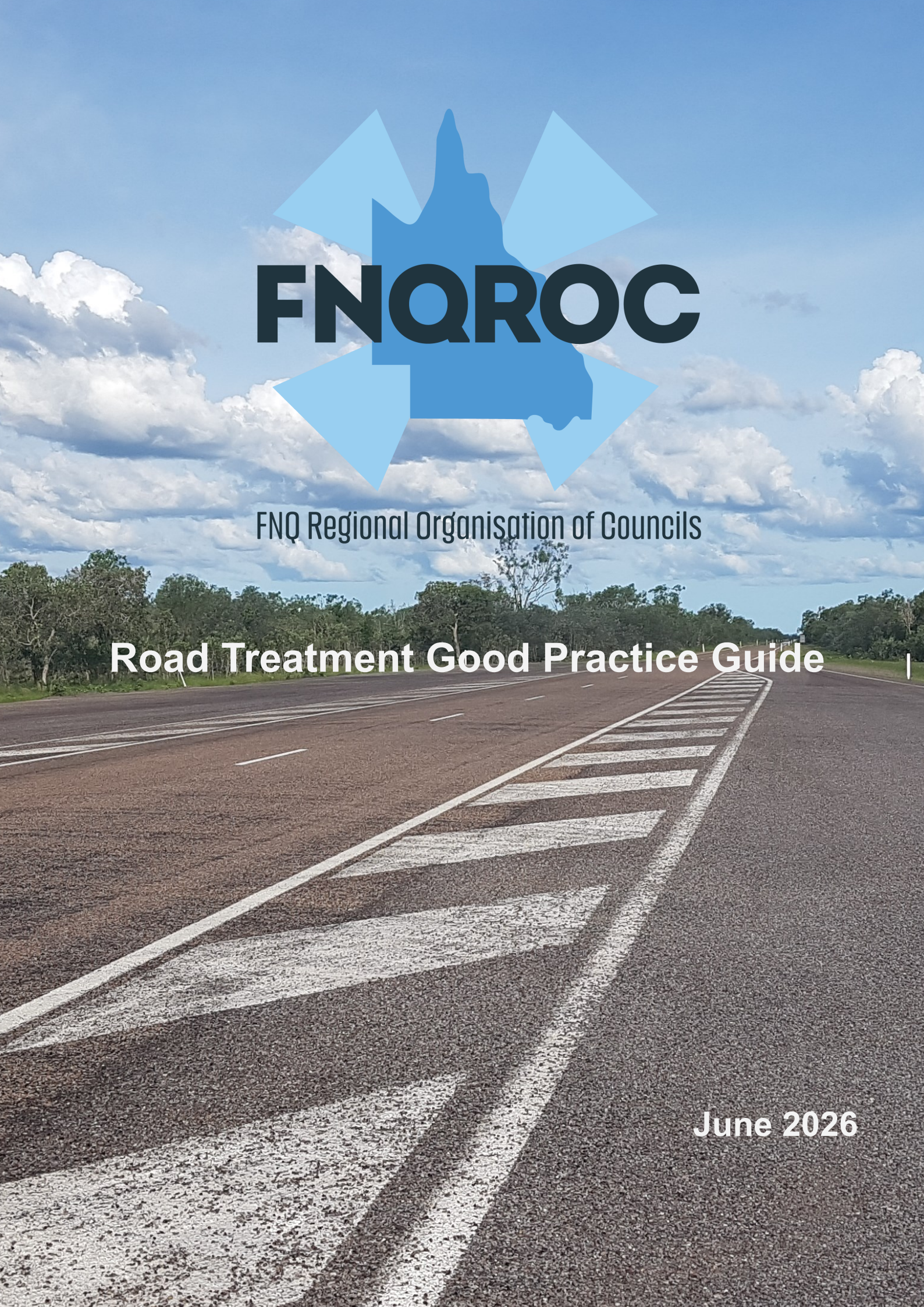


FNQROC

FNQ Regional Organisation of Councils

Road Treatment Good Practice Guide

June 2026

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Overview—Bitumen Seal & Asphalt Good Practice Guides

Overview - Bitumen Seal & Asphalt Good Practice Guides

FNQROC commissioned a Regional Road Surfacing's Study in May 2025.

The purpose of the study project is to develop a guideline / checklist to allow Councils within the FNQROC region to review the relevant factors and available surfacing options for a project and then select the most appropriate road surfacings option, based on a multi-layer assessment process. The process should rely on industry standards and design guidelines.

After consultation with FNQROC members in May and September 2025, the following Good Practice Guides (GPGs) have been developed to assist Councils in the selection of road surfacings:

01 – Initial Seal Choice
02 – Reseals & Asphalt Network Strategy
03 – Reseals & Asphalt - Network Programming and Proofing
04 – Reseal Type and Binder Choice
05 – Asphalt - Initial and resurfacing Choice
06 – Reseals - Comparison of Whole-of-Life Cost & Environmental Outcomes for various Binder Types

The GPGs provide a condensed version addressing the Purpose, Principles, Process, and Technical Details, with references to industry documents for further reading and consideration. The aim of the Guide is to assist Council staff in navigating the main issues for 90% of their general sealing and asphalt works. More complex circumstances, not addressed in the Guide, are likely to require further consideration of the relevant Austroads, QTMR and other industry documents, as referenced. For Council staff convenience, key tables and charts are re-produced within the Guide. Accordingly, the Guides will need to be reviewed and updated after any major re-issue of the industry documents. A check and update every 5 years is the minimum recommended.

Consultation with Councils also indicated that staff training in the theory, practical application of the theory, and on-the-ground training in processes, is required to be ongoing to ensure the workforce, which experiences regular staff turnover, is suitably equipped to undertake the job expected.

Section 1— Initial Seal Choice

FNQ Regional Organisation of Councils

Good Practice Guide - 01

Version 0.3
27/04/2026

New Construction - Selection of Initial seals

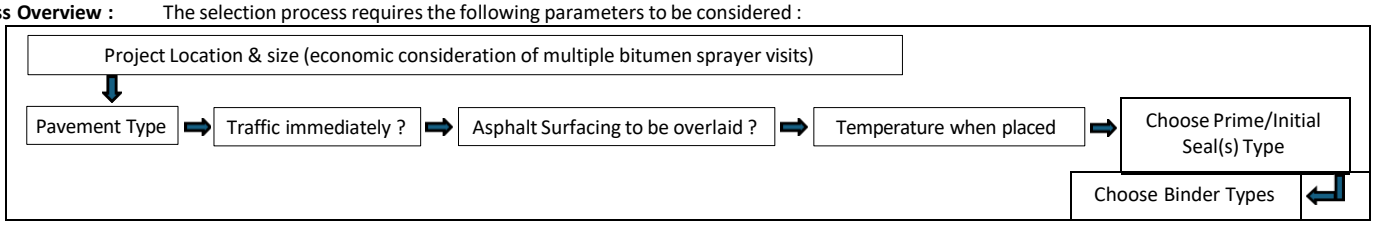
Purpose : The purpose of this document is to provide LGAs with summary notes on good practice in FNQ, outlining typical selection of Initial Seals on newly constructed pavements. References to key industry documents is provided.

Key References :

1 : AGPT04K-18 : Guide to Pavement Technology Part 4K : Selection and Design of Sprayed Seals — AGPT04K-18 | Austroads
2: AGPT04F-17 : Guide to Pavement Technology Part 4F : Bituminous Binders — AGPT04F-17 | Austroads
3 : MRTS11, QTMR Technical Specification, Sprayed Bituminous Treatments (Excluding emulsions)
4. MRTS 12, QTMR Technical Specification, Sprayed Bituminous Emulsion Surfacing
5. MRTS20, QTMR Technical Specification, Cutback Bitumen (Primes and Primer Seals)
Specifications (Department of Transport and Main Roads)

Principles : The purpose of the initial seal treatment is to ensure a strong bond between the new pavement base and the subsequent surfacing regime. It provides an essential water proofing protection of the underlying pavement and trafficable course that prevents deterioration of the pavement surface. The "initial seal treatment" actually refers to a 2 or 3 seal application process - rarely a 1 seal process can do the job. A seal provides all weather access, a surface texture that can provide skid resistance in all weather conditions, and provides the opportunity to place linemarking or pavement marking to improve safety for the driver. Some downsides might be noise and water spray characteristics in certain situations. Whilst an initial seal regime is always required on a gravel or cementitious modified gravel pavement. The most desired initial seal application includes a Prime, which achieves good bituminous penetration/adhesion into the base pavement material, followed by 2 seal coats, but this is not always possible due to traffic considerations. Hence the need to consider "Initial Seals" (previously called a Primerseal). *Ref 1 : Section 3.2.*
If traffic induces heavy braking and/or turning manoeuvres, a subsequent overlying asphalt surfacing should be considered.

Process Overview : The selection process requires the following parameters to be considered :



Key Technical Points :

The best initial sealing regime is a Prime (1st Coat) + 1 large aggregate seal (S/S) (2nd Coat) + 1 small stone aggregate (S/S) (3rd Coat). All other solutions are essentially a compromise to this integrity/structure, but may be necessary for various reasons. The prime penetrates into the base materials and provides great binding and adhesion for subsequent bitumen layers. Whilst penetration depth can vary depending on materials and base construction practices, typically a prime can penetrate an unbound base material between 5-10mm. *(Ref 1 : 3.2.1).* A **Prime is a hot high cut-back bitumen** and is very fluid, hence the penetration. Typically an AMC00 (100 parts bitumen to 100 parts Cutter (Kerosene)) is used. A Prime is considered to be cured when the surface is no longer tacky. Temperature will affect the curing period, but 1-3 days is typical for Hot-Cool weather respectively. The curing time is also affected by the 'absorption' characteristics of the base material. No traffic can use the primed surface in this time. After curing, light construction traffic only maybe able to use the primed surface, until first seal coat is applied. **Cold emulsion primes** (Proprietary products, not CRS 60) are available and are often utilised when pavement temperatures are very low, around 5°C, which is not a common problem in FNQ. On larger projects, it would be common to apply a prime coat once per week to cure/protect the completed pavement surface and minimise potential water ingress due to rain, until a sufficient length of road is ready for trafficking and the 2nd coat S/S applied. **Post the prime coat**, a large aggregate (14, 16, or 20mm) **Single/Single** spray seal is then applied and traffic allowed to use immediately. After 6-12 months the performance can be assessed (best having been through one summer season) and then a second coat smaller seal be designed and placed accordingly. An **alternative** to two seal visits is the single visit **Double/Double** (D/D) Seal (eg 14/7; 16/10; 20/10) which achieves a similar outcome but with a higher risk potential of bleeding/flushing if a spray rate design error, poor work practices or unexpected high traffic volumes are encountered *(Ref 1 : 3.2.2)* . This compromised inital seal regime, mainly for cost reduction purposes, appears quite common in FNQ. Continued performance monitoring shoudl be employed to ensure the seal intergity and performance is achieved.

In high speed rural highway solutions with medium to high traffic volumes, large aggregate sizes have windscreen damage potential, especially if good spread rates, rolling and brooming practice are not achieved. Accordingly, a D/D seal is useful in controlling windscreen damage issues. In residential environments where

If the seal is required to be trafficked immediately a hot cut-back initial seal (previously called a primerseal) is often chosen. Whilst this is a compromise in the desired structure integrity from that outlined above, it is a reasonable compromise due to traffic considerations. The aggregate size for a hot cut-back initial seal should be limited to a 7mm or 10mm (Ref 1 : 4.8.2). Hot Cut-Back initial seals require a long curing period to allow the volatiles (cutter/kerosene) to evaporate/escape out of the bitumen over time. This is dependent on the amount of cutter in the initial seal (type), hot weather and traffic conditions, with the curing period varying from 3-6 months. In very hot conditions where the pavement temperature is consistently above 40oC, a low cutter content initial seal such as an AMC7 (3% cutter) with small aggregate 7mm, a 1 month curing period is often sufficient. If a suitable curing period is not allowed, the bitumen remains soft and is prone to bleeding/flushing issues. (Ref 1 : 3.2.2, Ref 2 : 11.4). An alternative to a hot cut-back bitumen that also allows immediate trafficking is a 'cold' emulsion initial seal utilising a CRS60 or CRS67. This emulsion seal type can be covered by subsequent seal layers after a 3 day minimum period, thus providing a quicker completion than the hot cut-back bitumen period of 3-6 months.

Process :			Choice of Initial Seal Treatments		
			Pavement Type		
Number	Item Description		Unbound Gravel Non-Standard (Type 4 or local source); Material high in clay fines, with 'fatty' finished surface - very little penetration of prime able to be achieved	Unbound Gravel QTMR Standard (Type 2 or 3 with 'C' Grading); A well graded gravel that after brooming produces exposed large particles surrounded tightly by smaller particles and fines. *Ref 2: 2.10.1.2*	Cementitious Treated Gravel (Lightly Bound)
1	**Project Size/ # of Seal Visits**		In an ideal world 3 seal visits, Prime, 1st S/S seal, 2nd S/S seal would be implemented. However, for remotely located or very small project with no other works in the vicinity, 2 seal visits would typically be the minimum required. Visit 1 : either Prime or cut-back initial seal (7 or 10mm) or emulsion initial seal (7mm) Visit 2 : D/D 20/10; 16/10[8]; 14/7 ; 10/7; Avoid a one visit seal solution for an initial seal. However, if absolutely required, a Double/Double C170 (max 2% cutter on first coat) seal may be a fair compromise in very remote, low traffic environments. The compromise is successful bonding. A 2nd visit should be programmed for an early reseal within 3-5 years.		
2	**Traffic Immediately**	**Yes**	Initial Seal	Initial Seal	Initial Seal
		No	Prime (lower spray rates)[1] or Initial Seal	Prime	Prime (lighter than unbound spray rates)[1]
3	**An Asphalt Surfacing is to be placed over the initial seal regime.**		A prime or initial seal is still required		
4	**Min Pavement Temperature at placement[2]**	**10°C**	Prime (hot or cold) or Emulsion Initial Seal[6]		
		15°C	Prime (hot or cold) **or** AMC4 - AMC6 Initial Seal[3] **or** (cold) Emulsion Initial Seal[6]		
		20°C	Prime (hot or cold) **or** AMC4 to AMC7 Initial Seal[3] **or** (cold) Emulsion Initial Seal[6]		
5	**Seal Type**	**1st Coat**	Prime (hot or cold) or Initial Seal as per above requirements and referenced documents		
		2nd Coat	Use Austroads Table 4.7 (Ref 1, attached) to Choose a suitable Seal Type for the design circumstances		
		3rd Coat			
6	**Binder Type**	**1st Coat**	Prime AMC00 (hot) or Proprietary Emulsion Prime (cold); or Initial Seal (hot cut-back bitumen or cold emulsion seal) choice is provided in Table 4.6 of Part 4K *(Ref 1)* ; Note (i) : the decreasing cutter content in Hot Seasons. Note (ii) : Although Austroads Table 4.6 (Ref 1, attached) allows PMB initial seal for certain traffic/weather conditions. A PMB initial seal is not recommended due to potential poor adhesion when directly applied on pavement surface.		
		2nd Coat	Use Austroads Table 4.7 (Ref 1, attached) to Choose a suitable Binder Type for the design circumstances; Note : 20°C min pav temp for C170 & Crumbed Rubber and 25°C min pav temp for PMBs; Note : min cutter requirements vs pav temperature. If you are anticipating cracking/movement of the pavement (for example cementitious pavements have a higher risk of cracking) choose an appropriate PMB Binder.		
		3rd Coat			

Notes

1. Prime Spray Rates : Refer Table 5.4 AGPT04K-18 (provided below)
2. It can be difficult to predict the time / temperature and therefore the type of prime/initial seal at the time of design. Some flexibility ion the design documents and schedules might be required to ensure the correct treatment.
3. Cutback Bitumen Types *(Ref 4: Table 6.6) : Prime* AMC00 100 bit : 127 cut; Initial-Seals AMC4 100 bit : 18cut; AMC5 100 bit : 12 cut; AMC6 : 100 bit : 7 cut; AMC7 100 bit : 3 cut
4. Pavement Temperatures requires additional cutter to be added to bitumens for spraying purposes - Ref 2 : Cl 12.7 Cutting requirements.
5. Suitable Prime grade is AMC00 for most projects. A slightly thicker Prime AMC0 (100 : 87) is also available.
6. Avoid emulsion initial seals if rain is anticipated within 1-3 days from spraying. Emulsion may further emulsify in the event of heavy rain and cause bitumen and aggregate retention issues
7. Consider specifying and spraying additional binder in Coats 2 & 3 for untrafficked areas (shoulders etc). Up to an additional 0.5L/m2 is often required. This can be pre-sprayed outside of wheelpaths prior to the final full width application as per seal design.

8. Aggregate Size *(Ref 1 : 4.5.2)* : for D/D seals, the ALD of the second smaller aggregate should be approximately half (0.5) the ALD of the first larger aggregate ALD. Typical D/D seals include 10/5, 10/7, 14/5, 14/7, 16/7, 16/10, 20/7, 20/10.
Experience, not listed in Austroads documents, suggests that with well controlled aggregate spread rates and windows, good rolling , and good supervision, a maximum ALD ratio of small/large aggregate of 0.65 can work, such as 10/7 in residential areas; 14/10 or 16/10 in rural areas. Both aggregates must have Flakiness results between 15 - 25. Local and Industry expert assessment and supervision is required.

FNQ Typical Initial Seal Treatment Examples:

	Conditions		Seal & Binder Type					
	Immediate Traffic	Temperature	Initial Seal	Min Wait period to 2nd Coat	Max period to 2nd Coat	2nd Coat	3rd Coat	Comments
1	No	All	AMC00 Prime	1-3 days	1-2 mths[1]	14mm SS C170	7or10mm SS C170	3rd Coat placed 6 - 12 months after 2nd Coat
2	No	All	AMC00 Prime	1-3 days	1-2 mths[1]	14/7 DD C170		
3	Yes	Warm-Hot	7mm AMC7	1-2 mths	3-6 mths[2]	14/7 DD C170		7mm AMC7 suitable for AADT < 2000 ; also see General Notes
4	Yes	Warm-Hot	10mm AMC7	3 mths	6 mths	14/7 DD C170		
5	Yes	All	7 or 10mm Emulsion Seal [3]	3 days	3-6 mths[2]	14/7 DD C170		7mm CRS60 emulsion, 10mm CRS67 emulsion; CRS67 'runs less' in hot climates where higher spray rates are required

Notes :

1. Maximum period is dependent on weather conditions, monitor surface. Only low use by light construction vehicles allowed after cured (not tacky).
2. Dependent on traffic volumes and HV%, AADT 1000 - 2000 typically 3 months, lower AADTs upto 6 months. Consider rainfall risk
3. Tight control and monitoring on 7mm CRS60 in hot temps and high traffic, aim to cover with D/D C170 seal in 3-7 days

General Notes :

A. Heavy Vehicles can cause issues on 7mm initial seals - careful consideration required, use 10mm in lieu
B. Steep Grades, Tight Curves, Intersection areas, High HV% or Road Train route etc are likely to use a PMB in Seal Coats 2 & 3, refer Table 4.7 (Ref 1, attached)
C. With the exception of Primes, all seals are to be Trafficked immediately after application

Austroads Tables - as referenced

5.5.3 Initial Treatments — **Ref 1**

Primes

There is no formal design method for the selection and design for priming which is usually based on experience with the local pavement materials and prevailing weather conditions. A general guide to the selection of the grade of cutback bitumen primer and primer application rates is shown in Table 5.4.

Table 5.4: Guide to grades and application rates of primer

Pavement types	Grade (AS 2157)	Primer application rate (L/m²)
Tightly bonded	AMC 00	0.6 to 1.1
Medium porosity	AMC 0	0.8 to 1.1
Porous	AMC 1	0.9 to 1.3
Very porous (limestone and sandstone)	AMC 1	2 application rates: 1st @ 0.7 to 0.9 2nd @ 0.5 to 0.7
Hill gravels, granitic sands	AMC 0	0.8 to 1.1
Stabilised	AMC 00(1)	0.5 to 0.8
Concrete	AMC 00(1)	0.2 to 0.4

1 Can also consider using proprietary materials, or additional cutter in these cases.

The most suitable grade and application rate of primer will depend on the surface finish of the basecourse. Small-scale trials can be conducted on pavement materials in situ to test and compare the appropriateness of the prime grade and application rate.

Standard grades of bitumen emulsion are not suitable for priming but proprietary grades have been developed that should be used in accordance with manufacturer's guidelines.

Where a pavement stabilised with cementitious or chemical binders is to be primed with a bitumen emulsion, a check on the compatibility of the emulsion with the stabilised material should be undertaken. Emulsions will always be compatible with bitumen stabilised pavements.

