Low Volume Roads Technology Projects

Department of Infrastructure, Transport, Regional Development
and Local Government
and
Australian Stabilisation Industry Association Limited

Recycling unsealed roads to reduce dust & maintenance using insitu stabilisation

CONSTRUCTION REPORT FOR THE INSITU STABILISATION OF UNSEALED ROAD TRIALS USING LIME, CEMENTITIOUS AND POLYMER BINDERS




Preface

AusLink

AusLink is Australia's first National Land Transport planning, funding and investment decision making framework. By linking transport performance outcomes to projected economic growth and development, it is transforming the way Australian Governments plan and fund major road and rail systems infrastructure. This project is funded by the Australian Government as part of AusLink.

Department of Infrastructure, Transport, Regional Development and Local Government

The Department is responsible for:

- infrastructure planning and coordination;
- transport safety, including investigations;
- land transport;
- civil aviation and airports;
- transport security;
- delivery of regional and rural specific services;
- maritime transport including shipping;
- regional development;
- matters relating to local government; and
- major projects facilitation

Australian Stabilisation Industry Association (AustStab)

The Australian Stabilisation Industry Association was formed to promote and enhance the soil stabilisation and road recycling industry in Australia. The Association, commonly known as AustStab, has the following objectives:

- promote road recycling and environmental sustainability,
- set national standards of design and construction performance,
- maintain standards by operating a contactors accreditation scheme
- assist and coordinate research to make improvements, and
- educate and train people in the industry so that stabilisation is well understood.

Research Project Team

The project team consisted of:

Research project manager:	George Vorobieff, Project Director, AustStab
Financial manager:	Warren Smith, President AustStab (Stabilised Pavements of Australia)
Operations manager:	Scott Young, Downer EDI Works
Construction manager:	Andrew Middleton, Stabilised Pavements of Australia
Mix design specialist:	Peter Sheen, Testrite

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Executive Summary

This report details the construction of the five trial sites in South West NSW in a project jointly funded by AusLink and AustStab. It also covers construction compliance outcomes and construction costs for each site, along with averages to be used for estimates. This report should be read in conjunction with the laboratory report (AustStab, 2008). No performance data is detailed in this report.

Construction of the trial sites started on the 30 May at Griffith and the last trial site was constructed on the 1st September at Temora (see Figure I). The construction work provided an opportunity to:

- review the interim model specifications,
- compare the laboratory mix design results against the samples taken from the field during construction, and
- look at immediate treatment solutions that might arise during construction, such as wet spots

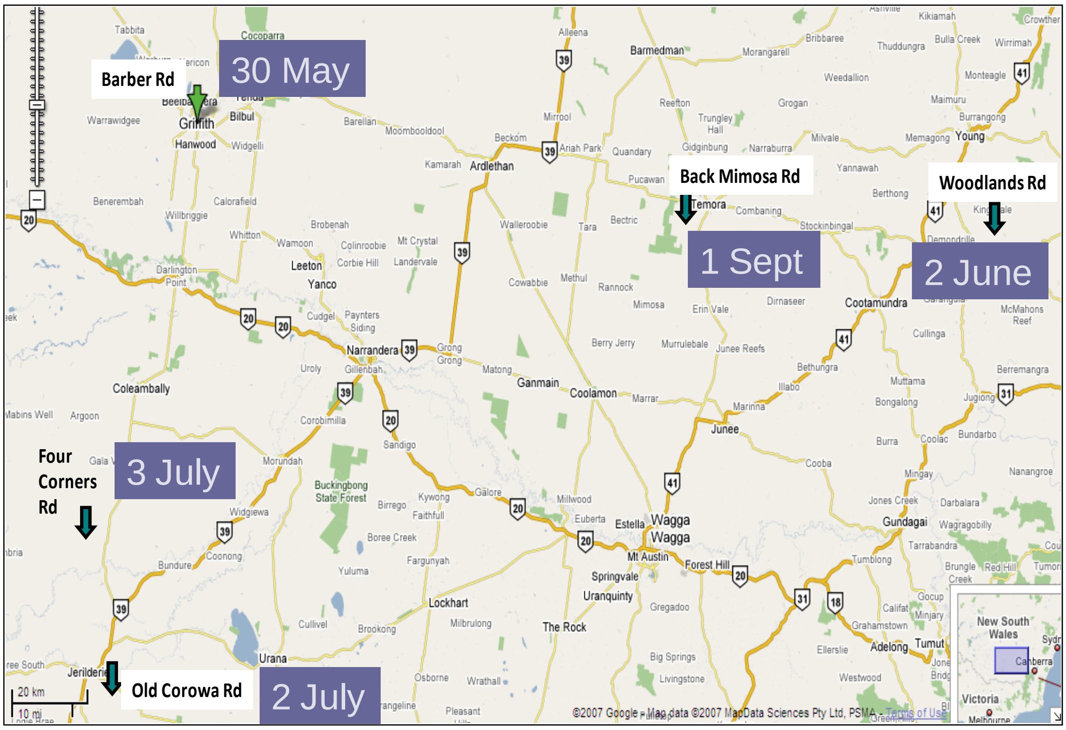

Figure I Location of trial sites and dates of construction in the south west region of NSW.

The stabilisation of unsealed roads to a width of 7 m and length of 1.5 km can be carried out in a single day, however this production level is reduced as a result of short day light hours, equipment breakdowns, delivery delays and the extent of drainage structures near the surface (eg culverts with high invert level). Production levels are typically 1 km per day on low volume roads and usually consist of three mixing runs across the road. Whilst two water carts were used for each of the sites, it is recommended that three water carts with a minimum 10 kl capacity are used to ensure continuous water supply to the mixer and for the slaking of the quicklime as required.

Compaction techniques used for unsealed roads are similar to sealed roads, except padfoot rollers are not recommended for compaction. Padfoot rollers have been trialled prior to this project but the pads leave surface impressions, which despite careful trimming, can result in early distress of the surface, such as pot holing. The stabilisation depth usually does not exceed 200 mm and a 12 to 16 t vibratory smooth drum roller has been shown to be adequate for achieving compaction.

For this project, construction specifications were developed for full and part-service contracts, and for the two main binder types, that is lime, cementitious and dry powdered polymer. The mixing of lime and cementitious binders requires a slightly different specification to that of the polymer so to avoid confusion in the field, two specifications were developed by AustStab. These specifications are detailed in Appendices A and B.

Whilst hydrated lime is used in the laboratory, quicklime is typically used by contractors in the field as this heavier binder is not so easily blown by wind and costs less. A common practice in Australia is to specify quicklime with an ALI exceeding 85% and then to convert the specified application lime rate by 0.76 to obtain the application rate of quicklime (AustStab, 2008).

The specified crossfall of the road was set at 4% and this was increased at curved sections of the roadway. In addition, the height difference between the crown and invert of the table drain (see Figures 7 and 8) was recorded after construction as a measure of how well the road would drain.

For four of the five trial sites, reference sections were identified in the stabilised and untreated (ie control) sections of the unsealed road for a comparison of the performance measures during the evaluation period. The location of these control sections are listed in Annexure C, and used in the tables in this report.

For these trials the stabilisation contractor typically completed the spread and mixing in one day at a cost was \$1.50/m^2. Shires used their own local plant and labour to compact and trim the sites after mixing and it was estimated that the cost for this work was about \$1.00/m^2. The average cost of the quicklime for each site was \$2.40/m^2 for the typical application rate of 3%. Therefore, for these trials the construction cost was \$4.90/m^2 for lime stabilisation at a 3% (hydrated lime) application rate.

Using the above costs estimates, the cost of the stabilisation of the unsealed roads was in the range of \$3.75 to \$6.50/m^2 when using a lime or cementitious binder. An extra \$2.00/m^2 to \$2.50/m^2 is likely with a polymer binder and this will increase if the site is remote from the polymer binder supplier.

The above rates do not take into account the whole of life cycle costs related to the future savings this treatment has to offer in minimising regular grading operations typical of unsealed roads. In addition, this study it is expected to show that this treatment will provide all weather access to communities that is not normally included in whole of life cost comparisons between pavement options for new of existing roads, but will be of great benefit to the communities. A report is currently being prepared outlining the whole of life costs of this treatment compared to resheeting and grading treatments used for unsealed roads.

The following recommendations are available to Shire engineers, consultants and contractors to assist in further improvements to the road construction process:

A. A minimum stabilisation width of 6 m.
B. When wet spots develop during construction with the use of the polymer binder, it was found that the area be remixed with a single pass and then compact.
C. Minimise the amount of unstabilised material being graded from the shoulder back into the pavement after primary compaction has been completed.
D. Maintain 4% camber to ensure sufficient surface drainage.
E. Whilst the generally accepted approach is to use two water carts, an assessment of the location of water supply to the project may indicate a further water cart may be required.

Table of Contents

1 INTRODUCTION

AustStab members have been working with rural local government engineers in NSW to develop long term cost effective solutions to minimise dust generation, cut demand on gravel pits and significantly reduce the maintenance frequency on unsealed low volume roads. Prudent spending of limited road maintenance funding is paramount to Shires and beneficial to rate payers and the wider public users of these roads.

A number of guides and papers on unsealed roads have been published over the last decade and Austroads is about to publish a guide outlining suggested treatments for unsealed roads for various traffic volumes (Austroads, 2008). Table 1 provides common road types associated with the selection of maximum speeds and minimum widths for unsealed roads in Australia. Whilst the Austroads guide recommends a minimum width of 7 m for the unsealed roads selected for the trials, AustStab recommends a minimum width of stabilisation of 6 m with the additional width of unstabilised material.

Table 1 Suggested unsealed roads attributes (Austroads, 2008).

