	204	155	124	101	86	69	58	34	0.280	0.073	0.997	0.279		0.992	0.073	
55.42	3	L	29.8	60	691	272	195	148	118	97	83	68	57	34	0.276	0.078	0.995	0.274		0.985	0.077	
55.43	3	L	30.0	60	690	269	194	147	119	98	84	69	58	35	0.273	0.076	0.993	0.271		0.982	0.074	
55.44	3	L	30.2	60	693	276	200	151	121	99	85	69	58	34	0.279	0.077	0.992	0.277		0.978	0.075	
55.45	3	L	30.1	60	689	270	196	148	118	97	84	69	57	34	0.275	0.075	0.992	0.272		0.980	0.074	
55.46	3	L	29.7	60	692	257	185	142	115	96	83	68	58	35	0.260	0.072	0.995	0.258		0.987	0.071	
55.47	3	L	29.6	60	693	275	199	151	121	100	87	71	60	35	0.278	0.077	0.996	0.276	***0.271***	0.989	0.076	***0.074***
56.29	12	L	43.7	60	690	310	213	165	142	125	113	97	85	55	0.314	0.098	0.920	0.289		0.811	0.079	
56.30	12	L	43.3	60	700	318	218	170	145	126	114	98	86	54	0.318	0.100	0.922	0.293		0.815	0.081	
56.31	12	L	44.1	60	696	328	224	172	145	127	114	96	84	51	0.330	0.105	0.919	0.303		0.808	0.085	
56.32	12	L	45.9	60	689	334	226	173	146	128	115	98	84	54	0.339	0.110	0.912	0.309		0.793	0.087	
56.33	12	L	45.9	60	686	339	233	178	151	131	117	99	87	53	0.346	0.108	0.912	0.315		0.793	0.085	
56.33	12	L	47.7	60	686	345	227	176	149	129	114	98	85	52	0.352	0.120	0.905	0.319		0.780	0.094	
56.34	12	L	47.7	60	689	337	222	169	141	121	108	90	77	45	0.342	0.116	0.905	0.309		0.780	0.091	
56.35	12	L	46.4	60	688	342	224	173	146	127	113	95	83	48	0.347	0.119	0.910	0.316		0.789	0.094	
56.36	12	L	46.6	60	688	328	220	168	141	120	106	89	76	45	0.334	0.110	0.909	0.304		0.788	0.087	
56.37	12	L	48.6	60	689	326	224	175	148	125	113	94	80	47	0.331	0.103	0.902	0.298	***0.305***	0.773	0.080	***0.086***

Table C 8: Falling weight deflectometer, 2015 Report No. 15 FWD 443-444/1 (MRWA 2015a)

															Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	14.9	60	686	331	237	173	136	106	90	72	63	40	0.337	0.095	1.100	0.371		1.310	0.125	
55.30	2	L	16.4	60	689	324	230	167	130	104	88	70	61	39	0.329	0.095	1.087	0.357		1.266	0.120	
55.31	2	L	19.8	60	689	328	232	169	132	104	88	70	61	38	0.333	0.098	1.058	0.352		1.176	0.115	
55.32	2	L	16.0	60	692	341	238	171	131	102	86	67	58	36	0.345	0.103	1.090	0.376		1.278	0.132	
55.33	2	L	19.7	60	692	339	238	171	130	102	84	64	54	31	0.343	0.102	1.059	0.363		1.178	0.120	
55.33	2	L	16.9	60	677	338	235	166	126	99	82	63	53	31	0.350	0.107	1.082	0.378		1.252	0.134	
55.34	2	L	19.8	60	693	320	222	158	121	94	77	60	50	29	0.323	0.099	1.058	0.342		1.176	0.116	
55.35	2	L	18.7	60	679	303	217	156	120	96	80	62	53	32	0.313	0.089	1.067	0.334		1.203	0.107	
55.36	2	L	19.8	60	693	298	212	150	116	91	76	59	50	29	0.301	0.087	1.058	0.318		1.176	0.102	
55.37	2	L	18.3	60	699	341	236	162	124	94	78	61	52	30	0.342	0.106	1.071	0.366	***0.356***	1.214	0.128	***0.120***
55.39	3	L	20.6	60	694	351	247	173	133	101	83	62	52	29	0.354	0.104	1.052	0.372		1.157	0.121	
55.40	3	L	20.2	60	694	334	243	176	134	105	87	65	55	32	0.337	0.092	1.055	0.356		1.166	0.107	
55.41	3	L	18.6	60	690	341	243	175	136	105	86	66	54	32	0.346	0.100	1.068	0.370		1.206	0.120	
55.42	3	L	20.2	60	694	344	246	175	132	102	84	62	53	29	0.347	0.098	1.055	0.366		1.166	0.115	
55.42	3	L	21.5	60	695	355	251	182	138	106	87	65	53	30	0.358	0.105	1.045	0.374		1.136	0.119	
55.43	3	L	21.4	60	694	353	254	186	144	110	90	67	55	30	0.356	0.100	1.046	0.372		1.138	0.114	
55.44	3	L	20.8	60	692	328	240	174	137	106	86	66	55	29	0.331	0.088	1.051	0.348		1.152	0.102	
55.45	3	L	19.2	60	689	327	237	172	135	105	84	63	51	28	0.332	0.092	1.063	0.353		1.191	0.109	
55.46	3	L	19.7	60	689	311	223	164	126	99	82	62	51	28	0.316	0.090	1.059	0.335		1.178	0.106	
55.47	3	L	21.8	60	693	317	234	168	131	102	84	63	53	29	0.320	0.084	1.043	0.334	***0.358***	1.130	0.095	***0.111***
56.29	12	L	30.4	60	688	270	199	157	138	121	110	92	83	53	0.275	0.073	0.991	0.272		0.974	0.071	
56.30	12	L	30.3	60	697	246	183	149	133	118	108	91	83	54	0.247	0.064	0.991	0.245		0.976	0.063	
56.31	12	L	30.5	60	695	258	190	151	135	121	110	88	80	51	0.260	0.068	0.990	0.257		0.973	0.067	
56.32	12	L	30.3	60	697	252	183	147	129	114	103	87	78	49	0.253	0.069	0.991	0.250		0.976	0.067	
56.33	12	L	30.5	60	697	248	188	152	135	121	110	93	85	54	0.249	0.060	0.990	0.247		0.973	0.059	
56.33	12	L	30.6	60	697	259	195	158	141	125	114	96	86	53	0.260	0.064	0.989	0.257		0.971	0.062	
56.34	12	L	31.5	60	694	256	193	156	138	123	113	95	85	53	0.258	0.063	0.983	0.254		0.956	0.060	
56.35	12	L	31.1	60	694	266	198	157	137	120	108	89	79	46	0.268	0.068	0.986	0.264		0.963	0.066	
56.36	12	L	31.4	60	695	259	193	153	134	118	106	87	78	45	0.261	0.067	0.984	0.257		0.958	0.064	
56.37	12	L	31.5	60	691	268	200	160	140	123	111	91	82	48	0.271	0.069	0.983	0.267	***0.257***	0.956	0.066	***0.064***

