LG TRRIP

Local Government Transport & Roads Research & Innovation Program

An initiative by: WALGA · Government of Western Australia · mainroads Western Australia · NTRO

Practitioners' Guideline: Reclaimed Asphalt Pavement in Asphalt Applications on Local Government Roads in WA

Author: Dr Chrysoula Pandelidi, Jaimi Harrison, Joe Grobler

March 2025

V3.0

About LG TRRIP

The Local Government Roads and Research and Innovation Program (LG TRRIP) is an initiative between Main Roads Western Australia and the Western Australian Local Government Association.

LG TRRIP has a strategic commitment to the delivery of collaborative research and development that positively contributes to the design, construction and maintenance of safe, sustainable transport infrastructure in Western Australia.

Acknowledgements

The authors would like to acknowledge the contribution of stakeholders that participated in engagement activities.

Version Control

Report version no.	Date	Released to client by	Nature of revision
1	12/07/2024	Chrysoula Pandelidi	Released to client for review
2	09/10/2024	Chrysoula Pandelidi	Live review
3	18/02/2025	Chrysoula Pandelidi	Final for publication

Contents

Acronyms and Glossary of Terms

Acronyms

AfPA	Australian Flexible Pavement Association
ARRB	Australian Road Research Board
DGA	Dense-graded asphalt
GGA	Gap-graded asphalt
IPWEA	Institute of Public Works Engineering Australasia
LG TRRIP	Local Government Transport and Roads Research and Innovation Program
MRWA	Main Roads Western Australia
NACOE	National Asset Centre of Excellence
PMB	Polymer modified binder
PSD	Particle size distribution
RAP	Reclaimed asphalt pavement
SMA	Stone mastic asphalt
WALGA	Western Australian Local Government Association
WARRIP	Western Australian Road Research and Innovation Program
WHS	Work health and safety

Glossary of terms

DGA	Dense-graded asphalt: A mixture of coarse aggregate, fine aggregate, filler and bitumen placed hot and compacted to a dense state as a pavement layer or resurfacing (Austroads 2015a).
GGA	Gap-graded asphalt: An asphalt mix in which one or more of the intermediate aggregate sizes are absent or present in small proportions (Austroads 2015a).
RAP	Reclaimed asphalt pavement: The material reclaimed from an asphalt pavement by various means (Austroads 2015a).
SMA	Stone mastic asphalt: A gap-graded asphalt mix with a high proportion of coarse aggregates that mechanically interlock. The gaps formed among these aggregates are filled with a mastic of binder, fines and filler (Austroads 2015a).

1 Introduction

1.1 Purpose and Scope

This guideline aims to provide practitioners with relevant information to make informed decisions regarding the selection, specification and construction of asphalt mixes that incorporate reclaimed asphalt pavement (RAP) on the local government network in WA. The guideline was developed based on the findings from a comprehensive desktop literature review and stakeholder consultation process documented in *Technical Report: Reclaimed Asphalt Pavement in Asphalt Applications on Local Government Roads in WA*.

This practitioners' guideline encompasses:

- an overview of RAP
- any impacts on the pavement as a result of using RAP
- potential risks and mitigation measures
- available specifications and guidance
- material supply
- mix design considerations
- additional considerations during asphalt construction.

1.2 Structure

The guideline was written in a concise manner to provide practitioners with an overview of the main elements to consider when using RAP in local government asphalt mixes. It, therefore, avoids repeating information that is similar across the different (and more familiar) asphalt mixes and is already comprehensively covered in other technical documents and specifications.

In this guideline:

- Section 2 provides a high-level introduction to RAP-containing asphalt project selection and delivery.
- Section 3 provides guidance regarding RAP material requirements and management.
- Section 4 summarises additional design considerations for asphalt mixes containing RAP.
- Section 5 describes asphalt manufacturing considerations when using RAP.

1.3 Limitations

This practitioners' guideline relates to the use of mixes incorporating RAP across the local government road network. It is, therefore, framed around the types of mixes typically found across the WA local government asphalt network.

Importantly, this document is a guideline only and should not be considered as a design or construction specification. The selection of an appropriate asphalt mix type, including the use of RAP, should be based on sound engineering judgement and experience that appropriately considers:

- the expected operating environment (including, but not limited to, the climate, traffic loadings and underlying pavement structure)
- the required in-service functional, structural and long-term performance properties of the asphalt mix
- the quality and availability of materials
- the availability of appropriate plant and equipment (where specialty equipment is required)
- the environmental and sustainability impacts of the materials
- the whole-of-life costs associated with the asphalt mix type.

