TyreStewardship AUSTRALIA

Tipping the balance

The business case for a circular economy for Australia's off-the-road tyres, conveyors, and tracks

Research Report

Australian Government Accredited Product Stewardship Scheme

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Thank you to the OTR Project Committee that oversaw the project, providing feedback and guidance from their perspectives of the OTR related products, OTR sectors, resource recovery value chain and stewardship, social justice and governance best practice.

Name	Position
Fiona Solomon	CEO, Aluminium Stewardship Initiative
Vanessa Zimmerman	CEO, Pillar Two
Paul Comninos	Executive Manager – Solutions Development, Bridgestone Mining Solutions
Scott Marvelley	Director – Service Engineering, ContiTech Australia
Steve Clifford	Independent (former Managing Director, Yokohama Tyre Australia)
Silvio de Denaro	Chair, Australian Tyre Industry Council
Chris McCombe	General Manager – Sustainability, Minerals Council of Australia

Setting out a path for improving the recovery of off-the-road tyres

Contents

Section 1 –
The need to improve the recovery of OTR tyres and conveyor belts

1. Introduction

1.1 Purpose

The purpose of this report is to:

- address knowledge gaps and provide evidence of the current state of OTR tyre, conveyor belt and rubber tracks (OTR rubber products) resource recovery across Australia
- define the value and opportunities of recovering OTR rubber products across Australia
- outline ideal approaches to achieve this that meet the needs of all involved parties in the value chain, government and the wider-community.

1.2 Background

Australia has generally achieved good resource recovery rates for passenger car, bus and truck tyres - about 90%. These tyres are being turned into roads, civil construction, pavements, playgrounds, gym mats, but the vast majority are being used as fuel in cement kilns and similar, usually overseas.

Tyres used in mining, agriculture, construction, manufacturing and aviation, as well as conveyor belts and rubber tracks (OTR rubber products), have had persistently low recovery rates of less than 11% across Australia. When OTR rubber products reach their end-of-life, they are mostly stockpiled or buried on site, sent to landfill or illegally dumped or burnt.

As significant mining and agriculture activities occur in regional and remote areas of Australia, this is also where these products reach their end-of-life. The handling and logistics of moving them to a resource recovery facility is challenging and expensive.

As a result, the many benefits of recovering valuable resources from these OTR rubber products, or exploring the environmental and commercial benefits of repairing and re-using them, have been limited.

Recovering OTR rubber products has mostly been limited to market segments using a smaller proportion of OTR tyres, generally in or near urban and industrial centres, while repair and re-use is uncommon. This is because there are unique barriers that make it harder to recover OTR rubber products than automotive tyres. This report investigates and provides solutions to these barriers.

1.2.1 Summary of recommended actions

This report puts forward actions to:

- broaden the Tyre Product Stewardship Scheme to include all OTR rubber products in a circular economy approach to tyre product stewardship
- improve recycling and recovery rates for OTR rubber products from priority sectors that use them
- establish a viable recovery pathway for OTR rubber products
- develop market opportunities for products using OTR rubber products to encourage recovery, recycling and investment.

In taking these actions, Tyre Stewardship Australia (TSA) will work closely and collaboratively with all the stakeholders that supply and recover OTR rubber products. Through research projects, demonstrations, recovery trials, regional/sectoral business cases and support, we will also explore commercial opportunities with parties who may have a role in recovering these materials, such as:

- existing participants in the tyre recovery sector
- new market entrants and technology proponents
- regional communities that live and work in areas that generate large amounts of OTR rubber products (e.g. in and near major mining operations and agricultural districts).

1.2.2 Funding

TSA and the Commonwealth Government[1] funded this business case together, with TSA leading its development. TSA is obliged to complete the business case in line with the Commonwealth grant funding agreement, and there is an opportunity for it to inform future work planning and implementation of the Scheme, and to shape collaborations with core stakeholders. Priority actions are outlined in a corresponding report, *Tipping the Balance, Summary and Action Plan.*

1.2.3 Expectations

All parties involved in managing end-of-life OTR tyres need to have a realistic appreciation of what this first investigation can and cannot deliver, particularly given that a 'one size fits all' approach to OTR rubber product recovery may fail to overcome the particular barriers and seize the opportunities of where these tyres are used.

What the National OTR tyre business case can and can't provide

Due to the many and varied types and applications of OTR rubber products across Australia, and their use in remote locations, this national business case for recovery will not provide all the answers for all stakeholders, so it's important to be clear about what it can and cannot provide.

What this business case can provide:

- a big step forward in defining what OTR rubber products are, and how and where they're used across Australia (including catchments where consumption and waste generation is concentrated)
- an overview of current end-of-life management of OTR rubber products, how this compares to international management, and the options for recovering different OTR rubber products
- an exploration of the barriers and opportunities for recovering end-of-life OTR rubber products, with targeted analysis for the key consumption and waste generation catchments
- identification of potential operational models to recover end-of-life OTR rubber products
- an improved understanding of the variables to consider when exploring end-of-life OTR rubber product management options, both upstream (demand for natural and synthetic resources and related impacts) and downstream (social, environmental and economic effects)
- an analysis of the costs, benefits, opportunities and risks of shifting from current disposal methods to a recovery model, including guidance for OTR rubber product generators, supply chains, regulators and other parties on what to consider when engaging in a circular economy
- a set of recommendations to start recovery solutions for end-of-life OTR rubber products.

This business case cannot provide a detailed feasibility analysis for applying recovery solutions for any particular end-of-life OTR rubber products, covering analysis of the capital and operational expenses, the return on investment, and project viability. That level of analysis is beyond the scope

[1] Commonwealth Government funding was provided through the National Product Stewardship Investment Fund.

of this document but will be needed as part of further analysis by industry using detailed project specifications.

not provide all the answers for all stakeholders, so it's important to be clear about what it can and cannot provide.

1.3 TSA and the Scheme's mandate and scope

1.3.1 Expectations

The Tyre Product Stewardship Scheme provides an Australian Competition and Consumer Commission (ACCC)-authorised, industry-led, voluntary framework to reduce the environmental, health and safety (EHS) impacts of the 56 million tyres (Equivalent Passenger Units or EPUs) that reach the end of their life in Australia each year.[2]

The aim of the Scheme is to reduce the amount of end-of-life tyres negatively affecting the environment via landfill, illegal dumping or undesirable export while increasing the recycling rate of end-of-life tyres.[3]

The Scheme is accredited under the voluntary product stewardship arrangements of the Commonwealth Product Stewardship Act 2011. This legislation provides the framework to manage the EHS impacts of products, in particular those that arise when disposing of end-of-life products.

There are many benefits in transforming a waste product into useful products, creating new industries and employment opportunities, while reducing the environmental harm caused by illegal dumping. These benefits rely on recovering more of the end-of-life tyres that are considered within the scope of the Scheme.

Scope of the Tyre Product Stewardship Scheme

The Scheme is national and applies to tyres on motorised vehicles and non-motorised trailers, including motorcycles, passenger cars, box truck trailers, buses, mining and earth-moving vehicles, cranes, excavators, graders, farm machinery, and forklifts. The Scheme does not currently extend to conveyor belts or rubber tracks.

The Scheme also provides benefits to individual participants, the community and the tyre industry as a whole. These include:

- increasing use of a resource currently being disposed of as waste
- increasing the number of tyres going to an environmentally-sound use
- enhancing the Australian recycling industry and creating sustainable markets for tyre-derived materials
- increasing our capacity to handle end-of-life tyres in Australia
- creating new markets for end-of-life tyres and tyre-derived materials
- improving the business environment for tyre collectors and recyclers

[2] One EPU contains as much rubber and other materials as a 'typical' passenger tyre. For the purposes of this report, the assumed weight of one new EPU is taken to be 9.5 kg and one end-of-life EPU is taken to be 8 kg.

[3] TSA, Guidelines for the Tyre Product Stewardship Scheme, amendment 1.1, March 2019.

- increasing consumer awareness of the impacts of end-of-life tyres disposal
- enhancing credibility for the tyre industry by showing leadership in environmental management and adopting corporate social responsibility strategies.

The ACCC reauthorised the Scheme's continuation for six years from May 2018, recognising that the Scheme guidelines call for an independent review every four years.[4] This independent review is outlined in section 1.3.6. If the ACCC decides to amend the Scheme to provide greater certainty of recovering all OTR rubber products at scale, there may be an opportunity to do this during the next reauthorisation process in 2024.

1.3.2 Tyre Stewardship Australia

Purpose

Tyre Stewardship Australia was formed to implement the national Tyre Product Stewardship Scheme (the Scheme) to develop viable supply chains and markets for end-of-life tyres. By transforming these tyres into useful commodities, TSA helps to create and develop new industries and employment opportunities while reducing the environmental harm caused by illegally dumping and stockpiling old tyres.

Participation

TSA consists of representatives from across the tyre supply chain including tyre manufacturers retailers, recyclers and collectors, as well as members of the Australian automotive industry.

Approach

TSA's approach is based upon:

- auditing and accrediting the end-of-life tyres supply chain
- promoting and engaging on end-of-life tyres management issues
- developing markets for end-of-life tyres.

Funding

TSA is funded by an ACCC-endorsed 25 cent levy (per EPU) voluntarily paid for every automotive tyre imported into Australia by Scheme contributors: Bridgestone, Continental, Goodyear Dunlop, Kumho, Michelin, Pirelli, Toyo Tires, Hankook, TyreConnect and Yokohama, as well as three autobrands of Mercedes, Porsch, and VW.

Contributing OTR tyre importers pay a separate voluntary levy based on rim size, including Ascenso, Bearcat, Kaltire, Bridgestone, Goodyear Dunlop, Michelin and Yokohama. We hope that other OTR tyre importers and OEMs to join in the future.

1.3.3 TSA's strategic goals

In 2020, TSA released its Strategic Plan 2020-23, setting out its core mission and priority activities developed to deliver on that mission.[5] The Strategic Plan sets out five strategic goals for TSA over this period to 2023:

- increase used tyre recovery and end markets
- continue to improve data and information on all used tyre fates, both in Australia and overseas
- grow the number of organisations contributing to and participating in the Tyre Product Stewardship Scheme

[4] ACCC, Determination AA1000409, May 2018.

[5] https://www.tyrestewardship.org.au/about-tsa/strategy/

- be perceived as a trusted entity, building relationships and value for its stakeholders
- be a significant contributor to the global circular economy for end-of-life tyres.

While TSA has historically focussed on automotive tyres, the opportunities and benefits of improving OTR rubber product recovery have become increasingly obvious. This has implications for the scope of achievement for the Scheme, as some large users of OTR rubber products have great influence over suppliers and the impacts of their global supply chains.

1.3.4 Achieving 80% end-of-life tyre recovery by 2030

To achieve its aims, TSA has aligned its objectives for end-of-life tyres recovery with the *National Waste Policy Action Plan*, prepared by Commonwealth, state and territory governments and the Australian Local Government Association in 2019.[6]

The Action Plan supports national packaging targets developed and agreed by Australian businesses and industry through the Australian Packaging Covenant Organisation, and the separate policies committed each state and territory committed to when it was released. The Action Plan also aims to enable a circular economy for waste in Australia, so businesses and households can get the full value of recyclable materials and work towards more sustainable resource use.

Target 3 of the Action Plan sets a goal of an 80% average recovery rate across all waste streams by 2030, including end-of-life tyres. As the product stewardship lead for end-of-life tyres, TSA has adopted this target across the total of end-of-life tyres generated by 2030, including passenger car, truck and OTR end-of-life tyres.[7]

Recovery rates of end-of-life tyre in 2021-22 were estimated and reported by TSA at 63% with recovery rates as high as 72% in previous years, largely due to reduced rates of automotive tyre recovery. Closing the gap between 63% and the 80% target by 2030 will require a major improvement in recovering OTR tyres used in priority industries.

Current contribution of passenger car, bus and truck tyres (automotive) recovery

Contribution of passenger car, bus and truck to overall generation of end-of-life tyres has consistently been between 70-75% over recent years with recovery rates sitting around 90% respectively for both passenger cars as well as bus and truck tyres. At the same time, OTR tyres, which make up the remaining third of tyres, have been hovering around 10% recovery. Collectively, this amounts to between 60 and 70% recovery rate across all types of end-of-life tyres.

Overall, recovery has plateaued in recent years, due to a combination of:

- new opportunities to recover automotive tyres being limited to remote locations and in smaller amounts
- limited progress in recovering end-of-life OTR tyres because of a set of barriers unique to those sectors and the effort needed to recover their OTR tyres (see Chapter 5).

[6] https://www.dcceew.gov.au/sites/default/files/documents/national-waste-policy-action-plan-2019.pdf

[7] While the national 80% recovery target for all streams may have originally been conceived and framed towards post consumer wastes, TSA's realm of responsibility includes other sources of waste including commercial, light and heavy industry. As such, it is appropriate that the national targets are ported to the Scheme as a minimum standard to attain across all end-of-life tyre streams.

TSA is addressing the first challenge with business cases for recovering tyres in more remote regions including the Northern Territory[8] and regional Queensland,[9] and engaging with potential partners willing to support, invest in, or offer end-of-life tyres for recovery in those regions.

This report addresses the second challenge.

1.3.5 The need to drive greater recovery of end-of-life OTR tyres

Even if we managed to recover 100% of automotive tyres, when added to the around 10% recovery of OTR tyres, the combined recovery rate would still be below the 80%.

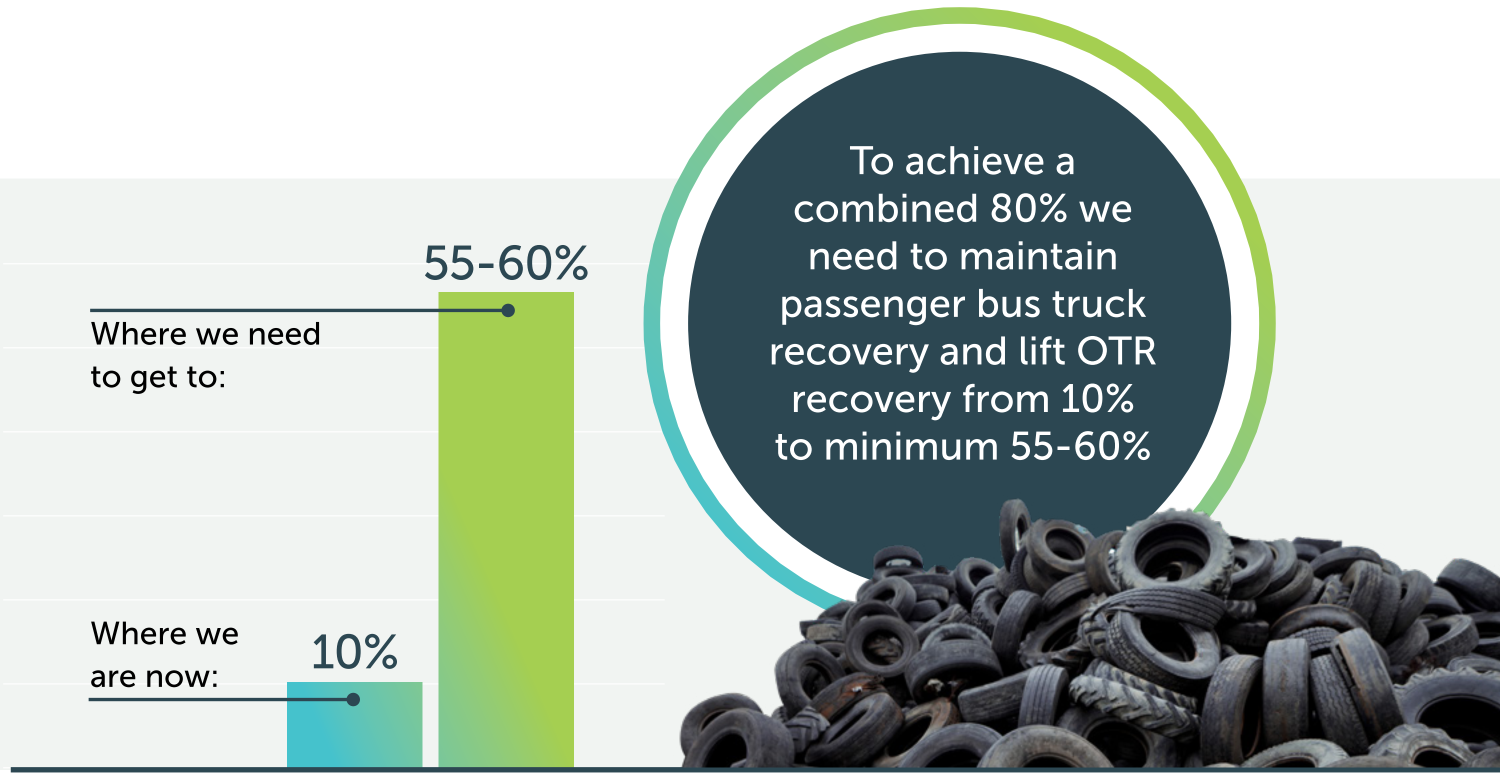
This means that without increasing the contribution from the OTR sector, the Scheme will not achieve the 80% recovery target set in the National Waste Policy Action Plan.

Another reason to recover more OTR tyres is the need to be consistent with long-standing expectations on households and businesses to recover on-road vehicle tyres (see Chapter 3).

What's needed to achieve 80%?

Assuming that recovery rates for automotive tyres stay fairly constant, we estimate that we will need to recover 60,000 – 80,000 tonnes of end-of-life OTR tyres to achieve the 80% recovery rate - an OTR tyre recovery rate of 55 to 60%.[10] (see Chapter 7).

TSA may need to adjust this estimate due to likely increases in generation of automotive and OTR tyres as timelines approach 2030.



8 https://www.tyrestewardship.org.au/reports-facts-figures/tyre-recycling-in-the-northern-territory/

9 https://www.tyrestewardship.org.au/reports-facts-figures/queensland-regional-business-case-for-a-circular-economy-for-used-tyres/

10 There will always be some degree of uncertainty regarding how many tonnes of OTR tyres recovered maps to a given recovery rate and vice versa, due to variability in OTR tyre generation volumes.

Beyond the 80% recovery rate?

There is the potential to aim for a 2030 target above 80%, depending on the relative proportion of end-of-life OTR tyres compared with overall end-of-life tyres generated in a given year. There are drivers for this that we discuss in Chapter 7.

Tracking the recovery rate over time

While consumption of automotive tyres trend upwards fairly predictably, reflecting population and economic growth rates, the same is not true for OTR tyres, which follow more complex trends based on industry activities that may be unpredictable or cyclical. If OTR tyre generation outstrips that of automotive tyres, they will contribute more to the 80% target, so a 55% recovery rate may not be enough.

For example, mining activities may follow macroeconomic cycles (reflecting the pace of global economic development) and non-cyclical commodity price trends. Agricultural activity levels may vary with weather and climate conditions and competing uses for land, with implications on vehicles used to work the land.

Over the next seven years, TSA will track the contributions of automotive and OTR tyres to the 80% recovery rate, and review target recovery rates for each of these sectors to keep to a target trajectory.

For now, we propose an OTR tyre recovery goal of 55% to 60% by 2030.

Understanding 10% recovered

The current OTR tyre recovery rate of around 10% relates mainly to OTR tyres generated in urban settings, including moderately-sized tyres (e.g. less than 2 metre diameter) from manufacturing and construction vehicles, and from the aviation sector.

The reality is that most end-of-life OTR tyres come from industries in regional and remote locations, that face other barriers to viable resource recovery. This means we need to re-think the scope of TSA's activities, and the nature of partnerships needed to overcome these barriers.

1.3.6 Scheme review and ACCC reauthorisation process

In 2021 TSA commissioned an independent review of the Scheme to meet the ACCC's requirements. This involved consultation with key stakeholders including governments, industry, global circular economy peers, and environmental, social, and governance advisors.

The review found that the program has successfully delivered public benefits at a small cost to the economy, but has reached a turning point.[11]

The review stated that, while TSA has done a good job in administering the Scheme, and has a high level of corporate governance understanding and practice, the Scheme's voluntary structure limits its ability to achieve more, and has a risk of becoming financially non-viable if a contributor left.

Voluntary or regulated?

Consequently, the review proposed that a regulated structure could enable the Scheme to expand its activities significantly, and pursue strategic opportunities and innovation for stakeholders in the circular tyre economy. This would align it with other schemes around the world.

[11] Arcoona Consulting, Tyre Stewardship Australia Tyre Product Stewardship Scheme – Independent Review, August 2022. https://www.tyrestewardship.org.au/news/independent-review-of-australias-tyre-product-stewardship-scheme/

This review raises important questions for TSA, regulators, and all stakeholders in the circular tyre economy. These include:

- whether a voluntary scheme for end-of-life tires has reached its maximum potential to make a difference
- who might be missing out under the current structure
- how a product stewardship organisation can support and advance circular economy principles
- whether there are opportunities to help local manufacturers use tyre-derived materials and invest in local recovery of used tyres.

The Priority Product List

On 8 November 2022, the Federal Minister for the Environment and Water announced the inclusion of end-of-life tyres on the annual Minister's Priority Product List. Companies that manufacture or import items on this list are responsible for the environmental impacts of their products throughout their lifecycle. This means that if voluntary participation does not increase, the government may consider regulation.

1.4 A path to a circular economy for used OTR tyres

The main ways tyres are recovered in Australia involve mechanical processing into:

- a shredded product of specified dimensions used as a fuel in kilns, boilers and furnaces
- granules and crumb used in flooring, industrial products, adhesives and road and pavement infrastructure.

These two recovery paths are taken as environmentally-sound outcomes when weighed against the alternatives of legal disposal into landfills and illegal burning, dumping and non-compliant stockpiling (i.e. at levels and using methods that do not meet waste tyre storage regulations).

1.4.1 Truly circular?

These two paths are well-established in Australia, and may provide near-term solutions if we can overcome some of the logistical and processing challenges of recovering large, remotely-located OTR tyres. That said, these methods don't necessarily represent the key principles of a circular economy.[12]

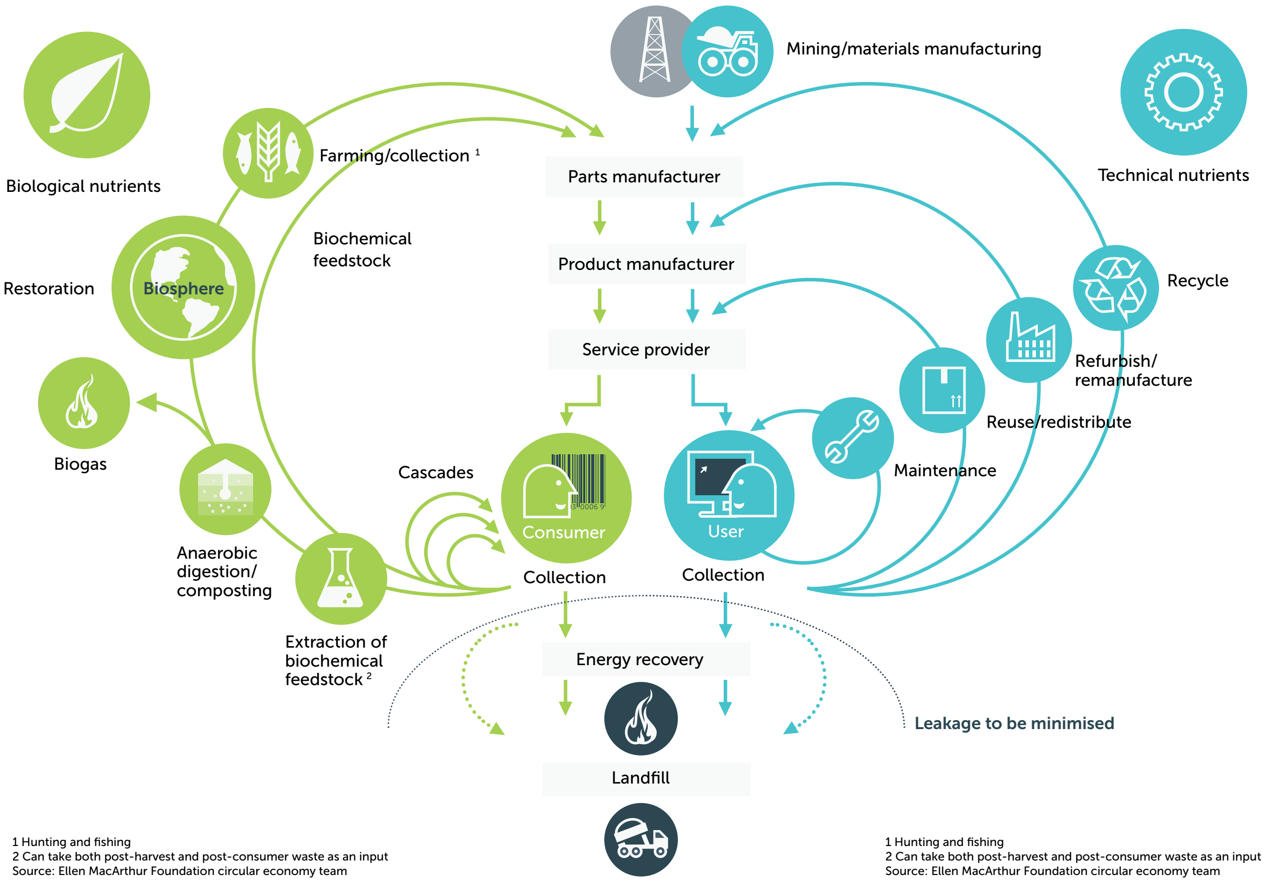
For example, using shredded tyres as fuel displaces one fuel with another along a linear path.[13] When using rubber crumb and granule for building, the material passes from one production and consumption system (tyres) to another system (e.g. roads or pavements), where it is then up to actors in that system to recover the material at its next end-of-life cycle.

In each case, there are questions around the long-term circularity, due to the nature of the downstream use and/or the transfer of responsibility to others.

[12] Ellen MacArthur Foundation, Towards the Circular Economy, 2013.

[13] While there is an argument that tyre-derived fuels (ultimately produced from latex and other materials) has a partial use of a renewable plant-base fuel source (latex), its use as a fuel does not diminish the pressure to replace tropical forests with rubber plantations. Other combustible components of the tyre – i.e. carbon black, nylon, synthetic rubber – are almost certainly fossil fuel derived and therefore non-renewable in nature.

Figure 1: Concept diagram for a circular economy, including biological and technical cycles.
Source: Ellen MacArthur Foundation, Towards the Circular Economy, 2013. (https://ellenmacarthurfoundation.org/)



A circular economy is a global economic model that aims to decouple economic growth and development from the consumption of finite resources. It is restorative by design, and aims to keep products, components and materials at their highest utility and value, at all times.

Unlike a linear economy, it is about optimising systems rather than components. This includes careful management of materials flowing in both biological and technical cycles.

Ellen MacArthur Foundation

Circularity Indicators: An approach to measuring circularity, 2015

1.4.2 Exploring new models

This observation is not intended to challenge current Australian tyre recycling practices, but the increased focus on OTR tyres, and the distinct ways some businesses use them, present an opportunity to test the viability of new models to recover tyres and extend their economic value.

Key parts of this exploration involve:

- factoring in how large users of OTR tyres view different solutions to recover tyres and extend their value during the use phase – including ESG, accounting and reporting obligations (potentially aligned to UN Sustainable Development Goals,[14] the Global Reporting Initiative framework[15] or the Task Force on Climate-Related Financial Disclosures[16])
- testing large OTR tyre users' willingness to influence their tyre supply chains to align their supply models to a circular economy approach
- accounting for the technical, logistical and commercial challenges involved in shifting from OTR tyre disposal to OTR tyre recovery, and the viability of solving these challenges over different timeframes and business cycles
- sharing information between parties to create a fuller picture of the impacts of the production and consumption of OTR tyres, so the OTR tyre supply chain and major generators can make decisions and commitments towards a circular economy for OTR tyres.

Progress on these points will provide a better understanding of what a circular economy of OTR tyres could look like (see Chapter 3 for an overview), while potentially identifying new collaboration approaches to align interests and obligations of OTR tyre stewardship, OTR tyre production and supply, and OTR tyre usage (see Chapter 6). This progress is likely to evolve over a longer term beyond the delivery of this business case, but it is a necessary priority for TSA's strategic goal no. 5: *TSA is a significant contributor to the global economy for end-of-life tyres.*

1.4.3 Priorities

Arguably, this exploration should also be a priority for large users of OTR tyres given:

- the amount they spend annually on OTR tyres
- the importance of OTR tyres to their business (as a strategic commercial asset)
- the amount of resources bound within each tyre for which they carry a duty of care in balance with the OTR tyre supply chain.

Supporting these priorities for progress, the *National Waste Policy Action Plan* (Target 2)[17] calls for relevant businesses and governments to drive greater waste avoidance, by:

- delivering targeted programs to build businesses' capability to identify and act on opportunities to avoid waste and increase materials efficiency and recovery (Action 2.05)
- developing or adopting appropriate standards that maximise the value of materials across the life of a product, to increase life cycle potential and avoid waste (Action 2.11).

Further, the *National Waste Policy Action* Plan Target 4 is oriented towards a greater use of recycled content in products used by government and industry, particularly in infrastructure, but sentiment applies other industrial consumption – such as using recycled tyre material in new or repaired tyres – in a way that extends the impact of the *National Waste Policy Action Plan* to other materials-intensive parts of the Australian economy.

[14] https://sdgs.un.org/goals
[15] https://www.globalreporting.org/
[16] https://www.fsb-tcfd.org/
[17] https://www.dcceew.gov.au/sites/default/files/documents/national-waste-policy-action-plan-annexure-2022.pdf

1.5 Key concepts used in this business case

This business case aims to define a pathway to increase the recovery of OTR tyres across Australia, based on identified opportunities to realise and share a range of benefits.

Across this report, we use a number of concepts to describe how greater OTR tyre recovery can be achieved while accounting for key features of the usage patterns for OTR tyres across the economy, and details particular to the Australian Tyre Product Stewardship Scheme.

Three important concepts arise throughout this report:

- two tiers – national level and catchment level
- principals and agents
- uncertainty in market-driven solutions.

1.5.1 Advancement on two tiers of OTR tyre recovery

National scale...

This business case assumes that TSA, the Commonwealth and state and territory governments, industry partners and stakeholders are committed to improving recovery of OTR rubber products at a national scale. That is, it has to identify and encourage OTR tyre recovery in the aggregate over a defined period.

Drivers for this aggregate approach may include:

- policy drivers and corporate goals at the national level
- the desire to capture and distribute multiple recognised benefits
- the intent to deliver on principles centring on the circular economy and environmental justice (see Section 3.1.1).

That said, any individual OTR tyre recovery actions that contribute to national outcomes need to account for the costs and constraints of establishing supply chains for processing OTR rubber products, and bringing products to markets. The viability of these supply chains will be affected by spatial, temporal and commercial characteristics that in turn rest upon the distribution of end-of-life OTR tyres across the Australian economy.

...with a catchment approach

Below the national level, a **catchment** analysis approach will enable us to test whether a given region of economic activity provides enough OTR tyre material to support new recovery solutions. The ideal catchments will have a large amount of tyres and fewer barriers to recovery, so they deliver early wins and make a meaningful contribution at the national level.

This report needs to define what catchment-level approaches are possible and can work across both the national and catchment-level tiers of OTR tyre recovery opportunity. We will still need to engage with OTR tyre users who are of moderate scale, but in remote locations where they have limited access to suitable tyre recovery infrastructure.

At present, trying to find a single solution for recovering OTR tyres across all catchments is not viable, due to the great diversity in catchment features across the country. In particular, the variations in mining and agriculture industries work against a 'one size fits all' approach. While a national business case cannot put forward a uniform solution, there is still an opportunity for an overall approach that can be tailored to suit different parts of the country, and provide a path to achieve 80% recovery by 2023.

Figure 2: Key levels to achieve OTR tyre recovery at the national scale, noting the need to achieve commercially viable recovery across multiple catchments.

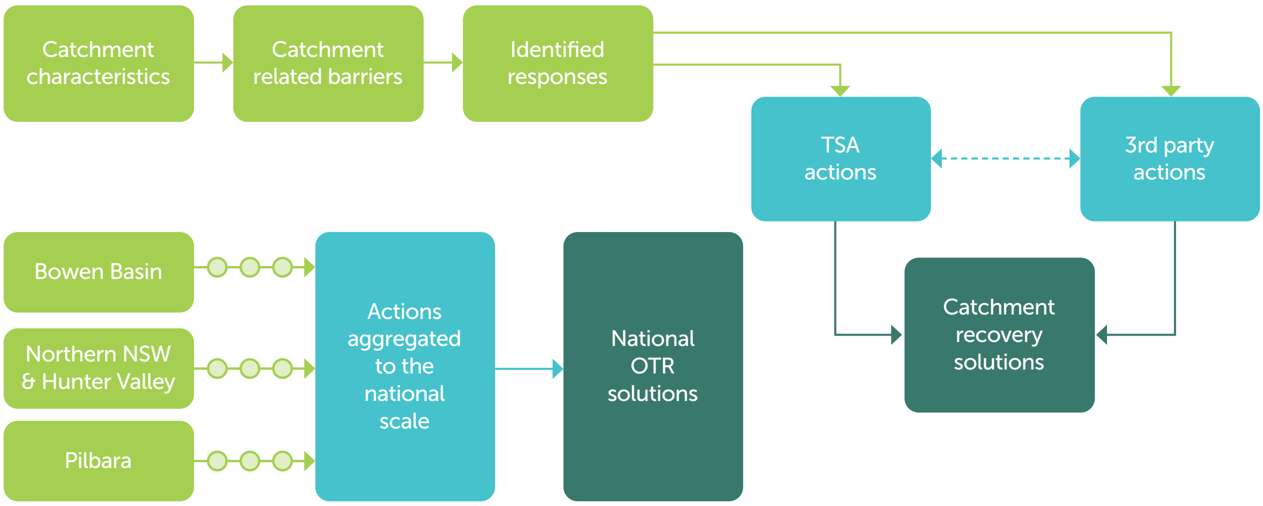


Figure 2 shows these relationships. By understanding the catchment features shown at the top of the diagram (in yellow), we can create ways to move away from disposal methods such as on-site burial, and towards one or more recovery methods. TSA and other parties (in blue) can then take actions which will create a catchment recovery solution (in green).

This process can then be replicated across multiple catchments (in orange, three catchments listed for illustrative purposes only) to identify actions that apply across all catchments, making a national OTR solution. This national solution may involve a coordinated set of measures that are best applied working with individual businesses or supply chains, at regional (i.e. catchment) scales, at the state or territory level and at the national scale.

1.5.2 Accepting uncertainty in the use of market-driven solutions

In much of the rest of the world, the product stewardship organisation participates directly in one or more parts of the recovery supply chain, typically where private businesses are poorly placed to act in this role. This arrangement may be backed by legislation requiring individual brand owners to take direct responsibility for their products, with the option to work under an industry collaborative model.

The collaborative model is often followed, in which the product stewardship organisation acts on behalf of responsible industries and supply chains. Industry must cover the cost of operating the organisation net of any revenues from recycling fees and the selling recovered products.

The Australian approach

The Australian Product Stewardship Scheme is different because private businesses do most of the physical tyre recovery activities within a regulated market environment (local governments sometimes transport or consolidate tyres for collection).

TSA's main role in recovery is to support, guide or otherwise intervene using non-coercive measures to improve recovery outcomes and to help strengthen or mature the markets for end-of-life tyre products. Its functions are predominantly persuasive and 'light touch', encouraging incentives and methods to de-risk legitimate commercial practices in the recovery supply chain.

This approach has lower administrative costs than a centralised 'top down' model, and uses the natural drive of competing businesses to find efficiencies and invest in new technologies. In short, the Australian model seeks to co-opt innovation and engender resilience through well-functioning market-based activity.

These advantages are counterbalanced by a level of uncertainty about tyre recovery outcomes and recovery rates. TSA and other partners depend on market actors responding to incentives to recover and use tyre-derived materials, in balance with other factors that reinforce or work against those incentives.

Setting targets

At the national level, any projections and planning towards a given OTR tyre recovery rate (see Chapter 7) need to be considered in terms of *confidence levels of achieving* a given result, rather than absolute numbers.

TSA and partners need to view their roles in terms of what actions can deliver a high degree of confidence that we will achieve a given set of outcomes at the catchment and national levels, compared to a business-as-usual approach of taking no action to influence behaviours. Once we establish targets for OTR tyre recovery, we can define actions and analytics frameworks to adjust to shifting market conditions that affect OTR tyre recovery ambitions.

2. Profile of OTR rubber products

This chapter explains what OTR products are, who uses them, the amounts consumed and amounts of waste generated. It provides separate profiles for OTR tyres, conveyors, and tracks.

OTR rubber products refers to tyres, tracks, and conveyor belts used on OTR equipment such as construction and mining equipment, agricultural tractors, industrial equipment, aircraft, and defence equipment.

2.1 OTR tyres

OTR tyres come in a range of rim sizes, from a forklift tyre with a rim of less than 20cm that you could pick up in one hand, to mining dump truck tyres with a rim size of nearly two metres (63 inch) that weigh up to five tonnes.

OTR tyres are not automotive tyres (i.e. car, bus, truck, 4-wheel drive, or motorbike tyres), which are used mostly for on-road applications.

2.1.1 Who uses OTR tyres and for what applications?

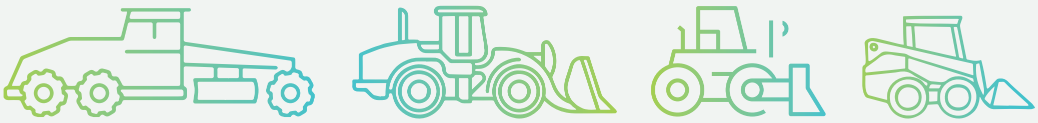
OTR tyres in most cases are used in heavy-duty industrial applications, such as carrying or towing heavy loads, earthworks, construction and demolition, and agriculture. In many cases, OTR vehicles are working on uneven, unstable, or slippery ground. To operate effectively in these settings, OTR tyres and tracks need to be designed to accommodate difficult working environments.

OTR tyre use is concentrated in a few sectors of the Australian economy. These sectors and example equipment[18] are:

Agriculture (and forestry) – tractors and harvesters

Aviation – aircraft

Construction (and demolition) – graders, bobcats, and loaders



Defence – specialised vehicles[19]

Industrial (manufacturing and trade) – forklifts and empty container handlers

Mining – rigid dump trucks and underground haulers.

[18] The equipment used within each sector can cross over and the list may be incomplete regarding the number of sectors OTR products are used. For example, the agriculture sector may use other niche heavy vehicles such cotton pickers whose tyres may be physically distinct from other tractor tyres or used in different regions across the country.