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	16.1	60	694	251	185	141	116	97	85	70	62	40	0.253	0.067	1.089	0.276		1.275	0.085	
55.30	2	L	16.3	60	696	261	191	145	119	98	86	70	61	39	0.262	0.070	1.088	0.285		1.269	0.088	
55.31	2	L	19.1	60	687	278	206	156	127	103	89	71	61	39	0.283	0.073	1.064	0.301		1.193	0.087	
55.32	2	L	17.3	60	681	281	202	151	121	99	85	68	60	37	0.289	0.081	1.079	0.312		1.241	0.101	
55.33	2	L	18.8	60	699	271	199	149	120	99	86	68	60	37	0.272	0.072	1.066	0.290		1.201	0.086	
55.33	2	L	16.3	60	696	275	202	151	122	99	86	68	58	36	0.277	0.074	1.088	0.301		1.269	0.094	
55.34	2	L	17.0	60	697	264	195	146	116	95	82	65	57	35	0.265	0.069	1.082	0.286		1.249	0.086	
55.35	2	L	18.3	60	693	267	195	144	115	94	82	64	56	33	0.270	0.073	1.071	0.289		1.214	0.089	
55.36	2	L	18.9	60	692	263	194	145	118	94	79	66	55	33	0.266	0.070	1.066	0.284		1.198	0.084	
55.37	2	L	16.6	60	689	276	199	147	118	96	82	65	56	33	0.281	0.079	1.085	0.304	***0.293***	1.261	0.100	***0.090***
55.39	3	L	18.5	60	703	257	189	144	118	96	83	66	56	33	0.256	0.068	1.069	0.274		1.209	0.082	
55.40	3	L	16.8	60	698	268	202	152	123	101	86	67	57	33	0.268	0.065	1.083	0.291		1.255	0.082	
55.41	3	L	18.3	60	692	269	200	152	122	100	85	67	57	33	0.272	0.070	1.071	0.291		1.214	0.085	
55.42	3	L	19.7	60	694	277	207	157	127	102	87	68	58	34	0.280	0.071	1.059	0.296		1.178	0.084	
55.42	3	L	20.2	60	692	270	199	150	121	98	84	67	57	33	0.273	0.072	1.055	0.288		1.166	0.084	
55.43	3	L	20.3	60	704	272	202	154	123	102	87	69	58	35	0.270	0.070	1.054	0.285		1.164	0.081	
55.44	3	L	19.7	60	694	274	205	154	125	102	87	69	59	34	0.276	0.069	1.059	0.293		1.178	0.082	
55.45	3	L	19.0	60	695	276	203	152	124	101	87	69	58	34	0.278	0.073	1.065	0.296		1.196	0.087	
55.46	3	L	19.7	60	694	258	191	145	119	99	86	68	59	34	0.260	0.067	1.059	0.275		1.178	0.079	
55.47	3	L	20.8	60	693	283	209	155	128	105	91	71	61	35	0.286	0.075	1.051	0.300	***0.289***	1.152	0.086	***0.083***
56.29	12	L	27.2	60	697	284	204	162	140	121	110	91	84	52	0.285	0.080	1.009	0.287		1.028	0.082	
56.30	12	L	27.2	60	680	286	209	162	139	121	109	91	80	52	0.294	0.080	1.009	0.297		1.028	0.082	
56.31	12	L	27.2	60	704	291	209	164	141	124	111	91	82	51	0.290	0.082	1.009	0.292		1.028	0.085	
56.32	12	L	27.4	60	705	292	209	162	140	121	109	91	81	51	0.290	0.083	1.008	0.292		1.025	0.085	
56.33	12	L	27.4	60	698	311	224	175	152	131	119	96	84	53	0.312	0.087	1.008	0.314		1.025	0.089	
56.33	12	L	27.4	60	694	297	218	170	147	127	115	93	84	51	0.300	0.080	1.008	0.302		1.025	0.082	
56.34	12	L	27.4	60	699	290	209	160	138	119	106	86	76	45	0.290	0.081	1.008	0.293		1.025	0.083	
56.35	12	L	27.5	60	693	299	216	171	147	128	115	95	85	51	0.302	0.084	1.008	0.305		1.023	0.086	
56.36	12	L	28.1	60	694	295	210	162	138	118	105	85	75	44	0.297	0.086	1.005	0.299		1.014	0.087	
56.37	12	L	27.9	60	697	308	225	174	150	129	115	93	82	48	0.309	0.083	1.006	0.311	***0.299***	1.017	0.084	***0.084***

Table C 9: Falling weight deflectometer, 2015 Report No. 15 FWD 461-462/2 (MRWA 2015b)

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa		Normalised to 700 kPa					
															No Temp Correction		Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	19.0	60	694	319	227	166	125	100	84	70	59	39	0.322	0.093	1.065	0.343		1.196	0.111	
55.30	2	L	18.6	60	696	324	232	168	126	101	83	67	58	37	0.326	0.093	1.068	0.348		1.206	0.112	
55.31	2	L	19.1	60	704	333	238	172	131	102	85	69	58	37	0.331	0.095	1.064	0.353		1.193	0.114	
55.32	2	L	18.9	60	696	336	238	166	125	97	81	63	53	35	0.338	0.099	1.066	0.360		1.198	0.118	
55.33	2	L	18.9	60	694	336	232	168	125	97	80	64	53	34	0.339	0.105	1.066	0.361		1.198	0.125	
55.33	2	L	18.9	60	694	333	233	165	123	94	76	58	49	29	0.336	0.101	1.066	0.358		1.198	0.122	
55.34	2	L	18.9	60	693	332	230	163	120	91	74	58	48	29	0.336	0.103	1.066	0.358		1.198	0.124	
55.35	2	L	18.7	60	694	328	232	162	119	94	76	58	49	31	0.331	0.097	1.067	0.353		1.203	0.117	
55.36	2	L	18.7	60	692	319	221	159	116	90	74	59	48	29	0.322	0.099	1.067	0.344		1.203	0.119	
55.37	2	L	18.6	60	690	346	241	166	124	93	76	60	48	30	0.351	0.106	1.068	0.375	***0.355***	1.206	0.128	***0.119***
55.39	3	L	18.5	60	695	322	228	165	124	96	77	60	49	28	0.324	0.095	1.069	0.346		1.209	0.114	
55.40	3	L	18.6	60	691	318	231	168	127	99	80	63	51	30	0.322	0.088	1.068	0.344		1.206	0.107	
55.41	3	L	18.5	60	677	333	238	173	130	100	82	63	51	30	0.345	0.099	1.069	0.368		1.209	0.119	
55.42	3	L	18.5	60	674	336	239	171	128	99	80	61	50	29	0.349	0.101	1.069	0.373		1.209	0.122	
55.42	3	L	18.5	60	696	352	255	185	139	105	85	66	53	29	0.354	0.097	1.069	0.378		1.209	0.118	
55.43	3	L	18.5	60	693	342	249	184	139	105	85	67	51	30	0.345	0.094	1.069	0.369		1.209	0.113	
55.44	3	L	18.5	60	693	326	236	175	131	101	82	63	51	29	0.329	0.091	1.069	0.352		1.209	0.110	
55.45	3	L	18.5	60	691	334	242	177	133	102	83	64	51	29	0.338	0.093	1.069	0.361		1.209	0.113	
55.46	3	L	18.4	60	692	332	242	170	129	101	82	62	51	29	0.336	0.092	1.070	0.359		1.211	0.111	
55.47	3	L	18.5	60	690	331	236	175	132	103	82	63	52	30	0.335	0.096	1.069	0.358	***0.361***	1.209	0.116	***0.114***
56.29	12	L	21.0	60	704	249	187	151	129	111	100	86	75	49	0.247	0.062	1.049	0.260		1.148	0.071	
56.30	12	L	21.3	60	697	232	176	141	122	106	96	82	72	46	0.233	0.057	1.047	0.244		1.141	0.065	
56.31	12	L	22.0	60	698	241	186	149	125	109	97	81	70	44	0.241	0.055	1.042	0.251		1.125	0.062	
56.32	12	L	22.1	60	698	231	173	140	119	104	93	79	69	44	0.232	0.058	1.041	0.242		1.123	0.066	
56.33	12	L	22.1	60	695	234	178	145	125	110	99	85	74	47	0.235	0.056	1.041	0.245		1.123	0.063	
56.33	12	L	21.9	60	695	250	189	153	131	115	103	88	76	48	0.252	0.062	1.043	0.262		1.127	0.069	
56.34	12	L	22.0	60	698	252	194	155	131	114	100	83	72	42	0.252	0.058	1.042	0.263		1.125	0.065	
56.35	12	L	21.9	60	696	258	195	158	131	112	99	82	71	41	0.260	0.063	1.043	0.271		1.127	0.071	
56.36	12	L	23.6	60	694	249	188	151	126	109	97	80	70	40	0.251	0.062	1.031	0.259		1.092	0.067	
56.37	12	L	23.0	60	694	270	203	162	138	117	104	87	74	44	0.272	0.067	1.035	0.282	***0.258***	1.104	0.074	***0.067***

															Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	23.9	60	700	301	221	167	131	106	91	76	65	43	0.301	0.080	1.029	0.309		1.086	0.087	
55.30	2	L	23.9	60	708	302	221	165	131	106	91	75	64	43	0.298	0.079	1.029	0.307		1.086	0.086	
55.31	2	L	24.2	60	688	311	224	167	131	105	89	72	62	40	0.317	0.089	1.027	0.325		1.081	0.096	
55.32	2	L	24.0	60	698	325	236	174	135	106	91	73	62	41	0.326	0.090	1.028	0.335		1.084	0.097	
55.33	2	L	24.0	60	701	309	225	171	133	104	89	72	61	40	0.308	0.083	1.028	0.317		1.084	0.090	
55.33	2	L	24.2	60	691	306	223	168	129	104	87	74	61	38	0.310	0.084	1.027	0.318		1.081	0.091	
55.34	2	L	23.9	60	702	300	219	163	125	100	84	69	58	36	0.300	0.081	1.029	0.308		1.086	0.089	
55.35	2	L	24.1	60	701	308	225	164	126	101	85	68	58	36	0.308	0.084	1.028	0.316		1.083	0.091	
55.36	2	L	23.7	60	705	301	222	168	134	100	88	73	62	37	0.299	0.078	1.030	0.308		1.090	0.085	
55.37	2	L	24.6	60	688	310	223	165	126	99	83	67	56	34	0.316	0.089	1.025	0.324	***0.317***	1.073	0.095	***0.091***
55.39	3	L	25.0	60	691	299	223	167	132	104	87	69	57	33	0.303	0.077	1.022	0.310		1.066	0.082	
55.40	3	L	24.8	60	698	316	236	175	137	108	89	71	59	35	0.317	0.081	1.023	0.325		1.069	0.086	
55.41	3	L	24.9	60	698	315	233	174	136	107	90	71	59	36	0.316	0.082	1.023	0.323		1.067	0.088	
55.42	3	L	24.6	60	700	314	239	179	138	110	91	72	60	36	0.314	0.074	1.025	0.321		1.073	0.080	
55.42	3	L	24.9	60	687	308	226	169	130	104	87	70	58	35	0.314	0.083	1.023	0.321		1.067	0.089	
55.43	3	L	25.1	60	686	307	229	173	134	106	89	71	60	37	0.314	0.079	1.021	0.320		1.064	0.085	
55.44	3	L	25.5	60	699	303	228	171	134	107	89	71	60	36	0.303	0.075	1.019	0.309		1.057	0.079	
55.45	3	L	24.7	60	702	309	229	169	132	106	89	72	61	36	0.308	0.080	1.024	0.315		1.071	0.085	
55.46	3	L	25.3	60	700	306	226	173	136	109	93	75	62	37	0.306	0.080	1.020	0.312		1.060	0.085	
55.47	3	L	25.8	60	685	312	232	174	135	110	93	75	63	37	0.319	0.082	1.017	0.325	***0.318***	1.051	0.086	***0.085***
56.29	12	L	41.6	60	699	303	210	165	141	124	111	96	85	55	0.303	0.092	0.929	0.282		0.830	0.077	
56.30	12	L	41.0	60	695	309	216	168	142	124	112	96	85	55	0.311	0.093	0.932	0.290		0.836	0.078	
56.31	12	L	41.0	60	694	307	214	164	137	121	109	90	80	50	0.310	0.094	0.932	0.289		0.836	0.078	
56.32	12	L	40.4	60	682	312	219	171	143	126	113	96	83	54	0.320	0.095	0.935	0.299		0.842	0.080	
56.33	12	L	40.6	60	696	334	233	183	154	134	120	102	88	55	0.336	0.102	0.934	0.313		0.840	0.085	
56.33	12	L	39.5	60	692	326	229	177	150	130	114	98	85	53	0.330	0.098	0.939	0.310		0.851	0.084	
56.34	12	L	40.2	60	697	316	224	168	138	120	107	90	78	47	0.317	0.092	0.936	0.297		0.844	0.078	
56.35	12	L	40.2	60	698	325	228	178	149	130	115	97	84	50	0.326	0.097	0.936	0.305		0.844	0.082	
56.36	12	L	40.1	60	696	320	228	173	143	124	109	89	79	46	0.322	0.093	0.936	0.301		0.845	0.078	
56.37	12	L	41.5	60	695	327	231	178	149	128	113	95	81	48	0.330	0.097	0.930	0.307	***0.299***	0.831	0.081	***0.080***

Table C 10: Falling weight deflectometer, 2016 Report No. 16 FWD 480/3 (MRWA 2016g)

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	16.4	60	701	354	254	188	140	110	91	75	63	41	0.353	0.100	1.087	0.384		1.266	0.127	
55.30	2	L	18.6	60	701	345	253	186	141	110	90	75	62	40	0.344	0.092	1.068	0.368		1.206	0.111	
55.31	2	L	21.9	60	699	359	255	187	139	109	90	74	62	39	0.359	0.104	1.043	0.375		1.127	0.118	
55.32	2	L	17.5	60	705	361	253	188	138	106	88	72	59	37	0.359	0.107	1.077	0.386		1.235	0.132	
55.33	2	L	21.0	60	702	354	253	185	136	106	87	70	58	35	0.353	0.101	1.049	0.370		1.148	0.116	
55.33	2	L	18.3	60	699	344	242	177	128	98	80	64	51	30	0.344	0.101	1.071	0.368		1.214	0.123	
55.34	2	L	18.2	60	701	353	243	174	128	97	79	63	52	30	0.352	0.109	1.071	0.377		1.217	0.133	
55.35	2	L	20.8	60	699	340	244	178	131	99	81	65	53	31	0.341	0.097	1.051	0.358		1.152	0.111	
55.36	2	L	20.2	60	700	332	237	172	127	97	79	64	51	29	0.332	0.096	1.055	0.351		1.166	0.111	
55.37	2	L	18.8	60	699	368	249	178	129	98	80	64	52	30	0.368	0.119	1.066	0.393	***0.373***	1.201	0.143	***0.123***
55.39	3	L	21.5	60	704	353	250	183	136	104	84	66	53	29	0.350	0.102	1.045	0.366		1.136	0.115	
55.40	3	L	19.0	60	703	342	246	183	135	105	85	67	54	31	0.341	0.096	1.065	0.363		1.196	0.115	
55.41	3	L	17.6	60	698	349	254	189	140	108	86	69	54	31	0.350	0.095	1.076	0.377		1.233	0.117	
55.42	3	L	21.3	60	702	359	249	183	134	103	83	66	53	30	0.358	0.109	1.047	0.375		1.141	0.125	
55.42	3	L	22.8	60	699	349	262	192	143	108	87	67	53	29	0.349	0.087	1.036	0.362		1.108	0.097	
55.43	3	L	22.2	60	701	368	263	196	144	112	89	70	55	31	0.368	0.105	1.040	0.383		1.121	0.118	
55.44	3	L	21.8	60	701	354	255	190	142	109	88	69	55	30	0.353	0.099	1.043	0.368		1.130	0.111	
55.45	3	L	17.8	60	700	346	257	192	142	109	88	69	55	30	0.346	0.089	1.075	0.372		1.227	0.110	
55.46	3	L	20.6	60	703	337	244	183	137	105	85	67	54	29	0.335	0.092	1.052	0.353		1.157	0.106	
55.47	3	L	22.4	60	697	332	245	182	135	106	86	67	54	30	0.333	0.087	1.039	0.346	***0.366***	1.117	0.098	***0.111***
56.29	12	L	31.3	60	701	257	194	160	134	119	108	93	82	51	0.257	0.063	0.985	0.253		0.959	0.060	
56.30	12	L	30.5	60	699	246	188	156	133	118	106	93	80	50	0.247	0.058	0.990	0.244		0.973	0.057	
56.31	12	L	30.7	60	699	255	193	157	133	117	103	90	77	47	0.255	0.062	0.989	0.252		0.969	0.060	
56.32	12	L	30.7	60	702	247	185	154	131	116	104	92	79	50	0.246	0.062	0.989	0.244		0.969	0.060	
56.33	12	L	31.1	60	699	244	184	152	131	115	104	91	78	49	0.244	0.060	0.986	0.241		0.963	0.058	
56.33	12	L	30.8	60	700	253	195	162	139	124	112	96	84	52	0.253	0.058	0.988	0.250		0.968	0.056	
56.34	12	L	31.0	60	703	265	198	162	136	119	106	91	77	45	0.264	0.067	0.987	0.260		0.964	0.065	
56.35	12	L	31.2	60	703	273	206	164	139	120	107	91	77	45	0.271	0.066	0.985	0.267		0.961	0.064	
56.36	12	L	31.4	60	703	276	202	165	136	119	106	91	78	46	0.275	0.074	0.984	0.270		0.958	0.071	
56.37	12	L	31.5	60	696	280	208	166	138	120	105	90	77	45	0.282	0.073	0.983	0.277	***0.256***	0.956	0.070	***0.062***

