APPLICATION OF AUSTROADS PAVEMENT DESIGN GUIDE FOR WANGANUI MATERIALS

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EXECUTIVE SUMMARY

The application of Austroads Pavement Design Guide to Taranaki brown ash has been investigated involving a comprehensive characterisation study of five sites in south Taranaki.

The characterisation involved trenching and sampling of the base, sub-base and subgrade, various non destructive and physical tests were carried out at each site as well as laboratory tests on collected samples.

Using the data obtained from the site characterisation of the five sites an assessment of subgrade strain experienced by the pavements has been made and compared to the Austroads Pavement Design Guide criteria.

This investigation has confirmed the field experience in Wanganui in that pavements constructed on brown ash can tolerate significantly higher deflections and therefore higher subgrade strains than given in the Austroads Pavement Design Guide.

The performance of four of the five road sections investigated has shown that when the performance of these pavements are analysed in terms of their *in situ* Californian Bearing Ratio (CBR) then they conform with the Austroads relationship.

The design of pavement overlays using a deflection based approach as given in Section 10 of the Austroads Guide is therefore not appropriate for volcanic subgrades, but this investigation indicates that the overlay design approach given in the New Zealand supplement to the guide would result in more realistic overlay thicknesses. There is insufficient data to confirm that the slope of the fatigue relationship given in the Austroads Guide is valid for brown ash subgrades.

The results also indicate that the scala penetrometer and the SASW technique could be used as rapid methods to assist in pavement overlay design. Both techniques give modulus values that are similar to those derived from the in situ CBR test.

As would be expected the laboratory soaked CBR gives a conservative estimation of in situ subgrade properties.

It is recommended that on volcanic soils:

- The Austroads Pavement Design Guide deflection based overlay procedure should not be used.

- The CBR x 10 estimation of modulus as an input to pavement design be used in designing unbound pavements.

- The relationship given above should not be used to calculate pavement deflections or the strains that could develop in bound materials. For this type of analysis CBR x 3 should be used to estimate the subgrade modulus.

- That further research be performed to determine if the slope of the subgrade fatigue life relationship given in the Austroads Guide is appropriate for volcanic subgrades.

- That further research be performed to determine the factors controlling the rate of permanent deformation of soils under dynamic loading.

ABSTRACT

The application of the Austroads Pavement Design Guide to Taranaki "brown ash" has been investigated. The study was designed to determine if the sub grade strain and deflection criteria given in the guide was appropriate for use on volcanic soils.

The research involved:

Task 1 Site selection and collection of data on the pavement history, present condition and traffic loadings.

Task 2 Site testing to characterise the materials and pavement dimensions.

Task 3 Comparison of the modulus values derived from the various site tests and analysis of the expected performance of the pavement using the measured parameters. This theoretical performance was then compared with the actual performance of the pavement.

It has been concluded that the deflection criteria given in the guide is not appropriate for use on the Taranaki "brown ash" sub grades but that pavement design based on the sub grade CBR compares favourably with the Austroads Guide.

1. INTRODUCTION

The Wanganui Transit New Zealand Regional Manager has identified a major difference between the pavement depth required by the Austroads Pavement Design Guide based on deflection measurements and that traditionally used in the area for pavement overlays.

Over the last decade a granular overlay of 70 mm has been used as the "normal" treatment thickness with good performance. However if the Austroads Pavement Design Guide criteria was applied, an overlay thickness in the order of 400 mm would be required.

As many of the pavements in Wanganui are constructed on a volcanic "brown ash" subgrade it was considered that the subgrade strain criteria used in the Austroads Pavement Design Guide may not be appropriate for this material. It was thought that some volcanic subgrades may be able to withstand high strains (i.e. high deflections) without incurring the damage which is assumed in the current design procedure.

In order to assess the reasons for the good performance of these pavements, the following research has been undertaken to assess the characteristics of the pavement materials. Using the data obtained from this characterisation an assessment of the expected life of the pavement has been made and compared to the actual performance of the pavements.

The characterisation involved trenching and sampling of the base, sub-base and subgrade, moisture, in situ density and in situ CBR measurements of the base and subgrade, and dynamic cone penetrometer testing of the subgrade.

Laboratory testing of some of the samples collected has included gradings of the base samples and remoulded CBR tests of the subgrade samples. Additional samples have been stored for subsequent testing in stage two of this research.

In addition to this testing, the sites were characterised by measurements over a grid of 12 points. At each point Spectral Analysis of Surface Waves (SASW) and Benkleman beam testing was carried out.

2. SITE SELECTION

Five sites in the Wanganui area were selected based on the following criteria:

a. Their condition was such that they exhibited rutting or roughness that was not attributed to failure of the basecourse material or chipseal.
b. The subgrade was "brown ash".

It was considered that by also obtaining an estimate of the past traffic that it would be possible to obtain the "life" of the pavement and compare this with the expected life obtained from the Austroads Pavement Design Guide.

An outline of each of the five sites selected is included below, with brief descriptions of their position, present condition, age and traffic volumes.

Traffic volume data is available on an annual basis for all sites back to 1980, with a figure for each site of percentage heavy vehicles. For sites that were last reconstructed prior to 1980, the traffic volumes were extrapolated assuming a growth rate of 2%. The figure for 1980 used for these extrapolations was obtained from a curve fitted to the annual traffic data to smooth out the statistical variations. Where the date of construction of the pavement is unclear the records use a default value of 1935.

A photographic record of the trenching and the general site has been made, although this has not been included in this report.

2.1 Ouri Stream Bridge

Location: SH45, RP 64/8.93 - 9.50.
This site is located 600 metres east of Pihama with the trial section being in the southbound lane starting 30 metres south of the bridge. The test pit location was at RP 64/8.98.

The description of the road surface from the feasibility report by Beca consultants in May 1996, includes "settlement, depressions and wheel track rutting along the outer tracks and to a lesser extent the inner tracks of both lanes" over approximately 37% of the surface. From visual evidence they suggest the rutting is the result of accumulated plastic strain of the subgrade under repeated loading.

The last recorded reconstruction of this section of road is 1935, described as 100mm of aggregate, although the feasibility report indicates "heavy maintenance" was carried out in 1994/95. The report attributes the short seal life to excessive flexing which is probably due to insufficient pavement depth to withstand current traffic loading. Comments from a local farmer at the time of site testing, suggest that the road has deteriorated rapidly in the last few years due to the increased volume of milk tankers servicing the dairy factory at Hawera.

The current traffic volume on this section of road 1170 AADT with 11.7% HCV. The estimated number of heavy vehicles passing over this section of road since the time of construction (1935) is 665,000.

2.2 Nopera Road

Location: SH45, RP 64/10.14 - 11.21.
This site is located 1200 metres east of Pihama with the trial section being in the southbound lane starting 500 metres south of the intersection of SH45 and Nopera Road. The test pit location was at approximately RP 64/10.60.

The description of the road surface from the feasibility report by Beca consultants in May 1996, includes "settlement, depressions and wheel track rutting along the outer tracks and to a lesser extent the inner tracks of both lanes" over approximately 59% of the surface. From visual evidence and coring they suggest the rutting is the result of accumulated plastic strain of the subgrade under repeated loading.

The last recorded reconstruction of this section of road is 1935, described as 100mm of aggregate, although the feasibility report indicates "heavy maintenance" was

carried out in 90/91 and 92/93. The report suggests that pavement thickness is insufficient to disperse current traffic loading. Comments from a local farmer at the Ouri bridge site also apply to this site.

The current traffic volume on this section of road 1170 AADT with 11.7% HCV. The estimated number of heavy vehicles passing over this section of road since the time of reconstruction (1935) is 665,000.

2.3 Warwick Road/Hills Road

Location: SH3, RP 279/1.46 - 1.96.
This site is located 2 kilometres south of Stratford with the trial section being in the southbound lane starting seven metres before the open road sign. The test pit location was at RP 279/1.54

The description of the road surface from the project report by Beca consultants in April 1995, includes settlement, depressions, wheel track rutting and cracking. The last recorded reconstruction of this section of road is 1986, described as 150mm of shellrock. The current traffic volume on this section of road 6340 AADT with 11.2% HCV. The estimated number of heavy vehicles passing over this section of road since the time of reconstruction (1986) is 1,332,000.

2.4 Anderson Road

Location: SH3, RP 287/1.00 - 1.32.
This site is located 2 kilometres north of Eltham with the trial section being in the northbound slow lane starting 100 metres north of the beginning of the slow lane. The test pit location was at approximately RP 287/1.16

The description of the road surface from the feasibility report by Beca consultants in May 1996, includes "settlement, depressions and wheel track rutting along the outer tracks of all three lanes and to a lesser extent the inner track" over approximately 28% of the surface. Also noted is "alligator and transverse cracking most of which is accompanied by flushing" over 8% of the surface. From visual evidence and coring they suggest the rutting is the result of accumulated plastic strain of the subgrade under repeated loading. This indicates that pavement thickness is insufficient to disperse current traffic loading.

There are no records for reconstruction of this section of road, although at route position 0.89 the date is given as 1935. This date has been assumed for this test section. The current traffic volume on this section of road 6340 AADT with 11.2% HCV.

2.5 Patea Township

Location: SH3, RP 321/16.04 - 338/0.06.
This site is located within the limits of Patea Township with the trial section being in the northbound lane starting 100 metres north of the intersection of SH3 and Hadfield Street. The test pit location was at approximately RP 321/16.85.

The description of the road surface from the feasibility report by Beca consultants in May 1996, includes "settlement, depressions and wheel track rutting along the outer tracks and to a minor extent the inner tracks of both lanes" over approximately 6% of the surface. This is more accurately represented as 14% of the actual traffic lanes, since much of the pavement surface is taken up with parking and a 2.5 metre wide median strip. From visual evidence and coring they suggest the rutting is the result of accumulated plastic strain of the subgrade under repeated loading. They note that this has been accelerated by the increase in the number of "B" train milk tankers in the area.

It is also noted in the feasibility report "that the existing drainage system does not provide for drainage of the pavement system". However this does not appear to be a problem since the water content measured in the basecourse is similar to other sites, and in the subgrade is significantly less that other sites.

The last recorded reconstruction of this section of road is 1935. The current traffic volume on this section of road 3870 AADT with 11.2% HCV. The estimated number of heavy vehicles passing over this section of road since the time of reconstruction (1935) is 2,376,000.

3. SITE TESTING

At each of the selected sites the trial section was marked out for the site testing. Twelve test locations were marked out for each trial section, consisting of 10 metre spacings in each wheel track.

3.1 Non Destructive Testing

3.1.1 SASW Testing

Spectral Analysis of Surface Waves (SASW) testing was carried out at each of the twelve test locations, the resulting velocity profiles are included in the Appendix and moduli calculated for each layer at the position of the test pits, are also included in Section 4.

SASW is a method for determining the shearwave profile of a pavement system by measuring the surface waves at two points on the surface. The waveforms at the surface are separated into their component frequencies and the surface wave velocities for each frequency are determined. Longer wavelengths travel deeper into the pavement and so their velocities are influenced by the shearwave velocities of these deeper layers.

By combining waveforms measured over different distances a dispersion curve of velocity versus frequency (or more commonly wavelength) is obtained. A pavement model is then used to produce a theoretical dispersion curve which is then matched to the experimental data, the model is then adjusted to give the best fit and thus the shearwave velocity is obtained.

The SASW testing utilised a Toshiba T4700CS laptop computer with a docking station, fitted with a National Instruments AT2150 dynamic Signal acquisition board and LabVIEW software. Two Bruel and Kjaer Model 4384 accelerometers, with type

2635 charge amplifiers and two DeRegt ADR711 accelerometers were used as sensors.

The cross power and coherence spectra of surface waves created by hammer blows on the ground were recorded for various sensor spacings. The coherence function and cross power spectrum were used to produce a dispersion curve of surface wave velocity versus wavelength.

Forward modelling was carried out using the programme WINSASW to find pavement models with theoretical dispersion curves closely approximating the experimental dispersion curves. This programme requires an initial model of layer thickness, shear wave velocity, density and poisson"s ratio. These models are relatively insensitive to slight variations in the assumed values of density and poisson"s ratio and generally only the shearwave velocity and depth values are adjusted to provide the best fit.

The resultant pavement models generally comprise either three or four layers, in some cases although the layers are shown as distinct changes they may actually represent a gradual change.

3.1.2 Benkleman Beam Testing

Benkleman beam testing was carried out in accordance with the TNZ T/1 specification at each of the twelve test locations. The shape of the deflection bowl was obtained by recording the deflection at 0.00, 0.20, 0.30, 0.45, 0.60, 0.90, 1.50 and 10.00 m. The uncorrected measurements are included in the Appendix and are also summarised in Section 4.

3.2 Physical Testing

At each site a trench was excavated down to the subgrade. These trenches extended across both wheeltracks and logs of the materials were made for each wheeltrack. During excavation density and water content readings were taken for the basecourse and subgrade and once the subgrade was exposed, in situ CBR and Scala penetrometer tests were made in each wheeltrack. The logs of the trenches and the results of the density, water content and CBR test results are tabulated in Section 4, the full test results are also included in Appendix.

Modulus values from both the CBR and Scala penetrometer are tabulated and graphed together with the SASW results in Section 4.

3.3 Sampling and Laboratory Testing

Samples were taken in each trench of basecourse, sub base and subgrade materials for laboratory testing and for proposed dynamic modulus testing at a later date. Particle size analysis tests were carried out on the basecourse samples and remoulded soaked CBR tests were performed on the subgrade material. The results of these tests are included in the Appendix and are also discussed in Section 4.

Undisturbed samples of the subgrade were also taken and have been stored for future testing. These samples were taken using 100mm push-in tubes, the ends were then sealed with wax to prevent moisture loss.

3.4 Modulus Calculations

The Young's modulus, E, has been calculated for the subgrade for each site using several methods.

From the SASW shearwave velocity profiles the shear modulus, G, is calculated using the equation:

$$G = \rho Vs^2$$

Where ρ = density, Vs = shearwave velocity. For these calculations the densities measured in the trench were used where available, otherwise typical densities were used. Since the shearwave velocity is squared the resulting modulus is far more sensitive to the shearwave velocity than the density.

The Young's modulus, E, is then calculated using the equation:

$$E = 2(1+\nu)G$$

Where ν = poisson's ratio. Typical poisson's ratio values were obtained from the Austroads manual. The SASW method is based on the assumption that the materials are isotropic, therefore only a single Young's modulus value is obtained.

For the CBR values the vertical Young's Modulus is calculated as CBR x 10 as recommended in the Austroads Pavement Design Guide where an anistropy of 2 is used.

To obtain an estimate of the Young's Modulus from the Scala penetrometer the Scala results (in mm/blow) at the depth of each CBR were obtained. Then using the relationship described in Figure 5.2 of the Austroads Guide the equivalent CBR value was obtained. This value is then multiplied by ten to give the Modulus estimate in the tables below. The same relationship was also used to convert all the Scala penetrometer data to Modulus for plotting on the graphs in Figure 2.

4. SUMMARY OF FIELD INVESTIGATION

The results of the site testing have been summarised in Sections 5 and 6. For each site there are two tables (Tables 1a 1b – 5a 5b) and a graph (in the Appendix). The first "a" table includes layer thickness CBR and estimates of Modulus. The subgrade Modulus values for both the SASW and Scala Penetrometer are the values at the depth of the CBR measurement. The second "b" table includes densities, water content and Benkleman Beam deflections for tests at the same locations as the trenching.

The trench location was chosen from the deflection measurement to reflect an average value for the site. It was noted that there were large differences between the wheel paths. For example at Ouri Stream Bridge the average maximum deflection was approximately 3.0mm in the OWT and 1.6mm in the IWT.

The graph shows the log of the trench for each wheeltrack, as well as the Modulus values from CBR, SASW and Scala penetrometer, plotted against depth from the surface.

Table 1a. Ouri Stream Bridge.

	Thickness mm	**Lab CBR (Remoulded) MPa**	**In Situ CBR MPa**	**SASW E MPa**	**Scala E MPa**
Outside Wheel Track					
Seal	80	-	-	1360	-
Basecourse	170	-	-	15	-
Subgrade	NA	70	54	57	102
Inside Wheel Track					
Seal	60	-	-	1610	
Basecourse	150	-	-	18	-
Sub base	140	-	-	-	-
Subgrade	NA	70	147	81	166

Table 1b. Ouri Stream Bridge.

	Wet Density t/m2	**Dry Density t/m2**	**Water %**	**Benkleman beam**	**Deflection Mm**
Outside Wheel Track					
Basecourse	2.17	2.03	6.8	At trench	3.03
Subgrade	1.49	0.98	51.9	Average	3.14
Inside Wheel Track					
Basecourse	2.25	2.14	4.8	At trench	1.93
Subgrade	1.54	0.96	60.3	Average	1.59

Table 2a. Nopera Road.

	Thickness mm	Lab CBR (Remoulded) MPa	In Situ CBR MPa	SASW E MPa	Scala E MPa
Outside Wheel Track					
Seal	30	-	-	2320	-
Basecourse	340	-	-	129	-
Subgrade 1	100	-	68	76	96
Subgrade 2	NA	10	-	26	-
Inside Wheel Track					
Seal	40	-	-	2720	
Basecourse	140	-	-	171	-
Sub base	40	-	-	-	-
Subgrade	NA	10	222	100	219

Table 2b. Nopera Road.

	Wet Density t/m2	Dry Density t/m2	Water %	Benkleman beam	Deflection Mm
Outside Wheel Track					
Basecourse	2.19	2.09	4.9	At trench	3.13
Subgrade	1.51	0.94	61.1	Average	2.68
Inside Wheel Track					
Basecourse	2.13	2.03	5.3	At trench	2.02
Subgrade	1.51	0.89	69.6	Average	2.41

Table 3a. Warwick Road/Hills Road.

	Thickness mm	**Lab CBR (Remoulded) Mpa**	**In situ CBR Mpa**	**SASW E Mpa**	**Scala E MPa**
Outside Wheel Track					
Seal	120	-	-	10060	-
Basecourse	240	-	-	445	-
Sub base	60	-	-	-	-
Subgrade	NA	20	132	171	89
Inside Wheel Track					
Seal	120	-	-	10390	-
Basecourse	430	-	-	820	-
Sub base	60	-	-	-	-
Subgrade	NA	20	110	146	102

Table 3b. Warwick Road/Hills Road.

	Wet Density t/m2	**Dry Density t/m2**	**Water %**	**Benkleman beam**	**Deflection mm**
Outside Wheel Track					
Basecourse	-	-	-	At trench	1.01
Subgrade	1.51	0.91	65.4	Average	0.98
Inside Wheel Track					
Basecourse	-	-	-	At trench	0.64
Subgrade	1.58	0.98	61.4	Average	0.67

Table 4a. Anderson Road.

	Thickness mm	**Lab CBR (Remoulded) Mpa**	**In situ CBR Mpa**	**SASW E Mpa**	**Scala E Mpa**
Outside Wheel Track					
Seal	30	-	-	3160	-
Basecourse	430	-	-	92	-
Subgrade	NA	10	41	35	44
Inside Wheel Track					
Seal	30	-	-	3160	-
Basecourse	300	-	-	105	-
Sub-base	130	-	-	-	-
Subgrade	NA	10	56	56	44

Table 4b. Anderson Road

	Wet Density t/m2	**Dry Density t/m2**	**Water %**	**Benkleman beam**	**Deflection mm**
Outside Wheel Track					
Basecourse	2.17	2.06	5.1	At trench	2.7
Subgrade	1.30	0.61	114.3	Average	2.8
Inside Wheel Track					
Basecourse	2.13	2.03	4.7	At trench	2.7
Subgrade	1.47	0.78	88.2	Average	2.43

Table 5a. Patea Township.

	Thickness mm	LabCBR (remoulded) MPa	In situ CBR MPa	SASW E MPa	Scala E MPa
Outside Wheel Track					
Seal	70	-	-	3390	-
Basecourse	140	-	-	145	-
Subgrade	70	-	-	-	-
Sub base	70	-	-	-	
Subgrade	NA	110	334	126	166
Inside Wheel Track					
Seal	50	-	-	3390	-
Basecourse	170	-	-	128	-
Subgrade	NA	110	131	104	166

Table 5b. Patea Township.