[19] There is limited public information about the defence sector use of OTR tyres due to the sensitivity of the information. Defence uses aircraft, construction vehicles, and other off-road vehicles specialised to military applications (e.g., armoured personnel carriers).

The sector and application influence the OTR rubber product:

- type, size, weight, quantities consumed, and waste generated
- location at end-of-life and distance to recovery facilities and related end markets
- end-of-life management, by regulation or industry standards
- economic or environmental factors
- barriers to and opportunities for recovery.

Different sectors have different requirements and usage conditions for the vehicles they use, which influence the physical features of the tyres attached to the vehicle. For example:

- forklifts used inside a warehouse have less need for strong all-weather traction, toughness, and shock absorption.
- mining vehicle tyres need to be highly durable and have excellent traction, given their ongoing use in carrying very heavy loads, on rough terrain, in a range of weather conditions.
- agriculture tyres need to have traction on a range of outdoor surfaces but don't have the same strength requirements as mining tyres, allowing for lighter weight characteristics and less rigidity.

Understanding typical tyre sizes, along with other physical features, is important for the types of equipment and logistical activities needed to recover OTR tyres, particularly the large tyres in the mining and agriculture sectors (see section 2.1.5 OTR tyre material composition and properties).

2.1.2 OTR tyre consumption and used tyre generation

Our analysis of the amounts of OTR tyre consumption is derived from ABS statistical publications, sector engagement, and unpublished TSA data.

The difference between OTR tyre consumption and OTR tyre waste generation is wear and degradation over the tyre's operating life.[20] For our analysis and this report:

- an imported new OTR tyre represents a replacement of an old tyre
- we've applied a wear rate of 16% to all new OTR tyres to represent the weight of a used tyre, but industry sources indicate this could be as high as 20% in some sectors[21].

The ABS import and export data for OTR tyres is in three categories (1) Agriculture and forestry, (2) Construction, mining, and industrial, and (3) Aviation. For the analysis below, we've separated category 2 into three sectors and provided estimates for each utilising data reported to TSA.

The figures discussed span before and after the global Covid-19 pandemic, and the economic and industry impacts of this event may affect these figures in future years. Pandemic-related economic impacts may also operate differently for OTR tyre generation than passenger car, bus, and truck.

[20] Unless stated otherwise, figures in this report refer to used OTR tyre generation, rather than consumption of new tyres.

[21] Wear and degradation rates of OTR tyres in different applications across the country are not clear. Further research will need to investigate wear and degradation of OTR tyres in their applications, environments, and conditions.

OTR tyre consumption

Table 1 details the estimated consumption of new OTR tyres in Australia in 2021-22.

Table 1: Estimated weight (tonnes) of OTR tyres consumed in Australia, 2021-22

Sector	Tonnes of OTR tyres	Proportions
Agriculture and forestry	18,000	11%
Mining	128,200	80%
Construction (and demolition)	8,500	5%
Industrial (manufacturing and trade)	5,600	3%
Aviation	600	<1%
Total	**160,900**	

In 2021-22, almost 630,000 new OTR tyres were imported into Australia, totalling around 160,000 tonnes. By weight, the greatest consumption was in mining, with agriculture and forestry the second largest sector. While OTR tyres used on construction, mining, and industrial equipment combined dominate on a weight basis, in 2021-22, around 355,000 individual agriculture and forestry OTR tyres were imported compared to under 250,000 construction, mining and industrial tyres. This demonstrates the variation in OTR tyres which includes size and weight, discussed further in section *2.1.5 OTR tyre material composition and properties.*

Used OTR tyre generation

We estimate that in the last three years Australia generated on average around 130,000 tonnes annually of used OTR tyres, with around 136,000 in 2021-22[22] (see Table 2) most of these being used in the mining sector by weight.

Table 2: Estimated used OTR tyre generation (tonnes) by sector 2019-20 to 2021-22

Sector	2019-20	2020-21	2021-22	3 Year Average
Agriculture and forestry	9,000	13,690	15,140	**12,600**
Mining	108,700	91,510	107,940	**102,700**
Construction (and demolition)	10,720	11,390	7,800	**10,000**
Industrial (manufacturing and trade)	7,150	7,590	5,190	**6,600**
Aviation	600	380	600	**500**
Total	**136,170**	**124,560**	**136,670**	**132,500**

Given the estimated national generation of 136,000 tonnes of OTR tyres in 2021, most of these tyres arise from the Western Australian economy (37%), followed by Queensland (34%) and New South Wales (18%), see Table 3 and Table 4. The rest of the states and territories' contributions together comprise the remaining 11% of the total amount of OTR tyres reaching end of life in 2021.

Table 3: Estimated used OTR tyre generation (tonnes) by sector and jurisdiction[23] in 2021-22

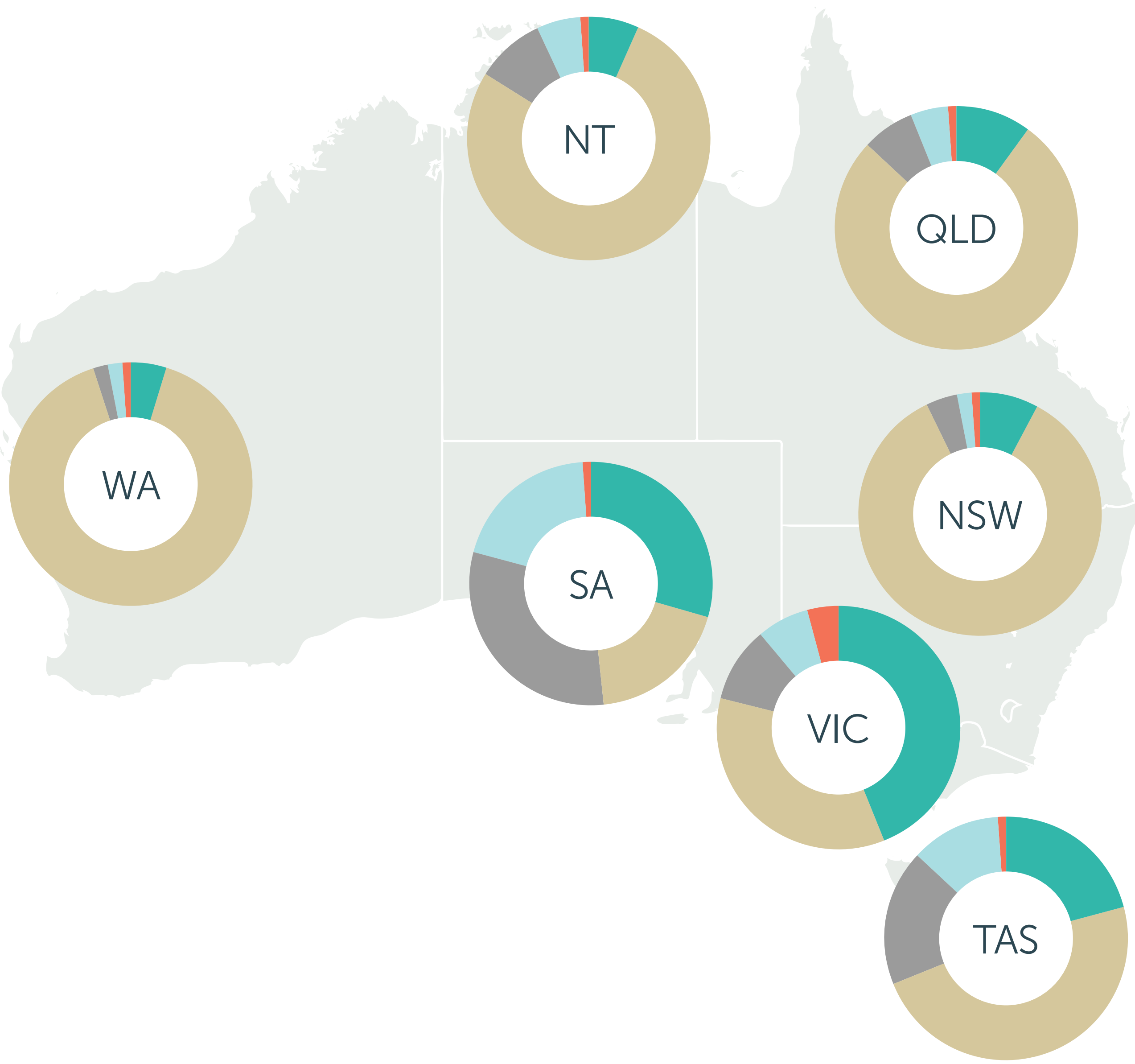
Sector	NSW	NT	QLD	SA	TAS	VIC	WA	Total
Agriculture and forestry	2,090	80	4,830	1,020	160	4,380	2,580	**15,140**
Mining	21,030	950	35,700	660	360	3,510	45,730	**107,940**
Construction (and demolition)	860	110	3,430	1,040	140	1,000	1,220	**7,800**
Industrial (manufacturing and trade)	580	70	2,290	690	90	660	810	**5,190**
Aviation	70	10	80	-	-	400	40	**600**
Total	**24,630**	**1,220**	**46,330**	**3,380**	**750**	**9,950**	**50,380**	**136,670**
Proportion by state	**18%**	**1%**	**34%**	**2%**	**1%**	**7%**	**37%**	

[22] This allowing for tyre wear and assumes imports of new OTR tyres into each state are representative of waste generation for those states (i.e. net imports of new OTR tyre represents a replacement of an old tyre),

[23] For the purpose of the analysis, ACT is included in the figures for NSW

Table 4: Estimated used OTR tyre generation (tonnes) in each jurisdiction (%), 2021-22

Sector	NSW	NT	QLD	SA	TAS	VIC	WA
Agriculture and forestry	8%	7%	10%	30%	21%	44%	5%
Mining	85%	78%	77%	19%	48%	35%	91%
Construction (and demolition)	4%	9%	7%	31%	18%	10%	2%
Industrial (manufacturing and trade)	2%	6%	5%	20%	12%	7%	2%
Aviation	<1%	1%	<1%	<1%	<1%	4%	<1%



For Western Australia, Queensland, and New South Wales, the figures are dominated by the extent of mining and agriculture sector activity, with other industries playing a more minor role. In Victoria and South Australia, agriculture is one of the largest end-of-life OTR sources. While generation in the Northern Territory is relatively modest, comparatively significant mining activity and limited broadacre cropping skew its OTR tyre generation profile towards mining tyres.

With these points in mind, this work uses the following assumptions:

- levels of end-of-life mining tyres are broadly correlated to the level of mining output in each state and territory, where this output is framed in terms of earth displaced by a mining operation over a given year (see Chapter 8)
- levels of agriculture tyres are broadly correlated to the level of agricultural output in each state and territory, with broadacre and irrigation farming output the main drivers, and larger livestock (sheep, cattle and goats), fruit and viticulture output levels being secondary drivers (see Chapter 9)
- levels of other end-of-life OTR tyres from other 'urban' sectors – aviation, construction, industrial broadly follow levels of economic activity and population.

The Australian OTR tyres market is forecast to grow at 6.1% per year from 2022-2027[24]. Many factors may influence the future amount of end-of-life OTR tyres, tracks, and conveyor belts generated nationally. These factors include:

- macroeconomic cycles and their influence on the levels of commercial activity in agriculture, mining, aviation, manufacturing, and trade
- residual impacts of the Covid-19 pandemic on sectoral activity, and similar economic impacts caused by future black swan events
- shifts in minerals demand, such as increased mining of lithium, nickel, cadmium, and other rare earth minerals associated with electric vehicles, batteries and renewable energy, and corresponding decreases in the demand for coal.
- economically-driven changes in consumer preferences, such as changes in dietary habits in developing countries linked to improved standards of living.
- vehicle practice changes including the trend towards larger tractors used on increasingly consolidated farmlands, the use of autonomous drive or electric vehicles in the mining and agriculture sectors, replacement of mining trucks with conveyor belts, and replacement of wheeled agriculture vehicles with tracked vehicles over time
- shifts in the quality and durability of OTR tyres used in different sectors, and the impact on the rate of disposal
- development of OTR tyre care, maintenance, repair, and re-use services and markets
- larger geostrategic factors and their influence on domestic investment in Defence-related vehicles and the drive towards greater self-sufficiency in selected sectors.

[24] MarketsandMarkets, OTR Tires Market – Global Forecast to 2027 (2022), 224.

2.1.3 Current used OTR tyre management and fate in Australia

Recovery rates of OTR tyres in Australia have consistently been low and estimated to be fluctuating either side of 10% for the past 3-5 years. In 2019, TSA published Used Tyres Supply Chain and Fate Analysis report estimated the fate of OTR tyres by tyre category[25] (see Table 5). The fate in 2021-22 is estimated to have similar proportions as those estimated in 2018-19 which shows there is high recovery of OTR tyres from the aviation, construction and industrial (manufacturing and trade) sectors but low recovery rates from the agriculture and mining sectors.

Table 5: Used OTR Tyres assumed local and export fate proportions by tyre category, 2018-19 (%)

Fate	Agriculture	Aviation	Construction	Manufacturing & trade	Mining
Casings & seconds (re-treading)	–	–	–	–	–
Civil Engineering	1%	–	1%	1%	1%
Crumb, granules & buffings	–	–	1%	1%	–
Pyrolysis	–	–	–	–	1%
Kilns/boilers/furnaces	–	–	–	–	–
Stockpiles (>40 t, 5,000 EPU)	2%	–	2%	2%	2%
Landfill	4%	4%	4%	4%	3%
Onsite disposal (mining, other OTR)	90%	10%	10%	10%	93%
Dumping dispersed	3%	3%	3%	3%	–
Export for processing	–	83%	79%	79%	–
Total	**100%**	**100%**	**100%**	**100%**	**100%**

These profiles of high generation in mining and agriculture coupled with low recovery rates inform a path to deliver the OTR tyre recovery levels needed to achieve and surpass an overall 80% tyre recovery rate by 2030. This report provides more detailed profiles of the sectors mining and agriculture that consume most of the amount of OTR tyres without recovering them at end-of-life, in Chapters 4, 8, and 9.

2.1.4 OTR tyre properties and impact on recovery

Physical features of OTR tyres (size and weight)

Table 6 includes analysis of OTR tyres by application, rim size and estimated average weights derived from OTR tyre import data reported to TSA. 'Industrial and forklift tyres' includes tyres used in manufacturing and trade sectors, while 'agriculture tyres' spans farming, cultivation, and primary production sectors including agriculture and forestry. 'Earthmoving tyres' includes tyres used on vehicles used in earthworks and mining activities, including large-scale open cut and underground mining.

[25] 'Manufacturing & trade' = 'industrial' sector outlined earlier in report

Table 6: OTR tyres by TSA reporting applications, rim size and estimated average weights

Application	Rim size (inches)	Estimated average weight (kg)
Earthmoving (Construction and demolition, mining)	<15"	<30
	15" to <20"	35
	20" to <24"	120
	24" to <29"	350
	29" to 35"	1,000
	39"	1,800
	45"	2,500
	49"	1,500
	51"	2,400
	57"	3,800
	63"	5,000
Agriculture (and forestry)	<15"	<30
	15" to <20"	30
	20" to <24"	70
	24" to <32"	100
	32" to <38"	170
	40"	200
	42"	280
	44"	410
	46"	230
	50"	200
	54"	170
Industrial and Forklift (Manufacturing and trade)	<8"	<30
	8" to <20"	30
	20" to <24"	120
	24" to <32"	280
	32" to <38"	840
	>= 38"	1,400
Aviation	<8"	<10
	8" to <20"	8
	>20"	100

The import tonnages of each rim size in the table above contains commercially sensitive data and is not included. While the tonnages are not provided, analysis of the import tonnages reported to TSA found:

- for the earthmoving (mining) sector most imports were greater than the 35 inch rim size, dominated by the 57 inch and 63 inch rim sizes.
- for agriculture vehicles, the import tonnages are mostly within the 42 inch, 24 to 32 inch range, with significant tonnages of 46 and 50 inch also reported.
- for industrial and forklift tyres, the most common rim size ranges are 24 to 32 inch, followed by the 8 inch to 20 inch range.

As outlined at the start of 2.2.1, understanding typical tyre sizes, along with other physical features, is important for the types of equipment and logistical activities that are suitable for recovering OTR tyres, particularly given the large tyres in the mining and agriculture sectors.

Material composition

A tyre is made of a unique mixture of materials, with each component carefully selected based on the requirements of the tyre. While most tyres contain similar ingredients in similar proportions, the exact mixture of materials in the tyre will depend on the type of tyre, its intended use, and the specific part of the tyre. Tyre tread, sidewall, and casing formulations may vary due to functional and physical requirements.

A key difference between passenger car, bus, truck and OTR tyres is the types of elastomers used, particularly in the thickest section of the tyre: the tread. Truck and OTR tyres have a much higher percentage of Natural Rubber (NR), or the chemically identical synthetic rubber Polyisoprene (IR). This is due to the much lower heat build-up characteristics of NR over synthetic Styrene Butadiene Rubber (SBR). In passenger car treads, the thinner cross section means there is lower heat build-up and here SBR is favoured over NR for its combination of superior wet grip, treadwear and rolling resistance.

Building from a strong knowledge of passenger and truck tyre composition, each material component has a unique and crucial role to play in the function of a tyre as summarised in Table 5. Further background on tyre composition is included at **Appendix 2.**

Table 7: The common materials, function, and estimated weight percentage (weight%) present in different tyres based on sector averages. Percentages below are for new tyres, rather than end-of-life tyres.

Materials of Construction	Material function	Passenger	Truck	OTR#
Metal Reinforcement	Resistance and rigidity.	14%	22%	12%
Fabric (E.g. Nylon/Radon)	Resistance, endurance, and comfort.	5%	1%	10%
Elastomer (natural/synthetic rubbers)	Durability, rolling resistance, wear and traction/grip, reduces heat generation.	45%	47%	47%
Carbon black/silica (fillers)	Wear resistance (abrasion), tear resistance (tensile strength), lower rolling resistance, wet grip, UV protection.	25%	23%	22%
Oils/anti-degradants/resins	Processing aids, softeners, inhibits external temperature, prevent light/ozone degradation.	8-9%	4%	6%
Zinc Oxide	Accelerators and crosslink formation in rubber	1-2%	2%	2%
Curing Agents (e.g. sulfur)		1%	1%	1%
Total		**100%**	**100%**	**100%**
Approximate Biomass%	For emission factors and reporting	~23.1%	~31.5%	-
Natural Rubber (NR) vs Synthetic Rubber (SR)	NR: high mechanical resistance, reduces heat generation.	18.4%	33.2%	-
	SR: often better longevity and rolling resistance	26.5%	13.6%	

Tyre compositions will vary depending on tyre type/brand; the above numbers are an average of tyre compositions from international sources (see **Appendix 2** for further details)
Note # - OTR tyre example composition is derived from one international reference only and is the subject of further research by TSA in 2023 to illustrate variability more accurately within and across sectoral uses.

Impact of tyre composition on tyre recovery

The composition of different tyre types is an important factor to consider for the end-of-life processing stage, the performance and quality of the tyre-derived material in end markets, and the health and environmental impacts of the material.

Reprocessing impacts

Physical reprocessing is designed to deconstruct the tyre and separate the steel from the rubber during successive size reduction steps. These processes aim to produce steel-free tyre-derived materials such as rubber granules and crumb rubber. For larger OTR tyres, the increase in the size of steel beads is important to consider during reprocessing, as it is unlikely that conventional equipment will be able to effectively shred and separate the steel from large or extra-large tyres.

Sophisticated equipment has emerged that can separate the fibre component from the elastomer and steel, which gives further opportunity for processing of tyres with a high percentage of fibre in the casing, such as passenger tyres and agriculture tyres. Not all tyre recyclers producing shred, granules and crumb rubber have access to this equipment. To guide facilities on which tyre types they have the capacity to reprocess, we need to understand is which tyres contain high proportions of fibre.

Chemical recycling processes are also emerging, such as pyrolysis and de-vulcanisation, and are beginning to be used in the global tyre recovery sector. Importantly, the consistency and quality of output from these processes relies on the homogeneity of the feedstock material. A reliably consistent tyre feedstock or feedstock tyre combination will require accurate information on tyre composition.

Information about the different tyre reprocessing technologies, and the technical and commercial maturity of these technologies are discussed in more detail in Chapter 4.

End-market impacts

Recovered tyre rubber is flexible, strong, and resilient, as well as impact, noise, and vibration absorbing. It is therefore a desirable material in many engineering, construction, and surfacing products, of which new applications are continuously being developed.

One consideration in using reprocessed materials in new products is the technical requirements for each application. Crumb rubber from truck tyres is commonly used and incorporated into crumb rubber-modified sprayed seals and asphalt, due to the beneficial properties relating to the different rubbers and carbon black, but this is only possible because of existing similarities in their material properties.

While similar polymers and fillers will be present in other tyre types (passenger and OTR), it is crucial that the different proportions of each do not impact the mechanical properties of the resultant road. TSA is supporting ongoing projects to investigate whether crumb rubber from different tyre types will meet technical specifications to enable uptake in asphalt road projects.

A similar approach may be required in other areas, such as concrete and permeable pavements, depending on the technical specifications in each market. Robust understanding of the chemical composition of each tyre is crucial to support and direct the research and trials in these markets.

Key knowledge gaps and future research

While general information about tyre design, construction, and composition is readily available, there is a clear lack of information about specific OTR tyre categories. After a detailed literature review of this topic, we could only identify one original source for the composition of an OTR tyre (summarised in Table 7 above), with no information on tyre size or type.

This reference provides a helpful foundation, but this business case demonstrates that the many categories and subcategories of OTR tyres are both unique and varied. The assumption that conveyor belts and tyres used for agriculture, earthmoving, aviation, and construction all have the same composition is an oversimplification. It follows that understanding tyre construction and composition is important for both conventional and emerging processing technologies and end markets.

TSA is undertaking research to determine the chemical composition of different OTR tyre sizes and categories. This research is planned for delivery in 2023 and we expect it to provide general information, without divulging commercially sensitive information, to the recycling industry and stakeholders to support increased OTR tyre recovery.

Finally, it is important when managing end-of-life materials to render them benign and not cause potential harm when re-used, particularly any environmental or human health impacts. There is increasing global awareness and interest in regulations about chemicals of potential concern and hazardous substances in materials and products. With a better understanding of material composition, we can understand these risks better, and manage or eliminate hazards to avoid unintended impacts and mismanagement issues.

TSA has been actively working on multiple research projects which aim to address different market barriers and knowledge gaps for end-of-life tyres. These projects include:

- analytical testing for the presence of chemicals of potential concern in tyre-derived materials
- developing management frameworks to mitigate any environmental and health impacts in reusing processed end-of-life tyre materials
- evaluating and managing site contamination risks for OTR tyres.

2.2 Conveyors belts

2.2.1 Who uses conveyor belts and for what applications?

Conveyor belts are used in a wide variety of materials handling applications, from small belts used in mobile machinery plant through to very large and long belts used to shift/load millions of tonnes of resources each year.

Conveyor belts size, weight, width, construction and materials composition depend on the belt application. The Australian Bureau of Statistics (ABS) import data segregates rubber conveyors by the belt width and by the reinforcing materials (either steel or fabric). The reinforcement material used in conveyors is particularly relevant as it has implications for the barriers and opportunities of conveyor recovery.

Australia imports significant quantities of conveyor belts, some fully fabricated to length, ready for use, and also in lengths (rolls) for fitting onshore to the application. Unlike tyres and rubber tracks, Australia still manufactures conveyors onshore, and consumption consists of the sum of imports and onshore manufacturing. Onshore manufacturing focuses mainly on large belt applications for heavy industries such as mining, where the belts are custom made for the client site and application.

2.2.2 Conveyor belt consumption in Australia

Conveyor imports

The ABS provides import data for Australian conveyor belt imports in seven different product categories. Table 8 provides the import tonnages for conveyors for the 2021-22 financial year for each jurisdiction and shows the following:

- around 30,000 tonnes of conveyors were imported into Australia in 2021-22
- belts reinforced with steel made up only around 35% of imports, with 65% of belt imports reinforced with textile materials
- WA dominated consumption across almost all belt types, followed by QLD, then NSW and VIC reflecting the scale of the resource sectors in these states.
- SA, TAS, NT all imported only relatively minor conveyor tonnages in 2021-22.

Table 8 Australian conveyor import tonnages by type and jurisdiction 2021-22 (Source ABS).

Conveyor type	Imports (Tonnes)	%	Total %
Conveyor belts or belting, of vulcanised rubber, reinforced only with metal, exceeding 915 mm but not exceeding 1375 mm in width	1,684		6%
New South Wales	190	11%	
Queensland	273	16%	
South Australia	21	1%	
Victoria	0	0%	
Western Australia	1,200	71%	
Conveyor belts or belting, of vulcanised rubber, reinforced only with metal, exceeding 1375 mm in width	8,384		28%
New South Wales	116	1%	
Northern Territory	153	2%	
Queensland	172	2%	
Victoria	19	0%	
Western Australia	7,925	95%	
Conveyor belts or belting, of vulcanised rubber, reinforced only with metal, not exceeding 915 mm in width	252		1%
New South Wales	3	1%	
Queensland	27	11%	
South Australia	-	0%	
Tasmania	3	1%	
Victoria	24	10%	
Western Australia	195	77%	
Conveyor belting, of vulcanised rubber, reinforced only with textile materials, not exceeding 915 mm in width	3,047		10%
New South Wales	602	20%	
Northern Territory	7	0%	
Queensland	1,042	34%	
South Australia	138	5%	
Tasmania	7	0%	
Victoria	423	14%	
Western Australia	829	27%	
Conveyor belting, of vulcanised rubber, reinforced only with textile materials, exceeding 915 mm in width	3,802		13%
New South Wales	662	17%	
Northern Territory	46	1%	
Queensland	918	24%	
South Australia	105	3%	
Victoria	438	12%	
Western Australia	1,632	43%	
Conveyor belts, of vulcanised rubber, reinforced only with textile materials	12,469		41%
New South Wales	2,278	18%	
Northern Territory	162	1%	
Queensland	1,876	15%	
South Australia	374	3%	
Tasmania	-	0%	
Victoria	1,765	14%	
Western Australia	6,013	48%	
Conveyor belts or belting, of vulcanised rubber (excl. those reinforced only with metal or only with textile materials)	408		1%
New South Wales	112	28%	
Queensland	121	30%	
South Australia	2	0%	
Tasmania	-	0%	
Victoria	66	16%	
Western Australia	106	26%	
Total	**~30,000**		**100%**

Review of ABS data for the previous (2020-21) financial year identified around 34,000 tonnes of conveyor imports, with similar proportions of belt type imports as shown in Table 8. This indicates that conveyor imports are relativily stable at around 30,000 to 35,000 tonnes per year.

Conveyor manufacturing in Australia

Continental (ContiTech) and Fenner Conveyors (a Michelin Group Company) both manufacture conveyors in Australia. Continental does all manufacturing in Bayswater Victoria and Fenner has eight manufacturing facilities around the country. Both companies have distribution and conveyor servicing centres set-up around the country, and close to major resource extraction areas.

The amount and type of conveyors manufactured onshore by Continental and Fenner is commercially sensitive information and actual production amounts are not known. Both companies are manufacturing large belts to service the resource sector in particular, so we estimate that at least the equivalent of the imported belt tonnages are manufactured onshore.

For the purposes of this analysis, we assume an estimated 30,000 to 50,000 tonnes of onshore conveyor manufacturing.

We also assume that the conveyor types that are manufactured onshore are similar in composition to conveyors imports (i.e. belts reinforced with steel around 35% and 65% reinforced with textile materials). While we understand that onshore manufacturing focusses on large heavy duty belts servicing the resource sector, less abrasive resources such as coal are understood to use fabric belts, rather than steel belts.

Conveyor belt refurbishment

Both Continental and Fenner provide conveyor repair services and also complete belt refurbishment services. Belt refurbishment is similar to tyre re-treading, i.e. using the belt carcass and applying a new rubber covering. Continental's website (Dec 2022) states that approximately 80% of all belts can be refurbished and promotes the following benefits of belt refurbishment:

- 65-75% of the new belt price, depending of used belt type and conditions
- same life/warranty time as a new belt
- reduction of disposal cost/stock
- less pollution.

Industry consultation indicates that belt refurbishment is currently not widely adopted in Australia, due to labour costs, logistics of belt removal and transport, and clients often prefer the convenience of full belt replacement.

Estimated total conveyor belt consumption

Based on the analysis presented above, the **total estimated conveyor belt consumption (imports plus onshore manufacturing) is 60,000 to 85,000 tonnes per annum.**[26]

Based on the composition of conveyor belt imports, we assume that around 35% of the total conveyor belt consumption tonnages are reinforced with steel and the remaining 65% are reinforced with textile materials.

Table 9 includes a summary of the upper and lower estimates of rubber conveyor consumption in Australia per year. It also provides the estimated proportion of conveyor type based on the reinforcement material (steel or fabric).

[26] ABS data analysis shows that exports of new conveyor belts out of Australia could be around 10,000 per year. These conveyors would not contribute to Australia's used conveyor tonnages. This is allowed for in the estimated range of onshore consumption provided.

Table 9 Estimated Australian conveyor belt consumption total and by type (tonnes per year)

	Consumption estimate (tonnes per year)	
	Lower	Upper
Conveyor imports	30,000	35,000
Onshore conveyor manufacturing	30,000	50,000
Total	**60,000**	**85,000**
Conveyor type		
Steel reinforced	20,000	30,000
Fabric reinforced	40,000	55,000

2.2.3 Used conveyor generation, management, and fate

Used conveyor generation

The lifespan of conveyor belts determines the period between consumption and the generation of used conveyors.

CSIRO 2023[27] notes that the "life span of conveyor belts depend on the application, usage and volumes and types of materials the conveyor belts are used for moving. Belts often last for 11-12 months, some less or more. The causes of reported conveyor belt failures include (1) product failure (rare); (2) damage (e.g. by large rocks); (3) worn out or fatigue of the casing (in this case, generally a longer section of the belt would need to be replaced). Many mines have the equipment to measure belt thickness and damage of conveyor belts in real-time to enable predictive maintenance or replacement of the belts, and hence, the projected lifespan of the conveyor belts does not necessarily reflect when they get changed out and disposed.

They might get changed out during shutdowns if the forecast indicates that it is too risky to wait longer in case a failure happens during a time that will interrupt operations. For example, the operation of conveyor belts is critical during the loading of ships in ports. Therefore, some of the remaining lifespan of a belt may be sacrificed, but the degree of the sacrifice depends on the location and the criticality of the belt. Conveyor belts are generally repaired on-site as it is not practical to send long conveyor belts for repair. The damaged conveyor belt can be repaired by doing what is known as "splicing", which joins the steel cords within the belt together. This involves matching up steel cords, cables joining, heating, and curing of rubber.

According to one stakeholder, when conveyor belts reach their end-of-life, most mine sites stockpile them on-site. There is reluctance to bury the entire steel wheel that holds the conveyor belt, and typically there is a lot of land area around mine sites for stockpiling. Unlike end-of-life tyres, there are no restrictions to stockpiling these materials. One stakeholder estimated that approximately 25% of used conveyor belts would be buried on-site." Page 33.

While there is uncertainty about the lifespan of conveyor belts (i.e. how lifespans could be extended by repair or refurbishment, or reduced due to early replacement) we can assume that the annual consumption of new conveyor products (60,000 to 85,000 tonnes) is in-effect the 'replacement rate' of current conveyors. Therefore we can assume that over-time, the consumption tonnages

[27] Boxall NJ, Tobin S, Minunno R, Cheng KY, Zaman A, Kaksonen AH. (2023) *Exploring opportunities for increasing value recovery from end-of-life tyres and conveyor belts in Western Australia*. Report for: Department of Water and Environmental Regulation (DWER) and Tyre Stewardship Australia (TSA). CSIRO, Australia. https://www.nespsustainable.edu.au/report-end-life-tyres-and-conveyor-belts

of conveyors equate to used conveyor generation. Noting that conveyors that are imported or manufactured onshore are assumed to be consumed (not stockpiled or unsold).

Given the relatively short lifespan noted by CSIRO 2023, of around a year, estimating waste generation of conveyors based on the previous few years of consumption is reasonable.

We estimate that around 60,000 to 85,000 tonnes of waste conveyors are generated in Australia currently. This estimate would decrease or increase with any significant change in consumption in future years and conveyor consumption needs to be monitored annually.

Used conveyor waste management and fate

As noted above CSIRO 2023, industry consultation found that conveyor belts used in the resource sectors are being stockpiled onsite in conveyor belt 'grave yard' areas or are being buried onsite.

Industry consultation completed for the business case found that there are only very small tonnages of conveyor recovery in Australia, currently (in the hundreds of tonnes per year). This finding is verified by the findings of CSIRO 2023, that analysed WA in detail (where conveyor consumption and waste generation is highest): "Currently, there are no dedicated recycling facilities for conveyor belts in WA. Stakeholders indicated that existing end-of-life tyre processing facilities are not designed for processing end-of-life conveyor belts because technically, this is problematic due to (1) size of used conveyor belts being too large to be handled by existing equipment; (2) composition of conveyor belts being too complex (e.g. embedded with fibre and steel cords that would cause damage to equipment). However, the same infrastructure that is used for tyre shredding and crumbing, could potentially also be used for processing conveyor belts after initial size reduction. Anecdotally, some companies are investigating the opportunities of setting up conveyor belt recycling plants in WA and shredding conveyor belts to extract steel and produce rubber crumbs. Based on stakeholder interviews, some companies receive old scrap conveyor belts from their clients for free, returning the belts to Perth. Some end-of-life conveyor belts are used to make top liners and used on agricultural floors to protect the hooves of animals. Lightweight ply or poly woven conveyor belts are to some extent repurposed for agricultural uses, e.g. in the horse industry in Hunter Valley in NSW. Heavier steel cord conveyor belts are not commonly re-used this way." Page 40.

Based on the above, Table 10 includes the assumed waste management and fate proportions for waste conveyors in Australia currently.

Table 10 Assumed used conveyor waste management and fate proportions currently (%)

Conveyor belt type	Reuse	Recycling	Energy recovery	Landfill (offsite)	Stockpiling (onsite)	Buried (onsite)
Steel reinforcement	0%	0%	0%	0%	75%	25%
Fabric reinforcement	<1%	<5%	0%	45%	25%	25%

Steel belts, mostly used in large heavy applications such as iron ore mining, are all assumed to be either stockpiled onsite or buried in-pit onsite. There may be some minor amount of re-use or recycling of these belts, but we couldn't identify any data to support this, and onsite management is understood to be the current fate of steel conveyors.

Fabric reinforced belts are used in a wider range of applications, including smaller applications within manufacturing in urban areas. When these smaller fabric belts reach end-of-life in urban areas, we assume they're sent to permitted landfills (offsite) and we expect this to be around 50% of waste fabric belt tonnages. Where fabric belts are used in large and remote applications, such as coal mines, we assume that the belts are managed onsite either in stockpiles or via pit burial (~50%).

Industry consultation identified a small industry set up to re-use fabric reinforced conveyor belts, by re-purposing them into flooring for the horse industry or as 'tub liners' for utility vehicles, but the tonnages re-used are assumed to be less that 1% (<1,000 tonnes) nationally.

Consultation also identified a small industry for recycling fabric conveyors into crumb, estimated to be less than 5% of used fabric conveyors.

2.3 Rubber tracks

2.3.1 Who uses rubber tracks and for what applications?

Rubber tracks have long been used on small-to-medium sized excavator applications and are increasingly being used across a variety of other construction vehicles (e.g. skid steers) and agricultural applications (e.g. tractor tracks). Consultation with track suppliers points to a significant shift in recent years from wheeled construction and agriculture vehicles to tracked vehicles that has seen rapid growth in track imports.

The rubber track size, weight, width, construction and materials composition are dependent on the track application. Like tyres, tracks are imported into Australia as a complete product ready for fitting to specific vehicles. Tracks are not imported as a 'roll' and then cut to size, as is the case with some conveyor product. Australia imports all track products and there is no onshore manufacturing.

Whilst composition of tracks varies by product specification, all tracks are understood to have a relatively high proportion of steel (to give tracks the required tensile strength) and the rubber that is used has a high proportion of natural rubber.

2.3.2 Rubber track consumption in Australia

The ABS provides import data for Australian rubber track imports, although the import code may include some tonnages that are not rubber tracks. The import code description is a catch-all for rubber not reported under a range of other import codes targeting rubber product imports. Consultation with conveyor suppliers confirmed that the import code used for tracks is typically the 4016 prefix followed by a range of postfix codes linked to product type.

Table 11 provides the import tonnages for the codes covering rubber track for the 2021-22 financial year for each jurisdiction and shows the following:

- around 25,000 to 30,000 tonnes of tracks were imported into Australia in 2021-22. Noting that the import codes may be capturing some imports that are not tracks and therefore be less than the 30,000 tonnes identified.
- VIC had the highest consumption, followed by NSW, QLD, then WA reflecting the scale of the construction and agricultural activity across these states
- consultation with suppliers found that most (~75%) of track imports were for construction vehicles (excavator and skid steers), which is reflected in the high import numbers for VIC and NSW, in particular, where construction activity drives consumption.

Table 11 Australian imports for codes covering rubber track by jurisdiction 2021-22, tonnes (Source ABS).

Import codes covering track imports	Tonnes
4016100012	797
Articles of cellular, vulcanised rubber, not covered by the preceding headings of this Chapter (excl. articles of hard rubber of HS 4017)	
New South Wales	182
Northern Territory	0
Queensland	100
South Australia	8
Tasmania	58
Victoria	408
Western Australia	41
4016990058	30,846
Articles of vulcanised rubber, not previously specified or included (excl. floor coverings, mats, erasers, gaskets, washers, seals, boat or dock fenders, inflatable articles, stationery & printers blankets; those of cellular or hard rubber)	
New South Wales	9,119
Northern Territory	4
Queensland	5,712
South Australia	691
Tasmania	26
Victoria	11,504
Western Australia	3,791
Total	**31,644**

Review of ABS data for the previous (2020-21) financial year identified around 30,000 tonnes of imports for codes covering rubber tracks, with similar state consumption proportions as shown in Table 11. This indicates that track imports are relativily stable at around 25,000 to 30,000 tonnes per year.

Based on the analysis presented above, the **total estimated track consumption is 25,000 to 30,000 tonnes per annum.** Exports of tracks out of Australia are assumed to be insignificant.

Tracks consumption may increase significantly in future years if the shift from wheeled machines to tracked machines continues in construction and agriculture, and consumption needs to be monitoried each year.

Table 12 includes a summary of the upper and lower estimates of tracks consumption in Australia per year by application.