Pavement type	Traffic spectrum	Attributes	Typical applications
U1	>200 veh/day and/or >20% heavy vehicles[2]	Up to 100 km/h[1] 9 m min. width – two lanes plus shoulder	Main unsealed roads carrying significant freight or livestock. Links to major resource developments, e.g. mines, gas fields, etc.
U2	200 – 100 veh/day and/or >10% heavy vehicles	Up to 100 km/h 9 m min. width – two lanes plus shoulder	Main links between communities, national parks, recreational areas, haul roads.
U3	100 – 200 veh/day and/or <10% heavy vehicles	Up to 80 km/h 7 m min width two lanes	Links between smaller communities, national parks, recreational and remote areas, haul roads within quarries/mines
U4	<20 veh/day	Up to 80 km/h 4 m min. width single lane	Main access to remote areas, difficult terrains and fire protection, national park access
U5	<10 veh/day	Up to 60 km/h 4 m min. width single lane	Minor access (four wheel drive or heavy duty vehicles) to remote locations, fire protection
Notes: 1. Speed is dependent upon terrain, road geometry and slipperiness/condition of wearing course (e.g. wet, gravelly or sandy). 2. Heavy vehicles are defined as Class 4 vehicles and above or mine haul trucks.			

This report details the construction of the five trial sites in South West NSW in a project jointly funded by AusLink and AustStab. It also covers construction compliance outcomes and construction costs for each site, along with averages to be used for estimates. This report should be read in conjunction with the laboratory report (AustStab, 2008). No performance data is detailed in this report.

The construction of the trial sites could not have happened without the financial and in kind support of the following organisations:

- Blue Circle Southern Cement
- Downer EDI Works
- Hyrock
- Independent Cement and Lime
- Polymix Industries
- Stabilised Pavements of Australia
- Unimin Australia

2 TRIAL SITES

Ten sites were initially selected in conjunction with Shire engineers from four different Shires in South West NSW. Site inspections were completed in November 2007 and five potential sites were then chosen for detailed investigation. The selection of these trial sites took into consideration the pavement material, topography, rainfall and existing performance of the site. These sites have been chosen to explore a range of materials and road topography. Table 2 and Figure 1 show the location of the trial sites.

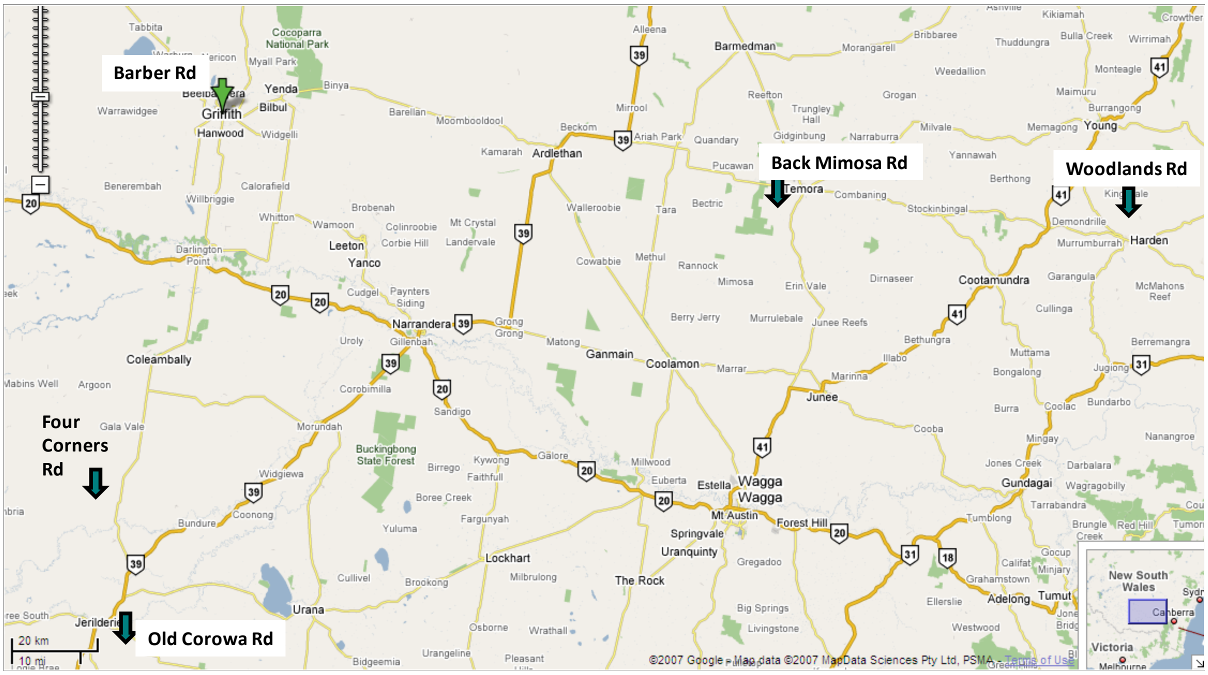

Figure 1 Location of trial sites in the south west region of NSW.

Table 2 Unsealed road sites to conduct trials (also refer to Figures 2 to 6).

Site	Road Name	Town	GPS Coordinates of one end of the site		Length (m)
			S	E	
1	Barber Rd	Griffith	34.25314	145.8491	1000
2	Woodlands Rd	Wombat	34.42101	148.2581	1250
3	Old Corowa Rd	Jerilderie	35.42889	145.8409	1250
4	Four Corners Rd	Jerilderie	34.86002	145.7514	500
5	Back Mimosa Rd	Temora	34.46140	147.50713	1250

Figure 2 View of trial site at Woodlands Road, Wombat after construction.

Figure 3 View of trial site at Back Mimosa Road, Temora after construction.

Figure 4 View of trial site at Barber Road, Griffith after construction.

Figure 5 View of trial site on Old Corowa Road, Jerilderie after construction.

Figure 6 View of trial site at Four Corners Road Jerilderie after construction. Photo on right shows clear distinction of the start of trial.

All of the unsealed roads that were treated had a permissible maximum speed limit of 100 kph.

3 CONSTRUCTION

3.1 General

The success of these trials requires consistent and quality construction work, such as sufficient power in the stabilisation machine and the primary mixing moisture controlled by a water spray bar inside the mixing chamber. Table 3 lists the Shires that constructed the trial sites in conjunction with the accredited stabilisation contractors who provided stabilisation equipment and trained operators. The contractors supplied the spreader with load cells and reclaimer with experienced operators. All other construction equipment was supplied by Council.

Table 3 Shires and contractors engaged for the trials.

Road Name	Town	Shire	Contractor	Date of construction
Barber	Griffith	Griffith	Downer EDI Works	30 May 2008
Woodlands	Wombat	Harden	Downer EDI Works	2 &3 June 2008
Old Corowa	Jerilderie	Jerilderie	Stabilised Pavements of Australia	2 & 3 July 2008
Four Corners	Jerilderie	Jerilderie	Stabilised Pavements of Australia	3 July 2008
Back Mimosa	Temora	Temora	Stabilised Pavements of Australia	1 September 2008

The stabilisation of unsealed roads to a width of 7 m and length of 1.5 km can be carried out in a single day, however this production level is reduced as a result of short day light hours, equipment breakdowns, delivery delays and the extent of drainage structures near the surface (eg culverts with high invert level).

Compaction techniques used for unsealed roads are similar to sealed roads, except padfoot rollers are not recommended for compaction. Padfoot rollers have been trialled prior to this project but the pads leave surface impressions, which despite careful trimming, can result in early distress of the surface, such as pot holing. The stabilisation depth usually does not exceed 200 mm and a 12 to 16 t vibratory smooth drum roller has been shown to be adequate for achieving compaction. Trials can be conducted to assess the appropriate mass of the roller and passes to achieve the specified densities. However density assessment for the construction and rehabilitation of unsealed roads is uncommon because of the long distances from laboratories and subsequent high geotechnical costs.

Production levels are typically 1 km per day on low volume roads and usually consist of three mixing runs across the road. Whilst two water carts were used for each of the sites, it is recommended that three water carts with a minimum 10 kl capacity are used to ensure continuous water supply to the mixer and for the slaking of the quicklime as required.

AustStab promotes construction cooperation with Shire and State Road Authorities through the application of full-service or part-service of the stabilisation of roads. The part-service method is where the specialist contractor provides a spreader and mixer, and spreads the binder and mixes with a stabiliser to the required depth. In part-service contracts, the compaction and trimming is carried out by the Shire, who also supply the water and water carts. This is a common rehabilitation practice used by many rural Shires for both sealed and unsealed roads.

For this project, construction specifications were developed for full and part-service contracts, and for the two main binder types. The mixing of lime and cementitious binders requires a slightly different specification to that of the polymer so to avoid confusion in the field, two specifications were developed by AustStab. These are detailed in Appendices A and B.

Full-service specifications have also been produced during the trials and these may be accessed from the AustStab website. These specifications will be amended during the post-construction evaluation and assessment of performance.

All binders supplied to the sites had Material Safety Data Sheets for the safe handling of the materials. No safety incidents were recorded during construction.

Three longitudinal mixing runs were used for all sites except at intersections where numerous mixing runs in several directions were used to evenly mix the material within the tapered zone. Due to the nominal 2.4 m width of the reclaimer, two overlapping mixing runs were carried out but the binder was not applied twice in these overlap regions. This was controlled by gates on the variable spreader used by the contractor.

The specified crossfall of the road was set at 4% and this was increased at curved sections of the roadway. In addition, the height difference between the crown and invert of the table drain (see Figures 7 and 8) was recorded after construction as a measure of how well the road would drain.

For four of the five trial sites, reference sections were identified in the stabilised and untreated (ie control) sections of the unsealed road for comparison of the performance measures during the evaluation period. The location of these control sections are listed in Annexure C, and used in the tables in this report.

The following section outlines the construction layout, equipment and methods used to conduct each of the trials.

Figure 7 View of typical profile of unsealed road.