Guide to Pavement Technology Part 4K: Selection and Design of Sprayed Seals

Ref 1

Table 4.6: Preliminary guide to the selection of initial seals

EHV(%)	Average seasonal temperature	Low traffic (<-200 v/l/d)[3]	Medium traffic (200–2000 v/l/d)[3]	High traffic (> 2000 v/l/d)
		Typical binder[5] and seal type		
Low (< 25%)	Cool[4]	AMC4 (S/S) CRS67 (S/S) CRS60 (D/D)	AMC5 (S/S) CRS67 (D/D)	AMC6 (S/S, D/D) CRS67 (D/D) Modified emulsion (D/D)
	Warm	AMC5 (S/S) CRS67 (S/S)	AMC6 (S/S) CRS67 (D/D)	AMC7 (S/S, D/D) CRS67 (D/D) Modified Emulsion (D/D) PMB[1][2] (S/S, D/D)
	Hot	AMC6 (S/S)	AMC7 (S/S)	AMC7 (S/S) PMB[1][2] (S/S, D/D)
High (≥ 25%)	Cool[4]	AMC5 (S/S) CRS67 (S/S, D/D)	AMC6 (S/S) PMB[1][2] (S/S, D/D) CRS67 (D/D)	CRS67 (D/D) Modified emulsion (D/D)
	Warm	AMC6 (S/S) CRS67 (S/S)	AMC7 (S/S) PMB[1][2] (S/S, D/D) Modified Emulsion (D/D)	AMC7 (S/S) PMB[1][2] (D/D) Modified emulsion (D/D)
	Hot	AMC7 (S/S)	AMC7 (S/S) PMB[1][2] (S/S, D/D)	AMC7 (S/S) PMB[1][2] (D/D)

1 *Guidance to field application of PMBs for sprayed seals (including cutting practice) is provided in Appendix E.*

2 *Care must be taken when using PMBs (especially SBS) because it is difficult to achieve sufficient adhesion to the base and aggregate wetting. To date successful trials have been undertaken only with crumb rubber binders (Austroads 2014a), and as yet other binders are unproven in this application, pending further trials.*

3 *When low or medium traffic is coupled with high-stress situations such as intersections, turning lanes, and grades, consider following guidance for the 'high traffic' category instead.*

4 *As sealing in cool and damp conditions increases the risk of seal failure, consideration should be given to postponing works if possible until weather conditions have improved.*

5 *Cutback bitumen grades nominated in the table are based on typical pavement materials used in Australia. Adjustment to the proportion of cutter oil content may be required for very porous (less cutter oil) or tightly bonded (more cutter oil) pavement surfaces. For tightly bonded surfaces (including stabilised pavements), pavement surface preparation is essential to achieving an adequate bond, particularly when emulsions, low cutter content cutback bitumen and PMB grades are used.*

5.1.2 Cutback Bitumen

Ref 2

Cutback bitumen may be supplied as a standard grade in accordance with AS 2157 *Cutback Bitumen*, as a proprietary product or field produced. Standard grades of cutback bitumen and their specified viscosity at 60 °C ranges, indicative cutter oil contents, typical application temperatures and use are shown in Table 5.1.

Table 5.1: Standard grades of cutback bitumen

Grade designation	Viscosity at 60 °C (Pa.s)	Indicative content of cutter oil (% volume)[1]	Typical application temperature (°C)	Typical application[2]		
				Priming	Initial seal and cold mix	Secondary seal (or reseal)
AMC7	43.0–86.0	4	150–175		✓	✓
AMC6	13.0–26.0	8	135–160		✓	✓
AMC5	5.5–11.0	12	120–150		✓	✓
AMC4	2.0–4.0	21	110–135		✓	
AMC3	0.55–1.1	27	95–115		✓	
AMC2	0.22–0.44	34	75–100		✓	
AMC1	0.06–0.12	42	60–80	✓		
AMC0	0.025–0.05	50	35–55	✓		
AMC00	0.008–0.016	60	10–30	✓		

1 *Cutter oil contents are given in '% volume of the total binder'; e.g. adding 8 litres of cutter oil at 15 °C to 92 litres of bitumen at 15 °C provides 100 litres of 8% volume cutback bitumen.*

2 *Typical applications as marked in the table are broadly in accordance with current practice. These may be different from the traditional applications as categorised in AS 2157.*

Cutback binders can also be produced in the field. These are produced by blending appropriate amounts of bitumen and cutter oil to suit the particular conditions.

Ref 1

Table 4.7: Preliminary guide to seal selection

	Design traffic (v/l/d)	≤ 200				201–750				751–2000				2001–5000				> 5000			
	Equivalent heavy vehicles (%)	< 15	15–26	26–45	> 45	< 15	15–26	26–45	> 45	< 15	15–26	26–45	> 45	< 15	15–26	26–45	> 45	< 15	15–26	26–45	> 45
Rural: roads, highways and freeways – no high stress areas	Temperature* – High	S/S			D/D HSS1	S/S			D/D HSS1			HSS2				XSS					XSS^
	Medium	S/S			D/D HSS1	S/S			D/D HSS1	S/S	D/D HSS1			HSS2			XSS				
	Low	S/S										D/D HSS1		HSS2							XSS
High stress locations	Small radius curves, roundabouts, driveways, turning lanes, intersections	D/D			HSS2	D/D			HSS2	XSS	HSS2			XSS		NO SEAL SUITABLE^					
	Grades# > 5%	S/S	D/D HSS1							HSS2				XSS				XSS^			
	Cracked pavements	• SAM – preferred SAM is an S/S (14 or 10 mm) but a D/D may be required where there are also high-stress conditions. Slow rate of movement cracking – environmental (S10E, S15E, S35E, S45R, S15RF). Rapid rate of movement – traffic induced (S15E, S20E, S45R, S15RF). • Minimum binder rate for SAM application is 1.5 L/m^2. • GRS – C170 with D/D is the preferred type of GRS (14/7 mm).																			

S/S	Single/single with C170 or C240. C320 or M500 binder may be appropriate for hot climates.
D/D	Double/double with C170 or C240. C320 or M500 binder may be appropriate for hot climates.
HSS1	Single/single seal with PMB for moderately severe sites (S10E, S35E, S45R or S15RF) and severe sites (S15E, S20E, S45R or S15RF)
HSS2	Double/double seal with PMB in first or both applications for medium traffic loading (S10E, S35E, S45R or S15RF) and heavy traffic loading (S15E, S20E, S45R or S15RF)
XSS	Double/double seal with PMB in both applications (S20E, S45R or S15RF) for high-stress areas. Seal performance may be inadequate under these conditions and may require alternative treatments
	Generally dense graded asphalt size 10 or 14 mm, where an XSS sprayed seal cannot be expected to cope

** Temperature categories are determined as per Appendix D.*

^ Seal performance may be inadequate under these conditions and may require alternative treatments.

 # Considerably steeper grades or combinations of extreme events may lead to unsatisfactory performance and may require alternative treatments.

FNQROC Regional Organisation of Councils

Good Practice Guide - 01

Section 2—Reseals & Asphalt Network Strategy

FNQ Regional Organisation of Councils

Good Practice Guide – 02

Version 0.4

24/06/2026

Reseals & Asphalt Resurfacing - Network Strategy

Purpose : The purpose of this document is to provide LGAs with summary notes on good practice in relation to a technically robust and consistently funded strategy of proactive resurfacing/resealing practice in Far North Queensland.

Key References :

1 : AP-T273-14 : Good Practice in Reseal Programming (Austroads) AP-T273-14 | Austroads

2. Austroads Guide to Asset Management, Part 1 (Austroads 2009)

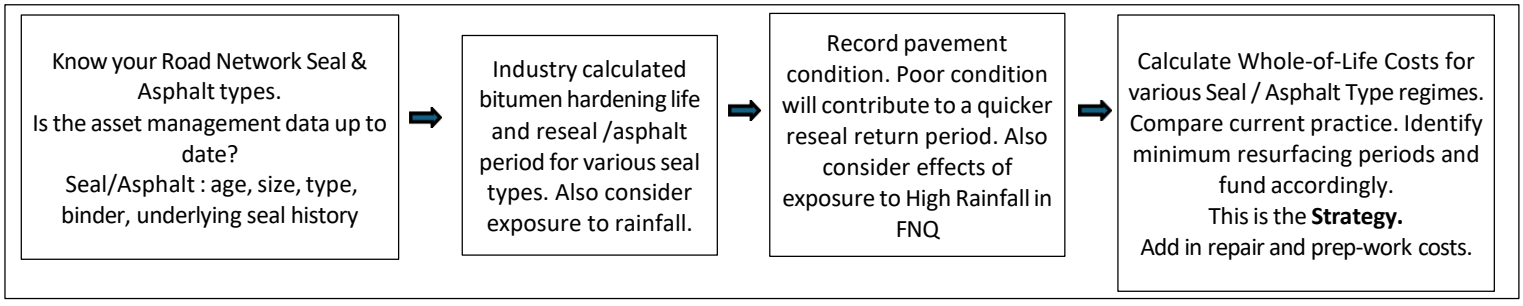
3. International Infrastructure Maintenance Manual (IIMM) (2012) and ISO 55000

4. FNQROC Good Practice Guide 06 - Whole of Life Costing & Environmental Outcomes for Bitumen Seals

Principles : The main role of a bitumen seal is to protect and waterproof the more expensive underlying pavement structure. All bitumen surfacings oxidise with exposure to heat over time. Oxidation causes the bitumen to harden and is more susceptible to cracking. In hotter climates even though the bitumen hardens quicker, binder cracking is not as prevalent as in colder climates until the bitumen oxidises to a higher level. The potential for cracking increases in cold climate areas. In Far North Queensland, this is unlikely to include any coastal areas, but areas up on the ranges and west of the ranges, experience cold temperatures during winter. These cracks allow moisture into the pavement weakening the pavement structure and distress occurs. Additionally, pavement structures that are not performing well due to high water tables or localised water ingress such as overtopping or wetting of subgrades, or are experiencing traffic loading well beyond the original design capacity, often demonstrate various distress which subsequently also causes cracking of the seal surfacing. These cracks allow moisture into the pavement and cause further detrimental effects to the pavement structure and performance, often increasing maintenance demand and potentially early pavement rehabilitation.

Asphalt surfacings with a thickness ≤ 50mm are not considered structural. Asphalts are often permeable (even though some are at low levels of permeability), and hence cannot be relied on as a waterproofing of the underlying unbound (gravel) pavement structure. Bitumen seal initial treatments (refer to GPG 01) are required prior to any placement of asphalt surfacing. Asphalts are a mixture of highly controlled aggregates, bitumen and other fillers and additives. Accordingly, asphalt also oxidises and hardens with heat exposure over time. In hot climate areas asphalts are at a high risk of rutting and accordingly it is important to choose the correct binder type. Cairns City Council has observed 25-30 years life from surfacing asphalts and employs a cost effective crack-sealing program to minimise moisture ingress. A well planned and technically robust reseal and asphalt network strategy minimises pavement damage and assists to ensure maintenance and pavement rehabilitation budgets are optimised and network-wide life-time cost are minimised. In many respects a reseal or asphalt replacement/overlay is akin to regularly servicing a vehicle, if you don't replace the oil in the vehicle at the prescribed interval, you risk doing major damage and requiring more expensive repairs. It's the same with reseals and asphalt resurfacing.

Process Overview :



A Simplified Example to Demonstrate a Strategy :

A bitumen sealed Road Network of 500km, has a total sealed area of 4 million m^2 (an average 8m width).
The current seal and binder types for the FNQ climate conditions and risks, identifies an average reseal return period of 10 years.
The average reseal cost is $7.50/m2 (2025), and includes linemarking where relevant.
Assuming 5km (1%) of reconstruction per year, or 10% over 10 years (400,000 m^2), an average reseal budget is calculated:
((4,000,000 - 400,000= 3,600,000m2) * $7.50/m2)/ 10 years = $2.7 M/yr (or $27.0M over 10 years).
Due to current old seals and low maintenance budgets, the required preparatory works and repairs, includes pavement repairs, edge repair, shoulder grading, devegetation, smoothing major bumps and hollows, potholes, drain cleaning, etc. On average it has been identified that a further $6/m2 is required, or $2.1 M/yr; This $6/m2 may decrease to $3-4/m2 once the strategy is implemented over 10 years, but we have some catching up to do first.
Therefore the total STRATEGY BUDGET is $4.8 M/yr. The current budget averages $2.5M/yr. A current shortfall of $2.3 M/yr.
Note : all dollar values are in 2025 dollars and budgets would need indexing to reflect year to year budgets.

Section 3 — Reseals— Network Programming and Proofing

FNQROC | FNQ Regional Organisation of Councils

Good Practice Guide – 03

Version 0.3
27/04/2026

Reseal/Asphalt - Network Programming, Proofing & Tender Documentation

Purpose :

The purpose of this document is to provide LGAs with summary notes on good practice in Reseal and Asphalt Programming, Proofing & Tender Documentation. References to key industry documents are provided.

Key References :

1 : AGPT04K-18 : Guide to Pavement Technology Part 4K : Selection and Design of Sprayed Seals
2. QTMR : Guideline (2024) : Preparing Pavements for Resealing - Planning Works
3. FNQROC - Reseal Type and Binder Choice - Good Practice Guide 04
4. FNQROC - Initial and Resurfacing Asphalt Choice 05

TEMPLATES :

A. Network Program - Pavement Renewal - Road Inspection Record (excel spreadsheet attached)
B. Reseal Proofing Inspection_Bitumen Surface and Repairs Assessment (excel spreadsheet attached)

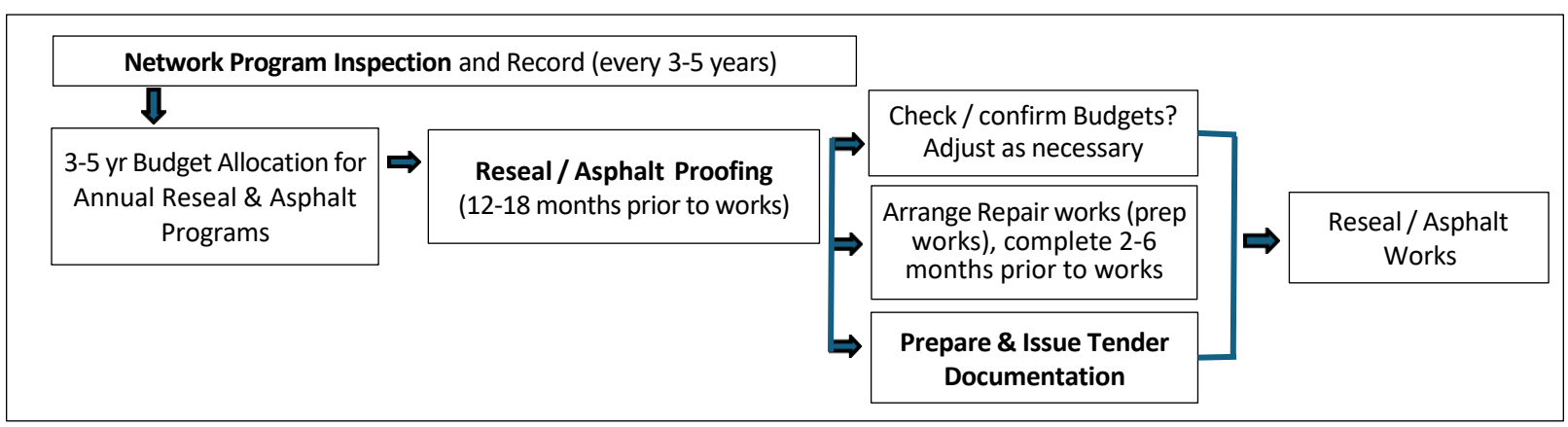
Principles :

The purpose of **Network Programming** is to implement the agreed Reseal & Asphalt Network Strategy (refer to 02 FNQROC - Reseals / Asphalt Network Strategy). The **Network Inspection** aims to assemble between 3-5 years of proposed road treatments, including reseals, asphalt re-surfacing and pavement rehabilitation. This process includes consideration of available AM data including existing seal type and size, seal age and pavement/surfacing condition data. A choice of Reseal/Asphalt Type (type, binder, size) is made along with a quick estimate of any obvious repairs required prior to sealing (broad quantum of pavement repair, kerb replacement, rut filling, asphalt surface correction (major humps and hollows), major crack sealing (cracks too active or wide for a bitumen seal to remedy), edge break, etc). These costs are maintained in a database/spreadsheet for pricing and are used to inform the Annual Reseal / Asphalt project proofing and other pavement programs. For rural reseals, a general allowance for table-drain cleaning and shoulder grading (light/medium/heavy) works are also costed-in. Geographic rationalisation and 'bunching of projects', for cost efficiencies, are considered with project priorities changed accordingly.

The **Reseal/Asphalt Proofing** stage undertakes a detailed inspection 12-18 months prior to the planned reseal/asphalt works. This inspection uses the previous data captured from the Network Programming inspection, and confirms that the Seal/Asphalt Type chosen remains suitable. It also checks and records actual sealed widths, linemarking, and considers whether additional bitumen spray runs are required for the project (example additional bitumen on untrafficked shoulder etc). Underlying repair works (prep works) schedules are collated (Chainage, Work type, quantity) and compared to original Network Program allowances with an overall review of Program Level costs - do the unders and overs balance out? Is any re-budgeting or re-prioritising required? The repair works are arranged to be undertaken by internal/external resources at least 2-6 months prior to reseal/asphalt works, deepending on repair work type(s) *(Ref 2: Table 4)* . Also consider any other major surfacing issues that have been advised by council staff throughout the last year - does this issue need to be added to the program? Nominal bitumen spray and aggregate spread rates are selected for seal/binder type chosen (this may include a prelim seal design). Asphalt projects will chose the appropriate asphalt type and include details about tie-in tapers at K&C, start and end locations.

Tender Documentation can be prepared based on the Reseal Proofing inspection seal information.

Process Overview :



Network Inspection

The **Network Inspection process** aims to identify the pavement and surfacing treatments required for various asset renewal programs. A road network in fair to good condition may actually be able to define treatments for a 10 year period. A poor condition network may only be able to achieve a 5 year outlook. Usually a road engineering team (overseer/foreman, senior engineer, engineer), with significant experience in pavements and surfacings, will inspect and record data that allows direct input into various asset-renewal programs. Typical inspection rates would average around 25-30km of inspection per day, depending on urban/rural split and traffic volumes. This could vary from a 3 minute drive over of a 500m residential street in good condition, with no treatment required in the next 10 years, to a 1-1.5 hour inspection of 35km road in varying condition with a range of treatments and repairs required. A 500km sealed road network could expect to take between 17 - 20 days of inspection. The inspection process often includes several passes (quick helicopter pass, slow detailed passes as required). This is a substantial effort and cost and is usually spread out over 2-4 months. This significant effort is also the reason why this process is usually only undertaken every 4-5 years.

The key steps include:

1. Verify the condition data and AM data;
2. Identify the likely cause of the condition (where possible) and identify the predominant issues;
3. Identify treatment options for resurfacing and pavement renewal, including any underlying repairs for resurfacing works
4. Record/confirm broad quantities of work required;
5. Confirm a suitable priority and year of works; and
6. Provide a planning level cost estimate.

The following pavement treatment selection logic is generally observed:

A. If the Pavement Asset is in a STRUCTRALLY SOUND condition, utilise surface-based treatments to address the issues as appropriate;
B. If the Pavement Asset is in a GENERALLY STRUCTURALLY SOUND condition, utilise a combination of repairs for non-endemic, minor or isolated structural pavement failures, followed by appropriate surface-based treatments;
C. If the Pavement Asset is exhibiting:

(i) A large amount of structural failure and pre-failure distress; and/or
(ii) Long wavelength (usually high amplitude) roughness, otherwise known as the undulating 'rock and roll' roughness associated with highly reactive soil subgrades;

A surface treatment may not be appropriate. Consider a structural solution or reconstitution of the existing pavement, where appropriate.

D. If there are a number of uncertainties of either the cause of the current condition or the existing pavement structure, then the Pavement Asset is marked as 'To Be Investigated'. (For programming purposes a 'possible treatment' is applied for cost purposes); and
E. For large lengths of roadway where pavement issues/defects are consistently present, consider a more extensive proactive program of structural treatment that will benefit road users over the next 20-30 years, these sections are identified as 'pavement rehabilitation' and require further investigation, discussion and consideration by the engineering management team.