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
															Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	22.0	60	700	260	193	148	117	97	84	72	61	40	0.260	0.068	1.042	0.271		1.125	0.076	
55.30	2	L	22.2	60	699	267	197	152	120	100	85	72	61	39	0.267	0.070	1.040	0.278		1.121	0.079	
55.31	2	L	22.7	60	698	292	215	165	129	104	88	75	62	39	0.293	0.078	1.037	0.304		1.110	0.087	
55.32	2	L	22.6	60	695	300	217	165	127	104	88	74	62	39	0.302	0.083	1.038	0.314		1.113	0.093	
55.33	2	L	23.2	60	699	285	209	159	124	101	85	73	61	37	0.285	0.076	1.034	0.295		1.100	0.083	
55.33	2	L	22.7	60	697	286	213	160	125	100	85	71	59	36	0.287	0.073	1.037	0.298		1.110	0.082	
55.34	2	L	22.9	60	698	279	203	153	118	96	81	68	57	35	0.280	0.076	1.036	0.290		1.106	0.084	
55.35	2	L	23.4	60	664	274	198	147	113	90	76	63	53	31	0.289	0.080	1.032	0.298		1.096	0.088	
55.36	2	L	22.4	60	700	267	198	149	117	94	80	67	55	33	0.267	0.069	1.039	0.278		1.117	0.077	
55.37	2	L	21.5	60	664	277	202	153	117	94	79	65	53	32	0.291	0.078	1.045	0.305	***0.293***	1.136	0.089	***0.084***
55.39	3	L	23.1	60	696	261	196	151	118	96	81	68	54	32	0.263	0.066	1.034	0.272		1.102	0.072	
55.40	3	L	22.4	60	702	288	214	163	127	102	86	70	57	33	0.287	0.074	1.039	0.298		1.117	0.082	
55.41	3	L	23.0	60	699	283	210	160	126	101	84	70	57	33	0.283	0.073	1.035	0.293		1.104	0.080	
55.42	3	L	23.6	60	694	287	212	165	127	103	86	71	57	33	0.289	0.076	1.031	0.298		1.092	0.083	
55.42	3	L	23.3	60	688	279	203	157	121	98	83	69	55	33	0.284	0.077	1.033	0.294		1.098	0.085	
55.43	3	L	23.8	60	664	279	206	158	121	98	81	68	56	32	0.294	0.077	1.030	0.303		1.088	0.083	
55.44	3	L	23.8	60	688	286	213	163	128	102	86	71	58	33	0.291	0.074	1.030	0.299		1.088	0.081	
55.45	3	L	22.8	60	663	277	203	156	121	98	83	68	56	33	0.292	0.079	1.036	0.303		1.108	0.087	
55.46	3	L	22.7	60	697	274	204	159	125	101	87	72	59	35	0.275	0.070	1.037	0.285		1.110	0.078	
55.47	3	L	24.2	60	663	292	217	167	130	104	87	72	59	34	0.309	0.079	1.027	0.317	***0.296***	1.081	0.085	***0.082***
56.29	12	L	23.6	60	658	301	217	170	139	120	106	92	79	51	0.320	0.089	1.031	0.330		1.092	0.097	
56.30	12	L	23.8	60	658	285	208	163	136	116	102	88	75	46	0.303	0.082	1.030	0.312		1.088	0.089	
56.31	12	L	29.3	60	658	275	201	161	132	114	101	86	75	47	0.292	0.078	0.998	0.291		0.994	0.078	
56.32	12	L	28.8	60	657	304	226	179	147	128	113	97	83	52	0.324	0.084	1.001	0.325		1.003	0.084	
56.33	12	L	28.7	60	657	306	220	173	142	121	106	92	77	47	0.326	0.091	1.002	0.326		1.004	0.092	
56.33	12	L	28.5	60	659	289	208	163	133	116	101	86	74	44	0.307	0.086	1.003	0.307		1.007	0.086	
56.34	12	L	29.1	60	658	296	214	170	138	118	104	90	75	46	0.315	0.088	0.999	0.315		0.998	0.087	
56.35	12	L	29.3	60	659	293	211	167	135	116	101	87	73	44	0.311	0.087	0.998	0.310		0.994	0.086	
56.36	12	L	29.6	60	658	303	220	175	142	123	107	91	77	45	0.322	0.088	0.996	0.320		0.989	0.087	
56.37	12	L	29.6	60	656	284	209	166	136	118	103	88	75	44	0.303	0.080	0.996	0.302	***0.314***	0.989	0.079	***0.087***

Table C 11: Falling weight deflectometer, 2016 Report No. 16 FWD 517/1-2 (MRWA 2016h)

Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (MIcron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Normalised to 700 kPa, No Temp Correction: Deflection (mm)	Normalised to 700 kPa, No Temp Correction: Curvature (mm)	Normalised to 700 kPa, Austroads 2008 Correction to 29°C: Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	28.0	60	702	341	252	193	147	119	97	83	70	42	0.340	0.089	1.005	0.342		1.015	0.090	
55.30	2	L	28.4	60	698	361	261	193	143	113	93	78	65	42	0.362	0.100	1.003	0.363		1.009	0.101	
55.31	2	L	28.7	60	701	370	256	189	141	113	92	78	65	41	0.370	0.114	1.002	0.370		1.004	0.115	
55.32	2	L	28.4	60	700	360	257	192	143	113	93	78	65	40	0.360	0.103	1.003	0.361		1.009	0.104	
55.33	2	L	28.4	60	702	366	261	191	143	115	89	76	64	38	0.365	0.105	1.003	0.366		1.009	0.106	
55.33	2	L	29.4	60	703	362	260	192	144	114	90	75	61	36	0.360	0.102	0.997	0.359		0.992	0.101	
55.34	2	L	28.9	60	699	350	248	182	133	104	83	68	54	31	0.350	0.102	1.001	0.351		1.001	0.103	
55.35	2	L	28.9	60	700	357	251	182	134	104	84	68	56	32	0.357	0.106	1.001	0.357		1.001	0.106	
55.36	2	L	29.1	60	700	358	249	181	135	106	83	68	56	32	0.358	0.109	0.999	0.357		0.998	0.108	
55.37	2	L	29.1	60	701	352	244	176	132	104	83	68	54	31	0.352	0.108	0.999	0.351	***0.358***	0.998	0.108	***0.104***
55.39	3	L	28.9	60	701	382	256	188	136	104	84	69	54	31	0.381	0.125	1.001	0.381		1.001	0.126	
55.40	3	L	30.3	60	700	366	257	188	138	109	86	70	55	31	0.366	0.110	0.991	0.363		0.976	0.107	
55.41	3	L	29.5	60	700	355	257	189	140	108	88	69	59	32	0.355	0.098	0.997	0.353		0.991	0.097	
55.42	3	L	29.0	60	697	354	247	184	137	108	86	71	56	32	0.356	0.108	1.000	0.356		1.000	0.108	
55.42	3	L	30.7	60	701	353	256	193	143	110	87	72	56	32	0.353	0.097	0.989	0.349		0.969	0.094	
55.43	3	L	30.1	60	699	359	260	189	140	108	86	70	56	31	0.359	0.099	0.992	0.357		0.980	0.097	
55.44	3	L	29.9	60	698	373	271	201	150	116	91	73	58	31	0.374	0.102	0.994	0.372		0.983	0.101	
55.45	3	L	29.3	60	703	380	282	206	155	117	93	74	59	32	0.378	0.098	0.998	0.377		0.994	0.097	
55.46	3	L	30.5	60	700	364	272	198	153	115	92	72	58	30	0.364	0.092	0.990	0.361		0.973	0.090	
55.47	3	L	29.8	60	701	372	271	204	149	116	92	73	58	32	0.372	0.101	0.995	0.370	***0.364***	0.985	0.099	***0.102***
56.29	12	L	41.4	60	703	278	206	171	145	127	113	100	84	52	0.277	0.071	0.930	0.257		0.832	0.059	
56.30	12	L	40.4	60	703	272	202	167	143	125	110	98	83	50	0.271	0.069	0.935	0.253		0.842	0.058	
56.31	12	L	39.0	60	699	288	207	169	143	125	108	95	80	46	0.288	0.081	0.941	0.271		0.857	0.069	
56.32	12	L	40.3	60	703	270	198	165	141	125	108	97	81	49	0.268	0.072	0.935	0.251		0.843	0.060	
56.33	12	L	39.8	60	701	288	210	175	151	132	116	103	87	51	0.287	0.078	0.938	0.270		0.848	0.066	
56.33	12	L	40.9	60	702	283	210	174	149	132	116	103	88	52	0.282	0.073	0.933	0.263		0.837	0.061	
56.34	12	L	39.7	60	702	317	218	173	145	125	110	100	79	48	0.316	0.099	0.938	0.297		0.849	0.084	
56.35	12	L	40.5	60	700	296	219	178	153	127	111	95	78	44	0.296	0.077	0.934	0.277		0.841	0.065	
56.36	12	L	38.5	60	698	296	213	173	151	129	110	99	77	47	0.297	0.083	0.944	0.280		0.862	0.072	
56.37	12	L	39.2	60	700	300	222	182	153	133	115	100	83	46	0.300	0.078	0.940	0.282	***0.270***	0.854	0.067	***0.066***