Table 12 Estimated Australian tracks consumption total and by application (tonnes per year)

	Consumption estimate (tonnes per year)	
	Lower	Upper
Construction	18.750	22,500
Agriculture	6,250	7,500
Total	**25,000**	**30,000**

Used tracks generation, management, and fate

Used track generation

The lifespan of rubber tracks determines the period between consumption and the generation of a used track. Whilst there is uncertainty about the lifespan of tracks (i.e. how lifespans could be extended by repair or a low amount of use, or reduced due to early failure) we can assume that the annual consumption of new track products (25,000 to 30,000 tonnes) is in-effect the 'replacement rate' of tracks that are in-use.

Therefore we can assume that over-time, the consumption tonnages of tracks equates to used track generation, noting all tracks that are imported are assumed to be consumed (not stockpiled or unsold).

We estimate that around 25,000 to 30,000 tonnes of used tracks are generated in Australia currently. This estimate would decrease or increase with any significant change in consumption in future years and track consumption needs to be monitored annually.

Track waste management and fate

Industry consultation completed for the business case could not identify any verifiable track recycling services. There are companies online marketing recycling and disposal services for tracks, but we couldn't verify the recycling processes, so assume that where this service is offered, the track is still disposed to landfill.

In Australia, currently, it is assumed that **all tracks used by the construction sector are disposed to licensed landfill (offsite)** either directly by the consumer or via a collection company that takes the track to landfill.

Consultation with tracks suppliers for the agriculture sector found that **almost all used tracks generated by farmers are kept on farm where the tracks are either stockpiled, buried or burned.**

The recovery and recycling of tracks represents a challenge and an opportunity. The challenge is to provide a recovery process that can handle the high steel content and manage the size and weight of tracks without needing to build a stand-alone 'tracks only' plant. There is unlikely to be enough consolidated tonnages to make a standalone tracks processing plant a viable investment. The opportunity is the relatively high value materials in used tracks (i.e. steel and natural rubber) that typically have good off-take markets.

3. Benefits of OTR tyre recovery

The recovery of end-of-life OTR tyres lags behind the recovery of passenger car, bus and truck tyres, despite its contribution to the amount of end-of-life tyres generated in Australia each year. While this may be a reason to drive greater uptake of OTR tyre recovery activities, there are other reasons why recovering OTR tyre should be viewed as preferred practice.

These can be divided into the public benefits of increased OTR tyre recycling activity instead of disposal and stockpiling, and the private benefits directly gained by an OTR tyre generator in shifting to tyre recovery.

These arguments are explored in the sections below. It is useful to support these sections with a clear definition of tyre recovery for the purposes of this business case. This helps to delineate environmentally sound practices from business-as-usual activities like in-pit burial, stockpiling, disposal, and other measures that fail to recover economic value from the resources held in end-of-life tyres.

The Scheme Guidelines provide the following definitions in its Glossary and Acronyms:[28]

- **Environmentally sound use** means 'the use of whole, part or recovered components of end-of-life tyre for applications that minimise or prevent environmental, health and safety damage or harm.'
- **Recycler** means 'a process to recover constituent materials from end-of-life tyres and use those materials to produce other products.'
- **Resource recovery** means 'the process of extracting materials or energy from a waste stream through reuse, recycling or recovering energy from waste.'
- **Tyre recycler** means 'a business or organisation recovering rubber, steel, textile and/or other materials and processing into a form that can be used as an intermediate product in manufacturing tyre-derived material, or to recover energy from end-of-life tyres.'

There is a need to ensure the environmental and social legitimacy of different methods to recover tyres, and how recovered materials are used. Many activities may be proposed as delivering tyre recovery outcomes, with varying, marginal, or no improvements in their environmental impacts relative to current disposal-oriented practices.

To have confidence in realising the benefits of recovery, OTR tyre generators may need to adopt practices to demonstrate a robust, environmentally and socially sound tyre recovery pathway that reflects their standards and which can withstand scrutiny from a range of stakeholders. This issue is explored further in Section 3.3.

[28] TSA, Guidelines for the Tyre Product Stewardship Scheme, amendment 1.1, March 2019.

The Scheme and its efforts to drive the environmentally sound use of end-of-life tyres

For the purposes of the Scheme, resource recovery activities that are applied to end-of-life tyres to achieve an environmentally sound use will include:

1. recycling into tyre crumb, shred, chips, granules, steel and other tyre components
2. use as a fuel (other than in direct incineration without effective energy recovery and unsustainable burning for energy recovery) or other means to generate energy
3. production of tyre-derived materials, including tyre-derived fuel
4. civil engineering.
   The following uses are excluded from the definition of environmentally sound use:
5. disposal through dumping, landfill, direct incineration or burning
6. stockpiling as an end point
7. unsustainable burning for energy recovery
8. export of baled tyres for operations listed under (v), (vi) and (vii) above.

TSA, Guidelines for the Tyre Product Stewardship Scheme, amendment 1.1, March 2019.

3.1 Public benefits

Previous work completed for TSA[29] has outlined a range of public benefits that can be described as environmental and economic benefits. These benefits also have a social benefit to the extent that OTR tyre recovery may drive business and employment opportunities, particularly in underdeveloped locations, and may improve the quality of landscapes available for public enjoyment. Another area of public benefit involves OTR tyre recovery as a way to deliver policy objectives, considering state and national circular economy priorities.

These public benefits mirror those for recovering passenger car, bus, and truck tyres, although their extent and distribution may differ with the location and recovery pathway for OTR tyres. These recovery benefits should be viewed as a point of difference from other measures to manage end-of-life tyres that don't involve resource recovery, such as landfill disposal, stockpiling, illegal dumping and burning, and burial on-site in pits and gullies.

Considering these, the public benefits are framed in terms of stated policy and regulatory interests of the Commonwealth, state, and territory governments, particularly the priority they have attached to resource recovery, stimulating the circular economy, and the need to address tyres as a challenging waste stream.

[29] Urban EP, Queensland regional business case for a circular economy for used tyres – North & Far North Queensland: Executive Summary, 2022.

3.1.1 Environmental

General environmental benefits

The general environmental benefits of recovering OTR tyres include:

- recovering resources that will otherwise be lost from the productive economy, including steel, rubber, carbon, or other materials, dependent on recovery technology
- reduced exposure to harms caused by illegal dumping and stockpiling including:
  - risk of fire and costs associated with fire incident responses
  - degraded natural environments and species habitats
  - lost visual amenity, and reduced enjoyment of contaminated landscapes
  - breeding grounds for vermin and other harmful species, including those that function as animal and human disease vectors
- the opportunity to set an example and lift the accepted standard for managing end-of-life products and materials used by different industries and the general public

Better custodianship of land that has been leased to mining companies and cultivated by agricultural concerns, realising tyre management outcomes in line with a 'caring for country' ethos where that land will ultimately be passed to other custodians.

Environmental justice

While important in their own right, the above points also carry an environmental justice dimension. There are differing approaches to describing environmental justice, and, noting that this concept continues to evolve, the literature identifies multiple aspects in the context of extractive industries:[30]

- **Distributive justice** refers to the distribution of environmental 'goods' and 'bads' among populations, and focuses on the inequitable distribution of hazards and risks in marginalised social spaces
- **Procedural justice** includes participatory aspects of environmental justice, especially whether or not members of the public have the opportunity to authentically participate in making decisions about environmentally risky activities
- **Recognitive justice** identifies historical and structural patterns of privileging certain worldviews and cultural systems over others, and endeavours to encourage the acceptance and inclusion of diverse cultures and worldviews in environmental decision-making
- **Restorative justice** focuses on the historical exclusion and displacement of Indigenous people and local communities whose relationships with the land have been changed through co-opting, industrialisation, and defilement of their ancestral homes.

[30] Malin, S. A *et al.*, 'Environmental justice and natural resource extraction: intersections of power, equity and access,' *Environmental justice and natural resource extraction: intersections of power, equity and access, Environmental Sociology*, 2019, Vol. 5, Issue 2, p. 109-116.

In several mining sector examples,[31] the land in which mining tyres are buried is not owned by the mining companies but is temporarily occupied during the mine's lifespan. This occupancy pattern includes mining on lands subject to native title rights and interests. If there is a way for mine operators to return post-mining land back to the state or traditional owners with minimal legacy issues, this should be explored seriously and inclusively.

The environmental justice dimension of this process is further important where the land is returned to those who are socioeconomically deprived, politically marginalised, or who have limited influence over decisions about how environmental impacts are recognised and treated.

There is also an environmental justice dimension where agriculture tyres are stockpiled or disposed on private land. All farmland exists in a wider landscape which supports vibrant agrarian and natural ecosystems, yet they are at risk from smoke and fire damage if tyre stockpiles catch fire. The tendency to leave tyres in gullies risks leaching chemicals and particulates into regional catchments. It may also lead to displacement and elevated erosion during high-impact flooding events, which occur with increasing frequency. The impacts of these incidents may extend well beyond property fences into surrounding farms and natural landscapes, despite neighbouring owners and custodians having limited to no ability to influence the practice of on-farm tyre stockpiling and disposal.

Different expectations for end-of-life tyre management

The current acceptance of mining and agricultural concerns' disposal or stockpiling on site sits in stark contrast to approved practices for managing end-of-life tyres in other sectors. Small businesses and households must bear the cost of recovering or disposing of these tyres in a highly-regulated environment, and ultimately carry the costs involved with recycling supply chains or the disposal of tyres to inert waste landfills that may be subject to substantial regulatory compliance costs, licence conditions, or waste levies.

Appendices 3 & 4 provide a detailed analysis of regulatory arrangements for managing end-of-life tyres in different uses and jurisdictions. Common regulatory measures for disposing of passenger car, bus, or truck tyres in an urban setting include:

- requirement to pay a waste levy, where the landfill is licensed by the state or territory environmental regulation authority and levy zone requirements apply
- requirement to place the end-of-life tyre in an inert landfill cell, with the requirement to construct the cell using multiple linings throughout its base and capping
- in some jurisdictions, the requirement to shred the tyre before landfilling it to allow for more efficient use of limited landfill airspace.

With the need to engage a licensed landfill operator and regulated waste transport services, these conditions impose obligations and related business or household costs that mining companies and agriculture businesses are not subject to. The expectation placed on mining companies and farm managers in managing end-of-life tyres is inconsistent with those faced by the wider community, and with a more equitable application of environmental protection measures.

[31] A full review of different mining sector occupancy models is outside the scope of this work, although it is anticipated that in many cases, the cessation of mining operations is followed by a level of rehabilitation and hand over of control to the Crown, traditional owners, or some other party.

Greenhouse gas emissions

Superficially, the practice of burying mining tyres in pit or stockpiling used agriculture tyres on farm may be appear to involve no greenhouse gas emissions, assuming those tyres remain inert and in place. However, from a lifecycle perspective, we should consider the greenhouse gas impacts of these practices in comparison to alternative end-of-life management activities.

To the extent that they rely on fossil fuel-based transport and power, all activities to recover end-of-life tyres will involve some level of greenhouse gas emissions generation. However, the very act of tyre recovery means that one or more commercial inputs is displaced by tyre-derived material. Under the 'tyres into tyres' model, emissions from the recovery of end-of-life tyres can be offset against emissions that would have been made in the production, supply, and usage of new tyres.

Tyre manufacturers' reduced demand for virgin rubber from latex plantations may have greenhouse gas emissions benefits through slowing deforestation in tropical rainforests which are important as carbon dioxide sinks in the global carbon cycle. Where tyre-derived material is used in products to add durability, such as crumb rubber in roads, the enhanced lifespan of these products may be counted as greenhouse gas abatement. Both can be offset against additional emissions from recovery activities.

Edge Environment has recently completed a report titled Greenhouse gas emissions analysis of waste tyre recovery, modelling the emissions in the recovery of truck and passenger car tyres that are then used as asphalt binder in road construction, aggregate replacement in concrete, and as a fuel in cement kilns.[32] TSA has also commissioned Edge Environment to complete a similar study for OTR tyre recovery, to be completed in 2023. Using modelling and insights from the current study, Edge Environment have assessed a preliminary OTR tyre scenario for agriculture tyre recovery, explained below.

While noting that greenhouse gas emissions reductions are an important environmental consideration, we should not focus on greenhouse gas emissions at the cost of other significant environmental concerns. While there may be a focus on operational and supply chain decarbonisation in segments of the mining and agriculture sectors, there is a need to take a balanced and holistic approach to impacts assessment, using lifecycle assessment and other tools. A high threshold for establishing evidence on impacts should not defer action on OTR tyre recovery.

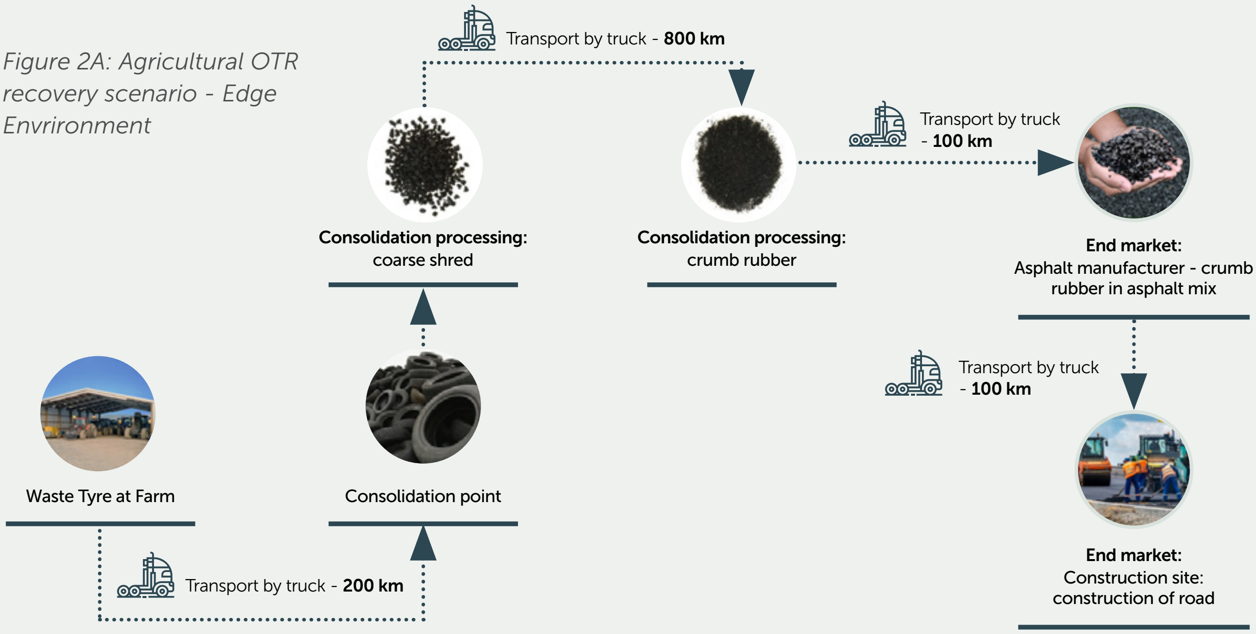
[32] In line with international LCA standards, this TSA commissioned report is currently undergoing third party review and will be publicly available once approved. The LCA analysis included emission impacts from waste tyre collection up to end market use.

Agricultural OTR recovery scenario – Edge Environment

For this scenario, tyres are transported to a consolidation point in a regional centre 200 km away. Due to the size of each tyre and the amount of tyres, a limited number can be collected at a time. In this scenario, we consider the collection of tyres with an average rim size of 96.5 cm, the median agricultural tyre size.

At the consolidation point, these tyres undergo a coarse shredding process to improve the efficiency of further transport to a crumb rubber processing plant. A full truckload of the shredded OTR tyres is then transported a further 800 km to an urban location where the crumb rubber facility is based. The tyre shreds are mechanically processed into crumb rubber, ready for use in end market products. In this scenario, we consider the potential benefits of using the OTR tyres as an asphalt binder in road construction.

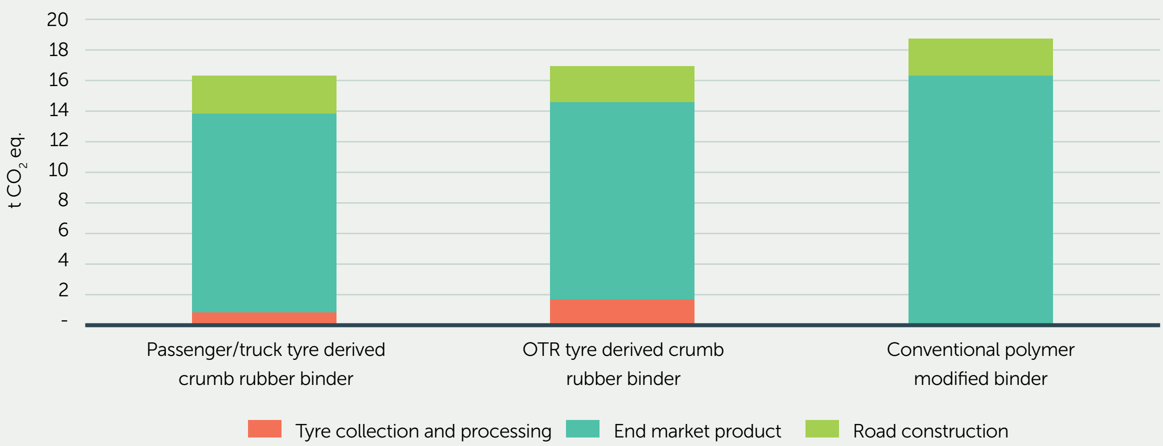
Figure 2A: Agricultural OTR recovery scenario - Edge Envrironment



Estimated Emissions Impacts

The use of crumb rubber derived from passenger and truck tyres shows an improvement of 6 – 14% emissions reduction when compared to the conventional fossil-derived polymer modified binders. This is based on a range of asphalt mix designs derived from Australian road construction specifications. While the collection and processing of the agricultural OTR tyre is more emissions-intensive compared to passenger and truck tyre processing, preliminary calculations showed a 4 – 10% improvement compared to the conventional alternative.

Figure 2B: Estimated emissions impacts from using crumb rubber in roads



Rubber demand and deforestation

Perhaps the most significant environmental benefits of recovering end-of-life OTR tyre material is the reduced demand for natural latex from plantations that are mainly based in south and southeast Asia and in west Africa, particularly if this material is used to re-tread, repair, or manufacture OTR tyres.

The demand for rubber in tyres is believed to be the dominant driver for the expansion of latex plantations across affected regions, which is expanding at an estimated rate of 2.4% per year. This places rubber as the fastest expanding tree crop in mainland southeast Asia (like the effect that expanding palm oil plantations have across southeast Asian island chains).[33]

Depending on the previous land use (e.g. swidden or 'slash and burn' farming versus natural tropical forestry), this growing economic reliance on latex to make tyres may be implicated with:

- loss of biodiversity from tropical rainforests, mainly in southeast Asia and west Africa
- reduction in the mass of tropical forest ecosystems functioning as carbon sinks
- impacts on regional water cycles, including increased evapotranspiration, depleted soil moisture during dry seasons, greater risk of erosion, and impaired water quality, compared with natural forest water cycles
- depleted soil nutrient levels, respiration functions and related soil microbiome activity[34]
- other adverse consequences of land use change occurring in high value ecosystems and less developed regional economies.

Further studies into these impacts have been published in recent years, including independent research into the distribution of different impacts of latex production across different countries of origin.[35] Arguably, all Australian mining companies can and should develop a better understanding of the impacts from sourcing their OTR tyres, through their own investigations and through dialogue with their suppliers.

3.1.2 Economic benefits

OTR rubber products are generated in many sectors of the Australian economy, and the amount of waste generated is directly linked to their level of economic activity: more earth moved or food grown directly generates more waste OTR rubber products. Although this waste has commodity value from the steel and crumb rubber contained within it, there is also economic value beyond that.

Through a recovery supply chain, value-added activities can convert this waste into end products using innovative approaches, technologies, and processes. This would not only recover the material but also create job opportunities and enhance the skills of the Australian workforce as well as the size and diversity of the Australian economy. Moreover, a large proportion of this benefit will be concentrated in regional areas where OTR tyre generation is concentrated.

These public economic benefits include:

- growing and diversifying the Australian economy, by expanding onshore economic activity to capture the valuable resources contained in OTR tyres
- regional development, through investment, employment and labour force development

[33] Gitz, V. *et al., Sustainable development of rubber plantations in a context of climate change: Challenges and opportunities*, 2020. https://www.cifor.org/knowledge/publication/7860/

[34] Monkai, J. et al., 'Conversion of rainforest to rubber plantations impacts the rhizosphere soil mycobiome and alters soil biological activity' in Land Degradation and Development, 2022, Vol. 33, Issue 17, p. 3411-3426.

[35] Proforest and Murphy, L., *Environmental risk assessment of natural rubber production and processing*, September 2021. https://sustainablenaturalrubber.org/reports/

- innovation and productivity, because addressing the OTR gap will require new methods, technologies and business models.

Growing and diversifying the Australian economy

Commodity value and opportunity cost

Australia produces around 130,000 tonnes of OTR tyres annually, which could be recycled into about 42,000 tonnes of steel and 78,000 tonnes of crumb rubber (noting that TSA is leading further research to better understand the composition of OTR tyres). Based on current market prices, this equates to $11 million in recovered steel and $62 million in crumb rubber, depending on quality. Consequently, by burying or stockpiling these materials, we are forfeiting at least $70 million in raw commodity value each year.

When a used tyre is buried, its potential return on investment is lost. The National Waste Policy Action Plan supports this notion, advocating for a circular economy that maximizes the value of recyclable materials. Failing to extract the value from used tyres is equivalent to discarding it. The 'tyres-into-tyres' circular economy model, outlined in Section 3.5, represents the ideal outcome of this approach.

Opportunity cost is an essential concept to consider when addressing the issue of waste management for OTR tyres. The decision to bury or stockpile used tyres may appear to be the most cost-effective choice now, but it neglects the potential value that could be recovered through recycling. By disregarding the next best alternative, we are not only losing out on the raw commodity value of approximately $70 million, but also the added benefits and value that recycled materials could bring to various industries and products. For example, when crumb rubber is used as a binder in road construction it may substitute for a synthetic polymer binder that may cost considerably more than the commodity price for crumb rubber.

Furthermore, there may be implicit costs to consumers of OTR tyres, who miss the opportunity to integrate recycled materials into their own operations, potentially reducing costs and improving sustainability.

The lack of explicit costs associated with onsite burial may also give the illusion of being a cost-effective solution, but these costs are merely hidden or postponed. Eventually, someone will bear the burden of managing these stockpiles or addressing the environmental impact of buried tyres – whether it be the original operator, a new landowner, the local community, or the government. By not considering the opportunity cost, and externality costs, we fail to recognize the long-term consequences and missed potential benefits of recycling and repurposing used OTR tyres. Embracing a circular economy model as proposed in the National Waste Policy Action Plan would help ensure that we capitalize on the value of used tyres.

Expanding the recycling sector

Recycling has played a role in the economy since before the industrial age, and it has recently re-established itself as a self-sufficient industry. Nevertheless, the Australian recycling sector has faced challenges over the past five to ten years, making it crucial to identify and address the underlying causes to secure the future of recycling OTR products.

Ensuring the accurate cost of collection, processing, and recycling is essential to prevent business failures due to financial strain. Thorough evaluation of suppliers, providers, and recyclers should be prioritized, and policy, regulation, and procurement must support those investing in waste-derived products. Moreover, recycling should involve continuous engagement of the entire supply chain to promote innovation, collaboration and consumption.

It's important to note that the "chicken or the egg" debate regarding stopping onsite burial and investing in recycling infrastructure should not hinder progress. Instead, we should view it as an opportunity to create an offer that benefits both consumers and recyclers. Economic incentives could persuade one side of the group to participate, while a compelling offer that creates commercial value could encourage others. Furthermore, ensuring there is enough volume to sustain businesses is crucial. While getting this platform started may seem challenging, with dedicated partners in dedicated markets, we may be able to kick this off successfully. By learning from past failures and creating a supportive ecosystem for the recycling industry, we can ensure a sustainable future for OTR products.

Access Economics estimates that the direct Full Time Equivalent employment created in waste recycling and resource recovery per 10,000 tonnes of recovered waste is 9.2.[1] Applying this, if we recovered the 130,000 tonnes of waste OTR tyres generated annually we could create about 120 FTE jobs. If we recovered the 85,000 tonnes of waste conveyors and rubber tracks, we could create about 78 FTE jobs. Applying their industry multiplier of 0.84 indirect jobs per direct job, this would create 101 indirect jobs from recovering OTR tyres and 66 jobs from recovering conveyors and rubber tracks.

Assuming this formula is correct for OTR rubber products, we could create 365 direct and indirect jobs in the OTR rubber product recovery and recycling industry, which would mostly be in regional or remote areas of Australia. Further research on unique properties of catchments, regions, or applications that generate OTR rubber product waste is required to validate this calculation.

Expanding the market for recycled materials

In Australia, recycled tyres are mostly processed into shredded rubber used as fuel or granules and crumb employed in flooring, adhesives, industrial products, and road surfaces. Years of market development activity in the country have demonstrated the advantages of crumb rubber. It is well-established that the more natural rubber a tyre contains, the better it performs, and the more valuable it is. When it comes to OTR tyres, the market can be assured that the collected products will contain high levels of natural rubber.

Fear of missing out

Since the Tyre Product Stewardship Scheme started in 2013 with a mandate to increase automotive tyre recovery, recovery rates have grown to 70%. The growth in investment that has enabled this clearly demonstrates that opportunities exist. While other countries are forging ahead with OTR recovery schemes, Australia runs the risk of falling behind and missing the opportunity to get its share of the global market for recycled OTR materials (see section 4.3).

Different choices about OTR tyre recovery paths, such as how the tyres will be recovered and where those activities take place, are major determinants for how economic benefits are distributed to different regions and sectors. If the recovery facilities are overseas, then so are the jobs and the business opportunities. If we allow this to happen, then we'll simply be transferring the value of the recovered tyres outside Australia.

Regional development

Investing in regional areas

OTR rubber product recovery is a huge untapped investment opportunity. If we can encourage markets to form, this will create major incentives to invest in recovery facilities and processes. These OTR rubber products are generated in largely regional and remote areas of Australia, so investment and job creation will necessarily be in these areas too.

Depending on the approach and the catchment area, facilities will need to be located in regional and remote areas. Governments recognise the value of supporting regional investment to promote an economy in which everyone can participate. There is significant economic benefit to be had from creating employment, improving productivity, and encouraging innovation in regional areas, all based on a clear and predictable supply of materials (see Chapter 10).

Governments and companies operating in these areas all have a role to encourage investment in facilities, equipment, solutions, and higher-value product management. One of TSA's roles is to send the right signals to all parties so the economic benefits of investing in these areas are clear.

The importance of regional development

Investment in our regions has major benefits for regional communities. As mentioned above, the investment will create economic and employment benefits through both direct and indirect effects. In terms of employment, the direct effects include the employment of staff in the recovery, recycling or logistics businesses. The indirect effects include expanding business and employment at:

- those businesses that supply those facilities, creating opportunities for trades, manufacturing, professional services and materials suppliers, among others
- businesses in the wider economy including hospitality, retail trade, and food and groceries, as the higher wages from employment induce consumers to spendmore locally.

Many of the locations that will house the logistics and recovery infrastructure for OTR tyres will be in areas where the regional economy is in transition. This includes the transition from economies largely relying on emissions and resource-intensive industries to more diversified and sustainable production.

Regional locations in Australia also tend to have higher levels of socioeconomic disadvantage on average, as well as lower levels of services and access to infrastructure. Stimulating regional economies helps address this gap, by creating business opportunities, supporting the need for infrastructure investment, creating employment opportunities and the opportunity to build labour force skills in growth sectors.

Innovation and productivity

Catalysing new markets

By fostering an environment that encourages innovation and expansion, the market for recycled materials is expected to grow, while supply chain costs trend towards greater efficiency. As recycled materials become more affordable, innovators will be motivated to capitalise on this opportunity and expand the market for recycled materials (see section 11.3). As a result, this growth will not only increase the value of recycled products but also contribute to the creation of a more sustainable and commercially-viable circular economy.

TSA recognises that market development activity has a lengthy gestation period. Once a market is activated through investment, demonstrations, or trials, the commercialisation process can take up to two years following the end of market development activation. TSA internal data also demonstrates that supporting investment in market development activities stimulates business investment. For every $1 million that TSA has provided to support market development activities, private businesses have invested $4.5 million. Drawing on its track record, TSA recommends an approach that combines incentives to maximize opportunities for innovation and investment in this market.

Innovation breeds investment

An expanded scheme will create investment opportunities in recovery services, recycling services and in manufacturers using recycled materials. In its independent review of the TSA Scheme in August 2022, Arcoona Consulting stated that under a regulated structure the Scheme could expand its activities and pursue strategic opportunities and innovation for stakeholders in the circular tyre economy.

Providing a mixture of incentives and regulation will foster a spirit of innovation that can be summarised as “build it and they will come”. A natural consequence is investment in recycling facilities and the creation of jobs. Investors will rapidly see new opportunities emerging to get a stake in systems like those that other countries have successfully implemented (as outlined in Appendix 4 – Global examples of used OTR product management). Some companies may even find it economic to invest in their own in-house solutions (see 11.4.5).

Barriers as opportunities

Section 5.2 of this report goes into detail about the barriers hindering OTR recovery in Australia. These include widely-dispersed feedstock, small numbers of large suppliers, uncertainty of market demand and limited opportunities to test solutions. Looked at another way though, these barriers can be seen as opportunities.

Dispersed feedstock volumes require innovative recovery methods and potentially creating new business in remote areas; small numbers of suppliers make negotiating service agreements more straightforward; uncertainty of market demand creates a first-mover advantage; and limited testing of preferred business models is a gap waiting to be filled by an innovator.

Savvy businesses may recognise that if they can develop service offerings that effectively resolve these barriers, they will be able to lock in service contracts with OTR rubber product waste generators, solve a systemic resource management issue, and satisfy a latent market demand. The public economic benefit of this is that this major logistical and resource management challenge is solved.

Innovation drives productivity

Research and innovation are the fundamental drivers of productivity growth, which ultimately lifts living standards for all Australians. The investment in new methods, technologies and business models is what helps Australian businesses compete in an increasingly competitive globalised economy.

The concept of productivity, which is defined as producing more with the same or fewer resources, goes hand-in-hand with circular economy thinking. By extracting more value from the resources contained in OTR tyres, keeping them circulating within the economy and reducing our use for virgin materials, we support a more resource-efficient and productive nation.

Further research

It's not in the scope of this report—nor is it TSA's role—to assign a definitive value to the potential OTR market. What our findings do show though, is that recovering and recycling OTR tyres is not simply an environmental obligation, it's an opportunity for people to make money by using a resource that is literally going to waste. By supporting the development of an effective OTR tyre recovery market, TSA and our stakeholders are opening an opportunity for Australian investment, innovation, and jobs to thrive. TSA recommends that further economic research be undertaken on a catchment basis to help identify unique employment, investment, and economic opportunities available through improving recovery.

3.1.3 Policy

At the time of writing, most Australian states and territories have a waste and resource recovery strategy or functional equivalent.[36] These strategies share a commitment to improve the recovery of resources from discarded products and materials, some explicitly referencing end-of-life tyres as a problematic material. They recognise a need to reduce the negative effects of less responsible forms of disposal, such as illegal dumping, littering, or unlicensed management of regulated waste streams. The need to lift improve these in remote and regional contexts is a common theme.

Efforts to improve recovery should contribute to state and territory objectives for resource recovery and the circular economy, given the impacts and lost opportunities of disposal or stockpiling on-site to manage end-of-life OTR tyres. These state and territory strategies are aligned with the National Waste Policy Action Plan (which also mentions tyres as a priority), so state and territory support for OTR tyre recovery will contribute to the national plan. National, state and territory strategies all recognise the value of high performing product stewardship schemes, and presumably support updates to the Tyre Product Stewardship Scheme to achieve better OTR tyre recovery outcomes.

[36] The Tasmanian Waste and Resource Recovery Strategy is still in draft form in March 2023.

To achieve OTR tyre recovery in each state and territory, we need to review resource recovery policy and regulatory settings at the national, state and territory levels. This is to ensure the policies affecting end-of-life OTR tyre recovery are collectively efficient, effective, and deliver clarity for stakeholders.

While thorough review of such policies is left to the implementation stage actions after completing this business case, we need to generally review OTR tyre recovery solutions against:

- resource recovery targets at the national, state/territory and regional levels
- national bans on the export of wastes including waste tyres (with limited exemptions)
- national environment protection and biodiversity conservation requirements
- regulatory and licence settings for the management, handling, transport, storage, disposal, and processing or treatment of regulated and controlled wastes
- state and territory energy-from-waste policies and similar related policies
- general environmental duties and chain-of-responsibility requirements
- other relevant laws, regulations, and guidelines relevant to waste and resource recovery
- legislation, policies, and other operating conditions applicable to primary source sectors such as mining and agriculture.

To assist a future systematic review of policy and regulatory settings, a limited review of state regulations as they are applied to end-of-life tyres and the waste generated by sectors linked with OTR tyre generation is in **Appendix 3.**

Our approach will support national, state and territory waste and resource recovery strategies to realise the public benefits of recovering OTR tyres in the future. Other policy interests such as domestic advanced manufacturing stimulus and regional and First Nations economic development and inclusion policies may also have relevance for selected catchments of OTR tyres.

3.2 Private benefits

End-of-life passenger car, bus and truck tyres are often the responsibility of tyre retailers or other third parties, who then determine how they are recovered or disposed of. Customer expectations, internal business values, competitive pricing based on low recovery costs, and regulatory pressure against disposal may support the recovery of tyres.

The high national rate of passenger car, bus and truck tyre recovery suggest most retailers and corporate fleet tyre service providers are using tyre recovery services rather than disposing in landfill, although there remain areas with challenging distances and limited opportunities to leverage scale economies.

OTR tyre generators, such as mining companies and agricultural businesses, appear less inclined or less able to outsource end-of-life tyre management decisions to third parties, with a preference for on-site-managed in-pit burial, in the case of mining, or on-site storage or stockpiling, in the case of agriculture. There is limited to no regulatory pressure for recovery in these sectors. Private incentives to actively shift towards OTR tyre recovery in those sectors are explored here.

3.2.1 In mining

Engagement with mining companies has uncovered several motivators and goals in moving towards OTR tyre recovery instead of in-pit burial. They generally include:

- the opportunity to respond to internal corporate drivers informed by Environment, Social and Governance (ESG) expectations, Global Reporting Initiative (GRI) obligations, UN Sustainable Development Goals, and other social responsibility factors due to shareholder or other pressure
- the rising recognition that continued in-pit burial of OTR tyres is at odds with community expectations towards waste management and appropriate care for ancient landscapes. Most car, bus, and truck owners pay to recover their end-of-life tyres, and there is a wider lift in public scrutiny and pressure on the behaviour of corporations to follow the same rules as everyone else.
- evolving internal procedures, industry standards, and workplace culture, particularly in the adoption of circular economy principles in mining operations and acceptance of greater accountability for practices across supply chains
- acceptance that on-site burial cannot continue indefinitely, and that the future direction of waste and resource recovery regulation and mining licences will eventually mandate a resource recovery solution for end-of-life mining tyres.

These benefits to mining companies in moving to OTR tyre recovery instead of disposal can be summarised as:

- internalising and accounting for recognised corporate responsibilities
- pre-empting risks to operating licences including commercial, social, and regulatory licences.

Failing to improve OTR mining tyre management at end-of-life may be construed as poor due diligence, and the continuation of in-pit burial a negligent corporate practice.

While cost efficiency is an important consideration, an increase in management costs associated with OTR tyre recovery could be considered an investment in sound corporate practice, to better manage risks while managing mine sites to a higher standard. This approach is like the sector's internalisation of OH&S responsibilities: sound end-of-life tyre management, including the costs of recovery, would become part of a mining company's standard operating practice.

Workforce safety and OTR mining tyre management

Feedback from the mining sector emphasises the importance of safety within the sector's operating standards. The sector has adopted practices and equipment that minimise health, wellbeing, and safety risks to internal team members, contractors, site visitors, and others.

Mining companies generally include and account for occupational health and safety standards and practices along their supply chains, including in waste and resource recovery.

Mining tyres used on earthmoving vehicles can weigh up to 4.5 tonnes and measure up to four metres in diameter. Their improper usage and handling can represent a lethal risk to mining workforces and others. Their handling, management and storage across supply, replacement, on-vehicle use, inspection, and maintenance, and removal for end-of-life management stages, all need to meet safety standards to prevent accidents.

Guidelines such as internal operating manuals, Australian Standards (e.g. Australian Standard 4457 for the maintenance and repair of OTR tyres), and other guidance, including guidelines published by states and territories, are used to support tyre safety:

In 2015, the WA Department of Mines and Petroleum released its guideline 'Tyre safety for earth-moving machinery on Western Australian mining operations.'

In 2020, the Queensland Government Mineral Mines and Quarries Inspectorate issued its guidance note 'Tyre, wheel and rim management.'

Current versions of these guidelines have limited content on the safe handling and management of end-of-life tyres, yet mining companies have a duty of care for the health and safety of contractors and their workforces involved in the recovery of end-of-life mining tyres. Downstream companies involved in processing and remanufacturing activities have similar duties to manage end-of-life mining tyres safely. To support safe OTR tyre recovery, TSA and those with a safety role in the sector should collaborate on expanded guidance material for the safe handling and management of end-of-life mining tyres.

Recent findings from an annual global survey into the major risks recognised by mining executives underscore these issues.[37] This showed that the first-ranked risk recognised by mining executives was 'Environmental risks, including new regulations', which displaced the 2021 top-ranked risk of 'Commodity price risk.' It also identified 'Community relations and social licence to operate' as third ranked.

'Talent risk', the ability to attract high performing technical and commercial executives and team members, was also a top ten challenge. This is likely intertwined with a need to show sound ESG practices and a forward-looking workplace culture, with a circular economy ethos serving as a core ingredient.

A similar survey undertaken by a Perth-based corporate services body specialising in the mining sector, State of Play, is revealing. When mining executives were asked 'why is mining perceived negatively by society' the top three answers out of ten were:

1. Environmental impact (by a significant margin)
2. Misunderstood mining benefits
3. Community impacts.

This survey found that 82% of mining sector respondents agreed that 'transparency of the source of raw materials will become a significant driver of value for [mining] companies.' This reinforces the view that operating licence concerns, including social licence, will have growing influence over operations

[37] https://home.kpmg/xx/en/home/insights/2022/04/global-mining-outlook-2022.html

in coming years.[38] Mining companies will face increasing scrutiny on whether they have adopted circular economy practices, particularly given that extracting resources from the environment is integral to their business model.

Addressing the materiality of the mining sector's impacts on the environment

The above discussion serves to illustrate that mining companies can't afford to ignore the environmental impacts of their operations, or of the supply chains and services on which their operations depend. It also shows that leaders in the mining sector increasingly acknowledge their responsibilities. For these leaders the focus is understanding the range of activities and decisions that incur an environmental cost, and then prioritising actions and changes in practice to mitigate those costs.