The context of suitable pavement treatment options is often pragmatically influenced by the following:

a. Road Network Hierarchy;
b. AADT and HV%;
c. The occurrence frequency and severity of pavement defects;
d. Existing Pavement structure and age, and whether a future 20-year life is desired/required;
e. Existing Pavement structure (especially for expansive subgrade soil material types) and whether early intervention can vastly affect the long-term life. For example, suitable surfacing and smoothing treatments may significantly pro-long pavement life; and
f. Risk & Cost/m2 . A 'reasonable' cost treatment must be selected, rather than a maximum full rehabilitation 'top-shelf' solution be applied to all roads in all locations. This is the Engineering Decision Making and Risk component of the process and is important for Constrained Funding Programs. This is why a suitably experienced engineering team is required. A treatment selection matrix is available and should be consistently applied/consulted.

More Details : Network inspection planning tasks, road data printout examples, data recording sheets, & example data entry spreadsheets are provided at FNQROC BPG Website

Reseal/ Asphalt (project) Proofing

1. Obtain the original Network Program Inspection data, that scoped the original project.
2. Note the inspection date (as more time passes, condition maybe worse).
3. Measure & record width changes vs chainage, & calculate a more accurate area for the project
4. Measure & record major repair issues as per defect type, repair type, chainage start/end, lateral details (Lane/WP/Width), re-calc qty for various repair treatments.
5. For reseals, note major changes in surface texture[1] that might effect seal spray rates; record :chainage start/end, Lateral/width details (Lane/WP/Shldr etc), existing agg size, surface texture description[1]**.**
6. For reseals, note major areas that are untrafficked, consider the need for additional bitumen (extra spray run) (eg shoulders or central medians/ turning lanes). Ensure the additional spray runs are specified in the Schedule of Rates.
7. For Asphalt projects, confirm milling locations, areas and depths. Consider tie-ins at K&C (longitudinal), Start and End chainages (lateral/transverse).
8. Assess and confirm whether the Seal/Asphalt Type, aggregate size and binder proposed by the Network Inspection, still remains appropriate *(Ref: 3 & 4)*
9. For reseals confirm the spray rates(s) and spread rates required for various sections (prelim seal design)
10. For asphalt projects, confirm the underlying waterproofing SAMI seal required. (typical 10mm or 14mm 1.6 -1.8 L/m2 S20E)
11. Assess costs across the entire program (total cost of all projects) and highlight any overall/total budget deficiencies. Agree with management on action to be taken.

Repairs (Prep Works) : Where required, arrange Repair Works with internal/external contractors as a program of repair works, for cost efficiency.

Tender Documentation :

Collate the information from the Proofing inspection for input into Project Works Schedule of Quantities calculations.
Ensure separate items are specifically provided for extra bitumen sprays runs, where required. This provides the Contractor with clear notice that and additional spray runs are required, where specified.

NOTE 1. Description of Seal Conditions	
1. Flushed - Free binder on surface completely covering aggregate	4. Matte - Good textured seal, binder 2/3 of ALD
2. Black - Binder near top of aggregate	5. Hungry - Binder 1/2 of ALD
3. Smooth - Worn aggregate, minimal texture depth	6. Very Hungry - Binder < 1/3 of ALD (not visible)

TEMPLATES : Refer to FNQROC Best Practice Guide WebSite for excel spreadsheet templates for use and amendment by Councils, as required.

Section 4 — Reseal Type and Binder Choice

FNQ Regional Organisation of Councils

Good Practice Guide - 04

Version 0.2
27/04/2026

Reseal Type & Binder Choice

Purpose :

The purpose of this document is to provide LGAs with summary notes on good practice in choosing Reseal and Binder types. Please note that this document is not a seal design process.

Key References :

1 : AGPT04K-18 : Guide to Pavement Technology Part 4K : Selection and Design of Sprayed Seals	AGPT04K-18 | Austroads
2 : AP-T273-14 : Good Practice in Reseal Programming	AP-T273-14 | Austroads
3 : AGPT04F-17 : Guide to pavement Technology Part 4F : Bituminous Binders	AGPT04F-17 | Austroads
4. AGPT03-09 : Guide to Pavement Technology Part 3 : Pavement Surfacings	AGPT03-09 | Austroads

Principles :

The purpose of a bitumen reseal is to ensure that the thin bitumen surfacing, originally applied to the underlying pavement structure, continues to provide a waterproof membrane whilst maintaining good surface functionality such as skid resistance. The bitumen seal's ability to maintain a waterproof layer depends on it's ability to resist/accommodate pavement cracking. Ironically, bitumen itself hardens and cracks as it ages and is exposed to heat. Accordingly, a bitumen reseal is a proactive treatment which is applied to an existing bitumen seal (or asphalt, in some circumstances) to fill cracks, reinstate skid resistance and maintain bitumen seal integrity and durability. Thus maximising the life of the more expensive underlying pavement. It is desirable to reseal before the existing bitumen surface has hardened, becomes 'brittle' (less viscous) and exhibits binder cracking. Thus avoiding problems of major reflective cracking. If the bitumen sealed surface is not proactively maintained /resealed the probability of more expensive underlying pavement failures and repairs/rehabilitation increases. The bitumen reseal is a relatively low cost treatment, typically $6-10/m2 and upto $13-16/m2 (2025) in more remote areas with small areas <20,000m^2. The underlying pavement structure, which the seal is protecting, has a typical range of replacement cost between $75-150+/$m^2$. So, there is good economic reason to ensure regular resealing. That is, a reseal costs in the order of 6-10% of the underlying asset cost, but with a typical reseal life of 10 years, this equates to 0.6-1% of the underlying asset cost per year. Responsible asset management allows budgets for these reseal cycles.

The life of the bitumen is dependent on :

(a) aggregate size and seal type single/single or double/double applications;

(b) temperature zone (low, medium, high). FNQ is in the High zone; and

(c) binder type and quality;

Pragmatically, the resealing life can also be dependant on :

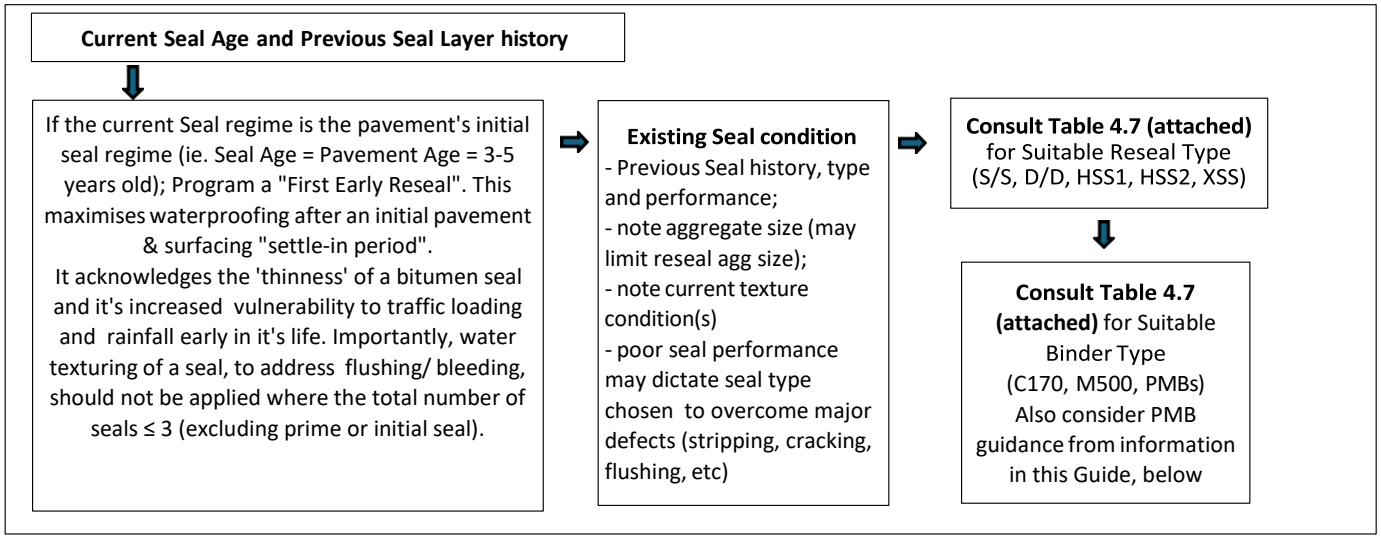
(i) the underlying pavement structure and material type, it's response to load and it's subsequent cracking and other defects;

(ii) traffic wear and seal design, leading to conditions that adversely effect skid resistance.

(iii) rainfall exposure risk (generally considered high to very high in FNQ).

For example, a pavement that is strong and performing well is likely to demand a reseal based on bitumen age and hardening, oxidation - heat exposure over time. Whereas a weak pavement, maybe consisting of marginal gravel materials, that is not performing well, is likely to demand a reseal prior to reaching the hardening/oxidation age, due to its cracking condition or other pavement defects such as rutting that could increase the cracking potential.

Process Overview : **Choosing a Seal and Binder Type**



Technical Details :

FNQ : Local Practice

Many LGAs in FNQ use C170 for sealing purposes and report fair to good performance. PMBs are utilised in challenging traffic, intersection, grade, tight curves - range crossings, or poor pavement condition. Whilst Austroads guides allow the use of C170 in High Temp zones, it does suggest C320 or M500 may be appropriate as they are stiffer binders at elevated temperatures with higher softening points, and therefore demonstrate less flushing / bleeding in hot weather. Industry consultation indicates that Multigrade Binders and stiffer grades of bitumen are only avaiable ex-Brisbane and not stored in Townsville/Cairns.

Oxidation *(Ref 3 : 3.4.2)*

This is considered to be the predominant cause of hardening of bitumens in service. Like many organic substances, bitumen is slowly oxidised when in contact with atmospheric oxygen. The degree of oxidation is dependent on temperature, time and thickness of the binder film. Sunlight is also a factor, but because the bitumen is a good light absorber, the very rapid reaction to light is confined to about the top 5 µm of the exposed material which upon hardening forms a protective film against further light penetration.

Above 40 °C, the rate of oxidation roughly doubles for each 10 °C increase in temperature. At high pavement temperatures, the reaction rate is controlled by the reactivity of the bitumen and by the rate of diffusion of oxygen into the bitumen film. It is for this reason that surfacings are designed with as thick a binder film as can be practically achieved.

PMBs

4.3.2 Polymer Modified Binders (PMBs) **Ref 4: 4.3.2**

Polymer modified binders (PMBs) are used in sprayed sealing work to achieve enhanced performance where there is a need to:

- improve shear resistance in high-stress (vertical and horizontal) applications
- minimise or delay reflection cracking
- reduce water penetration
- improve aggregate retention
- reduce temperature dependence
- reduce oxidation in high temperature regimes.

PMBs can be used in sprayed sealing applications for high stress seals (HSS), strain alleviating membranes (SAMs) and strain alleviating membrane interlayers (SAMIs).

A detailed guide to PMB classes and applications is provided in the *Guide to Pavement Technology – Part 4F: Bituminous Binders* (Austroads 2008c) and (Austroads 2006c). A summary of the guidelines for the use of PMBs in HSS, SAM and SAMI applications is provided in Table 4.1. This lists possible applications without necessarily identifying the optimum material for each case.

Table 4.1: Selection of PMB and multigrade bitumen

Application	Service condition				Binder class					
	Cracking		Traffic		S10E	S20E	S25E	S35E	S45R S15RF	S18RF
	Activity	Width severity	Site severity	Loading						
HSS	NA	NA	Severe	All		✓		✓	✓	
			Moderate	Heavy		✓		✓	✓	
				Medium		✓		✓	✓	
SAM	Slow	All	NA	All	✓			✓	✓	
	Rapid	High	NA	All		✓	✓			✓
		Low	NA	All		✓	✓		✓	
SAMI	All	All	NA	All			✓			✓

✓indicates suitable binder class
Source: Austroads (2006c)

6.2 Specification and Class of PMBs

Ref 3

The Australian PMB specification is listed in AGPT/T190 *Specification Framework for Polymer Modified Binders*. The specification includes a number of classes of hot binders which are available commercially in Australia which are used in sprayed sealing and HMA applications. AGPT/T190, however, does not include all potential PMB types that may be suitable for these applications. PMBs used in other types of applications (e.g. microsurfacing and crack sealing) are also not included in this specification.

The PMB classification grading system included in AGPT/T190 uses a coding system to primarily indicate the application and polymer type of the PMB as follows:

- **S** for **S**ealing applications of PMBs, followed by a 2-digit code and a polymer type code
- **A** for **A**sphalt applications of PMBs, followed by a 2-digit code and a polymer type code.

Polymer type codes used for this coding system are:

- **E** for **E**lastomeric types (Section 6.2.1)
- **P** for **P**lastomeric types (Section 6.2.2)
- **R** for crumb **R**ubber materials (Section 6.2.3)
- **RF** for crumb **R**ubber binders that are '**F**ield-produced' (Section 6.2.3).

Table 6.1: History of naming conventions of Austroads PMB grades

	Early development (pre-1990)	Current AGPT/T190
Sealing grade	SBS[5] 3%	S10E
	SBS 4%	S15E
	SBS 5%	S20E
	SBS 6%	S25E
	SBS 7%	–
	(PBD[6])	S35E
	5 part crumb rubber	–
	18 part crumb rubber	S45R/S15RF
	20 part crumb rubber	–
	25 part crumb rubber	S18RF
	–	–
Asphalt grade	SBS 6%	A10E
	SBS 5%	A15E
	SBS 4%	A20E
	(PBD)	A25E
	EMA[7]	–
	EVA[8]	A35P
	Crumb rubber	A27RF

6.2.1 Elastomers

Ref 3

Elastomers provide flexibility and elasticity leading to improved resistance to cracking and permanent deformation. They are used in sprayed seals and asphalt to make the binder more flexible and resilient, as well as in crack sealing materials and some emulsion applications.

The most common elastomeric polymers used in Australia include:

- **SBS (styrene-butadiene-styrene)**: SBS is the predominant polymer type used in modified binders. At high concentrations, it is particularly useful for crack control in strain alleviating membrane (SAM) and strain alleviating membrane interlayer (SAMI) applications and for improved resistance to permanent deformation and fatigue in asphalt. At lower concentrations, it is used for improved cohesion and durability in OGA, and for improved service life in sprayed seals. SBS polymers can also be incorporated into emulsions for sprayed sealing, microsurfacing and crack sealing applications.
- **PBD (polybutadiene)**: PBD modified binders generally have good adhesion characteristics and are used in sprayed sealing applications where cohesion and a moderate level of flexibility are required. These binders can also be used in thin surfacing asphalt applications.
- **Natural rubber**: Natural rubber in a latex form can be used in modified emulsions for sealing and microsurfacing applications.

6.2.3 Crumb Rubber

Crumb rubber is obtained from the shredding, grinding or cryogenic processing of scrap rubber from vehicle tyres. The crumb rubber particle size and shape (morphology) arising from the method of manufacture are important parameters that affect the performance of the crumb rubber blend with bitumen. When blended with bitumen, the material behaves as a form of elastomer, but the resulting binder is a composite of discrete particles dispersed in a liquid, and therefore behaves sufficiently differently from other elastomers to warrant a separate category. When incorporated in sprayed seals and asphalt, the highly elastic rubber particles contribute significantly to the performance of the binder.

For use in sprayed seals, crumb rubber binders are broadly divided into two groups:

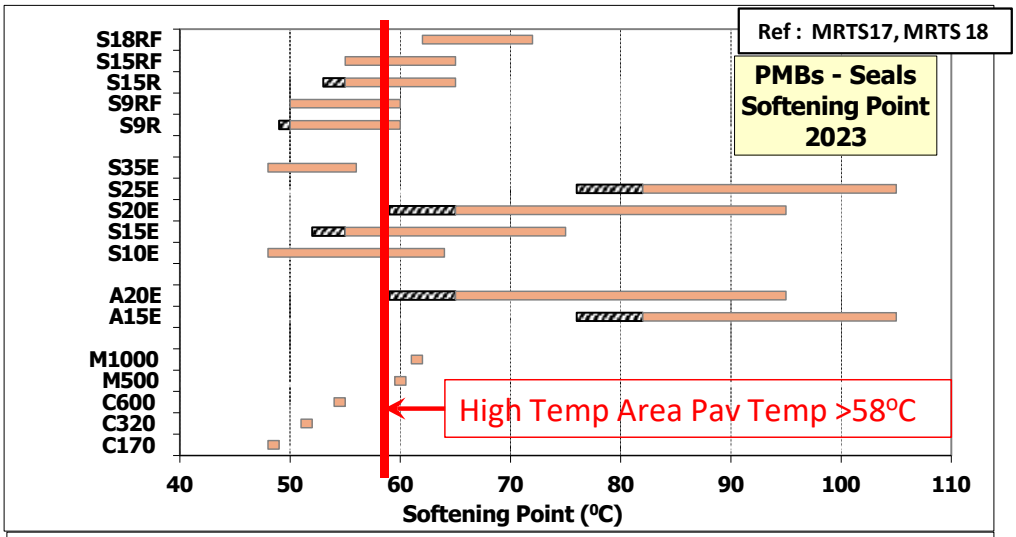
Factory-produced/plant-manufactured

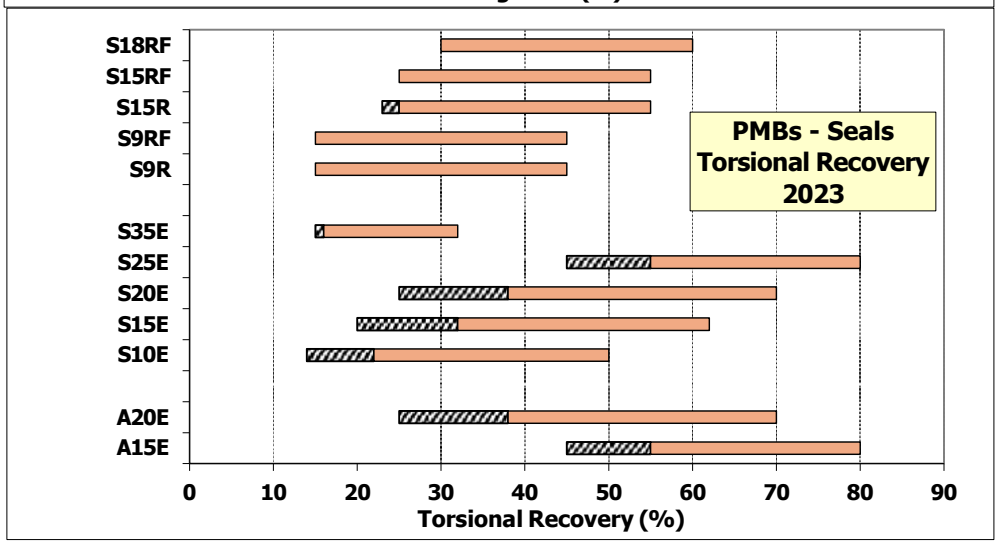
'Factory-produced' or 'plant-manufactured' crumb rubber binders are bitumens modified with crumb rubber and generally with additives (e.g. combining oil). Production is generally remote from the application site. The Austroads PMB specification (AGPT/T190) provides one grade (i.e. S45R) for this type. This type is also known as 'crumb rubber modified binder' to distinguish it from the other type below.

A description of each of the current PMB classes and their relevant applications in sprayed seals and asphalt is summarised in Table 6.2 and Table 6.3.

Table 6.2: Sprayed sealing classes of PMB

Class	Description
S10E	A PMB typically manufactured with an SBS polymer to achieve a low level of elastomeric modification. Used for strain alleviating membrane (SAM) applications where there is a slow rate of environmental crack activity or for improved aggregate retention in higher stress applications where the use of bitumen may result in loss of stones.
S15E	A PMB typically manufactured with an SBS polymer to achieve a medium level of elastomeric polymer modification with similar uses to S10E. S15E can additionally be used for SAM applications where there is a rapid rate of traffic induced crack activity where the crack widths are small. S15E will also perform better at sites with higher stresses.
S20E	A PMB typically manufactured with an SBS polymer to achieve a high level of elastomeric polymer modification. S20E can be used for SAM applications where there is a rapid rate of traffic induced crack activity for low and high cracking severity. S20E will also perform better at sites with higher stresses (e.g. when 'high stress seal 2' (HSS2) and 'extreme stress seal' (XSS) seals (Austroads 2013c) are constructed).
S25E	A PMB typically manufactured with an SBS polymer to achieve a very high level of elastomeric polymer modification used in strain alleviating membrane interlayer (SAMI) seals.
S35E	The properties of S35E were developed based on an alternative elastomeric PMB utilising a PBD polymer. The other elastomeric-class PMBs generally use an SBS polymer. The use of a PBD polymer modifier results in a somewhat different matrix of properties to SBS-based PMBs and hence this material is listed as a separate grade. S35E is used for SAM applications where there is a slow rate of environmental crack activity or for improved aggregate retention similar to S10E.
S45R	A PMB plant-manufactured with crumb rubber to achieve a medium level of elastomeric modification with similar uses to S15E and S20E on high stress applications. S45R is used for SAM applications where there is either a slow rate of environmental crack activity or a rapid rate of traffic induced crack activity with low crack severity.
S15RF	A field-blend of 15% crumb rubber (by weight of the total blend) for use in applications similar to S45R.
S18RF	A field-blend of 18% crumb rubber (by weight of the total blend) for use in SAMI seals and SAM applications where there is a rapid rate of traffic induced crack activity with high cracking severity.