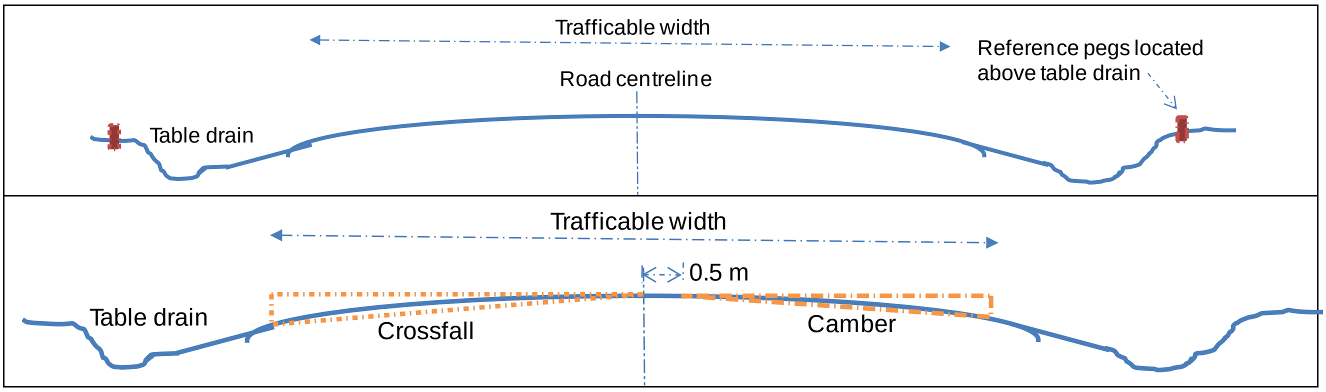

Figure 8 View of typical cross sections of unsealed roads defining crossfall and camber.

3.2 Barber Road

This site consists of an intersection which allowed the straight section of treated road to be assessed against turning traffic. Stabilisation consisted of a 750 m length of Barber Road and a 250 m long section of McNamara Road as shown in Figure 9. The control section was located in McNamara Road.

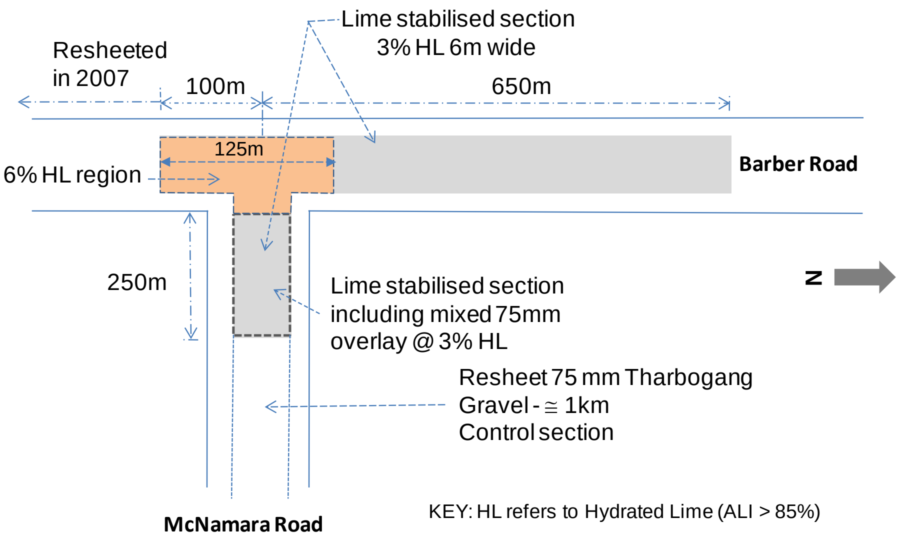

Figure 9 View of stabilisation area for Barber and McNamara Roads, Griffith.

The binder used for this trial was quicklime supplied from Blue Circle Southern Cement's Marulan plant with an Available Lime Index (ALI) of 92%. Whilst hydrated lime is used in the laboratory, quicklime is typically used by contractors in the field as this heavier binder is not so easily blown by wind and costs less. A common practice in Australia is to specify quicklime with an ALI exceeding 85% and then to convert the specified application lime rate by 0.76 to obtain the application rate of quicklime (AustStab, 2008). Therefore the simplified approach to determine the field spread rate is to use the following calculation[1]:

$$Rate_{SPREAD} = 0.76\ Rate_{FQ}\ \gamma\ T$$

Where:

Where:	$Rate_{SPREAD}$	=	Field application rate of quicklime (kg/m^2)
	$Rate_{FQ}$	=	The specified application rate of lime from laboratory testing (%)
	γ	=	Dry density of the pavement material (kg/m^3)
	T	=	Thickness of stabilised layer (m)

[1] Binder application rate is only calculated by density rather than volume as the latter approach creates a greater error in the spread rate.

For this site, the field application rate (quicklime) was 2.3 and 4.1% for the straight and intersection zones respectively. The mixing depth was kept constant at 150 mm and the spread rate was 6.9 and 12.3 kg/m^2. Quicklime was supplied by two bulk tanker loads and the lime was slaked after spreading as shown in Figure 10. Cold weather at the time of construction and high reactive quicklime created a dense steam cloud during slaking.

Figure 10 View of quicklime being slaked on Barber Road at about 8:00am on a very cold morning.

Mixing commenced after slaking was completed which was typically after 15 minutes. The mixing run directions adopted for the Barber Road project are shown in Figure 11, with three passes across the width of the road for a total stabilisation width of 6 m.

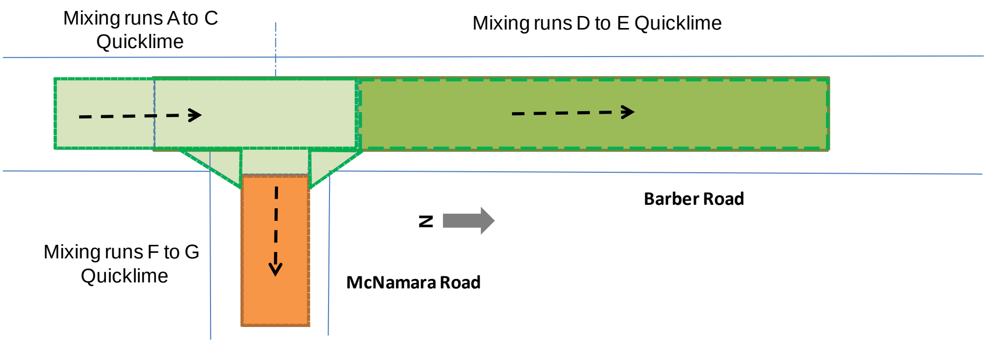

Figure 11 View of mixing runs for Barber and McNamara Roads, Griffith.

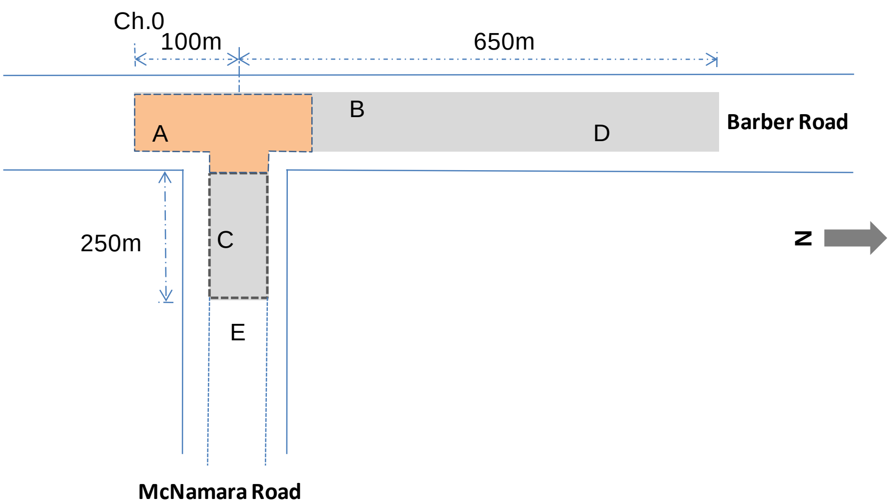

Figure 12 Location of sections for Barber and McNamara Roads, Griffith.

The equipment used at this site was:

- Variable rear drop spreader – 2.4 m nominal width & 25 t capacity
- Terex/CMI RS425 Reclaimer Mixer - 2.4 m nominal width
- Smooth drum roller (VM166B) - 2 m wide roller at 16 t capacity
- Multipac multi-wheel roller (VP2400)
- Caterpillar grader
- Two water carts

The camber of the road after final trimming was carried out by survey at 5 sections for this site as listed in Table 4 (refer to Figure 12). The camber was in the range of 1.5 to 5.9% for Barber Road and 3.5 to 4.6% for McNamara Road.

Table 4 The camber (%) and table drain invert (TDI) difference from crown for Barber and McNamara Roads project.

Section.	Chainage (m)	Left hand side		Right hand side		Remarks
		Camber	TDI (m)	Camber	TDI (m)	
A	51	5.3	0.57	5.9	0.50	
B	156	4.4	0.55	2.9	0.45	
C[1]	121	1.5	0.29	3.1	0.26	McNamara Road
D	565	4.6	0.48	3.5	0.25	
E	363	7.3	0.48	4.9	0.48-	Control section in McNamara Road
NOTE: 1. The zero chainage for Section C and E are taken from the centreline at the intersection.						

3.3 Woodlands Road

The Woodlands Road site commenced at the intersection of Gladstone Road and the stabilisation included the intersection and curved section of road. The road was undulating as shown in Figure 13 and there was also a minor property access road. This site consisted of 1000 m stabilised section with a cement/slag binder followed by 250 m of a polymer based binder as shown in Figure 14.

The binder used for this trial was a blend of GP cement and ground granulated blast furnace slag in a 70:30 proportion by mass. This cementitious binder is commonly referred to as Ecoblend[2] and was supplied from Independent Cement and Lime (ICL) from their Port Melbourne plant. The Ecoblend was supplied by two bulk tanker loads and spread and mixed as shown in Figure 15. The target application rate was set at 3 and 5% respectively. For this site and mixing depth (150 mm), the field spread rate was 9 and 15 kg/m^2 for application rates of 3 and 5%.

The polymer used at this site was PR11 from Polymix Industries. PR11L is a 50:50 blend of Polymix and hydrated lime and was shipped from the Wodonga (Victoria) plant by bulk tanker. The mixing depth for this section was 150 mm and the spread rate was 6 kg/m^2.