There is likely to be differing degrees of urgency and focus on addressing environmental impacts for businesses within the sector. The environmental issues prioritised and acted on by different miners will in part be driven by the locations mined, commodities extracted, scale and method of mining techniques, and stakeholder perceptions of or influence on their business.

Consultation with the mining sector shows an increasing use of ESG materiality tools and processes to identify which environmental, social and governance issues are most important to address and internalise. This also reveals that some of the larger mining corporations in Australia actively acknowledge the circular economy as an area that deserves appropriate attention, and that end-of-life OTR tyres are an early priority in shifting practices to a circular economy.

The International Council for Mining and Metals (ICMM) has developed a system to help its members prioritise the adoption of circular economy approaches and business models,[39] with tyres flagged as a priority material. Members of the ICMM include the largest mining businesses active in Australia and beyond.[40]

> 'Process and product are tied together. For materials to be truly circular, both the way they are produced and consumed must be circular. In the case of mining, this means having operations that have a net positive contribution to the environment and society, and working with the wider metals supply chain to promote the responsible use and recovery of metals after they enter markets.'
>
> International Council of Mines and Minerals (ICMM)
>
> https://www.icmm.com/en-gb/our-work/innovation-for-sustainability/circular-economy

In short, some mining companies operating in Australia recognise OTR tyres are a problem and want a solution that resolves the key issues with certainty, while giving confidence that the solution meets the company's standards and obligations. Other mining companies may not have formed a position yet or may have determined that current practices are not material. These warrant direct engagement to better understand what factors drive their determination of ESG materiality.

This report supports an analysis of the materiality of end-of-life OTR tyre management practices, while urging that a wider range of external parties should be authentically canvassed and incorporated into this analysis.

The interplay of potential costs and benefits, including private and public costs, shows that the process of determining materiality may not be best undertaken through purely internal processes. External stakeholders and independent expertise will bring a broader base of knowledge that help to inform

[38] State of Play, *State of Play: Strategy report*, Vol. 5, 2022.

[39] https://www.icmm.com/en-gb/our-work/innovation-for-sustainability/circular-economy

[40] https://www.icmm.com/en-gb/our-story/our-members

decisions on the significance of any particular issue, and what strategies to resolve the issue are deemed satisfactory over different timeframes.

3.2.2 In agriculture

By weight, the agricultural sector consumes the second greatest quantity of OTR tyres in the country. These tyres are often stockpiled by farmers or other productive landholders at end-of-life, though, anecdotally, other *ad hoc* disposal activities are also employed. Advice provided to TSA by Dairy Australia indicates significant quantities of silage wrap are burned, and it is likely that some tyres have a similar fate.

A fraction of agriculture tyres may have a second life on property. Some tyres may be used to weigh down silage on farms that carry livestock, while others may be used to construct fencing or to control erosion. This may not be condoned by environmental regulators.[41]

A survey by the Victorian Department of Environment, Land, Water and Parks (DELWP) provides further insight into the use of end-of-life tyres on farmland.[42] Responses from 122 participants indicate that most tyres are used in silage production, and that about 69% of respondents keep less than 2,500 EPUs or about 25 tonnes of tyres on site for this purpose. The tyres are stored closely together during much of the year but are then laid out to produce silage towards the summer months. This may lessen the fire risk associated with significant stockpiles.

The survey did not gather information on whether the tyres were mainly OTR (e.g. tractor), truck, or passenger car tyres. Insights from the survey include that farmers:

- see tyres as an important resource for the production of silage
- consider the use of tyres for silage as a positive environmental outcome
- find alternatives that reduce or avoid the use of tyres in silage production, such as heavy silage covers and sandbags, challenging to implement
- were concerned around the accessibility and high cost of tyre disposal, which lead to unwanted tyres being stored long term
- felt a better general understanding of the actual risks from waste tyres on farms is needed and stressed the importance of clear and relevant guidance on managing risks
- expressed concern over increasing regulation and expect that any regulation of tyres on farms should be proportionate to risk.

The survey is valuable in showing that some storage of end-of-life tyres on farming properties is viewed as an economically useful and environmentally sound practice, although practicalities may favour the use of passenger car, bus, and truck tyres for silage production over OTR tyres. Although silage is mainly useful for livestock, and large agriculture tyres mainly arise from broadacre and irrigation cropping, tracking how this practice is used in other parts of the country would support a broader understanding of tyre recovery. However, silage production is not a sufficient reason to keep large amounts of tyres on property.

[41] EPA Victoria, *Using waste tyres on farms and other private property*, April 2017. https://www.epa.vic.gov.au/about-epa/publications/1652

[42] DELWP, *DELWP review of regulations for waste tyres on farms*, April 2022. https://engage.vic.gov.au/delwp-review-regulation-waste-tyre-use-and-storage-farms

Section 3.1 discusses the benefit of avoiding risks to the underlying and surrounding agricultural land from stockpiled or dumped end-of-life OTR tyres, including:

- fire and smoke damage to property, equipment, livestock, and crops
- land contamination from particulates, leachates, and the whole tyres themselves
- pests and nuisance species including vermin, snakes, and human and livestock disease vectors
- lost visual amenity, and reduced enjoyment from contaminated landscapes.

There is also the opportunity cost of the land on which end-of-life tyres are stored. Areas used for tyre stockpiling may have other uses offering greater value.

The benefits in having end-of-life OTR tyres managed and recovered through off-site solutions can be summarised as better land asset management and business practices.

These benefits include better land care, pest management, disease control, fire safety, and general on-site risk management. Where farmland is leased, passed on from generation to generation, or bought and sold according to market valuation, these benefits offer improved business operations and a better level of care for a long-lasting capital asset.

While running an agricultural concern is a cost-intensive enterprise, any solution to recover excess end-of-life OTR tyres found on agricultural properties needs to be affordable. Given that end-of-life tyres may be accumulating on some properties over several years or even decades, a tyre recovery regime may need to involve several collection visits phased over multiple production seasons, within tight budget constraints.

3.3 Promoting legitimacy

OTR tyre recovery has not adopted standard practices in the mining and agricultural sectors in Australia. Without widely-accepted recovery solutions, there may be experimentation with different solutions to meet industry and community expectations within commercial constraints.

Some OTR tyre generators may shift their standards over time, where basic standards of resource recovery are periodically upgraded to higher or more ambitious standards of circular economy practice.

Not all solutions produce equal outcomes or equal public and private benefits, and some benefits match more closely to resource recovery or circular economy standards than others. Understanding how mining and agricultural sectors determine the legitimacy of OTR tyre recovery solutions will support them to develop effective standards.

When considering OTR tyre recovery pathways and the nature, scale and distribution of their benefits, these sectors may consider:

- corporate drivers, including internal standards and objectives, shareholder and business owner imperatives, industry trends, the need to comply with operating procedures, and the application of risk management frameworks
- regulatory drivers, including industry and environment protection regulations, accepting that regulations may both shape and respond to the introduction of new OTR tyre recovery methods and technologies
- community sentiments, with a priority on Indigenous peoples and local communities and business sectors that may be impacted near the point of generation, or along the recovery supply chain.

Resource recovery activities often involve a variety of third-party impacts and externalities that, if improperly managed, erode the integrity of the OTR tyre solution in place. Some solutions may seem to offer only marginal improvements on business-as-usual management of end-of-life OTR tyres, such that they lack legitimacy.[43]

This underlines the importance of adopting an inclusive discussion with regulators and the community to develop preferred OTR tyre recovery solutions, considering the benefits that the solution may provide. Ideally, this would involve corporate policies and decision-making practices that prioritise transparent community engagement before, during, and after developing and implementing a preferred solution. This process would support community and sector legitimacy in the adoption of OTR tyre recovery solutions.

3.4 Indigenous peoples and local communities

In 2022-23, TSA commissioned research projects to understand best practice in how industries, and potentially OTR tyre recovery operators in future, engage with indigenous peoples and local communities (IPLC).

This research produced two papers which will be published in 2023:

- Collaborating with Indigenous peoples and other local communities in tyre recovery – Global Review and Recommendations
- *Good Practices in Australia for Indigenous Peoples and Local Community Engagement.*

This research was prioritised, recognising that mining and agricultural activities are often co-located in areas of significance to local communities and First Nations peoples across Australia, and that new operations to recover tyres need to account for historic, existing and future issues, perceptions and points of sensitivity for
those communities.

TSA has incorporated the UN Sustainable Development Goals in its current strategic plan, and therefore prioritises appropriate and responsible pathways to recover tyres, including OTR tyres, that respect and support indigenous people and local communities.

Figure 3: These UN Sustainable Development Goals are prioritised in TSA's Strategic Plan (2020-2023). Further details are available in TSA, TSA Strategic Plan (2020-23), 2020.
Source: https://www.tyrestewardship.org.au/about-tsa/strategy/

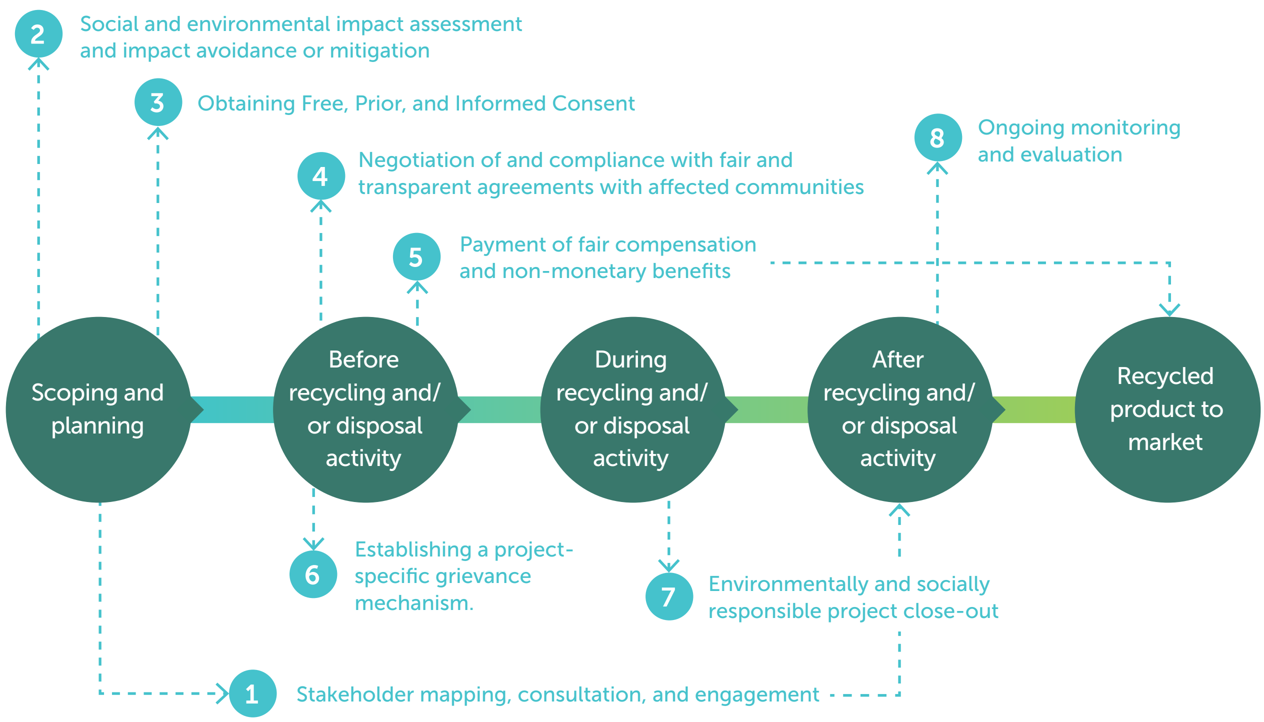
[43] For example, the use of crushed recycled glass as a daily cover on open landfill cells to suppress dust and wind-blown litter is often seen as a weak example of resource recovery, when that same material could be recycled to produce new glass packaging or other 'higher value' products.

In TSA's research, best practice approaches for engaging with IPLCs were determined by drawing on leading examples of engagement across the world. The research team synthesised the following list of practices for tyre recovery operators to adopt when exploring, planning, and undertaking business activities with the potential to impact IPLCs.[44]

1. Stakeholder mapping, consultation, and engagement throughout the entire life of any recycling project.
2. Social and environmental impact assessment and impact avoidance or mitigation.
3. Obtaining Free, Prior, and Informed Consent (FPIC).
4. Negotiation of and compliance with fair and transparent agreements with affected communities.
5. Payment of fair compensation and non-monetary benefits.
6. Establishing a project-specific grievance mechanism.
7. Ongoing monitoring and evaluation.
8. Environmentally and socially responsible project close-out.

Importantly, the practices should focus on and include the informed and active participation of both women and men that may be affected by tyre recovery business operations.

Figure 3A: Best practice engagement with IPLCs



TSA is building on this research with further research into how best practice may be applied in the Australian context and in recognition of the major sources of OTR tyres in regional and remote Australia, i.e. mining and agricultural activities.

[44] Bledsoe D. and Hannay, L, Collaborating with Indigenous Peoples and Local Communities in OTR Rubber Product Recovery, 2023. https://www.tyrestewardship.org.au/reports-facts-figures/iplc-engagement-best-practices/

ICMM Position Statement

The ICMM Position Statement on Indigenous Peoples and Mining urges its members to commit to the following practices:[45]

- respect the rights, interests, special connections to lands and waters, and perspectives of Indigenous Peoples, where mining projects are to be located on lands traditionally owned by or under customary use of indigenous peoples.
- adopt and apply engagement and consultation processes that ensure the meaningful participation of indigenous communities in decision making, through a process that is consistent with their traditional decision-making processes and is based on good faith negotiation.
- work to obtain the consent of indigenous peoples as required by the ICMM position statement.

The ICMM identifies in its position statement that the proposed approach to working and engaging with indigenous peoples are directly aligned to the following principles to which its members are committed:

- **Principle 3**: Respect human rights and the interests, cultures, customs and values of employees and communities affected by our activities.
- **Principle 6**: Pursue continual improvement in environmental performance issues, such as water stewardship, energy use and climate change.
- **Principle 9**: Pursue continual improvement in social performance and contribute to the social, economic and institutional development of host countries and communities.

To further help its members consider best practice in working with, engaging, and mitigating potential impacts on indigenous communities, ICMM has published an in-depth guide[46] for mining companies that operate near indigenous communities and their cultural sites. This includes twelve separate tools to achieve best practice.

While focused on the concerns of indigenous peoples, this guide could be used to consider concerns of non-indigenous local communities impacted by mining activity. It could also be adapted to mining-related activities, such as the handling and recovery of end-of-life mining tyres. Mining companies may also have their own best practice material which they expect tyre recovery contractors to comply with when engaging and working with indigenous peoples and local communities.

3.5 Tyres into tyres

There are many potential benefits from applying the tyres into tyres method of OTR recovery. In this method the end-of-life tyres are used as a resource from which to extract material inputs to manufacture new OTR tyres or extend the life of existing OTR tyres through repair or re-tread activities. While this recovery pathway is not commercially mature enough to immediately adopt in the Australian market, the benefits are worth exploring.

The use of end-of-life OTR tyre material for producing new tyres, or extending the life of existing tyres, reflects the ideals of circular economy and waste hierarchy models while enhancing the resilience of the tyre recovery sector. The business case forecasts actions to 2030, and involves timelines that may accommodate commercial trials for innovative solutions such as tyres into tyres and tyre re-tread that reflect a 'high order' circular economy model for OTR tyres.

[45] ICMM, *Position Statement: Indigenous peoples and mining*, 2013. https://www.icmm.com/en-gb/our-principles/position-statements/indigenous-peoples

[46] ICMM, *Good practice guide: Indigenous peoples and mining*, 2nd edition, 2015. https://www.icmm.com/website/publications/pdfs/social-performance/2015/guidance_indigenous-peoples-mining.pdf

The large scale of OTR tyres potentially available for a 'tyres into tyres' solution from one or more of the larger catchments of tyres (e.g. in the Pilbara, Bowen Basin, or Hunter Valley and Northern NSW catchments, see Chapter 10), may be attractive to new market entrants willing to invest in higher order circular economy solutions, and could be a good area to undertake these trials. The use of end-of-life OTR tyre material to produce new tyres or extending the life of existing tyres is consistent with product stewardship, and offers market differentiation for leading tyre manufacturers and importers.

Several mining companies that aim to become global leaders in sustainability have expressed interest in a 'tyres into tyres' recovery path over energy recovery, downcycling higher quality materials, or binding useful material in an inert matrix for limited demonstrable benefit. Such companies also enter large purchase agreements for mining tyres spanning several decades in Australia and in their global operations. They are well-positioned to exert positive influence over their tyre supply chains should they wish to do so.

Accounting for the supply chain impacts of OTR tyres in the mining sector is consistent with emerging efforts to decarbonise that sector. Mining sector representatives have disclosed a goal of achieving net zero greenhouse gas emissions across their supply chains (i.e. Scope 3 emissions) which, at minimum, represents an acknowledged responsibility for upstream carbon impacts.[47] This has led to the Electric Mine Consortium, joined by a number of major mining companies, and its collective commitment to a fully electrified, zero carbon business model for mining operations.[48] Other mining companies have elected to set an internal carbon price to drive business decisions in line with carbon abatement objectives.[49]

Mining companies should look to assume a similar duty of care towards their production inputs beyond their energy and greenhouse gas emission characteristics, including for mining tyres, and account for the wider impacts associated with this demand. While this could involve active attempts towards using end-of-life OTR tyre material as a resource to lower demand for virgin rubber in tyre manufacture, other efforts could involve procurement and operational policies designed to extend the productive lifespan of mining tyres during their use.

An active commitment to improve tyre recovery outcomes will help set the Australian mining sector up as a global leader in sustainability. This could involve long term circular economy collaboration models between the more responsible mining companies and their mining tyre supply chains, with facilitation and guidance provided by an impartial stewardship organisation like TSA.

[47] Fortescue Metals Group is one major company with the goal of net zero Scope 3 emissions by 2040. Other mining companies have pledged to reduce Scope 3 emissions by a percentage amount (e.g. Anglo-American).

[48] https://www.electricmine.com/

[49] Internal carbon prices have been set by, for example, IGO Ltd and Rio Tinto Ltd.

Section 2 – Barriers, enablers, and partners

4. Delivering, managing & recovering OTR tyres

This chapter examines the supply of OTR tyres to the mining and agriculture sectors. The supply chain is important to understand as it provides insight into how tyres could be handled at end-of-life, or how to remove barriers to efficient and appropriate OTR recovery solutions. If this is the case, engagement with suppliers and potential changes to procurement settings may be useful to achieving greater levels of OTR tyre recovery.

This chapter also examines how the supply chain for recovering OTR tyres could take place, with key steps outlined. While there are limited larger scale precedents for OTR tyre recovery from agriculture and mining industries in Australia, there are examples from the recovery of passenger car, bus and truck tyres that may be instructive in identifying general stages of activity to account for. International examples of OTR recovery are also summarised alongside a review of emerging technologies.

How the analogous activities take place for mining and agriculture OTR tyres, the parties involved, and the commercial relationships needed for each stage to occur, are all driven by the particular needs and barriers faced by the sub-sectors and regions involved in OTR tyre use. These needs and barriers may have commonalities and differences to those faced in recovering passenger car, bus and truck tyres, and are explored in detail in Chapter 5.

The supply of OTR tyres to the mining and agriculture sectors are treated separately, given the distinct activities to procure and ship OTR tyres to each.

4.1 OTR tyre supply

4.1.1 In mining

The reliable delivery of OTR tyres to the mining sector is vital to ensure that large earthmoving and other vehicles used to move unprocessed ore can operate. These large OTR vehicles typically work as the first stage to transport ore from the mine site to processing and shipping facilities, within a wider transport network of conveyors, large on-road freight trucks, or bulk cargo trains. In open-cut mines these vehicles are also used to shift overburden to expose ore in preparation for mining.

OTR mining tyres have been described as a strategic asset: without the steady supply of suitable mining tyres that quickly wear in a harsh mining environment, operations to extract and transport the valuable ore commodity for processing may quickly come to a halt. Large mining tyres are typically worn and replaced every two years.

The supply of large mining tyres for earthmovers is established through a direct commercial relationship with OTR tyre importers, including importers that voluntarily contribute levy funds to TSA. Depending on the location of the mine, the OTR tyres may be imported through the main commercial and industrial ports sited near capital cities and other coastal centres across Australia, or may be delivered to regional ports that mainly function as export hubs for mining and agricultural commodities or other exported goods.

Iron ore miners operating in the Pilbara may source OTR tyres arriving at nearby Port Hedland, as well as from the Port of Fremantle. If the latter, those tyres will then need to be trucked over 1,500 kilometres to the Pilbara region. Similarly pragmatic arrangements may be in place for tyres used in the Bowen Basin and Hunter Valley coalfields.

Third-party OTR tyre logistical and service companies may assist the storage and movement of OTR tyres between entry points to the country and their mining operation. Such companies may provide a range of services including testing, storage, freighting, and tyre repair and re-tread services, though re-tread is uncommon in the Australian market. There are some examples of mining companies using in house teams to conduct care, maintenance, and repair services to extend the life of their tyres.[50]

Some independent operators also stock OTR tyres for sale to mining companies, as distinct from sales directly through the importer. These companies may require specialised trucks and trailers to move OTR tyres that are up to 4 metres in diameter, and must adopt safety protocols to ensure such tyres are handled and transported safely. Because of their potential role in testing for damage prior to a repair, re-tread, or disposal decision, these service companies may be involved at the OTR tyre's end-of-life as well as its beginning.

4.1.2 In agriculture

Large tyres are needed for a wide range of agricultural vehicle applications. Providing agricultural tyres to end customers is achieved through a regional network of private tyre retailers working to various scales and customer areas. They get their tyres directly from importing brands or through third-party wholesalers who may carry a range of brands and directly serve as retailers in agriculture markets.

Agricultural tyre retailers in New South Wales and Queensland have identified that their predominant customers are involved in broadacre and irrigation cropping of cereal grains, legumes, rice, or cotton. Fruit, vegetable, and seed-cropping businesses exhibit less demand. While these states also contain pastoral activity, rearing livestock does not have as high a demand for agriculture tyres and may employ contractors who provide and use their own vehicles.

Tyre retailers have observed that the size of tyres used in the agriculture sector has increased in past decades in line with increasing vehicle horsepower, with more than half the tyres used being 38 inch / 96 cm or larger in rim size. There has been an increase in the range of tyres available in the market, including an influx of brands targeting lower price points which are perceived as lesser quality.

Agricultural tyres are generally replaced on farm. Retailers have reported that increasing formal training and education in the farming sector has led to newer farmers being more conscious of the costs and benefits of maintaining their equipment, and farmers are increasingly managing their vehicles and tyres to extend operating lifespan and improve productivity. Tyre retailers cautioned that this was still a minority of their markets, with most farmers making little effort to preserve the commercial value of their tyres. Interest in tyre inspections, repairs, and related after-sale care has similarly been limited, with service cost a factor.

Retailers have commented that lower quality tyres have been entering the market in recent years, and tyre failure, where tyres fail before their expected lifespan without obvious cause, has become increasingly common compared to traditional wear or damage. This may undermine longevity gains from improved tyre care.

Early tyre failure may be exacerbated by changing vehicle use or vehicle modification, where the tyre is not suited to the vehicle's new use. Different vehicles are designed to be fitted with different tools, and the decision to fit a larger tool than intended by the vehicle manufacturer will lead to faster tyre wear and earlier failure expected from normal use. OEM vehicle manufacturers and importers should provide education and support to farmers to ensure that the tyres being used are appropriate for the vehicle.

The harvest and sowing seasons see higher tyre sales and demand for tyre services. Up to six hours of lost vehicle and driver productivity may occur during these seasons if a tyre needs to be replaced

[50] The Bengalla Mining Company (mining coal in the Hunter Valley) has been able to achieve 20% increases in tyre life through in-house care and maintenance practices, along with other operational savings. https://newhopegroup.com.au/wp-content/uploads/BENGALLA_TYRE_SERVICE_MASTER-1.mp4

midway through a harvesting or sowing shift, with exact downtime dependent on distance to retailer and stock availability.

Whether tyres are replaced at the farm or at the retailer the farmer typically stores it on their farm. If a short-term contractor's tyre is replaced on farm this tyre is also normally left on farm and not considered the responsibility of the contractor. Farmers then usually:

- store the tyres near an outbuilding (e.g. shed), to be stockpiled indefinitely
- bury the tyre on site
- burn the tyre in pits, along with plastic drums and other waste
- use the tyre for civil works on property, including for soil erosion redemption, silage and grain feed cover weights, or for use in feed troughs, or
- keep the tyres as spares for later use.

There are a variety of applications to which agricultural tyres are used, and tyre customers are widely dispersed across agricultural districts in Australia. After-sales care to maintain the working life of agriculture tyres is limited, with scant regard for how the treatment and care for tyres may improve farm operations and profitability. The main way to manage end-of-life agriculture tyres involves on-farm disposal or marginally beneficial applications.

The desire by farmers to keep costs to a minimum would appear to be the key driver for the observed behaviours involving end-of-life tyres, with a reluctance to pay tyre retailers or third parties to manage or recover end-of-life agriculture tyres. Current practices do not show a conscientious and diligent approach towards agriculture tyre recovery. Deliberate efforts across the supply chain and customer base will be needed to replace current practices.

4.2 Tyre recovery facilities in Australia

4.2.1 OTR tyre recovery facilities

Limited amounts of OTR tyres are recovered in facilities in Australia, mostly using equipment designed for passenger car, bus, and truck tyres. Where they are recovered, OTR tyres are firstly consolidated and coarsely shredded or sectioned using general-purpose heavy-duty shredders or hydraulic shears and then fed into processing equipment designed to receive smaller-sized tyres.
This breakdown process generally:

- lowers logistical costs and related handling challenges
- improves storage efficiencies at depots and tyre recovery facility yards that may otherwise become space constrained
- ensures that the resulting fragments and segments are able to be fed into and processed by machinery downstream with minimal workflow disruption.

This first step can be somewhat makeshift depending on the equipment used, manual handling steps, and workflow management. Larger OTR tyres may also degrade general-purpose processing equipment more quickly. Machinery designed for de-beading and sectioning large tyres for subsequent processing is now entering the market and may improve efficiency and durability in this step. Because demand for OTR tyre recovery is low, the steps to process OTR tyres at tyre recycling facilities may be viewed as interrupting the efficient processing of smaller end-of-life tyres.

Along with other barriers discussed in the next chapter, these factors contribute to a higher cost per tonne to process OTR tyres compared with passenger car, bus, and truck tyres. There are also some practical issues with reorienting a passenger car, bus, and truck tyre processing facility so that it can manage more OTR tyres. Nonetheless, some tyre recovery operators have commenced site upgrades to better process OTR tyres.

These activities are not the only potential pathway to recovery. Alternative approaches to recover OTR tyres could bypass the involvement of passenger car, bus, and truck tyre recovery facilities entirely, with material flows, processing stages and end markets designed specifically to recover OTR tyres.

4.2.2 Passenger car, bus, and truck tyre recovery facilities

In Australia, end-of-life tyres received at tyre processing facilities are typically passenger car, bus, and truck tyres. Ignoring tyres for re-tread or resale as seconds, the main facilities operating at a commercial scale, either:

- Dedicated shredding facilities, where the tyre is shredded to a 50 to 150 mm grade containing rubber and steel (and, in the case of passenger car tyres, a nylon mesh layer) and shipped overseas as a tyre-derived fuel (TDF) for use in kilns, boilers or furnaces in parts of Asia. While there has been some interest expressed in using this fuel domestically (e.g. in cement kilns), this practice is not taking place at the time of writing.
- Crumbing and granulation facilities that separate rubber and steel components (and, in the case of passenger car tyres, a nylon mesh). These then progressively break down the rubber component into finer particles from granule to crumb. These products are used in tyre adhesive, niche civil infrastructure, playground and other flooring surfaces, and road binder applications.

Examples exist where the initial shredding process produces tyre fragments that are then crumbed or granulated in overseas facilities.

In Queensland and New South Wales, there are also some pilot-scale tyre pyrolysis plants operating, although these facilities are yet to demonstrate a capacity to work at a commercial scale and deliver products for which there is a high or stable market demand. While a range of other technologies are also being explored for recovering end-of-life tyres, they are yet to progress to a level of commercial maturity in the Australian market context.

The dedication of existing processing facilities to passenger car, bus, and truck tyres can be seen in the estimated processing capacity within each state and how much of that capacity is available to OTR tyres, see Table 13. As can be seen, generally there is less than 10% of current processing available to process OTR tyres leaving current processing capacity for OTR well short of the estimated 130,000 tonnes of OTR tyres generated annually.

Investment in processing capacity for OTR tyres is occurring, but more will be needed to lift OTR tyre recovery rates to similar levels seen in car, bus, and truck tyres.

Table 13: Estimated processing capacity (tonnes) and OTR capacity of current throughput capacity by state[51]

State	Total capacity	OTR capacity of current throughput capacity	OTR proportion of total capacity	# Companies
NSW	120,000	8,000	7%	7
Vic	105,000	4,000	4%	5
Qld	145,000	17,000	12%	8
WA	30,000 +/- 5,000	2,000 +/- 500	7%	3
SA/Tas	30,000 +/- 5,000	2,000 +/- 500	7%	3
Total	**430,000 +/- 10,000**	**33,000 +/- 1,000**	**8%**	**26**

4.3 Other ways to recover OTR tyres

Generally, OTR tyre processing would follow these steps:

1. Designation and storage as end-of-life OTR tyres unsuitable for re-tread, repair, or re-use in secondary markets.
2. Transfer to a processing facility.
3. Processing in one or more stages, which may involve transfer from intermediate to final processing facilities and combination with other tyre material.
4. Shipping of tyre-derived materials to destination markets.
5. Use in end markets as a final product or as a commodity input.

Commercial activities that follow this sequence will need to account for the characteristics and constraints of the OTR tyres processed, including amount, location, tyre size, or proximity to passenger car, bus, and truck tyres.

While contextual factors will determine the needs in each 'catchment' for end-of-life OTR tyres (discussed in Chapter 10), another key consideration is the availability of processing technologies in the Australian market. These will need to function as a cornerstone for the OTR tyre recovery supply chain including downstream markets. This chapter explores proven and emerging technologies and recovery pathways that may be suitable, with commentary on their commercial maturity and their application in the domestic economy.

4.3.1 Alternative recovery pathways

This section outlines alternative pathways to recover OTR tyres, without using facilities servicing passenger car, bus, and truck tyres. Two 'model' recovery pathways are depicted, one for mining and one for agriculture. In doing so, this section:

- outlines a plausible recovery pathway for agricultural and mining OTR tyres in Australia (unique characteristics of individual catchments are discussed in Chapter 10)
- encourages consideration of the need for purpose-built pathways to recover OTR tyres using technologies that are commercially proven in Australia to feed current or emerging domestic and overseas end markets.

To this end, the pathways incorporate mechanical processing technologies to serve relatively mature end markets and needs in Australia (i.e. using crumb and granule products) and in overseas destinations (i.e. tyre-derived fuel).

[51] Limited data was available at time of report on capacity of all tyre processing facilities across Australia. The following data should be used as a guide only and may not represent all facilities operating in Australia.

A recovery pathway for mining OTR tyres

Figure 4 illustrates a recovery pathway for OTR tyres generated in the mining sector. There are several potential approaches for OTR tyre collection, transport, and processing, which depend on factors unique to catchments or regions where mining activity occurs. These include:

- using reverse logistics to transport whole tyres from an individual mine site to a processing facility or consolidation point, at any distance from the source of tyres
- a catchment-based consolidation point to undertake consolidation processing for transport of related products to a more distantly located product processing plant. The product processing plant could be situated at the consolidation point or hub.
- a product processing plant located away from the mining catchment or region.

Depending on the preferred approach, the relative amount of OTR tyres being handled, and preferences around consolidation processing, there are implications for transport vehicles and related logistical impacts.

Figure 4: A recovery pathway for end-of-life OTR tyres from the Australian mining sector, for illustrative purposes only. Potential viability of one configuration of services and operations over others will depend on features that are individual to the catchment of OTR tyres.

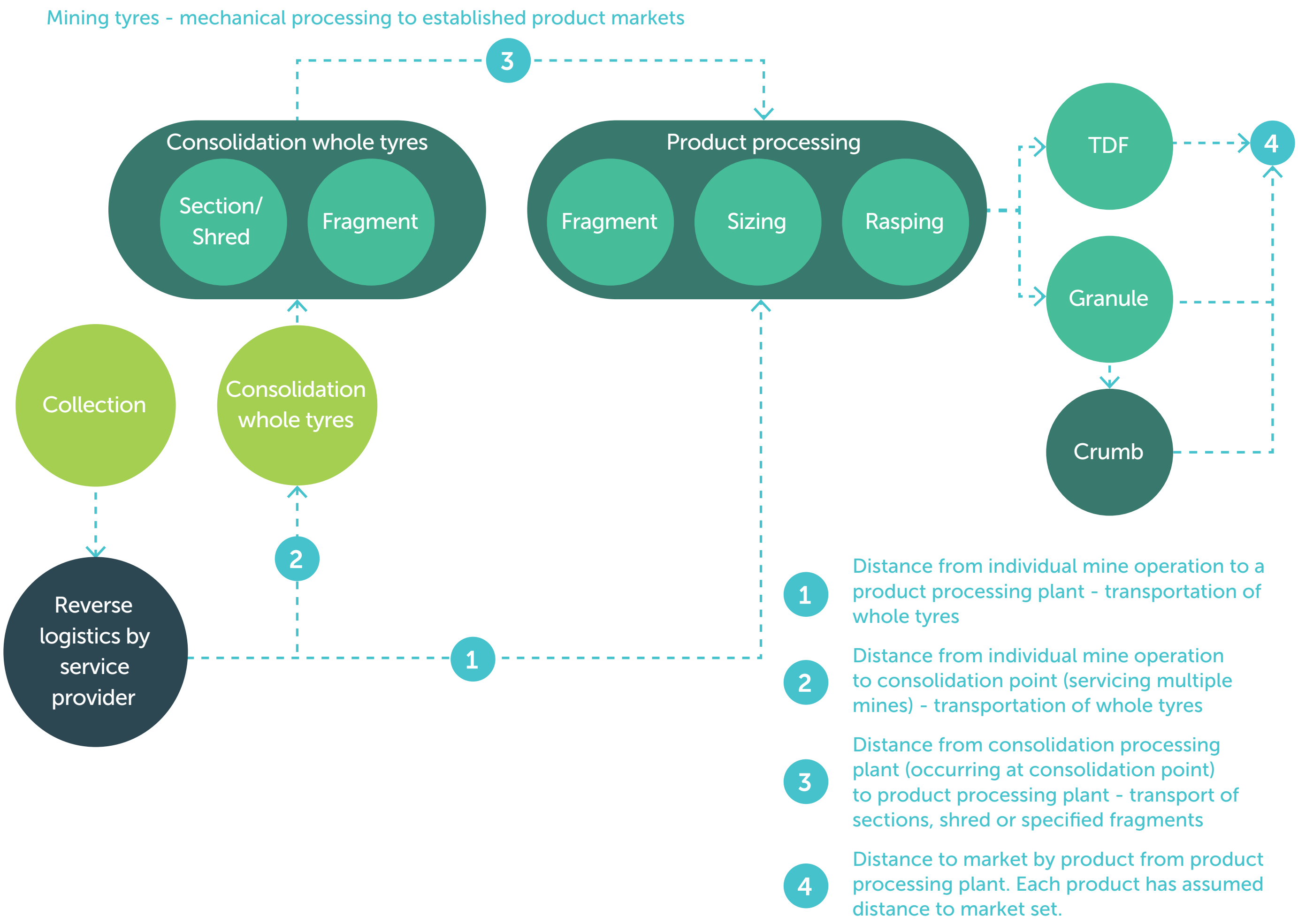


Figure 5 provides a recovery pathway for OTR tyres generated in the agriculture sector, including activities across the service supply chain. The characteristics of an individual agricultural catchment will have a considerable bearing on how exactly recovery is undertaken.

Several assumptions have been made to support this analysis and distinct variations within this recovery pathway. These variations relate to whether a consolidation processing stage (i.e. baling or shredding) is warranted, given relative amounts and logistical considerations.

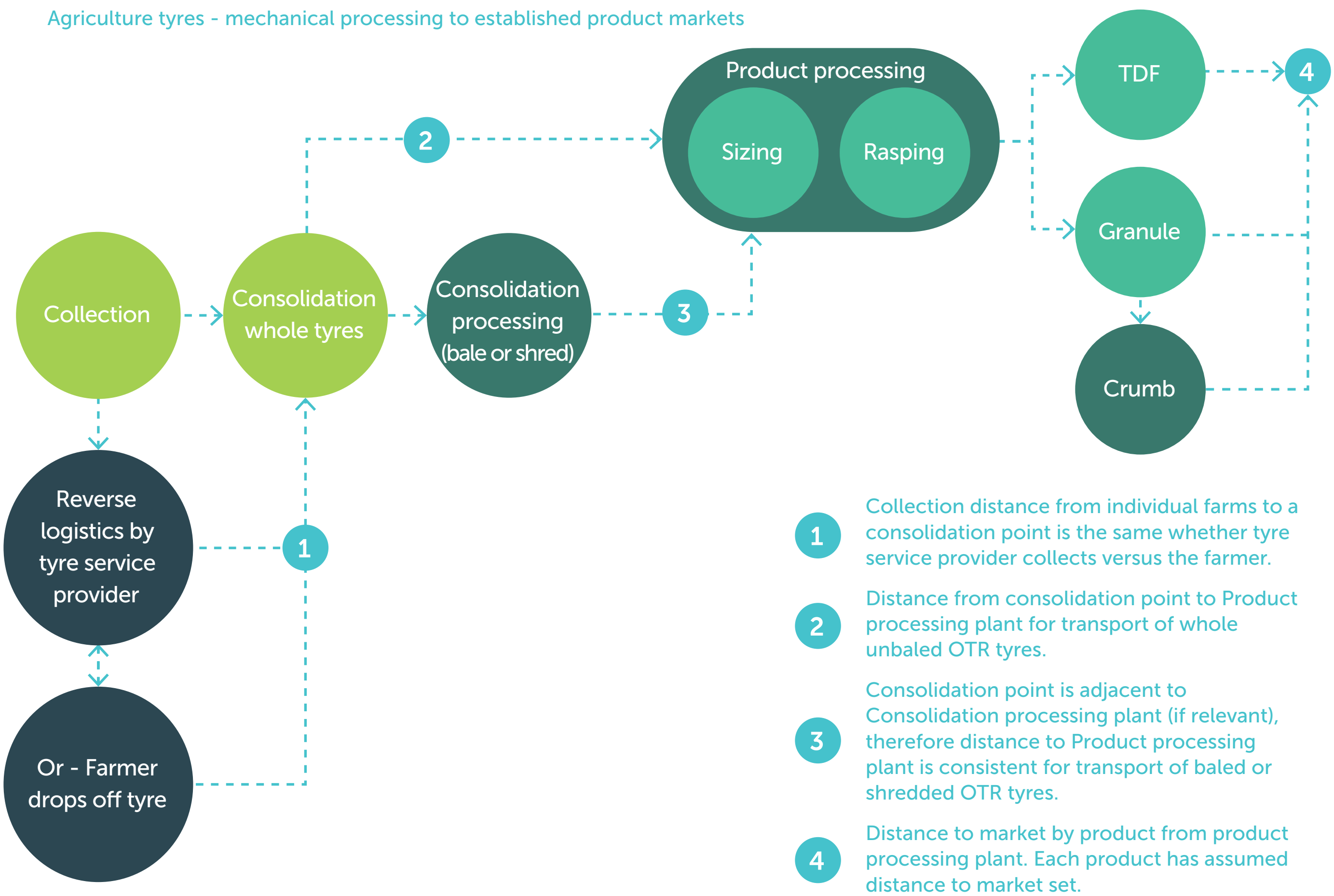
The tyre processing sector and mechanical processing proponents indicate that agricultural tyres have some handling challenges, given their relative flexibility in comparison to more rigid mining tyres. Pre-processing using sectioning or similar is not a requirement, as is typically the case for large mining sector OTR tyres.