Pavement Temperature - Input into the selection of Bitumen Grade for sprayed sealing and asphalts (Table 7.4 Part 4K; Table 4.3 AP-T235-13 - Guide to the Selection and Use of PMBs and Multigrade Bitumens)

Site		Latitude °S	Latitude Category	Longitude °E	Highest T90 (BoM)		Temp Category	
Mareeba	Airport	17.07	< 24 ° S	145.43	35.2	59.2	> 58 o C	High
Cairns	Aero	16.87	< 24 ° S	145.75	33.6	57.6	> 58 o C	High
Ingham	Composite	18.65	< 24 ° S	146.18	35.5	59.5	> 58 o C	High
Croydon	Township	18.20	< 24 ° S	142.24	40.0	64.0	> 58 o C	High
Cooktown	Airport	15.45	< 24 ° S	145.19	34.8	58.8	> 58 o C	High

Table 4.7: Preliminary guide to seal selection

	Design traffic (v/l/d)	≤ 200				201–750				751–2000				2001–5000				> 5000			
	Equivalent heavy vehicles (%)	< 15	15–26	26–45	> 45	< 15	15–26	26–45	> 45	< 15	15–26	26–45	> 45	< 15	15–26	26–45	> 45	< 15	15–26	26–45	> 45
Rural: roads, highways and freeways – no high stress areas	Temperature* – High	S/S			D/D HSS1	S/S			D/D HSS1				HSS2				XSS				XSS^
	Medium	S/S			D/D HSS1	S/S			D/D HSS1	S/S		D/D HSS1		HSS2				XSS			
	Low	S/S										D/D HSS1		HSS2							XSS
High stress locations	Small radius curves, roundabouts, driveways, turning lanes, intersections	D/D			HSS2	D/D			HSS2 XSS	HSS2				XSS				NO SEAL SUITABLE^			
	Grades# > 5%	S/S	D/D HSS1							HSS2				XSS				XSS^			
	Cracked pavements	• SAM – preferred SAM is an S/S (14 or 10 mm) but a D/D may be required where there are also high-stress conditions. Slow rate of movement cracking – environmental (S10E, S15E, S35E, S45R, S15RF). Rapid rate of movement – traffic induced (S15E, S20E, S45R, S15RF). • Minimum binder rate for SAM application is 1.5 L/m^2. • GRS – C170 with D/D is the preferred type of GRS (14/7 mm).																			

S/S	Single/single with C170 or C240. C320 or M500 binder may be appropriate for hot climates.
D/D	Double/double with C170 or C240. C320 or M500 binder may be appropriate for hot climates.
HSS1	Single/single seal with PMB for moderately severe sites (S10E, S35E, S45R or S15RF) and severe sites (S15E, S20E, S45R or S15RF)
HSS2	Double/double seal with PMB in first or both applications for medium traffic loading (S10E, S35E, S45R or S15RF) and heavy traffic loading (S15E, S20E, S45R or S15RF)
XSS	Double/double seal with PMB in both applications (S20E, S45R or S15RF) for high-stress areas. Seal performance may be inadequate under these conditions and may require alternative treatments
	Generally dense graded asphalt size 10 or 14 mm, where an XSS sprayed seal cannot be expected to cope

** Temperature categories are determined as per Appendix D.*

^ Seal performance may be inadequate under these conditions and may require alternative treatments.

 # Considerably steeper grades or combinations of extreme events may lead to unsatisfactory performance and may require alternative treatments.

Section 5 — Iniitial and Resurfacing Asphalt Choice

Initial and Resurfacing Asphalt Selection

Purpose :

The purpose of this document is to provide LGAs with summary notes on good practice in choosing Asphalt mix and binder type for initial and re-surfacing non-structural applications.

Key References :

1. AGPT03-09 :Guide to Pavement Technology Part 3 Pavement Surfacings	AGPT03-09 | Austroads
2. AGPT04B-14 : Guide to Pavement Technology Part 4B Asphalts	AGPT04B-14 | Austroads
3 : AGPT04F-17 : Guide to pavement Technology Part 4F : Bituminous Binders	AGPT04F-17 | Austroads
4. AP-T235-13 : Guide to the Selection and use of PMBs and Multigrade Bitumen	AP-T235-13 | Austroads
5. MRTS 30 : QTMR Technical Specification, Asphalt Pavements	Specifications (Department of Transport and Main Roads)

Principles :

The purpose of an asphalt surfacing is to provide a higher quality surfacing than a bitumen seal that can succesfully perform in higher traffic induced stress locations such as intersections, steep grades, tight curves, heavy vehicles, turning traffic, shear forces, braking, and can also be adopted in areas where noise and aesthetic issues are important.

Dense graded asphalt is the most used asphalt type by LGAs and will be the focus of this GPG.

Other asphalt types include:

(i) Fine Gap Graded - was developed to have good durability in locations such as residential streets and lightly trafficked roads. It is a variation on dense graded asphalt, but with some aggregate fractions reduced or omitted. Consists of a larger proportion of fine aggregate for improved workability and ease of compaction. When combined with relatively high binder content, exception durability can be achieved.*(Ref 1 : 5.6)*

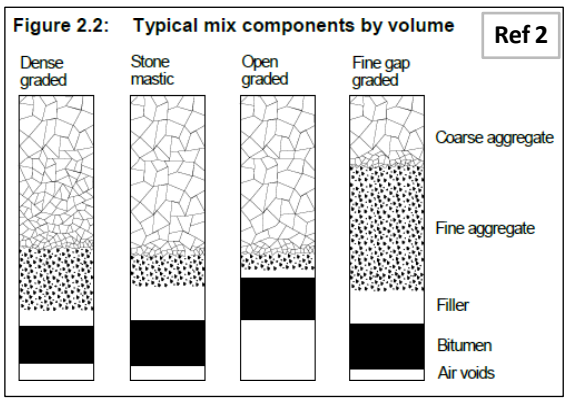
(ii) Open Gap Graded asphalt has 18-25% air voids and is porous by design and used for rapid removal of water from the surfacing improving safety. (Ref 1 : 5.4)

(iii) Stone Mastic Asphalt has a large percentage of course aggregate with stone-on-stone contact and provides a mix with good deformation resistance. (Ref 1 : 5.5)

(iv) Recycled Asphalt Product (RAP) from previous removal can be incorporated into new asphalt projects at the Plant.

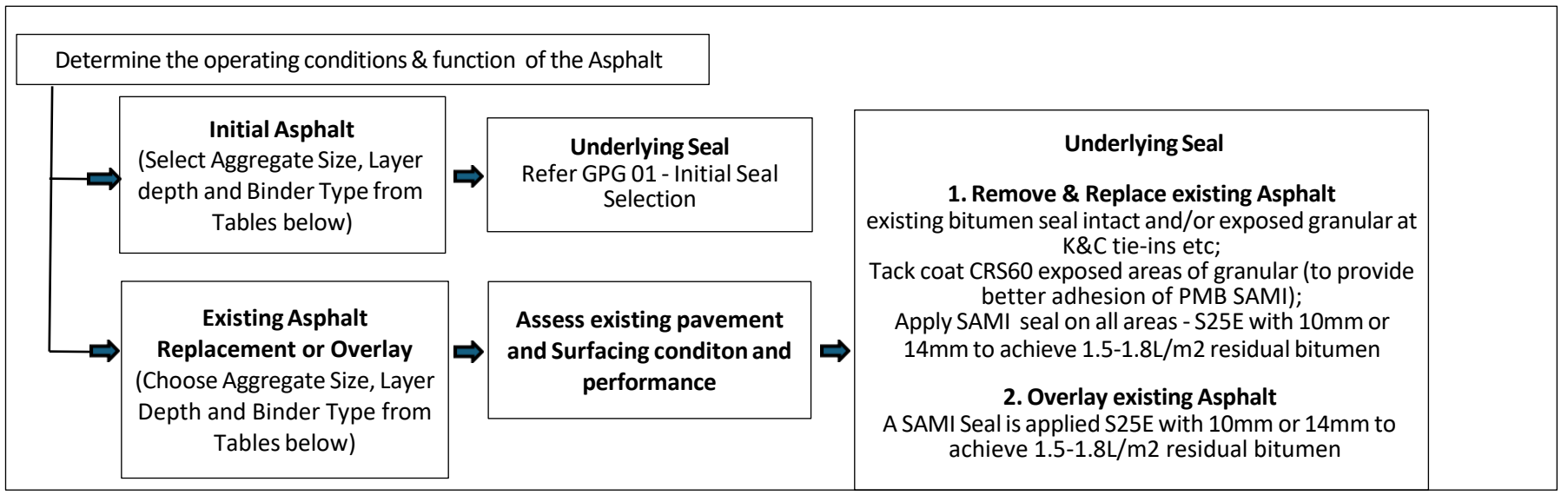
(Ref 1 :5.8; Ref 4 : 7.1.4)

(v) Warm Mix Asphalt : The use of 'warm mix asphalt' is associated with a reduction in the temperatures of manufacture, paving and compaction of asphalt mixes.



This lowering of temperature brings with it reductions in energy consumption, fume and odour emission, mix oxidation, and construction times where cooling of the asphalt layer prior to overlay or opening to traffic is a concern. (Ref 1 : 5.9)

Process Overview : Selecting an Asphalt and Binder Type



FNQ : Local Practice

In LGAs with major cities or towns, asphalt is often used as the surfacing for major arterial/collector roads with high traffic and/or heavy vehicles, with 50mm AC14 dense graded asphalt often specified. The surfacing is typically placed on an unbound granular (gravel) pavement and bitumen seal. With the exception of rural towns, which tend to use a bitumen seals in residential areas, Councils often specify that new residential subdivisions shall be Asphalt surfaced typical with 30-35mm AC10 dense graded. Where urban cul-de-sacs exist, these tend to be re-asphalted even though the adjacent street may receieve a bitumen re-seal. Urban and rural round-abouts are typcially surfaced with a suitable asphalt to resist shear forces and scrubbing wear. Urban streets and rural roads with a high proportion andhigh volumes of Heavy Vehicles are often surfaced with a suitable asphalt. On rural roads asphalt surfacing may be placed at Cane-Train Crossings, intersections, steep grades , tight curve areas such as mountain range crossings etc.
Binder choice for residential streets is usually the Standard C320 grade bitumen binder.
The choice of binder on major roads may vary depending on the degree of traffic loading / tight turning/ braking / steep grades / major HVs the site is expected to endure. In the event of an end-of-life asphalt overlay or remove/replacement of asphalt the existing condition needs to be considered. In these cases, often a PMB Binder is chosen. Typical Binders considered include A15E (5% SBS Polymer) & A20E (4% SBS Polymer).

Operating Conditions & Function of Asphalt:

Consider : 1. Traffic (light/moderate/heavy); 2. Traffic forces (shear, braking, turning, intersections); 3. Speed; 4. Skid Resistance; 5. Texture; 6. Noise; 7. Line Marking type and variety for; 8. Water Spray; 9. Appearance (Aesthetics); 10. Service Life.
Use the following Tables as a guide to your choice of Application, Aggregate Size, Layer Thickness and Binder type

Table 5.2: Selection of nominal size of dense graded asphalt mix

Ref 1 : Table 5.2

Nominal size (mm)	Typical layer thickness (mm)[1]	Typical use
5	15–20	Available in limited locations for use as very thin surfacing layer with fine surface texture
7	20–25	Commonly used for surfacing residential streets and pedestrian areas where thin layers and fine surface texture required
10	25–35	General purpose wearing course mix suitable for both light and moderate traffic applications
14	35–45	Wearing course mix for heavier traffic applications; also intermediate course to suit layer thickness
20	> 50	General purpose base and intermediate course mix for wide range of uses
28	>60	Less commonly used than 20 mm for base and intermediate course; control of segregation can sometimes be an issue
40	>100	Occasionally used as a heavy duty base; control of segregation can be a significant problem

Notes:
To ensure adequate compaction of asphalt mixes containing heavily modified polymer modified binders, a minim thickness of 3.5 times the nominal size is generally recommended.
Source: Austroads (2006b)

Table 2.1: Typical mix sizes for various applications

Application	Typical mix size
Dense graded wearing course	
▪ lightly trafficked pavements	7 or 10 mm
▪ medium to heavily trafficked pavements	10 or 14 mm
▪ highway pavements	Generally 14 mm (also 10 mm)
▪ heavy duty industrial pavements	14 or 20 mm
Dense graded corrective course	5, 7, 10, 14 or 20 mm
Stone mastic asphalt wearing course	7, 10 or 14 mm
Open graded wearing course	10 or 14 mm
Open graded basecourse (drainage layers)	14, 20 or 28 mm
Fine gap graded asphalt	Generally 10 mm (also 7 mm)
Minor patching	10 mm (also 5, 7, 14 and 20 mm)
Major patching	All sizes as appropriate

Ref 2 : Table 2.1

Selection of Surfacings

Table 6: Guide to the selection of dense graded asphalt wearing course

Traffic Category [1]	Laboratory Compaction Level	Design Air Voids (%)	Binder (Class/Type)	Recommended use
Light	50 cycles	4.0	170	Residential streets and car parks. Foot traffic.
			320	Sometimes used for above in warmer climates.
Medium	80 cycles	4.0	170	Normal conditions and lower traffic ranges, particularly in cooler regions.
			320	Good general purpose mix for a wide range of applications.
Heavy	120 cycles	4.0	320	General purpose mix for heavily trafficked applications. Generally combined with use of polish-resistant aggregates.
			600, Multigrade or PMB	Higher performance mixes for greater traffic loadings. Stiffer binders require strong, stiff base.
Very heavy	120 and 350 cycles	5.0	320	Heavily trafficked intersections, slow moving traffic, requires coarse grading.
			600, Multigrade or PMB	Special applications such as very heavily trafficked intersections, heavy duty industrial pavements, and aircraft hard standing. Requires coarse grading.

Notes: 1. See Table 7

Ref : AAfPA Course 2013Q sec05 selection of surfacings v2010

Table 5.1: Traffic loading

Ref 4 : Table 5.1

Indicative traffic volume		Traffic category	
Commercial vehicles/lane/day	Structural design level (ESAs)*	Free-flowing vehicles	Stop/start or climbing lane or slow-moving
< 100	$< 5 \times 10^5$	Light	Medium
100–500	5×10^5–5×10^6	Medium	Heavy
501–1000	5×10^6–2×10^7	Heavy	Very heavy
> 1000	$> 2 \times 10^7$	Very heavy	Very heavy

8.3 Pavement Types

Ref 1 : 8.3

8.3.1 Suitability

The general suitability of the various pavement types with respect to road class and typical equivalent standard axles (ESAs) is shown in Table 8.2, where ✓✓ regions are the best-perceived application for the pavement type and the ✓ regions indicate adequate performance. ✗ regions indicate applications that are generally not recommended. In this general overview, there is no discernment based on environmental or other regional factors.

Table 8.2: Suitability of pavement types

Situation		Rural[a]				Urban[a]				
Road class (See)		1	2	3	4	5	6	7	8	9
Design traffic (ESAs)		10^6 – 10^8	10^5 – 10^7	10^5 – 10^6	10^4 – 10^5	$<10^4$	10^7 – 10^9	10^5 – 10^7	10^4 – 10^5	$<10^5$
Pavement type	Granular/sprayed seal	✓[b]	✓	✓✓	✓✓	✓✓	✗[c]	✗[c]	✗[c]	✓
	Granular/thin asphalt	✓[b]	✓[b]	✓	✓	✓	✗[c,e]	✓[b,c]	✓✓	✓✓
	Granular/thick asphalt	✓	✓	✓	✗[d]	✗[d]	✗[c,e]	✓	✓✓	✓✓
	Deep strength asphalt	✓✓	✓✓	✗[d]	✗[d]	✗[d]	✓✓	✓✓	✓	✓
	Full depth asphalt	✓✓	✓✓	✗[d]	✗[d]	✗[d]	✓✓	✓✓	✓	✓
	Concrete	✓✓	✓	✗[d]	✗[d]	✗[d]	✓✓	✓✓	✓	✓
	Concrete segmental pavers	✗[d]	✗[d]	✗[d]	✗[d]	✓	✗[d]	✗[d]	✓	✓

✓✓ Most suitable ✓ Adequate performance ✗ Not recommended

Notes:

a. Pavement types recommended are based on design for free-flowing traffic. For high stress conditions such as turning traffic, accelerating and braking traffic and on steep grades, other considerations may govern.

b. This type of pavement can be used successfully in this road class but very good quality control of materials and construction processes, together with good maintenance, are required.

c. Generally require high maintenance.

d. Usually uneconomic when considered on whole-of-life cost basis.

e. May be difficult to achieve satisfactory structural design.

Source: adapted from APPA (2002).

Table 8.1: Road classes

Ref 1 : 8.2

Road class [2]	Description of function	Perceived importance	Project reliability [1]	Design ESAs range
Rural classes				
1	Principal links between major regions and capital cities	Very important	Very high	10^6–10^8
2	Linking capitals and key towns, capitals and major regions	Important	High	10^5–10^7
3	Linking important centres, Class 1 and 2 roads and rural arterials	Less important	Medium	10^5–10^6
4	Provides access to abutting property.	Low importance	Low	10^4–10^5
5	One type of activity and not Class 1, 2, 3 or 4	Not important	Very low	$<10^4$
Urban classes				
6	Main link that performs massive traffic movements.	Very important	Very high	10^7–10^9
7	Supplements Class 6 by distributing to local streets	Important	High	10^5–10^7
8	Provide access to abutting property	Less important	Medium	10^4–10^5
9	One type of activity and not Class 6, 7 or 8	Low importance	Low	$< 10^5$

Notes:

1. *The desired project reliability is the chance that the pavement being considered will carry its design traffic before reaching a terminal level of serviceability, given that:*
   - *the pavement is designed in accordance with established procedures*
   - *the pavement is constructed and maintained in accordance with industry standard specifications*
   - *materials used meet the industry standard specification requirements*
   - *the desired project reliability is chosen by the designer.*
2. *The classifications provided in the table are indicative only and do not necessarily relate to SRA Network Rankings. By rationally assessing the risks associated with any type of pavement type and road class, the level of project reliability can be varied to suit individual needs.*

Source: AAPA (2002).

Binders & Layer thickness

Ref 5 : 1.1

Guidance[1] on the selection of binder grade for use in dense graded asphalt is provided in the table below.

Application	Traffic Volume (Average Daily ESAs in the Design Lane in the Year of Opening)		Typical Binders
	Free Flowing	High Shear[2]	
Surfacing layer	< 1000	< 300	C320
	< 3000	< 1000	M1000[3]
	All	All	A15E[4]
Layer below surfacing	< 3000	< 1000	C320
	All	< 3000	C600, M1000
	All	All	A15E[4]
Layers covered by at least two layers of asphalt	All	< 3000	C320
	All	All	C600, M1000, A15E[4]

[1] This table has been developed to assist designers in selecting binders to optimise performance outcomes on projects. Mixes may be used outside these parameters and still provide acceptable long-term performance.

[2] High shear areas include signalised intersections and approaches, roundabouts and approaches, and other areas with very slow moving heavy vehicles. For bus stops, busways and bus-only lanes, specialist advice should be sought from the Principal Engineer (Asphalt and Surfacings).

[3] M1000 typically has a shorter oxidation life than C320 and A15E binders. More frequent resurfacing should be anticipated where M1000 binder is used in surfacing layers.

[4] A15E binder is typically used in situations where enhanced deformation and/or fatigue resistance is desired.

Ref 5 : 8.6

8.6 Course and layer thicknesses

A course of dense graded asphalt may be comprised of more than one layer. Where a course is comprised of more than one layer, and the layer thicknesses have not been specified, the Contractor shall nominate the thickness of each layer in the AQP.

8.6.1 Nominated layer thickness

The nominated thickness of a layer of asphalt must be within the limits specified in Table 8.6.1.