1.4 The Use of RAP in Asphalt

1.4.1 Overview or Reclaimed Asphalt Pavement

RAP derives from the milling of existing asphalt wearing, intermediate and base course during re-surfacing activities as well as from plant surplus and site returns. RAP is well specified as a material in WA and the Institute of Public Works Engineering Australasia (IPWEA)/Australian Flexible Pavement Association (AfPA) Asphalt Specification (Western Australia) also permits the use of RAP in dense-graded asphalt (DGA) mixes on local government roads.

RAP can be incorporated back into new asphalt either in situ or at the asphalt plant as a partial aggregate replacement. The latter process is most common in WA and is the focus of this practitioners' guideline.

DGA is the most common mix type across the WA local government road network, followed by stone mastic asphalt (SMA), and with limited applications of gap-graded asphalt (GGA). In addition, the local government asphalt network is primarily made of thin asphalt surfacings on a granular pavement, while the type of work undertaken is typically rehabilitation projects. As such, any potential use of RAP would mainly be limited to wearing course layers on local government roads.

1.4.2 What to Expect when Using RAP in Asphalt

Asphalt mixes containing 15% by mass (wt.%) RAP are typically found to be comparable to asphalt without any RAP, in the following characteristics:

- tensile strength
- weathering performance
- rutting resistance
- ravelling resistance
- fatigue cracking resistance.

Asphalt with more than 15 wt.% RAP is expected to exhibit (if appropriate adjustments to the binder grade not are made):

- greater stiffness
- increased deformation resistance
- decreased fatigue resistance due to the ageing of the RAP binder.

While there are several benefits from the use of RAP, certain challenges and risks may arise, as shown in Table 1.

Table 1: Constraints and mitigation measures

Constraint	Mitigation
Potential inconsistencies in RAP management and mix design practices	• Ensure an appropriate RAP management plan is in place
Managing RAP variability and additional testing requirements	• Ensure appropriate RAP management plan is in place • Confirm laboratory capacity to undertake relevant testing
Availability of supply, especially in areas of low RAP generation	• Carefully consider RAP availability at a project level • Consider sustainable levels of RAP content in a mix
RAP viscosity	• Ensure the assessment of RAP binder viscosity when more than 10 wt.% RAP is considered for use in the mix

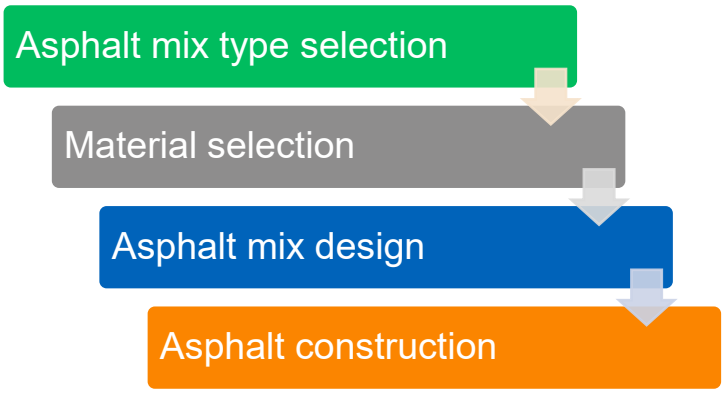
2 RAP Project Selection and Delivery

Key documents:

- Australian Road Research Board (ARRB) *Sealed Roads Best Practice Guide* (Lyons et al. 2020)
- Austroads (2024) *Guide to Pavement Technology Part 2: Pavement Structural Design*
- Austroads (2014) *Guide to Pavement Technology Part 4B: Asphalt*
- Austroads (2019) *Guide to Pavement Technology Part 8: Pavement Construction*
- Institute of Public Works Engineering Australasia (IPWEA) & Australian Flexible Pavement Association (AfPA) (2023) Asphalt Specification (WA) *Technical Specification, Tender Form and Schedule for Supply and Laying of Asphalt Road Surfacing*

Figure 1 provides a brief overview of the main steps involved during the delivery of an asphalt project.