Agriculture tyres of various sizes can be accommodated within a product processing plant configured to produce TDF, granule, or crumb. Given the flexibility of large whole tractor tyres there is likely to be a reliance on chopping or shredding of large agriculture OTR tyres using a fit-for-purpose excavator or similar device. This reflects a potential departure from the use of direct feed conveyor belts as are used for passenger car, bus, and truck tyres. The need for the excavator is removed if the agriculture tyres have been pre-processed into shred, where that shred can be transported via conveyor.

In analysis in Chapters 9 and 10, the amount of agriculture tyres within catchments suggest it is unlikely that a purpose-built OTR recovery system for agriculture tyres is optimal. Consideration of a 'model' scenario enables analysis of logistical and consolidation characteristics in the management and recovery of end-of-life agricultural tyres.

Depending on the catchment, there are several other complementary feedstock options, such as mining OTR tyres or passenger, bus, or truck tyres sourced from regional centres, which may be vital for a commercially viable processing plant.

Figure 5: A recovery pathway for end-of-life OTR tyres from the Australian agriculture sector, for illustrative purposes only. Potential viability of one configuration of services and operations over others will depend on features that are individual to the catchment of OTR tyres. OTR tyre recovery in other countries



4.3.2 OTR tyre recovery in other countries

TSA recently completed a desk-based review of the global management of end-of-life OTR rubber products (tyres, tracks, and conveyors) and the regulatory levers and interventions that have been used to improve resource recovery, such as re-treading, recycling into products, or use as a fuel replacement. A summary of the review findings are provided in **Appendix 4.**

Countries were selected for review because they had similar characteristics to the Australian context or based on their published OTR products resource recovery performance. In total, seven countries were reviewed as outlined in Table 14 below.

Table 14: Characteristics of countries reviewed during research conducted for TSA.

Country	Significant mining	Significant agriculture	Remote location large OTRs?	Tyre stewardship in place?
Canada	✓		✓	✓
South Africa	✓		✓	✓
Chile	✓		✓	Developing
New Zealand		✓		Developing
Denmark		✓		✓
France		✓		✓
Germany		✓		

The review highlighted that countries and regions across the globe are:

- operating under very different tyre recovery schemes
- engaging in unique conversations about roles and responsibilities
- responding to home-grown regulatory requirements.

These factors all contribute to country-specific market supply and demand. Innovation and development in tyre processing technologies is therefore also at different stages of commercial maturity.

While innovation is occurring, global tyre processing facilities are predominantly producing end-of-life tyre products similar to those in Australia.[52] According to research conducted by TSA, the conventional technologies processing at a commercial scale can be summarised into several key processes and products as shown in Table 15.

[52] Shulman, V. L. *Management of end-of-life tires. Tire Waste and Recycling* (INC, 2021). doi:10.1016/b978-0-12-820685-0.00027-2.

Table 15: Examples of conventional technologies processing at a commercial scale in other countries.

Process	Product	Product size	Example applications
Re-treading: remove/ buff off old tread, and replace with new tread	- Buffings	~1-5 mm	Surfacing applications, playgrounds, sports flooring
Shredding equipment to reduce size of tyres*	- Tyre-derived fuel or TDF - Tyre-derived aggregate or TDA	~50-150 mm	Waste to energy: used as a solid fuel for combustion in kilns, furnaces, and boilers Civil infrastructure applications: backfill and retaining walls
Ambient granulation equipment to produce particles that are free of steel and fibre**	- Rubber granules	~1-15 mm	Surfacing applications: playgrounds, sports flooring, artificial turf infill
Ambient grinding/milling equipment for further size reduction**	- Crumb/crumbed rubber	<1 mm	Adhesives, polymer composites, road binders in asphalt and sprayed seal

* Shredding may be through a separate shredding system, or an integrated feed line into the granulator system.

** During the granulation and grinding size reduction processes, steel and fibre (passenger tyres only) are continually separated using magnets or raspers respectively, to provide the desired product.

4.3.3 Alternative tyre processing technologies

Various other technologies have been proposed to address the challenges of passenger, bus, and truck and OTR tyre processing, with each technology at a different stage of commercial maturity. The processing technologies outlined above have been set up to receive passenger, bus, and truck tyres as feedstock. Due to the unique challenges of the large size of OTR tyres and their steel beads, and physical features of heavy duty conveyor belts, other physical processing methods may be needed.

Physical processing technologies

To enable similar processing and size reduction of larger OTR tyres, additional equipment is available to reduce the size of a tyre to an appropriate feed size for shredding and granulation systems. There are also alternate technologies to reduce the size of tyres, which use physical methods beyond physical shears or blades.

Pre-processing equipment

Bead-breaking and de-beading technology are commercially available and can remove the large steel bead in large OTR tyres, which would otherwise reduce the life of shredders' blades.

Downsizing equipment is also commercially available, with equipment such as hydraulic or mechanical shears that can cut a tyre or conveyor belt into pieces for efficient transport and to a suitable size for physical processing.

Water Jet Processing

Water jet technologies are an emerging process and involve using high pressure water to wash and cut tyres, then further breakdown both tread and sidewalls of tyres into granules and powder. The process strips away the rubber component of tyres from textile and steel, to provide different sizes of rubber products, which can then be dried and recovered. The technology, currently in the early stages of commercialisation in Italy, can process OTR tyres up to 2m in size.

As well as producing rubber granules and crumb rubber free from steel and fibre, the process claims to partially de-vulcanise the rubber material. While de-vulcanisation will be covered further below, this property can enable significantly more market options for processed crumb rubber using tyre and rubber compounding or formulations.

Cryogenic Grinding

This process involves immersing or spraying rubber products with cryogenic liquids, such as liquid nitrogen, to rapidly cool the rubber to a temperature so it is brittle.[53] Once it reaches critical temperature, impacting and shearing (generally with a hammer mill) reduce the size of the rubber material. The material is then warmed consistently and passed through magnets, cyclones, and screens to remove steel and fibre and separate the different sized particles. Cryogenic processing is often used as a subsequent size reduction process after initial ambient processing to reduce granules and crumb rubber to sizes less than 0.2 mm.[54]

The unique processing using cryogenic liquids will produce products with different shapes and sizes compared to conventional ambient grinding. In cryogenic processing, the rubber is shattered, rather than ground, meaning the particle surface is smoother compared to ambient grinding, with a lower surface area. While the rugged surfaces of ambient crumb rubber are preferred for asphalts and roads (due to better surface interaction with bitumen), cryogenic rubber powder has demonstrated more benefits as an artificial turf infill. This is due to improved interactions with the silica in sand and a reduced tendency to hold air bubbles causing it to float away in wet weather.

Cryogenic systems have existed for several decades, and there are various technology examples worldwide. There are currently no known cryogenic tyre processing technologies in Australia. This may be due to the added cost of liquid nitrogen, additional safety considerations for cryogenic liquids, or may be based on the different product size and shape outputs driven by the market.

Chemical processing technologies

The global focus of material recovery is currently transitioning from traditional physical recycling and re-use processes to circularity for end-of-life materials. Different chemical technologies and methods are emerging to recover high value chemicals from end-of-life products, such as tyres. OTR tyres and conveyor belts are seen as a highly valuable material, considering the large amount of natural and synthetic rubbers, hydrocarbons, carbon black and steel that may be recoverable via chemical processing. Two such examples of chemical processing technologies for tyres, at different stages of commercial maturity, are discussed below.

Thermal decomposition processes

The thermal decomposition of tyres is known by many names, the most widely accepted of which is **pyrolysis.**[55] As well as being varied in name, the specific technical details of each pyrolysis technology are similarly diverse. Technical specifications unique to each process are generally proprietary, and include requirements for feedstock preparation, reactor type, heating process, temperature range, and downstream processing technology. Here we outline the typical commonalities between the process and products, without discussing technical specifications that are generally commercial-in-confidence.

Pyrolysis is a thermal heating process that can be used to decompose end-of-life tyres and rubber products, then separate the residual components into various products. The tyre material is heated in a closed reactor free from oxygen, generally between 400 – 700°C.

53 Anderson, J. 'Cryogenic tire recycling,' in Trevor M. Letcher, Valerie L. Shulman, Serji Amirkhanian (Eds.) *Tire Waste and Recycling*, 2021, p. 81-96.

54 See https://www.genan.eu/products/powder/#cryogenicpowder (2023) and https://lehightechnologies.com/what_we_do/what_is_micronized_rubber_powder/ (2023).

55 Martínez, J. D., Jung, C. G. & Bouysset, J. P. 'Pyrolysis' In Trevor M. Letcher, Valerie L. Shulman, Serji Amirkhanian (Eds.) *Tire Waste and Recycling*, 2021, p. 165-224.

The four main products produced during the process are:

- **Steel**: can be resold to scrap steel markets (separated before or after the pyrolysis)
- **Oil**: the condensable liquids which can be used in fuel blend or as a bunker fuel. Further processing and refining or distillation can produce higher value oil fraction for fuel use.
- **Char**: the carbon and inorganic residue, sometimes referred to as recovered carbon black, will generally need additional processing to meet relevant specifications and maximise the value (activation, grinding etc.). Can be used as a carbon black replacement, as a fuel or a filler in products.
- **Syngas**: the non-condensable gases, which are often re-used on site for electrical generation.

The commercial maturity of pyrolysis technologies is a relatively disputed topic. Europe, Canada, North America, and South America have several early-stage commercial scale plants, but all are currently working to prove commercial viability from the sale of sustainable end-market products rather than gate fees. Australian planned and upscaling sites will need to overcome a similar challenge. Across Asia there are numerous commercially operating pyrolysis plants, but regulatory and safety issues are often compromised to achieve financial viability.

De-vulcanisation processes

Virgin rubbers are free-flowing polymers with elastic properties. Vulcanisation is a manufacturing process where polymer chains are crosslinked during a “curing” step. In the case of tyre rubber, sulfur is introduced, which crosslinks the different rubber chains via carbon and sulfur bonds, to create a stronger and more durability material while keeping the elastomer properties.

The aim of de-vulcanisation is to regenerate the free-flowing rubber and produce an extrudable, mouldable material for remanufacturing. De-vulcanising involves the selective breakdown of the crosslinked sulfur bonds without further breakdown of the rest of the polymer network.[56] Chemically, this is quite challenging, as bonding between the carbon atoms in the rubber polymer network has a very similar energy to the sulfur bonding in the crosslinks. While chemically challenging, a de-vulcanisation product is the most chemically similar to virgin rubber materials, so it is a desirable product.

Most de-vulcanisation technologies require a homogenous powdered end-of-life tyre rubber feedstock. This technology has been demonstrated using various reactor processes and different de-vulcanisation aids. These techniques all work to decrease crosslink density (how many crosslinks remain) and increase the de-vulcanisation efficiency (break crosslinks without breaking polymer chain).

The extruded product is generally referred to as a ‘tyre-derived polymer’ (TDP). Whilst there are currently no operating facilities in Australia, some early-stage commercialisation efforts are emerging globally, such as in Ontario, Canada.

[56] Dierkes, W. & Saiwari, S. ‘Regeneration and devulcanization.’ In Trevor M. Letcher, Valerie L. Shulman, Serji Amirkhanian (Eds.) Tire Waste and Recycling, 2021, p. 97-144.
See also Gursel, A., Akca, E. & Sen, N. ‘A review on devulcanization of waste tire rubber.’ Period. Eng. Nat. Sci. 6, 154–160 (2018).

Emerging tyre processing technologies summary

Table 16 provides a summary of the processes, products, benefits, and uses of the technologies discussed above.

Table 16: Emerging processing technologies for OTR tyres and conveyors.

Process and feedstock	Product	Size	Benefits and uses
Bead-breaking and de-beading – up to 63" rim	OTR tyre carcass Bead removed	n/a*	Facilitates subsequent physical processing to limit damage to equipment blades
Hydraulic or mechanical shears – up to 63" rim	OTR tyre and conveyor pieces	n/a*	Economic transport of material and improved feedstock for downstream processing
Waterjet processing – currently taking tyres up to 2 m in size	Crumb rubber powder Rubber granules	<1 mm 1-4 mm	Rubber compounding, adhesives, polymer composites, road binders in asphalt and sprayed seal
Cryogenic processing – feedstock is generally pre-processed tyre pieces or granules	Crumb rubber powder Rubber granules	<1 mm 1-4 mm	Paints, coatings, adhesives Artificial turf infill
Pyrolysis – whole, shredded, shredded and steel removed	Scrap steel Tyre pyrolysis oil Recovered char Syngas	n/a	Scrap steel markets Bunker fuels and fuel blends Carbon black markets, fillers Onsite energy generation
De-vulcanisation - feedstock is generally pre-processed tyre granules or powder	Tyre-derived polymer (TDP)	Extruded rubber material	New tyres, tyre re-treads, conveyor belts, rubber moulding, consumer rubber goods

*will depend on the original size of the tyre/conveyor

5. Barriers and enablers to OTR tyre recovery

Since the authorisation of the Tyre Product Stewardship Scheme in April 2013 there has been increasing investment in tyre recovery services in Australia. End-of-life tyre recovery rates have grown to around 70% over this period, but this growth has almost entirely been from recovery of passenger car, bus, and truck tyres. There has been little improvement in OTR tyre recovery, and these trends suggest that OTR tyre recovery is harder than passenger car, bus, and truck tyre recovery.

The barriers in this chapter affect the recovery of end-of-life OTR tyres differently, impacted by:

- uncertain or variable location(s) and timeframes for OTR tyre generation
- OTR tyre generators' preferred recovery outcomes
- commercial constraints and priorities of different parties
- technology profiles of different solutions, and how they fit within a given market environment
- other factors.

This chapter analyses the barriers to adopting OTR tyre recovery practices and the barriers to investing in OTR tyre recovery facilities. These represent the different perspectives of OTR tyre generators and OTR tyre processors, respectively. While these two types of barriers are linked, separating them may provide useful insights given these differing perspectives.

This chapter considers potential enablers that support recovery of OTR tyres. These enablers may otherwise be overlooked when considering seemingly insurmountable barriers, but they may present a unique opportunity to begin recovery activities in a niche in the market.

All barriers and enablers will be framed to contextualise differences or similarities with passenger car, bus, and truck tyre recovery activities in Australia. This comparative approach is intended to support an understanding of how the tyre recovery sector can expand into OTR tyre recovery from its successes in passenger car, bus, and truck tyre recovery.

The barriers and enablers in this section should be read as high-level and indicative only. Further research is required to understand specific catchment-level issues and priorities to achieve a national OTR tyre recovery target.

5.1 Barriers to adoption

Previous studies[57] and publications[58] released by TSA show several barriers to recovering OTR tyres at scale in Australia from the perspective of OTR tyre waste generators seeking alternatives to disposal. Consistent with the findings on OTR tyre recovery rates in Chapter 2, these barriers are more likely to affect mining and agriculture sectors, because they generate more end-of-life OTR tyres than manufacturing, construction, and aviation.

Table 17 describes the barriers to adoption of tyre recovery practices that may apply to the agricultural and mining sectors' end-of-life OTR tyres. Individual generators and regions with many generators ('OTR tyre catchments') may be affected by each barrier differently, and interdependencies or feedback loops may apply. For example, a lack of nearby OTR tyre recovery services supports arguments for regulations allowing on-site management of end-of-life OTR tyres, because it is impractical to recover without available recovery options.

Regulations that allow tyres to be managed on-site inhibit the development of nearby OTR recovery services, as there is no material for these services to process and no contracts to fund them. These factors go hand in hand, with each factor contributing to the other.

[57] Urban EP, Northern Territory regional business case for a circular economy for used tyres, 2022.

[58] TSA, Guidelines for the Tyre Product Stewardship Scheme, amendment 1.1, March 2019.

Table 17: Barriers to end-of-life OTR tyre generators adopting tyre recovery services.

Barrier	Description
Low regulatory pressure that permits mining companies and agricultural landholders to manage end-of-life OTR tyres on premises, in a way that is not consistent with expectations placed on other sectors.	Current state and territory regulations (often enacted through mining licences rather than through environmental legislation) make it possible to dispose of end-of-life OTR tyres through internal, on-site practices. This involves a different regulatory standard than those applied to other wastes (i.e. generated by other sectors and the public, and managed in licensed landfills).
Low cost of on-site disposal on large rural landholdings and mining tenements.	The option to dispose of OTR tyres on site is not affected by regulation-driven scarcity and involves very low marginal costs, in contrast to almost all other waste and resource recovery markets.
Lack of nearby OTR tyre recovery service providers due to low or absent demand (see Section 5.2 for additional barriers faced by service providers)	Because regulatory settings allow for on-site disposal at low cost, demand for OTR tyre recovery services is suppressed. This induces an absence of OTR tyre recovery services geared to deliver on OTR tyre recovery needs.
Unfamiliarity and uncertainty towards OTR tyre recovery technologies, end markets and environmental outcomes	Some OTR tyre generators are reluctant to commit to a tyre recovery service where there is uncertainty towards the legitimacy and stability of outcomes delivered (based on the generator's preferences and expectations), yet are also confronted by a lack of precedent to reduce this uncertainty.
High OTR tyre recovery fees	OTR tyres typically incur high recovery costs due to needing specialised equipment, operations, and maintenance schedules to process large, heavy duty tyres. These special requirements need to be internalised in the fee rate offered to OTR tyre generators.
High transport overheads to freight end-of-life OTR tyres to processing facilities, and/or to freight products to end markets	There is generally no or limited correlation between where mining and agricultural activities take place and the locations of end markets; with mining and farmland often very remote (including offshore), and impacted by seasonal barriers (e.g. wet seasons).
Limited public scrutiny of end-of-life OTR tyre management practices	As mining and agriculture typically occur some distance from urban centres and with limited public access, on site practices to manage end-of-life OTR tyres may be obscured from public scrutiny, reducing pressure to align practices with community standards.
Lack of business prioritisation in light of other business priorities	Perceptions that environmental performance and/or land custodianship (on mining leases and farmlands) are not essential to core business may persist, such that the issue of improved end-of-life OTR tyre management is continually downgraded or deferred.
Internal barriers and procedural overheads particularly where the OTR tyre generator is a large corporation involving multiple business units in due diligent decision making	Particularly for larger mining firms, decisions concerning a change to the management of end-of-life OTR tyres may need to involve at the site and corporate levels: operations; procurement; sustainability; OH&S; legal, compliance & due diligence; and other departments.
	This may introduce a level of internal friction and leadership ambiguity to the process to trial and/or lock in new arrangements, which may work against the opportunity to seize the moment for change.

5.2 Barriers to investment

Section 5.1 examined barriers from the perspective of OTR tyre generators. This section explores additional barriers faced by third-party service providers of OTR tyre recovery services. This perspective is important for understanding various factors that inhibit investment in recovery facilities, logistics, and technologies. Table 18 provides an overview of those barriers.

This table omits barriers that are described in the previous table regarding barriers to adoption from the perspective of the tyre generator. Those barriers also affect investment, but do not need to be restated from the perspective of OTR tyre recovery service providers. For example, the inability to compete with low-cost on-site disposal is a barrier for would-be OTR tyre recovery operators, but this is covered in the previous section in terms of those low costs preventing the OTR tyre generator from considering other solutions including recovery services.

Table 18: Barriers to investment in end-of-life OTR tyre recovery services.

Barrier	Description
Dispersed feedstock compared with passenger car, bus and truck tyres sourced in large metropolitan areas or more populous regions.	As OTR tyre recovery is capital intensive, the limited availability of OTR tyres in some locations means that high fixed capital costs need to be spread across a limited amount of tyres, leading to a high cost per tonne to recover through fees. Large OTR tyres may also lack consolidation points to enable transport economies while requiring specialist vehicles to transport them, leading to additional overheads beyond the need to factor in long distances.
Uncertain base of customers and quantities in regions that have few large mining companies and/or agricultural landholders subject to global economic variables.	While individual mining companies may suggest a high demand for OTR tyre recovery services, this represents a significant commercial risk if the service provider is reliant on a small number of contracts or if the services are skewed to a single commodity segment. Unlike passenger car, bus, and truck tyres, end-of-life OTR quantities may correlate to the level of mining activity in each location. This may be affected by ramp downs, pauses, and closures to operations, which in turn may be driven by global economic factors and commodity prices. Similarly, the use of agricultural land for cropping versus grazing may be unpredictable over the medium term, with flow on impacts on the demand for OTR tyre recovery services in each region.
Uncertainty in offloading recovered products to end markets due to large quantities of OTR tyres entering the market additional to existing supply.	Current domestic demand for tyre-derived material (e.g. crumb rubber in roads; granule in playground surfaces and niche flooring) is being met through supply of materials derived from passenger car, bus, and truck tyres. The introduction of large amounts of OTR tyre-derived materials into domestic markets, additional to existing supply, may have unpredictable effects on price and may be challenging for end markets to absorb over the near term. This may come at a time where domestic markets are facing other pressures (e.g. due to the ban on exporting baled tyres, and high costs to ship tyre-derived fuel to overseas markets).

Barrier	Description
Limited opportunity to test and refine offerings to OTR tyre generators.	Due to unfavourable factors and limited traction on the customer side (described in Section 5.1), tyre recovery service providers have had limited incentive to pursue this market segment. As such, business development, market engagement, and technology and commercial model feasibility testing efforts may be curtailed. This may lead to commercial offerings being sub-optimal responses to OTR tyre generators' needs, compared to circumstances where there is a clear demand signal and commercial reward for investing in an optimised solution for OTR tyre generators. Tyre recovery operators may prefer to direct their efforts towards passenger car, bus and truck tyre markets, whose needs are a known quantity.

As with Table 17, this is indicative only and the barriers listed may affect OTR tyre recovery markets differently by location or client. The tyre recovery industry is exploring new business opportunities to recover OTR tyres from the mining and agriculture sectors, which may help to manage the barriers identified.

Without reforms to the market environment or interventions to make OTR tyre recovery more favourable, there are limits to what private businesses can achieve given their influence over the market and supply chain partners, and their need to work within regulatory, social, and commercial constraints.

5.3 Enablers supporting recovery

The above sections outline barriers to OTR tyre recovery, but this chapter would be incomplete without identifying the unique enablers supporting OTR tyre recovery (see Table 19). These enablers may mitigate the barriers above or indicate niche opportunities to develop a market for OTR tyre recovery that can then expand into other opportunities.

Table 19: Enablers supporting OTR tyre recovery over on-site disposal.

Enabler	Description
Clarity around OTR tyre recovery outcomes over the long term, helping OTR tyre recovery service providers to define their offering prior to capital commitment	Limited engagement with OTR tyre generators in the mining sector suggests that those mining companies that are exploring OTR tyre recovery are deeply interested in understanding the downstream fates and impacts of their tyres (i.e. beyond seeing all recovery services as being equivalent). This is enabling for service providers who can appropriately configure their recovery offering to match clients' priorities and goals.
Opportunity to lock in large contracts over a medium-term, multi-year period	In the passenger car, bus and truck tyre sectors, new tyre recovery capacity may face a ramping up period before full utilisation, based on slow acquisition of new customers. This delayed utilisation may be less prevalent when servicing larger OTR tyre generators, where the service provider can lock in OTR tyre recovery services for a large amount of tyres from the outset. Ideally this contract would include historic stockpiles and multiple years of OTR tyre generation to provide a level of commercial certainty to both parties and help reduce fees on a per-tonne basis.
First mover advantages including the opportunity from reforms to how mining companies and farms are regulated	Being a first mover in the Australian market provides an opportunity to develop a strong reputation for recovery services, which can be used when pursuing future contracts. A first mover may also benefit from environmental and mining regulators recognising that OTR tyre recovery is commercially feasible in a given region, and then amending rules to halt the option of on-site end-of-life tyre management in those locations.
Alignment with circular economy and regional development priorities pursued and enacted by Commonwealth, state, and territory governments	Commonwealth, state, and territory tiers of government are generally moving to adopt circular economy strategies including having end-of-life tyres recognised as a priority within relevant policy frameworks. These policy settings may include incentives to encourage OTR tyre recovery. Stimulus packages may be available to drive regional investment, including in areas where end-of-life OTR tyres are generated. Where some form of financial support or other positive measures is included, this may help lower the cost of OTR tyre recovery or mitigate other barriers.

5.4 TSA's role

The barriers and enablers identified indicate where TSA and other public agents may shift the operating environment towards increasing OTR tyre recovery to become the easier and more readily justified option compared with disposal.

The measures that TSA and others may pursue to improve OTR tyre recovery may be introduced at various scales, including:

- the national scale, e.g. through overarching reforms to the Scheme or new measures by the Commonwealth Government
- the state and territory scale, e.g. through changes to environmental protection and other industry-facing regulations and other measures like public funding, procurement, etc.
- the regional or catchment scale, e.g. targeted funding programs and regional or aggregated procurement strategies, or regional business cases to drive investment in solutions
- the scale of individual supply chains and businesses, e.g. direct engagement, research, development and commercialisation funding, knowledge transfer, etc.

The barriers and enablers described are distinct from those in the more established markets for the recovery of passenger car, bus, and truck tyres. The majority of passenger car, bus, and truck tyre recovery activity may have fewer obstacles considering:

- the less formidable technology specifications and operational settings for equipment to process passenger car, bus and truck tyres into useful tyre-derived materials
- closer proximity between end-of-life tyre points of generation, recovery facilities and end markets densely located in urban areas
- less onerous challenges in transporting and handling tyres of up to 20 kilograms in weight (in contrast to tyres of between 100 kilograms and four to five tonnes in weight)
- high environmental standards applied to businesses and households in the disposal of end-of-life tyres, which drive up the cost of disposal and enable recovery services to compete – in stark contrast to permissions to dispose on site with limited regulation
- established convention and acceptance of the responsibility to dispose of or recover tyres with a high standard of care, which is yet to arise in some OTR tyre sectors.

The barriers to adopting or investing in OTR tyre recovery in the mining and agriculture sectors are different to those in recovering end-of-life passenger car, bus, and truck tyres. TSA and other parties should expect to use new techniques, or develop new market development and regulatory approaches to improve OTR tyre recovery.

The success that TSA and others' activities will have is dependent on how they respond to the unique features of different catchments for OTR tyres. In Chapters 8 through 10, key catchments for OTR tyres are discussed and mapped across the Australian economy to help identify which measures should be used in response to the barriers and enablers affecting each catchment.

6. Partnerships & collaboration

TSA has an established record working with public, non-profit, and private partners in researching and developing pathways to improved tyre recovery. This is demonstrated through the development and delivery of the *National Market Development Strategy for Used Tyres*[59] and the record of achievement demonstrated in TSA's administration of the Tyre Stewardship Fund.[60]

TSA has established the TSA Circular Economy Collaborator program, working with a range of organisations whose activities align with TSA's vision of contributing to a sustainable society.[61] This initiative, along with the above-mentioned collaboration, underscores that TSA needs to work with others whose scope, interests, capabilities and authorising environments work to complement TSA's activities and its core mission.

6.1 The TPSS and TSA's role

6.1.1 Background

As discussed in Chapter 1, the Tyre Product Stewardship Scheme provides an authorised, industry-led, voluntary framework to reduce the environmental, health and safety impacts of end-of-life tyres arising across Australia each year.[62]

TSA implements the Scheme and promotes the development of viable supply chains and markets for end-of-life tyres. Its approach is based on:

1. Audit and accreditation of the end-of-life tyre supply chain
2. Promotion and engagement on end-of-life tyre management issues
3. The development of markets for end-of-life tyres.

More recently, TSA has come to frame its core operations as including activities that fit within its ACC-authorised organisational remit. These activities include:

- monitoring compliance of voluntary Scheme participants
- tracking tyre-related material flows and their impacts on Scheme outcomes
- managing the Tyre Stewardship Fund and other funding channels
- business development to ensure TSA continues to function and deliver impacts with respect to Scheme goals
- stimulating and strengthening the resilience of tyre recovery supply chains
- conducting and coordinating research and gather intelligence in line with supporting the Scheme's aims
- engaging in a range of communications, promotion and advocacy activities
- undertaking other actions and initiatives consistent with TSA's role and functions.

59 https://www.tyrestewardship.org.au/reports-facts-figures/market-development-strategy/
60 https://www.tyrestewardship.org.au/innovation/tsa-funding-overview/
61 https://www.tyrestewardship.org.au/tsa-circular-economy-collaborator/
62 One EPU contains as much rubber and other materials as a 'typical' passenger tyre. For the purposes of this report, the assumed weight of one new EPU is taken to be 9.5 kg and one end-of-life EPU is taken to be 8 kg..

6.1.2 Limits to TSA's functions

While TSA has an extensive range of functions, there are limits to what TSA can do under the present design of the Tyre Product Stewardship Scheme, and clear gaps in what the organisation can directly take on given the barriers identified in Chapter 5. TSA lacks the means to deploy regulatory instruments (directed at, for example, environment protection or industry performance standards), and it has limited authority to represent and advocate on matters beyond the Scheme's specific remit.

Some of its functions, such as research and infrastructure funding, need to be managed to avoid developing conflicts of interest or unduly distorting markets for the supply of tyres and the recovery of end-of-life tyres.

These constraints point to a need for TSA to work with others whose functions, authorisations, networks, and resources complement TSA's. This is particularly true where there is a common interest in the recovery of end-of-life OTR tyres and the internalisation of circular economy principles in the procurement, use, and end-of-life management of OTR tyres. A basis for this collaboration and indicative partners is discussed below.

6.1.3 The OTR tyre committee

TSA recognises that an uplift in OTR tyre recovery will require it to develop a better understanding of how OTR tyres are supplied, used, and managed across the Australian economy. This understanding will be substantially different from the knowledge and expertise it has accumulated about the characteristics and dynamics of passenger car, bus, and truck tyres.

To accelerate its understanding while building legitimacy with stakeholders over the development of this business case, TSA convened an Off-the-Road Tyres Committee. The purpose of this committee is to 'provide knowledge and guidance to the OTR Tyre Project' (i.e. this project).

Duties in the terms of reference for this committee are:

- the Committee will assist the TSA Board meet its oversight responsibilities by reviewing the OTR Project progress, sharing insights to inform and guide the OTR Project and providing advice and making recommendations on the OTR Project or to the TSA Board
- the Committee will not have decision making powers, rather they will present direct industry feedback to the TSA Board and OTR Project.
- the role of Committee includes:
  - monitoring the OTR Project's progression
  - reviewing and testing research findings and other information to guide the development of the OTR Project activities
  - sharing insights with the Committee on OTR markets, industries and activities from their respective occupations and areas of expertise
  - reviewing the draft Business Case and other documents.

The committee currently consists of the individuals shown in Table 20. From time to time, standing representatives have elected to delegate their attendance at committee meetings on an as-needs basis.

Table 20: Current membership of the TSA OTR Tyres Committee.

Member	Representation
David Spear (Chair)	TSA Board Chair
Fiona Solomon	CEO, Aluminium Stewardship Initiative
Vanessa Zimmerman	CEO, Pillar Two
Paul Comninos	Executive Manager – Solutions Development, Bridgestone Mining Solutions
Scott Marvelley	Director – Service Engineering, ContiTech Australia
Steve Clifford	Independent (former Managing Director, Yokohama Tyre Australia)
Silvio de Denaro	Chair, Australian Tyre Industry Council
Chris McCombe	General Manager – Sustainability, Minerals Council of Australia
Lina Goodman	CEO, TSA
Sandra Scalise	Director Strategy, Marketing and Communications, TSA

After the national OTR tyre business case report is published, TSA may change the terms of reference or revise the membership of the committee in line with shifting the organisation towards implementation.

6.2 Partners and stakeholders

Table 19 lists potential partners who may offer interventions, advocacy positions, increased scrutiny and attention, and other measures that may be useful in addressing barriers and enabling OTR tyre recovery. This list is illustrative, not exhaustive, and further engagement on a jurisdictional, regional, or catchment basis may indicate additional partners with a complementary interest. This may also provide further insight into preferred roles and terms sought by different parties.

As TSA works to achieve OTR tyre recovery in different catchments (see Chapter 10), it will gain further insight into the nature and extent of barriers particular to those catchments and the types of partners available to cooperate with TSA on improving OTR tyre recovery. This step ensures that the right partners are brought together in the right ways, with a clear understanding of their roles, and is needed to support changing practices in a timely, orderly, and minimally disruptive way.

The list shows different stakeholder classes, example organisations, the roles that they may have, and the barriers or enablers that may apply to them. Sometimes, these stakeholders have a broad role rather than being mapped to a barrier on a one-to-one basis. This table may support further engagement centred on a clarification of roles and confirmation of interests linked with the benefits in Chapter 3.

Table 21: Potential partners and their roles in improving OTR tyre recovery or shifting to a circular economy for OTR tyres. This list is for illustrative purposes pending confirmation of interests, to be achieved via stakeholder consultation.