Table 8.6.1 – Nominated layer thickness limits

Asphalt Type	Nominal Size of Asphalt (Asphalt Designation)	Layer thickness (mm)	
		Minimum	Maximum
Dense graded asphalt	7 mm (AC7M and AC7H)	25	35
	10 mm (AC10M and AC10H)	35	50
	14 mm (AC14M and AC14H)	50	70
	20 mm (AC20M and AC20H)	60	100
Open graded asphalt	10 mm (OG10)	25	35
	14 mm (OG14)	35	45
Stone mastic asphalt	10 mm (SMA10)	35	40
	14 mm (SMA14)	50	60

Table 2.2: Typical asphalt layer thickness

Nominal mix size (mm)	Compacted layer thickness (mm)
5	15 to 20
7	20 to 30
10	25 to 40
14	35 to 55
20	50 to 80
28	70 to 110

Ref 2

Polymer Modified Binders

3.4.3 Polymer Modified Binder

Ref 2: 3.4.3

Polymer modified binders (PMBs) are generally used to enhance the properties of bituminous binders in order to improve performance on heavily trafficked pavement surfaces, areas of high shear stresses and in some cases, greater flexibility. Performance gains include increased elasticity, improved cohesion, and reduced temperature susceptibility thus improving flexibility, cohesion or resistance to deformation of asphalt mixes at high temperatures.

A wide range of polymer types can be successfully incorporated into bitumen. In practice, a relatively small range of synthetic polymers, as well as crumbed rubber, are used in bituminous materials in Australasia.

The grades and classes of modified binder are set out in the *Specification framework for polymer modified binders* (Austroads Test Method AGPT/T190) and guidelines are covered in Austroads (2008b) and Austroads (2013a).

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6.2 Specification and Class of PMBs

Ref 3 : 6.2

The Australian PMB specification is listed in AGPT/T190 *Specification Framework for Polymer Modified Binders*. The specification includes a number of classes of hot binders which are available commercially in Australia which are used in sprayed sealing and HMA applications. AGPT/T190, however, does not include all potential PMB types that may be suitable for these applications. PMBs used in other types of applications (e.g. microsurfacing and crack sealing) are also not included in this specification.

The PMB classification grading system included in AGPT/T190 uses a coding system to primarily indicate the application and polymer type of the PMB as follows:

- **S** for **S**ealing applications of PMBs, followed by a 2-digit code and a polymer type code
- **A** for **A**sphalt applications of PMBs, followed by a 2-digit code and a polymer type code.

Polymer type codes used for this coding system are:

- **E** for **E**lastomeric types (Section 6.2.1)
- **P** for **P**lastomeric types (Section 6.2.2)
- **R** for crumb **R**ubber materials (Section 6.2.3)
- **RF** for crumb **R**ubber binders that are '**F**ield-produced' (Section 6.2.3).

Ref 3 : 6.2

Asphalt grade	SBS 6%	A10E
	SBS 5%	A15E
	SBS 4%	A20E
	(PBD)	A25E
	EMA[7]	–
	EVA[8]	A35P
	Crumb rubber	A27RF

Ref 3 : Table 6.1

Table 6.3: Asphalt classes of PMB — Ref 3 : Table 6.3

Class	Description
A10E	A PMB typically manufactured with an SBS polymer to achieve a very high level of elastomeric polymer modification. A10E is mainly used for improving deformation resistance and the fatigue performance of dense-graded asphalt (DGA) for demanding applications. It is used in Southern Australia in open-graded asphalt (OGA) and stone mastic asphalt (SMA) in very heavy traffic loading environments.
A15E	A PMB typically manufactured with an SBS polymer to achieve a high level of elastomeric polymer modification providing enhanced rutting and/or fatigue performance for DGA. It is sometimes used in SMA and OGA in heavy traffic loading environments.
A20E	A PMB typically manufactured with an SBS polymer to achieve a medium level of elastomeric polymer modification with applications similar to A25E where a more viscous binder is required. A20E is also used for enhancing the rutting or fatigue performance of DGA in less demanding sites.
A25E	A PMB typically manufactured with a PBD polymer to achieve a low level of elastomeric polymer modification. A25E can be used to provide improved temperature susceptibility and reduced binder drain-off in OGA and SMA applications and improved durability in OGA.
A35P	A PMB typically manufactured with an EVA polymer to achieve a high level of plastomeric polymer modification. Applications include maximising rut resistance for very heavy duty locations and where high surface stresses occur such as heavy vehicle turning areas, race-track surfaces and container terminals.
A27RF	Crumb rubber, 25–30% by weight of the total binder, is added to the mixing chamber of an asphalt plant using the 'dry process' (Section 6.2.3) to produce a rubber-modified asphalt. This produces an asphalt with very high fatigue resistance for specialised applications such as over jointed concrete pavements.

6.2.1 Elastomers — Ref 3 : 6.2.1

Elastomers provide flexibility and elasticity leading to improved resistance to cracking and permanent deformation. They are used in sprayed seals and asphalt to make the binder more flexible and resilient, as well as in crack sealing materials and some emulsion applications.

The most common elastomeric polymers used in Australia include:

- **SBS (styrene-butadiene-styrene)**: SBS is the predominant polymer type used in modified binders. At high concentrations, it is particularly useful for crack control in strain alleviating membrane (SAM) and strain alleviating membrane interlayer (SAMI) applications and for improved resistance to permanent deformation and fatigue in asphalt. At lower concentrations, it is used for improved cohesion and durability in OGA, and for improved service life in sprayed seals. SBS polymers can also be incorporated into emulsions for sprayed sealing, microsurfacing and crack sealing applications.
- **PBD (polybutadiene)**: PBD modified binders generally have good adhesion characteristics and are used in sprayed sealing applications where cohesion and a moderate level of flexibility are required. These binders can also be used in thin surfacing asphalt applications.
- **Natural rubber**: Natural rubber in a latex form can be used in modified emulsions for sealing and microsurfacing applications.

6.2.3 Crumb Rubber — Ref 3 : 6.2.3

Crumb rubber is obtained from the shredding, grinding or cryogenic processing of scrap rubber from vehicle tyres. The crumb rubber particle size and shape (morphology) arising from the method of manufacture are important parameters that affect the performance of the crumb rubber blend with bitumen. When blended with bitumen, the material behaves as a form of elastomer, but the resulting binder is a composite of discrete particles dispersed in a liquid, and therefore behaves sufficiently differently from other elastomers to warrant a separate category. When incorporated in sprayed seals and asphalt, the highly elastic rubber particles contribute significantly to the performance of the binder.

For use in sprayed seals, crumb rubber binders are broadly divided into two groups:

Factory-produced/plant-manufactured

'Factory-produced' or 'plant-manufactured' crumb rubber binders are bitumens modified with crumb rubber and generally with additives (e.g. combining oil). Production is generally remote from the application site. The Austroads PMB specification (AGPT/T190) provides one grade (i.e. S45R) for this type. This type is also known as 'crumb rubber modified binder' to distinguish it from the other type below.

Table 5.1: Guide to the selection of asphalt PMBs and multigrade bitumens

Ref 1 : Table 5.1

Application	Service condition		Binder class							
	Traffic	Temperature	M500/ 170	M1000/ 320	A27RF[1]	A35P	A25E	A20E	A15E	A10E
Rutting resistance	Very heavy	All		✓		✓				✓
	Heavy	High or medium	✓	✓		✓			✓	✓
Fatigue resistance (marginal pavement)	Very heavy to heavy	All			✓				✓	✓
Rutting and fatigue (marginal pavement)	Very heavy to heavy	All							✓	✓
	Medium							✓	✓	✓
Rutting and fatigue (adequate pavement)	Very heavy to heavy	High or medium		✓				✓	✓	✓
		Low	✓	✓	✓			✓	✓	✓
Open graded asphalt	Very heavy to heavy	High				✓			✓	✓
		Medium or low				✓	✓	✓	✓	
	< Heavy	All				✓	✓	✓	✓	
Stone mastic asphalt	Heavy	All		✓			✓	✓	✓	✓

Notes:
✓ indicates suitable binder class
Crumb rubber modified asphalt (dry mix to A27RF Class) has provided excellent performance over cracked pavements in road trials along with good rutting resistance.
Source: Austroads (2006c)

Asphalt Replacement and/or Asphalt Overlay -Underlying Seal (SAMI)

Ref 2 : 2.4.2

2.4.2 Treatment Types

Rehabilitation may involve the provision of structural overlay to improve the strength of the pavement or a non-structural overlay where the primary purpose is to provide a new wearing surface without significantly changing the strength of the pavement.

Overlay treatments can be combined with a strain alleviating membrane interlayer (SAMI) to waterproof the pavement or reduce reflective cracking prior to placing the overlay.

Ref 2 :

4.3.2 Polymer Modified Binders (PMBs)

Polymer modified binders (PMBs) are used in sprayed sealing work to achieve enhanced performance where there is a need to:

- improve shear resistance in high-stress (vertical and horizontal) applications
- minimise or delay reflection cracking
- reduce water penetration

- improve aggregate retention
- reduce temperature dependence
- reduce oxidation in high temperature regimes.

PMBs can be used in sprayed sealing applications for high stress seals (HSS), strain alleviating membranes (SAMs) and strain alleviating membrane interlayers (SAMIs).

A detailed guide to PMB classes and applications is provided in the *Guide to Pavement Technology – Part 4F: Bituminous Binders* (Austroads 2008c) and (Austroads 2006c). A summary of the guidelines for the use of PMBs in HSS, SAM and SAMI applications is provided in Table 4.1. This lists possible applications without necessarily identifying the optimum material for each case.

Table 4.1: Selection of PMB and multigrade bitumen

Application	Service condition				Binder class					
	Cracking		Traffic		S10E	S20E	S25E	S35E	S45R S15RF	S18RF
	Activity	Width severity	Site severity	Loading						
HSS	NA	NA	Severe	All		✓		✓	✓	
			Moderate	Heavy		✓		✓	✓	
				Medium		✓		✓	✓	
SAM	Slow	All	NA	All	✓			✓	✓	
	Rapid	High	NA	All		✓	✓			✓
		Low	NA	All		✓	✓		✓	
SAMI	All	All	NA	All			✓			✓

✓indicates suitable binder class
Source: Austroads (2006c)

Section 6 — Whole of Life Costing and Environmental Outcomes

Whole of Life Costing & Environmental Outcomes for Bitumen Seals – Technical Information & Good Practice Guide

Executive Summary

Thirty-year Whole-of-Life Cost (WoL) analysis suggests that moving to a Crumbed Rubber or Polymer Modified Binder (PMB) bitumen for reseals not only provides longer life and improved crack resistance, it can cost the same or less than an equivalent C170 seal regime (currently used). The lower cost over 30 years is due to the additional life provided by the higher quality seals (refer Attachment E).

A full explanation of Whole-of-Life costing and associated assumptions is provided in this document. It should be noted that C170 bitumen is the most common used in FNQ reseal history and forms the basis of all comparisons.

The **CO2 footprint** for **crumbed rubber** is **25-27% lower** than C170 bitumen, when calculated on a 30-year-WoL cost basis. If a bio-binder is introduced the CO2 footprint for a bio-crumbed-rubber is lowered further to 60% of C170 bitumen. The CO2 footprint for a **PMB** is **19-23% higher** than C170 bitumen, when calculated over a 30-year-WoL cost basis. When a bio-binder is introduced the CO2 footprint of a **bio-PMB is 6-10% higher** than C170 bitumen.

In broad terms, when compared to C170 bitumen (currently used), **the introduction of Crumbed Rubber bitumen lowers long term costs and decreases the CO2 footprint.** The use of crumbed rubber, which is produced by the recycling of vehicle tyres, **can save around 680,000** (27,000 T) **truck tyres from Landfill over 30 years.** Crumbed rubber also provides the added advantages of better resistance to cracking which in turn maximises waterproofing of the underlying gravel pavement, and will assist in minimising future pavement maintenance costs. Some bitumen spraying contractors are reticent to spray crumbed rubber and this is discussed further in Section1. Polymer Modified Bitumen long term costs are also cheaper than C170 bitumen, however the CO2 footprint increases between 6% - 23% depending on whether bio-binders are utilised.

It should be noted that the purchase price of Crumbed Rubber bitumen costs 5% more than C170 bitumen and PMB costs 9% more than C170 bitumen. These additional costs require a corresponding increase in initial cash flow but in the long-term will provide cheaper 30-year WoL cost due to the additional life they can provide. Both products provide better resistance to cracking and maintain a higher standard of waterproofing and aggregate retention. Waterproofing is obviously very important as FNQ experiences some of the highest rainfall in Australia.

In FNQ, many councils are already deficient in the funding applied to the reseal program because they are not achieving reasonable network coverage rates. This further magnifies the funding challenge. Good Practice Guide 02, Reseals and Asphalt Strategy and it's Key References are helpful here.

Both crumbed rubber and PMB bitumen products can be modified with a bio-binder (< 10% bitumen volume replacement) to reduce the CO2 footprint. However, these bio-binders currently come at an increased price, see cost summary below in Tables 1 and 2.

If moderate crack resistance is required then **crumbed rubber** (Cr Rub) can be implemented, with the added advantage of saving 100,000's of truck tyres from Landfill over 30 years. When compared to C170 bitumen (currently used), it can be shown that the 30-year WoL cost for S15R Crumbed Rubber is 7-9% cheaper and has a nett reduction in CO2 emissions of 25-27%, on average. Likewise, the introduction of a bio-binder, such as

Puma's CarbonBind, demonstrates a 4-7% 30-yr WoL cost reduction and a massive 60% CO2 emissions reduction. An initial increase in cashflow between 5-8.5% is required to fund the higher quality crumbed rubber bitumen binder for the first cycle of reseals (10 – 14 years). The 2025 values have remained in the table below for comparison purposes. They are displayed in 'struck-out' fashion and reveal the cost and CO2 sensitivities when compared to 2026 outputs. Refer to the last paragraph of the Executive Summary for further explanation.

Table 1. 10mm Reseal, C170 vs Crumbed Rubber. Reseal Cost & 30-Year-WoL Cost

		10mm Total Reseal Cost[1] ($/m2) per Bitumen Type			**30-yr WoL Cost[2] ($/m2) / CO2[4] (kg/m2) per Bitumen Type**			**Number of Truck Tyres Saved from Landfill over 30 yrs** (FNQ Network)
Year	**C170 Cost ($/T)**	**C170**	**S15R Cr Rub**	**S15R Carbon-Bind Cr Rub**	**C170**	**S15R Cr Rub**	**S15R Carbon-Bind Cr Rub**	
~~2025~~	~~1,580~~	~~5.61~~	~~5.99~~	~~6.23~~	~~30.33 / 3.38~~	~~28.93 / 3.57~~	~~29.70 / 2.36~~	
2026	2,085	7.40	7.78 (+5%)	8.03 (+8.5%)	30.29 / 4.23	27.74 / 3.12	28.62 / 1.68	681,146 (27,246 T)
			Average % Change [3] from C170 -ve = decrease = improvement +ve = increase = poorer outcome			**-9% / -27%**	**-7% / -61%**	

Note 1 : Average Total Reseal Cost across geographic centres used. Total Reseal Costs in the Cooktown area, are 7-8% higher on average than the cost values shown.
Note 2 : The 30-yr WoL cost varies for each geographical centre based on Pavement Temperature which affects bitumen life. The values shown in the Table above are the lowest calculated. Costs for all Centres are provided in Attachment C.
Note 3 : The Average change is calculated across all geographical centres.
Note 4 : CO2 values have been taken from industry advice provided by Puma Bitumen and their Lifecyle Analysis. It also reflects international standards and those values adopted by the AfPA (Australian Flexible Pavement Association).

If high crack resistance is required, then **PMBs** are the only choice.
When compared to C170 bitumen (currently used), it can be shown that the 30-year WoL cost for a S15E PMB is 9-12% cheaper but has a nett increase in CO2 emissions of 19-23%, on average. The introduction of a bio-binder, such as Puma's CarbonBind, demonstrates an 9-12% 30-yr WoL cost reduction and an increase CO2 emissions of 6-10%, when compared to C170. An initial increase in cashflow around 9% is required to fund the higher quality PMB bitumen binder for the first cycle of reseals (10 – 14 years). The 2025 values have remained in the table below for comparison purposes. They are displayed in 'struck-out' fashion and reveal the cost and CO2 sensitivities when compared to 2026 outputs. Refer to the last paragraph of the Executive Summary for further explanation.

Table 2. 10mm Reseal, C170 vs PMB. Reseal Cost & 30-Year-WoL Cost

		10mm Total Reseal Cost[1] ($/m2) per Bitumen Type			30-yr WoL Cost[2] ($/m2) / CO2[4] (kg/m2) per Bitumen Type		
Year	**C170 Cost ($/T)**	**C170**	**S15E PMB**	**S15E Carbon-Bind PMB**	**C170**	**S15E PMB**	**S15E Carbon-Bind PMB**
~~2025~~	~~1,580~~	~~5.61~~	~~6.29~~	~~6.29~~	~~30.33 / 3.38~~	~~28.77 / 4.35~~	~~28.77 / 3.86~~
2026	2,085	7.40	8.09 (+9%)	8.09 (+9%)	30.29 / 4.23	27.19[5] / 5.09	27.19[5] / 4.56
			Average % Change [3] from C170 -ve = decrease = improvement +ve = increase = poorer outcome			**-12% / +19 %**	**-12% / +6%**

Note 1 : Average Total Reseal Cost across geographic centres used. Total Reseal Costs in the Cooktown area, are 7-8% higher on average than cost values shown.
Note 2 : The 30-yr WoL cost varies for each geographical centre based on Pavement Temperature which affects bitumen life. The values shown in the Table above are the lowest calculated. Costs for all Centres are provided in Attachment C.
Note 3 : The Average change is calculated across all geographical centres.
Note 4 : CO2 values have been taken from industry advice provided by Puma Bitumen and their Lifecyle Analysis. It also reflects international standards and those values adopted by the AfPA (Australian Flexible Pavement Association).
Note 5 : S15E and S15E Carbon Bind (Bio Binder) are listed as the same price. This appears to be a temporary commercial decision to encourage the use of bio-binders. It is unsure if this equal pricing is sustainable.

During the devolvement of this document between September 2025 and May 2026, the CO2 attributed to the standard bitumen grade C170 increased and the CO2 attributed to crumbed rubber decreased to better allow for the latex carbon negative components. The bitumen price increased due to world oil volatility (March-April 2026). These elements have been taken into account by the analysis and the results reported. In summary, whilst costs have increased the relativity of the 30-year WoL cost analysis has remained the same. CO2 values have significantly changed. The analysis spreadsheets developed for FNQROC, have been established to allow easy entry of any modified input data, which in turn allows study of any future updated values.

This Good Practice Guide provides technical information addressing:

1. The Bitumen Industry in FNQ
2. Detailed Whole-of-Life Analysis : Technical Assumptions, Details and Explanation
    2.1. Whole-of-Life Analysis – What is it?
    2.2. Technical Industry Information for use in Whole-of-Life Cost and CO2 Analysis
    2.3. WoL Analysis FNQROC – Inputs and Outputs – Brief Overview
3. Conclusions
4. Indicative Road Network Reseal Funding required

1. The Bitumen Industry in FNQ

At the time of writing this document the bitumen industry in North Queensland / Far North Queensland operates with three functioning elements which include : Bitumen Suppliers (Base bitumen storage), Bitumen blenders/retailers, Bitumen Spraying Contractors and Asphalt manufacturers/laying Contractors.

(Base) Bitumen Suppliers (Townsville)	Bitumen Retailers (Blends of Bitumen) (Townsville)	Bitumen Spraying Contractors (Cairns)
Viva	Ixom (previously Bituminous Products)	RPQ/Downer
		PNQ (Heidelberg)
Puma	Puma	Boral
	Fulton Hogan	FGF
		Koppens

The majority of bitumen products can be provided from Townsville including Standard Cutback Bitumen (AMC00, etc), C170, C320, Crumbed Rubber blends, PMB blends, some Bio-blends (increasing array due by late 2026). There is some storage capacity in Cairns.

However, emulsions, multigrades M500, M1000, grade C600 and some bio-blends of bitumen require transportation from Brisbane.

Crumbed rubber has been gaining an increasing market share over the past decade with Carroll Engineering, located in Townsville, providing crumbed rubber to the bitumen industry. Carrol Engineering uses truck and major industry plant tyres (not car tyres), mainly from North Queensland, to process the tread (the walls have too much steel) into crumbed rubber. Crumbed rubber processing does leave small traces of steel (from tyres) in the product and this presents a challenge by causing increased wear to bitumen pumps in all parts of the storage, mixing and spraying process.

This is one reason why some spraying contractors are reticent to implement crumbed rubber in FNQ. Some spraying contractors would likely not make the move to crumbed rubber unless there is a sufficient quantity and long term commitment. Industry information indicates that the slight increase in operational costs to cover additional pump wear, possible extra tanks, more controlled heating and mixing, and cleaning practices, is not significant over the long term and is recouped by the sale price.