	Wet Density t/m2	Dry Density t/m2	Water %	Benkleman beam	Deflection mm
Outside Wheel Track					
Basecourse	2.12	2.01	5.4	At trench	1.45
Subgrade	1.76	1.47	20.4	Average	1.56
Inside Wheel Track					
Basecourse	2.13	2.03	5.0	At trench	1.59
Subgrade	1.59	1.15	38.4	Average	1.88

5. ANALYSIS OF RESULTS

5.1 Traffic Loads

Traffic data and extrapolation method for each road were discussed in Section 2. The power law factor, Fp equal to 1.1 and mean ESA per HCV equal to 1.0 were adopted for estimating traffic load in terms of ESA (Equivalent Single Axle). These figures were taken from Design Traffic Data for the New Zealand Supplement in the Austroads Pavement Design Guide. The estimated traffic loadings per lane (ESA) based on two lanes are presented below in Table 6.

Table 6. Actual traffic load (ESA) for various roads.

Location	**Reconstruction year**	**Estimated ESA (1938 to 1980)**	**Estimated ESA from traffic count data (1980 to 1996)**	**Total ESA/lane until 1996 NL**
Ouri Stream Bridge	1935	447,751	283,749	365,750
Nopera Road	1935	447,751	283,749	365,750
Warwick Road/ Hills Road	1986	-	-	732,600
Anderson Road	1986*	-	-	732,600
Patea Township	1935	1,537,575	1,076,025	1,306,800

5.2 Comparison of Modulus Values

The estimated moduli of subgrade of the IWT and OWT obtained using various methods are tabulated below in Table 7. Also presented in the table are the thickness of base layers, including the thickness of chipseal surface when it is greater than or equal to 50 mm.

The conversion from CBR to vertical modulus value was calculated by multiplying by ten as recommended in the Austroads Pavement Design Guide. The deflection bowl modulus was back calculated using the EFROMD2 software. In the analysis only the deflection bowl and layer thickness were used as an input. The analysis was performed without any attempt to modify the results by adjustments based on a knowledge of the subgrade type or in situ CBR data. As the derivation of the SASW Modulus is based on the assumption that the material is isotropic, the modulus has been multiplied by 1.5 to obtain the vertical modulus (based on an assumed Poisson's ratio of 0.45)

Table 7. Comparison of vertical modulus values.

Location		Thickness	Lab CBR MPa	In Situ CBR MPa	SASW E MPa	Scala E MPa	Deflection Bowl E MPa
Ouri Stream Bridge	IWT	350	70	147	86	102	50
	OWT	250	70	54	122	166	50*
Nopera Road	IWT	180	10	222	150	219	17
	OWT	340	10	68	114	96	46
Warick Road / Hills Road	IWT	610	20	110	219	102	87
	OWT	420	20	132	257	89	58
Road Anderson	IWT	430	10	56	84	44	22
	OWT	430	10	41	53	44	36
Patea Township	IWT	220	110	131	156	166	34
	OWT	350	110	334	189	166	93

6. APPLICATION TO THE AUSTROADS PAVEMENT DESIGN GUIDE

The Design Guide (1992) recommends a mechanistic approach, which uses the compressive strain at the top of the subgrade to evaluate pavement life. Commercially available software CIRCLY version 3.0 was used to evaluate compressive strain. It uses a modular sublayering system as described in the guide and treats each layer as elastic.

6.1 Input Parameters

The various input parameters for the elastic analysis of pavement layers using CIRCLY to evaluate the pavement life are listed below.

6.1.1 Subgrade Moduli

Subgrade moduli were obtained from field or lab measurements and were presented in Table 7. They varied considerably between the wheel paths (IWT and OWT) and also among the method of measurements. Therefore all the results were analysed separately.

For the modulus from deflection bowl and SASW, the value at the trench was used to allow a direct comparison with the other measurements.

6.1.2 Thickness of Granular Layer

Thickness of the granular base layer and the surface were taken from the trench data. All the road surfaces were chipseal and their elastic behaviour under traffic loads is not known therefore in the analysis it was assumed that chipseal perform in the same way as the base materials and any thickness larger than 50 mm was included in the basecourse thickness.

There is a considerable difference between IWT and OWT thicknesses and this has resulted in a significant difference in subgrade strains.

6.1.3 Modulus of Granular Layer

Moduli of the granular base generally range from 300 to 500 MPa. For the analysis, a Young's modulus of 300 MPa is assumed, which is considered justified for the study as it gives conservative results and is also substantiated by the fact that the results (pavement life) are not very sensitive to the moduli. An anistropic configuration with a ratio of vertical to horizontal moduli of 2 was assumed.

6.1.4 Traffic

A traffic load equivalent to ESA as defined in the guide, and the load spectrum with tyre pressure of 0.70 MPa and a contact radius of 95 mm was assumed.

6.2 Comparison of Results

6.2.1 Strain-Life Relationship

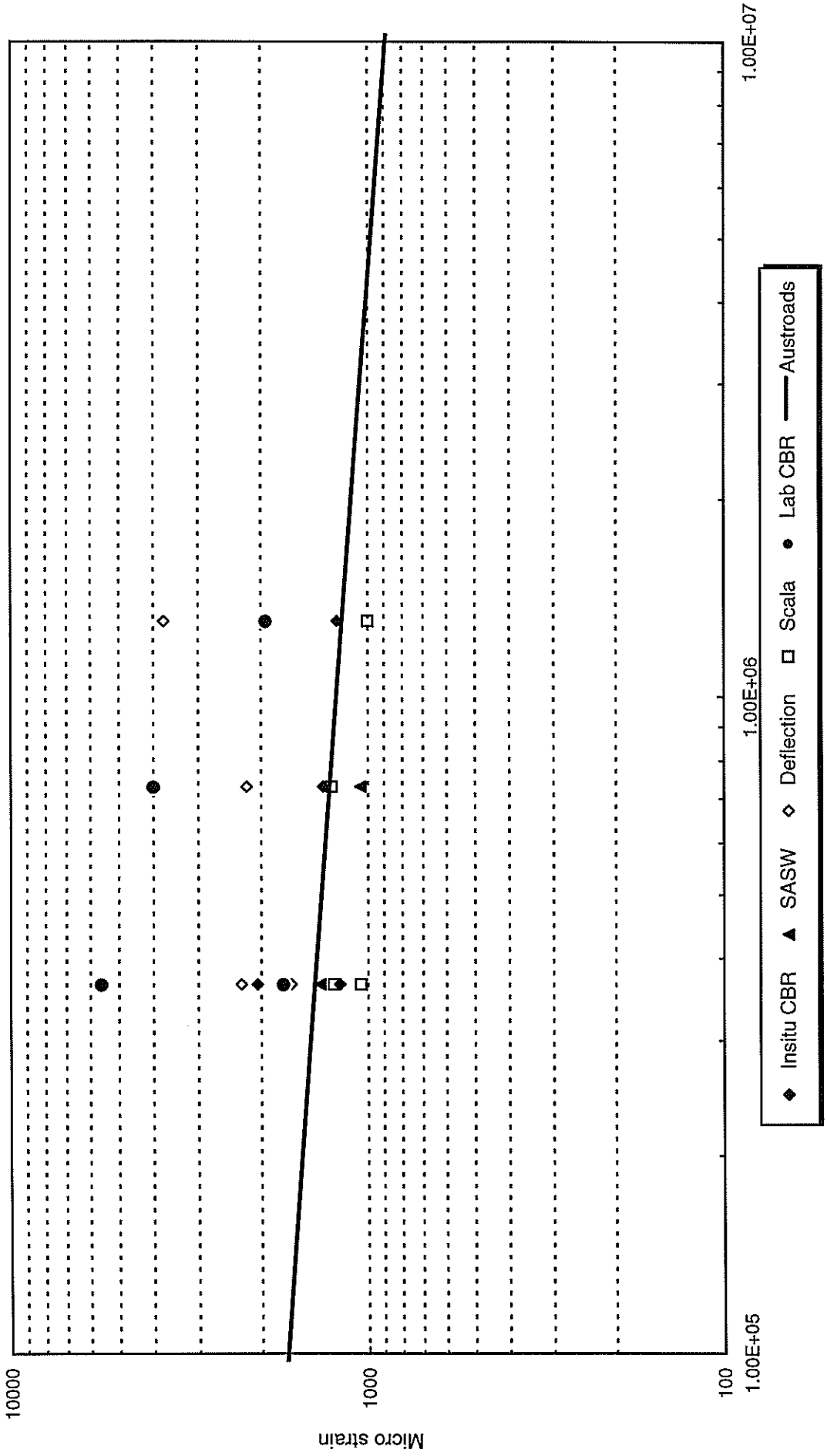
The compressive subgrade strains obtained from the Circly Analysis are given in Table 8. These results are illustrated in Figure 1 together with the Austroads Pavement Design Guide fatigue relationship. In this figure only the highest strain for each road section has been plotted except for the extreme in situ strain for Nopera using the laboratory CBR. It can be seen that:

1. Warwick Road appears as an outlier with a very low strain.
2. The in situ CBR and Scala-derived strains fall very close to the Austroads relationship.
3. The SASW-derived strains also fall close to the Austroads relationship.
4. The deflection-based strains are significantly greater than the Austroads relationship.

Table 8. Compressive subgrade strain based on modulus from different tests.

Site		**Total ESA**	**Test Method**				
			Lab	In situ	SASW	Scala	Deflection
Ouri	IWT	365750	1137	611	1514	550	1492
	OWT		1733	2048	3072	1251	2275
Nopera	IWT	365750	13057	1036	3003	1048	
	OWT		5606	1201	1644	903	1648
Warick	IWT	1332000	1375	370	441	394	447
	OWT		2441	544	657	751	1054
Anderson	IWT	732000	4009	1053	1580	1268	2197
	OWT		4009	1338	2366	1268	1499
Patea	IWT	1306800	1941	2012	2208	1002	3747
	OWT		781	1220	1044	1002	899

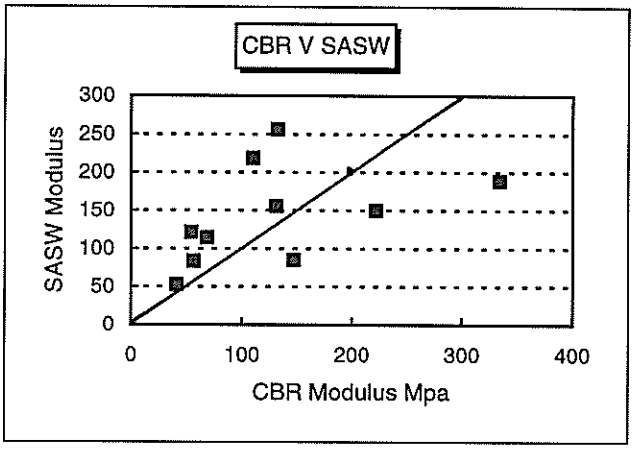
Figure 1. Maximum subgrade strain traffic relationship.

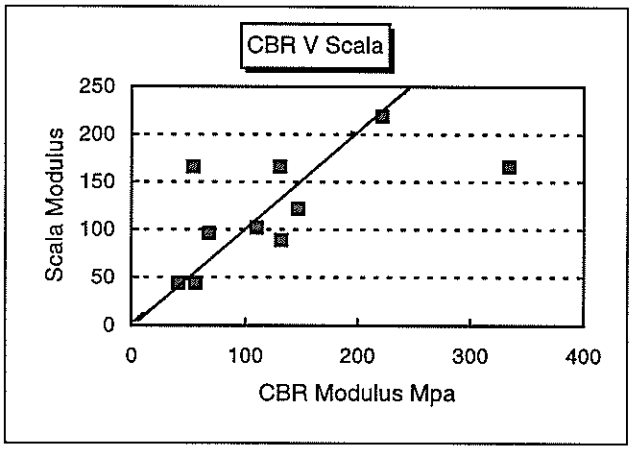


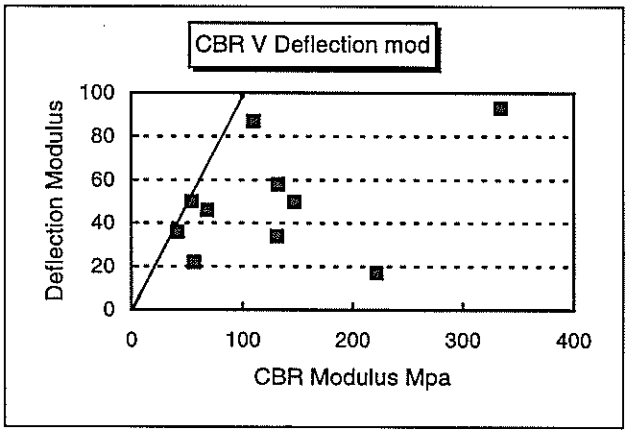
6.2.2 Comparison of Modulus

Figure 2 compares the relationship between the CBR derived modulus and that obtained with the other methods on each graph the 1:1 relationship is shown. Although there is a general trend in the relationships there is considerable scatter in all the data. From an inspection of the data it would appear that the deflection derived modulus values result in the worst correlation with the CBR derived values.

Figure 2. Comparison of modulus values derived from the various test methods.



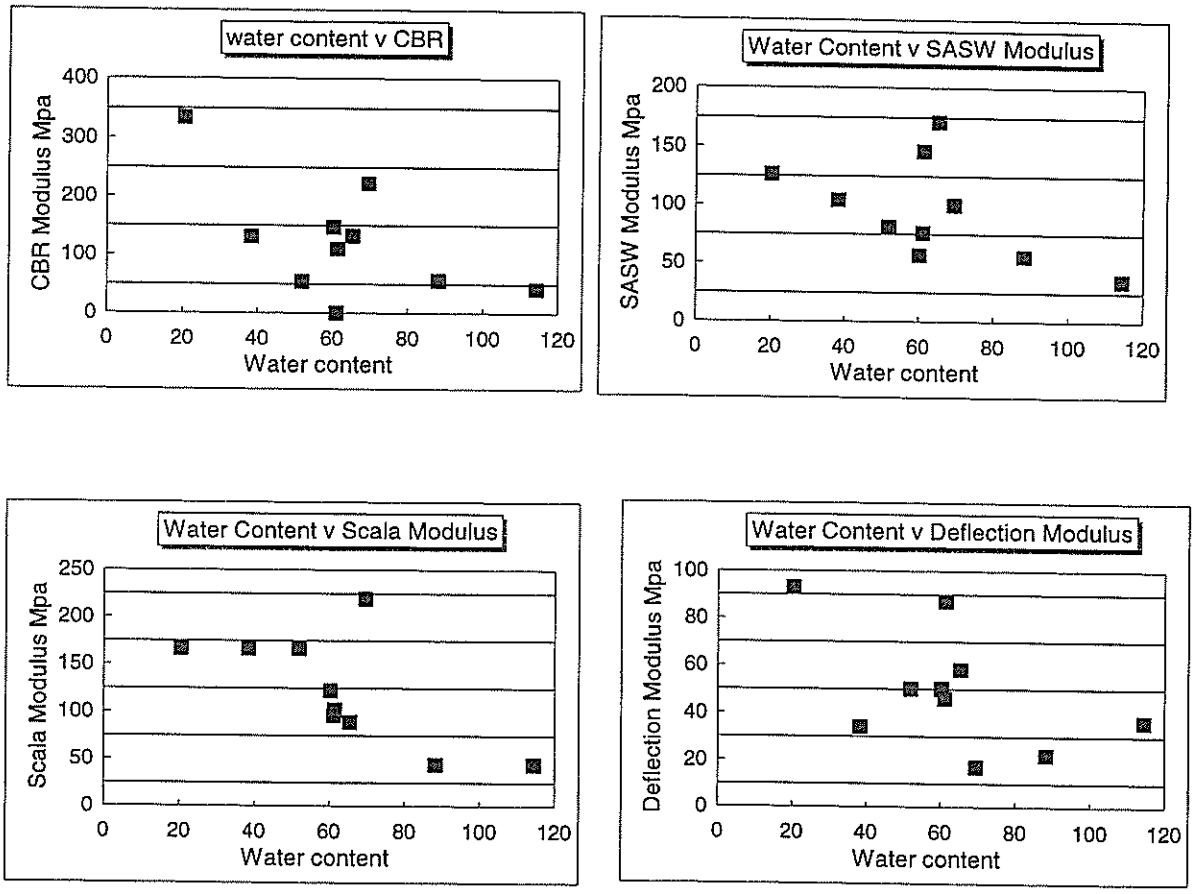




6.2.3 Water Content - Modulus Relationships

Figure 3 illustrates the relationship between the water content of the brown ash subgrade and modulus. In all cases there is a general trend with higher modulus values associated with lower water contents.

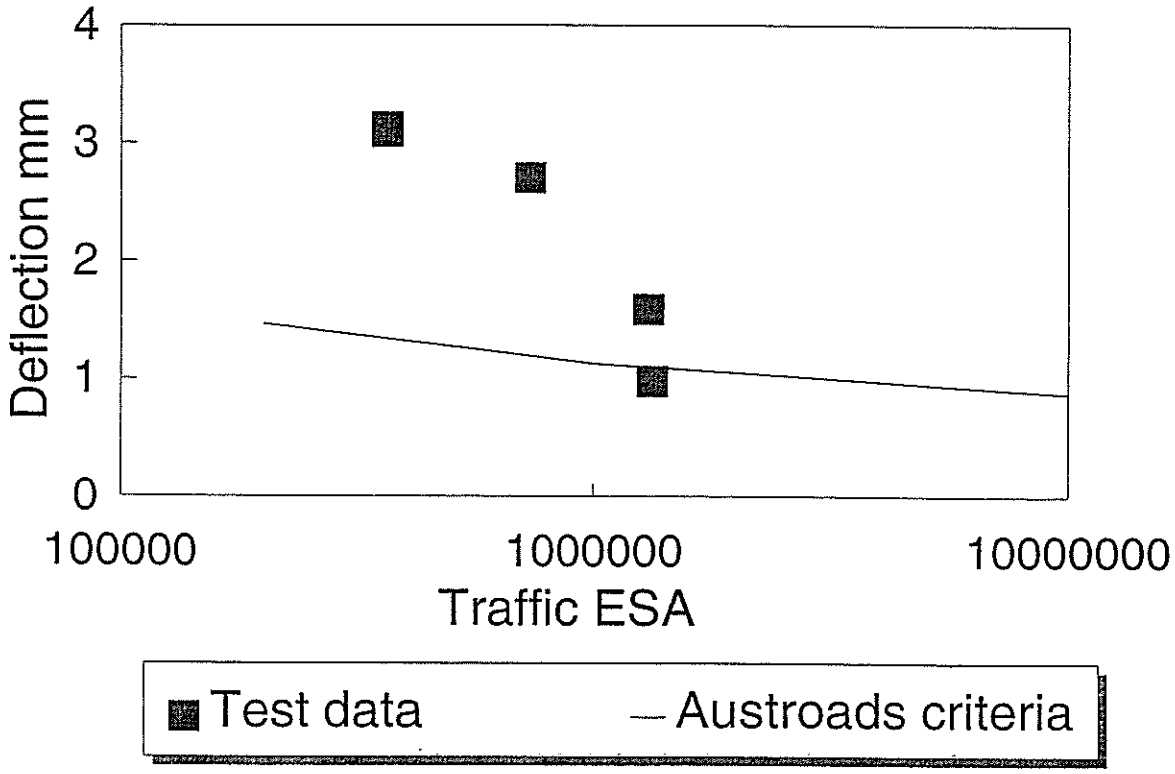
Figure 3. Water content modulus relationships.



6.2.4 Deflection - Life Relationship

Figure 4 illustrates the relationship between the maximum deflection (at the trench) and the observed pavement life. The three lower volume road sections have deflection values well above the relationship given by Austroads.

Figure 4. Comparison of deflection requirements of the Austroads Guide with the test sites.



7. DISCUSSION

Of the five road sections analysed Warick Rd appears as an outlier. It has a significantly lower deflection and subgrade strain than the other sections even though the subgrade is brown ash with similar modulus and water content values. The Circly analysis and comparison with the Austroads strain criteria suggest that this section has failed prematurely. The only major difference between this section and the others is that the basecourse is composed of shellrock where the other pavements have a granular base. It is considered that this pavement may have failed through a shear failure of the basecourse rather than an accumulation of plastic strain in the subgrade.

The performance of the other four road sections compare well with the Austroads Guide based on the in situ CBR results. In a current Transfund Research Project (Alabaster, 1998), a review of models relating the accumulation of plastic strain in subgrade soils has been performed. This review has highlighted two models which use a ratio of the applied stress to the static shear stress as a controlling variable in the deformation characteristics of soils under dynamic loading rather than modulus or compressive strain. It is considered that as the CBR test is a measure of the shear strength of a soil that the relationship found in this research tends to support the theoretical models.