Three mixing runs over the road width were used except at the intersection where a range of mixing run directions was needed to evenly mix the material. The direction of mixing is shown in Figure 16.

[2] For more information about Ecoblend, download the technical details at www.auststab.com.au/unsealed/Ecoblend_Jan2008.pdf

Figure 13 Views of the curved section of road and undulating section after stabilisation.

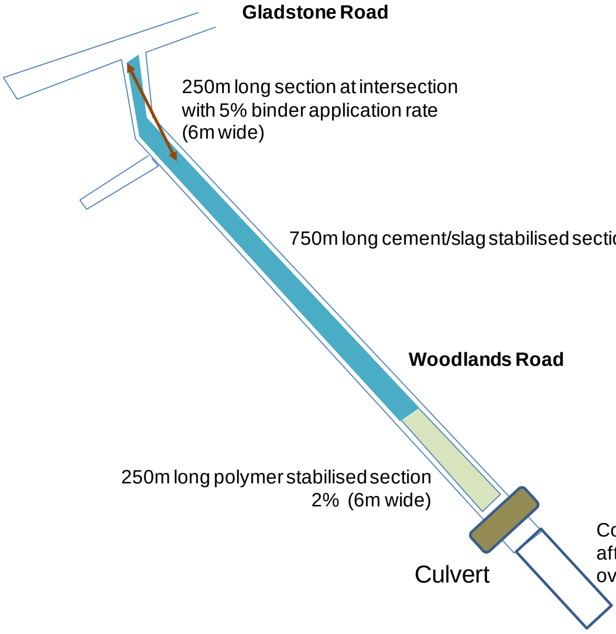

Figure 14 Plan view of stabilised section for Woodlands Road, Wombat.

Figure 15 Spreading (left) and mixing operations using the cementitious binder.

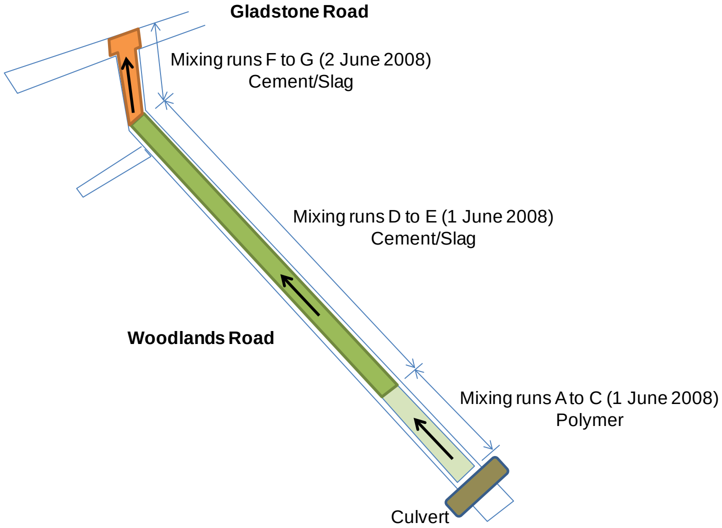

Figure 16 View of mixing runs for Woodlands Road, Wombat.

The equipment used at this site was:

- Variable rear drop spreader – 2.4 m nominal width & 25 t capacity
- Terex/CMI RS425 Reclaimer Mixer - 2.4 m nominal width
- Smooth drum roller (VV2004) - 2 m wide roller at 23 t capacity
- Multipac multi-wheel roller (VP2400)
- Caterpillar grader
- Two water carts

The camber of the road after final trimming, was carried out by survey at 7 sections at the site (including 2 in the untreated area, refer to Figure 17) and the results are listed in Table 5. The camber was in the range of 2.8 to 6.3% with a 6 to 7% one way crossfall at the bend in the road.

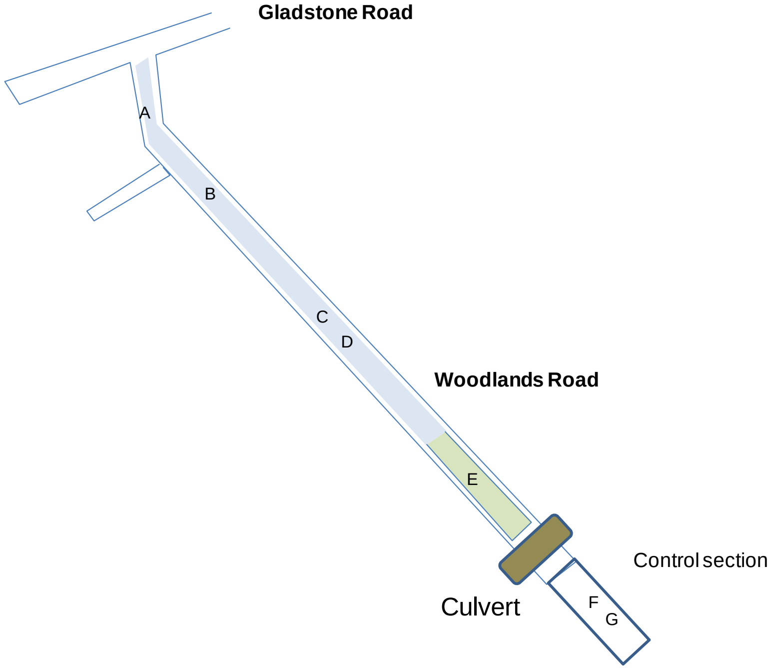

Figure 17 Location of sections for Woodland Road, Wombat.

A soft spot (a 20 to 25 mm deep rut) in the polymer stabilised section was observed during compaction (see Figure 18) and at the end of day's construction (1 June 2008), a dry mixing run was carried out on the centre of the soft spot (16 m long and 600 mm wide) at Chainage 1068 followed by compaction and trimming to shape. An inspection one month later (1st July 2008) showed no deformation or distress at the previous soft spot as shown in Figure 18.

Table 5 The camber and table drain invert (TDI) difference from crown for the Woodlands Road project.

Section.	Chainage	Left hand side		Right hand side		Remarks
		Camber	TDI (mm)	Camber	TDI (mm)	
A	152	5.5	0.59	2.8	0.52	Flat grade
B	497	3.6	0.18	5.6	0.41	On crest
C	855	5.5	0.29	6.0	0.38	In cutting
D	908	4.6	0.78	5.0	1.52	Road on fill
E	1138	4.0	0.82	4.9	1.51	Road on fill
F	1304	5.6	0.29	5.2	0.32	Control section – fill
G	1333	6.3	0.45	6.3	0.47	Control section – cut

Figure 18 A wet spot in the polymer section was identified (left) on the day of construction and corrected by dry mixing and recompaction (right).

3.4 Old Corowa Road

This site started at the end of the sealed west end section of Old Corowa Road and was a longitudinal road with a relatively flat profile as shown in Figure 19. Stabilisation consisted of a 1,250 m length of unsealed roadway as shown in Figure 20.

Figure 19 An overview of the treated road (left) and a view of the Polyroad spread onto the surface prior to mixing (right).

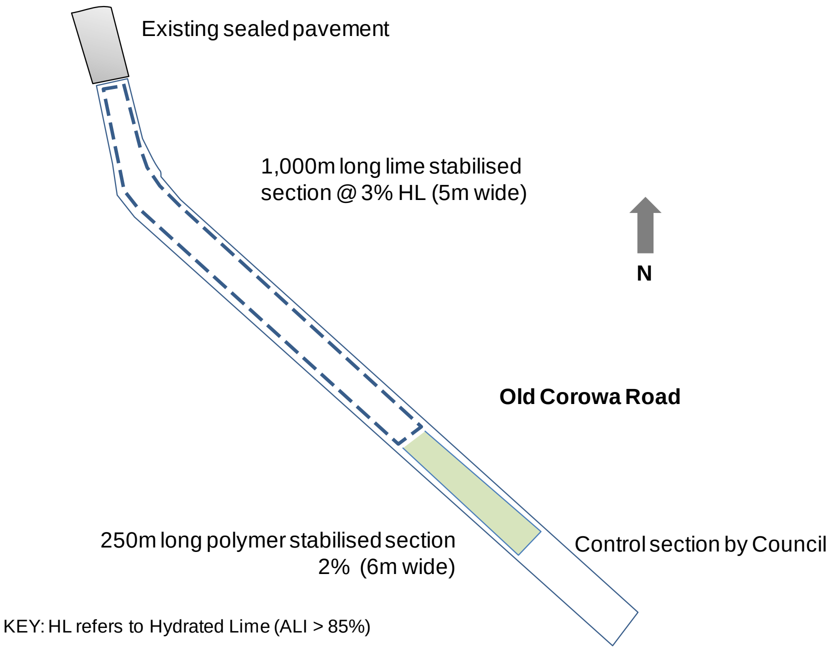

Figure 20 Plan view of stabilised section for Old Corowa Road, Jerilderie.

The binder used for this trial was quicklime with an Available Lime Index (ALI) of 62% and was supplied from Unimin's Lilydale plant in Victoria[3]. The target application rate for this project was adjusted to allow for the difference between the ALI of the hydrated lime used in the laboratory and the lower ALI from Unimin. For this site and a mixing depth of 150 mm, the spread rate was 11 kg/m^2. Quicklime was supplied by three bulk tanker loads and the lime was slaked after spreading.

Three mixing runs were used per width of road and the lime mixing run was limited to 500 m due to the smaller capacity water carts. Some sections of the road were ripped prior to spreading to increase productivity due to the hardness of the formation and the lower engine output of stabiliser (see Figure 21). Surface ripping is not required as most stabiliser and reclaimers have the capacity of mixing existing hard materials. However, if rock floaters are known to occur in the roadway, some Shires will rip to the target stabilisation depth to identify the existence of floaters to minimise damage to the stabilisation rotor.

Figure 21 The road was ripped prior to spreading the binder to improve the production rate for the mixing.

[3] The nearest Unimin plant to the site was Lilydale even though the NSW lime plant is located near Tamworth.