Another challenge is the mixing, storage and transport within a well controlled temperature range. If crumbed rubber is over-heated for certain periods of time, product degradation occurs rapidly. Also, constant and good mixing process is required to avoid segregation of the crumbed rubber from bitumen. In general, simple and easily implemented controls can be put in place to ensure the crumbed rubber product meets specification compliance.

Carroll Engineering also has a crumbed rubber plant in SEQ which provides a backup crumbed rubber resource to their Townsville plant, if required. Tyre Cycle is another major crumbed rubber supplier in SEQ.

2. Detailed Whole-of-Life Analysis : Technical Assumptions, Details and Explanation

This section of the report address :

(i) Whole-of-Life Analysis – What is it?
(ii) Technical Industry Information for use in Whole-of-Life Cost and CO2 Analysis
(iii) WoL Analysis FNQROC – Inputs and Outputs

2.1 Whole-of-Life Cost Analysis – What is it ?

Whole-of-Life Cost Analysis, also referred to as Life Cycle Analysis, is the economic calculation of engineering treatments over a long term asset ownership period, typically 30 years or more, to identify the lowest life cycle cost solution.

A typical asset related example is the use of a more expensive product with increased durability (life) compared to a cheaper product with less durability (life). Assuming the products can be re-applied at the end of their life, both can be compared over a long asset ownership timeframe (several re-application cycles), with analysis indicating the most cost effective solution for the asset owner.

AGPT04K-18, Guide to Pavement Technology Part-4K Selection -Design Sprayed Seals, defines Whole-of-Life Costing in section 2.2.3, as follows:

> **2.2.3 Whole-of-life Costing**
>
> Whole-of-life costing recognises all user costs and road construction and maintenance costs that are expected in the long term and is used to evaluate alternative treatments that have different construction and maintenance cash-flow streams.
>
> Cost elements should include construction and future maintenance and rehabilitation, as well as user costs. User costs can include increased vehicle operating costs due to deteriorated pavement roughness and delay expected during maintenance and rehabilitation activities.

Part 4K also states:

> The life of sprayed seals is influenced by climate including such effects as seasonal temperature variation, moisture change in pavement materials and binder oxidation at high temperatures. These factors will influence both the type of treatment and frequency of retreatment. Rainfall may also influence the choice of treatment to achieve particular texture levels without compromising waterproofing.

In a comparison of different seal and binder types the ‘user costs’ side of the economic equation would be considered identical for various bitumen seal options. **Therefore, this analysis has a focus on the ‘product cost’ side of the equation and ignores ‘user costs’.** This is useful and reasonable, as Council’s are mainly interested in the affordability of various options over time, and do not generally consider ‘user costs’ as a major decision trigger.

Typically, when economists undertake whole of life analysis they apply cost inflation for future cost escalation and then apply discounting rates to express these future costs in today’s monetary value.

This WoL affordability analysis simplifies the approach by applying 2026 monetary value for all treatments and expresses all values in 2026 $. This provides a simplistic view for the comparison of affordability purposes only. If future budgets (usually 3-5 years) are to be derived from this information, each future year should individually have cost escalation applied (typically 3%/yr average).

The key parameter in the WoL analysis is Bitumen Seal Life. Bitumen Seal Life is dependant on the following factors:

(i) Seal type : S/S or D/D

(ii) Aggregate size (mm) : 7, 10, 14, 14/7, 14/10, 20/10

(iii) Binder Types : C170, Crumbed Rubber (S15R) & PMB (S15E ≈ 4% SBS Polymer, Medium level of elastic polymer modification) and two CO2 improved environmental outcomes.

(iv) The bitumen hardening Life (Y) for C170 has been calculated based on:

The resulting seal life model, *Y* (years), is defined as follows:

$$Y = \left[\frac{0.158 \times TMIN - 0.107 \times R + 0.84}{0.0498 \times T - 0.0216 \times D - 0.000381 \times S^2} \right]^2$$

where

Y = seal life (years)

T = (*TMAX* + *TMIN*)/2

TMIN = yearly mean of the daily minimum air temperature (^{0}C)

TMAX = yearly mean of the daily maximum air temperature (^{0}C)

D = the ARRB Durability Test result (days, usually taken as 8 to 10)

S = nominal size of seal (nominal stone size, mm)

R = risk factor with a scale from 1 (very low risk) to 10 (very high risk).

Ref : *Austroads, AP-T160-10, Asphalt and Seal Life Prediction Model Based on Hardening (Arrb, Mr John Oliver)*

It is considered that the Crumbed rubber (S15R) and PMB (S15E ≈ 4% SBS) options chosen are good representations/surrogates of the suite of crumbed rubber and PMBs generally used on road networks, with seal life and costs not varying significantly for other types.

2.2 Technical Industry Information for use in Whole-of-Life Cost and CO2 Analysis

There are many technical components and inputs into the WoL analysis. This section outlines the references and values used in the analysis.

- The **bitumen binder supply-to-site cost** averages 54% (51%-60%) of the total SS reseal cost ($/m2) and is dependent on location and size (area, m2) of the project. Transport to site is included in these FNQROC figures. Based on FNQROC 2024/25 reseals.

- The estimated **Supply of Binder (C170) ex Storage** averages 41% of the total SS reseal cost ($/m2). Cook Shire Council experienced 30-33% in 2024/25 due to small quantities, large transport distances and DD seal types.

- The **bitumen binder supply cost ex-storage (Townsville)** varies for Binder Types. Based on C170 prices, the percentage increases are expressed as follows:
  - **C170** = 1.0 (2025 : ≈ $1,580/tonne, at 962 Litres/Tonne, ≈ $1.64/Litre)
    (2026 : ≈ $2,085/tonne, at 962 Litres/Tonne, ≈ $2.17/Litre)
  - **S15R** (Crumbed Rubber) = x 1.15
  - **S15E** (PMB ≈ 4% SBS) = x 1.30

- Puma's **CarbonBind S15R** (Enviro Crumbed Rubber) = x 1.25
- Puma's **CarbonBind S15E** (Enviro PMB) = x 1.30

Sustainability and product data referenced are based on information provided by Puma Bitumen at the time of the project and reflect typical Queensland operations. Figures are indicative only and may change as production processes or data sources are updated.

- Advice from NTRO indicates the **Durability of C170 bitumen in Queensland** is generally considered to be 8 days (Durability test method) and has been used in the calculation of bitumen life in FNQ for various locations with specific BoM temperature data.
  This is based on verbal discussion with bitumen experts from the National Transport Research Organisation (NTRO) in 2025.

- **Bitumen Seal life research work in Australia** has not been consistently well funded since the 1970's, despite millions of litres used per annum. A lack of scientific and engineering data exists for the life of various binders. Accordingly, the best industry average advice (NTRO) is as follows:
  - The Bitumen Life attributed to Crumbed Rubber is C170 Life + 2 Years
  - The Bitumen Life attributed to PMBs is C170 Life + 3 Years

  These lives have been utilised in the WoL cost and CO2 analysis.
  This is based on verbal discussion with bitumen experts from the National Transport Research Organisation (NTRO) in 2025.

- Whilst there are varying road asset standards and condition for pavement and surfacing around FNQROC, the general consensus, with the exception of Cairns Regional Council which have indicated a low risk environment, is:
  - Pavement materials are often non-standard materials (local gravels, marginal materials)
  - Pavement thickness does not always match design standards, especially thin old pavements
  - Seal life has not always been managed well and old seals exist, with cracking evident
  - Many roads are exposed to Semi Trailer and B-Double heavy vehicles, concentrated season HV movements, with some western areas accommodating Type 1 & 2 Road Trains.
  - FNQ has a high rainfall risk
  - **Due consideration of the above risks arrives at a Risk Factor of 8 for use in the Bitumen Life Hardening Model, with the results generally meeting industry expectations on bitumen life as shown in the Tables attached.**

- Puma's **CarbonBind Products** effectively remove ≤ 10% of bitumen and replace with a Plant-Based Oil Product to achieve the improved environmental outcomes whilst maintaining bituminous product performance.
  (Ref : Puma Bitumen, Email Technical advice, 2025; 2026)

- **Table 2.1** Bitumen binder Type vs CO2 Global Warming Potential (GWP)

		Global Warming Potential (GWP) (kg of CO2/Tonne of Binder)				
	C170	**CarbonBind C170**	**S15R****	**CarbonBind S15R****	**S15E**	**CarbonBind S15E**
~~2025 ; first analysis~~	~~425~~	~~235~~	~~471~~	~~246~~	~~664~~	~~565~~
Feb 2026 ; new values	710	516	539	290	949	850

** 2026 values now Include negative carbon offsets for Latex Rubber in crumbed rubber, and hence its lower than C170 (standard bitumen) value.

(Ref : Puma Bitumen, Email Technical advice, 2025; 2026)

Note : Carbon Bind C170 has not been used in the WoL cost analysis and is shown here for CO2 comparison.

- Industry has calculated a broad/general rule that: 2/3 of the CO2 emissions for a reseal is due to the binder type, with the other 1/3 of CO2 emissions relating to transport to site, other materials and construction. The transport, other materials and construction components would have similar CO2 emissions regardless of type of binder sprayed, and accordingly have been excluded from comparison environmental calculations in this report.

(Ref : Puma Bitumen, Email Technical advice, 2025)

Preparation of data for WoL analysis includes the following calculations :

1. **Binder Life** using the Arrb (John Oliver) Bitumen Hardening Model for Cairns, Cooktown, Croydon, Ingham & Mareeba. Refer to Attachment E for Binder Life Summary.
   The industry standard bitumen binder life calculated by this method is often mistakenly considered by Councils as too conservative. When investigated with Councils, it is evident that there is no technical data to corroborate their position, with Councils working to a Cost-Constrained model which is often driven by available funds and not technical outcomes.
2. **Sprayed Seal designs** for C170 7, 10, 14, 10/7, 14/7, 20/10 seal types (baseline) for medium AADT 300 (15%). Spray rates for crumbed rubber and PMBs are applied from the C170 value.
3. **Industry average market value of C170 ex Townsville**, used as the base supply cost.
4. **A typical Industry percentage increase is applied to baseline C170** (1.0) in order to calculate the cost ($/m2) for binders S15R (x1.15), CarbonBindS15R (x1.25), S15E (x1.3) & CarbonBindS15E (x 1.3).
5. **Total Reseal cost ($/m2)** calculations for all seal types with all binder types, extrapolated from calculated Binder Supply costs & FNQROC 2024/25 reseal data.
6. **CO2 calculations for all seal types and binders, adjusted to kg/m2, based on sprayed L/m2.**
7. **Apply costs and CO2 for a 30 year period** to calculate the whole-of-Life cost for two chosen seal regimes:
   i. 10mm SS reseal regime
   ii. 14/7mm DD reseal regime

The Whole-of-Life calculation is considered a Broad Analysis Technique, in order to provide an indication on the effect on costs, budgets and environmental outcomes. There are a range of averages and assumptions in the data, but they are relative and useful for broad analysis. This includes the technical assumption that 10mm SS or 14/7 DD reseals can be applied on an old 10 or 14/7 seals at the end of its bitumen hardening life. The base assumption for life cycle costing is that a reseal is required at Year zero (0) and then repeated at the bitumen life intervals until it reaches 30 years. Additional seal regimes using a variety of different Initial Seals, therefore affecting the first reseal intervention period, were undertaken. In all cases, whilst the absolute value of the WoL cost varies, the

general patterns remained the same. This would effectively result in slightly different percentage cost reductions and CO2 reduction/increases, as relevant. **Care should be exercised in attempting to use the broad data analysis at a more site specific level. Detailed site specific data would require site specific calculations and values to be run through a suitable model.**

The major parameter in WoL costing is the life of the bitumen which drives the number of treatments over 30 years.

The costs used is an average based on 2024/25 Reseal program. It is a reasonable average unit rate, however it won't always reflect every geographic centre 100% accurately. The cost is reflective of bitumen spray rates for a road with an AADT 300 (15%).

2.3 WoL Analysis FNQROC – Inputs and Outputs - Brief Overview

Inputs. Two reseal life regimes were chosen to calculate and demonstrate the WoL Costs and CO2 outcomes. The regimes chosen were C170 10mm SS reseal and C170 14/7 DD reseal. Cost and CO2 were calculated for all Binders in each Council location (Cairns shown below), as every location has the potential for differing seal life. Please refer to the Spreadsheet FNQROC_WoLC_EnviroCO2_Reseals_April2026.xlsx , for details on all WoL Scenarios considered in the analysis. Attachment C provides a summary.

In the demonstrated example below, it indicates that the 30-Year-WoL cost of a C170 14/7mm DD seal regime is more expensive than a C170 10mm SS seal regime each. It should also be noted that the analysis excludes the Initial Seal Treatments, with the WoL analysis comparing the outcome if a reseal is triggered today at 'Year 0'. This provides a structured analytical process to assess life time cycle costs and a range of scenarios can be reviewed.

Table 2.2 Example of C170 Bitumen Reseal Life Cycle for 2 Reseal Regimes - Croydon

	Simple Network Average Whole-of-Life Costing - Bitumen Seal Network									
	Location/Council : Croydon					Location/Council : Croydon				
	Reseal Regime 1 - 10mm SS (C170, S15R, CBindS15R, S15E, CBindS15E)					Reseal Regime 2 - 14/7 DD (C170, S15R, CBindS15R, S15E, CBindS15E)				
	Scenario 1 (C170 10mm SS Reseals)	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2	Scenario 6 (C170 DD 14/7 Reseals)	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2
~~Treatment 1~~	~~Prime AMC00~~					~~Prime AMC00~~				
~~Treatment 1A~~	~~14mm C170 SS Seal~~					~~20/10mm C170 DD Seal~~				
Treatment 2	(First early application) C170 10mm reseal SS reseal	8.0	0.0	7.40	1.03	C170 14/7 DD Reseal	9.2	0	12.16	1.70
Treatment 3	C170 10mm reseal SS reseal	8.0	8.0	7.40	1.03	C170 14/7 DD Reseal	9.2	9.2	12.16	1.70
Treatment 4	C170 10mm reseal SS reseal	8.0	16.0	7.40	1.03	C170 14/7 DD Reseal	9.2	18.4	12.16	1.70
Treatment 5	C170 10mm reseal SS reseal	8.0	24.0	7.40	1.03	C170 14/7 DD Reseal	9.2	27.6	12.16	1.70
Treatment 6	C170 10mm reseal SS reseal	8.0	32.0	7.40	1.03	C170 14/7 DD Reseal	9.2	36.8	12.16	1.70
	April 2026 C170 Bitumen cost = $2,085/Tonne		AT 30 Years	35.15	4.91	April 2026 C170 Bitumen cost = $2,085/Tonne		AT 30 Years	51.81	7.23
Carbon Price (2025)	$70/tonne of CO2	70	$/m2 of C02		0.34	$70/tonne of CO2		$/m2 of C02		0.51
			CO2 % Cost		1.0%			CO2 % Cost		1.0%

Note. April 2026 Industry average market value of C170 ex Townsville is used in conjunction with FNQROC's 2024/25 Reseal prices to calculate the Reseal Cost.

Outputs. A comparison of the 30-Year Whole-of-Life Cost and CO2 emissions for the two seal regimes is provided in the charts below. The data used in the calculations is summarised and attached for reference.

It indicates that on a whole-of life-cost (30yrs) basis :

(i) SS PMB Seals average \$3.76/m^2 (12%) less than SS C170 seals

(ii) DD PMB Seals average \$4.24/m^2 (9%) less than DD C170 seals

(iii) SS Crumbed Rubber Seals average \$3.05/m^2 (9%) less cost than SS C170

(iv) DD Crumbed Rubber Seal average \$3.52/m^2 (7%) less cost than DD C170 Seals

(v) Unsurprisingly PMBs have the highest CO2 emissions being 19-23% greater than C170. However, PMBs also provide the best life and best protection against cracking.

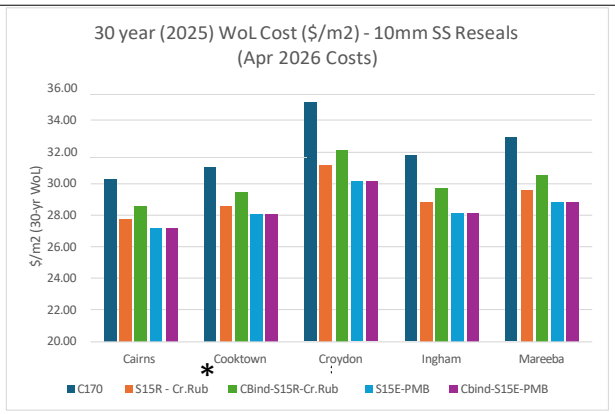
(vi) Crumbed Rubber CO2 emissions average 25-27% lower than C170

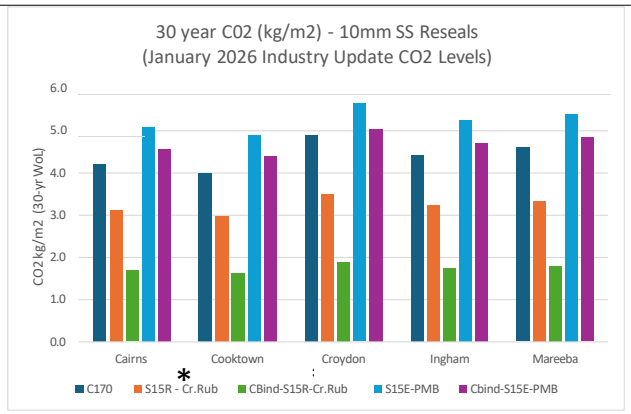
(vii) The CarbonBind S15R Crumbed Rubber has the lowest CO2 emissions and averages 60% less than C170.

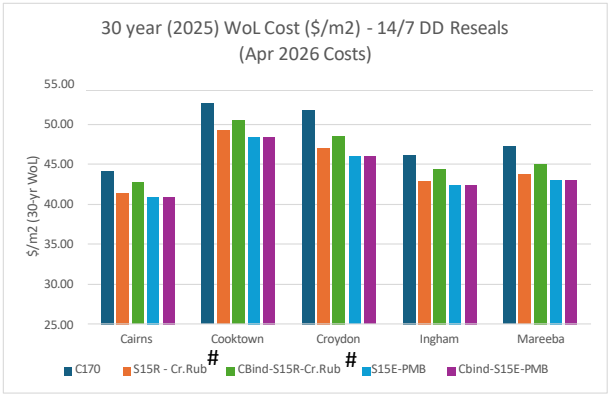
(viii) The use of crumbed rubber, which is produced by the recycling of vehicle tyres, could save approximately 680,000 (27,246 T) truck tyres from Landfill over 30 years, if implemented across FNQROC.

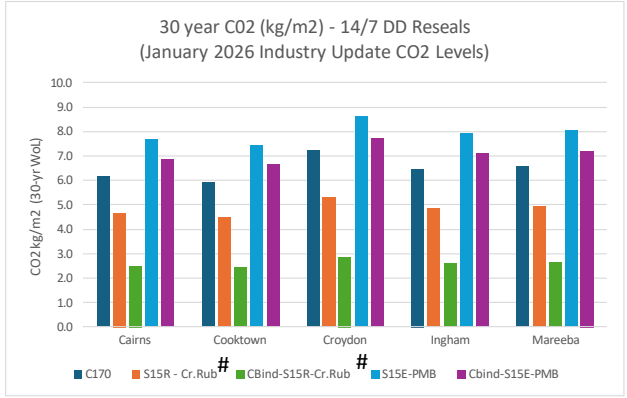
(ix) Other Seal regimes can be modelled, if FNQROC Councils require. The excel spreadsheets provided as part of this project allow Council Engineers to explore further.