Figure 1: Main steps to asphalt project delivery



Austroads *Guide to Pavement Technology Part 4B: Asphalt* summarises that the appropriate asphalt mix treatment depends on factors including, but not limited to:

- overall pavement design
- performance requirements
- condition of existing pavement
- operating environment
- construction requirements
- whole-of-life costs.

These guide decisions regarding:

- asphalt mix type
- nominal size of the aggregates in the mix
- layer thickness
- type of binder
- type of aggregate.

Table 2 provides some high-level guidance for mix type selection.

Table 2: Asphalt mix type selection and use of RAP

Mix type	Aggregate nominal size (mm)	Application	Can RAP be used?	Relevant specification(s)
DGA	10, 14 and 20	Highways, arterial, industrial and distribution roads	YES in 50 blow mixes (maintenance and < 2,000,000 ESA)	IPWEA/AfPA Asphalt Specification (WA)
	5, 7, 10 and 14	Residential streets, cul-de-sacs and recreational areas	YES	IPWEA/AfPA Asphalt Specification (WA)
SMA	5, 7, 10 and 14	Where good rut resistance and fatigue performance are required	NO	IPWEA/AfPA Asphalt Specification (WA)
GGA(1)	10 and 14	Medium to heavily trafficked roads where improved crack resistance is required(1)	NO	Specification 517
OGA(1)	10	Arterial roads	NO	Specification 516

1. Crumb rubber–modified asphalt mixes.

3 Materials Selection and Specification

Key documents:

- AfPA (2022) *Reclaimed Asphalt Pavement (RAP) Management Plan Best Practice*
- IPWEA & AfPA (2023) Asphalt Specification (WA) *Technical Specification, Tender Form and Schedule for Supply and Laying of Asphalt Road Surfacing*
- Specification 511: *Materials for Bituminous Treatments*
- Austroads Technical Specification ATS 3135: *Supply of Reclaimed Asphalt Pavement Material*

3.1 RAP Material Requirements

The primary requirements of RAP materials are:

- RAP must be obtained from surplus plant mix asphalt or the material reclaimed from an asphalt layer in situ
- RAP must not contain granular pavement materials, clay, soil or organic matter; bricks, concrete, glass or building materials; or laterite asphalt, tar-based products, geotextile fabrics, raised pavement markers or road surface treatments, such as high friction surfacings, or coloured pavement markings.

Important properties to consider, that may impact the stockpiling and use of RAP, include:

- contaminant levels
- presence of polymer modified binders (PMBs) or other materials such as strain alleviating membrane interlayer or recycled materials
- particle size distribution (PSD)
- RAP moisture content
- bitumen content.

3.2 Material Supply and Management

It is advisable that, where feasible and for maximum sustainability benefit, RAP be used in close proximity to where it was extracted. Note that it is preferable to identify a sustainable level of RAP usage consistent with supply and local availability.

Clause 511.09.02 in Specification 511:2025 describes the processing and storage requirements for RAP, covering:

- separation and coverage of stockpiles
- crushing and screening of fines, and separation of fractions
- consistency and flowability.

Clause 511.09.03 in Specification 511:2025 defines the stockpile management and testing of RAP, including the requirements for asphalt manufacturers to have a RAP management plan, which must discuss:

- the process commencing at the origin of the RAP, stockpiling prior to processing, processing, storage and testing maintenance
- capability of the plant to incorporate the specific RAP level
- process for manufacture of asphalt containing RAP

- sample testing for PSD and bitumen content in accordance with WA 730.1 and moisture content in accordance with WA 212.1 or 212.2 (see Table 3).

Additional best practice advice for RAP management is available by AfPA. Further to the systems listed, when RAP is to be included in the mix, a RAP management plan should be in place. These are to be put together by the asphalt manufacturer. Austroads (2016) *AP-R517-16 Maximising the Use of Reclaimed Asphalt Pavement in Asphalt Mix Design: Field Validation* provides a proposed list of items to be included in the RAP management plan that include (but are not limited to):

- plan for sourcing, processing, transport and storage for RAP
- testing and inspection plan for the RAP
- binder blend viscosity of asphalt mix containing RAP
- a strategy on how to incorporate RAP with varying binder viscosities.