Volcanic soils such as the brown ash do not conform to the CBR- modulus relationship given in the Austroads Guide based on back calculation of the deflection bowl. It would appear that the low strain modulus derived from the SASW measurement may have a better correlation.

8. CONCLUSIONS

This investigation has confirmed the field experience in Wanganui in that pavements constructed on brown ash can tolerate significantly higher deflections and therefore higher subgrade strains than given in the Austroads Pavement Design Guide.

The performance of four of the five road sections investigated has shown that when the performance of these pavements are analysed in terms of their in situ CBR then they conform with the Austroads relationship.

The design of pavement overlays using a deflection based approach as given in Section 10 of the Austroads Guide is therefore not appropriate for volcanic subgrades, but this investigation indicates that the overlay design approach given in the New Zealand supplement to the guide would result in more realistic overlay thicknesses. There is insufficient data to confirm that the slope of the fatigue relationship given in the Austroads Guide is valid for brown ash subgrades.

The results also indicate that the scala penetrometer and the SASW technique could be used as rapid methods to assist in pavement overlay design. Both techniques give modulus values that are similar to those derived from the in situ CBR test.

As would be expected the laboratory soaked CBR gives a conservative estimation of in situ subgrade properties.

9. RECOMMENDATIONS

It is recommended that on volcanic soils:

- The Austroads Pavement Design Guide deflection based overlay procedure should not be used.

- The CBR x 10 estimation of modulus as an input to pavement design be used in designing unbound pavements

- The relationship given above should not be used to calculate pavement deflection or the strains that could develop in bound materials. For this type of analysis CBR x 3 should be used to estimate the subgrade modulus.

- That further research be performed to determine if the slope of the subgrade fatigue life relationship given in the Austroads guide is appropriate for volcanic subgrades.

- That further research be performed to determine the factors controlling the rate of permanent deformation of soils under dynamic loading.

APPENDIX

Benkleman beam

SASW

Trench logs

Density and Water content

Scala penetrometer

CBR In situ and Remoulded

Particle Size Analysis

2/07/97

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Austroads Testing Wanganui Ouri Stream Bridge East Site SH45 RP 64/8.93 to 9.50	Lab Ref	97/M0504
	Inquiries to	Evan Huirua
	Report No.	970504.1
	Page	1

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Ouri Stream Bridge East	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	18 June 1997

Bowl of Deflection Test Report

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **18-06-1997**

Site Location	Displacement metres Dial Gauge Reading mm							
	0	0.2	0.3	0.45	0.6	0.9	1.5	10
Site 1	10.02	9.52	9.23	8.6	8.32	7.95	7.85	7.81
Site 2	10	9.8	9.6	9.5	9.4	9.3	9.2	9.15
Site 3	10.01	9.78	9.6	9.32	9.15	8.95	8.87	8.82
Site 4	10.1	9.83	9.7	9.6	9.53	9.41	9.33	9.27
Site 5	10	9.55	9.25	8.8	8.6	8.58	8.56	8.53
Site 6	10	9.82	9.7	9.52	9.42	9.3	9.24	9.18
Site 7	10.02	9.6	9.3	9.1	8.95	8.8	8.78	8.73
Site 8	10	9.74	9.61	9.48	9.38	9.29	9.24	9.2
Site 9	10	9.5	9.03	8.8	8.5	8.3	8.31	8.25
Site 10	10.02	9.88	9.73	9.61	9.53	9.4	9.32	9.27
Site 11	10	9.65	9.41	9.1	8.8	8.6	8.54	8.48
Site 12	10	9.8	9.6	9.5	9.4	9.37	9.32	9.28

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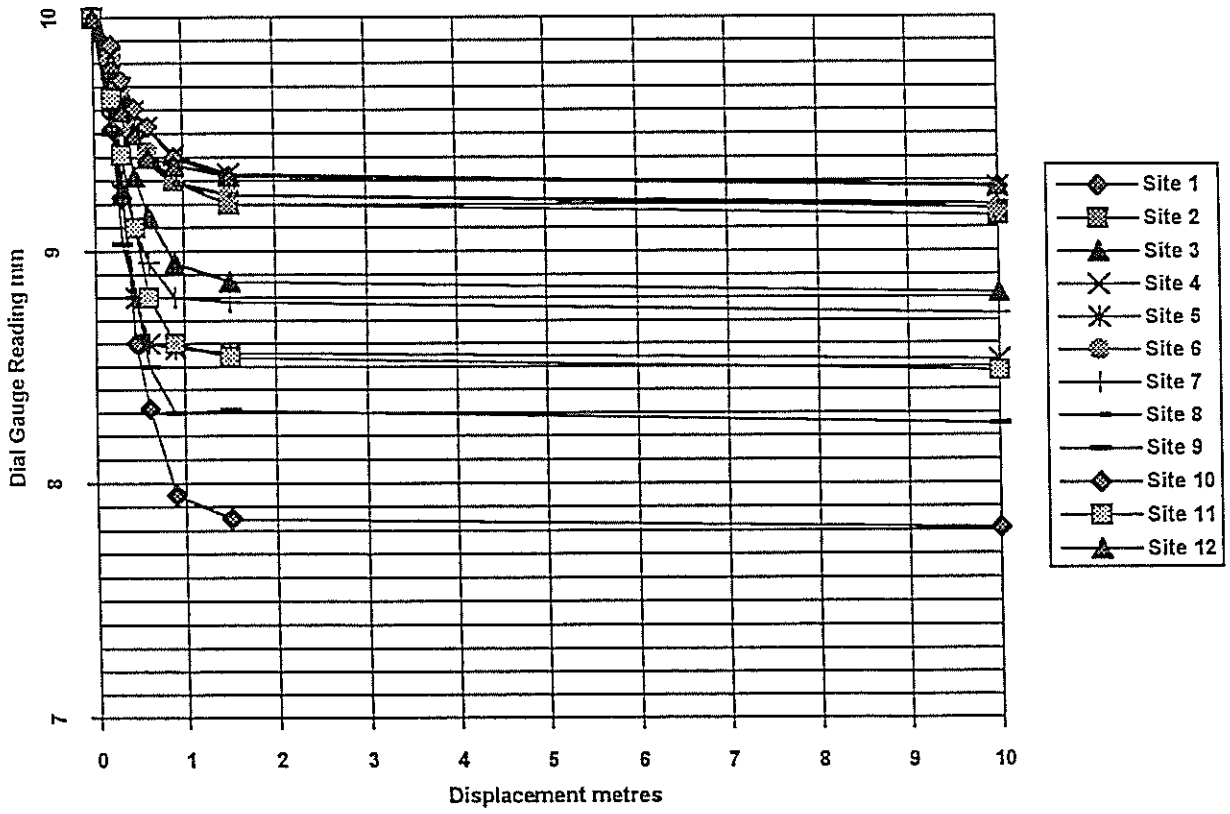
Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Ouri Stream Bridge East**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Bowl of Deflection Test Report Graph

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **18-06-1997**



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Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Nopera Road South	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	18 June 1997

Bowl of Deflection Test Report

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **19-06-1997**

Site Location	Displacement metres Dial Gauge Reading mm							
	0	0.2	0.3	0.45	0.6	0.9	1.5	10
Site 1	10.02	9.8	9.63	9.44	9.27	9.05	8.98	8.96
Site 2	10.01	9.85	9.6	9.4	9.22	8.9	8.67	8.65
Site 3	10.01	9.7	9.4	9.15	8.9	8.66	8.55	8.55
Site 4	10	9.83	9.7	9.5	9.38	9.2	9.11	9.08
Site 5	10.03	9.8	9.56	9.29	9.08	8.69	8.5	8.49
Site 6	10	9.85	9.72	9.54	9.43	9.3	9.17	9.12
Site 7	10.05	9.8	9.5	9.3	9.1	8.65	8.54	8.53
Site 8	10.01	9.87	9.73	9.57	9.48	9.34	9.24	9.19
Site 9	10.04	9.9	9.7	9.5	9.32	9.1	8.93	8.88
Site 10	10.01	9.87	9.76	9.6	9.5	9.36	9.25	9.23
Site 11	10.04	9.9	9.75	9.56	9.37	9.1	8.92	8.87
Site 12	10	9.87	9.5	9.3	9	8.7	8.55	8.48

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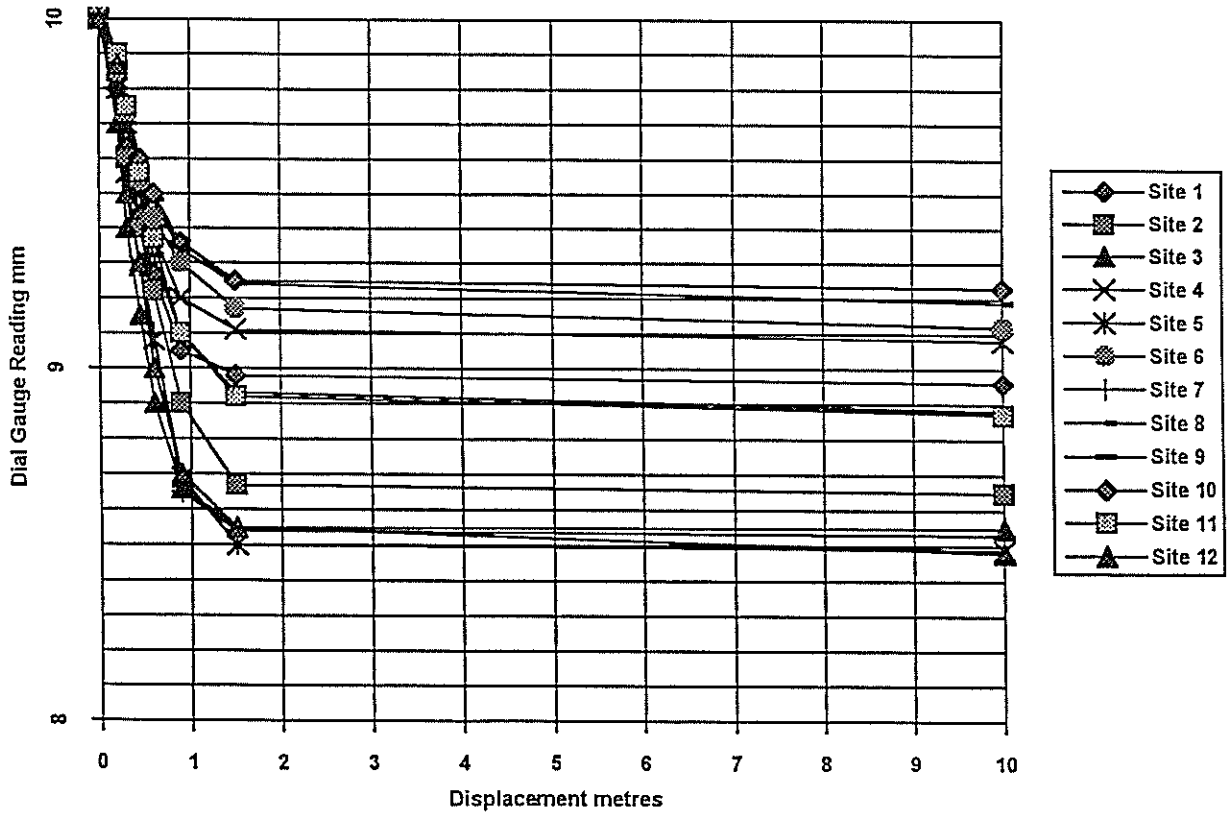
Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Nopera Road South	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	18 June 1997

Bowl of Deflection Test Report Graph

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **19-06-1997**



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Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Warwick Rd - Hills Rd**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**21 June 1997**

Bowl of Deflection Test Report

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **21-06-1997**

Site Location	Displacement metres Dial Gauge Reading mm							
	0	**0.2**	**0.3**	**0.45**	**0.6**	**0.9**	**1.5**	**10**
Site 1	10	9.94	9.91	9.88	9.86	9.84	9.81	9.74
Site 2	10.01	9.97	9.95	9.93	9.92	9.91	9.89	9.82
Site 3	10.02	9.97	9.92	9.87	9.85	9.81	9.77	9.69
Site 4	10.01	9.99	9.98	9.96	9.95	9.93	9.9	9.84
Site 5	10	9.92	9.82	9.79	9.76	9.73	9.7	9.64
Site 6	10	9.95	9.91	9.88	9.86	9.84	9.82	9.78
Site 7	10.01	9.97	9.92	9.86	9.83	9.8	9.76	9.71
Site 8	10.01	9.98	9.96	9.93	9.91	9.89	9.86	9.81
Site 9	10.01	9.96	9.9	9.76	9.72	9.65	9.6	9.54
Site 10	10.01	9.92	9.86	9.81	9.78	9.74	9.71	9.67
Site 11	10	9.96	9.91	9.84	9.8	9.75	9.71	9.65
Site 12	10	9.95	9.9	9.86	9.82	9.79	9.76	9.72

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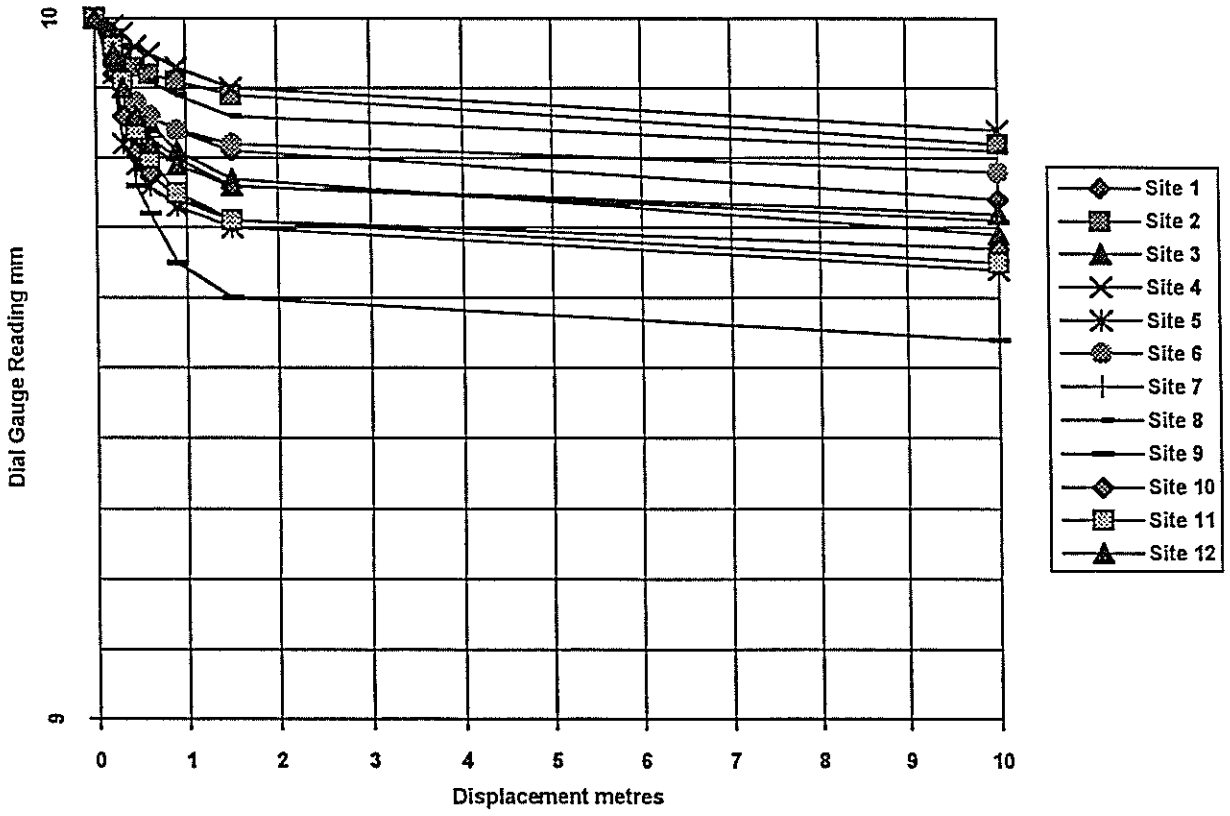
Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Warwick Rd - Hills Rd**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**21 June 1997**

Bowl of Deflection Test Report Graph

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **21-06-1997**



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Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Anderson Road North**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**23 June 1997**

Bowl of Deflection Test Report

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **23-06-1997**

Site Location	Displacement metres Dial Gauge Reading mm							
	0	**0.2**	**0.3**	**0.45**	**0.6**	**0.9**	**1.5**	**10**
Site 1	10.01	9.92	9.78	9.6	9.5	9.37	9.2	9.1
Site 2	10	9.9	9.82	9.69	9.58	9.5	9.3	9.15
Site 3	10	9.84	9.73	9.63	9.54	9.45	9.4	9.34
Site 4	10	9.9	9.85	9.77	9.7	9.6	9.51	9.46
Site 5	10.01	9.83	9.67	9.48	9.32	9.16	9.07	9
Site 6	10	9.89	9.79	9.64	9.54	9.36	9.21	9.13
Site 7	10	9.6	9.4	9	8.7	8.34	8.02	7.9
Site 8	10	9.88	9.75	9.53	9.38	9.13	8.84	8.71
Site 9	10.02	9.85	9.7	9.53	9.4	9.19	8.99	8.9
Site 10	10	9.85	9.63	9.6	9.48	9.3	9.12	8.99
Site 11	10.01	9.89	9.7	9.5	9.35	9.15	8.97	8.9
Site 12	10	9.84	9.75	9.6	9.5	9.35	9.21	9.12

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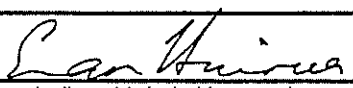
Laboratory Manager  Date 2/7/97

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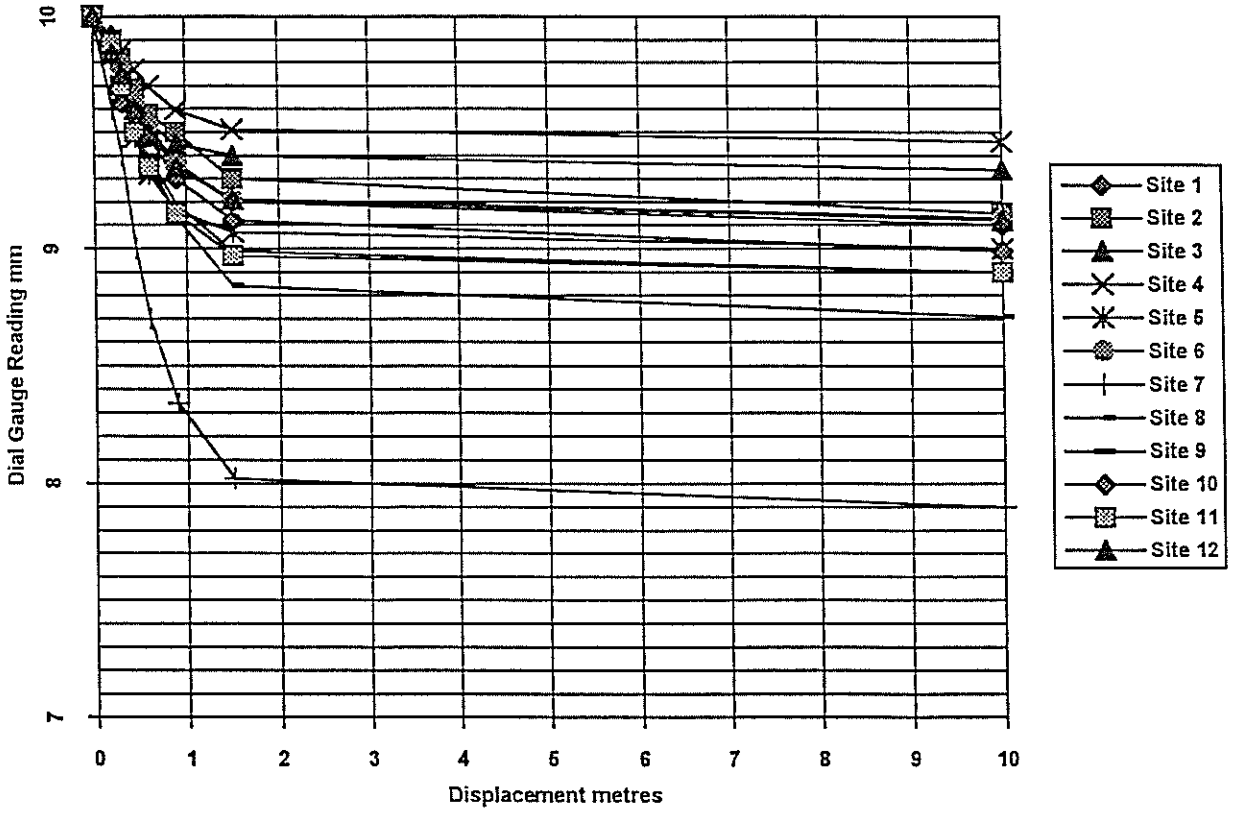
Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Anderson Road North**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**23 June 1997**