Stakeholder class	Indicative organisations	Potential roles	Potential barriers
OTR tyre brands & importers	All brands importing OTR tyres (as defined in this business case) into Australia	• Pay membership of Scheme • Explore business models and service inclusions in line with 'higher order' circular economy outcomes (i.e. aspiring to a 'tyres into tyres' model), including potential integration of one or more steps in the recovery supply chain • Share data with customers on ESG impacts of supply chain	High transport overheads Lack of nearby OTR tyre recovery service providers Lack of business prioritisation High OTR tyre recovery fees Internal barriers and procedural overheads Uncertain base of customers & tyre generation
Environmental protection regulatory authorities	EPA (NSW, Vic, Tas, SA, NT) DWER (WA) DES (Qld) DCCEEW or new national EPA (Commonwealth)	Consider regulatory and non-regulatory options such as: • Increased standards on disposal of OTR tyres to bring them in line with other end-of-life tyres • Provision of clarity on path for regulating OTR tyres and evidence required to justify continued disposal • Public disclosure requirements for disposal of mining tyres • Guidelines for use and/or recovery of end-of-life agriculture tyres beyond an amount suitable for on farm applications (e.g. silage production) • Upfront advanced recovery fees for tyre types and uses where there is limited take up of tyre recovery services in response to tightened regulations	Limited public scrutiny Low regulatory pressure Low cost of on-site disposal Lack of business prioritisation Uncertain base of customers & tyre generation

Stakeholder class	Indicative organisations	Potential roles	Potential barriers
Mining companies	Open cut and underground mining companies – with a focus on those active in catchments as set out in Chapter 10	• Explore and evaluate recovery services for newly arising and stockpiled end-of-life mining tyres and conveyor belts, based on recognised benefits (see Chapter 3) • Engage with TSA on preferred options in line with corporate ESG standards and commit to short to longer term recovery goals • Progress towards mining tyre recovery as standard practice across operations where this is viable • Explore options with TSA and suppliers on measures / guidelines to extend the working lifespan of mining tyres, including repair, re-tread, revised specifications and revised use and management; and integrate with procurement terms and conditions; and incorporate into internal procedures • Explore circular economy models and related commercial arrangements with tyre suppliers to lower impacts from the use of OTR tyres • Proactively and appropriately engage with Traditional Owners and land custodians on preferred solutions and potential roles involved in OTR tyre recovery • Disclose OTR tyre generation to TSA to enable and encourage solutions to enter the market at the catchment scale	Low cost of on-site disposal Lack of nearby OTR tyre recovery service providers Lack of business prioritisation Unfamiliarity and uncertainty towards OTR tyre recovery technologies Internal barriers and procedural overheads Uncertain base of customers & tyre generation Limited opportunity to test and refine offerings to OTR tyre generators
Mining sector peak bodies	Australian and state and territory level minerals and resource councils	• Engage with mining companies on the ESG aspects of mining tyres and conveyor belts, and direct them to sources of expertise on options • Help broker between mining companies, TSA and regulators on minimally disruptive and commercially feasible pathways to recover tyres • Support engagement of mining operators at the catchment scale to encourage tyre recovery economies	Low regulatory pressure High transport overheads Lack of nearby OTR tyre recovery service providers Lack of business prioritisation Internal barriers and procedural overheads Uncertain base of customers & tyre generation

Stakeholder class	Indicative organisations	Potential roles	Potential barriers
Mining sector regulators & issuers of mining licences	State and territory departments of mines, resources and primary industries and other equivalent resources sector regulators	• Provide consistent and clear pressure on mining operators to improve how they manage OTR tyres over time • Continue to engage with Traditional Owners and local communities on the cost of on site burial and the need to respond to community expectations • Work with environmental protection regulatory authorities to ensure aligned approaches and bring mining licence conditions closer standards placed on other sectors' management of end-of-life tyres	Low regulatory pressure Limited public scrutiny Lack of business prioritisation Uncertain base of customers & tyre generation
Farmers & other agricultural businesses	Broadacre and irrigation crop farmers Livestock (cattle, sheep) farmers Other growers & primary producers	• Provide input regarding on farm usages of end-of-life agriculture tyres, to enable capture as legitimate recovery paths • Represent farmers' needs and constraints regarding tyre recovery options at the regional (catchment) scale, to TSA and to state and territory options – including suitable locations for consolidating agriculture tyre generation • Participate in regional pilots and ongoing services to recover agriculture tyres	High transport overheads Lack of nearby OTR tyre recovery service providers Dispersed waste tyre feedstock Uncertain base of customers & tyre generation Limited opportunity to test and refine offerings to OTR tyre generators
Farming peak bodies	Regional, state and national farmers federations Commodity based peak bodies, e.g. MLA, Dairy Australia, cotton growers associations, cattlemen's associations etc.	• Help drive interest in participation in regional pilots and ongoing services • Liaise between farming communities and TSA and environment protection regulatory authorities on appropriate settings and measures to encourage agriculture tyre recovery • Support TSA in preparing guidelines and education material to support best practice use of agriculture tyres (selection, care and maintenance, appropriate fitting to a given vehicle use, repair, end-of-life management)	Low regulatory pressure High transport overheads Lack of business prioritisation Internal barriers and procedural overheads Dispersed waste tyre feedstock Uncertain base of customers & tyre generation
Farming produce supply chains and co-operatives	Meat, grain and dairy co-operatives and wholesale buyers	• Explore options to locate agriculture tyre drop off points with wheat bins and other food and fibre commodity receival sites	High transport overheads Lack of nearby OTR tyre recovery service providers Dispersed waste tyre feedstock

Stakeholder class	Indicative organisations	Potential roles	Potential barriers
OTR tyre retail, logistics, transport, handling and inspection businesses	Various regional OTR tyre retailers and service providers, providing sales, logistics, handling, inspection and other services to mining companies and farmers	• Explore options with customers and tyre importers to perform reverse logistics, storage and related services necessary for recovering end-of-life OTR tyres • Seek guidance and potential support from TSA and public agencies, to expand scope of services to repair and re-tread where this is backed by a strong business case	High transport overheads Lack of nearby OTR tyre recovery service providers Dispersed waste tyre feedstock Uncertain base of customers & tyre generation Limited opportunity to test and refine offerings to OTR tyre generators
OTR tyre recycling companies	Various tyre processing services and technology proponents	• Engage with TSA on commercial needs that are to be fulfilled so that they can confidently invest in OTR tyre recovery solutions servicing different catchments • Seek funding opportunities to upgrade existing facilities, build new facilities and/or invest in equipment to enable receival of OTR tyres • Engage with TSA on issues, concerns and unrealised opportunities concerning end markets for tyre-derived materials sourced from OTR tyres • Engage with mining companies on options to deliver on 'higher order' circular economy outcomes in line with ESG obligations	High transport overheads Lack of nearby OTR tyre recovery service providers High OTR tyre recovery fees Unfamiliarity and uncertainty towards OTR tyre recovery technologies Limited opportunity to test and refine offerings to OTR tyre generators
Businesses in end markets for tyre-derived materials Research and development teams seeking to apply tyre-derived materials in new applications	Road construction companies, councils, state road network managers, infrastructure and precinct construction businesses, Defence, flooring and surfaces, tyre repair and manufacturers, and other potential markets Researchers, technologists and circular economy start ups seeking to commercialise products made from tyre-derived material	• Engage with TSA Market Development team on opportunities to use tyre-derived material from OTR tyres in their products and infrastructure, based on the commercial and compositional properties of these materials • Explore options to invest in regional infrastructure that uses tyre-derived material as an incentive to encourage mining and agriculture tyre recovery	Lack of nearby OTR tyre recovery service providers Uncertainty in offloading recovered products to end markets

Stakeholder class	Indicative organisations	Potential roles	Potential barriers
Councils & regional organisations of councils	Councils, regional organisations of councils, joint authorities and similar	• Engage with mining and farming businesses in their LGAs and regions on interests in and preparedness to shift to OTR tyre recycling • Investigate economic development opportunities linked to OTR tyre recovery and engage with state and territory bodies for support • Review transfer stations for potential role in receiving end-of-life agriculture tyres • Engage with TSA on options to integrate OTR tyre recovery infrastructure with new or existing infrastructure for passenger car, bus and truck tyres	Limited public scrutiny Lack of nearby OTR tyre recovery service providers High OTR tyre recovery fees Dispersed waste tyre feedstock Uncertain base of customers & tyre generation
Public funding agencies and other agencies using non-regulatory interventions	DSDILGP (Qld), WA Waste Authority (WA), EPA NSW (NSW), Sustainability Victoria (SV), DCCEEW (Commonwealth)	• Factor in the opportunity for recovering OTR tyres into how positive intervention programs are deployed, noting the benefit of extending the circular economy in regional economies • Co-fund business cases, trials and case studies in support of OTR tyre recovery business model refinement	Lack of nearby OTR tyre recovery service providers High OTR tyre recovery fees Uncertainty in offloading recovered products to end markets Limited opportunity to test and refine offerings to OTR tyre generators
Traditional Owners & land custodians	Aboriginal land councils and other Traditional Owner entities	• Provide scrutiny and directly ask questions of responsible parties in terms of how they manage end-of-life OTR tyres • Give input on the preferred model for managing end-of-life OTR tyres, given potential impacts on Country and culturally significant sites • Explain what OTR tyre recovery solutions are viewed as being congruent with social licence, and what role they offer to contribute	Limited public scrutiny Lack of corporate prioritisation
Natural ecosystem & land protection NGOs Other regional community groups Industry stewardship groups	Natural resource management associations, land care groups, other ecosystem protection NGOs, Aluminium Stewardship Initiative (ASI)	• Provide scrutiny and directly ask questions of responsible parties in terms of how they manage end-of-life OTR tyres • Give input on the preferred model for managing end-of-life OTR tyres, given potential impacts on ecosystems and communities • Explain what OTR tyre recovery solutions are viewed as being congruent with social licence, and what role they offer to contribute	Limited public scrutiny Lack of corporate prioritisation

6.3 Integrating a 'tyres into tyres' model

In Chapter 3.5, the business case explored the situation where mining companies and other generators of end-of-life OTR tyres may be interested in participating in a circular economy for OTR tyres. The main example used in this case was a pathway to recover tyre material that allowed their use to repair, re-tread, or manufacture tyres – a so-called 'tyres into tyres' closed loop recovery model.

A benefit of these recovery strategies is that they may lower, decelerate, or reverse the supply chain impacts of producing tyres, including the expansion of rubber plantations and loss of natural tropical forests. This land use change is associated with depleted carbon sequestration, impaired ecosystem functions, and impoverished biodiversity, so improvements in land use can have substantial environmental benefits.

Other measures to extend the operating life of OTR tyres, which reduce demand for virgin materials in tyre production such as natural latex, may sit adjacent to this recovery model. Mechanisms for extending this life could variously cover:

- preferred purchase of more durable alternatives
- improved tyre fitting in line with intended uses
- adoption of better practices in driving heavy off-road vehicles in a range of conditions
- introduction of measures and procedures designed to improve the care, maintenance and level of repair for tyres worn or damaged during operation
- technological advancements in OTR tyre manufacture, such as sensor based tyre pressure monitoring systems[63]
- a shift towards conveyor belts where this improves operations, delivers savings, and lowers materials intensity per unit of output.

In this more holistic approach to managing tyres and related supply chains, the scope of stewardship activity shifts upstream to include a range of stages such as use, procurement, manufacturing, design, and so on. In other words, this stewardship of OTR tyres fits closer with a circular economy framing instead of an end-of-life management framing that has historically been applied with a focus on the waste hierarchy.[64] There may be unique collaboration and partnering opportunities in promoting this approach.

6.3.1 Reconfiguring supply chains for a circular economy

In Australia the tyre recovery market and the OTR tyre supply chain is not configured to manage the challenges and opportunities above. However, engagement with mining companies suggests that some which generate the most OTR tyres have internalised strong positions on ESG performance, and are actively interested in a 'tyres into tyres' circular economy model for managing and recovering tyres. This model may be perceived to support strong compliance with ESG reporting objectives and shareholder expectations.

TSA may need to determine whether it wants to adopt a circular economy interpretation of tyre management or a reduced harms approach. A circular economy interpretation would focus on whether practices and outcomes contribute to an effective circular economy, while a reduced harms

63 MarketsandMarkets, *OTR Tires Market – Global Forecast to 2027* (2022), 53.

64 While upstream stages such as design is sometimes actively attended to in traditional product stewardship, this typically takes the form of 'design for recycling' initiatives where product design focuses on the use of non-toxic recyclable materials and production methods that are amenable to disassembly.

approach would focus on avoiding potentially harmful activities like disposal, dumping, burning, or stockpiling.

While a 'tyres into tyres' approach is likely consistent with the Scheme, it affects OTR tyre importers and supply chains who may be asked to support mining companies with this interest. Impacts may include changes to tyre specifications, take-back arrangements, disclosure requirements, or a range of other aspects involved in how they supply OTR tyres to their customers.

A 'tyres into tyres' recovery model would also affect which recovery technologies and end markets are appropriate. For example, it may be necessary for a tyres into tyres model to encourage new technologies into the Australian market which are compatible with that approach, such as rubber de-vulcanisation and the physical processing of the rubber matrix into finer particles. The commercial viability of such technologies will depend on the unique features of OTR tyre catchments and the competing commercial interests and trade-offs of stakeholders.

The levels of complexity, commercial novelty, and risk associated with new methods of tyre recovery that can achieve and sustain a 'tyres into tyres' recovery model in the Australian market environment are not trivial, and would involve steep learning curves for all parties. However, given the quantities that may be available in some OTR tyre catchments, the economic and environmental impacts at hand could more than compensate for these concerns. Moreover, it offers an opportunity to shift the prevailing approach to managing end-of-life OTR tyres, and demonstrate Australia as world leaders in tyre stewardship innovation.

6.3.2 Coordination and engagement to achieve 'tyres into tyres' recovery

Considering the above, there may be a place for TSA to bring together ambitious and proactive OTR tyre generators, OTR tyre importers and their supply chains, tyre recovery service providers, and relevant technologists to coordinate a tyres into tyres economy.

This may be a realistic objective which could be targeted in parallel with other more established recovery methods that are sufficient over the short term, but which are not adequately ambitious for sector leaders' ESG targets.

The selection of a viable OTR tyre catchment and suitable partners is key, along with a staged approach to:

1. Confirm and agree on objectives for a 'tyres into tyres' recovery model including extended lifespan of tyres in use, with minimum consistency across multiple participating OTR tyre generators, if relevant.
2. Research technology and business models to specify technology components and integrations, business model parameters, and technical and commercial dependencies.
3. Leverage and develop existing commercial arrangements, procurement settings and contracting processes for the supply of OTR tyres to help meet stewardship outcomes.
4. Establish direct procurement and contractual arrangements for end-of-life OTR tyre management, with limited change to procurement outcomes and contractual arrangements with brands (OTR tyre importers and supply chain partners).
5. Monitor and progressively update the service model in line with improving 'tyres into tyres' recovery and related qualitative outcomes.

The above steps may indicate changes in business models for OTR tyre generators and suppliers, including, for example, a shift to a tyre leasing model or the incorporation of after-sales obligations. Tyre management across much of the aviation sector may also prove instructive (see below). Such a model would arguably provide clarity and consistency about which party or parties hold responsibility for the tyre before, during and after the usage phase, but this arrangement is not presumed as a necessary end point to achieve a desirable circular economy outcome. All commercially practical and feasible options should be kept on the table and tested in an impartial manner.

If this is a direction that OTR tyre generators – particularly mining companies – seek to prioritise, TSA can collaboratively support this with a dedicated program of work. TSA can offer an independent, technology-agnostic and business-model-agnostic perspective and established expertise to the collaboration, and it can also provide a range of capabilities to develop the preferred OTR tyre recovery model.

TSA's capabilities include market engagement, research and development funding, government advocacy, knowledge transfer, business case development, and others. TSA can further provide a degree of transparency and objectivity in being outcomes-focused without a presumed private commercial stake in any one solution. This may position TSA to bring local communities and Traditional Owner groups into discussions in a way that builds trust and legitimacy into the solution while conferring confidence in its social licence.

6.3.3 Aviation tyre management – a model with lessons for mining tyres?

Consultation found that re-treading of used OTR tyres is not generally practised in Australia, except for aviation OTR tyres. Larger aviation OTR tyres (greater than 15 inches in diameter) are commonly re-treaded up to six or seven times once a set number of landings have been completed, to extend the life of the tyre.[65]

Australia exports all large aviation OTR tyres for re-tread offshore to specialist facilities that provide complete refurbishment of the tyres before sending tyres back for continued use.

Larger commercial airline operators often lease tyres from the main aviation tyre manufacturers (Goodyear, Michelin, Dunlop, Bridgestone). The airlines use the tyre for the agreed number of take-offs and landings, before the tyre is returned to the tyre manufacturer for refurbishment and re-tread.

The current situation for used mining tyre repair

Repair of partly worn, but damaged, mining tyres is common in Australia. This service is available through dedicated repair providers, such as Bridgestone Mining Solutions Australia (BMSA) which has six mining OTR tyre repair service centres[66]. Due to the high cost of new mining tyres (around $40,000 to 50,000 for a large mining tyre) there is a strong financial driver to repair mining tyres where significant tread remains. Apart from repair, some mine operators currently put chains around worn tyres to get more life out of the tyre before disposal.

The current situation for used mining tyre re-treading

Re-treading of mining OTRs is currently not happening in Australia, but there have been attempts to re-tread mining tyres in the past that have failed. The main cause of failure was wear or damage to the casing, making the re-treaded tyre less reliable. The adhesive bond between the casing and the re-tread was not typically the cause of failure.

65 Randell Environmental Consulting compiled content for this section of the business case highlighting the leading example provided by current re-tread commitment of the Aviation sector and some mining operations elsewhere in the world.

66 See https://www.bridgestoneminingsolutions.com.au/tyre-repair last accessed December 2022

Although re-treading is not happening in Australia, Kal Tire promotes a global mining tyre re-treading business that has been operating for over 45 years in locations outside of Australia, demonstrating its commercial possibility.[67] Kal Tire re-tread over 10,000 OTR tyres annually in the United Kingdom, West Africa, Canada, Chile, and Mexico.

Large and very large mining tyre leasing

For large and very large OTR tyres used in the mining sector in particular, a model of tyre leasing like that used in the aviation sector could be established. This would be based on contractual agreements that set out:

- an agreed number of hours of use for the tyre before changeover, to ensure the tyre casing is not excessively worn and damaged
- the supply for the next (refurbished) tyre for use
- backloading of the worn tyre to a refurbishment and re-tread facility
- terms for the recycling of worn tyres that are unable to be refurbished again due to damage or the agreed number of re-use cycles being met.

Developing a tyre leasing model for the mining sector would require mining companies to make long-term commitments to this tyre purchasing model, and long term commitments from tyre manufacturers to develop this complex service offering.

While implementing a tyre leasing model in the mining sector would require significant time and resources, the benefits could be significant. Some of the key barriers to mining tyre recovery linked to manual handling, reverse logistics, used tyre refurbishment, and reprocessing technology investments based on contracted tyre supply could be resolved.

Given the opportunities to address these multiple challenges while sharing responsibilities between generators and supply chains, the future stewardship of OTR tyres needs to consider the role of leasing, takeback and other provisions to internalise the end-of-life phase in updated procurement arrangements.

[67] See https://www.kaltiremining.com/en/sustainable-solution/retreads-repairs/ last accessed December 2022

Section 3 –
A national target for OTR tyre recovery

7. A national target for OTR tyre recovery

As set out in the Introduction, this business case has the task of setting a path to recover end-of-life OTR tyres from across the Australian economy. This is intended to contribute to the National Waste Policy Action Plan's 80% recovery rate for all waste by 2030, and achieve a wealth of private and public benefits illustrated in Chapter 3. This chapter explains what would be required to achieve, and exceed, that goal.

7.1 OTR tyres within the 80% national target

Australia has been able to show higher levels of passenger car, bus, and truck tyre recovery in recent years, yet the environmentally-sound recovery of OTR tyres continues to lag. Automotive tyre recovery rates have levelled off at around 90%. TSA is working towards improvements in automotive tyre recovery through separate work, focused on more challenging regional locations. OTR tyre recovery remains at around 10%, with much of this attributed to aviation, manufacturing, and construction tyre recovery in or near urban environments. Agriculture and mining tyres make up the largest quantity of OTR tyres by weight, yet trail in terms of their recovery outcomes due to a range of challenges.

There is a prime opportunity to achieve an 80% recovery rate across all end-of-life tyres by improving the recovery of end-of-life OTR tyres. This will depend on the ability to recover a specific amount of OTR tyres and reach an OTR tyre recovery rate well above the 10% recovery estimated in recent years. The OTR tyre recovery rate needed to reach an overall 80% target for all end-of-life tyres will both depend on how many tyres are generated in Australia overall, and the proportion of end-of-life OTR tyres that contribute to this total. As shown in Chapter 2, both parameters shift over time and will need to be factored into OTR tyre recovery rate targets.

7.1.1 Variable annual tyre generation

Table 22 shows end-of-life tyre generation across automotive and OTR tyres from 2019-20 to 2021-22. If automotive tyre recovery rates over these years were around 90% (i.e. reflecting current recovery levels), then achieving an overall 80% recovery rate across all tyres will rely on a shifting rate of OTR tyres being recovered. This is due to changes in the overall generation of tyres and the proportion of tyres classed as OTR tyres.

With OTR tyres making up roughly a third of end-of-life generation, across this period, the level of OTR tyre recovery to achieve an overall 80% recovery rate in each year ranges between 64,000 tonnes and 77,000 tonnes in absolute terms. Required OTR tyre recycling rates range between 50% and 60% in general terms. In the most recent year (2021-22), a 53% recovery rate would have been needed, achieved by the recovery of around 71,000 tonnes of OTR tyres.

Table 22: Indicative end-of-life passenger car, truck and OTR tyres generated in Australia (2014-2021), enabling an estimated proportion of OTR tyres generated each year. Used in combination with estimated recovery rates for passenger car and truck tyres, this table allows for a calculation of the necessary recycling rates of OTR tyres needed to achieve an 80% tyre recovery rate across all tyres each year. The rightmost column sets out estimates using three-year average figures derived from 2019-20-2021.-22

	2019-20	2020-21	2021-22	3 Year Average
EOL Passenger, truck, and bus tyres (tonnes)	314,000	359,000	366,000	346,400
EOL OTR tyres (tonnes)	136,000	125,000	135,000	132,000
Total end-of-life tyres (tonnes)	450,000	484,000	501,000	478,400
OTR proportion of overall total	30%	26%	27%	28%
EOL tyre recovery target tonnes (required for an 80% recovery rate)	360,000	387,200	400,800	382,700
Passenger, truck, and bus EOL tyre recovery (assuming an 90% rate)	282,600	323,100	329,400	311,700
OTR target recovery tonnes to address shortfall	77,400	64,100	71,400	71,000
OTR target recovery rate to meet 80% overall recovery target	57%	51%	53%	54%

7.1.2 A conservative OTR tyre recovery target

Even if 100% of automotive tyres were recovered, this is unlikely to reach the overall target of 80% recovery of all end-of-life tyres unless there is a significant increase in the recovery rate of OTR tyres. Using OTR tyre generation from 2021-22 as a reference year, to meet the national target of 80% recovery we should seek to recover 55% to 60% of all OTR tyres by 2030 which may range from anywhere between 60,000 tonnes and 80,000 tonnes in absolute terms, at minimum. Given yearly variation in end-of-life tyre generation from all sources, a conservative target for OTR tyre recovery is 60%. About 10,000 tonnes of end-of-life OTR tyres are currently recovered, so an additional 50,000-70,000 tonnes would need to be recovered each year to meet the 80% recovery target for all end-of-life tyre by 2030.

This target may need to be revised if TSA seeks to recover OTR tyres that may have been stockpiled over previous years but which are not accounted for in our estimates of annual end-of-life tyre generation. A better approach may be to work with relevant sectors, like mining and agriculture, to set separate targets for recovering stockpiled OTR tyres. Using separate targets for stockpile recovery also mitigates the risk of distorting estimates of annual OTR tyre generation and recovery.

7.2 Opportunities within sectors that consume OTR tyres

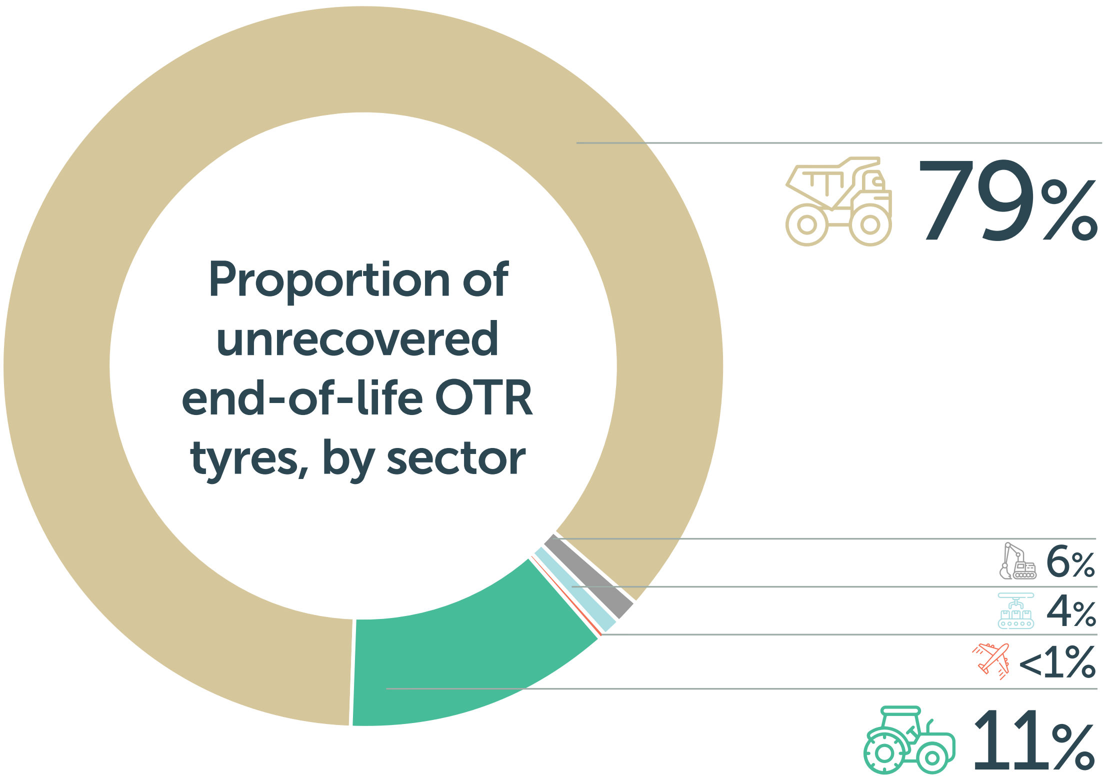
Using 2021-22 data, Table 23 shows end-of-life OTR tyres generated by sector and the contribution by each sector. While Figure 6 shows proportion of unrecovered end-of-life OTR tyres, by sector utilising the fate of OTR tyres by category outlined in Section 2.1.3 Current used OTR tyre management and fate in Australia.

Together, they show the greatest opportunity to lift the national recovery rate is OTR tyres is in the mining and agriculture sectors which together represent greater than 90% of unrecovered OTR tyres.

Table 23: OTR tyre generation and recovery (tonnes), by major sectors that use OTR tyres.

Sector	2021 EOL OTR generation (tonnes)	Contribution to EOL OTR generation
Agriculture and forestry	15,100	11%
Mining	107,900	79%
Construction (and demolition)	7,800	6%
Industrial (manufacturing and trade)	5,200	4%
Aviation	600	<1%
Total	**136,600**	**100%**

Figure 6: Proportion of unrecovered end-of-life OTR tyres, by sector. The largest opportunity to lift tyre recovery rates is from OTR mining and agriculture tyres.



Aviation, construction, and industrial sectors generate relatively fewer tonnes of tyres and exhibit relatively established recovery practices, with some room for improvement. In contrast, mining and agriculture generate much greater quantities of OTR tyres but demonstrate little to no recovery.[68]

Mining and agriculture will need to make a major contribution to OTR tyre recovery by 2030 to reach a 60% recovery target. If action was left solely to the other sectors, the best possible OTR tyre recovery rate would be 11% given that they only generate 11% of OTR tyres annually. At current generation this recovery would equate to 14,000 tonnes per year recovered, far short of the nominal target of 60,000 – 80,000 tonnes.

Given current recovery at 10,000 tonnes per year, an additional 50,000-70,000 tonnes of end-of-life OTR tyres should be targeted at minimum for recovery from the mining and agriculture sectors. This is between 40-60% of the combined 123,000 tonnes of OTR tyres generated by these two sectors each year.

Given relative OTR tyre generation in these two sectors, nominal 60% sector recovery targets for each of these sectors might be:

- recover at least 64,000 tonnes of mining sector OTR tyres each year by 2030
- recover at least 9,000 tonnes of agriculture sector OTR tyres each year by 2030.

These nominal targets should only include OTR tyres that are newly reaching their end-of-life, not those currently in long term stockpiles. While recovery from long term OTR tyre stockpiles is important, and may be a focus of separate targets, if these are included within the annual recovery target this may give a false understanding of changing end-of-life OTR tyre management and recovery practices.

While TSA may seek to recover OTR tyres that have been buried or stockpiled, these should be separated from figures describing the recovery of OTR tyres that are just reaching their end-of-life. Separating these figures will give an accurate estimate of annual generation and recovery rates, which will better support national policy setting to improve recovery.

7.3 Beyond an 80% national target

So far, Chapter 7 has assumed that TSA and partners have a primary interest in achieving a national end-of-life tyre recovery rate of 80% by 2030 per the National Waste Policy Action Plan. There are, however, strong benefits from improving or accelerating OTR tyre recovery independent of that plan (see Chapter 3). This section reviews arguments for pursuing a more ambitious recovery target that would realise these benefits.

7.3.1 Difficulty forecasting OTR tyre generation

As explained earlier in this chapter, annual generation of end-of-life passenger car, bus, and truck tyres has followed a consistent, predictable trend of modest growth. However, end-of-life OTR tyre generation has been more volatile, increasing or decreasing with the level of economic activity in each sector and with changing sector practices.

If there is a significant increase in OTR tyre generation between now and 2030 the overall tyre waste recovery target will be even harder to achieve, even if more tyres from all sources are recovered in absolute terms. Without a corresponding plan to lift the recovery of mining and agriculture OTR tyres, and close the gap relative to automotive tyre recovery, increased OTR tyre generation due to rising economic activity or other industry-specific factors would make any 2030 recovery target harder to achieve. A higher target

68 This observation does not include some degree of agricultural tyre re-use on property that cannot be quantified through ABS data, including resource recovery services.

for OTR tyre recovery may also serve as a buffer against any drop in automotive tyre recovery rates due to unforeseen events.

The possibility of increased OTR tyre generation is reasonable considering past trends and recent forecasts on the global demand for Australian mining[69] and agricultural[70] commodities. The simplest way to mitigate this possibility would be to commit to a higher target than the nominal 60% recovery target, on the reasonable assumption that OTR tyres as a proportion of all end-of-life tyres could rise over time.

Even if OTR tyre generation stays stable compared with passenger car, bus, and truck tyre generation, an increased recovery target would offer a 'no regrets' approach as the net effect will be an overall tyre recovery rate that exceeds 80% by 2030.[71]

7.3.2 Public and private benefits in regional Australia

Chapter 3 discussed multiple benefits from recovery instead of on-site burial and indefinite stockpiling of OTR tyres. These included public environmental benefits, public economic benefits, achievement of state and territory circular economy objectives, various benefits to mining companies, and various benefits to farmers and other agricultural landholders.

These benefits apply independently of the National Waste Policy Action Plan, and a national target for end-of-life tyre recovery may be secondary for stakeholders to whom these benefits would apply. Recovery targets for OTR tyres should be aligned to achieve these benefits, without incurring excessive or irresponsible public or private costs, regardless of the National Waste Policy. Focused effort on understanding where the potential benefits are greatest, and educating partners and stakeholders about them, will be essential to ensure OTR tyre recovery takes place where it is most beneficial.

7.3.3 Achieving equity in tyre recovery

In Chapter 1 we observed that owners of on-road trucks and passenger cars currently recover about 90% of their tyres, mainly through their tyre retailers and other third-party service providers. This recovery is the main reason why the overall tyre recovery rate is as high as 64% today.

Even though it would be a marked improvement on business-as-usual, an OTR tyre recovery target of 60% would be a much lower target for mining corporations and farmers than what households and businesses reliant on road transport vehicles are achieving. In many cases, these businesses and households must comply with environmental regulations like licensed landfill standards and waste levies, including in regional Australia, which farmers and mining companies can circumvent using on-site disposal.

The current arrangements for, and expectations on, end-of-life tyre management do not reflect a level playing field across the economy, with the greater regulatory and financial burden to recover tyres placed on households and other businesses in sectors other than agriculture and mining. These other sectors can't avoid their duty to manage their end-of-life tyres, regardless of their capacity to pay the cost of management.

Setting a recovery target for OTR tyres that is substantially below what other sectors have already achieved may be unambitious and an unequal standard, regardless of the unique challenges to OTR recovery discussed in Chapter 5. Conversely, a higher recovery target for OTR tyres presents an opportunity to acknowledge that other sectors have 'done the heavy lifting' to date, and that it is now the turn of the agricultural and mining sectors to do their share in improving end-of-life tyre recovery.

69 https://www.minerals.org.au/news/australian-mining-box-seat-meet-growing-global-commodity-demand

70 https://www.agriculture.gov.au/sites/default/files/documents/delivering-ag2030-april-2022.pdf

71 This point assumes that passenger car, bus, and truck tyre recovery rates can be maintained at or above the current 89 to 90%.

7.3.4 Early leaders in OTR tyre recovery

In preparing this business case TSA has engaged with the mining and agriculture sectors and their tyre supply chains, seeking to understand their challenges, interests, and outlooks on tyre recovery. As is to be expected, there are different views in these sectors and their supply chains.

Engagement activities have identified that some businesses, including large scale mining companies, have a sense of urgency to resolve their outstanding liabilities for end-of-life OTR tyres. They recognise that their current practices cannot continue indefinitely and are devoting resources to determine and implement a preferred model for OTR tyre recovery.

However, these early leaders in OTR tyre recovery are not well placed to address all the barriers that they face alone, and need to call on others, including tyre recovery service providers, regulators, and others with a potential role in tyre recovery. TSA can offer these early leaders expertise and access to established networks, helping to determine an optimal solution for those that want to move away from on-site disposal methods.

If these early adopters meet their timelines in the near term, many OTR tyres from the mining sector may be recovered by the midpoint of this decade. A shift towards recovery in the Pilbara alone may even be enough to drive OTR tyre recovery in the mining sector to the nominal 46,000 tonne target, depending on OTR tyre generation in the Pilbara each year.

If this were accomplished, it would not be appropriate for TSA and its partners to downgrade their efforts for the remaining years to 2030 based on achieving a nominal recovery target earlier than was originally planned. Doing so would be an abandonment of opportunities to realise benefits elsewhere across the economy, and a failure to transfer lessons from these early wins to other challenging OTR tyre catchments.

The best approach may be to set interim targets through to 2030 which progressively build on past successes. Using this approach, TSA and partners would target a 60% OTR tyre recovery rate, nominally 80,000 tonnes per year, as early as possible. They would work on targeted catchments, and then set revised goals in accordance with the next best opportunities available in OTR tyre recovery. Ideally, and depending on available opportunities, the OTR tyre recovery rate would move towards achieving parity with passenger car, bus, and truck tyre recovery rates by 2030.

7.3.5 Scheme levy-payers' expectations

The Scheme is currently being funded by OTR tyre levies voluntarily paid by major OTR tyre importers, on the understanding that these funds will be directed towards activities which promote the recovery of end-of-life OTR tyres. The levy-paying OTR importers represent a dominant share of the overall OTR tyre market in Australia, though not 100%.

They reasonably expect that the Scheme's ambition for OTR tyre recovery reflects the amount of tyres they bring into the economy, and that TSA is pursuing all opportunities to achieve greater OTR tyre recovery. Their expectation may be that TSA continues to encourage an ever more sophisticated and resilient OTR tyre recovery economy, and that it responds to different catchments and market niches by supporting an appropriate configuration of services, technologies, and logistical capabilities discussed in Chapter 4.

Further, they may wish to differentiate their brand in mining and agriculture tyre markets based on their funding of the Scheme, which shows their desire to realise the benefits to the community and the environment from improved OTR tyre recovery, as discussed in Chapter 3. In doing so, they would have a direct and explicit stake in the Scheme's outcomes which are not clearly related to the National Waste Policy Action Plan or its stated targets. The accomplishment of a higher recovery target would be consistent with these payers' expectations on TSA to support effective tyre recovery.

7.4 Setting a suitable national target for OTR tyre recovery

This chapter has discussed national OTR tyre recovery targets and how to accomplish those targets by additional recovery from the agricultural and mining sectors. It proposed that TSA should prioritise conservative OTR tyre recovery targets to confidently achieve a national target of 80% recovery for all end-of-life tyres. It then argued that TSA should strive to exceed this target given various benefits and equity concerns raised.

TSA may seek to adopt qualitative rather than quantitative objectives for different types of recovery, such as a 'tyres into tyres' circular economy model for OTR tyres, or measures to extend the economic value of whole intact OTR tyres that may otherwise be designated as entering their end-of-life phase.

As explored in Section 1.4, there is uncertainty in relying on commercial, market-based activities to deliver OTR tyre recovery outcomes which affect whether the targets will be reached. This is consistent with the design and workings of the Scheme, which relies on decentralised and market-led commercial activity to achieve recovery outcomes.

TSA and others have a clear role in improving this probability while working within the confines of their operational and, in some cases, legislated responsibilities. In TSA's case, this role is determined by the Scheme design and how it applies its functions and capabilities within the Scheme's authorisation (see Chapter 6 for an overview of TSA's scope of functions).

Ultimately, performance of any final national targets for OTR tyre recovery will depend on the profile of different catchments from which end-of-life OTR tyres are recovered and their compatibility with different recovery solutions. Ideally, TSA and partners may first look to catchments that involve larger quantities of end-of-life tyres whose owners recognise them as viable for recovery, and whose barriers are deemed sufficiently surmountable to warrant close attention.

However, there may be some catchments with interesting features, like regional economic or demographic features, or the presence of one or more businesses looking to lead in innovative circular economy business models, that may increase those catchments' importance. The following chapters are devoted to exploring catchments in detail, focusing on the mining and agriculture sectors (Chapters 8 & 9).

In Chapter 10, it becomes clear that the larger catchments identified demonstrate an opportunity to achieve an OTR tyre recovery rate beyond 60%, using an appropriate application of tools and strategies. It would be appropriate to commit to this goal as an initial step, and progressively lift targets over time based on successive improvement in recovering OTR tyres.

8. Opportunities to recover OTR tyres in the mining sector

The Australian mining sector is a major contributor to the national economy, with an estimated net added value of $216 billion (2020-21) to Australia's $1.98 trillion Gross Domestic Product.[72] Australia is a leading producer and exporter of mining commodities, and is a top ten exporter in multiple sectors.

The two largest mining companies in the global economy (by market capitalisation at the time of writing) – BHP Group Ltd and Rio Tinto Group – are ASX listed and have Australian headquarters located in Melbourne, Victoria. Other mining 'majors' have a significant presence in the Australian mining and extractive industries sectors, particularly in Western Australia, Queensland and New South Wales. Other states and territories have significant but comparatively smaller mining sectors.

The Australian mining sector is relatively sophisticated in its use of technologies, operating open-cut and underground and applying more niche processes used in areas like uranium mining. The sector uses large quantities of OTR tyres and industrial conveyor belts.

8.1 Key commodities mined

Australia has established mining operations in most significant commodities including iron ore, bauxite, gold, copper, uranium and black coal, as well as niche resources such as mineral sands, nickel, lead, zinc and manganese. Australia is expected to increase its operations for resources such as lithium, nickel and rare earth minerals used in renewable energy and vehicle electrification.

Table 24 gives an overview of a subset of major commodities mined in Australia, details of locations of major mines, approximate amount of ore extracted,[73] key players, and estimated amounts of end-of-life OTR tyres generated by each subsector.

Figures used for tyre generation in this section are approximate and have been developed from the ground up, as opposed to relying on port of import as conducted in previous sections, as individual mining sectors and mines experience different rates of tyre wear. Conveyor belts in place of mining vehicles adds another layer of complexity to estimating amounts.

This table does not try to precisely apportion tyres between commodity types, but does shows a wide range of scales of commodity production and OTR tyre generation, assuming that tyre usage roughly approximates with production (as production approximately indicates for amount of earth displaced).

[72] https://www.abs.gov.au/statistics/industry/industry-overview/australian-industry/latest-release

[73] Extraction estimates were prepared by reviewing outputs of mining operations associated with different commodities, as published by private mining companies. TSA cannot independently verify these third party statements, and acknowledges that there may be some time lags or gaps in the reporting data. However, broad indications of mining output volume are believed to be accurate to within 10% of actual figures, and are sufficient for the purposes of deriving relative volumes of economic contribution and OTR tyre usage.

Table 24: Major mining sectors by commodity output (million tonnes per year or mtpa, or kilotonnes per year or ktpa as appropriate). Note, details may change due to changes in mine ownership, mergers and acquisitions and the introduction, ramp up, ramp down and closure of mines operating across the country.