4 Asphalt Mix Design Considerations

Key documents:

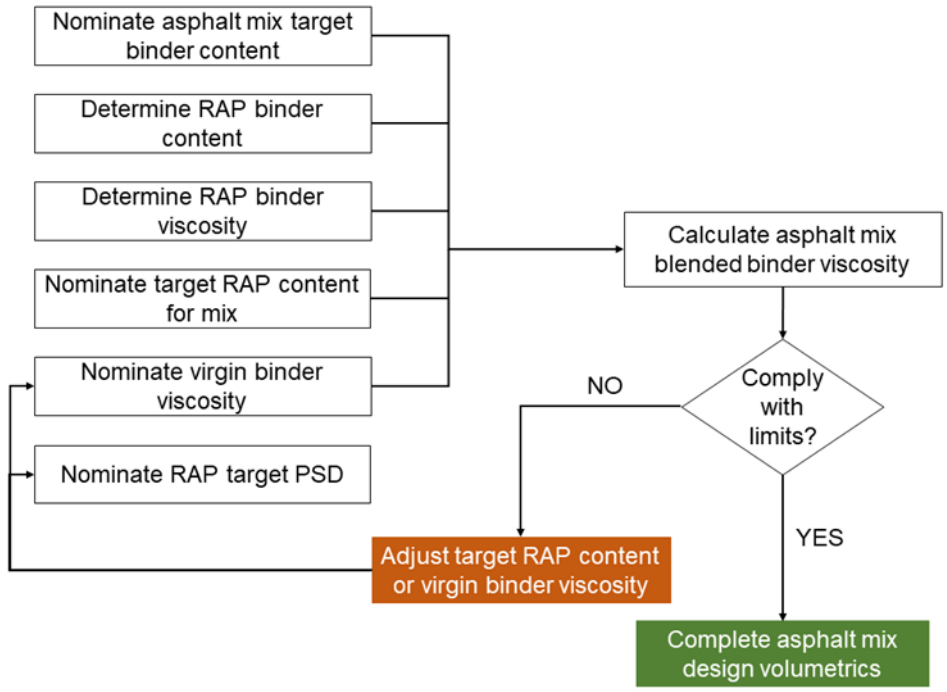
- Australian Road Research Board (ARRB) *Sealed Roads Best Practice Guide* (Lyons et al. 2020)
- Austroads (2014) *Guide to Pavement Technology Part 4B: Asphalt*
- IPWEA & AfPA (2023) Asphalt Specification (WA) *Technical Specification, Tender Form and Schedule for Supply and Laying of Asphalt Road Surfacing*

The use of RAP should be considered depending on availability and performance requirements of the resulting pavement. Additionally, consideration needs to be given to the use of RAP in mixes with PMBs, as its presence may result in a decrease of the overall content of PMB, hence, potentially compromising the desired performance.

RAP Approval Levels have been adopted by most transport agency specifications, which may consider levels of screening/grading, stockpiling and management requirements, and performance testing, and impact the resultant wt.% of RAP allowable for use.

If less than 15 wt.% RAP is used, no changes to the asphalt mix design are required. Figure 2 provides an overview of the asphalt mix design process when more than 15 wt.% RAP is included in the asphalt mix.

Figure 2: Proposed asphalt mix design process



Source: Adapted from van Aswegen and Latter (2019).

Table 3 provides a summary of methods to use when considering the incorporation of RAP at concentrations above 15 wt.%.

Table 3: Test methods for asphalt mix design process for mixes with more than 15 wt.% reclaimed asphalt pavement

Step	Test methods
Determine RAP binder content	WA 730.1
Determine RAP binder viscosity	AGPT/T193
Determine RAP moisture content	WA 212.1
Determine RAP aggregate PSD	WA 210.1

Following the determination of the binder blend viscosity targeted for the asphalt mix design, the strategy for incorporating RAP with different binder viscosities and/or binder, may include:

- varying the RAP content in the mix
- altering the class of the virgin binder in the mix (referred to as grade bump)
- incorporating rejuvenators as needed
  - this may require a separate mix design to be developed by the road agencies (Austroads 2016).

5 Asphalt Construction

Key documents:

- IPWEA & AfPA (2023) Asphalt Specification (WA) *Technical Specification, Tender Form and Schedule for Supply and Laying of Asphalt Road Surfacing*

5.1 Manufacture and Transport of Asphalt

Manufacture and transport of asphalt covers:

- asphalt mixing plant requirements
- mix temperature
- storage temperature
- the use of workability additives
- testing requirements and frequency
- vehicle type
- temperature for transport.