Bowl of Deflection Test Report Graph

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **23-06-1997**



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Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06	Lab Ref Inquiries to Report No. Page	97/M0501 **Evan Huirua** 970501.1 1

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Patea Township Site**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**20 June 1997**

Bowl of Deflection Test Report

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **20-06-1997**

Site Location	Displacement metres Dial Gauge Reading mm							
	0	**0.2**	**0.3**	**0.45**	**0.6**	**0.9**	**1.5**	**10**
Site 1	10	9.8	9.7	9.6	9.55	9.52	9.49	9.47
Site 2	10	9.87	9.67	9.4	9.32	9.26	9.24	9.2
Site 3	10.01	9.72	9.58	9.45	9.39	9.34	9.31	9.29
Site 4	10.02	9.83	9.7	9.47	9.35	9.25	9.24	9.2
Site 5	10	9.85	9.75	9.55	9.45	9.4	9.38	9.35
Site 6	10	9.8	9.63	9.43	9.32	9.25	9.24	9.23
Site 7	10.03	9.73	9.58	9.3	9.17	9.1	9.07	9.03
Site 8	10.01	9.67	9.48	9.2	9	8.85	8.83	8.8
Site 9	10.02	9.89	9.77	9.55	9.45	9.38	9.35	9.32
Site 10	10.02	9.86	9.78	9.42	9.27	9.1	9.06	9.02
Site 11	10	9.87	9.76	9.63	9.53	9.48	9.45	9.42
Site 12	10.01	9.83	9.7	9.53	9.38	9.23	9.2	9.17

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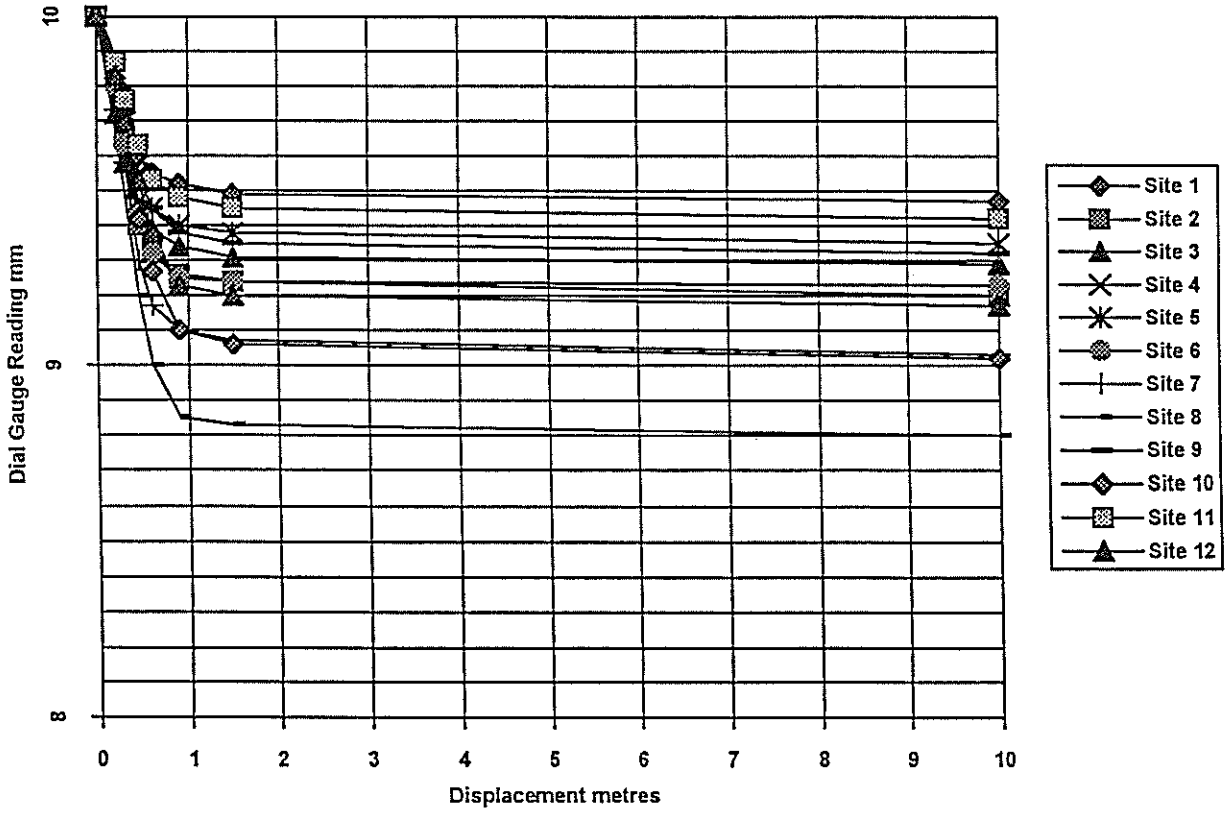
Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06	Lab Ref Inquiries to Report No. Page	97/M0501 Evan Huirua 970501.1 2

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Patea Township Site	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	20 June 1997

Bowl of Deflection Test Report Graph

Test Method **TNZ T/1:1977 Benkelman Beam Test**
Date tested **20-06-1997**



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Laboratory Manager Lan Huirua Date 1 / 7 / 97

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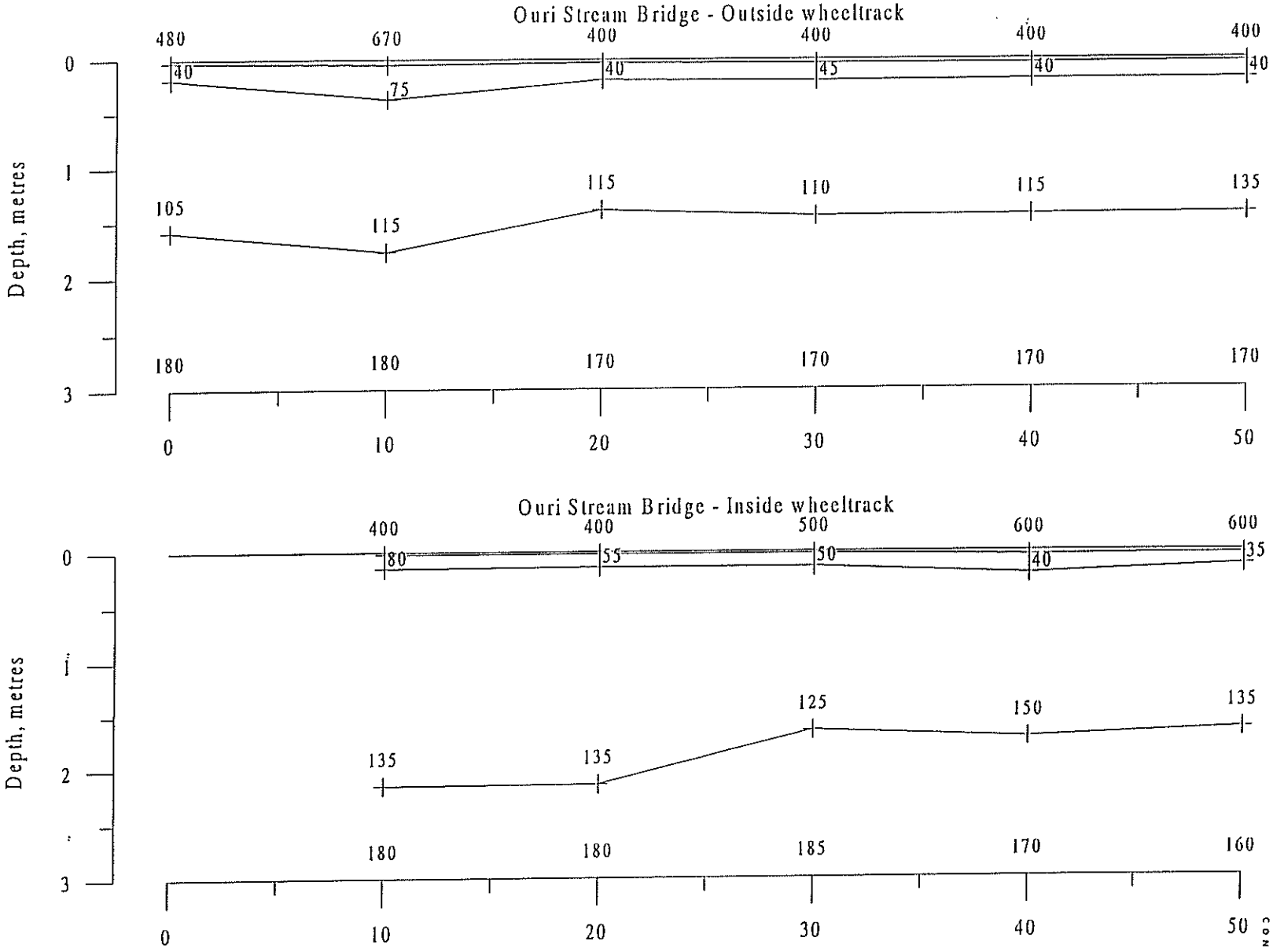

SASW shearwave profiles, velocities in m/s

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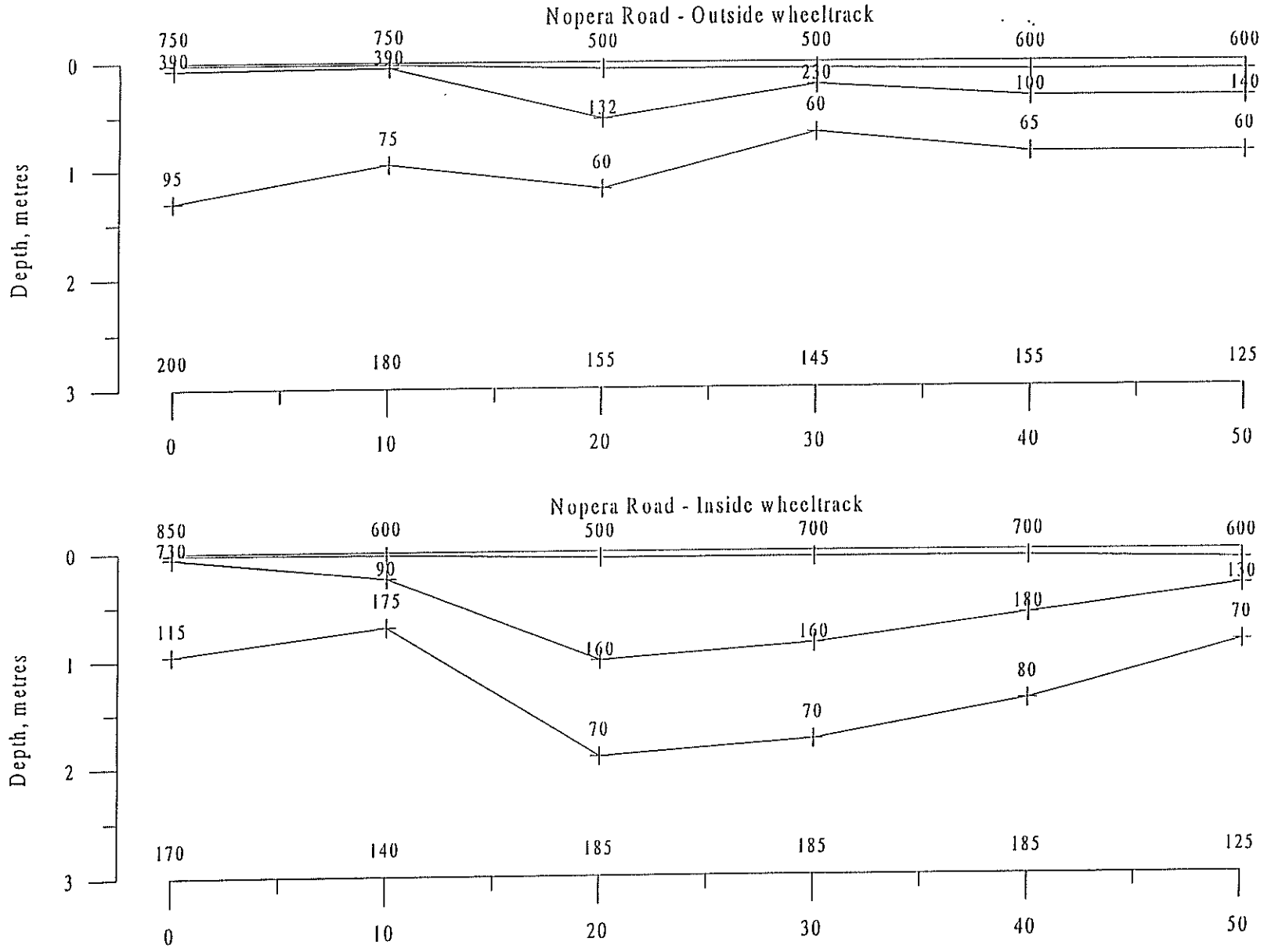

SASW shearwave profiles, velocities in m/s

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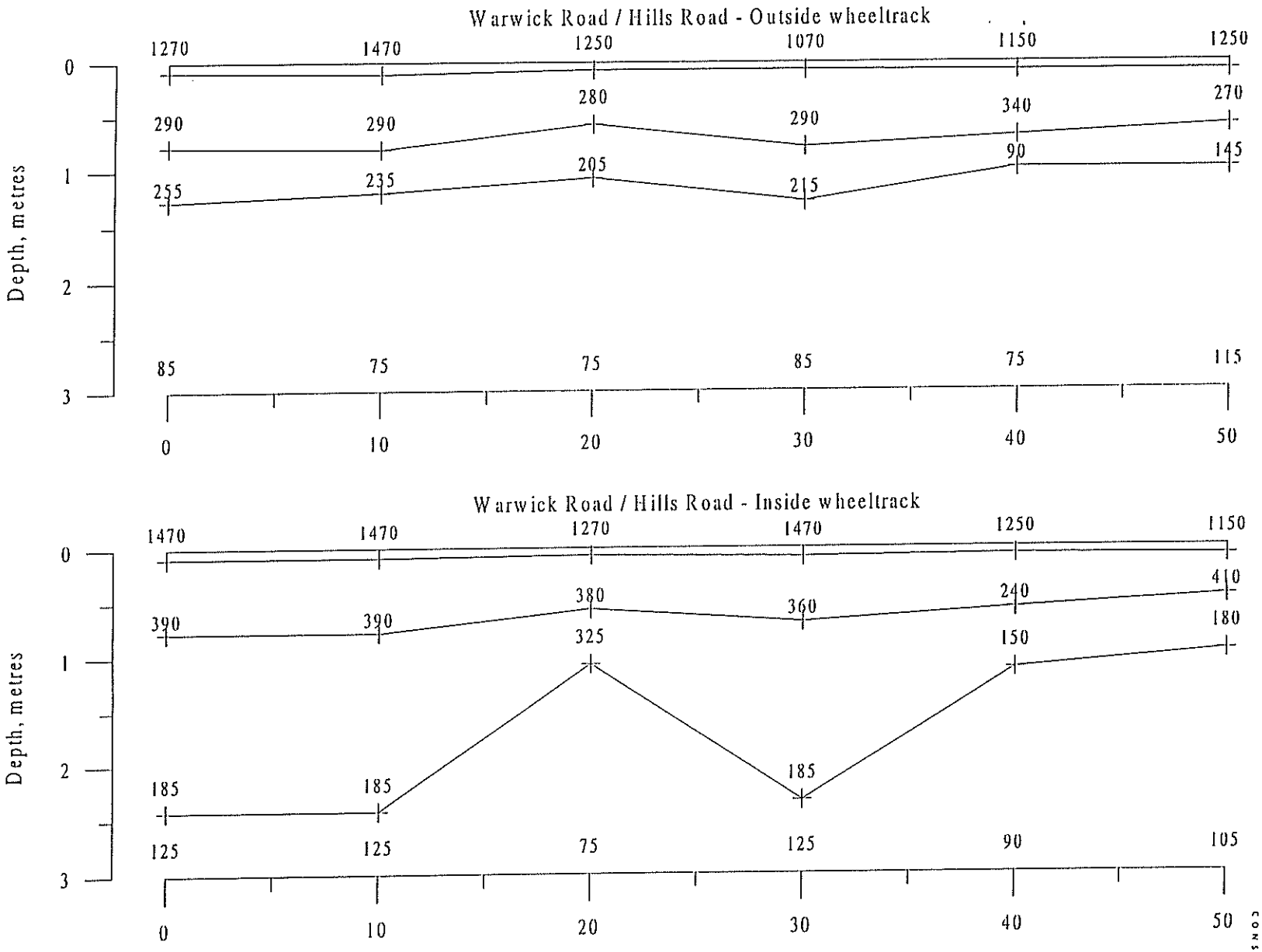

SASW shearwave profiles, velocities in m/s

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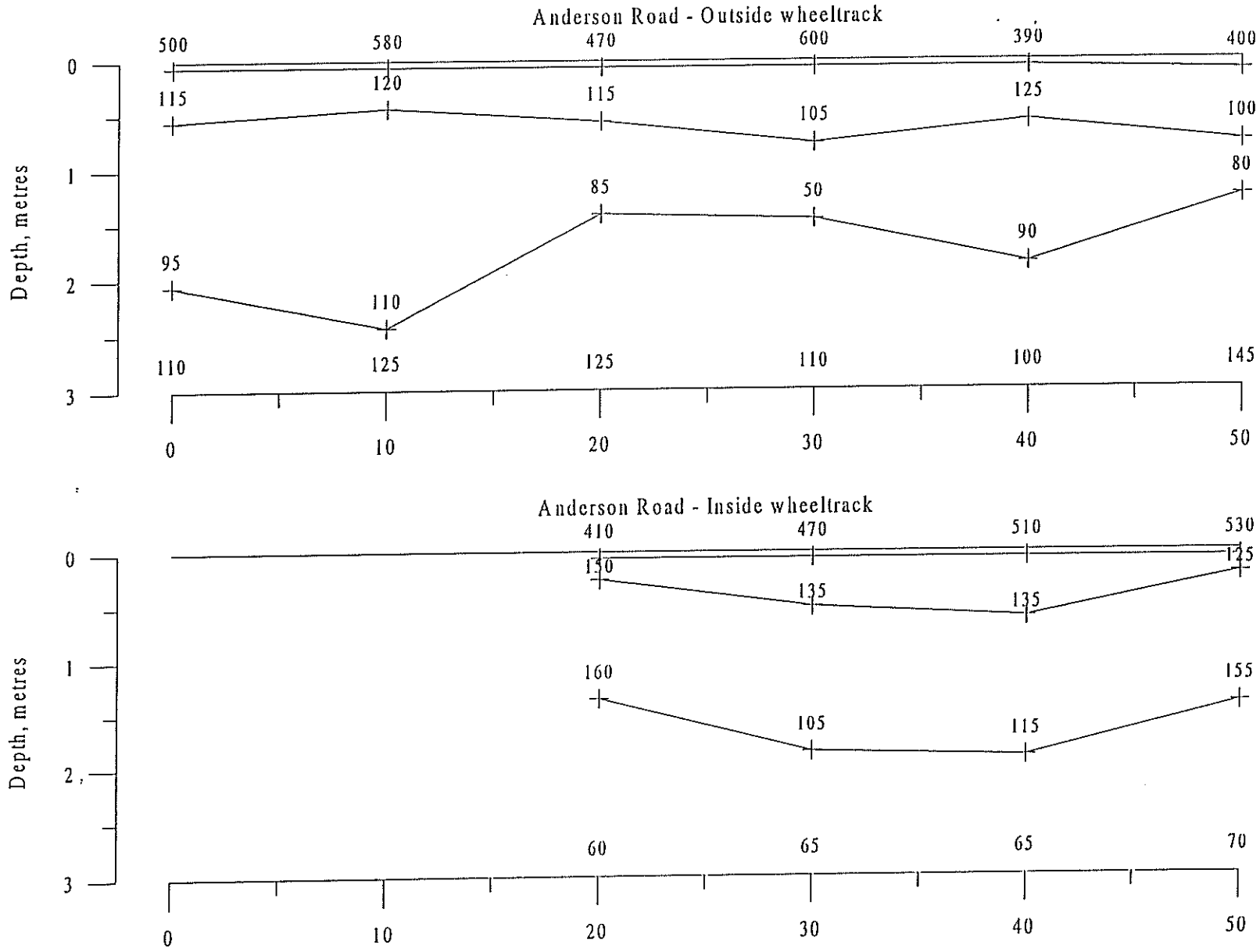