															Normalised to 700 kPa No Temp Correction		Normalised to 700 kPa Austroads 2008 Correction to 29°C					
Station (km)	Trial Section	Lane	Surface Temp (°C)	Designed Asphalt Thickness (mm)	Load (kPa)	Defl. 1 (Micron) 0mm	Defl. 2 (Micron) 200mm	Defl. 3 (Micron) 300mm	Defl. 4 (Micron) 400mm	Defl. 5 (Micron) 500mm	Defl. 6 (Micron) 600mm	Defl. 7 (Micron) 750mm	Defl. 8 (Micron) 900mm	Defl. 9 (Micron) 1500mm	Deflection (mm)	Curvature (mm)	Deflection Correction Factor	Deflection (mm)	Section Mean	Curvature Correction Factor	Curvature (mm)	Section Mean
55.29	2	L	22.4	60	699	328	247	191	150	123	102	88	73	48	0.328	0.081	1.039	0.341		1.117	0.091	
55.30	2	L	22.2	60	703	328	246	190	148	120	99	85	71	45	0.326	0.081	1.040	0.339		1.121	0.091	
55.31	2	L	23.9	60	697	341	255	196	150	122	100	85	70	46	0.342	0.087	1.029	0.352		1.086	0.094	
55.32	2	L	23.2	60	698	349	254	195	150	120	99	84	70	45	0.350	0.095	1.034	0.362		1.100	0.105	
55.33	2	L	23.5	60	700	336	249	190	148	118	97	83	68	43	0.336	0.087	1.032	0.347		1.094	0.095	
55.33	2	L	24.8	60	699	332	248	192	146	117	96	80	66	41	0.333	0.084	1.023	0.341		1.069	0.090	
55.34	2	L	23.8	60	698	326	241	184	141	111	91	77	64	40	0.327	0.086	1.030	0.337		1.088	0.093	
55.35	2	L	24.1	60	701	323	238	180	139	111	91	76	63	38	0.323	0.086	1.028	0.332		1.083	0.093	
55.36	2	L	24.9	60	703	332	244	187	144	114	93	77	61	38	0.330	0.087	1.023	0.338		1.067	0.093	
55.37	2	L	24.1	60	702	342	252	192	144	114	92	77	63	37	0.341	0.089	1.028	0.350	***0.344***	1.083	0.097	***0.094***
55.39	3	L	25.0	60	701	330	255	198	153	122	98	80	65	38	0.329	0.075	1.022	0.337		1.066	0.080	
55.40	3	L	24.1	60	701	347	265	203	155	124	100	82	66	39	0.346	0.082	1.028	0.356		1.083	0.089	
55.41	3	L	23.5	60	703	337	255	199	152	122	98	82	67	39	0.336	0.082	1.032	0.347		1.094	0.090	
55.42	3	L	23.6	60	703	341	258	198	153	122	99	82	66	39	0.340	0.083	1.031	0.350		1.092	0.091	
55.42	3	L	24.5	60	703	335	254	196	150	120	97	82	66	39	0.334	0.081	1.025	0.342		1.075	0.087	
55.43	3	L	23.9	60	701	331	254	196	151	120	98	80	66	39	0.331	0.077	1.029	0.341		1.086	0.084	
55.44	3	L	24.0	60	705	332	255	199	153	122	100	83	67	41	0.330	0.076	1.028	0.339		1.084	0.083	
55.45	3	L	25.3	60	698	333	252	193	149	119	97	81	66	39	0.334	0.081	1.020	0.341		1.060	0.086	
55.46	3	L	25.3	60	701	329	254	197	153	123	102	85	69	40	0.328	0.074	1.020	0.335		1.060	0.079	
55.47	3	L	25.2	60	703	340	261	202	156	125	102	85	69	41	0.339	0.079	1.021	0.346	***0.343***	1.062	0.084	***0.085***
56.29	12	L	34.7	60	703	332	245	200	165	143	124	110	93	57	0.331	0.087	0.964	0.319		0.908	0.079	
56.30	12	L	34.7	60	701	329	243	194	161	139	122	107	90	55	0.329	0.086	0.964	0.317		0.908	0.078	
56.31	12	L	34.0	60	699	314	228	185	154	134	117	103	86	53	0.314	0.086	0.968	0.304		0.918	0.079	
56.32	12	L	34.9	60	703	344	258	208	174	151	130	114	98	60	0.343	0.086	0.963	0.330		0.906	0.078	
56.33	12	L	33.7	60	700	348	255	204	169	146	127	111	93	56	0.348	0.093	0.970	0.337		0.922	0.086	
56.33	12	L	34.8	60	700	318	231	188	155	136	117	102	86	52	0.318	0.086	0.964	0.306		0.907	0.078	
56.34	12	L	34.6	60	700	332	244	195	162	139	119	105	88	52	0.332	0.089	0.965	0.321		0.910	0.081	
56.35	12	L	33.1	60	699	333	245	194	160	137	116	101	84	49	0.333	0.088	0.973	0.324		0.931	0.082	
56.36	12	L	35.3	60	702	348	256	206	170	145	125	108	90	52	0.347	0.092	0.961	0.333		0.901	0.083	
56.37	12	L	33.6	60	702	334	243	196	161	140	120	104	87	50	0.333	0.091	0.970	0.323	***0.322***	0.924	0.084	***0.081***

APPENDIX D CIRCLY ANALYSES

D.1 Design Moduli for Current System

D.1.1 Asphalt

The surfacing layers of Sections T2, K2, K3 and K12 are 10 mm of Class 320 OGA overlying a 10 mm thick layer of Class 170 DGA. The remaining sections (T4, T6, R2, R3 and R4) are a single surface of 10 mm Class 170 DGA. The design moduli for these materials, were selected based on the procedure presented in Clause 2.7 of MRWA (2013), are presented in Table D 1 below.