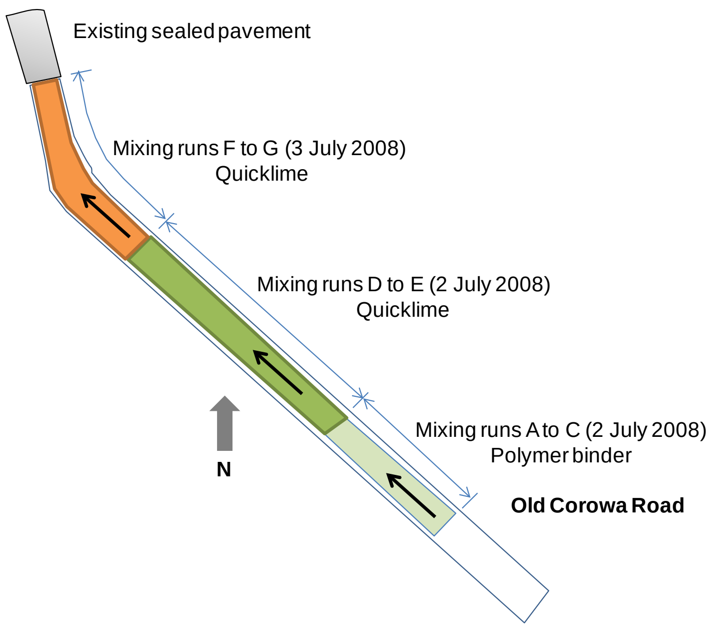

Figure 22 View of mixing runs for Old Corowa Road, Jerilderie.

The equipment used at this site was:

- Variable rear drop spreader – 2.4 m nominal width & 25 t capacity
- CAT 250 Reclaimer Mixer - 2.4 m nominal width
- Smooth drum roller (Dynapac) - 2 m wide roller at 15 t capacity
- Multi-wheel roller
- Caterpillar grader
- Two water carts

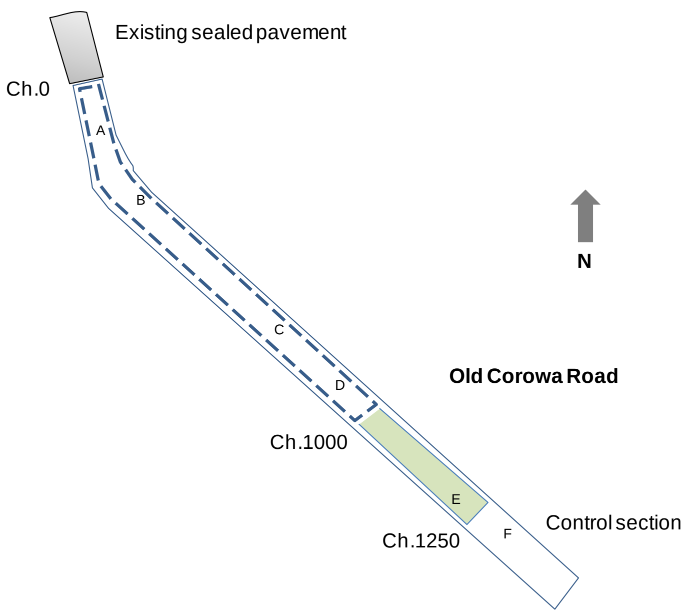

Figure 23 Location of sections for Old Corowa Road, Jerilderie.

The camber of the road after final trimming was carried out by survey at 6 sections selected for this site (see Figure 23) with the results are listed in Table 6. The camber was in the range of 3.0 to 6.9% with a 6% one way crossfall at the bend in the road.

Table 6 The camber (%) and table drain invert (TDI) difference from crown for the Old Corowa Road project.

Section.	Chainage	Left hand side		Right hand side		Remarks
		Camber	TDI (mm)	Camber	TDI (mm)	
A	143	5.8	0.65	-5.8	0.72	Road camber constant at bend in road
B	220	4.7	0.70	0.3	0.74	Section is located at the end of bend
C	823	6.9	1.02	3.0	0.80	
D	963	4.1	0.63	4.2	0.80	
E	1204	4.8	1.01	4.1	0.93	
F	1361	8.2	0.84	4.4	0.71	Control section

Rainfall occurred at the site three days after construction and during an inspection by Denis Gelle (Jerilderie Shire), there was no indication of the road being excessively slippery or excessively soft along the lime section when travelling at an estimated speed of 40 kph. However the pavement looked visually slippery immediately prior to the polymer section and when travelling along the polymer section at just 20 kph the car (a Holden Commodore SV6), immediately began to lose rear wheel traction and steering capabilities. Eventually the car began to slip sideways towards the road shoulder due to the camber of the road and the extreme build up of road pavement materials on the vehicle's tyres.

Gelle proceeded to inspect the existing gravel pavement (Control section) further to the south and then traversed back across the polymer section in a northerly direction. The same slippery conditions were experienced as when travelling in the southerly direction.

Gelle considered the polymer trial section to be extremely slippery and was given approval by the Shire engineering manager to place 48 m^3 of road base. This was delivered and spread over the polymer trial section on 7th July, 2008 and rectified the situation leaving the road in a safe driveable condition. This treatment provided the section with about 40 to 50 mm of road base cover as shown in Figure 24.

Figure 24 View of road base cover on the polymer trial section at Old Corowa Road, Jerilderie.

3.5 Four Corners Road

This site was the shortest trial at only 400 m in length and 6 m wide as shown in Figure 25. The binder used for this trial was a cement/slag (80:20) blend at a 4% application rate. The binder was supplied from Independent Cement and Lime (ICL) from the Port Melbourne plant. The mixing depth for this site was 150 mm and the spread rate was 12 kg/m^2.

Mixing commenced from the eastern end and three passes were used as shown in Figure 26.

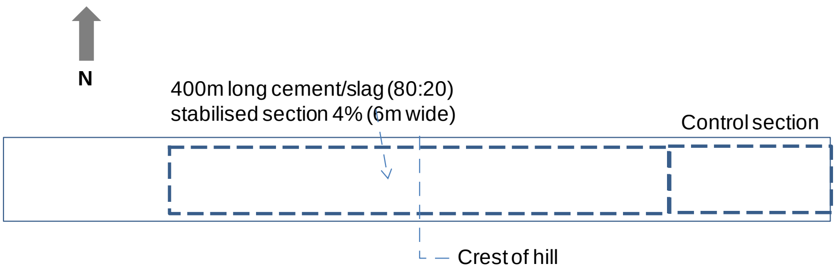

Figure 25 Plan view of stabilised section for Four Corners Road, Jerilderie.

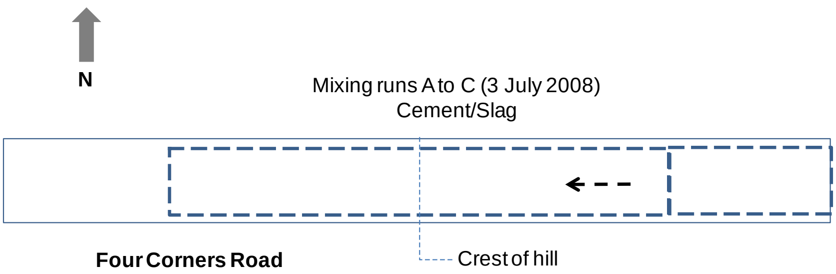

Figure 26 View of mixing runs for Four Corners Road, Jerilderie.

The equipment used at this site was:

- Variable rear drop spreader – 2.4 m nominal width & 25 t capacity
- CAT 250 Reclaimer Mixer - 2.4 m nominal width
- Smooth drum roller (Dynapac) - 2 m wide roller at 15 t capacity
- Multi-wheel roller
- Caterpillar grader
- Two water carts

The camber of the road after final trimming was carried out by survey and at one section for this site and the result is listed in Table 7. The camber was in the range of 3.3 to 3.8%. The control sections had significant loose material on the surface as shown in Figure 27 that would make it difficult to measure the camber of the road.

Figure 27 Views of significant amount of loose material typical of some section of the unstabilised road on Four Corners Road, Jerilderie.

Table 7 The camber (%) and table drain invert (TDI) difference from crown for the Four Corners Road.

Section.	Chainage	Left hand side		Right hand side		Remarks
		Camber	TDI (m)	Camber	TDI (m)	
A	94	3.3	0.84	3.8	0.71	

3.6 Back Mimosa Road

This site starts at about 2 km from the end of the sealed Back Mimosa Road, just after the concrete floodway. This road can be inundated during heavy rainfall and will be ideal to review its performance after very wet conditions and compare this with the control sections. The longitudinal road profile was relatively straight and flat as shown in Figure 28. Stabilisation consisted of a 1,250 m length of unsealed roadway (see Figure 29) with a concrete floodway approximately midway in the trial section as shown in Figure 29.

The binder used for this trial was quicklime with an Available Lime Index (ALI) of 90% . The spread rate was 9.1 and 12.2 kg/m^2 respectively, for this site and a mixing depth set at 150 mm and 200 mm. The quicklime was supplied in two bulk tanker loads from Hyrock's plant in Carbon[4] (NSW) and the quicklime was slaked after spreading. The polymer binder was applied to the eastern end of the trial site for 250 m in length.

Figure 28 Views of stabilised section for Back Mimosa Road, Temora.

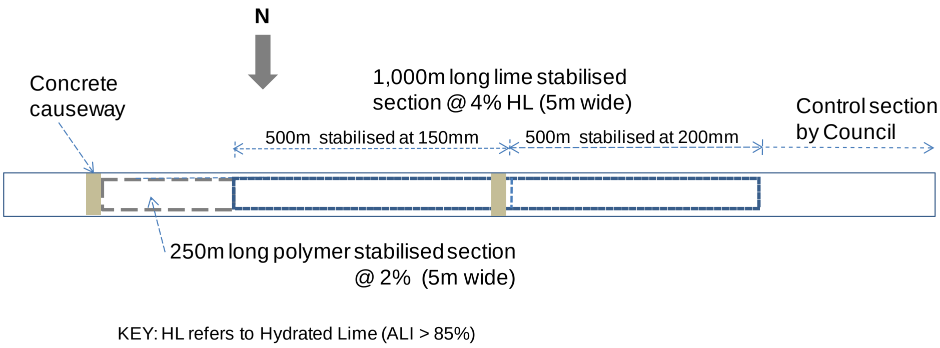

Figure 29 Plan view of stabilised section for Back Mimosa Road, Temora.