SASW shearwave profiles, velocities in m/s

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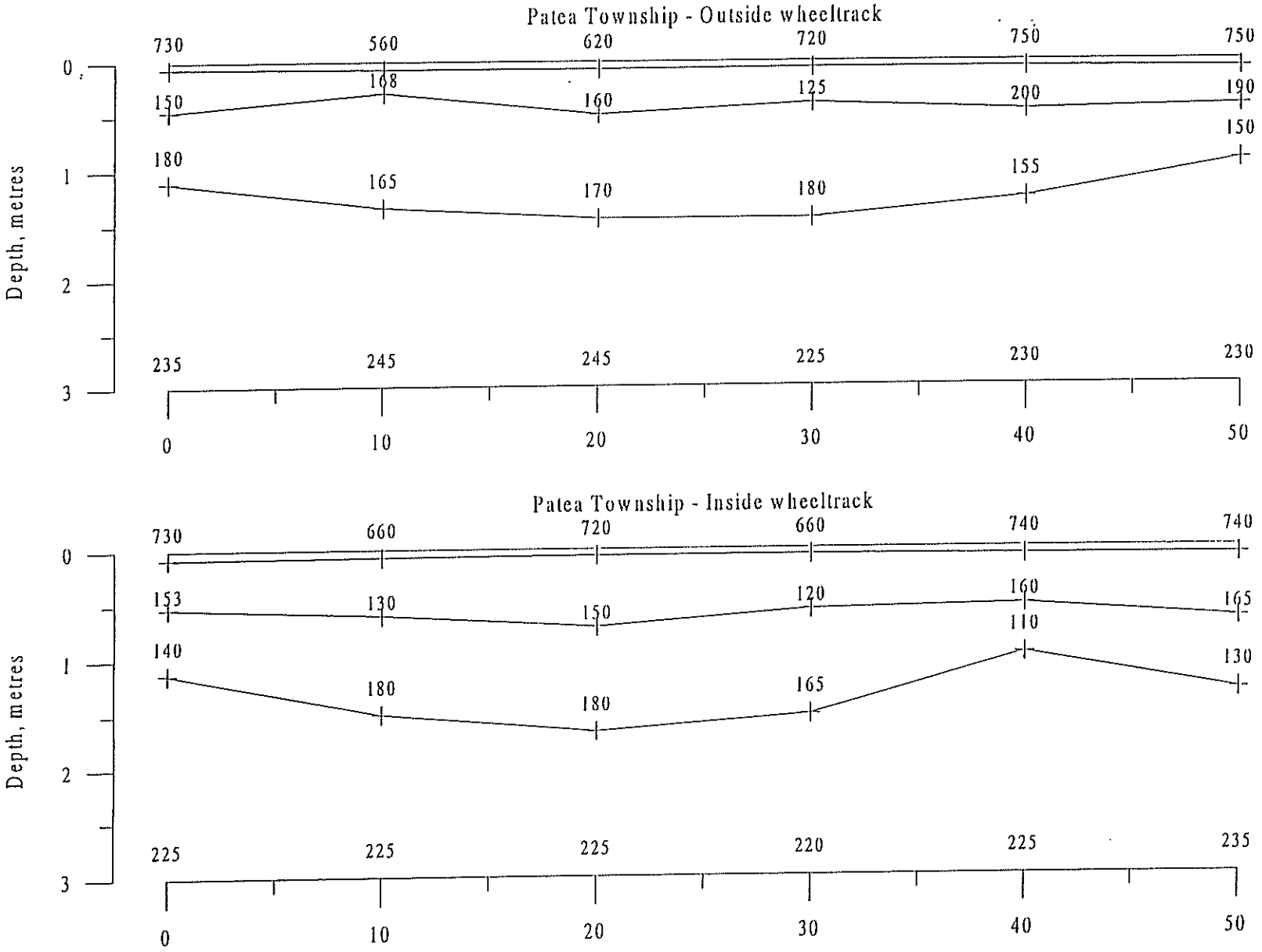

SASW shearwave profiles, velocities in m/s

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Austroads Testing Wanganui Ouri Stream Bridge East Site SH45 RP 64/8.93 to 9.50	Lab Ref Inquiries to Report No. Page	97/M0504 **Evan Huirua** 970504.1 **10**

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Ouri Stream Bridge East**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Pavement Trench Log

Date of log **18-06-1997**

	Detail	*Thickness*	*Description*
Ouri Stream Bridge East 5 (OWT) Trench		mm	
	Seal	80	
	B/C	170	Volcanic Silty Sandy GRAVEL
	S/G	NA	Soft Brown ASH (fairly sandy)
6 (IWT) Trench	Seal	60	
	B/C	150	Volcanic Silty Sandy GRAVEL
	S/B	140	Firm Pumice
	S/G	NA	Soft Brown ASH

Signed
Laboratory Manager Evan Huirua

Date 2/7/97

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Austroads Testing Wanganui Nopera Road South Site SH45 RP 64/10.14 to 11.21	Lab Ref Inquiries to Report No. Page	97/M0505 Evan Huirua 970505.1 10

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Nopera Road South**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Pavement Trench Log

Date of log 19-06-1997

	Detail	*Thickness*	*Description*
Nopera Road South 5 (OWT) Trench		mm	
	Seal	30	
	B/C	340	Volcanic Silty Sandy GRAVEL
	S/G	100	Firm Brown ASH (depth of CBR 410mm)
	S/G	NA	Soft Light Brown Plastic SILT

6 (IWT) Trench	Seal	40	
	B/C	140	Volcanic Silty Sandy GRAVEL
	S/B	40	Firm Pumice
	S/G	NA	Soft Light Brown Plastic SILT (depth of CBR 220mm)

Signed Laboratory Manager Evan Huirua	Date 21/7/97

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Austroads Testing Wanganui Warwick Rd - Hills Rd Site SH3 RP 279/1.46 to 1.95	Lab Ref Inquiries to Report No. Page	97/M0503 **Evan Huirua** 970503.1 10

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Warwick Rd - Hills Rd**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**21 June 1997**

Pavement Trench Log

Date of log **21-06-1997**

	Detail	*Thickness*	*Description*
Warwick Rd - Hills Rd 5 (OWT) Trench		mm	
	Seal	120	
	B/C	240	Volcanic Silty Sandy GRAVEL
	S/B	60	Gravelly Light Brown Plastic SILT
	S/G	NA	Soft Brown ASH (depth of CBR 700mm)
6 (IWT) Trench	Seal	120	
	B/C	430	Volcanic Silty Sandy GRAVEL
	S/B	60	Gravelly Light Brown Plastic SILT
	S/G	NA	Soft Brown ASH (depth of CBR 670mm)

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Laboratory Manager Evan Huirua Date 21/7/97

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Austroads Testing Wanganui Anderson Road North Site SH3 RP 287/1.00 to 1.32	Lab Ref Inquiries to Report No. Page	97/M0502 Evan Huirua 970502.1 10

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Anderson Road North	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	23 June 1997

Pavement Trench Log

Date of log 23-06-1997

	Detail	*Thickness*	*Description*
Anderson Road North 9 (OWT) Trench		mm	
	Seal	30	
	B/C	430	Silty Sandy GRAVEL (volcanic)
	S/G	NA	Light to Reddish Brown ASH (wet) depth to CBR 650mm
10 (IWT) Trench	Seal	30	
	B/C	300	Silty Sandy GRAVEL (volcanic)
	S/B	130	Gravelly SILT
	S/G	NA	Light to Reddish Brown ASH (wet) depth to CBR 650mm

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Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06	Lab Ref Inquiries to Report No. Page	97/M0501 Evan Huirua 970501.1 10

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Patea Township Site	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	20 June 1997

Pavement Trench Log

Date of log 20-06-1997

	Detail	*Thickness*	*Description*
Patea Township		mm	
5 (OWT)	Seal	70	
Trench	B/C	140	Grey Silty Sandy GRAVEL (volcanic)
	S/G	70	Light Brown SILT (gravels)
	S/B	70	Black SAND
	S/G	NA	Light Brown SILT (depth to CBR 350mm)

6 (IWT)	Seal	50	
Trench	B/C	170	Grey Silty Sandy GRAVEL (volcanic)
	S/G	NA	Light Brown SILT (depth to CBR 280mm)

Signed Laboratory Manager Evan Huirua	Date 1/7/97

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Austroads Testing Wanganui Ouri Stream Bridge East Site SH45 RP 64/8.93 to 9.50	Lab Ref Inquiries to Report No. Page	97/M0504 Evan Huirua 970504.1 4

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Ouri Stream Bridge East**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Insitu Density Test Report

Test method **NZS 4407:1991 Test 4.2.1 Nuclear - Direct Transmission Method**
Date of test **18-06-1997**

Ouri Stream Bridge East Trench at sites 5 and 6

5 (OWT) B/C	Detail	1	2	3	Average
	Wet t/m3	2.199	2.125	2.187	2.170
	Dry t/m3	2.051	1.990	2.055	2.032
	Water %	7.200	6.800	6.400	6.800

5 (OWT) S/G	Detail	1	2	3	Average
	Wet t/m3	1.415	1.535	1.509	1.486
	Dry t/m3	0.908	1.032	0.999	0.979
	Water %	55.900	48.800	51.100	51.933

6 (IWT) B/C	Detail	1	2	3	Average
	Wet t/m3	2.245	2.245	2.244	2.245
	Dry t/m3	2.142	2.142	2.141	2.142
	Water %	4.800	4.800	4.800	4.800

6 (IWT) S/G	Detail	1	2	3	Average
	Wet t/m3	1.479	1.566	1.572	1.539
	Dry t/m3	0.918	0.979	0.984	0.960
	Water %	61.100	59.900	59.800	60.267

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Laboratory Manager Evan Huirua Date 2/7/97

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Austroads Testing Wanganui Nopera Road South Site SH45 RP 64/10.14 to 11.21	Lab Ref	97/M0505
	Inquiries to	Evan Huirua
	Report No.	970505.1
	Page	4

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Nopera Road South	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	18 June 1997

Insitu Density Test Report

Test method **NZS 4407:1991 Test 4.2.1 Nuclear - Direct Transmission Method**
Date of test **19-06-1997**

Nopera Road South Trench at sites 5 and 6

5 (OWT) B/C	Detail	1	2	3	Average
	Wet t/m3	2.122	2.250	2.198	2.190
	Dry t/m3	2.029	2.147	2.089	2.088
	Water %	4.600	4.800	5.200	4.867

5 (OWT) S/G	Detail	1	2	3	Average
	Wet t/m3	1.487	1.555	1.501	1.514
	Dry t/m3	0.916	0.971	0.933	0.940
	Water %	62.300	60.200	60.900	61.133

6 (IWT) B/C	Detail	1	2	3	Average
	Wet t/m3	2.092	2.155	2.156	2.134
	Dry t/m3	1.989	2.048	2.044	2.027
	Water %	5.200	5.200	5.500	5.300

6 (IWT) S/G	Detail	1	2	3	Average
	Wet t/m3	1.508	1.516	1.512	1.512
	Dry t/m3	0.886	0.891	0.897	0.892
	Water %	70.200	70.100	68.500	69.600

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Austroads Testing Wanganui Warwick Rd - Hills Rd Site SH3 RP 279/1.46 to 1.95	Lab Ref	97/M0503
	Inquiries to	Evan Huirua
	Report No.	970503.1
	Page	4

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Warwick Rd - Hills Rd	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	21 June 1997

Insitu Density Test Report

Test method **NZS 4407:1991 Test 4.2.1 Nuclear - Direct Transmission Method**
Date of test **21-06-1997**

Warwick Rd - Hills Rd Trench at sites 9 and 10

5 (OWT) B/C	Detail	1	2	3	Average
	Wet t/m3	Not tested	Not tested	Not tested	Not tested
	Dry t/m3	Not tested	Not tested	Not tested	Not tested
	Water %	Not tested	Not tested	Not tested	0.000

5 (OWT) S/G	Detail	1	2	3	Average
	Wet t/m3	1.442	1.591	1.502	1.512
	Dry t/m3	0.855	0.968	0.920	0.914
	Water %	68.600	64.400	63.200	65.400

6 (IWT) B/C	Detail	1	2	3	Average
	Wet t/m3	Not tested	Not tested	Not tested	Not tested
	Dry t/m3	Not tested	Not tested	Not tested	Not tested
	Water %	Not tested	Not tested	Not tested	Not tested

6 (IWT) S/G	Detail	1	2	3	Average
	Wet t/m3	1.545	1.599	1.596	1.580
	Dry t/m3	0.954	0.992	0.991	0.979
	Water %	62.000	61.200	61.100	61.433

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Austroads Testing Wanganui Anderson Road North Site SH3 RP 287/1.00 to 1.32	Lab Ref	97/M0502
	Inquiries to	Evan Huirua
	Report No.	970502.1
	Page	4

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Anderson Road North**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**23 June 1997**

Insitu Density Test Report

Test method **NZS 4407:1991 Test 4.2.1 Nuclear - Direct Transmission Method**
Date of test **23-06-1997**

Anderson Road North Trench at sites 9 and 10

9 (OWT) B/C	Detail	1	2	3	Average
	Wet t/m3	2.200	2.156	2.148	2.168
	Dry t/m3	2.093	2.053	2.044	2.063
	Water %	5.100	5.000	5.100	5.067

9 (OWT) S/G	Detail	1	2	3	Average
	Wet t/m3	1.289	1.292	1.325	1.302
	Dry t/m3	0.601	0.600	0.621	0.608
	Water %	114.300	115.300	113.200	114.267

10 (IWT) B/C	Detail	1	2	3	Average
	Wet t/m3	2.123	2.099	2.158	2.127
	Dry t/m3	2.032	2.009	2.055	2.032
	Water %	4.500	4.500	5.000	4.667

10 (IWT) S/G	Detail	1	2	3	Average
	Wet t/m3	1.427	1.499	1.491	1.472
	Dry t/m3	0.755	0.796	0.796	0.782
	Water %	89.100	88.200	87.300	88.200

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Laboratory Manager Evan Huirua Date 2/7/97

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Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06	Lab Ref Inquiries to Report No. Page	97/M0501 Evan Huirua 970501.1 4

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Patea Township Site	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	20 June 1997

Insitu Density Test Report

Test method **NZS 4407:1991 Test 4.2.1 Nuclear - Direct Transmission Method**
Date of test **20-06-1997**

Patea Township Trench 1.5m south of Sites 5 and 6

	Detail	Test 1	Test 2	Test 3	Average
5 (OWT) B/C	Wet t/m3	2.058	2.156	2.132	2.115
	Dry t/m3	1.958	2.047	2.013	2.006
	Water %	5.100	5.300	5.900	5.433

	Detail	Test 1	Test 2	Test 3	Average
5 (OWT) S/G	Wet t/m3	1.772	1.765	1.752	1.763
	Dry t/m3	1.475	1.446	1.474	1.465
	Water %	20.100	22.100	18.900	20.367

	Detail	Test 1	Test 2	Test 3	Average
6 (IWT) B/C	Wet t/m3	2.156	2.174	2.065	2.132
	Dry t/m3	2.055	2.069	1.965	2.030
	Water %	4.900	5.100	5.100	5.033

	Detail	Test 1	Test 2	Test 3	Average
6 (IWT) S/G	Wet t/m3	1.569	1.612	1.578	1.586
	Dry t/m3	1.132	1.172	1.134	1.146
	Water %	38.600	37.500	39.100	38.400

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Laboratory Manager Evan Huirua

Date 1 / 7 / 97

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Austroads Testing Wanganui Ouri Stream Bridge East Site SH45 RP 64/8.93 to 9.50		Lab Ref Inquiries to Report No. Page	97/M0504 Evan Huirua 970504.1 8

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Ouri Stream Bridge East**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Scala Penetrometer Test Report

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test **18-06-1997**

Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm	Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm
1	370	370	370	290	310	280	21	1150	1110	1340	1220	1290	1300
2	390	400	390	330	330	320	22	1200	1150	1350	1270	1320	1310
3	420	450	430	360	360	360	23	1240	1190		1300	1350	1320
4	450	490	490	410	410	420	24	1290	1220		1340	1360	1330
5	500	530	550	460	460	470	25	1340	1260		1370	1390	
6	570	570	600	510	520	600	26		1310		1390		
7	650	610	640	570	580	660	27		1340				
8	670	650	710	620	650	730	28		1370				
9	700	690	830	670	700	770	29		1400				
10	720	720	870	710	750	830	30						
11	750	760	930	770	810	880	31						
12	790	800	990	820	880	940	32						
13	830	850	1030	870	930	980	33						
14	880	890	1070	930	990	1030	34						
15	940	920	1110	1010	1050	1070	35						
16	1000	960	1170	1060	1090	1110	36						
17	1040	990	1210	1090	1130	1160	37						
18	1050	1020	1270	1120	1170	1200	38						
19	1080	1040	1300	1150	1210	1250	39						
20	1110	1070	1320	1190	1250	1260	40						

Signed
Laboratory Manager

Date 21/7/97

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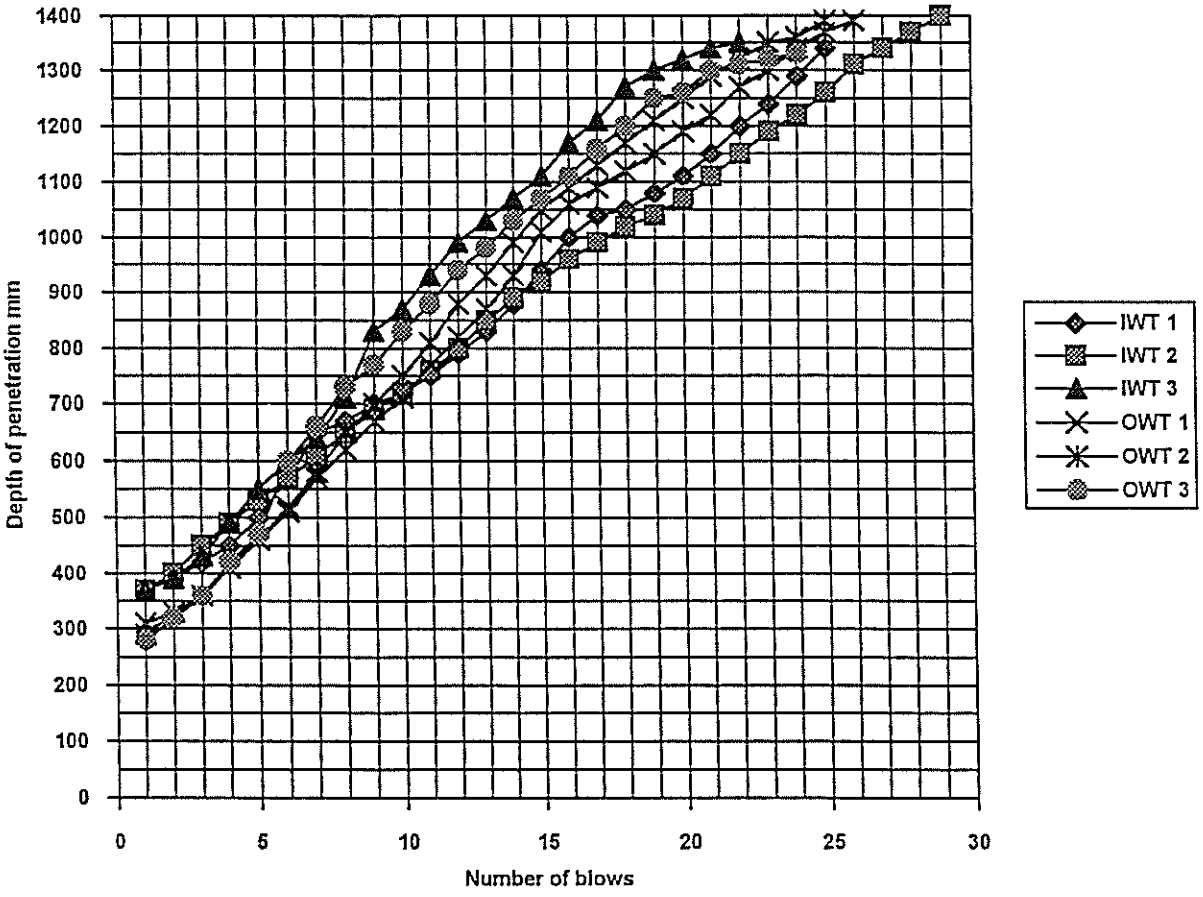
Austroads Testing Wanganui Ouri Stream Bridge East Site SH45 RP 64/8.93 to 9.50	Lab Ref Inquiries to Report No. Page	97/M0504 Evan Huirua 970504.1 9