Table D 1: Asphalt modulus values as per ERN9 (MRWA 2013a)

<table>
<tr><th>ID</th><th>Material</th><th>Posted speed limit (km/h)</th><th>Design modulus (MPa)</th><th>k parameter</th></tr>
<tr><td>T2</td><td rowspan="4">10 mm Class 320 OGA</td><td>100</td><td rowspan="4">2 500</td><td rowspan="4">N/A</td></tr>
<tr><td>K2</td><td rowspan="3">110</td></tr>
<tr><td>K3</td></tr>
<tr><td>K12</td></tr>
<tr><td>T2</td><td rowspan="9">10 mm Class 170 DGA</td><td rowspan="3">100</td><td rowspan="3">2 720</td><td rowspan="3">4 488</td></tr>
<tr><td>T4</td></tr>
<tr><td>T6</td></tr>
<tr><td>R2</td><td rowspan="3">90</td><td rowspan="3">2 600</td><td rowspan="3">4 561</td></tr>
<tr><td>R3</td></tr>
<tr><td>R4</td></tr>
<tr><td>K2</td><td rowspan="3">110</td><td rowspan="3">2 820</td><td rowspan="3">4 430</td></tr>
<tr><td>K3</td></tr>
<tr><td>K3</td></tr>
</table>

D.1.2 Granular Materials

Each of the trial sections comprises a base layer of either CRB or BSL overlying a limestone subbase. The thickness of the base layer ranges from 77 to 220 mm for the CRB and from 60 to 230 mm for the BSL. The limestone thickness ranges from 133 to 285 mm.

As per ERN9 (MRWA 2013a) and AGPT 02 (Austroads 2012), the base and subbase are modelled together and split into five equal sublayers. The modulus of the granular material is determined by considering presumptive values supplied in Austroads (2012) in addition to the subgrade strength. For design purposes, MRWA typically uses 600 MPa for CRB and 500 MPa for BSL base materials over a crushed limestone subbase, and sand subgrade with an assigned modulus of 120 MPa. The subbase modulus specified by MRWA does not usually exceed 250 MPa for crushed limestone.

D.1.3 Subgrade

As per the ERN9 requirement, the modulus of the sand subgrade was limited to of 120 MPa which corresponds to a CBR of approximately 12%.

D.2 Layer Thickness

As previously discussed, the thickness of each granular layer and the asphalt surfacing for the Tonkin and Reid Highway trial sections was measured as part of the stage 2 field investigation. However, due to the larger number of measurement locations, it was decided to use the thickness measurements from the construction reports. However, the asphalt thickness has been taken from the cores extracted during the investigation due to a lack of data in the construction reports regarding the surfacing. Pavement profile data for the Kwinana Freeway was based on the as-constructed values measured in the field. The thicknesses of each section are presented in Table D 2 in addition to the design thicknesses.

D.3 CIRCLY Input: Current Design

CIRCLY analyses were undertaken using both the design thickness and the as-constructed thicknesses in conjunction with the standard load pressure of 750 MPa over a radius of 92.1 mm. As per ERN9, traffic multipliers of 1.13 for asphalt fatigue and 1.64 for subgrade rutting and shape loss were used in the analyses which represent urban freeways and highways respectively.

The profile components for each trial section are shown in Table D 2, Table D 3 and Table D 4.

Table D 2: CIRCLY profiles: Tonkin Highway

ID	Material	Design thickness (mm)(1)	As-constructed thickness (mm)	Modulus (MPa)(2)
T2	10 mm Class 320 OGA	30	44	2 200
	10 mm Class 170 DGA	30	44	2 720
	BSL	75	66	500
	Crushed limestone	225	231	
	Sand Subgrade	–	–	120
T4	10 mm Class 170 DGA	30	101	2 720
	BSL	75	60	500
	Crushed limestone	225	238	
	Sand Subgrade	–	–	120
T6	10 mm Class 170 DGA	30	55	2 720
	CRB	75	77	600
	Crushed limestone	225	221	
	Sand Subgrade	–	–	120

1 Mechanistic analysis includes additional 10 mm construction tolerance to asphalt materials as per ERN9 Clause 1.8.

2 Design granular modulus as per ERN9.

Table D 3: CIRCLY profiles: Reid Highway

ID	Material	Design thickness (mm)(1)	As-constructed thickness (mm)	Modulus (MPa)(2)
R2	10 mm Class 170 DGA	30	49	2 600
	BSL	100	113	500
	Crushed limestone	230	271	
	Sand Subgrade	–	–	120
R3	10 mm Class 170 DGA	30	51	2 600
	CRB	100	90	600
	Crushed limestone	230	259	
	Sand Subgrade	–	–	120
R4	10 mm Class 170 DGA	30	50*	2 600
	CRB	200	210	600
	Crushed limestone	130	133	
	Sand Subgrade	–	–	120

1 Mechanistic analysis includes additional 10 mm construction tolerance to asphalt materials as per ERN9 Clause 1.8.

2 Design granular modulus as per ERN9.

Table D 4: CIRCLY profiles: Kwinana Freeway

ID	Material	Design thickness (mm)(1)	As-constructed thickness (mm)	Modulus (MPa)(2)
K2	10 mm Class 320 OGA	30	29	2 500
	10 mm Class 170 DGA	30	36	2 820
	CRB	125	160	600
	Crushed limestone	255	250	
	Sand Subgrade	–	–	120
K3	10 mm Class 320 OGA	30	29	2 500
	10 mm Class 170 DGA	30	36	2 820
	CRB	230	255	600
	Crushed limestone	150	160	
	Sand Subgrade	–	–	120
K12	10 mm Class 320 OGA	30	28	2 500
	10 mm Class 170 DGA	30	36	2 820
	BSL	230	270	500
	Crushed limestone	150	160	
	Sand Subgrade	–	–	120

1 Mechanistic analysis includes additional 10 mm construction tolerance to asphalt materials as per ERN9 Clause 1.8.

2 Design granular modulus as per ERN9.

APPENDIX E EFROMD3 BACK-CALCULATION

E.1 Introduction

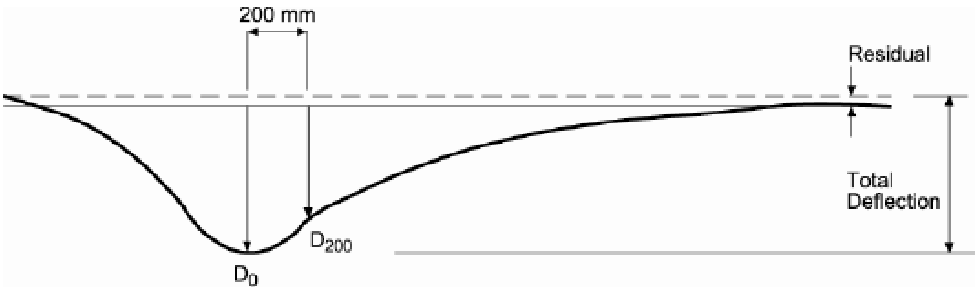
The purpose of this Appendix is to detail and present the methodology and results of an in-depth EFROMD3 modulus back-calculation study. EFROMD3 analysis was used in conjunction with the results of a FWD investigation undertaken during a field investigation at both the Tonkin and Reid Highways. FWD testing was undertaken at 5 metre intervals along both the OWP and BWP of both highways. The back-calculation of layer moduli was undertaken taking consideration of the as-constructed thicknesses of each pavement material in addition to other construction considerations such as material type, embankment data, and sub-surface conditions.

The back-calculated moduli from both the OWP and BWP were compared in an attempt to gain a better understanding of the influence of loading on the development of stiffness. In addition, historic data for the Reid Highway was also analysed to develop a timeline of pavement strength and loading history.

E.2 FWD Loading and Pavement Response

Input into EFROMD3 includes the output data of the FWD test, i.e. the deflection measured under nine geophones located at increasing distances away from the loaded area. These distances are measured from the edge of the FWD plate, which corresponds to 150 mm from the load centre. At this location, D_0, the deflection is at its maximum. As the distance from D_0 increases, the deflection decreases (see Figure E 1).