Figure 30 View of floodway about midway through the trial and some scouring adjacent to the roadway.

[4] Hyrock's lime supply division is now owned by Unimin.

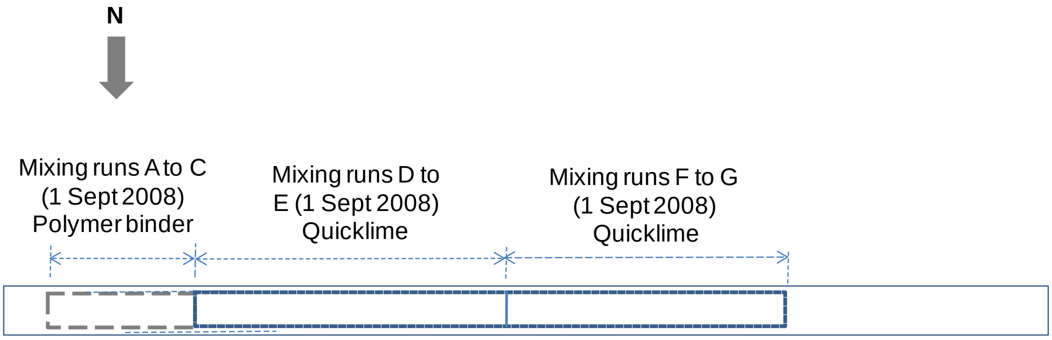

Figure 31 View of mixing runs for Back Mimosa Road, Temora.

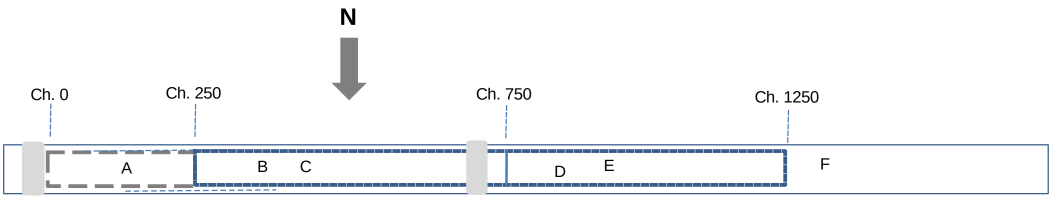

Figure 32 Location of reference sections for Back Mimosa Road, Temora.

The equipment used at this site was:

- Variable rear drop spreader – 2.4 m nominal width & 25 t capacity
- CAT 250 Reclaimer Mixer - 2.4 m nominal width
- Smooth drum roller (Dynapac) - 2 m wide roller at 15 t capacity
- Multi-wheel roller
- Caterpillar grader
- Two water carts

The camber of the road after final trimming and at the five sections (including one in the untreated area, refer to Figure 32) for the site was carried out by survey and results are listed in Table 8. The camber was in the range of 2.0 to 5.4%.

Table 8 The camber (%) and table drain invert (TDI) difference from crown for the Back Mimosa Road project.

Section.	Chainage	Left hand side		Right hand side		Remarks
		Camber	TDI (m)	Camber	TDI (m)	
A	125	4.4	0.16	3.7	0.21	Polymer
B	400	5.2	0.37	4.7	0.18	150 mm lime
C	489	4.8	0.16	2.5	0.07	150 mm lime
D	870	5.1	0.58	5.4	1.05	200 mm lime
E	1066	5.1	0.34	4.7	0.34	200 mm lime
F	1379	4.5	0.21	4.6	0.29	Control section

4 CONSTRUCTION COMPLAINCE

The specifications adopted for this project require the following compliance measures:

Spread rate
Verify that the binder spread rate has been determined once in every lot or as directed by the engineer as per AustStab National Guidelines.

Depth
The depth of stabilisation was checked only during mixing by measuring the depth of 'cutting' and mixing and allowing for bulking on a regular basis.

Density
The density of the compacted layer was measured using the ratio of insitu density by NDG and recompacted treated material (expressed as a percentage).

Density measurements are a costly exercise for remote sites and uncommon for unsealed roads. This conformance measure may be incorporated as a provisional item in the final versions of the model specifications. Table 9 details the relative compaction values obtained during the construction of the trial sites[5].

Table 9 Maximum and minimum relative compaction results for the four trial sites.

Road Name	Location [A]	Insitu CBR [B]	Reference Density (t/m^3) [C]	Relative compaction	Remarks
Barber Rd, Griffith	A C	52 55	2.2	101.5 95.0	-
Woodlands Rd, Wombat	B E	55 55	2.2	97.5 101.0	-
Old Corowa Rd, Jerilderie	B D	- 31	2.05	95.5 89.0	The material may have been compacted too dry of OMC
Back Mimosa Rd, Temora	A E	> 50	2.09	101.0 95.5	-

NOTES: A. Refer to Tables 4 to 8 for more information about the location of sections.
B. The insitu CBR was determined by DCP testing after mixing and prior to compacting the stabilised material.
C. Reference density was determined using RTA Test Method T173 with standard compactive effort.

Whilst not included in the specification, sufficient camber of the road is essential for the quick removal of surface water for safe driving conditions and to minimise the infiltration of water into the unsealed surface. The camber selected for this project was determined by the Shire to conform with their common practices, however AustStab recommends a minimum crossfall of 3%. Figure 33 shows the typical crossfall achieved from the crown matching the road centreline and also one-way crossfall on a curved section of lime treated unsealed roads.

In any road recycling process, the existing pavement material moisture content varies. For insitu stabilisation when the existing moisture content is above optimum, water may not be added during mixing operations[6]. However, the specification does require the contractor to manage the insitu moisture content

[5] Due to the short length of the Four Corners Road trial site, no compaction measurements were taken.
[6] 'Wet patches' in roads ready for rehabilitation is sometimes difficult to indentify prior to stabilisation and many contractors will not prewet the road with a water cart to avoid over wetting the pavement material.

in the range of 80 to 110% of optimum moisture content[7]. During the construction of the polymer section of the trial site at Woodlands Road, a wet patch was identified during compaction as shown in Figure 34. This section was remixed again without the addition of binder and water, and was compacted a day later in the same manner as the section treated to allow the material to dry out. The remixed section showed no signs of distress after a site inspection on the 11th July.

(a) Crown matches the centreline of the road.	(b) one way crossfall is used for curved sections of roadway.

Figure 33 View of typical crossfalls adopted for the trial sites.

(a) Wet patch identified during compaction.	(b) Same section of roadway 6 weeks later.

Figure 34 View of wet patch in the polymer treated section and after the section was remixed on the same day (Woodlands Road, Wombat).

As with sealed roads, adequate surface drains allow the water to find its way into the natural water course or into adjacent paddocks (see Figure 35). On roads with grades exceeding 3% or at the longitudinal sag, the table drains may require special attention as shown in Figure 36(a). Good unsealed road practices ensure that eroded material from the uphill side of the unstabilised road is not deposited onto the road at the sag as shown in Figure 36(b). Although the accumulation of this deposited material over the treated sections should not reduce its material strength, it may create dust problems from moving vehicles when dry.

[7] It is common practice for the OMC to be taken as the value of the untreated material.

Figure 35 View of typical table drains for unsealed roads.

(a) Sufficient outlets to table drains are required.	(b) Untreated pavement material being eroded and deposited on the road after rainfall.

Figure 36 View of table drains details to improve runoff control for unsealed roads.

5 CONSTRUCTION COSTS

All five trial sites were carried out using a part-service agreement between the specialist contractor and the Shire. There were four basic cost categories as follows:

- Supply of binder (ex factory)
- Haulage cost of the binder
- Establishment, supply of spreader and mixer and spreading and mixing operations
- Supply of grader, water carts, compaction equipment and local Shire staff

Lime and cementitious binders are widely available in Australia as shown in Figure 37. For this project the cost of the supply (excluding transportation) of the binders were:

- quicklime at $200 per tonne
- cement/slag at $220 per tonne
- polymer at $700 per tonne

When selecting a binder for use on unsealed roads, the transportation costs should be given consideration as recent increases in diesel costs will impact directly on the cost of supplying the binder to the site. The quicklime transport costs for this project was estimated $40 per tonne. The Polyroad cartage costs were charged at the nominal rate as the trial sites required less than 10 t of binder. It is suggested that the same cartage costs are used for Polyroad as per other binder types.

The polymer and lime blended binder for these trials was supplied by Polymix industries[8], located at Wodonga, Victoria. As there is only one supply outlet for this binder, with bulk tanker shipments only from Wodonga, haulage costs are much higher. In comparison, lime is available from a number of sources around Australia.

The spreading and mixing operations was estimated at \$0.75 to \$1.50/m^2. Whether the unsealed road is stabilised to 5 or 7 metres in width, there are three spreader and mixing runs across the pavement. Therefore, production capacity per day varies from 1 to 1.5 km depending on numerous factors, including:

- Daylight hours
- Traffic levels of the road and any restrictions
- Timing of the supply of the bulk tanker containing the binder
- Engine capacity and width of mixing rotor
- Number of water carts and the distance for the source of water from the site

For these trials the stabilisation contractor typically completed the spread and mixing in one day at a cost was \$1.50/m^2. Shires used their own local plant and labour to compact and trim the sites after mixing and it was estimated that the cost for this work was about \$1.00/m^2. The average cost of the quicklime for each site was \$2.40/m^2 for the typical application rate of 3%. Therefore, for these trials the construction cost was \$4.90/m^2.