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Ouri Stream Bridge East**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Scala Penetrometer Test Report Graph

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test **18-06-1997**



Signed
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Date 2/7/97

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Austroads Testing Wanganui Nopera Road South Site SH45 RP 64/10.14 to 11.21	Lab Ref Inquiries to Report No. Page	97/M0505 **Evan Huirua** 970505.1 8

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Nopera Road South**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Scala Penetrometer Test Report

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test 19-06-1997

Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm	Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm
1	240	230	230	460	460	450	21						
2	260	245	260	530	520	490	22						
3	270	260	270	670	650	610	23						
4	280	290	290	730	710	710	24						
5	310	320	310	830	810	800	25						
6	330	350	330	930	910	860	26						
7	390	390	390	1060	1030	960	27						
8	440	450	430	1250	1190	1080	28						
9	500	490	490	1420	1330	1230	29						
10	570	570	560	1530	1460	1380	30						
11	800	680	650	1630	1560	1510	31						
12	800	780	780		1660	1610	32						
13	920	890	870			1710	33						
14	1040	950	970				34						
15	1270	1010	1070				35						
16	1540	1130	1270				36						
17		1320	1530				37						
18		1480					38						
19							39						
20							40						

Signed
Laboratory Manager Evan Huirua Date 2/7/97

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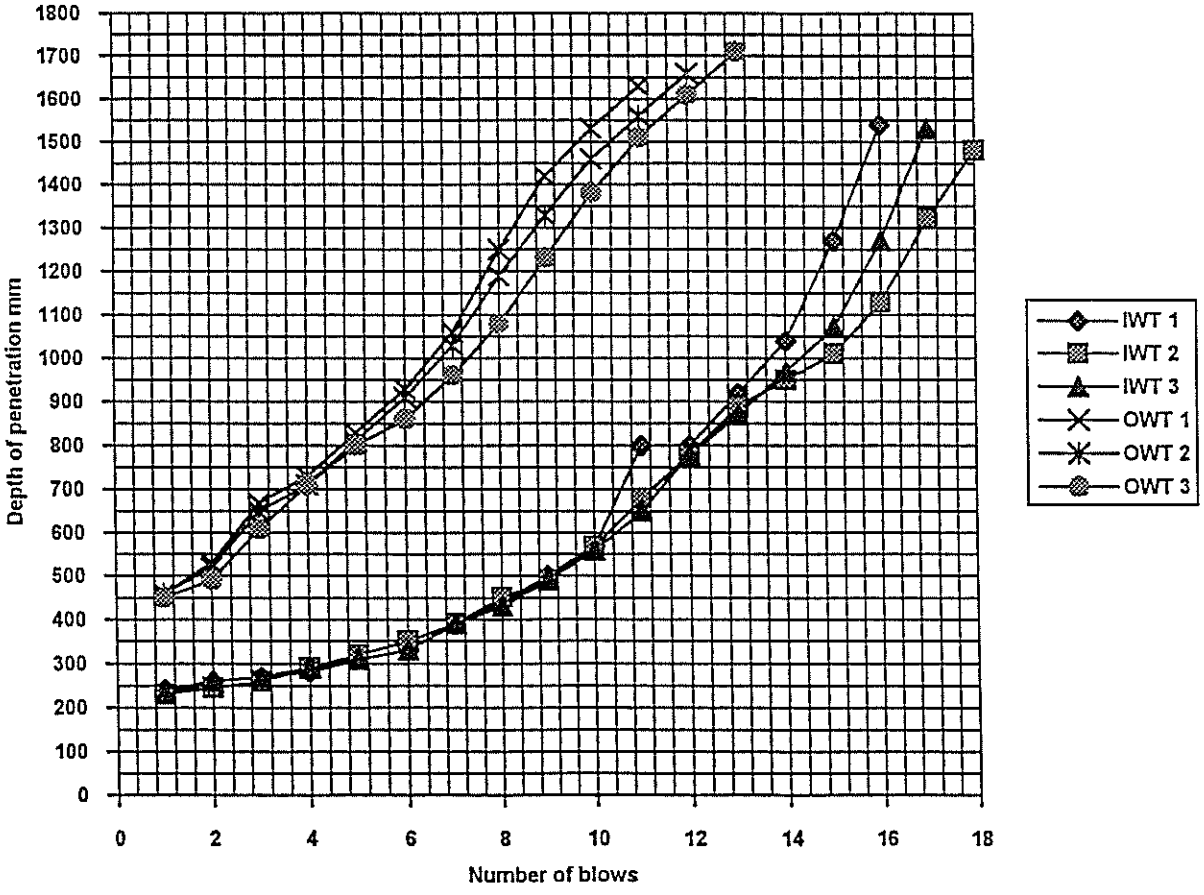
Austroads Testing Wanganui Nopera Road South Site SH45 RP 64/10.14 to 11.21		Lab Ref Inquiries to Report No. Page	97/M0505 Evan Huirua 970505.1 9

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Nopera Road South**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Scala Penetrometer Test Report Graph

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test **19-06-1997**



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Laboratory Manager Lan Huirua

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Austroads Testing Wanganui Warwick Rd - Hills Rd Site SH3 RP 279/1.46 to 1.95	Lab Ref Inquiries to Report No. Page	97/M0503 Evan Huirua 970503.1 8

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Warwick Rd - Hills Rd	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	21 June 1997

Scala Penetrometer Test Report

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test **21-06-1997**

Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm	Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm
1	700	720	720	740	760	760	21				1720	1870	1740
2	740	740	740	790	810	800	22				1780	1930	1800
3	790	770	770	850	860	850	23				1850	1960	1880
4	830	810	810	900	920	900	24				1930	2000	1950
5	870	830	850	950	970	950	25				1950	2030	1980
6	920	900	920	1000	1020	1000	26				1980		2010
7	940	910	940	1040	1060	1050	27				2010		
8	950	920	950	1080	1110	1090	28						
9	970	930	960	1120	1170	1120	29						
10	980	940	970	1160	1220	1150	30						
11	990	945	980	1210	1280	1200	31						
12	1000	950	985	1260	1330	1260	32						
13	1010	960	990	1300	1380	1310	33						
14	1020	970	1000	1360	1420	1370	34						
15				1400	1460	1410	35						
16				1450	1520	1450	36						
17				1500	1570	1500	37						
18				1540	1630	1550	38						
19				1580	1700	1590	39						
20				1650	1770	1640	40						

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Laboratory Manager Evan Huirua

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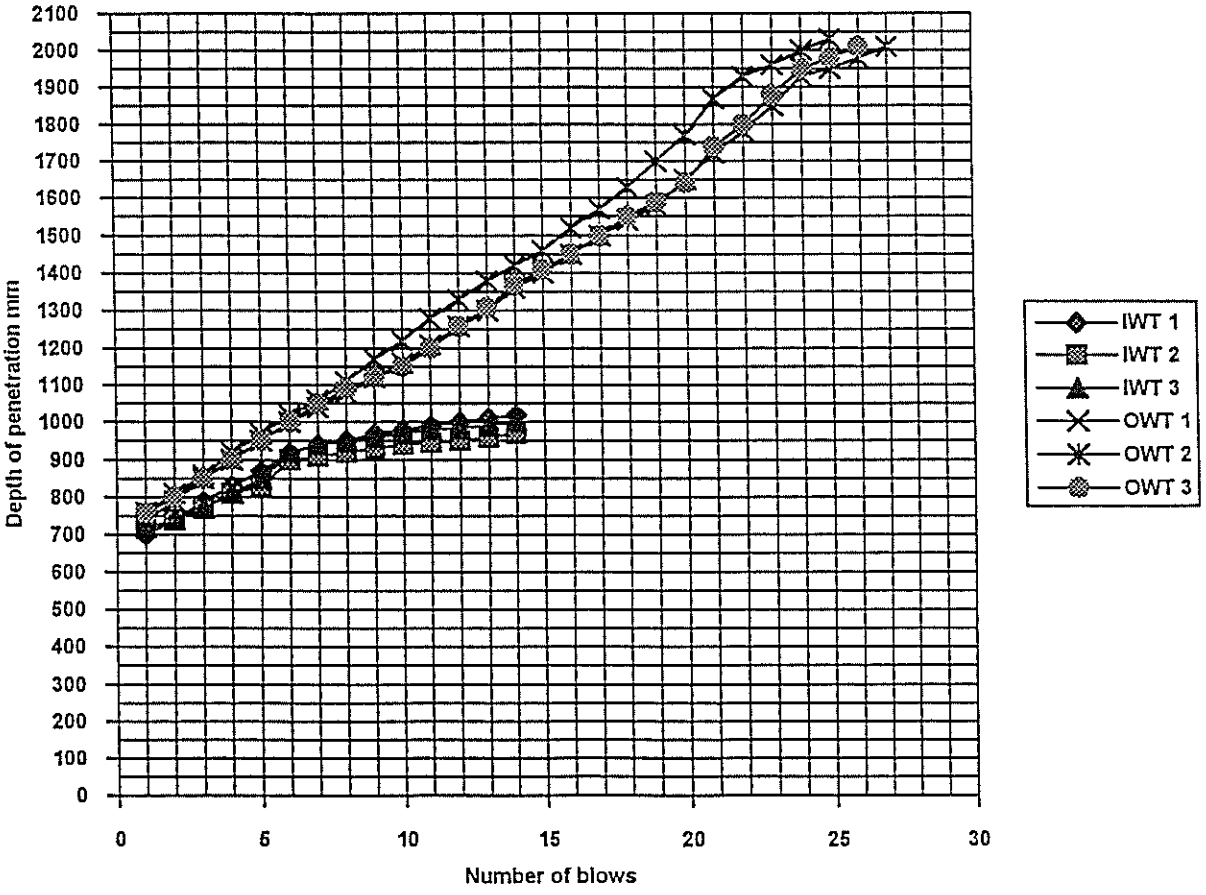
Austroads Testing Wanganui Warwick Rd - Hills Rd Site SH3 RP 279/1.46 to 1.95		Lab Ref Inquiries to Report No. Page	97/M0503 Evan Huirua 970503.1 9

Job	**Austroads Testing Wanganui**	Sampled by	Evan Huirua
Location	**Warwick Rd - Hills Rd**	Sample method	NZS 4402:1986
Origin	**Existing Pavement**	Sample condition	Damp - sealed
		Sampling date	21 June 1997

Scala Penetrometer Test Report Graph

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test **21-06-1997**



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Austroads Testing Wanganui Anderson Road North Site SH3 RP 287/1.00 to 1.32		Lab Ref Inquiries to Report No. Page	97/M0502 Evan Huirua 970502.1 8

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Anderson Road North**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**23 June 1997**

Scala Penetrometer Test Report

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test **23-06-1997**

Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm	Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm
1	860	790	780	850	780	800	21		1910				
2	1290	950	950	1190	950	1000	22		1950				
3	1420	1070	1090	1380	1300	1270	23		1990				
4	1500	1170	1250	1490	1410	1400	24						
5	1590	1230	1350	1570	1500	1540	25						
6	1660	1290	1460	1630	1570	1600	26						
7	1730	1360	1530	1680	1630	1650	27						
8	1790	1410	1590	1750	1690	1700	28						
9	1870	1460	1630	1800	1750	1750	29						
10	1930	1510	1680	1880	1820	1800	30						
11	1990	1570	1730	1940	1900	1880	31						
12		1590	1780	2000	1950	1930	32						
13		1630	1840		2000	1980	33						
14		1660	1900				34						
15		1700	1990				35						
16		1730					36						
17		1770					37						
18		1820					38						
19		1850					39						
20		1880					40						

Signed Laboratory Manager Evan Huirua	Date 2/7/97

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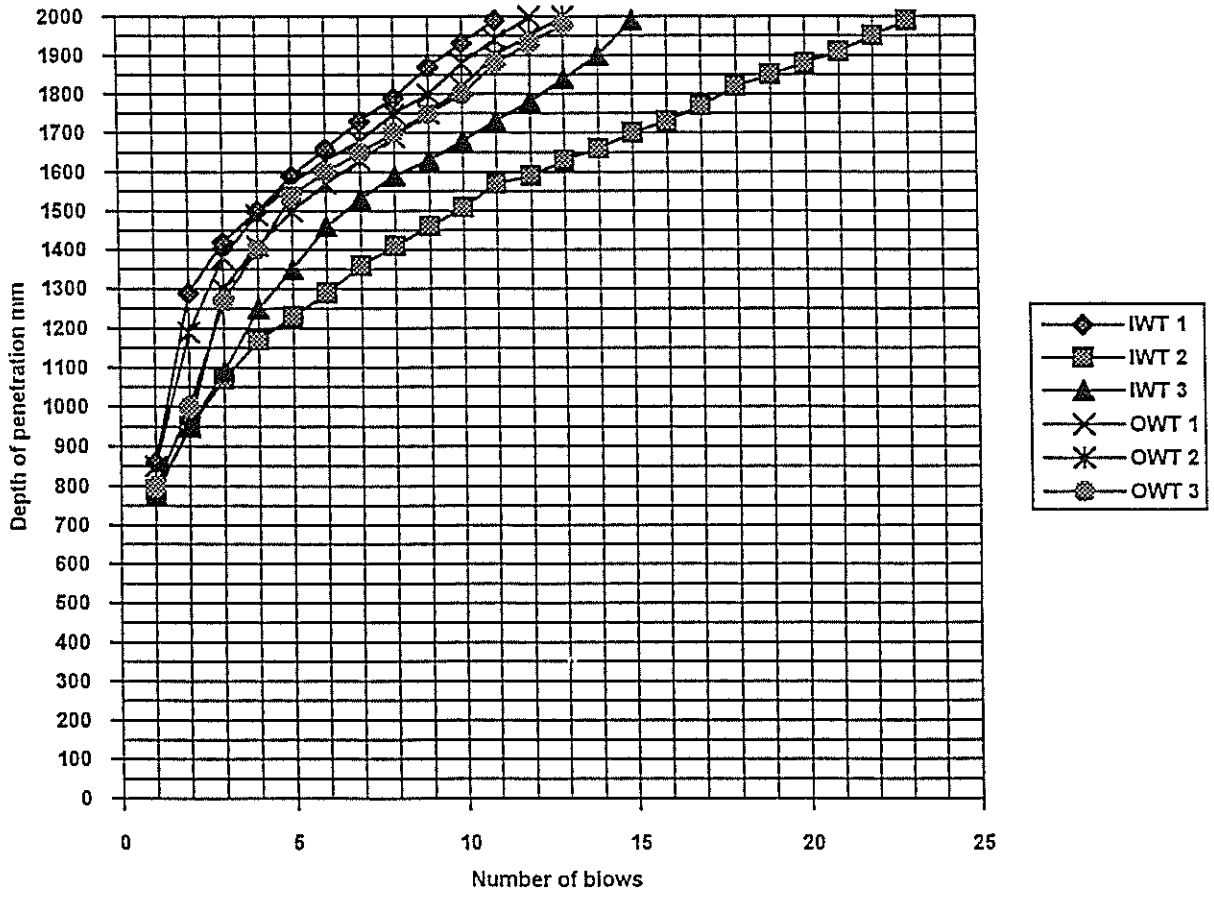
Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Anderson Road North**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**23 June 1997**

Scala Penetrometer Test Report Graph

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test **23-06-1997**



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Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06		Lab Ref Inquiries to Report No. Page	97/M0501 Evan Huirua 970501.1 8

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Patea Township Site	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	20 June 1997

Scala Penetrometer Test Report

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test **20-06-1997**

Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm	Blow	IWT 1 mm	IWT 2 mm	IWT 3 mm	OWT 1 mm	OWT 2 mm	OWT 3 mm
1	300	300	300	370	370	370	21	780	780	780	810	820	820
2	310	310	320	380	380	380	22	810	820	810	840	850	840
3	330	340	340	390	390	390	23	850	850	850	870	870	870
4	350	350	360	400	400	400	24	880	890	880	910	910	910
5	380	380	380	410	410	410	25	910	920	910	950	940	940
6	400	400	400	420	420	420	26	950	950	950	990	970	970
7	430	430	430	440	430	430	27	1000	990	990	1030	1000	1000
8	460	450	460	460	460	450	28	1040	1040	1040	1070	1030	1030
9	480	480	480	490	480	480	29	1070	1070	1070	1100	1070	1070
10	510	500	500	510	510	510	30	1120	1100	1100	1140	1090	1100
11	530	520	520	540	540	540	31	1150	1130	1120	1170	1110	1120
12	560	540	540	560	560	570	32	1170	1150	1150	1190	1130	1140
13	580	570	580	590	590	600	33	1190	1180	1180	1220	1150	1170
14	600	600	600	610	620	620	34	1210	1200	1210	1250	1170	1190
15	620	620	630	640	650	640	35	1230	1230	1230	1270	1190	1220
16	640	640	650	660	670	670	36	1250	1250	1250	1290	1210	1230
17	660	670	670	690	710	710	37	1270	1280	1270	1320	1230	1250
18	690	690	700	720	730	740	38	1290		1280	1340	1250	1290
19	710	720	720	740	760	760	39				1350	1270	1320
20	750	750	750	780	790	780	40					1290	1350
							41					1300	
							42					1310	
							43					1340	
							44					1350	

Signed
Laboratory Manager Evan Huirua

Date 1/7/97

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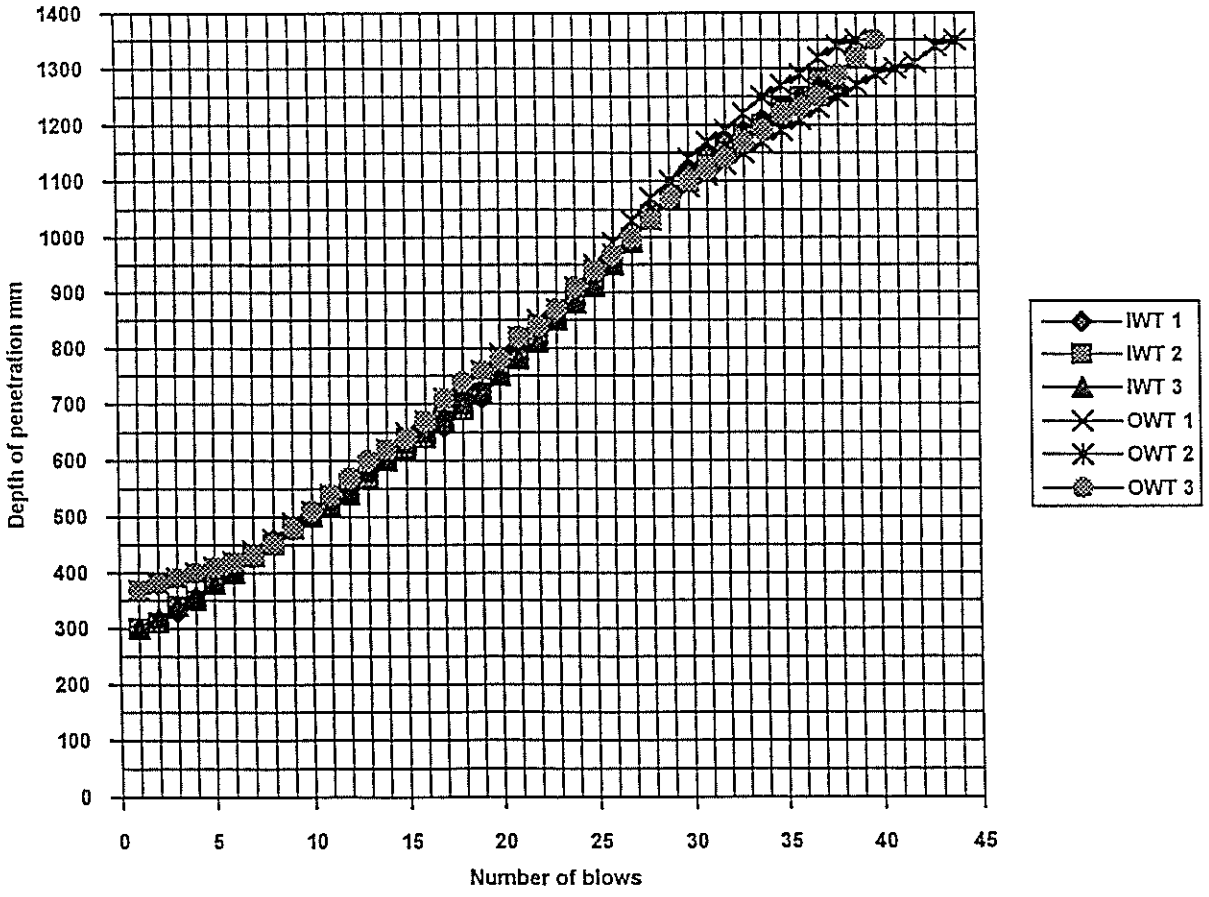
Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06		Lab Ref Inquiries to Report No. Page	97/M0501 Evan Huirua 970501.1 9