Table 4 summarises some key considerations during the manufacture and transport of asphalt containing RAP.

Table 4: Additional considerations for the manufacture and transport of asphalt containing RAP

	Manufacture and transport guidance
Asphalt mixing plant	• Central mixing plant of any configuration (batch, continuous or drum) as long as it complies with AS 2150 • Consider plant capability when adding > 15 wt.% RAP
Asphalt mix temperature	• May need to adjust virgin aggregate temperature due to RAP moisture, temperature of RAP and greater stiffness in RAP binder
Use of additives	• Rejuvenators may be used in high-content RAP mixes

5.2 Asphalt Placement, Compaction and Finishing Requirements

Asphalt laying includes surface preparation, equipment, weather conditions, compaction and density requirements. The IPWEA/AfPA Asphalt Specification (WA) provides requirements for the preparation of the works (Section 8), details for laying of the mix (Section 9) and acceptance of asphalt in situ (Section 11), covering:

- undue delays
- delivery
- protection of drains and removal of debris
- traffic management and control
- joints
- survey control
- delivery dockets
- compaction
- density requirements.

There are no additional requirements to consider when RAP is used.

5.3 Work Health and Safety and Environmental Considerations

Impacts to the environment are primarily associated with the materials that have been used in the manufacture of the original asphalt pavement, i.e. a recycled material. Additionally, former site conditions, and the use of the road may impact the contamination level of the RAP. In case there is doubt surrounding potential contamination of the milled asphalt, a suitably qualified environmental professional should be consulted.

RAP deriving from asphalt that did not contain recycled materials originally is not considered to pose any additional risks to work health and safety (WHS) when compared to the use of virgin materials. Additional consideration, however, may need to be given to RAP that includes materials such as crumb rubber or recycled polymers including a risk assessment. This may be further dependent on RAP stockpiling practices, for example, if full awareness of the material contained in the stockpile is not available.

The individual risk of rejuvenators, when used, would need to be considered on a case-by-case basis, as rejuvenator products are highly variable. Potential impacts to the environment may include leaching of polycyclic aromatic hydrocarbons and critical metals. The rejuvenator being considered needs to be accompanied by a safety data sheet, which would guide practitioners in its use and provide relevant WHS measures required, if any.

Additional Resources

AfPA (2022)	Reclaimed Asphalt Pavement (RAP) Management Plan Best Practice
ARRB Hall et al. (2022)	Best Practice Expert Advice on the Use of Recycled Materials in Road and Rail Infrastructure: Part A: Technical Review and Assessment
Austroads	Guide to Pavement Technology Part 2: Pavement Structural Design (2024)
	Guide to Pavement Technology Part 4B: Asphalt (2014)
	Guide to Pavement Technology Part 4E: Recycled Materials (2022)
	Guide to Pavement Technology Part 8: Pavement Construction (2019)
	Maximising the Re-use of Reclaimed Asphalt Pavement: Outcomes of Year Two – RAP Mix Design (2015b)
	Maximising the Use of Reclaimed Asphalt Pavement in Asphalt Mix Design: Field Validation (2016)
	ATS 3135: Supply of Reclaimed Asphalt Pavement Material
LG TRRIP	Practitioners Guideline: Sustainable Road Construction Practices for Local Government roads in WA
National Asset Centre of Excellence (NACOE)	Implementing the Use of Reclaimed Asphalt Pavement (RAP) in TMR – Registered Dense-graded Asphalt Mixes – Year 1 (Yousefdoost et al. 2018)
	Implementing the Use of Reclaimed Asphalt Pavement (RAP) in TMR – Registered Dense-graded Asphalt Mixes – Background Analysis Report (Yousefdoost 2018)
Western Australian Road Research and Innovation Program (WARRIP)	Implementing the Increased Use of Reclaimed Asphalt Pavement (RAP) (van Aswegen & Latter 2019)

References

Australian Flexible Pavement Association 2022, *Reclaimed Asphalt Pavement (RAP) management plan best practice*, AfPA, Eight Mile Plains, Qld.

Austroads 2014, *Guide to pavement technology part 4B: asphalt*, 2nd edn, AGPT04B-14, Austroads, Sydney, NSW.