Commodity (and co-extracted minerals)	Types of mine	States & territories	Major regions	Operator concentration	Major operators (indicative only)	Commodity production	OTR tyres (est.)
Iron ore	Open-cut	WA, SA, TAS	Pilbara WA Mid-west WA	4 major operators in Pilbara region	Rio Tinto BHP Fortescue Metals Hancock Prospecting	~ 900 mtpa	44,000 tpa
Black coal (thermal and metallurgical)	Open-cut & underground	QLD, NSW	Bowen Basin QLD Hunter Valley NSW Northern NSW Surat Basin QLD Galilee Basin QLD	Many operators (~20) across NSW and QLD regions	BHP / BHP Mitsubishi QCoal Glencore Sumitomo Anglo American Wesfarmers Coal Whitehaven Yancoal	~ 440 mtpa	21,500 tpa
Gold (Silver, Copper)	Open-cut & underground	WA, NSW, QLD, NT, VIC	Goldfields-Esperance WA Peel region WA Mid-west WA Central/West NSW Townsville QLD Tanami NT Bendigo VIC	Many operators (~30) of small, medium & large scale	Newmont Northern Star Resources Gold Fields Newcrest Red 5 Regis Resources Evolution Mining	~ 300 tpa gold (200 mtpa earth displaced)	9,800 tpa
Bauxite	Open-cut	QLD, WA, NT	Southwest WA Gove Peninsula NT Weipa QLD	4 major operators across WA, NT, QLD	Alcoa Rio Tinto South32	~ 90 mtpa	4,400 tpa
Brown coal	Open-cut	VIC	Latrobe Valley VIC	2 major operators linked to Victorian energy production		~ 46 mtpa	2,300 tpa
Manganese oxide	Open-cut	NT	Groote Eylandt NT	Single operator (other operators may be in pre-extraction stages)	GEMCO	~ 6 mtpa	300 tpa
Lead and Zinc (Magnesium, Silver)	Open-cut	QLD, NT, WA	Mount Isa QLD	Small number of operators	Glencore South32	~ 3 mtpa	150 tpa
Mineral sands	Open-cut	WA, NSW, SA, QLD	Mid-west WA Southwest WA Western NSW Townsville QLD	Small number of operators	Iwatani Australia / Doral Iluka Tronox	~ 2.5 mtpa	120 tpa
Lithium (spodumene)	Open-cut	WA	Southwest WA Pilbara WA Great Southern WA Goldfields-Esperance WA	Small number of operators	Talison Lithium Orocobre Pilbara Minerals	~ 2 mtpa	100 tpa
Nickel	Open-cut & underground	WA	Goldfields-Esperance WA Great Southern WA	Small number of operators	BHP (Nickel West) Glencore IGO First Quantum	~ 170 ktpa	<10 tpa
Uranium oxide (Copper, Gold, Silver)	Open-cut, underground, in situ recovery	SA	Roxby Downs SA Leigh Creek SA	2 major operators (post closure of Ranger Dam in NT)	BHP Heathgate Resources	~ 4.4 ktpa	<1 tpa

Notes to the table:

1. Estimates of commodity production are derived directly from mining outputs as published by Commonwealth and state/territory reports and from corporate websites. In the case of gold, grade of deposit has been used to generate an estimate of earth movements to extract ore.
2. This table uses a nominal OTR tyre generation conversion rate of 49 tonne of OTR tyres per one million tonnes of production. This approximation is derived from a sampling of mining operations and OTR tyre generation values undertaken for this project. For reasons outlined in the report, we expect individual mining operations to diverge from this conversion rate. Some analysis has deemed this calculation accurate enough to show relative OTR tyre generation by sector and catchment (see later in this chapter for a further explanation of site-specific factors driving OTR tyre use).

Output variations across sectors

The annual movements from different mining sectors vary widely, with iron ore heading towards one billion tonnes per year at the upper end, while other ores are several kilotonnes to hundreds of kilotonnes. In the case of gold, while 300 tonnes were produced in 2021, this gold typically extracted at a grade of 1 to 5 grams per tonne of gold bearing ore.[74]

Factoring in the grades of different mines, the mining of 300 tonnes may have led to the displacement of around 200 million tonnes of earth. We presume the use of mining tyres correlates with the material extracted in a year, noting that each mine will have its factors affecting tyre use.

Mining techniques

Different industries rely on open-cut or underground mining techniques, with some relying on open-cut only (e.g. iron ore, bauxite). Open-cut and underground operations may use different types of tyres, and a different mix of conveyors, rail, and bulk haul vehicles to transport ore. This brings greater uncertainty for how many tyres are consumed, as each technique may involve greater or lesser reliance on OTR tyres.

Dispersal & clusters

Regional dispersal is relevant because larger catchments could potentially support dedicated infrastructure that can recover a larger tonnage of OTR tyres.

Location is also relevant in terms of access to nearby facilities that process car and truck tyres, provide tyre-derived materials to domestic markets, or ship products to international destinations.

Some sectors, such as iron ore, brown coal, and black coal, have operations clustered in areas such as the Pilbara, the Latrobe Valley, and Bowen Basin and regional NSW. Others, particularly the gold sector, are far more dispersed (although gold also has major centres such as Goldfields-Esperance).

Concentration

The level of operator concentration in a region may be important, as a more fragmented region may need more mining companies to buy in to recovery. On the other hand, regions with fewer and larger players may have greater resources and stronger institutional pressure to alter their practices.

From this viewpoint, the iron ore, bauxite, and nickel sectors have higher concentrations of larger global players, while the black coal and gold sectors are far more fragmented and involve many players of multiple scales.

[74] This grade range is based on estimates published by the industry market research service, Aurum Analytics, on a quarterly basis. Grades have been matched to gold production at individual mining operations to derive an estimate of the amount of earth displaced by the gold sector as a whole. https://www.aurumanalytics.com.au/

Overlaps

There may be some overlaps in regions across different mining sectors. For example, gold, bauxite, and lithium are mined in south-west WA, while iron ore, lithium and gold are mined in the Pilbara (although iron ore dominates). In some locations, mining overlaps with agricultural holdings that use large tyres, such as in south-west WA, the Hunter Valley, northern NSW and elsewhere. Tyre recovery solutions in these locations may need to cater to multiple operator needs while taking advantage of a level of customer diversification.

8.2 Mining regions as OTR tyre catchments

A key concept centres on mining regions as catchments that generate OTR tyres to recovery supply chains. Larger catchments become important both in terms of:

- their potential contribution to a national OTR tyre recovery target (see Chapter 7), and
- their viability to support recovery infrastructure that can process OTR tyres to a given standard at an acceptable price.

The more productive mining regions in Australia are potential priorities. Table 25 provides details for some of the leading commodities shown in the previous table, breaking production down into major catchments.

The three rightmost columns show how much each region relies on OTR vehicle tyres, with the output (expressed in million tonnes per annum) showing how much material was worked from the mine site in recent years, and percentage contribution comparing the total material worked across these ten regions.

This table is not exhaustive, as there are smaller mines and regions which aren't part of a larger geographic cluster. Where we mention gold, the annual figure is the amount of earth displaced to extract the gold given the grade of the mineral body (typically in the range of 1 to 5 grams per tonne), so it's useful to consider the Output column as an indicator of earth displacement rather than commodity output.

These regions account for around 95% of all mining operations across the country, so they may account for approximately 77,000 tonnes of end-of-life mining tyres each year. The rightmost column estimates mining tyres from each region, given their proportional contribution to this 95% of all mining occurring across the country.

Table 25: Major regions that generate OTR mining tyres in large amounts, determined by earth displaced (million tonnes per year).

Region	Major commodities by earth displaced	Output (mtpa)	Percentage contribution	End-of-life tyres (tonnes per year)
Pilbara WA	Iron ore Gold	890 mtpa	57.0%	43,890 tonnes
Bowen Basin QLD	Black coal Gold	190 mtpa	12.2%	9,390 tonnes
Hunter Valley NSW	Black coal	155 mtpa	9.9%	7,620 tonnes
Peel and Southwest WA	Bauxite Gold	73 mtpa	4.7%	3,620 tonnes
Goldfields-Esperance WA	Gold	66 mtpa	4.2%	3,230 tonnes
Northern NSW	Black coal	54 mtpa	3.4%	2,620 tonnes
Gippsland	Brown coal	46 mtpa	2.9%	2,230 tonnes
Cape York QLD	Bauxite	38 mtpa	2.4%	1,850 tonnes
Central West NSW	Gold	32 mtpa	2.1%	1,620 tonnes
Mid-West WA	Iron ore Gold	19 mtpa	1.2%	920 tonnes
Total		**1,560 mtpa**	**100%**	**77,000 tonnes**

Note: as we undertake business cases to analyse features of these catchments, we may develop different estimation methodologies that provide more precise estimates. Business cases underway for Hunter Valley and Northern NSW already indicate that these catchments generate more than estimated here.

Key observations from this table include:

- the Pilbara dominates the sector, accounting for 57% of the estimated material displaced by mining. About 20 mtpa of this displacement is from gold mining, with the majority of 870 mtpa from iron ore. The Pilbara is estimated to account for 44,000 tonnes of end-of-life mining tyres each year.
- WA accounts for 67.1% of the estimated earth displacement from the ten largest mining regions, and 51,700 tonnes of end-of-life mining tyres per year; followed by New South Wales at 15.4% (11,800 tonnes of mining tyres); Queensland at 14.6% (11,200 tonnes of mining tyres); and Victoria at 2.9% (2,300 tonnes of mining tyres).
- a further 12% and 10% of earth displacement occurs from Bowen Basin and Hunter Valley. Gold mining in Bowen Basin contributes about 4 mtpa compared with 186 mtpa from coal. Bowen Basin and Hunter Valley mining activities are estimated to account for 9,400 tonnes and 7,600 tonnes per year of end-of-life mining tyres.
- this table only includes mining activities from the ten largest regions by mining output and is assumed to cover about 95% of mining across the country. A remaining 5% arise from various other locations across the country. Most of these mines will be producing kilotonnes of ore rather than millions of tonnes per year, with a correspondingly reduced demand for mining tyres.

A subset

Given these estimates, it may be useful to focus on a subset of these regions as the best opportunity to improve OTR tyre recovery levels. Mines outside these regions should not be excluded, but may need a different approach, and this may be the strategy for states and territories that have more dispersed amounts of end-of-life mining tyres.

Table 26 gives an estimate of end-of-life mining tyres by state and territory using the ground up method, factoring in larger catchments and residual mining tyres from solitary mines.

Table 26: Estimated annual amounts of OTR mining tyres generated (tonnes) in selected states and territories derived from catchment level data.

State / territory	Mining tyres from large catchments (tonnes)	Mining tyres from solitary mines (tonnes)
New South Wales	11,800	430
Victoria	2,300	120
Queensland	11,200	920
Western Australia	51,700	1,350
South Australia	-	520
Tasmania	-	30
Northern Territory	-	710

Output vs tyre consumption: 49 tonnes of tyres per million tonnes of ore

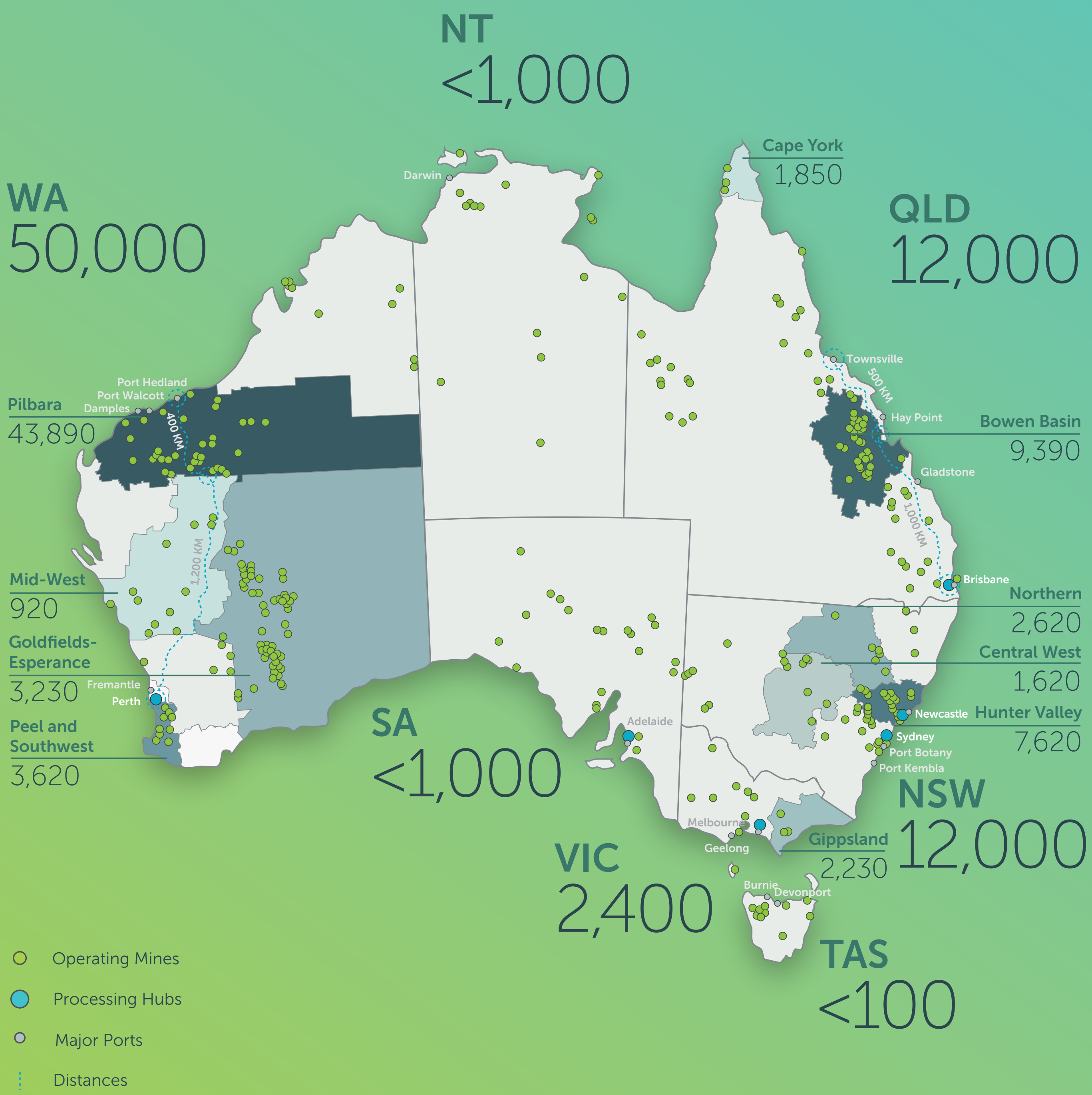
Sector-wide, the ten largest catchments produce 1,560 million tonnes per year while estimated to be generating 77,000 tonnes of OTR tyres per year. This suggests that for every million tonnes per year of ore material displaced, about 49 tonnes of end-of-life mining tyre are generated.

At the individual mine level, other factors will no doubt depart from this estimate, such as:

- the balance between mining vehicles and conveyor belts used to transport materials
- whether the mine uses open-cut, underground or other methods
- average mining vehicle transport distances per unit of ore mined
- mine geometry, determining gradients and associated wear levels of mining vehicle tyres
- mine geology and weather conditions, influencing tyre wear and damage rates
- procurement decisions, which may involve selecting more (or less) durable tyres or tyres not optimal for the uses and conditions
- the extent of care, maintenance and repair operations, and procedures to replace based on wear levels and/or hours of use.

The conversion factor may not apply to smaller mines producing only hundreds of kilotonnes of earth, as they may wear tyres out more quickly or more slowly for a given output.

Figure 6A: Map of Australia with catchment-derived mining tyre generation (tonnes)



9. Opportunities to recover agriculture tyres

After mining, the agriculture sector is the next opportunity to recover OTR tyres. The Australian agriculture sector is a significant contributor to the national economy, with an estimated net added value of $31.5 billion (2020-21) to Australia's $1.98 trillion Gross Domestic Product.[75]

Historically, Australia has been a leading producer and exporter of grain, wool and meat, as well as niche produce and value-added goods. Agriculture is a cornerstone of Australia's regional economies alongside mining and tourism, and is an expanding economic sector in northern Australia.

9.1 The use of OTR vehicles in agricultural practice

As a developed economy, Australia relies on specialised agricultural machinery and vehicles. Large agriculture vehicles and wheel-mounted equipment have a range of classifications. The Tractor and Machinery Association of Australia identifies the following groupings:[76]

- tractors – garden tractors, utility tractors (including compact utility tractors), large/open farm tractors, row crop tractors, orchard tractors
- combine-harvesters and headers
- tractor-pulled balers, hay tools and windrowers
- sprayers (trailing or self-propelled)
- tractor-pulled seeding and tilling equipment.

This same reference identifies sales across these machinery types outlined in Table 27. The last row shows lower-horsepower commercial mowers mainly used in non-agricultural settings (e.g. parks, estates, golf courses).

Table 27: Agriculture vehicles and implements sold in the Australian market.

Type	Units sold (2021)
Tractor	17,090
Combine harvester	1,081
Baler	985
Self-propelled windrower	65
Tractor pulled hay tools	2,432
Commercial mower	9,432

The greatest opportunity for OTR tyre recovery is combine harvesters and tractors, because they are used heavily across Australia and have larger tyre diameters. Tyres from other equipment may be stockpiled on farming properties, but we expect that any solution for larger tyres will also work for them.

[75] https://www.abs.gov.au/statistics/industry/industry-overview/australian-industry/latest-release

[76] Agriview Pty Ltd., 2021 Tractors and Machinery Report, 2022.

In 2022, TSA engaged with agriculture tyre retailers in Queensland and New South Wales. They confirmed that the main markets for large tyres were in the broad-acre cropping and irrigation businesses, such as:

- cereals and grains, like wheat, barley, oats, triticale, sorghum, rice
- legumes, like lentils, peas, broad beans, chickpeas, lupins, soybean
- corn (maize)
- cotton seed and cotton lint
- canola and sunflower seed.

While other segments such as livestock, fruit and viticulture also use agriculture tyres, the retailers' sales were lower for these than for broad-acre cropping and irrigation sectors.

If the amounts of agriculture tyres used in each state approximately correlates with the production in these commodities, we can assume that these commodities account for perhaps 80% of agriculture tyre usage, with the remaining 20% from other agricultural industries.

State and territory vehicle sales profile

A breakdown of the above sales by state as percentages and number of vehicles sold in each horsepower range is outlined in Table 28. Combine harvester tyres are included in the >200 horsepower column, and we have left out tractors of 60 horsepower or less, as their tyres can be recovered in the same way as automotive tyres.

Vehicle sales may not precisely correlate with the consumption and subsequent end-of-life generation of OTR tyres, but this table is a useful validation point for estimates generated in Section 9.2.

Table 28: Break down of new tractor and combine harvester sales by state and territory, segmented according to vehicle horsepower rating.

State or territory	% sales, > 60HP	Sales 60-100HP	Sales 100-200HP	Sales >200HP
New South Wales	31.6%	1,245	1,532	1,122
Victoria	24.4%	760	1,661	594
Queensland	19.5%	981	1,019	409
Western Australia	11.1%	230	370	772
South Australia	9.1%	226	460	425
Tasmania	2%	Breakdown by horsepower not available		
Northern Territory	1%	Breakdown by horsepower not available		
Total vehicles sold	**12,332**	**3,442**	**5,042**	**3,322**

The most vehicles are sold in New South Wales, followed by Victoria and Queensland, while Western Australian only accounts for 11.1%, but about one-quarter of all large tractors and combine harvesters were sold in Western Australia, whereas Victoria (at 18%) and Queensland (at 12%) have lower sales for vehicles rated >200 horsepower.

While Western Australia and New South Wales may lead in broadacre and irrigation farming output, Western Australia generates a higher proportion of large vehicle tyres, which may have ramifications for processing and logistical requirements.

This suggests that Western Australian farmers are working larger properties with bigger vehicles, and that the size of agriculture tyres is larger and heavier in Western Australia.

9.2 OTR tyre distribution across the agriculture economy

In 2021-22 it was estimated Australia generated around 15,000 tonnes of end-of-life agriculture and forestry tyres with Victoria, Queensland, New South Wales, and Western Australia being the largest users of agriculture tyres, see Table 29.

To identify catchment areas of high usage, and therefore generation of end-of-life agriculture tyres, we're assuming broad-acre and irrigation represent 80% of tyre usage while the remaining 20% distribution largely follows the distribution of livestock head across the country within each state[77].

Table 29 Estimated weight (tonnes) of Agriculture end-of-life OTR tyres generated in Australia, 2021-22

State	EOL OTR tonnes	Percentage of total
New South Wales	2,090	**14%**
Victoria	4,380	**29%**
Queensland	4,830	**32%**
Western Australia	2,580	**17%**
South Australia	1,020	**7%**
Tasmania	160	**1%**
Northern Territory	80	**<1%**
Total	**15,140**	

9.2.1 Broad acre & irrigation and livestock production

Table 30 shows the percentage breakdown of agriculture commodities (as listed in Section 9.1) produced in each state over the last one, five and ten year timeframes. It doesn't include the ACT or NT as they don't produce enough to register.

The three timescales smooth out short-term production impacts from drought and floods (e.g. 2020-21 was a year of plenty in New South Wales with unusually high yields).[78]

Table 30: Share of major broad-acre and irrigation cropping output by state, based on ABS figures.

State	1 year (2020-21)	5 year (2016-21)	10 year (2012-21)
New South Wales	35.3%	25.3%	27.9%
Victoria	16.4%	17.5%	15.3%
Queensland	5.5%	6.3%	7.7%
Western Australia	28.3%	34.5%	33.2%
South Australia	14.3%	16.2%	15.7%
Tasmania	0.2%	0.2%	0.2%

Over the medium-to-longer term, Western Australia (~33%) is the largest producer from broadacre and irrigation crops, followed by New South Wales (~28%). Victoria (~16%) and South Australia (~16%) then

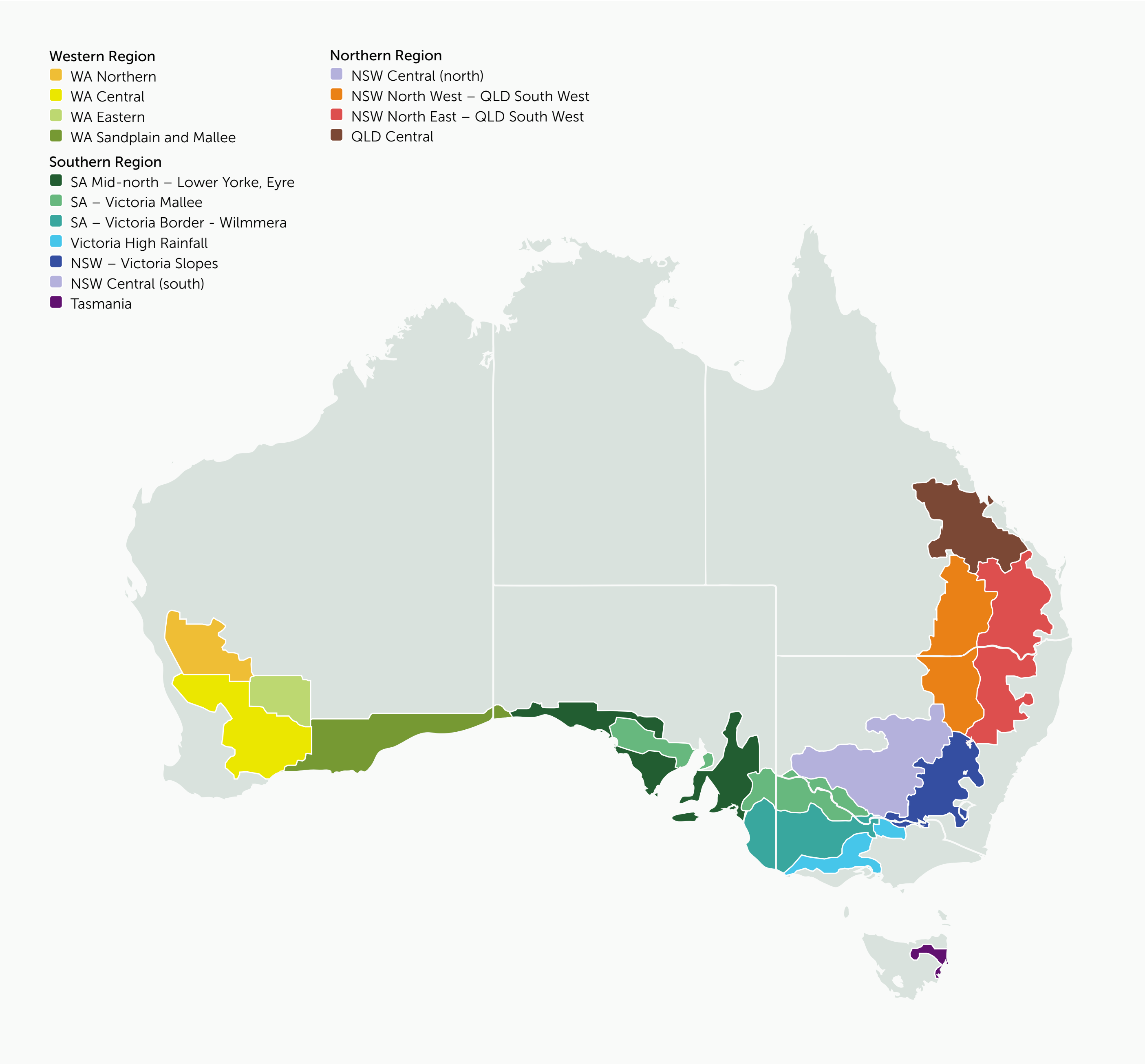
[77] Agriculture estimates were prepared are based on the distribution of agriculture production within each state. TSA cannot independently verify these findings however, broad indications of agriculture vehicle sales within each state suggest estimates to be accurate to within 10% of actual figures and are sufficient for the purposes of deriving relative volumes of economic contribution and OTR tyre usage.

[78] https://www.agriculture.gov.au/abares/research-topics/agricultural-outlook/data#australian-crop-report-data

produce roughly similar amounts, followed by Queensland (~6.8%). Tasmania comes last with less than 1% of the national total.

A distribution map[79] published by AEGIC shows that NT and the ACT have little measurable grain cropping (Figure 7):

Figure 7: Distribution of major grain growing regions across Australia. Source: Australian Export Grain Innovation Centre (AEGIC).



As indicated, the distribution of the remaining agriculture tyres outside of broadacre and irrigation largely follows the distribution of livestock head across the country within each state. Table 31 shows a potential state and territory distribution of livestock across Australia.

[79] https://www.aegic.org.au/australian-grain-production-a-snapshot/

Table 31: Estimated share of agriculture tyres involved in activities other than broadacre and irrigation cropping by state, based on managed livestock. These estimates should be viewed as highly approximate.

State	Livestock (thousand head)	Percent of total
New South Wales	24,100	27%
Victoria	19,300	22%
Queensland	12,800	15%
Western Australia	16,100	18%
South Australia	11,200	13%
Tasmania	2,600	3%
Northern Territory	1,900	2%

This estimate is highly approximate, as it does not include marginal adjustments from the distribution of other farming production (e.g. fruit, viticulture and sugarcane), and does not distinguish based on climate nor native vegetation versus modified pasture grazelands.

9.2.2 Breakdown by region within states

This section goes into more detail for the states we have identified as the larger contributors of end-of-life agriculture tyres (see Section 9.2). By breaking these states into regions, we aim to identify commercially-viable catchments of agriculture tyres. In some cases, these regions may overlap with mining tyre catchments, so both sectors may need to be considered in parallel when exploring an OTR tyre recovery solution for that location (see Chapter 10).

The process used to determine regional catchments of agriculture tyres is much the same as that used to for states and territories, but regional data from the Commonwealth and state governments are the main reference sources (rather than state- and territory-level data on agriculture commodity outputs). In some cases, this regional data has focused on key agricultural regions rather than giving a comprehensive description of all regions in a state.

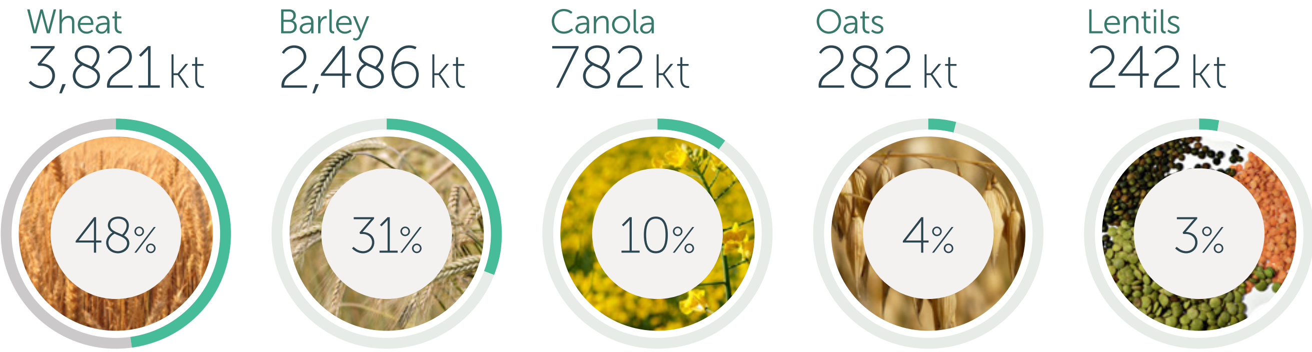
Victoria

Victoria is second in terms of agriculture tyres generated per year, with about 3,500 tonnes per year from broadacre and irrigation cropping, and 880 tonnes per year from other agricultural activities. These activities are spread across six regions recognised by the Victorian Government, including a region centred on Greater Melbourne and including semi-rural hinterlands and the Mornington Peninsula.

The main crops are cereals (wheat, barley, and oats) and canola and lentils as shown below (Table 32). Other crops make up the remaining 4%.

Table 32: Estimated outputs of broadacre and irrigation crops (kilotonnes per year) in Victoria.

Crop	5-year average yield (kilotonnes)	Percentage of total
Wheat	3,821	48%
Barley	2,486	31%
Canola	782	10%
Oats	282	4%
Lentils	242	3%



The Victorian Government does not report region-specific yields for broadacre crops, but ABS provides Australian Statistical Geography Standard (ASGS) classifications that approximate state regions.[80] This enables us to refine state-wide production levels to derive insights at the regional level.

In short, the Grampians (43%) region and the Loddon Mallee region (36%) account for most of the broadacre and irrigation output from the state, with smaller contributions from the remaining regions as shown in Table 33 below. It stands to reason that these areas of the state will generate a proportionate amount of agriculture tyres from broadacre cropping vehicles.

[80] The ASGS Statistical Area Level 4 region designated as Victoria – North West straddles the Grampians and Loddon Mallee regions of Victoria. To address this conflation of areas, crop production levels from the local government areas within the two regions were scaled up (via aggregation) to generate Grampians and Loddon Mallee broadacre and irrigation yield estimates.

The table below also maps the combined head of sheep and cattle to each region, based on MLA estimates of livestock numbers. We have used these figures to apportion the agriculture tyres generated outside broadacre cropping and irrigation activity.

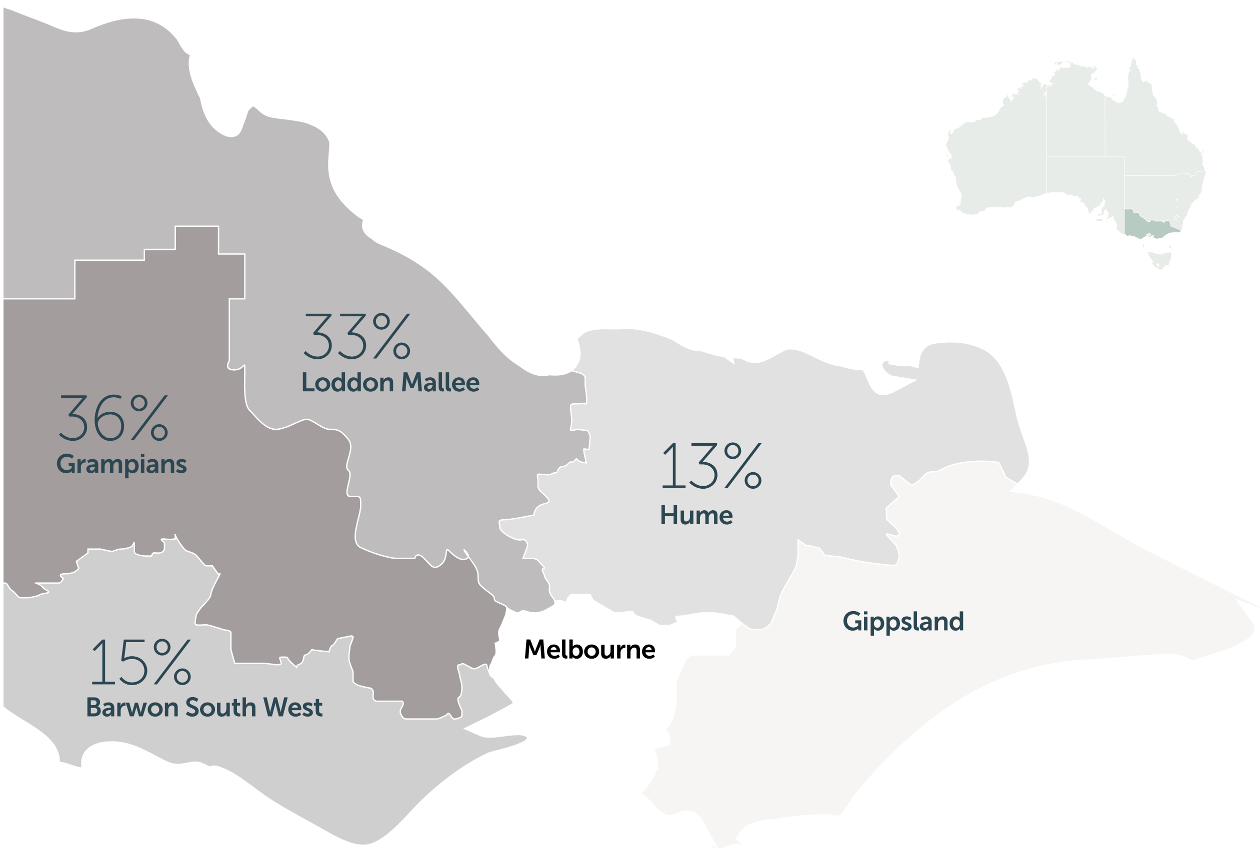
Table 33: Estimated regional breakdown of agricultural tyres (tonnes per year) in Victoria.

Region	Broadacre cropping		Livestock		OTR tyres (tonnes)
	Tonnes yield	OTR tyres (tonnes)	Headcount	OTR tyres (tonnes)	
Loddon Mallee	3,539,462 (36%)	1,270	3,609,905 (19%)	170	1,440
Hume	1,268,130 (13%)	460	2,719,870 (14%)	130	590
Gippsland	27,009 (<1%)	10	1,420,617 (8%)	70	80
Grampians	4,156,534 (43%)	1,490	2,314,716 (12%)	110	1,600
Barwon South West	737,000 (8%)	260	8,481,188 (45%)	390	650
Melbourne	23,798 (<1%)	10	390,994 (2%)	20	30

Note: Livestock tonnes add to 890, 10 more than the reported 880 for Vic

When combining end-of-life OTR tyre estimates across the Victorian agricultural economy as a whole, this analysis suggests that the key regions that generate agriculture tyres are Grampians (36% of the total) and Loddon Mallee (33%), followed by Barwon South West (15%) and Hume (13%). More than four-fifths of the agriculture tyres are generated west of Melbourne.

Figure 7A: Victorian regions with proportion of agricultural tyre generation



Queensland

Queensland is a major agricultural producer, with the sector generating an estimated 4,830 tonnes of end-of-life agriculture tyres each year. Queensland is divided into ten economic regions,[81] including large tracts of rural land and more compact and urbanised regions towards the southeast.

Based on ABS data, Table 34 shows the state's major broadacre and irrigation crops, noting that broadacre yields (e.g. wheat, barley and oats) lag behind the production of other states, while Queensland is a major state for rearing cattle.

Table 34: Estimated outputs of broadacre and irrigation crops (kilotonnes per year) in Queensland.

Crop	5-year average yield (kilotonnes,)	Percentage of total
Wheat	842	29%
Sorghum	764	26%
Chickpeas	434	15%
Cottonseed	287	10%
Barley	215	7%
Cotton lint	210	7%
Maize	103	4%
Oats	22	1%
Broad beans	15	1%

The Queensland Government does not report region-specific yields, but ABS provides Australian Statistical Geography Standard (ASGS) classifications we can approximate to state regions.[82]

Using this method, we can see that the geographic spread of the above crops tends towards the Darling Downs South West, Central, and Mackay Isaac Whitsunday regions. Most these crops are in the eastern portions of these regions, with the Darling Downs South West being the main croplands for the majority of these commodities(i.e. output seems to diminish north of the Darling Downs).

The percentage allocation of these crops in major producing regions is shown in Table 35 below.

[81] https://www.statedevelopment.qld.gov.au/regions/queensland

[82] The ASGS Statistical Area Level 4 region referred to as Queensland – Outback is an exception, with the region spreading along the western portion of the state from the southernmost to northernmost extremities. However, this region only corresponds to about 1% of broadacre and irrigation produce across the state.

Table 35: Estimated regional breakdown of agricultural tyres (tonnes per year) in Queensland.

Region	Broadacre cropping		Livestock		OTR tyres (tonnes)
	Tonnes yield	OTR tyres (tonnes)	Headcount	OTR tyres (tonnes)	
Central	412,624 (11%)	420	4,697,188 (37%)	360	780
Far North	11,521 (<1%)	10	1,096,894 (9%)	80	90
Mackay Isaac Whitsunday	270,994 (7%)	280	118,172 (1%)	10	290
North	17,855 (<1%)	20	1,249,795 (10%)	100	120
South East	29,123 (1%)	30	304,117 (2%)	20	50
Wide Bay Burnett	70,976 (2%)	70	768,138 (6%)	60	130
Darling Downs South West	2,959,748 (78%)	3,030	3,338,177 (26%)	250	3,280
North West	0	-	1,170,657 (9%)	90	90

Note: Table adds to 4,810, 20 less than the reported 4,830

We used the distribution of cattle and sheep livestock across regional Queensland published by MLA to determine the distribution of tyres from other agricultural activities.[83] We concede that this does not directly pick up other niche commodities (e.g. tropical fruit, sugarcane) which are grown in well-defined regions along the Queensland coastal areas. The MLA livestock distribution maps also don't precisely match the Queensland Government's official regions, so approximation was required.

From MLA data, the wide rural band of Central Queensland has the greatest livestock count (mainly in the Fitzroy Basin to the region's east), followed by the Darling Downs South West region (mainly in the Darling Downs district), and the regions north of Central Queensland are also significant contributors. We apportioned the agricultural tyres associated with activities outside of broadacre and irrigation cropping according to this livestock distribution.

Combining these estimates with those from broadacre and irrigation cropping, the Darling Downs South West (specifically its eastern portion) produces about 3,030 tonnes of end-of-life agriculture tyres per year (68% of the state total).

Central Queensland produces about 780 tonnes per year (16%), with the remainder allocated as minor proportions to the other regions shown above. The eastern Central Queensland region is also notable as it potentially overlaps with mining activity in the Bowen Basin (see Chapter 8).