Figure 2.1 Graphical Presentation of 30-yr WoL Costs & CO2 for two reseal regimes









*** Crumbed Rubber**

EXAMPLE : Cairns 30 yr Period - 10 SS reseal regime - 5,735,219m2

	30 Years	Per Yr
Tonnes of S15R	36,299	1,210
Truck Tyres saved from Landfill 5 Tyre/1T S15R (#)	181,494	6,050
Tonnes of Tyres (40kg/tyre) Used in Cr Rubber (T)	7,260	242
Landfill cost Saved @ \$70/T (\$)	508,184	16,939

 # Crumbed Rubber

EXAMPLE : Cairns 30 yr Period - 14/7 DD reseal regime - 5,735,219m2

	30 Years	Per Yr
Tonnes of S15R	45,374	1,512
Truck Tyres saved from Landfill 5 Tyre/1T S15R (#)	226,868	7,562
Tonnes of Tyres (40kg/tyre) Used in Cr Rubber (T)	9,075	302
Landfill cost Saved @ \$70/T (\$)	635,230	21,174

Table 2.3 WoL Cost & CO2 Difference when compared to C170 bitumen

Location	Life Reseal Regime	S15R - Cr.Rub				CBind-S15R-Cr.Rub				S15E-PMB				Cbind-S15E-PMB			
		WoL S15R Cr Rub to C170 **cost** diff		WoL **CO2** S15R to C170 diff		WoL CBind S15R Cr Rub to C170 **cost** diff		WoL **CO2** CBind S15R to C170 diff		WoL S15E to C170 **cost** diff		WoL **CO2** S15E to C170 diff		WoL CBind S15E to C170 **cost** diff		WoL **CO2** CBind S15E to C170 diff	
Average 10 SS		**-3.05**	**-9%**	**-1.20**	**-27%**	**-2.14**	**-7%**	**-2.70**	**-61%**	**-3.76**	**-12%**	**0.82**	**19%**	**-3.76**	**-12%**	**0.27**	**6%**
Cairns	10 SS	-2.55	-8%	-1.11	-26%	-1.67	-6%	-2.55	-60%	-3.10	-10%	0.86	20%	-3.10	-10%	0.33	8%
Cooktown	10 SS	-2.40	-8%	-1.02	-25%	-1.56	-5%	-2.40	-60%	-2.93	-9%	0.89	22%	-2.93	-9%	0.37	9%
Croydon	10 SS	-4.02	-11%	-1.41	-29%	-3.03	-9%	-3.02	-62%	-5.01	-14%	0.73	15%	-5.01	-14%	0.14	3%
Ingham	10 SS	-2.98	-9%	-1.20	-27%	-2.06	-6%	-2.70	-61%	-3.66	-12%	0.82	19%	-3.66	-12%	0.28	6%
Mareeba	10 SS	-3.31	-10%	-1.27	-28%	-2.37	-7%	-2.80	-61%	-4.10	-12%	0.80	17%	-4.10	-12%	0.23	5%
Cairns	14/7 DD	-2.73	-6%	-1.51	-24%	-1.42	-3%	-3.66	-59%	-3.19	-7%	1.50	24%	-3.19	-7%	0.70	11%
Cooktown	14/7 DD	-3.34	-6%	-1.41	-24%	-2.08	-4%	-3.49	-59%	-4.07	-8%	1.52	26%	-4.07	-8%	0.74	13%
Croydon	14/7 DD	-4.76	-9%	-1.94	-27%	-3.27	-6%	-4.39	-61%	-5.85	-11%	1.36	19%	-5.85	-11%	0.47	6%
Ingham	14/7 DD	-3.25	-7%	-1.62	-25%	-1.89	-4%	-3.85	-60%	-3.87	-8%	1.47	23%	-3.87	-8%	0.64	10%
Mareeba	14/7 DD	-3.50	-7%	-1.68	-25%	-2.12	-4%	-3.95	-60%	-4.20	-9%	1.46	22%	-4.20	-9%	0.62	9%
Average 14/7 DD		**-3.52**	**-7%**	**-1.63**	**-25%**	**-2.16**	**-4%**	**-3.87**	**-60%**	**-4.24**	**-9%**	**1.46**	**23%**	**-4.24**	**-9%**	**0.63**	**10%**

Note. A negative value indicates a decrease in cost or CO2 emissions when compared to C170 bitumen, providing an improved outcome.
Correspondingly, a positive value indicates an increase in cost or CO2 emissions when compared to C170 bitumen, providing a poorer outcome.

3. Conclusions

Whole-of-Life Cost (WoL) analysis over 30 years suggests that moving to a Crumbed Rubber or Polymer Modified Binder (PMB), not only provides longer life and improved crack resistance, it can cost the same or less than an equivalent C170 seal regime (currently used). The same or lower cost over 30 years is due to the additional life provided by the higher quality seals.

The CO2 footprint for crumbed rubber is 25-28% lower than C170 bitumen, when calculated on a 30-year-WoL cost basis. If a bio-binder is introduced the CO2 footprint for a bio-crumbed rubber is lowered further to 60% of C170 bitumen. The CO2 footprint for a PMB is 19-23% higher than C170 bitumen, when calculated over a 30-year-WoL cost basis. When a bio-binder is introduced the CO2 footprint of a bio-PMB is 6-10% higher than C170 bitumen.

In broad terms, when compared to C170 bitumen (currently used), **the introduction of Crumbed Rubber bitumen lowers long term costs and decreases the CO2 footprint.** The use of crumbed rubber, which is produced by the recycling of vehicle tyres, **can save between around 680,000** (27,246 T) **truck tyres from Landfill over 30 years.** Crumbed rubber also provides the added advantages of better resistance to cracking which in turn maximises waterproofing of the underlying gravel pavement, and will assist in minimising future pavement maintenance costs. Polymer Modified Bitumen long term costs are also cheaper than C170 bitumen, however the CO2 footprint increases between 5% - 14% depending on whether bio-binders are utilised.

It should be noted that the purchase price of Crumbed Rubber bitumen costs 5% more than C170 bitumen and PMB costs 9% more than C170 bitumen. These additional costs require a corresponding increase in initial cash flows but provide cheaper WoL cost over a 30 year period due to the additional life they can provide. Both products provide better resistance to cracking and maintain a higher standard of waterproofing and aggregate retention. Waterproofing is obviously very important as FNQ experiences some of the highest rainfall in Australia.

The higher quality seal selected can either be a Crumbed Rubber binder or Polymer Modified binder (PMB). In addition, both the crumbed rubber and PMB products can be modified with a bio-binder (< 10% bitumen volume replacement) to reduce the CO2 footprint. However, the bio-binders come at an increased price, see cost summary below.

If moderate crack resistance is required then **crumbed rubber** (Cr Rub) can be implemented, with the added advantage of saving 100,000's of truck tyres from Landfill over 30 years. When compared to C170 bitumen (currently used), it can be shown that the 30-year WoL cost for S15R Crumbed Rubber is 7-11% cheaper and has a nett reduction in CO2 emissions of 25-27%, on average. Likewise, the introduction of a bio-binder, such as Puma's CarbonBind, demonstrates a 4-7% 30-yr WoL cost reduction and a massive 60% CO2 emissions reduction. An initial increase in cashflow between 5 - 8.5% is required to fund the higher quality crumbed rubber bitumen binder for the first cycle of reseals (10 – 14 years). The 2025 values have remained in the table below for comparison purposes. They are displayed in 'struck-out' fashion and reveal the cost and CO2 sensitivities when compared to 2026 outputs.

Table 3.1 10mm Reseal, C170 vs Crumbed Rubber. Reseal Cost & 30-Year-WoL Cost

		10mm Total Reseal Cost[1] ($/m2) per Bitumen Type			**30-yr WoL Cost[2] ($/m2) / CO2[4] (kg/m2) per Bitumen Type**			**Number of Truck Tyres Saved from Landfill over 30 yrs** (FNQ Network)
Year	**C170 Cost ($/T)**	**C170**	**S15R Cr Rub**	**S15R Carbon-Bind Cr Rub**	**C170**	**S15R Cr Rub**	**S15R Carbon-Bind Cr Rub**	
~~2025~~	~~1,580~~	~~5.61~~	~~5.99~~	~~6.23~~	~~30.33 / 3.38~~	~~28.93 / 3.57~~	~~29.70 / 2.36~~	
2026	2,085	7.40	7.78 (+5%)	8.03 (+8.5%)	30.29 / 4.23	27.74 / 3.12	28.62 / 1.68	680,000 (27,246 T)
			Average % Change [3] from C170 -ve = decrease = improvement +ve = increase = poorer outcome			**-9% / -27%**	**-7% / -61%**	

Note 1 : Average Total Reseal Cost across geographic centres used. Total Reseal Costs in the Cooktown area, are 7-8% higher on average than the cost values shown.
Note 2 : The 30-yr WoL cost varies for each geographical centre based on Pavement Temperature which affects bitumen life. The values shown in the Table above are the lowest calculated. Costs for all Centres are provided in Attachment C.
Note 3 : The Average change is calculated across all geographical centres.
Note 4 : CO2 values have been taken from industry advice provided by Puma Bitumen and their Lifecyle Analysis. It also reflects international standards and those values adopted by the AfPA (Australian Flexible Pavement Association).

If high crack resistance is required, then **PMBs** are the only choice.
When compared to C170 bitumen (currently used), it can be shown that the 30-year WoL cost for a S15E PMB is 9-12% cheaper but has a nett increase in CO2 emissions of 19-23%, on average. The introduction of a bio-binder, such as Puma's CarbonBind, demonstrates an 9-12% 30-yr WoL cost reduction and an increase CO2 emissions of 6-10%, when compared to C170. An initial increase in cashflow around 9% is required to fund the higher quality PMB bitumen binder for the first cycle of reseals (10 – 14 years). The 2025 values have remained in the table below for comparison purposes. They are displayed in 'struck-out' fashion and reveal the cost and CO2 sensitivities when compared to 2026 outputs.

Table 3.2. 10mm Reseal, C170 vs PMB. Reseal Cost & 30-Year-WoL Cost

		10mm Total Reseal Cost[1] ($/m2) per Bitumen Type			30-yr WoL Cost[2] ($/m2) / CO2[4] (kg/m2) per Bitumen Type		
Year	**C170 Cost ($/T)**	**C170**	**S15E PMB**	**S15E Carbon-Bind PMB**	**C170**	**S15E PMB**	**S15E Carbon-Bind PMB**
~~2025~~	~~1,580~~	~~5.61~~	~~6.29~~	~~6.29~~	~~30.33 / 3.38~~	~~28.77 / 4.35~~	~~28.77 / 3.86~~
2026	2,085	7.40	8.09 (+9%)	8.09 (+9%)	30.29 / 4.23	27.19[5] / 5.09	27.19[5] / 4.56
			Average % Change [3] from C170 -ve = decrease = improvement +ve = increase = poorer outcome			**-12% / +19 %**	**-12% / +6%**

Note 1 : Average Total Reseal Cost across geographic centres used. Total Reseal Costs in the Cooktown area, are 7-8% higher on average than cost values shown.
Note 2 : The 30-yr WoL cost varies for each geographical centre based on Pavement Temperature which affects bitumen life. The values shown in the Table above are the lowest calculated. Costs for all Centres are provided in Attachment C.
Note 3 : The Average change is calculated across all geographical centres.
Note 4 : CO2 values have been taken from industry advice provided by Puma Bitumen and their Lifecyle Analysis. It also reflects international standards and those values adopted by the AfPA (Australian Flexible Pavement Association).
Note 5 : S15E and S15E Carbon Bind (Bio Binder) are listed as the same price. This appears to be a temporary commercial decision to encourage the use of bio-binders. It is unsure if this equal pricing is sustainable.

4. Indicative Road Network Reseal Funding Required

Applying the WoL outcomes to each Council network reveals the cost outcomes displayed in the Table below. If all FNQROC councils moved to Crumbed Rubber bitumen for reseals, the following outcomes would be realised:

A) Total Road Network : Length = 3,590km with an area of 23.3 Million m^2.
B) $675 Million over 30 years (in 2025 $) to complete reseals to industry minimum standard.
(This represents a 9% cost saving over C170 bitumen, currently used.
C) $22.5 Million per annum is required to service this regime of resealing. A saving of $2.3 Million per year when compared to C170 Bitumen, currently used.
D) 27,954 Tonnes of CO2 would be saved over 30 years. (C170 103,365 less S15R 75,411).
This could be stated as an approximate saving of 1,000 tonnes of CO2 per year.
(Crumbed Rubber reseals have an annual CO2 impact of 2,500 tonnes, compared to 3,500 tonnes for C17) bitumen on 30 yr WoL basis)
E) 681,146 (27,246 T) Truck Tyres would be saved from Landfill over 30 years.
This could also be expressed as approximately 1,000 T of Truck Tyres per annum.

It should be noted, that if the costs above are not funded, then the CO2 and Tyre Outcomes would be lower.

Table 4.1 Indicative Road Network Reseal Funding

Council	Bitumen Life based on BoM Location	Seal Area (m2, Million)	Seal Length km	10mm Reseal Scenario						
				C170 Bitumen			Crumbed Rubber S15R Bitumen			
				$ Mill /30 Yrs (2025 $)	S Mill / Year (2025 $)	CO2/ 30 Yrs (Tonne)	$ Mill /30 Yrs (2025 $)	S Mill / Year (2025 $)	CO2/30 Yrs (Tonne)	Number of Tyres Used / 30 Years
Cairns	Cairns	5.735	780	174	5.8	24,259	159	5.3	17,893	161,524
Cassowary	Ingham	4.222	667	134	4.5	18,746	122	4.1	13,679	123,587
Cook	Cooktown	2.345	335	73	2.4	9,402	67	2.2	7,010	63,437
Croydon	Croydon	1.620	210	57	1.9	7,954	50	1.7	5,670	51,266
Douglas	Cairns	1.023	146	31	1.0	4,329	28	0.9	3,193	28,824
Etheridge	Croydon	0.875	125	31	1.0	4,296	27	0.9	3,063	27,690
Mareeba	Mareeba	3.224	582	106	3.5	14,830	95	3.2	10,736	96,924
Tablelands	Mareeba	4.006	709	132	4.4	18,428	119	4.0	13,340	120,434
Yarrabah	Cairns	0.265	36	8	0.3	1,121	7	0.2	827	7,462
Total		**23.315**	**3,590**	**745**	**24.8**	**103,365**	**675**	**22.5**	**75,411**	**681,146**

ATTACHMENT A – Pavement Temperature Zone – Binder Type and Seal Life

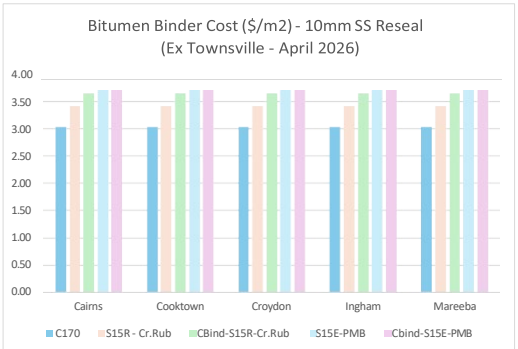
Pavement Temperature - Input into the selection of Bitumen Grade for sprayed sealing and asphalts (Table 7.4 Part 4K; Table 4.3 AP-T235-13 - Guide to the Selection and Use of PMBs and Multigrade Bitumens)								
Site		**Latitude °S**	**Latitude Category**	**Longtitude °E**	**Highest T90 (BoM)**	**Tmax**	**Temp Category**	
Mareeba	Airport	17.07	< 24 ° S	145.43	35.2	59.2	> 58 o C	High
Cairns	Aero	16.87	< 24 ° S	145.75	33.6	57.6	> 58 o C	High
Ingham	Composite	18.65	< 24 ° S	146.18	35.5	59.5	> 58 o C	High
Croydon	Township	18.20	< 24 ° S	142.24	40.0	64.0	> 58 o C	High
Cooktown	Airport	15.45	< 24 ° S	145.19	34.8	58.8	> 58 o C	High

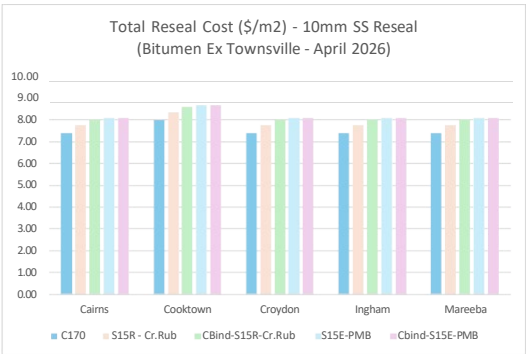
ATTACHMENT B – FNQROC 2024/25 Reseal Cost Summary

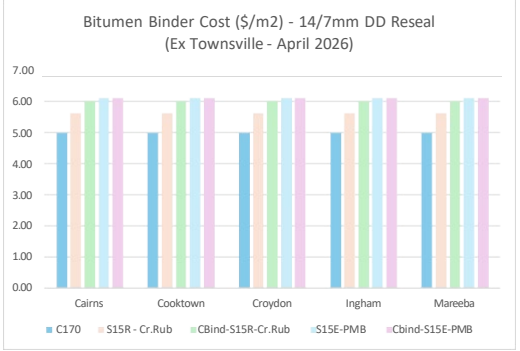
FNQROC Reseals 24/25							1580 $/T C170	962 L/T C170
LGA	Geographic	Binder Type	Area (m2)	Avg Spray Rate (L/m2)	Aggregate Size	Total Price $/m2 (incl Mob; ex Line Marking)	Binder Ex-Storage ($/m2)	% Binder Supply (ex Storage)/Total Price
CCRC	Urban	C170	31,772	1.57	14SS; 10 SS	6.38	2.58	40%
CCRC	Rural	C170	130,740	1.69	14SS; 10 SS	6.84	2.78	41%
CCRC	mobilisation				Avg	6.61		
CSC	Lakeland	C170	10,500	2.80	14/10 DD	15.64	4.60	29%
CSC	Rossville	C170	19,800	2.80	14/10 DD	15.17	4.60	30%
CSC	Cooktown	C170	39,700	2.80	14/10 DD	13.93	4.60	33%
CSC	Laura	C170	1,500	2.80	14/10 DD	27.18	4.60	17%
CSC	mobilisation							
DSC	Urban	S35E	9,786	1.49	10SS; 7SS	6.28	2.44	39%
DSC	Rural	S35E	87,041	1.80	10	7.06	2.96	42%
DSC	mobilisation				Avg	6.67		
MSC	Urban	C170	28,982	1.50	10	5.93	2.46	42%
MSC	Rural	C170	60,169	1.70	14; 10; 7	6.73	2.79	41%
MSC	mobilisation				Avg	6.33		
TRC	Northern	C170	176,591	1.89	14SS; 10 SS	7.50	3.10	41%
TRC	Southern	C170	96,788	1.78	14SS; 10 SS	7.46	2.93	39%
TRC	mobilisation				Avg	7.48		

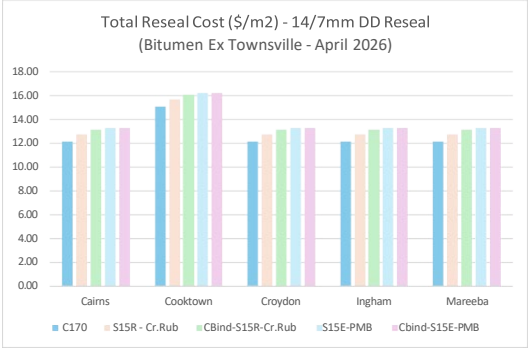
Note 1. The % Binder to Total Cost ratio averages 41% for a SS reseal. Cooktown has DD reseal ratio of 33%, when excluding small quantum reseals. A derived Cooktown SS rati has been calculated at 38%. These values has been used to derive the varying unit cost rates in the WoL cost analysis.
It should be noted that due to insufficient data, it is currently assumed that as the bitumen supply price increases (April 2026, increased to $2,085/T from $1,580/T) the ratio remains the same.

The standardisation of this ratio means that for the same reseal parameters (AADT, HV%, spray rate) the base average unit rate in the WoL costing analysis across all geographic areas is the same, except for Cooktown. The graphs below show that Binder cost is the same and Total Reseal Cost (Average) is the same for all locations, except for Cooktown. Not that it is the binder life (refer Attachment E), which varies for each location, that changes the 30-yr WoL cost.









ATTACHMENT C : WoL Cost Analysis – Location, Binder Type, Seal Life, Spray Rate, Cost and CO2 values.