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Patea Township Site**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**20 June 1997**

Scala Penetrometer Test Report Graph

Test method **NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer Method**
Date of test **20-06-1997**



Signed Laboratory Manager	Evan Huirua	Date 1 / 7 / 97

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Austroads Testing Wanganui Ouri Stream Bridge East Site SH45 RP 64/8.93 to 9.50	Lab Ref Inquiries to Report No. Page	97/M0504 Evan Huirua 970504.1 5

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Ouri Stream Bridge East**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

California Bearing Ratio Test Report (Insitu)

Test method **NZS 4402:1986 Test 6.1.3 California Bearing Ratio (Insitu method)**
Date of test **18-06-1997**

Site Number	Depth of test mm	Water Content of the top 30mm of soil from under the plunger %	CBR at depth of penetration %
5 (OWT) Subgrade Brown ASH	**250**	**40**	**5.0 at 2.5mm**
6 (IWT) Subgrade Brown ASH	**350**	**45**	**15 at 2.5mm**

Test details
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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Approved Signatory
Laboratory Manager Lan Huirua Date 2/7/97

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Austroads Testing Wanganui Ouri Stream Bridge East Site SH45 RP 64/8.93 to 9.50	Lab Ref Inquiries to Report No. Page	97/M0504 **Evan Huirua** 970504.1 6

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Ouri Stream Bridge East**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

California Bearing Ratio Test Report (Remoulded)

Test method **NZS 4407:1991 Test 3.15 California Bearing Ratio (Remoulded Specimens)**
Date of test **24-06-1997**

Sample description	Wet density as compacted *at standard compaction* t/m^3	Dry density as compacted *at standard compaction* t/m^3	Swell %	Water Content before soaking %	Water Content after penetration %	CBR at depth of penetration %
Pavement Subgrade Brown ASH Location Sites 5 and 6	**1.84**	**1.36**	**0.4**	**34**	**34**	**7.0 at 5.0mm**

Test details
The fraction passing 19.0mm in as received condition was used in the test
The samples were compacted using NZ Standard Compaction at as received water content
The samples were compacted and soaked immediately following mixing
The samples were soaked for 4 days prior to testing for bearing strength
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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Laboratory Manager Evan Huirua Date 2/7/97

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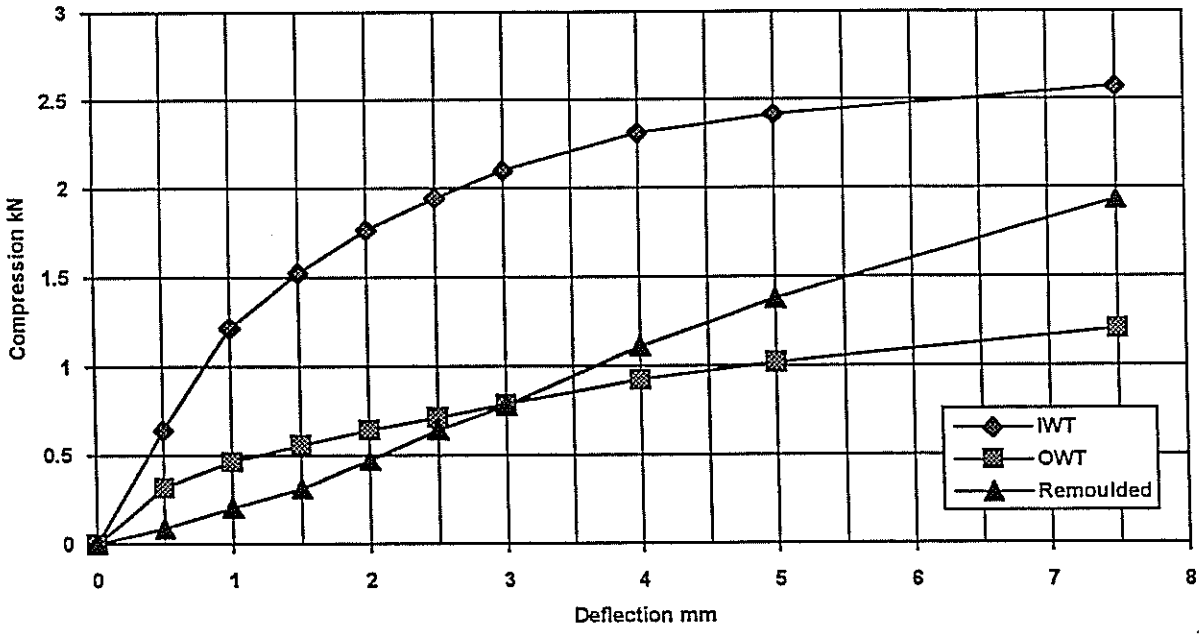
Austroads Testing Wanganui Ouri Stream Bridge East Site SH45 RP 64/8.93 to 9.50	Lab Ref Inquiries to Report No. Page	97/M0504 Evan Huirua 970504.1 7

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Ouri Stream Bridge East	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	18 June 1997

California Bearing Ratio Test Graph (Insitu and Remoulded)

Date of test 18-06-1997

mm	0.0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	7.5
IWT kN	0	0.6405	1.218	1.5225	1.764	1.9425	2.1	2.31	2.415	2.5725
OWT kN	0	0.315	0.462	0.5565	0.6405	0.714	0.7875	0.924	1.0185	1.2075
Remoulded	0	0.09	0.20	0.31	0.47	0.64	0.78	1.11	1.38	1.93



Signed
Laboratory Manager Evan Huirua

Date 2/7/97

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Austroads Testing Wanganui Nopera Road South Site SH45 RP 64/10.14 to 11.21	Lab Ref Inquiries to Report No. Page	97/M0505 Evan Huirua 970505.1 5

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Nopera Road South**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

California Bearing Ratio Test Report (Insitu)

Test method **NZS 4402:1986 Test 6.1.3 California Bearing Ratio (Insitu method)**
Date of test **19-06-1997**

Site Number	Depth of test mm	Water Content of the top 30mm of soil from under the plunger %	CBR at depth of penetration %
5 (OWT) Subgrade Brown ASH	410	50	**7.0 at 2.5mm**
6 (IWT) Subgrade Brown ASH	220	55	**20 at 2.5mm**

Test details
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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Laboratory Manager Sam Huirua Date 2/7/97

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Austroads Testing Wanganui Nopera Road South Site SH45 RP 64/10.14 to 11.21		Lab Ref Inquiries to Report No. Page	97/M0505 **Evan Huirua** 970505.1 6

Job Location Origin	**Austroads Testing Wanganui** **Nopera Road South** **Existing Pavement**	Sampled by Sample method Sample condition Sampling date	**Evan Huirua** **NZS 4402:1986** **Damp - sealed** **18 June 1997**

California Bearing Ratio Test Report (Remoulded)

Test method **NZS 4407:1991 Test 3.15 California Bearing Ratio (Remoulded Specimens)**
Date of test **24-06-1997**

Sample description	Wet density as compacted *at standard compaction* t/m^3	Dry density as compacted *at standard compaction* t/m^3	Swell %	Water Content before soaking %	Water Content after penetration %	CBR at depth of penetration %
Pavement Subgrade Brown ASH Location Sites 5 and 6	1.74	1.22	0.2	43	42	1.0 at 5.0mm

Test details
The fraction passing 19.0mm in as received condition was used in the test
The samples were compacted using NZ Standard Compaction at as received water content
The samples were compacted and soaked immediately following mixing
The samples were soaked for 4 days prior to testing for bearing strength
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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Laboratory Manager Evan Huirua Date 2/7/97

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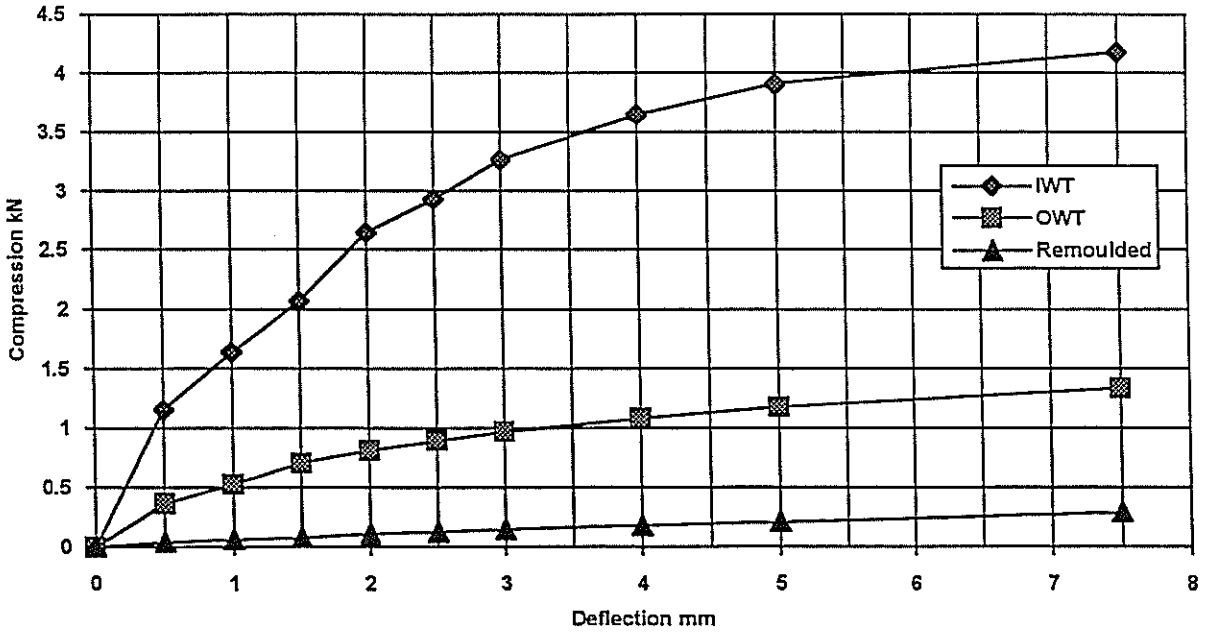
Austroads Testing Wanganui Nopera Road South Site SH45 RP 64/10.14 to 11.21		Lab Ref Inquiries to Report No. Page	97/M0505 **Evan Huirua** **970505.1** 7

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Nopera Road South**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

California Bearing Ratio Test Graph (Insitu and Remoulded)

Date of test 19-06-1997

mm	0.0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	7.5
IWT kN	0	1.155	1.638	2.0685	2.646	2.9295	3.2655	3.6435	3.906	4.179
OWT kN	0	0.3675	0.525	0.7035	0.8085	0.8925	0.966	1.0815	1.176	1.3335
Remoulded	0	0.04	0.06	0.08	0.11	0.13	0.15	0.18	0.21	0.29



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Laboratory Manager Evan Huirua Date 2/7/97

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Austroads Testing Wanganui Warwick Rd - Hills Rd Site SH3 RP 279/1.46 to 1.95	Lab Ref Inquiries to Report No. Page	97/M0503 Evan Huirua 970503.1 5

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Warwick Rd - Hills Rd**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**21 June 1997**

California Bearing Ratio Test Report (Insitu)

Test method **NZS 4402:1986 Test 6.1.3 California Bearing Ratio (Insitu method)**
Date of test **21-06-1997**

Site Number	Depth of test mm	Water Content of the top 30mm of soil from under the plunger %	CBR at depth of penetration %
5 (OWT) Subgrade Brown ASH	**700**	**52**	**13 at 2.5mm**
6 (IWT) Subgrade Brown ASH	**670**	**52**	**11 at 2.5mm**

Test details
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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Approved Signatory
Laboratory Manager Evan Huirua

Date 2/7/97

2/07/97

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Austroads Testing Wanganui Warwick Rd - Hills Rd Site SH3 RP 279/1.46 to 1.95	Lab Ref Inquiries to Report No. Page	97/M0503 Evan Huirua 970503.1 6

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Warwick Rd - Hills Rd	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	21 June 1997

California Bearing Ratio Test Report (Remoulded)

Test method **NZS 4407:1991 Test 3.15 California Bearing Ratio (Remoulded Specimens)**
Date of test **24-06-1997**

Sample description	Wet density as compacted *at standard compaction* t/m^3	Dry density as compacted *at standard compaction* t/m^3	Swell %	Water Content before soaking %	Water Content after penetration %	CBR at depth of penetration %
Pavement Subgrade Brown ASH Location Sites 5 and 6	1.66	1.06	0.2	56	55	2.0 at 5.0mm

Test details
The fraction passing 19.0mm in as received condition was used in the test
The samples were compacted using NZ Standard Compaction at as received water content
The samples were compacted and soaked immediately following mixing
The samples were soaked for 4 days prior to testing for bearing strength
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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Laboratory Manager Evan Huirua Date 2/7/97

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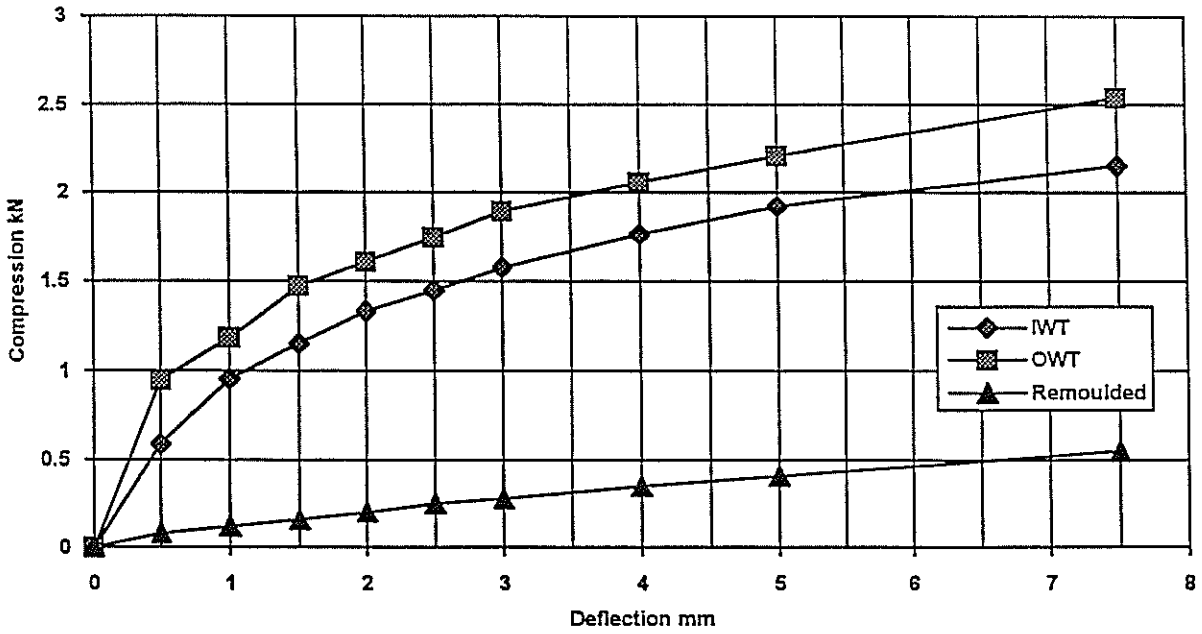
Austroads Testing Wanganui Warwick Rd - Hills Rd Site SH3 RP 279/1.46 to 1.95	Lab Ref	97/M0503
	Inquiries to	Evan Huirua
	Report No.	970503.1
	Page	7

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Warwick Rd - Hills Rd**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**21 June 1997**

California Bearing Ratio Test Graph (Insitu and Remoulded)

Date of test **21-06-1997**

mm	0.0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	7.5
IWT kN	0	0.588	0.9555	1.155	1.3335	1.449	1.575	1.764	1.9215	2.1525
OWT kN	0	0.945	1.1865	1.47	1.6065	1.743	1.89	2.058	2.205	2.541
Remoulded	0	0.08	0.12	0.16	0.20	0.25	0.28	0.35	0.41	0.55



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Austroads Testing Wanganui Anderson Road North Site SH3 RP 287/1.00 to 1.32	Lab Ref Inquiries to Report No. Page	97/M0502 Evan Huirua 970502.1 5

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Anderson Road North	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	23 June 1997

California Bearing Ratio Test Report (Insitu)

Test method **NZS 4402:1986 Test 6.1.3 California Bearing Ratio (Insitu method)**
Date of test **23-06-1997**

Site Number	Depth of test mm	Water Content of the top 30mm of soil from under the plunger %	CBR at depth of penetration %
9 (OWT) Subgrade Brown ASH	650	72	4.0 at 2.5mm
10 (IWT) Subgrade Brown ASH	650	68	6.0 at 2.5mm

Test details
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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Laboratory Manager Evan Huirua Date 2/7/97

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Austroads Testing Wanganui Anderson Road North Site SH3 RP 287/1.00 to 1.32		Lab Ref Inquiries to Report No. Page	97/M0502 Evan Huirua 970502.1 6

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Anderson Road North	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	23 June 1997

California Bearing Ratio Test Report (Remoulded)

Test method **NZS 4407:1991 Test 3.15 California Bearing Ratio (Remoulded Specimens)**
Date of test **24-06-1997**

Sample description	Wet density as compacted *at standard compaction* t/m^3	Dry density as compacted *at standard compaction* t/m^3	Swell %	Water Content before soaking %	Water Content after penetration %	CBR at depth of penetration %
Pavement Subgrade Brown ASH Location Sites 5 and 6	**1.62**	**1.00**	**0**	**62**	**58**	**1.0 at 2.5mm**

Test details
The fraction passing 19.0mm in as received condition was used in the test
The samples were compacted using NZ Standard Compaction at as received water content
The samples were compacted and soaked immediately following mixing
The samples were soaked for 4 days prior to testing for bearing strength
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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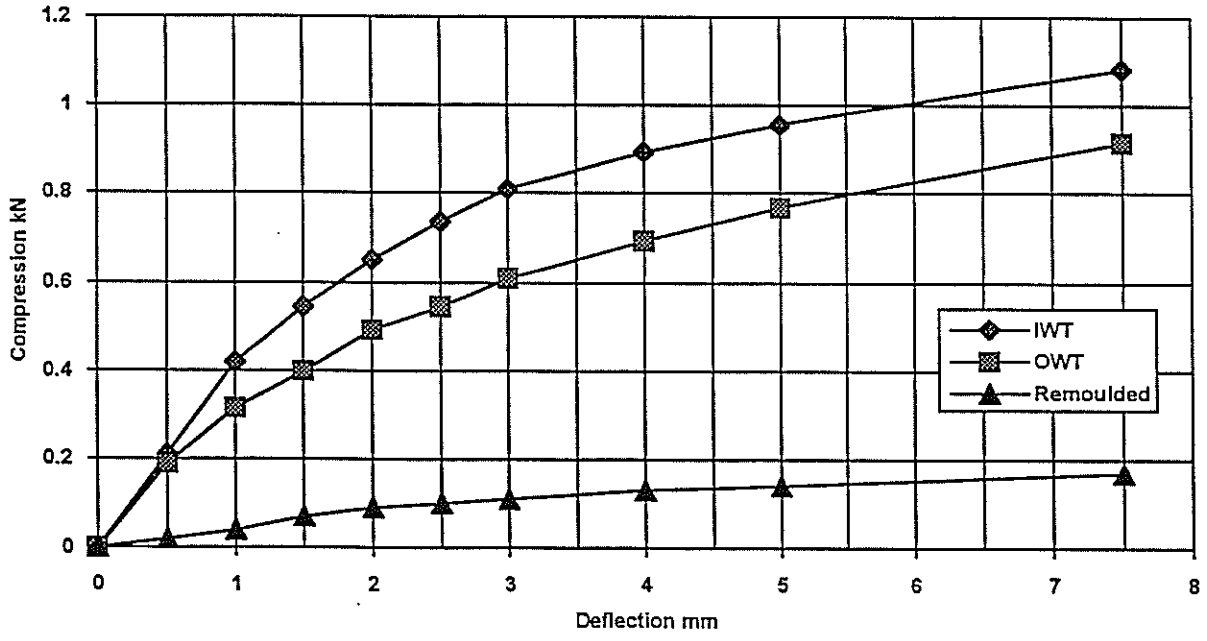
Austroads Testing Wanganui Anderson Road North Site SH3 RP 287/1.00 to 1.32	Lab Ref Inquiries to Report No. Page	97/M0502 Evan Huirua 970502.1 7