Austroads 2015a, *Austroads glossary of terms*, 6th edn, AP-C87-15, Austroads, Sydney, NSW.

Austroads 2015b, *Maximising the re-use of reclaimed asphalt pavement: outcomes of year two - RAP mix design*, AP-T286-15, Austroads, Sydney, NSW.

Austroads 2016, *Maximising the use of reclaimed asphalt pavement in asphalt mix design: field validation*, AP-R517-16, Austroads, Sydney, NSW.

Austroads 2019, *Guide to pavement technology part 8: pavement construction*, 2nd edn, AGPT08-19, Austroads, Sydney, NSW.

Austroads 2022, *Guide to pavement technology part 4E: recycled materials*, 2nd edn, AGPT04E-22, Austroads, Sydney, NSW.

Austroads 2024, *Guide to pavement technology part 2: pavement structural design,* 4.4 edn, AGPT02-24, Austroads, Sydney, NSW.

Bondietti, M, Manton, C & Howland, C 2023, 'Local government guidelines for sustainable road construction practices in WA', *NTRO international technical conference, 2023, Port Melbourne, Vic.,* NTRO|ARRB, Port Melbourne, Vic., 12 pp.

Hall, B, Grenfell, J, Pandelidi, C, Yaghoubi, J, Chaudhry, U, Lyons, M, O'Connor, G, Harrison, J & Feigen, D 2022a, *Best practice expert advice on the use of recycled materials in road and rail infrastructure: part A: technical review and assessment*, ARRB, Australia.

Howland, C, Feigen, D, Bartlett, D & Grenfell, J 2023, *Practitioners Guideline: Sustainable road construction practices for Local Government roads in WA*, prepared by NTRO for LG TRIPP, LG TRIPP, Perth, WA.

Institute of Public Works Engineering Australasia (WA) & Australian Flexible Pavement Association (WA Branch) 2023, *Technical specification, tender form and schedule for supply and laying of asphalt surfacing*, revision no. 5, IPWEA and AfPA, Perth, WA.

Lyons, M, Garton, D, Martin, T, Moffatt, M, Milling, D, Patrick, S, Harrison, J, Thomas, L & Rice, Z 2020, *Sealed roads best practice guide*, no. 3, ARRB, Port Melbourne, Vic. Accessed 26 September 2024, <https://www.arrb.com.au/bestpracticeguides>.

van Aswegen, E & Latter, L 2019, *Implementing the increased use of reclaimed asphalt pavement (RAP)*, contract report WARRIP 2017-002, prepared by ARRB for WARRIP, WARRIP, Perth, WA.

Yousefdoost, S 2018, *P57: Implementing the use of Reclaimed Asphalt Pavement (RAP) in TMR registered dense-grade asphalt mixes - background analysis report*, contract report P57, prepared for the Queensland Department of Transport and Main Roads under the NACOE program, ARRB Group, Port Melbourne, Vic.

Yousefdoost, S, Rebbechi, J & Patho, L 2018, *P57: Implementing the use of Reclaimed Asphalt Pavement (RAP) in TMR - registered dense-graded asphalt mixes (Year 1 -2016/2017)*, contract report P57, prepared for the Queensland Department of Transport and Main Roads under the NACOE program, ARRB Group, Port Melbourne, Vic.

Australian Standards

AS 2150:2020, *Asphalt – a guide to good practice.*

Austroads Test Methods

AGPT/T193:2015, *Design of bituminous binder blends to a specified viscosity value.*

ATS-3135-23, *Supply of reclaimed asphalt pavement material*.

Main Roads Western Australia Specifications

Specification 511:2025, *Materials for bituminous treatments*.

Specification 516:2024, *Crumb rubber open graded asphalt*.

Specification 517:2024, *Crumb rubber gap graded asphalt*.

Main Roads Western Australia Test Methods

Test method WA 210.1:2013, *Particle size distribution of aggregate.*

Test method WA 212.1:2022, *Determination of the moisture content of an aggregate – oven drying method (standard method).*

Test method WA 212.2:2022, *Determination of the moisture content of aggregate – microwave oven drying method (subsidiary method)*.

Test method WA 730.1:2021, *Bitumen content and particle size distribution of asphalt and stabilised soil – centrifuge method.*

Perth, Western Australia