Figure E 1: Pavement response to FWD load (Figure 4.5 of Austroads 2011).

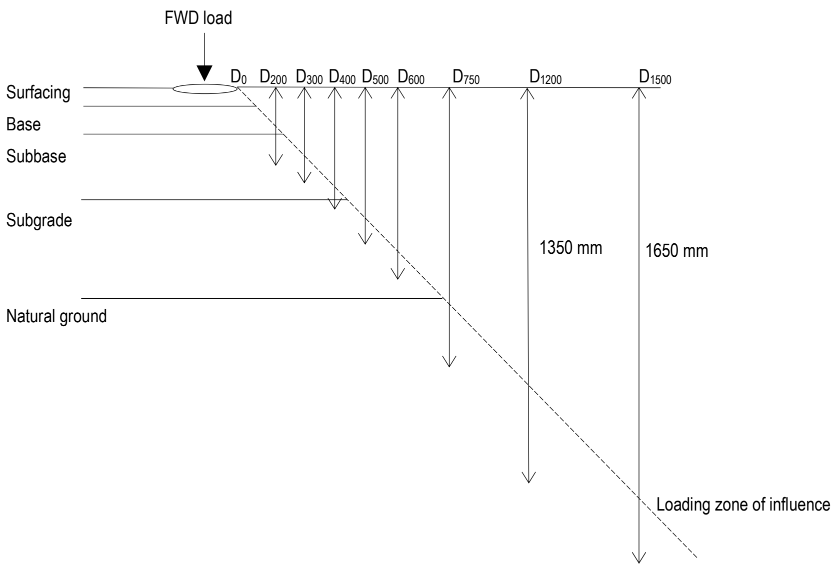


Source: Austroads (2011).

When a load is applied to a pavement surface, the '45° rule' can be applied to identify the zone of influence below the load as shown in Figure E 2). For example, the layers of pavement influencing the deformation created by the FWD load at a depth of 1500 mm below the surface corresponds to the deflection measured at a horizontal distance 1500 mm away from the loaded area (D_{1500}). Similarly, pavement layers 250 mm below the surface will correspond to D_{200}. For thin pavement systems, it is likely that D_{1500} and sometimes D_{1200} will fall below the placed pavement system and into the natural ground.

To enable the modulus of an imported subgrade material to be understood rather than the natural ground, the known depth of the placed subgrade was used in the EFROMD3 profile model. The modulus calculated for this layer was assumed to correspond only to that of the placed material. The moduli of the layers below this placed material are assumed to correspond to the natural ground, a placed embankment, or a combination of the two.

Figure E 2: Typical zone of influence from FWD loading on a thin pavement system



E.3 Natural Ground Conditions

The 1:250 000 Environmental Geological Map series produced by the Geological Survey of Western Australia Pinjarra sheet (Geological Survey of Western Australia 1980) indicates that the natural subsurface conditions below the trial pavements in Section T4, R2 and R3 were Bassendean sands. The presence of Bassendean sands over Guildford formation clays are also inferred in Section T6. Guildford clays are typically of low plasticity and can also show marginal swell potential ($0.5<I_{SS}<3$). They are often stiff to hard in consistency, increasing in strength when dry.

Localised iron-cementation is often encountered within the Bassendean sand system and the Guildford formation. This iron cementation, which can vary in thickness up to a maximum of 4 metres, is caused by seasonal fluctuations of the water-table. These pockets of cementation are common at the interface of Bassendean sands and Guildford formation clays due to the inherent nature of water to perch on the clayey surface during wetter months, and eventually evaporate when temperatures rise. This indurated material is often referred locally as Coffee Rock and can easily cause refusal of a 20 tonne hydraulic excavator. Larger excavators and rock breakers have been widely used, with comparatively slow excavation productivity. Test procedures used to identify areas at risk usually include (Hillman et al. 2003):

- Standard Penetrometer Test (blow counts in excess of 30)
- Electric Friction Cone Penetrometer or CPT (cone resistances of greater than 20 MPa in sands and greater than 5 MPa in high friction ratio clays)
- Borehole core (Point Load Index $Is_{(50)} > 0.03$ MPa).

E.4 Input into EFROMD3

E.4.1 Material Profile

The input pavement profile for the back-calculation is detailed in Table E 1. The mean basecourse and subbase thicknesses were taken from the construction and monitoring reports. Available data regarding the thickness of the imported subgrade (and the embankment at Section T4) is also included.

Asphalt thicknesses were taken from the Stage 2 investigation reports. Both maximum and minimum thicknesses were analysed to examine the influence of the thickness of the surfacing on the back-calculated modulus of the granular basecourse. The same approach was taken for the Reid Highway as details regarding surfacing were not included in the original construction and monitoring reports. The Kwinana Freeway data was taken from the construction report as no investigation was undertaken at this site.

The thickness of the base and subbase was combined and then divided into five equal sublayers as per the mechanistic procedure presented in Austroads (2012). As the Tonkin Highway sections had a very thin base, analyses were also undertaken when the base and subbase layers were modelled separately, with the subbase divided into five equal sublayers. Comparison of the EFROMD3 output demonstrated very similar results for both methods.

Table E 1: Input into EFROMD3: pavement profiles

<table>
<tr><th>ID</th><th>Material purpose</th><th>Material</th><th>Thickness (mm)</th><th>Maximum total thickness (mm)</th></tr>
<tr><td rowspan="7">T2</td><td rowspan="2">Asphalt</td><td>10 mm OGA, Class 320 binder??</td><td rowspan="2">75-88</td><td rowspan="7">885+</td></tr>
<tr><td>10 mm DGA Class, 170 binder</td></tr>
<tr><td>Basecourse</td><td>2% BSL</td><td rowspan="2">5 x 59</td></tr>
<tr><td>Subbase</td><td>Crushed limestone</td></tr>
<tr><td>Subgrade</td><td>Yellow white sand</td><td>500</td></tr>
<tr><td>Embankment</td><td>Grey black sand</td><td>Infinite</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="5">T4</td><td>Asphalt</td><td>10 mm DGA Class 170 binder</td><td>65-101</td><td rowspan="5">950+</td></tr>
<tr><td>Basecourse</td><td>2% BSL</td><td rowspan="2">5 x 60</td></tr>
<tr><td>Subbase</td><td>Crushed limestone</td></tr>
<tr><td>Subgrade</td><td>Yellow white sand</td><td>550</td></tr>
<tr><td>Embankment</td><td>Grey black sand</td><td>Infinite</td></tr>
<tr><td rowspan="5">T6</td><td>Asphalt</td><td>10 mm DGA, Class 170 binder</td><td>43-55</td><td rowspan="5">873+</td></tr>
<tr><td>Basecourse</td><td>Crushed rock base (CRB)</td><td rowspan="2">5 x 60</td></tr>
<tr><td>Subbase</td><td>Crushed limestone</td></tr>
<tr><td>Subgrade</td><td>Yellow white sand</td><td>520</td></tr>
<tr><td>Natural ground</td><td>Clayey gravel (potential Coffee Rock)</td><td>Infinite</td></tr>
<tr><td rowspan="4">R2</td><td>Asphalt</td><td>10 mm DGA, Class 170 binder</td><td>45-49</td><td rowspan="4">934+</td></tr>
<tr><td>Basecourse</td><td>2% BSL</td><td rowspan="2">5 x 77</td></tr>
<tr><td>Subbase</td><td>Crushed limestone</td></tr>
<tr><td>Subgrade</td><td>Yellow white sand</td><td>500, infinite</td></tr>
<tr><td rowspan="4">R3</td><td>Asphalt</td><td>10 mm DGA, Class 170 binder</td><td>39-51</td><td rowspan="4">901+</td></tr>
<tr><td>Basecourse</td><td>CRB</td><td rowspan="2">5 x 70</td></tr>
<tr><td>Subbase</td><td>Crushed limestone</td></tr>
<tr><td>Subgrade</td><td>Yellow white sand</td><td>500, infinite</td></tr>
<tr><td rowspan="4">R4*</td><td>Asphalt</td><td>10 mm DGA, Class 170 binder</td><td>50*</td><td rowspan="4">894+</td></tr>
<tr><td>Basecourse</td><td>CRB</td><td rowspan="2">5 x 70</td></tr>
<tr><td>Subbase</td><td>Crushed limestone</td></tr>
<tr><td>Subgrade</td><td>Yellow white sand</td><td>500, infinite</td></tr>
<tr><td rowspan="3">K2