Using the above costs estimates and the potential to gain efficiency in various ways, such as longer working hours in the summer months, the cost of the stabilisation of these unsealed roads was in the range of \$3.75 to \$6.50/m^2 when using a lime or cementitious binder[9]. An extra \$2.00/m^2 to \$2.50/m^2 is likely with a polymer binder and this will increase if the site is remote from the polymer binder supplier.

The above rates do not take into account the whole of life cycle costs related to the future savings this treatment has to offer in minimising regular grading operations typical of unsealed roads. In addition, this study it is expected to show that this treatment will provide all weather access to communities that is not normally included in whole of life cost comparisons between pavement options for new of existing roads, but will be of great benefit to the communities. A report is currently being prepared outlining the whole of life costs of this treatment compared to resheeting and grading treatments used for unsealed roads.

6 RECOMMENDATIONS

The construction work provided an opportunity to

- review the interim model specifications,
- compare the laboratory mix design results against the samples taken from the field during construction,
- look at immediate treatment solutions that might arise during construction, such as wet spots

The following recommendations are available to Shire engineers, consultants and contractors to assist in further improvements to the road construction process:

A. A minimum stabilisation width of 6 m
B. When wet spots develop during construction with the use of the polymer binder, it was found that the area be remixed with a single pass and then compact.

[8] Polyroad is an Australian designed and manufactured polymer binder from Polymix Industries.
[9] For an unsealed road stabilised to 6 m width, the cost per kilometre is \$22,500 to \$39,000.

C. Minimise the amount of unstabilised material being graded from the shoulder back into the pavement after primary compaction has been completed.
D. Maintain 4% camber to ensure sufficient surface drainage.
E. Utilise two water carts if the water supply is close by and consider a third water cart if the water supply source is at a sufficient distance from the work site that will interrupt the mixing operations.

7 CONCLUSIONS

This report has presented details of the construction of five trial unsealed roads sites between May to August 2008. The trial sites were located in four different shires in South West NSW:

- Barber Road, Griffith
- Woodlands Road, Wombat
- Old Corowa Road, Jerilderie
- Four Corners Road, Jerilderie
- Back Mimosa Road, Temora

The binders used to stabilise the unsealed roads to a depth of 150 mm included:

- Quicklime
- Cement and slag blend
- Polymix and hydrated lime blend

Four specifications were developed for the trials which allowed the Shires to use specialist contractors to support their own staff and supply equipment, or employ full service providers.

All the trials were successfully constructed with the exception of the polymer treated section on Old Corowa Road which became slippery after rainfall just after construction.

The cost of the trials was \$4.90/m^2 and it is estimated that the stabilisation of the unsealed roads was in the range of \$22,500 to \$39,000 per km for a 5 to 6 m wide stabilised section.

REFERENCES

Austroads (2006) *Guide to Pavement Technology Part 4(d): Stabilised Materials* Austroads Project No: TP1089, Sydney, NSW.

AustStab (2008) *Lime Stabilisation Practice* AustStab Technical Guideline, Australian Stabilisation Industry Association, Chatswood, NSW.

Appendix A Model Specification for Insitu Stabilisation of Unsealed Low Volume Roads using Lime or Cementitious Binders

1 General

The purpose of this specification is for the rehabilitation of unsealed roads by insitu stabilisation with a insoluble dry powdered synthetic polymer (IDPSP) binder with or without the addition of a resheet for shape correction of increasing the depth of stabilised material. Incorporation of the binder shall be accomplished using a purpose built calibrated spreader for binder spreading and mixing with a purpose built stabiliser.

This specification shall be used with a schedule of rates.

The Council shall carry out detailed inspection of the site for services and culverts and be responsible for all service alterations that are necessary before stabilisation commences.

2 Description

The stabilised pavement shall be composed of a combination of subgrade and pavement material and binder uniformly mixed in accordance with this Specification, or as directed by the Engineer.

Stabilisation shall be undertaken by using the equipment described in this specification and using a minimum of two mixing operations to ensure uniformity of the binder in the pavement material.

3 Materials

3.1 Binder

The binder shall be an insoluble dry powdered synthetic polymer with or without hydrated lime supplied in accordance with this specification.

The IDPSP shall be supplied to the manufacturer's specification with third party quality assurance certification. Hydrate lime when used as a blend with the polymer shall comply with AS1672.11 and have a minimum Available Lime Index of 85%.

When required by the Engineer, the Contractor shall furnish documentary or other acceptable evidence of the quality and date of manufacture of the binder, and any binder that is not satisfactory shall be rejected**.**

3.2 Water

The Council shall supply the water, including water tanker, used for the work.

3.3 Granular Materials

[*Delete if not applicable*]
If additional granular pavement material is required to improve the existing pavement material or correct pavement levels, this material shall be supplied by the Council and spread by the Contractor to the specified levels.

[*Delete if not applicable*]
If additional granular pavement material is required to improve the existing pavement material or to correct pavement levels, this material shall be supplied and spread by the contractor to the specified levels.

4 Lowering of Services

Council shall lower all services and utilities as necessary.

5 Spreading of Binder

The binder shall be uniformly spread at a controlled mass by area rate (kg/m^2) across the pavement. The rate of spreading shall be such as to provide the specified binder content in the compacted material. The spreader shall be equipped with gates to allow variable widths of binders to be deposited onto the pavement surface.

The contractor shall record the area of spread, tonnage of binder used per run, and mat or tray results at regular [at least daily] intervals, and keep these records as recommended in the Quality Manual. The construction tolerance for the spread rate is ±10% of the specified value.

Once the binder has been spread, the only traffic that may travel over the area to be stabilised, shall be construction plant employed for the stabilisation work.

Binder shall not be spread when the wind speed exceeds 25 km/hr, if rain is imminent or the binder may be subject to run off due to water flows. All binder spread shall be incorporated into the pavement on the same day as it is spread.

6 Mixing

The total specified quantity of binder required for the full depth of the treatment shall be uniformly spread over the surface to be treated prior to the mixing process, or incorporated in the pavement by an approved controlled mechanical feed in one operation in a manner satisfactory to the Engineer. No equipment except that used in spreading and mixing will be allowed to pass over the freshly spread binder until mixing operations are complete.

Water shall be added during the mixing process by means of a controlled pressure feed distributor located inside the mixing chamber. The moisture content shall be uniformly distributed through the pavement material.

The mixing equipment shall be so operated that the mixed depth of stabilised pavement shall be to the full-specified depth. Mixing using graders, profilers, rotary hoes and other agricultural type implements shall not be approved for stabilisation work.

Mixing shall proceed in lanes working from one side of the pavement to the other, without intervening lanes of unmixed material.

7 Moisture Content

The moisture content of the material immediately after mixing shall be 80% to 110% of the moisture content specified by the Engineer and not greater than the optimum moisture content.

8 Compaction

The compaction achieved, as determined by tests of the insitu material, shall not be less than 98% standard of the maximum dry density.

9 Not used

10 Curing

The Council shall carry out the necessary curing works.

11 Provision for Traffic

[*Delete not applicable paragraph*]
The work shall be carried out in such a manner that the road is open to traffic at all times, and so that there is a minimum of interference to the passage of traffic by the Contractor's plant and equipment. All traffic management shall be carried out in accordance with AS1742 and the State Road Authority Code of Practice.

[*OR*]
The contractor shall be permitted to carry out a full road closure during the work.

The work shall be executed so that each section is completed to the full width at the end of the day’s works.

The provision of traffic management shall be the responsibility of the [*Delete to show correct situation*] Council/Contractor. All traffic management shall be carried out in accordance with AS1742 and the State Road Authority Code of Practice

12 Sampling and Testing

12.1 Spread rate

The spread rate shall be verified as per AustStab National Guideline *Verification of binder spread rate* once in every lot or as directed by the engineer.

12.2 Depth

The depth of stabilisation shall be verified by measuring the depth of "cutting" adjacent to an existing pavement material in at least two locations within the lot and measured to the nearest 5 mm. The construction tolerance for the stabilised and compacted depth is ±20 mm.

12.3 Density

The density of stabilisation shall be verified by testing in at least two locations within each lot in accordance with AS1289 Method 5.4.1 and Method 5.3.1 or by Nuclear Density Gauge in direct transmission mode to AS 1289.5.8.1.

13 Acceptance/Rejection Criteria

Where the binder addition, compaction, shape or stabilised depth does not meet the specified requirements, the Engineer and Contractor shall resolve the disposition by negotiation. Such disposition may include acceptance as is, acceptance with conditions, or rework of the affected area.

Schedule of Rates

The following schedule rates are to be completed by the Contractor and the rates are exclusive of GST.

Item	Description of work	Quantity	Unit	Unit Rate $
1	Site establishment		Per visit	
2	Supply of binder		m^2	
3	Spreading and mixing operations		m^2	
4	Minimum day rate (provisional)		Per day	

Appendix B Model Specification for Insitu Stabilisation of Unsealed Low Volume Roads using Insoluble Dry Powdered Synthetic Polymer Binders

1 General

The purpose of this specification is for the rehabilitation of unsealed roads by insitu stabilisation with a insoluble dry powdered synthetic polymer (IDPSP) binder with or without the addition of a resheet for shape correction of increasing the depth of stabilised material. Incorporation of the binder shall be accomplished using a purpose built calibrated spreader for binder spreading and mixing with a purpose built stabiliser.

This specification shall be used with a schedule of rates.

The Council shall carry out detailed inspection of the site for services and culverts and be responsible for all service alterations that are necessary before stabilisation commences.

2 Description

The stabilised pavement shall be composed of a combination of subgrade and pavement material and binder uniformly mixed in accordance with this Specification, or as directed by the Engineer.

Stabilisation shall be undertaken by using the equipment described in this specification and using a minimum of two mixing operations to ensure uniformity of the binder in the pavement material.

3 Materials

3.1 Binder

The binder shall be an insoluble dry powdered synthetic polymer with or without hydrated lime supplied in accordance with this specification.

The IDPSP shall be supplied to the manufacturer's specification with third party quality assurance certification. Hydrate lime when used as a blend with the polymer shall comply with AS1672.11 and have a minimum Available Lime Index of 85%.