April 2026 - Increased Bitumen Price																Apr-26	2085 $/T		Factors maintain 2025 differen			C170 – 1.039 kg/l	962	L/Tonne		710	539	290	949	850
April 2026 - Industry Updated kg of CO2/ T of Bitumen values												Binder Factors (4K) Tables 6.3 & 6.4				1	1.11	1.19	1.23	1.23	S15R – 1.055 kg/l	948	L/Tonne	**Cooktown**	kgCO2/Tonne of mixture sprayed				
							2	2	3	3	**S/S**	1.1	1.1	1.1	1.1	$/Tonne	% increases from C170				S15E - 1.035 kg/l	966	L/Tonne	**small qts**	962	948	948	966	966
							Binder Life (Years)				**D/D**	1.1	1.1	1.1	1.1	962	948	948	965	965	**C170 Baseline from FNQROC 2025**			**Cookt SS**	**38%**	L/Tonne				
		Arrb's Bitumen Hardening Model					**(Hardening Model C170 + Industry Averages PMB/CrRub)**									L/tonne					**41%**	**Majority**			**Cookt DD**	**33%**						
	Tmax				**Seal Type &Aggregate**		**Binder Type**					**Typical Spray Rate (l/m2) AADT 300 (15%)**					**Binder Cost ($/m2) - Ex Storage**					**Estimated Total Reseal Cost ($/m2)**					**Global Warming Potential (GWP) (kg of CO2) per m2**				
Location	**(A'Rds Seal design)**	**Tmin (yrly)**	**Tmax (Yrly)**	**T**	**Type**	**Agg**	**C170**	**S15R**	**CarbonBind S15R**	**S15E**	**CarbonBind S15E**	**C170**	**S15R**	**CarbonBind S15R**	**S15E**	**CarbonBind S15E**	**C170**	**S15R**	**CarbonBind S15R**	**S15E**	**CarbonBind S15E**	**C170**	**S15R**	**CarbonBind S15R**	**S15E**	**CarbonBind S15E**	**C170**	**S15R**	**CarbonBind S15R**	**S15E**	**CarbonBind S15E**
Cairns	58	20.7	29.7	25.2	S/S	7	9.4	11.4	11.4	12.4	12.4	0.90	1.0	1.0	1.0	1.0	1.95	2.20	2.36	2.39	2.39	4.76	5.00	5.16	5.20	5.20	0.66	0.56	0.30	0.97	0.87
Cairns	58	20.7	29.7	25.2	S/S	10	9.7	11.7	11.7	12.7	12.7	1.40	1.5	1.5	1.5	1.5	3.03	3.42	3.66	3.72	3.72	7.40	7.78	8.03	8.09	8.09	1.03	0.88	0.47	1.51	1.36
Cairns	58	20.7	29.7	25.2	S/S	14	10.4	12.4	12.4	13.4	13.4	1.90	2.1	2.1	2.1	2.1	4.12	4.64	4.97	5.05	5.05	10.04	10.56	10.90	10.98	10.98	1.40	1.19	0.64	2.05	1.84
Cairns	58	20.7	29.7	25.2	D/D	10/7	10.3	12.3	12.3	13.3	13.3	1.80	2.0	2.0	2.0	2.0	3.90	4.39	4.71	4.78	4.78	9.52	10.01	10.33	10.40	10.40	1.33	1.13	0.61	1.95	1.74
Cairns	58	20.7	29.7	25.2	D/D	14/7	11.4	13.4	13.4	14.4	14.4	2.30	2.5	2.5	2.5	2.5	4.98	5.61	6.02	6.11	6.11	12.16	12.79	13.19	13.29	13.29	1.70	1.44	0.77	2.49	2.23
Cairns	58	20.7	29.7	25.2	D/D	20/10	14.9	16.9	16.9	17.9	17.9	3.20	3.5	3.5	3.5	3.5	6.94	7.81	8.38	8.50	8.50	16.92	17.79	18.36	18.48	18.48	2.36	2.00	1.08	3.46	3.10
Cooktown	58.8	22.1	29.7	25.9	S/S	7	10.0	12.0	12.0	13.0	13.0	0.90	1.0	1.0	1.0	1.0	1.95	2.20	2.36	2.39	2.39	5.13	5.38	5.54	5.57	5.57	0.66	0.56	0.30	0.97	0.87
Cooktown	58.8	22.1	29.7	25.9	S/S	10	10.4	12.4	12.4	13.4	13.4	1.40	1.5	1.5	1.5	1.5	3.03	3.42	3.66	3.72	3.72	7.99	8.37	8.61	8.67	8.67	1.03	0.88	0.47	1.51	1.36
Cooktown	58.8	22.1	29.7	25.9	S/S	14	11.1	13.1	13.1	14.1	14.1	1.90	2.1	2.1	2.1	2.1	4.12	4.64	4.97	5.05	5.05	10.84	11.36	11.69	11.77	11.77	1.40	1.19	0.64	2.05	1.84
Cooktown	58.8	22.1	29.7	25.9	D/D	10/7	11.0	13.0	13.0	14.0	14.0	1.80	2.0	2.0	2.0	2.0	3.90	4.39	4.71	4.78	4.78	11.82	12.32	12.63	12.70	12.70	1.33	1.13	0.61	1.95	1.74
Cooktown	58.8	22.1	29.7	25.9	D/D	14/7	12.1	14.1	14.1	15.1	15.1	2.30	2.5	2.5	2.5	2.5	4.98	5.61	6.02	6.11	6.11	15.11	15.74	16.14	16.23	16.23	1.70	1.44	0.77	2.49	2.23
Cooktown	58.8	22.1	29.7	25.9	D/D	20/10	15.6	17.6	17.6	18.6	18.6	3.20	3.5	3.5	3.5	3.5	6.94	7.81	8.38	8.50	8.50	21.02	21.89	22.46	22.59	22.59	2.36	2.00	1.08	3.46	3.10
Croydon	64	20.5	33.8	27.15	S/S	7	7.7	9.7	9.7	10.7	10.7	0.90	1.0	1.0	1.0	1.0	1.95	2.20	2.36	2.39	2.39	4.76	5.00	5.16	5.20	5.20	0.66	0.56	0.30	0.97	0.87
Croydon	64	20.5	33.8	27.15	S/S	10	8.0	10.0	10.0	11.0	11.0	1.40	1.5	1.5	1.5	1.5	3.03	3.42	3.66	3.72	3.72	7.40	7.78	8.03	8.09	8.09	1.03	0.88	0.47	1.51	1.36
Croydon	64	20.5	33.8	27.15	S/S	14	8.5	10.5	10.5	11.5	11.5	1.90	2.1	2.1	2.1	2.1	4.12	4.64	4.97	5.05	5.05	10.04	10.56	10.90	10.98	10.98	1.40	1.19	0.64	2.05	1.84
Croydon	64	20.5	33.8	27.15	D/D	10/7	8.4	10.4	10.4	11.4	11.4	1.80	2.0	2.0	2.0	2.0	3.90	4.39	4.71	4.78	4.78	9.52	10.01	10.33	10.40	10.40	1.33	1.13	0.61	1.95	1.74
Croydon	64	20.5	33.8	27.15	D/D	14/7	9.2	11.2	11.2	12.2	12.2	2.30	2.5	2.5	2.5	2.5	4.98	5.61	6.02	6.11	6.11	12.16	12.79	13.19	13.29	13.29	1.70	1.44	0.77	2.49	2.23
Croydon	64	20.5	33.8	27.15	D/D	20/10	11.7	13.7	13.7	14.7	14.7	3.20	3.5	3.5	3.5	3.5	6.94	7.81	8.38	8.50	8.50	16.92	17.79	18.36	18.48	18.48	2.36	2.00	1.08	3.46	3.10
Ingham	59.5	18.9	29.2	24.05	S/S	7	8.7	10.7	10.7	11.7	11.7	0.90	1.0	1.0	1.0	1.0	1.95	2.20	2.36	2.39	2.39	4.76	5.00	5.16	5.20	5.20	0.66	0.56	0.30	0.97	0.87
Ingham	59.5	18.9	29.2	24.05	S/S	10	9.1	11.1	11.1	12.1	12.1	1.40	1.5	1.5	1.5	1.5	3.03	3.42	3.66	3.72	3.72	7.40	7.78	8.03	8.09	8.09	1.03	0.88	0.47	1.51	1.36
Ingham	59.5	18.9	29.2	24.05	S/S	14	9.8	11.8	11.8	12.8	12.8	1.90	2.1	2.1	2.1	2.1	4.12	4.64	4.97	5.05	5.05	10.04	10.56	10.90	10.98	10.98	1.40	1.19	0.64	2.05	1.84
Ingham	59.5	18.9	29.2	24.05	D/D	10/7	9.7	11.7	11.7	12.7	12.7	1.80	2.0	2.0	2.0	2.0	3.90	4.39	4.71	4.78	4.78	9.52	10.01	10.33	10.40	10.40	1.33	1.13	0.61	1.95	1.74
Ingham	59.5	18.9	29.2	24.05	D/D	14/7	10.7	12.7	12.7	13.7	13.7	2.30	2.5	2.5	2.5	2.5	4.98	5.61	6.02	6.11	6.11	12.16	12.79	13.19	13.29	13.29	1.70	1.44	0.77	2.49	2.23
Ingham	59.5	18.9	29.2	24.05	D/D	20/10	14.3	16.3	16.3	17.3	17.3	3.20	3.5	3.5	3.5	3.5	6.94	7.81	8.38	8.50	8.50	16.92	17.79	18.36	18.48	18.48	2.36	2.00	1.08	3.46	3.10
Mareeba	59.2	18.1	29	23.55	S/S	7	8.4	10.4	10.4	11.4	11.4	0.90	1.0	1.0	1.0	1.0	1.95	2.20	2.36	2.39	2.39	4.76	5.00	5.16	5.20	5.20	0.66	0.56	0.30	0.97	0.87
Mareeba	59.2	18.1	29	23.55	S/S	10	8.7	10.7	10.7	11.7	11.7	1.40	1.5	1.5	1.5	1.5	3.03	3.42	3.66	3.72	3.72	7.40	7.78	8.03	8.09	8.09	1.03	0.88	0.47	1.51	1.36
Mareeba	59.2	18.1	29	23.55	S/S	14	9.4	11.4	11.4	12.4	12.4	1.90	2.1	2.1	2.1	2.1	4.12	4.64	4.97	5.05	5.05	10.04	10.56	10.90	10.98	10.98	1.40	1.19	0.64	2.05	1.84
Mareeba	59.2	18.1	29	23.55	D/D	10/7	9.3	11.3	11.3	12.3	12.3	1.80	2.0	2.0	2.0	2.0	3.90	4.39	4.71	4.78	4.78	9.52	10.01	10.33	10.40	10.40	1.33	1.13	0.61	1.95	1.74
Mareeba	59.2	18.1	29	23.55	D/D	14/7	10.4	12.4	12.4	13.4	13.4	2.30	2.5	2.5	2.5	2.5	4.98	5.61	6.02	6.11	6.11	12.16	12.79	13.19	13.29	13.29	1.70	1.44	0.77	2.49	2.23
Mareeba	59.2	18.1	29	23.55	D/D	20/10	13.9	15.9	15.9	16.9	16.9	3.20	3.5	3.5	3.5	3.5	6.94	7.81	8.38	8.50	8.50	16.92	17.79	18.36	18.48	18.48	2.36	2.00	1.08	3.46	3.10

ATTACHMENT D – WoL Reseal Treatment Data

	Simple Network Average Whole-of-Life Costing - Bitumen Seal Network						April 2026 C170 Bitumen cost = $2,085/Tonne																			
	Location/Council : Croydon						Croydon					Croydon					Croydon					Croydon				
	Reseal Regime 1 - 10mm SS (C170, S15R, CBindS15R, S15E, CBindS15E)						Same Seal Regime 1 - Change of Binder Only																			
	Scenario 1 (C170 10mm SS Reseals)	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2	Scenario 2 (S15R 10mm SS Reseals) Crumbed Rubber	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2	Scenario 3 (CarbonBind S15R 10mm SS Reseals) Enviro Crumbed Rubber	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2	Scenario 4 (S15E 10mm SS Reseals) PMB	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2	Scenario 5 (CarbonBind S15E 10mm SS Reseals) Enviro PMB	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2
~~Treatment 1~~	~~Prime AMC00~~					~~Prime AMC00~~					~~Prime AMC00~~					~~Prime AMC00~~					~~Prime AMC00~~				
~~Treatment 1A~~	~~14mm C170 SS Seal~~					~~14mm C170 S/S Seal~~					~~14mm C170 S/S Seal~~					~~14mm C170 S/S Seal~~					~~14mm C170 S/S Seal~~				
Treatment 2	(First early application) C170 10mm reseal SS reseal	8.0	0.0	7.40	1.03	(First early application) S15R 10mm reseal S/S Seal	10.0	0.0	7.78	0.88	(First early application) CBind-S15R 10mm SS reseal	10.0	0.0	8.03	0.47	(First early application) S15E 10mm SS reseal	11.0	0	8.09	1.51	Cbind-S15E 10mm SS reseal	11.0	0.0	8.09	1.36
Treatment 3	C170 10mm reseal SS reseal	8.0	8.0	7.40	1.03	S15R 10mm reseal S/S Seal	10.0	10.0	7.78	0.88	CBind-S15R 10mm SS reseal	10.0	10.0	8.03	0.47	S15E 10mm SS reseal	11.0	11.0	8.09	1.51	Cbind-S15E 10mm SS reseal	11.0	11.0	8.09	1.36
Treatment 4	C170 10mm reseal SS reseal	8.0	16.0	7.40	1.03	S15R 10mm reseal S/S Seal	10.0	20.0	7.78	0.88	CBind-S15R 10mm SS reseal	10.0	20.0	8.03	0.47	S15E 10mm SS reseal	11.0	22.0	8.09	1.51	Cbind-S15E 10mm SS reseal	11.0	22.0	8.09	1.36
Treatment 5	C170 10mm reseal SS reseal	8.0	24.0	7.40	1.03	S15R 10mm reseal S/S Seal	10.0	30.0	7.78	0.88	CBind-S15R 10mm SS reseal	10.0	30.0	8.03	0.47	S15E 10mm SS reseal	11.0	33.0	8.09	1.51	Cbind-S15E 10mm SS reseal	11.0	33.0	8.09	1.36
Treatment 6	C170 10mm reseal SS reseal	8.0	32.0	7.40	1.03																				
			AT 30 Years	35.15	4.91			AT 30 Years	31.14	3.50			AT 30 Years	32.12	1.88			AT 30 Years	30.14	5.64			AT 30 Years	30.14	5.05
Carbon Price (2025)	$70/tonne of CO2	70	$/m2 of C02		0.34				$ of C02	0.25				$ of C02	0.13				$ of C02	0.39				$ of C02	0.35
			CO2 % Cost		1.0%					0.8%					0.4%					1.3%					1.2%
Area of Sealed Road Network			m2	1,000,000	(per million m2, awaiting network sealed area data)			m2	1,000,000				m2	1,000,000					1,000,000				m2	1,000,000	
Life Time Surfacing			$ Mill	35.2				$ Mill	31.1				$ Mill	32.1					30.1				$ Mill	30.1	
			Tonnes C02		4,908			Tonnes C02		3,502			Tonnes C02		1,884			Tonnes C02		5,639			Tonnes C02		5,051
								Tonnes of S15R		6,329			Tonnes of S15R		6,329										
						Truck Tyres saved from Landfill 5 Tyres/1T S15R (#)				31,646	Truck Tyres saved from Landfill 5 Tyres/1T S15R (#)				31,646										
						Tonnes of Tyres Used in Cr Rubber (T)				1,266	Tonnes of Tyres Used in Cr Rubber (T)				1,266										
						Landfill cost Saved @ $70/T ($)				88,608	Landfill cost Saved @ $70/T ($)				88,608										
Average annual			$ Mill	1.2				$ Mill	1.0				$ Mill	1.1					1.0				$ Mill	1.0	
			Tonnes C02		164			Tonnes C02		117			Tonnes C02		63			Tonnes C02		188			Tonnes C02		168
Current Spend (2025 $)	(Fictitous value for demonstration purposes - awaiting real life data)		$ Mill	0.8					0.8					0.8					0.8					0.8	
Deficiency			$ Mill	0.4					0.2					0.3					0.2					0.2	
	Solutions range from $1.0 Million per annum to $1.6 Million per annum per 1 Million m2 (awaiting actual Road Area data) ;																								
	The calculations above are an average analysis, well expecting that areas with poor condition, due to pavement performance issues, will require resealing undertaken earlier. No reseals should be undertaken later																								
	NOTES																								
	Cost are considered Pure Reseal Costs Only and do not include Prep Works Repairs; Repair allowance muts be derived from Network Level inspection / & Project Proofing over time; As seals condiiton improves, repairs should decerease - Monitor																								

ATTACHMENT D – WoL Reseal Treatment Data - *Continued…*

	Simple Network Average Whole-of-Life Costing - Bitumen Seal Network																								
	Location/Council : Croydon						Croydon					Croydon					Croydon					Croydon			
	Reseal Regime 2 - 14/7 DD (C170, S15R, CBindS15R, S15E, CBindS15E)						Same Seal Regime 2 - Change of Binder Only																		
	Scenario 6 (C170 DD 14/7 Reseals)	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2	Scenario 7 (S15R DD 14/7 Reseals) Crumbed Rubber	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2	Scenario 8 (CarbonBind S15R DD 14/7 Reseals) Enviro Crumbed Rubber	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2	Scenario 9 (S15E DD 14/7 Reseals) PMB	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2	Scenario 10 (CarbonBind S15E DD 14/7 Reseals) Enviro PMB	Seal Life	Year	Cost (2025 $) ($/m2)	kgCO2/ m2
~~Treatment 1~~	~~Prime AMC00~~					~~Prime AMC00~~					~~Prime AMC00~~					~~Prime AMC00~~					~~Prime AMC00~~				
~~Treatment 1A~~	~~20/10mm C170 DD Seal~~					~~20/10mm C170 DD Seal~~					~~20/10mm C170 DD Seal~~					~~20/10mm C170 DD Seal~~					~~20/10mm C170 DD Seal~~				
Treatment 2	C170 14/7 DD Reseal	9.2	0	12.16	1.70	S15R 14/7 DD Reseal	11.2	0	12.79	1.44	CBind-S15R 14/7 DD reseal	11.2	0	13.19	0.77	S15E 14/7 DD Reseal	12.2	0	13.29	2.49	CBind-S15E 14/7 DD Reseal	12.2	0	13.29	2.23
Treatment 3	C170 14/7 DD Reseal	9.2	9.2	12.16	1.70	S15R 14/7 DD Reseal	11.2	11.2	12.79	1.44	CBind-S15R 14/7 DD reseal	11.2	11.2	13.19	0.77	S15E 14/7 DD Reseal	12.2	12.2	13.29	2.49	CBind-S15E 14/7 DD Reseal	12.2	12.2	13.29	2.23
Treatment 4	C170 14/7 DD Reseal	9.2	18.4	12.16	1.70	S15R 14/7 DD Reseal	11.2	22.4	12.79	1.44	CBind-S15R 14/7 DD reseal	11.2	22.4	13.19	0.77	S15E 14/7 DD Reseal	12.2	24.4	13.29	2.49	CBind-S15E 14/7 DD Reseal	12.2	24.4	13.29	2.23
Treatment 5	C170 14/7 DD Reseal	9.2	27.6	12.16	1.70	S15R 14/7 DD Reseal	11.2	33.6	12.79	1.44	CBind-S15R 14/7 DD reseal	11.2	33.6	13.19	0.77	S15E 14/7 DD Reseal	12.2	36.6	13.29	2.49	CBind-S15E 14/7 DD Reseal	12.2	36.6	13.29	2.23
Treatment 6	C170 14/7 DD Reseal	9.2	36.8	12.16	1.70																				
			AT 30 Years	51.81	7.23			AT 30 Years	47.04	5.29			AT 30 Years	48.53	2.85			AT 30 Years	45.96	8.60			AT 30 Years	45.96	7.70
Carbon Price (2025)	$70/tonne of CO2		$/m2 of C02		0.51				$ of C02	0.37				$ of C02	0.20				$ of C02	0.60				$ of C02	0.54
			CO2 % Cost		1.0%					0.8%					0.4%					1.3%					1.2%
Area of Sealed Road Network			m2	1,000,000				m2	1,000,000				m2	1,000,000				m2	1,000,000				m2	1,000,000	
Life Time Surfacing			$ Mill	51.8				$ Mill	47.0				$ Mill	48.5				$ Mill	46.0				$ Mill	46.0	
			Tonnes C02		7,233			Tonnes C02		5,292			Tonnes C02		2,847			Tonnes C02		8,597			Tonnes C02		7,700
								Tonnes of S15R		7,911			Tonnes of S15R		7,911										
						Truck Tyres saved from Landfill 5 Tyres/1T S15R (#)				39,557	Truck Tyres saved from Landfill 5 Tyres/1T S15R (#)				39,557										
						Tonnes of Tyres Used in Cr Rubber (T)				1,582	Tonnes of Tyres Used in Cr Rubber (T)				1,582										
						Landfill cost Saved @ $70/T ($)				110,759	Landfill cost Saved @ $70/T ($)				110,759										
Average annual			$ Mill	1.7				$ Mill	1.6				$ Mill	1.6				$ Mill	1.5				$ Mill	1.5	
			Tonnes C02		241			Tonnes C02		176			Tonnes C02		95			Tonnes C02		287			Tonnes C02		257
Current Spend (2025 $ Mill)	(Fictitous value for demonstration purposes - awaiting real life data)			0.8					0.8					0.8					0.8					0.8	
Deficiency ($ Mill)				0.9					0.8					0.8					0.7					0.7	

FOR ALL SHIRES – Refer Spreadsheet provided

ATTACHMENT E – Reseal Life Graphs