Cont…</td><td rowspan="2">Asphalt</td><td>10 mm OGA, Class 320 binder</td><td rowspan="2">65</td><td rowspan="3">975+</td></tr>
<tr><td>110 mm DGA, Class 170 binder</td></tr>
<tr><td>Basecourse</td><td>CRB</td><td>5 x 82</td></tr>
</table>

ID	Material purpose	Material	Thickness (mm)	Maximum total thickness (mm)
	Subbase	Crushed limestone		
	Subgrade	Yellow sand	500, infinite	
K3	Asphalt	10 mm OGA, Class 320 binder	65	920+
		10 mm DGA Class, 170 binder		
	Basecourse	CRB	5 x 83	
	Subbase	Crushed limestone		
	Subgrade	Yellow sand	500, infinite	
K12	Asphalt	10 mm OGA, Class 320 binder	64	994+
		10 mm DGA Class, 170 binder		
	Basecourse	2% BSL	5 x 86	
	Subbase	Crushed limestone		
	Subgrade	Yellow sand	500, infinite	

Notes:

- Multiple values indicates consecutive layers of the same material.
- Measured surfacing thickness of R4 an average from R2 and R3
- R4 only used for timeline investigation due to modification in 2014.

E.4.2 Seed Moduli

Maximum, minimum and seed modulus values are required for each layer of the input pavement profile. These values are presented in Table E 2 in addition to the assigned Poisson's ratio and degree of anisotropy of each material (Ev/Eh).

Table E 2: EFROMD3 input: seed moduli

ID	Material purpose	Material	Minimum modulus (MPa)	Maximum modulus (MPa)	Seed modulus (MPa)	Poisson's ratio	Ev/Eh
T2/T4/T6	Surfacing	10 mm DGA/OGA	1 000	20 000	2 800	0.40	1
	Basecourse	2% BSL	50	2 000	1 500	0.35	2
		CRB	50	2 000	1 500		
	Subbase	Crushed limestone	50	2 000	1 500		
	Subgrade	Yellow white sand	20	2 000	200		
	Embankment	Grey black sand	20	1 000	300		
	Natural ground	Clayey gravel (potential Coffee Rock)	20	3 000	700		
R2/R3/R4	Surfacing	10 mm DGA	1 000	20 000	7 000	0.40	1
	Basecourse	2% BSL	50	2000	1500	0.35	2
		CRB	50	2000	1500		
	Subbase	Crushed limestone	50	2000	1500		
	Subgrade	Yellow white sand	20	1000	200, 300		
K2/K3/K12	Surfacing	10 mm DGA/OGA	1000	20000	2800	0.40	1
	Basecourse	2% BSL	50	2000	1500	0.35	2
		CRB	50	2000	1500		
	Subbase	Crushed limestone	50	2000	1500		
	Subgrade	Yellow white sand	20	2000	200, 300		

Notes:

- Multiple values indicates consecutive layers of the same material.

E.5 Results of Back-calculation

E.5.1 Tonkin Highway

The results of the back-calculation for the Tonkin Highway are shown in Table E 3, Table E 4 and Table E 5. The values chosen to calculate these representative moduli are those at test chainages with high deflections/curvatures and low back-calculation errors, a method which is detailed in Appendix E of Austroads (2011). The equivalent stiffness method was used to calculate the discrete base and subbase moduli from the five sublayers.

Table E 3: Back calculated representative modulus: Tonkin Highway, Section T2, left lane

Section	Base	Location	Thickness of surfacing (mm)	Back-calculated modulus (MPa)			
				Asphalt	BSL	Limestone	Subgrade
T2	BSL	OWP	75	5 000	510	360	280
			88	8 080	500	340	280
		BWP	75	4 520	620	520	280
			88	2 870	830	500	300

Table E 4: Back calculated representative modulus: Tonkin Highway, Section T4, left lane

Section	Base	Location	Thickness of surfacing (mm)	Back-calculated modulus (MPa)			
				Asphalt	BSL	Limestone	Subgrade
T4	BSL	OWP	65	7 490	1050	430	180
			86	3 150	880	410	190
		BWP	65	9 450	1150	520	170
			86	6 150	600	530	180

Table E 5: Back calculated representative modulus: Tonkin Highway, Section T6, left lane

Section	Base	Location	Thickness of surfacing (mm)	Back-calculated modulus (MPa)				
				Asphalt	CRB	Limestone	Subgrade	Natural ground
T6	CRB	OWP	43	9 800	660	430	190	570
			55	7 820	590	330	185	560
		BWP	43	8 220	830	324	210	620
			55	6 680	675	370	210	570

Subgrade and Natural Ground

The natural ground in Section T6 – comprising cemented layers and stiff to very stiff clays – underlying T6 is reinforced by modulus values in Table E 5 above. The modulus of the placed subgrade varies slightly from 185 MPa to 210 MPa. The modulus of the placed subgrade embankment material at T2 and T4 varies from 170 MPa to 280 MPa.

The results of CBR testing undertaken on recovered sand samples and compacted to close to the in situ values (Table E 6) resulted in a CBR of 20%. CBR testing undertaken during construction close to the in situ density values produced CBRs of 19.5% for 94% compaction and 25.8% for 96% compaction. These values suggest modulus values of approximately 195 MPa and 250 MPa respectively.

Table E 6: Results of laboratory CBR testing: Tonkin Highway, sand subgrade

ID	Density ratio (%)	Moisture ratio (%)	CBR[1]
Laboratory testing on recovered sand samples, 2017			
T6	94.5	76.5	20.0
T4	95.0	77.0	20.0
Laboratory testing at construction, 1980			
T4/T6	96.0	74.0	25.8
T4/T6	94.0	83.0	19.5

1 Test surcharge of 13.5 kg.

E.5.2 Reid Highway

The back-calculated moduli for the Reid Highway are shown in Table E 7 and Table E 8.

Table E 7: Back-calculated representative moduli: Reid Highway, Section R2, westbound lane

ID	Base	Thickness of surfacing (mm)	Location	Modulus (MPa)			
				Asphalt	BSL	Limestone	Subgrade
R2	BSL	45	OWP	10 300	480	270	220
		49		9 150	420	280	220
		45	BWP	11 235	710	230	225
		49		10 180	650	230	225

Table E 8: Back-calculated representative moduli: Reid Highway, Section R3, westbound lane

ID	Base	Thickness of surfacing (mm)	Location	Modulus (MPa)			
				Asphalt	CRB	Limestone	Subgrade
R3	CRB	39	OWP	14430	670	260	220
		51		9480	470	250	220
		39	BWP	13350	800	270	220
		51		10095	620	240	220

Subgrade

The modulus of the imported subgrade in Sections R2 and R3 was very similar, ranging from 218 MPa to 222 MPa in the OWP. These values were also close to the values for the Tonkin Highway; this suggests that they are both Bassendean sands.

E.5.3 Kwinana Freeway

The back-calculated moduli for the Kwinana Freeway are shown in Table E 9. Data was only available for the OWP of these sections. In addition, there was only one value of surfacing thickness available rather than a range.

Table E 9: Back-calculated representative moduli: Reid Highway, left lane, OWP

ID	Base	Thickness of surfacing (mm)	Modulus (MPa)			
			Asphalt	BSL	Limestone	Subgrade
K2	CRB	65	8510	450	200	250
K3	CRB	65	7480	400	160	310
K12	BSL	64	5200	870	490	220

Subgrade

The modulus of the imported subgrade varied a little between locations. In addition, the modulus values were slightly higher than those at the Tonkin and Reid Highways. This is expected as Tamala sands are known to be a stronger than Bassendean sands in terms of bearing capacity.