When required by the Engineer, the Contractor shall furnish documentary or other acceptable evidence of the quality and date of manufacture of the binder, and any binder that is not satisfactory shall be rejected.

3.2 Water

The Council shall supply the water, including water tanker, used for the work.

3.3 Granular Materials

[*Delete if not applicable*]
If additional granular pavement material is required to improve the existing pavement material or correct pavement levels, this material shall be supplied by the Council and spread by the Contractor to the specified levels.

[*Delete if not applicable*]
If additional granular pavement material is required to improve the existing pavement material or to correct pavement levels, this material shall be supplied and spread by the contractor to the specified levels.

4 Lowering of Services

Council shall lower all services and utilities as necessary.

5 Spreading of Binder

The binder shall be uniformly spread at a controlled mass by area rate (kg/m^2) across the pavement. The rate of spreading shall be such as to provide the specified binder content in the compacted material. The spreader shall be equipped with gates to allow variable widths of binders to be deposited onto the pavement surface.

The contractor shall record the area of spread, tonnage of binder used per run, and mat or tray results at regular [at least daily] intervals, and keep these records as recommended in the Quality Manual. The construction tolerance for the spread rate is ±10% of the specified value.

Once the binder has been spread, the only traffic that may travel over the area to be stabilised, shall be construction plant employed for the stabilisation work.

Binder shall not be spread when the wind speed exceeds 25 km/hr, if rain is imminent or the binder may be subject to run off due to water flows. All binder spread shall be incorporated into the pavement on the same day as it is spread.

6 Mixing

The total specified quantity of binder required for the full depth of the treatment shall be uniformly spread over the surface to be treated prior to the mixing process, or incorporated in the pavement by an approved controlled mechanical feed in one operation in a manner satisfactory to the Engineer. No equipment except that used in spreading and mixing will be allowed to pass over the freshly spread binder until mixing operations are complete.

Water shall be added during the mixing process by means of a controlled pressure feed distributor located inside the mixing chamber. The moisture content shall be uniformly distributed through the pavement material.

The mixing equipment shall be so operated that the mixed depth of stabilised pavement shall be to the full-specified depth. Mixing using graders, profilers, rotary hoes and other agricultural type implements shall not be approved for stabilisation work.

A minimum of two mixing passes is required to obtain uniform mixing.

Mixing shall proceed in lanes working from one side of the pavement to the other, without intervening lanes of unmixed material.

7 Moisture Content

The moisture content of the material immediately after mixing shall be 80% to 110% of the moisture content specified by the Engineer and not greater than the optimum moisture content.

8 Compaction

The compaction achieved, as determined by tests of the insitu material, shall not be less than 98% standard of the maximum dry density.

9 Not used

10 Curing

The Council shall carry out the necessary curing works.

11 Provision for Traffic

[*Delete not applicable paragraph*]

The work shall be carried out in such a manner that the road is open to traffic at all times, and so that there is a minimum of interference to the passage of traffic by the Contractor's plant and equipment. All traffic management shall be carried out in accordance with AS1742 and the State Road Authority Code of Practice.

[*OR*]
The contractor shall be permitted to carry out a full road closure during the work.

The work shall be executed so that each section is completed to the full width at the end of the day's works.

The provision of traffic management shall be the responsibility of the [*Delete to show correct situation*] Council/Contractor. All traffic management shall be carried out in accordance with AS1742 and the State Road Authority Code of Practice

12 Sampling and Testing

12.1 Spread rate

The spread rate shall be verified as per AustStab National Guideline *Verification of binder spread rate* once in every lot or as directed by the engineer.

12.2 Depth

The depth of stabilisation shall be verified by measuring the depth of "cutting" adjacent to an existing pavement material in at least two locations within the lot and measured to the nearest 5 mm. The construction tolerance for the stabilised and compacted depth is ±20 mm.

12.3 Density

The density of stabilisation shall be verified by testing in at least two locations within each lot in accordance with AS1289 Method 5.4.1 and Method 5.3.1 or by Nuclear Density Gauge in direct transmission mode to AS 1289.5.8.1.

13 Acceptance/Rejection Criteria

Where the binder addition, compaction, shape or stabilised depth does not meet the specified requirements, the Engineer and Contractor shall resolve the disposition by negotiation. Such disposition may include acceptance as is, acceptance with conditions, or rework of the affected area.

Schedule of Rates

The following schedule rates are to be completed by the Contractor and the rates are exclusive of GST.

Item	**Description of work**	**Quantity**	**Unit**	**Unit Rate $**
1	Site establishment		Per visit	
2	Supply of binder		m^2	
3	Spreading and mixing operations		m^2	
4	Minimum day rate (provisional)		Per day	

Appendix C Construction test results

C1 Tests

The post-construction testing was carried out by staff from Aitken Rowe Testing Laboratories at Griffith and Wagga Wagga laboratories. All testing was carried at the control sections listed in Sections 4.x to 4.x of this report from samples collected behind the stabiliser. The insitu CBR was determined from DCP readings taken at the base of the mixing run as shown in Figure C1.

Figure C1 DCP testing at the top of the formation prior to compacting the loose stabilised material. A GPS reading was also taken at the location to allow future reference of the test location.

All loose material collected was bagged to maintain the insitu moisture content and with the exception of the Temora project, the loose material was taken back to the laboratory for immediate remoulding and curing. At the Temora site a field laboratory was setup at about 5km from the site.

In this Appendix, the following test results are provided at each site[10]:

- Maximum dry density (MDD) at standard compaction
- Optimum Moisture Content (OMC) at standard compaction
- Field Moisture Content (FMC)
- Relative Compaction (RC) – compliance set at 98% using standard compaction.

Samples were also taken from behind the stabiliser and remoulded and cured for 28-days and longer to compare the UCS laboratory mixes with the material stabilised on site. In some cases a capillary rise test was conducted on remoulded samples of the polymer stabilised sections. These capillary rise and UCS test results are detailed in the performance study report.

C2 Barber Rd, Griffith

The site construction data for Barber and McNamara Roads is detailed in Table C1 with the average MDD of 2.2 t/m^3 and the difference between the FMC and OMC was in the range of 2 to 4%. At the time of construction the insitu CBR at the underside of mixing was greater than 52%.

The compaction of the stabilised material was under direct supervision by the Shire and the relative compaction was in the range of 95 and 101.5%. The low readings at Sites C and D could have been the results of this work being late in the day and the subsequent reduction in compaction effort.

[10] No post construction testing was carried out at Four Corners Road, Jerilderie.

Table C1 The density and CBR results at construction at the Barber and McNamara Roads, Griffith.

Section	Binder	MDD (t/m^3)	OMC (%)	FMC (%)	RC (%)	Insitu CBR (%)
A	Quicklime	2.27	8.0	5.5	101.5	52
B	Quicklime	2.19	10.5	8.0	99.0	55
C	Quicklime	2.12	10.0	6.0	95.0	55
D	Quicklime	2.27	8.0	6.0	95.5	77

C3 Woodlands Rd, Wombat

The site construction data for Woodlands Road is detailed in Table C2 with the average MDD of 2.2 t/m^3 and the difference between the FMC and OMC was in the range of 1.7 to 2.9%. At the time of construction the insitu CBR at the underside of mixing was greater than 45%.

The compaction of the stabilised material was under direct supervision by the Shire and the relative compaction was in the range of 97.5 and 101.0%.

Table C2 The density and CBR results at construction at the Woodlands Road, Wombat site.

Section	Binder	MDD (t/m^3)	OMC (%)	FMC (%)	RC (%)	Insitu CBR (%)
A	Cement/Slag	2.21	6.5	3.6	99.5	55
B	Cement/Slag	2.27	7.9	6.2	97.5	55
C	Cement/Slag	2.19	7.5	5.5	99.5	45
D	Cement/Slag	2.23	8.2	6.3	98.5	54
E	Polymer	2.14	12.4	9.5	101.0	55

C4 Old Corowa Rd, Jerilderie

The site construction data for Old Corowa Road is detailed in Table C3 with the average MDD of 2.05 t/m^3 and the difference between the FMC and OMC was in the range of 1 to 4.5%. At the time of construction the insitu CBR at the underside of mixing was greater than 29%.

The compaction of the stabilised material was under direct supervision by the Shire and the relative compaction was in the range of 89 and 95.5%. The low readings at this site could have been the result of insufficient moisture for compaction and delays in spreading operations reducing the time for sufficient compaction by the smooth drum roller.

Table C3 The density and CBR results at construction at the Old Corowa Road, Jerilderie site.

Section	Binder	MDD (t/m^3)	OMC (%)	FMC (%)	RC (%)	Insitu CBR (%)
A	Quicklime	2.01	14.5	13.5	95.0	-
B	Quicklime	2.02	11.5	8.0	95.5	-
C	Quicklime	2.11	11.0	6.5	93.5	61
D	Quicklime	2.06	13.0	9.5	89.0	31
E	Polymer	-	-	-	-	29

C5 Back Mimosa Rd, Temora

The site construction data for Back Mimosa Road is detailed in Table C4 with the average MDD of 2.09 t/m^3 and the difference between the FMC and OMC was in the range of 1 to 3.5%. At the time of construction the DCP cone could not penetrate the surface indicating that the insitu CBR at the underside of mixing was greater than 50%.

The compaction of the stabilised material was under direct supervision by the Shire and the relative compaction was in the range of 95.5 and 101%. The low readings at this site could have been the result of a combination of insufficient moisture for compaction and rolling pattern by the smooth drum roller.

Table C4 The density and CBR results at construction at the Back Mimosa Road, Temora site.

Section	Binder	MDD (t/m^3)	OMC (%)	FMC (%)	RC (%)	Insitu CBR (%)
A	Polymer	2.14	10.0	8.1	101.0	> 50
B	Quicklime	2.14	12.7	11.7	96.0	> 50
C	Quicklime	2.09	9.9	8.3	99.0	> 50
D	Quicklime	2.07	14.0	12.0	98.5	> 50
E	Quicklime	2.01	12.0	8.5	95.5	> 50

[END]