Job	Austroads Testing Wanganui	Sampled by	Evan Huirua
Location	Anderson Road North	Sample method	NZS 4402:1986
Origin	Existing Pavement	Sample condition	Damp - sealed
		Sampling date	23 June 1997

California Bearing Ratio Test Graph (Insitu and Remoulded)

Date of test **23-06-1997**

mm	0.0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	7.5
IWT kN	0	0.21	0.42	0.546	0.651	0.735	0.8085	0.8925	0.9555	1.0815
OWT kN	0	0.189	0.315	0.399	0.4935	0.546	0.609	0.693	0.7665	0.9135
Remoulded	0	0.02	0.04	0.07	0.09	0.10	0.11	0.13	0.14	0.17



Signed
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Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06		Lab Ref Inquiries to Report No. Page	97/M0501 Evan Huirua 970501.1 5

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Patea Township Site**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**20 June 1997**

California Bearing Ratio Test Report (Insitu)

Test method **NZS 4402:1986 Test 6.1.3 California Bearing Ratio (Insitu method)**
Date of test **20-06-1997**

Site Number	Depth of test mm	Water Content of the top 30mm of soil from under the plunger %	CBR at depth of penetration %
5 (OWT) Subgrade Light Brown SILT	350	20	35 at 2.5mm
6 (IWT) Subgrade Light Brown SILT	280	27	13 at 2.5mm

Test details
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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Laboratory Manager Evan Huirua
Date 1/7/97

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Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06		Lab Ref Inquiries to Report No. Page	97/M0501 **Evan Huirua** 970501.1 6

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Patea Township Site**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**20 June 1997**

California Bearing Ratio Test Report (Remoulded)

Test method **NZS 4407:1991 Test 3.15 California Bearing Ratio (Remoulded Specimens)**
Date of test **24-06-1997**

Sample description	Wet density as compacted *at standard compaction* t/m^3	Dry density as compacted *at standard compaction* t/m^3	Swell %	Water Content before soaking %	Water Content after penetration %	CBR at depth of penetration %
Pavement Subgrade Light Brown SILT Location Sites 5 and 6	1.96	1.60	0.6	24	24	11 at 5.0mm

Test details
The fraction passing 19.0mm in as received condition was used in the test
The samples were compacted using NZ Standard Compaction at as received water content
The samples were compacted and soaked immediately following mixing
The samples were soaked for 4 days prior to testing for bearing strength
The rate of penetration was 1mm/min.
A surcharge mass of 4 kg was used and the base weight diameter was 150mm.

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Laboratory Manager Evan Huirua Date 1/7/97

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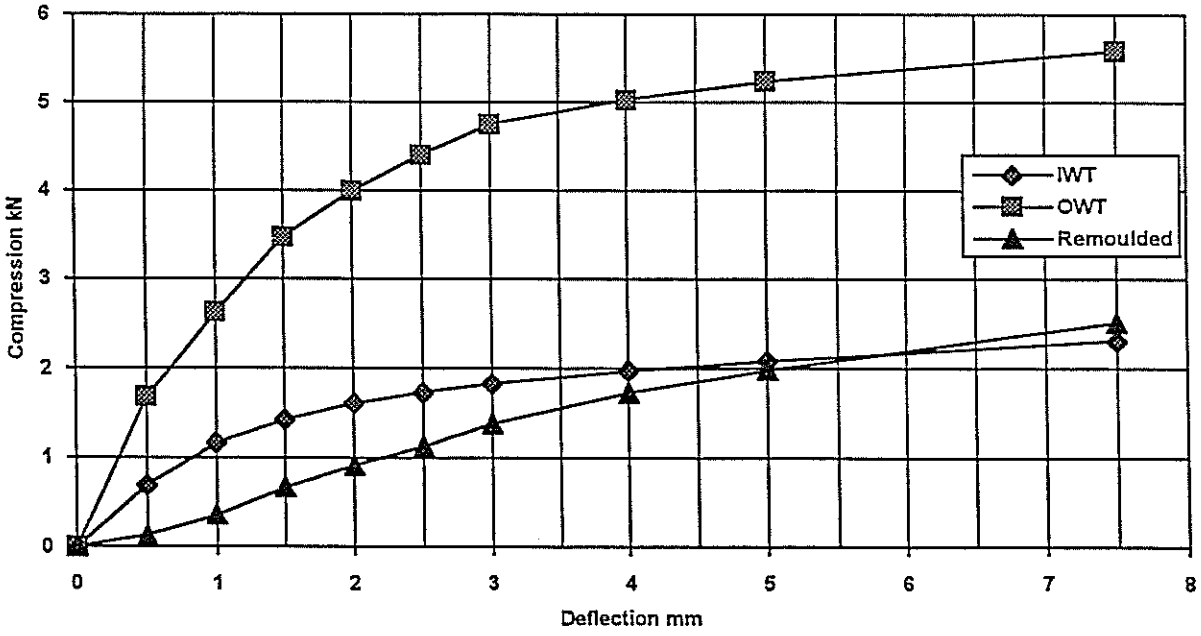
Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06	Lab Ref Inquiries to Report No. Page	97/M0501 Evan Huirua 970501.1 7

Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Patea Township Site**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**20 June 1997**

California Bearing Ratio Test Graph (Insitu and Remoulded)

Date of test 20-06-1997

mm	0.0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	7.5
IWT kN	0	0.693	1.1655	1.428	1.6065	1.7325	1.827	1.974	2.079	2.31
OWT kN	0	1.68	2.625	3.465	3.99	4.41	4.7565	5.0295	5.2395	5.586
Remoulded	0	0.13	0.36	0.67	0.91	1.13	1.38	1.73	1.98	2.51



Signed
Laboratory Manager Ian Huirua

Date 1/7/97

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Austroads Testing Wanganui Ouri Stream Bridge East Site SH45 RP 64/8.93 to 9.50	Lab Ref Inquiries to Report No. Page	97/M0504 Evan Huirua 970504.1 3

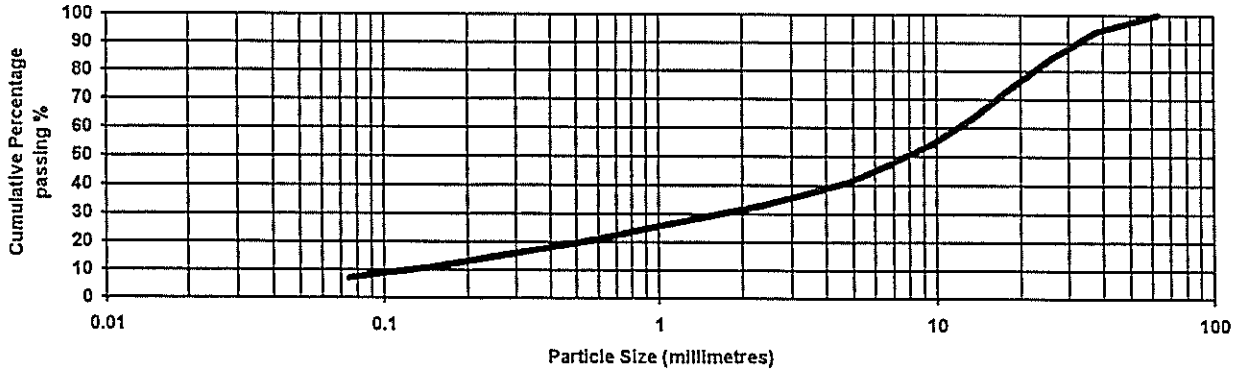
Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Ouri Stream Bridge East**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Particle Size Distribution Test Report and Graph

Date of test **27-06-1997 Pavement Basecourse**

Sieve Size	Cumulative Percentage Passing %	Not specified
63.0mm	100	NA
53.0mm	98	NA
37.5mm	94	NA
26.5mm	85	NA
19.0mm	75	NA
13.2mm	63	NA
9.50mm	54	NA
6.70mm	47	NA

Sieve Size	Cumulative Percentage Passing %	Not specified
-	-	-
4.75mm	41	NA
2.36mm	33	NA
1.18mm	27	NA
600µm	21	NA
300µm	16	NA
150µm	11	NA
75µm	7	NA



Silt		Sand			Gravel
Medium	Coarse	Fine	Medium	Coarse	

Test method
NZS 4407:1991 Test 3.8.1

Wet Sieving
The percentage passing the finest sieve was obtained by difference

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Date 2 / 7 / 97

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Austroads Testing Wanganui Nopera Road South Site SH45 RP 64/10.14 to 11.21		Lab Ref Inquiries to Report No. Page	97/M0505 Evan Huirua 970505.1 3

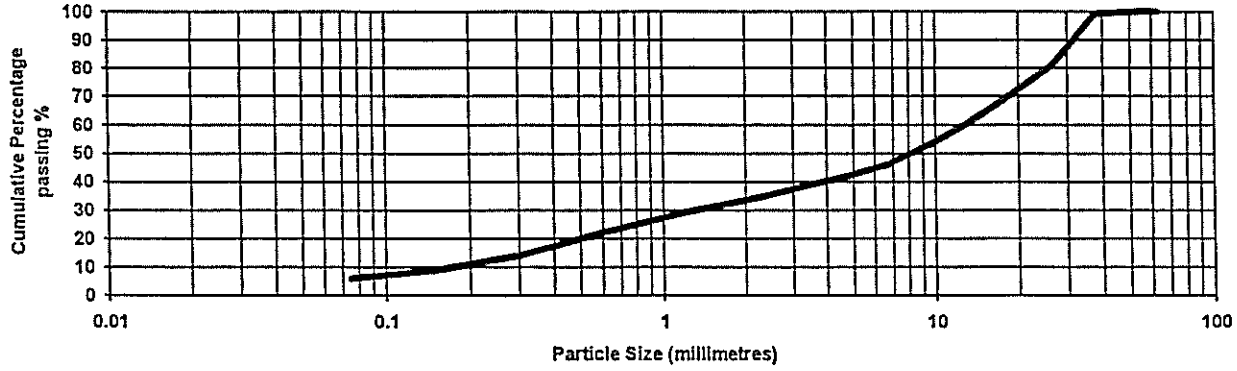
Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Nopera Road South**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**18 June 1997**

Particle Size Distribution Test Report and Graph

Date of test **27-06-1997 Pavement Basecourse**

Sieve Size	Cumulative Percentage Passing %	Not specified
63.0mm	100	NA
53.0mm	100	NA
37.5mm	99	NA
26.5mm	81	NA
19.0mm	71	NA
13.2mm	61	NA
9.50mm	53	NA
6.70mm	46	NA

Sieve Size	Cumulative Percentage Passing %	Not specified
-	-	-
4.75mm	42	NA
2.36mm	35	NA
1.18mm	29	NA
600μm	22	NA
300μm	14	NA
150μm	9	NA
75μm	6	NA



Silt		Sand			Gravel
Medium	Coarse	Fine	Medium	Coarse	

Test method
NZS 4407:1991 Test 3.8.1

Wet Sieving
The percentage passing the finest sieve was obtained by difference

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Austroads Testing Wanganui Warwick Rd - Hills Rd Site SH3 RP 279/1.46 to 1.95		Lab Ref Inquiries to Report No. Page	97/M0503 Evan Huirua 970503.1 3

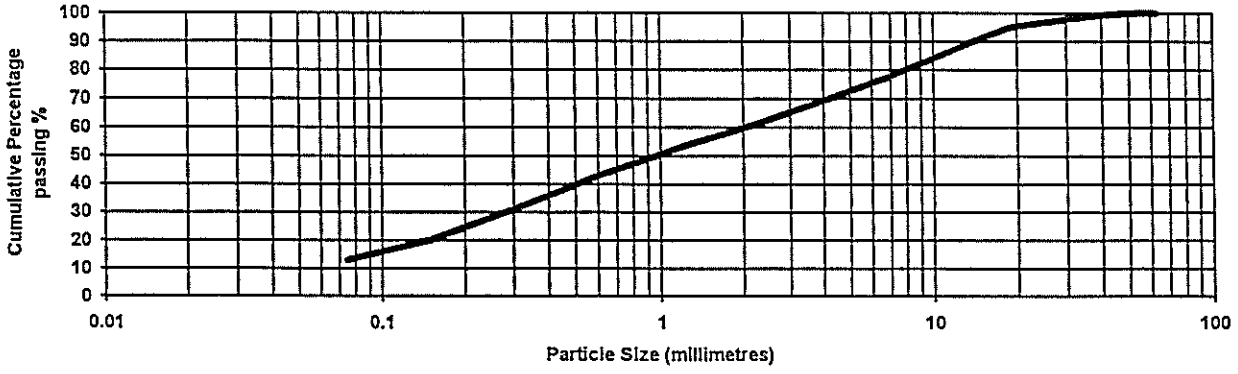
Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Warwick Rd - Hills Rd**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**21 June 1997**

Particle Size Distribution Test Report and Graph

Date of test **27-06-1997 Pavement Basecourse**

Sieve Size	Cumulative Percentage Passing %	Not specified
63.0mm	100	NA
53.0mm	100	NA
37.5mm	99	NA
26.5mm	97	NA
19.0mm	95	NA
13.2mm	89	NA
9.50mm	83	NA
6.70mm	77	NA

Sieve Size	Cumulative Percentage Passing %	Not specified
-	-	-
4.75mm	72	NA
2.36mm	62	NA
1.18mm	53	NA
600µm	43	NA
300µm	31	NA
150µm	20	NA
75µm	13	NA



Silt		Sand			Gravel
Medium	Coarse	Fine	Medium	Coarse	

Test method
NZS 4407:1991 Test 3.8.1

Wet Sieving
The percentage passing the finest sieve was obtained by difference

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Laboratory Manager Evan Huirua Date 2/7/97

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Austroads Testing Wanganui Anderson Road North Site SH3 RP 287/1.00 to 1.32	Lab Ref Inquiries to Report No. Page	97/M0502 Evan Huirua 970502.1 3

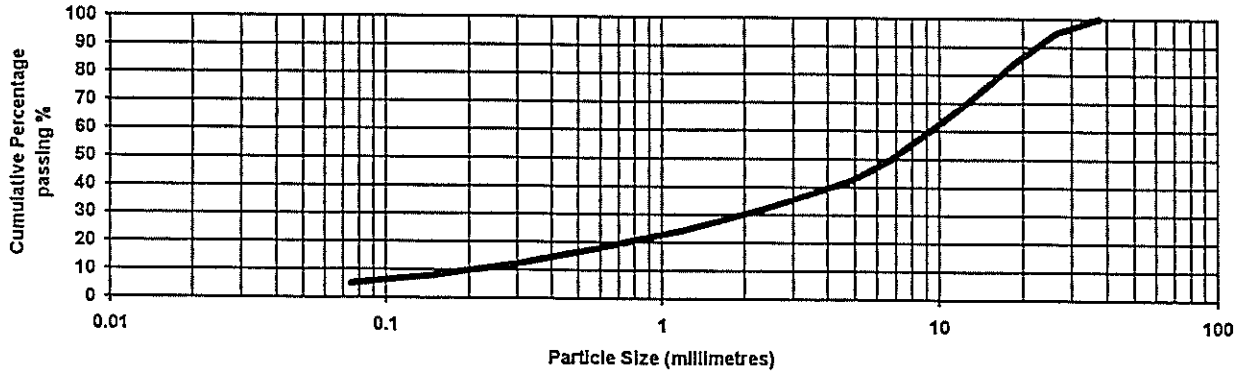
Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Anderson Road North**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	**23 June 1997**

Particle Size Distribution Test Report and Graph

Date of test **27-06-1997 Pavement Basecourse**

Sieve Size	Cumulative Percentage Passing %	Not specified
63.0mm	-	NA
53.0mm	-	NA
37.5mm	100	NA
26.5mm	95	NA
19.0mm	85	NA
13.2mm	72	NA
9.50mm	61	NA
6.70mm	50	NA

Sieve Size	Cumulative Percentage Passing %	Not specified
-	-	-
4.75mm	42	NA
2.36mm	32	NA
1.18mm	24	NA
600µm	18	NA
300µm	12	NA
150µm	8	NA
75µm	5	NA



Silt		Sand			Gravel
Medium	Coarse	Fine	Medium	Coarse	

Test method
NZS 4407:1991 Test 3.8.1

Wet Sieving
The percentage passing the finest sieve was obtained by difference

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Austroads Testing Wanganui Patea Township Site SH3 RP 321/16.04 to 338/0.06	Lab Ref Inquiries to Report No. Page	97/M0501 Evan Huirua 970501.1 3

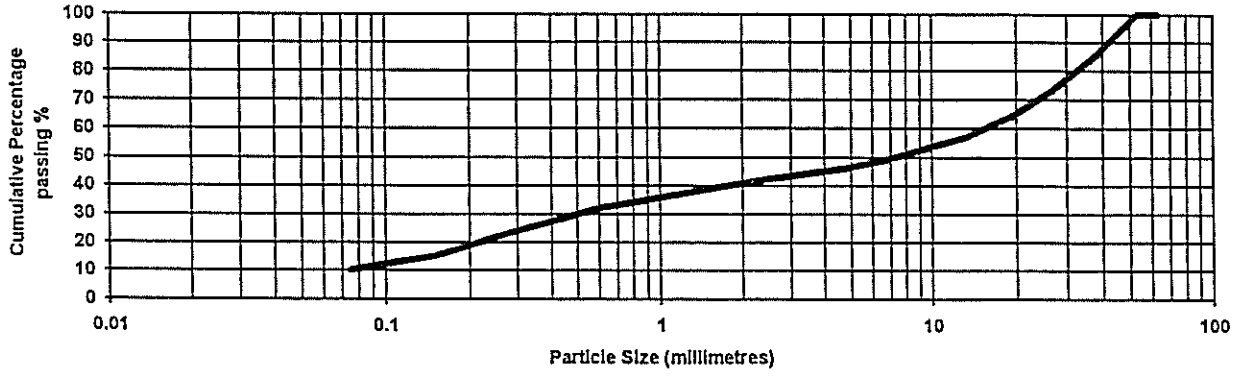
Job	**Austroads Testing Wanganui**	Sampled by	**Evan Huirua**
Location	**Patea Township Site**	Sample method	**NZS 4402:1986**
Origin	**Existing Pavement**	Sample condition	**Damp - sealed**
		Sampling date	20 June 1997

Particle Size Distribution Test Report and Graph

Date of test **27-06-1997 Pavement Basecourse**

Sieve Size	Cumulative Percentage Passing %	Not specified
63.0mm	100	NA
53.0mm	100	NA
37.5mm	85	NA
26.5mm	73	NA
19.0mm	64	NA
13.2mm	57	NA
9.50mm	53	NA
6.70mm	49	NA

Sieve Size	Cumulative Percentage Passing %	Not specified
-	-	-
4.75mm	46	NA
2.36mm	42	NA
1.18mm	37	NA
600μm	32	NA
300μm	24	NA
150μm	15	NA
75μm	10	NA



Silt		Sand			Gravel
Medium	Coarse	Fine	Medium	Coarse	

Test method
NZS 4407:1991 Test 3.8.1

Wet Sieving
The percentage passing the finest sieve was obtained by difference

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