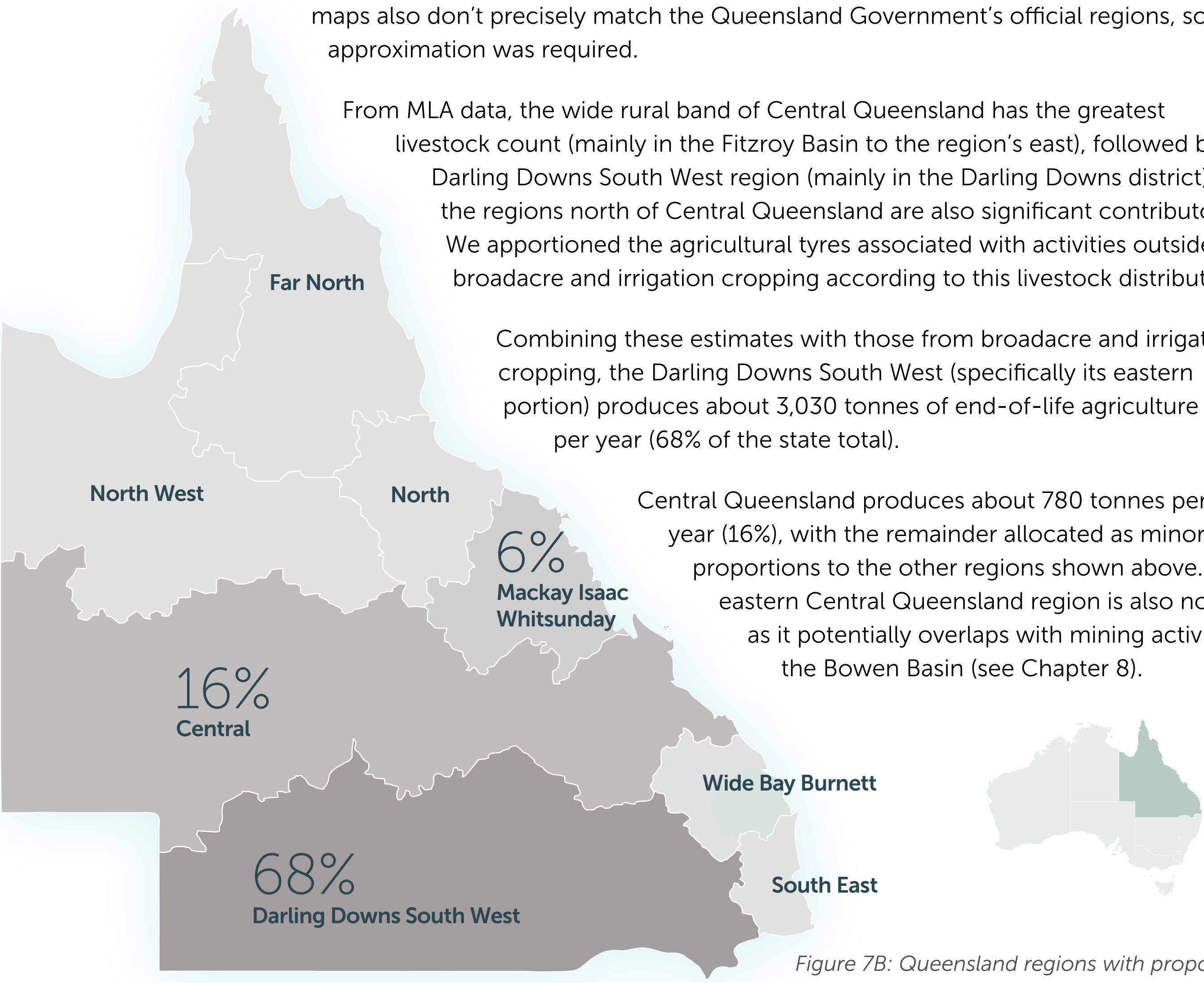


Figure 7B: Queensland regions with proportion of agricultural tyre generation

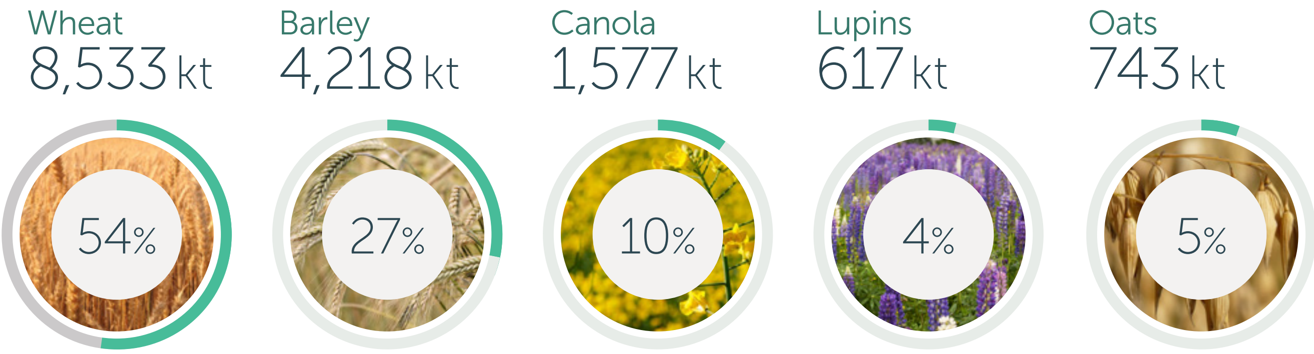
[83] This approach is described under the New South Wales heading within the same section.

Western Australia

Western Australia is the leading producer of broadacre and irrigation farming commodities by kilotonne and a significant location for livestock grazing. In terms of average crop yields over the last five years, Table 36 (derived from ABS yield data) shows that wheat and barley are the main crops from Western Australian farmers. Other crops make up less than 1% of the total.

Table 36: Estimated outputs of broadacre and irrigation crops (kilotonnes per year) in Western Australia.

Crop	5-year average yield (kilotonnes)	Percentage of total
Wheat	8,533	54%
Barley	4,218	27%
Canola	1,577	10%
Lupins	617	4%
Oats	743	5%



Yet there is agriculture as far north as the Kimberley, where cattle are grazed and irrigators draw water from the Ord River, and tropical fruit operators based around the coastal parts of the Gascoyne region.

Outputs from these areas are much lower than in the south and west of the state, according to ABARE data[84], so we don't examine their role in generating end-of-life agriculture tyres here, but tyre recovery services for mining tyres in the Pilbara could also recover agriculture tyres from the Kimberley and Gascoyne regions.

The Perth and Peel regions produce fruit and vegetables and may not use a lot of large agriculture tyres. They can possibly use Perth-based tyre recovery facilities and OTR tyre recovery services that could be set up for aluminium and gold mines in the Peel region.

In Section 9.2, we estimated that Western Australia contributed 2,060 tonnes of tyres from broadacre and irrigation cropping activities and 520 tonnes of tyres from other agriculture such as livestock grazing. Using crop tonnage and livestock head data, Table 37 seeks to designate these state totals at a regional scale.[85, 86]

[84] https://www.agriculture.gov.au/abares/research-topics/aboutmyregion

[85] https://www.agric.wa.gov.au/crops/regional-snapshots-value-broadacre-agriculture-south-west-wa

[86] https://www.agric.wa.gov.au/export-services/western-australian-beef-industry

Table 37: Estimated regional breakdown of agricultural tyres (tonnes per year) in Western Australia.

Region	Broadacre cropping		Livestock		OTR tyres (tonnes)
	Tonnes yield	OTR tyres (tonnes)	Headcount	OTR tyres (tonnes)	
Wheatbelt	6,921,800 (44%)	910	6,865,000 (49%)	250	1,160
Mid West	2,611,400 (17%)	350	877,000 (6%)	30	380
Great Southern	3,515,200 (22%)	450	3,614,000 (26%)	140	590
Goldfields-Esperance	2,655,200 (17%)	350	843,000 (6%)	30	380
South West	0	-	623,000 (4%)	20	20
Kimberley	0	-	152,000 (1%)	10	10
Gascoyne	0	-	678,000 (5%)	30	30
Pilbara	0	-	243,000 (2%)	10	10
Perth & Peel	0	-	0	0	0

This shows that the Wheatbelt region is the main generator of agriculture tyres, although the Great Southern, Midwest and Goldfields-Esperance regions are also important. Descriptions of each region from the state government suggest that:

- cropping in the Midwest is mainly concentrated in the North Midlands and Batavia Coast districts.
- broadacre cropping in the Goldfields-Esperance region is mainly concentrated in the southwest corner of this region, in the Esperance Port Zone (as distinct from the main area of gold mining, which is inland towards Kalgoorlie-Boulder and Leonora).

Figure 7C: WA regions with proportion of agricultural tyre generation

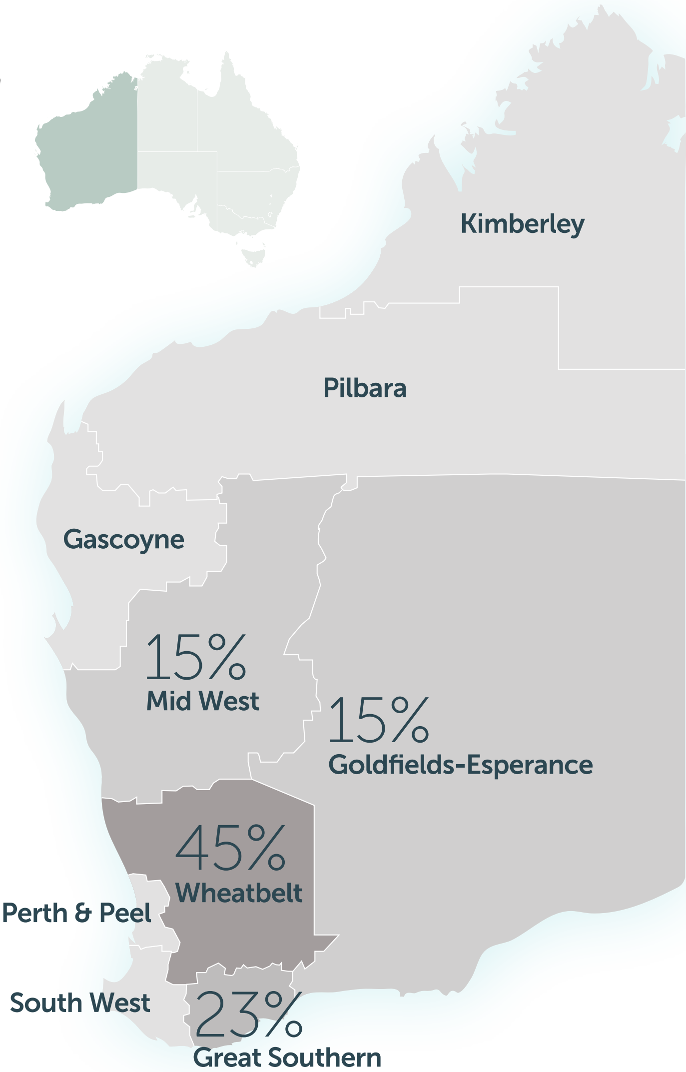


Figure 7D: Geraldton, Esperance, and Busselton area

Taking these points together we can surmise that agriculture tyres mainly come from an approximate triangle with apexes at Greater Geraldton (in the Midwest), Esperance (in the Goldfields-Esperance) and Busselton (in the Southwest). From a tyre catchments and logistical corridors perspective, it may be useful to separate this triangle into two parts above and below the Perth Metropolitan Area.

At present, we don't have enough data to allocate tyres across these two nominal catchments, although they're likely to be roughly equal, given the spread of regions and their estimated OTR tyre amounts as set out in Table 37 above. For our purposes, the upper and lower catchments may involve 390 tonnes of end-of-life agriculture tyres apiece, with smaller amounts dispersed throughout the rest of the state.

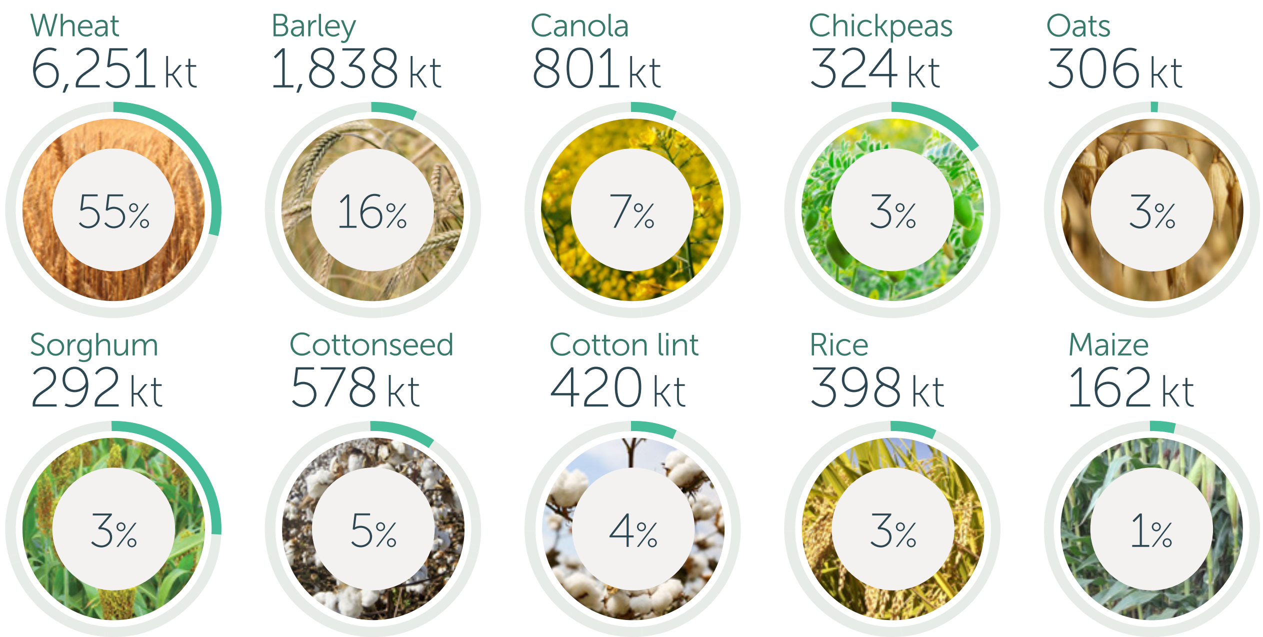
New South Wales

New South Wales is estimated to generate similar amounts to Western Australia with a total of 1,670 tonnes per year from broadacre cropping and irrigation plus 420 tonnes from other agricultural activities. This total of 2,090 tonnes per year may be dispersed across up to eleven regions recognised by NSW Department of Primary Industries.

Annual yield data for major crops show that wheat and barley dominate the state's broadacre crops, making up 70% of the state's total by kilotonne. Other crops are also harvested as shown in Table 38 below.

Table 38: Estimated outputs of broadacre and irrigation crops (kilotonne per year) in New South Wales.

Crop	5-year average yield (kilotonnes)	Percentage of total
Wheat	6,251	55%
Barley	1,838	16%
Canola	801	7%
Chickpeas	324	3%
Oats	306	3%
Sorghum	292	3%
Cottonseed	578	5%
Cotton lint	420	4%
Rice	398	3%
Maize	162	1%



New South Wales does not release regional crop yields (i.e. by mass of commodity), but figures and percentages based on gross value added by commodity are available.[87] Assuming that commodity value correlates with cropping output for each region, we can derive the percentage share of outputs from different regions and apportion state-wide cropping vehicle tyre amounts based on the share of output of broadacre and irrigation crops by region.

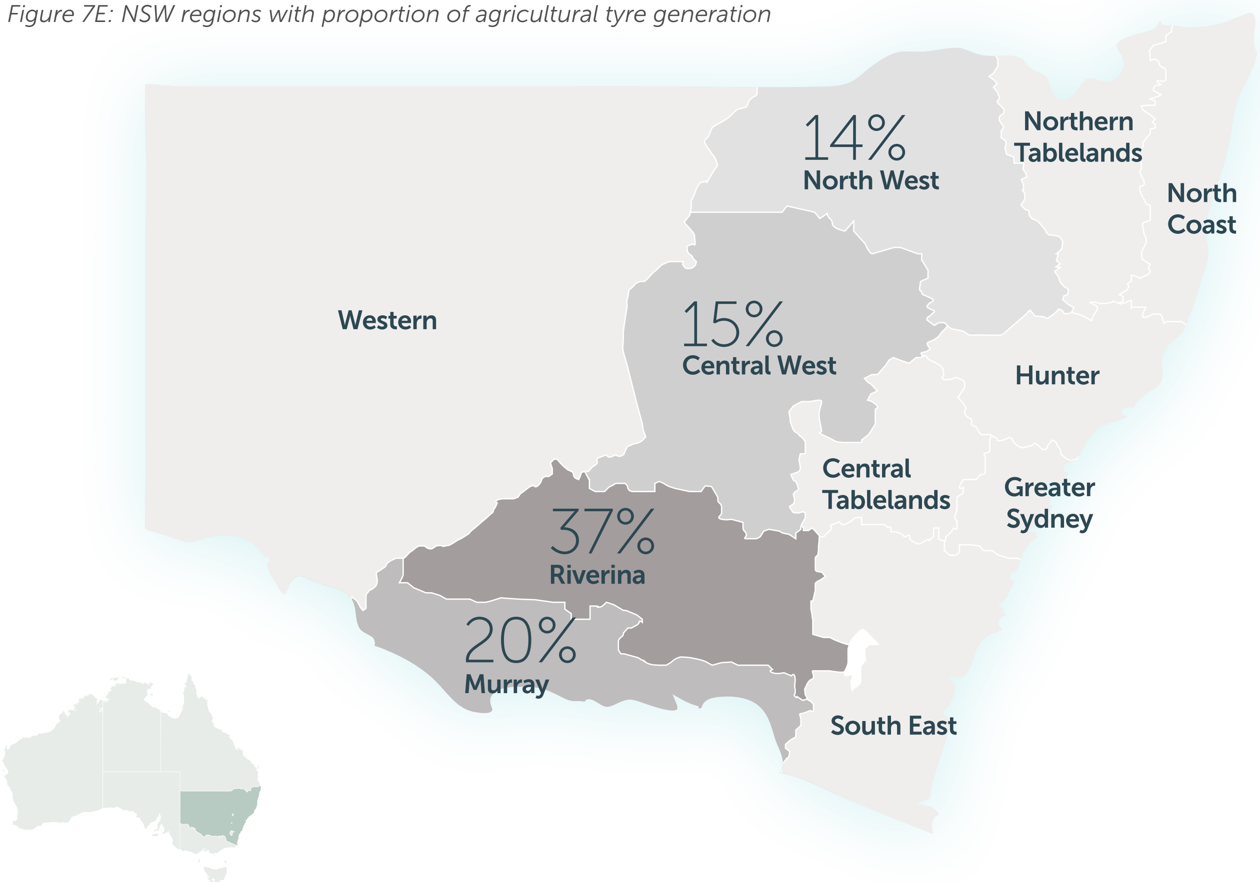
[87] https://www.dpi.nsw.gov.au/about-us/publications/pdi/2021/regional-output

Table 39 below uses this approach to allocate end-of-life cropping vehicle tyres by region, based on an estimated share of cropping output.[88]

Table 39: Estimated regional breakdown of agricultural tyres (tonnes per year) in New South Wales.

Region	Broadacre cropping		Livestock (cattle & sheep)		OTR tyres (tonnes)
	% share	OTR tyres (tonnes)	Headcount	OTR tyres (tonnes)	
Central Tablelands	2.3%	40	2,705,769 (9.3%)	40	80
Central West	14.3%	240	5,101,864 (17.5%)	70	310
Murray	22.3%	370	3,136,573 (10.8%)	50	420
North West	16.0%	270	1,835,755 (6.3%)	30	300
Riverina	40.7%	680	5,979,426 (20.5%)	90	770
South East	0.8%	10	4,044,732 (13.9%)	60	70
Western	3.0%	50	3,106,854 (10.7%)	40	90
Northern Tablelands	0.6%	10	2,221,699 (7.6%)	30	40
North Coast	-	-	388,187 (1.3%)	10	10
Sydney	-	-	46,013 (0.2%)	-	-
Hunter	-	-	574,917 (2.0%)	10	10
Note: Livestock tonnes add to 430, 10 more than the reported 420					

Figure 7E: NSW regions with proportion of agricultural tyre generation



88 Note, the DPI data tables use a minimum threshold for gross value added of $3 million for any regional commodity output, leading to data gaps for smaller volumes of output for any given region. Nonetheless, the data used to estimate agriculture tyre amounts from broadacre and irrigation cropping by region represents over 80% of the state's total broadacre and irrigation cropping output.

Generally, broadacre and irrigation cropping is most common in the hinterland west of the coastal regions, led by the Riverina region (41% of total) followed by the Murray region (22%). The regions of North West (16%) and Central West (14%) are also significant producers. We have apportioned large agriculture tyres along the same lines.

Regional data on livestock is not directly available from the New South Wales Government. Meat and Livestock Australia (MLA) periodically releases regional headcount estimates and distribution maps for sheep and cattle, and can be combined and then used as a source.[89] These estimates use the agriculture regions adopted by NSW Department of Primary Industries (see figure 39).

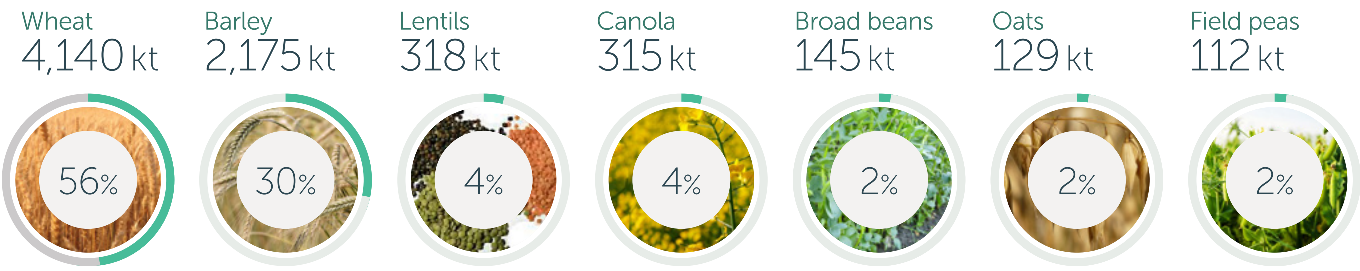
Combining agriculture tyres from broadacre and irrigation cropping with other agricultural sources, the Riverina generates over one-third (37%) of agriculture tyres, followed by the Murray region at one-fifth (20%) of agriculture tyres, Central West (15%) and North West (14%) regions. The remaining 14% of agriculture tyres mainly arise from the Central Tablelands, South East, and Western regions. In short, the central south of the state is the main area that agriculture tyres come from. As the focus moves inland or towards coastal regions (particularly the northern coastal parts of the state), the amount of agriculture tyres substantially diminishes.

South Australia

South Australia produces 820 tonnes per year from broadacre and irrigation cropping, with tyres from other agricultural activities around 200 tonnes per year. Table 40 shows the major crops produced in the state.

Table 40: Estimated outputs of broadacre and irrigation crops (kilotonnes per year) in South Australia.

Crop	5-year average yield (kilotonnes)	Percentage of total
Wheat	4,140	56%
Barley	2,175	30%
Lentils	318	4%
Canola	315	4%
Broad beans	145	2%
Oats	129	2%
Field peas	112	2%



The South Australian Government recognises eight regions which vary greatly in size.[90] In terms of productivity data, it designates fourteen separate districts that don't precisely map onto these eight regions.[91] Neither of these boundaries closely match with the ASGS classification system Statistical Area Level 4, which ABS use to publish data on crop production levels, whose boundaries are too coarse to determine where agricultural tyres are distributed across South Australia.

[89] https://www.mla.com.au/prices-markets/Trends-analysis/livestock-distribution-maps/

[90] https://regionaldevelopmentsa.com.au/regions/

[91] https://www.pir.sa.gov.au/primary_industry/grains/crop_and_pasture_reports

For convenience, we used the fourteen districts recognised by South Australia in reporting crop yields to define the areas where agriculture tyres are used, but we aggregated some of these districts to provide a scale that compares with other parts of the country.[92] This produces six regions of crop report districts, and a seventh to include livestock reared in the north and west beyond the cropping zone, i.e. the 'Arid Lands' region.

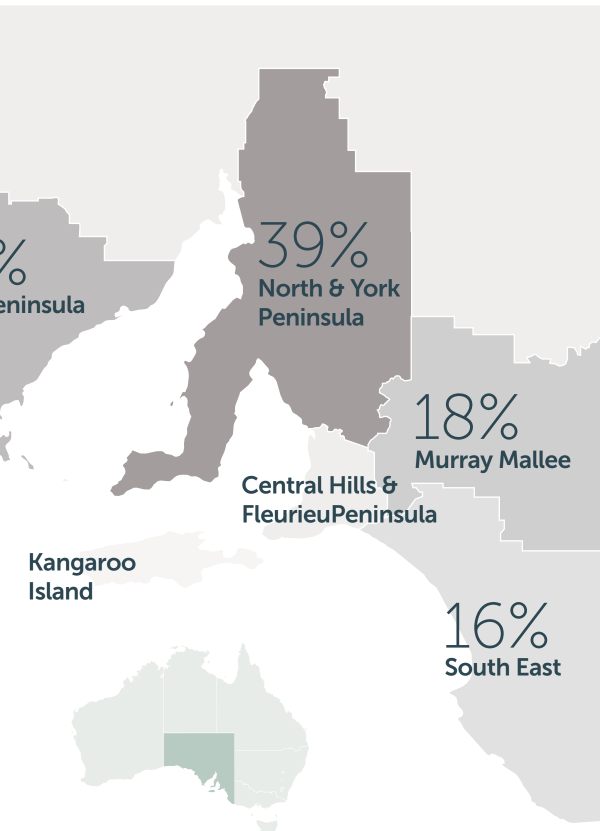
Based on South Australian district crop reports, the major regions for growing broadacre and irrigation crops are the Yorke Peninsula and North districts (immediately to the north and west of Adelaide) with 45% of the produce by weight, followed by the Eyre Peninsula (25%), further west. The South Australian Murray and Mallee (19%) and South East (9%) are also important cropping regions.

We used livestock distribution as a proxy for tyres generated from other agriculture activities, (using MLA livestock distribution maps for reference data). We understand that the coastal South East accounts for about 38% of livestock grazing activity, with the Murray Mallee, Eyre Peninsula and Northern and Yorke Peninsula regions also significant.

Table 41: Estimated regional breakdown of agricultural tyres (tonnes per year) in South Australia.

Region	Broadacre cropping		Livestock		OTR tyres (tonnes)
	Tonnes yield	OTR tyres (tonnes)s	Headcount	OTR tyres (tonnes)	
Eyre Peninsula	2,266,500 (25%)	200	1,433,400 (12%)	20	220
North & Yorke Peninsula	4,140,750 (45%)	370	1,803,419 (15%)	30	400
Kangaroo Island	59,250 (1%)	10	695,158 (6%)	10	20
Central Hills & Fleurieu Peninsula	70,600 (1%)	10	450,727 (4%)	10	20
Murray Mallee	1,760,420 (19%)	160	1,943,394 (16%)	30	190
South East	837,500 (9%)	80	4,541,464 (38%)	80	160
Arid Lands	0 (0%)	-	974,904 (8%)	20	20
Note: (Broadacre tyres add to 830), 10 more than the reported 820					

Figure 7F: SA regions with proportion of agricultural tyre generation



In estimating total end-of-life agriculture tyre amounts (Table 41), the Northern and Yorke Peninsula region accounts for 400 tonnes per year (39% of the state total), followed by Eyre Peninsula (21%) and the Murray Mallee region (18%).

The South East produces a further 160 tonnes (16%) and other locations produce much smaller amounts. In short, while agriculture tyre use appears to be spread across the southern part of the state, a slightly greater balance occurs to the west of Adelaide compared with the east of the state.

92 That is, most of the districts used in South Australia are substantially below the level of the state region scales used elsewhere, such as in Victoria, New South Wales and Queensland.

9.2.3 Dominant catchments by agriculture tyre amounts

The preceding pages describe the major states in terms of agriculture tyre use and the generation of end-of-life agriculture tyres.

To understand the scale of the demand for recovery services in the states that generate the most tyres, we need to understand the dispersal of agriculture tyres in these states. From a national standpoint, it also helps decide which regions to prioritise to contribute to a national tyre recovery target.

With this interest in mind, Table 42 lists the top ten agricultural regions in terms of their estimated amounts of end-of-life agriculture tyres produced each year, and their percentage contribution to the national total of 15,000 tonnes per year.

Together, these ten regions account for an estimated 11,280 tonnes of end-of-life agriculture tyres each year, or 75% of the total national figure by weight. Noting that the three largest mining regions tally to about 80% of end-of-life mining tyres (see Chapter 8), this fraction shows the greater geographic dispersal of agriculture tyres compared to mining tyres.

Table 42: Major regions that generate OTR agriculture tyres in large amounts, as determined according to analysis conducted over previous sections of this chapter.

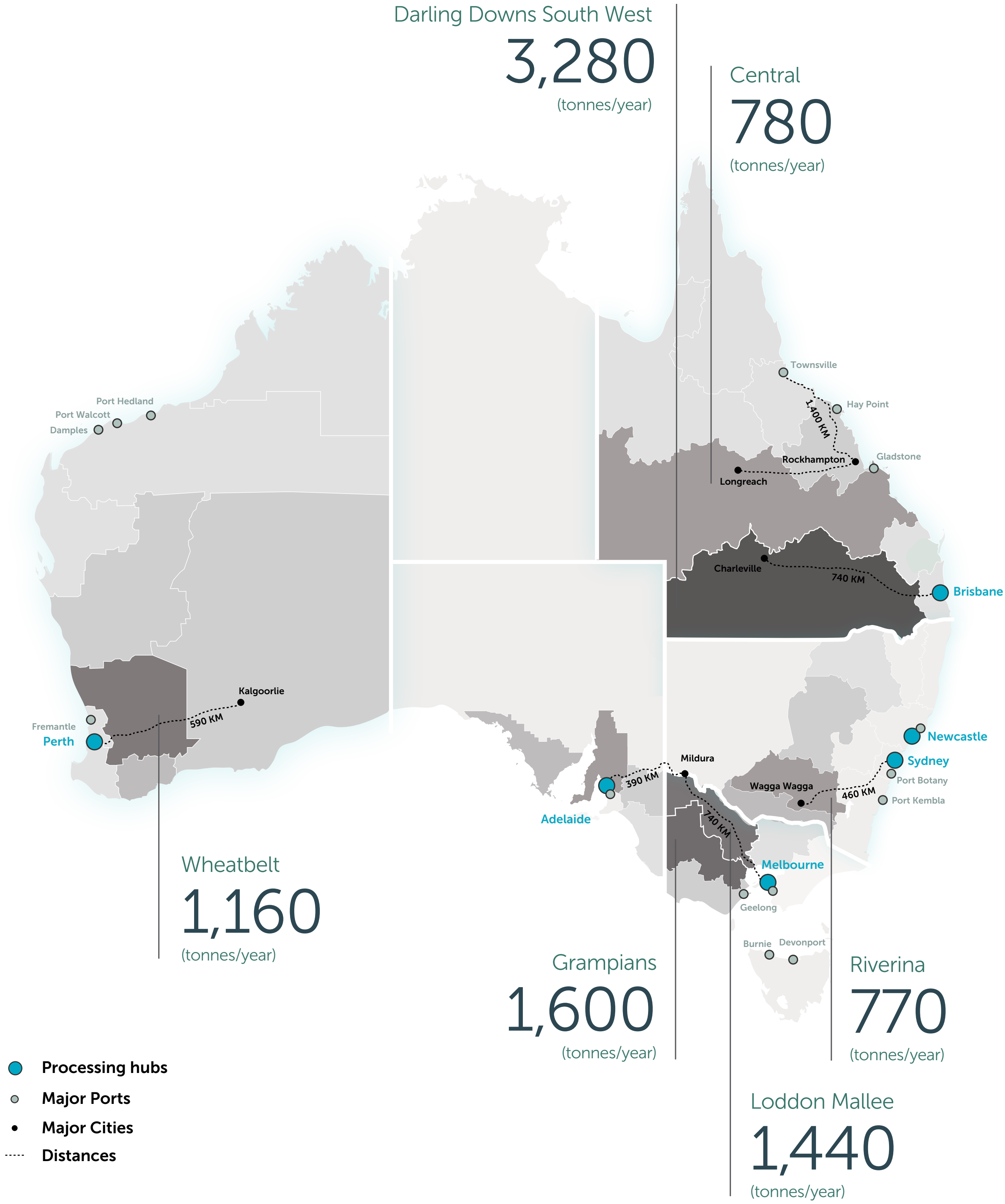
Region	State	End-of-life agriculture tyres (tonnes/year)	Percentage of all agriculture tyres
Darling Downs South West	QLD	3,280	22%
Grampians	VIC	1,600	11%
Loddon Mallee	VIC	1,440	10%
Wheatbelt	WA	1,160	8%
Central	QLD	780	5%
Riverina	NSW	770	5%
Barwon South West	VIC	650	4%
Great Southern	WA	590	4%
Hume	VIC	590	4%
Murray	NSW	420	3%

Among these ten regions, Victoria accounts for four regions, while Queensland, New South Wales, and Western Australia account for two each. In each case, broadacre and irrigation cropping activities are the main driver for agriculture tyre consumption, with livestock secondary.

This report has not had the opportunity to examine demand for tyres in smaller-yielding niches such as fruit and nut cropping, sugarcane, viticulture, and forestry. These sectors may use lower amounts of tyres, but still contribute significant quantities to local and regional economies that cannot recycle them through automotive tyre recovery methods.

Further work is required to build a more accurate profile of tyre use in each of these agriculture subsectors and update this regional analysis, while opening possibilities to establish regional tyre recovery solutions across the country.

Figure 7G - Map of Australia with catchment-derived agriculture tyre generation (tonnes)



Section 4 – Achieving OTR tyre recovery across Australia

10. Priority catchments

We have now examined the distributions of mining and agriculture OTR tyres, their links to major commodities, distributions across states and territories and regional concentrations of activities that generate end-of-life tyres.

In some regions where farmland and mining are co-located, both sectors are generating large quantities of OTR tyres. This section defines 'catchments' (see Section 1.4) that have higher OTR tyre generation in both sectors, and therefore may have the economies of scale to support local recovery (see Chapter 7).

A subset

This section examines a subset of catchments to identify:

- barriers linked to the features specific to each catchment
- possible solutions and their technological, logistical and commercial aspects
- roles, relationships and activities needed to shift from current practices to increased OTR recovery
- other aspects at the catchment level that affect partnership arrangements at a national scale (see Section 1.4).

This chapter shows that we can achieve OTR tyre recovery in significant quantities, particularly if the solution takes advantage of where and how OTR tyres are used across the country. Note that the findings and suggestions in this chapter are provisional and illustrative only. We have not had enough opportunity yet to engage with stakeholders in each catchment, nor have we subjected the proposed recovery pathways to rigorous feasibility studies.

We are doing some of this work in parallel to this report, and this will enable TSA to build on the foundations in this chapter, with a strong evidence base for OTR tyre recovery that reflects the circumstances in each catchment.

Other factors

The extent to which a given catchment represents 'low hanging fruit' for tyre recovery will have to take other factors into account, including:

- internal pressures for mining companies and farming businesses to replace tyre disposal with recovery, such as ESG and carbon efficiency goals.
- external drivers such as the views of local stakeholders, the political and social environment, and regulatory settings
- geographic, infrastructural, financial and human capital factors that will differ from one catchment to another.

The ability of different catchments to contribute to a national tyre recovery outcome needs to factor in tyre generation and economies of scale, as well as the individual catchment characteristics. We need to study these local factors in more detail, but other parts of this report strongly position TSA and others to take a multi-factorial approach to creating recovery solutions tailored to the needs of individual catchments.

The frameworks in this report will require impact assessments, engagement with indigenous people and local communities, and cost-benefit analyses at the catchment scale, to ensure we identify the most suitable recovery path for each priority catchment.

Cost-benefits at catchment scale

A catchment scale cost-benefit analysis is most appropriate given:

- their distinct features and the realisation that there is no 'one size fits all' solution that will suit all catchments
- the scale of business and public decision making and investment in a solution that is likely to take place at the catchment rather than the national scale, so an aggregated national cost benefit analysis is of limited value, particularly as TSA and other stakeholders are not currently seeking a national-scale decision
- recognising and treating costs and benefits – particularly in relation to ESG priorities and community interests – is subjective and must account for local issues that don't suit the types of assumptions, simplifications and operational judgements typically applied at the national scale.

We also note that TSA may need to build capabilities for solitary mining operations and farmers based in more isolated locations, wherever they're located within a catchment. This would be expected of a national scheme, but is more likely to need focus on the logistics of recovering tyres from these locations than on building dedicated recovery infrastructure.

10.1 High generation OTR tyre catchments

Table 43 below defines eleven priority catchments, chosen because they:

- are confined to a limited geographic area, and
- can deliver OTR tyres to a tyre recovery solution.

Their common feature is that they generate enough OTR tyres to compensate for the transport costs of transporting and processing them. For example, this might be a mining or agricultural area with a diameter of 300km or less that has the roads and industrial centres needed to transport tyres, or a longer corridor connected to industrial centres and ports via the freight sector.

We examine some catchments in more detail to identify their key features and the barriers we will need to overcome to create a recovery solution for them. This may identify barriers specific to that catchment and common barriers we can address through systemic, national responses. This may help identify which catchments combine a large recovery potential with few barriers.

Table 43 includes a brief description of each catchment for reference. In just over half the cases, most of the tyres available from the catchment come from mining operations (certainly in the three largest), but agriculture is the main source in some.

Tonnes and percentages

The rightmost column of Table 43 shows the total tonnes of OTR tyres generated from each catchment (mining and agriculture) and what percentage this makes up of the total OTR tyres generated across these 11 catchments in 2021 (88,800 tonnes). So, for example, we estimate the Bowen Basin catchment generates up to 10,170 tonnes per year or 8% of the 88,000 tonnes generated across the priority catchments in 2021. This consists of 9,390 tonnes of mining tyres and 780 tonnes of agriculture tyres.

Stockpiles

We have limited details of the level and status of OTR tyre stockpiles in each catchment, which is another variable we need to understand better to define the commercial opportunities of recovering OTR tyres from each catchment. We expect that mining sites that have been operating longer will have stockpiled substantial quantities of tyres, but some of them may not be suitable for recovery or may not be a high priority.

Ongoing viability

The viability of each catchment will be driven in part by the past and future levels of mining and agricultural activity in the area. Table 43 analyses catchments based on historic information, but further analysis of catchment viability will need to consider future trends such as the movement of Australian mines away from coal and towards new economy minerals. TSA will need to monitor the activity levels of each catchment to ensure we target our efforts and to help investment in recovery where it is most needed.

Potential

Across the eleven catchments shown, around 90,000 tonnes per year are potentially recoverable. This would increase OTR tyre recovery by 65 percentage points. Combined with a base recovery level of 14,000 tonnes (from aviation, trade and construction sectors), this could achieve a total OTR recovery level of over 100,000 tonnes per year (75% across all OTR sectors, nearly on par with national recovery rates achieved for automotive tyres).

These recovery rates are upper limits and can only be achieved if we recover all OTR tyres from each catchment. This is unlikely without positive inducements (including regulatory instruments).

Australia's use of market-based approaches to tyre stewardship leads to probabilistic rather than deterministic outcomes (as explained in Section 1.4). Stronger measures to drive change in practice would increase the recovery rates.

After Table 43, the business case examines selected catchments in detail, in particular the barriers to OTR tyre recovery in the mining and agriculture sectors. This aims to define a range of activities for TSA and other parties to consider to raise OTR tyre recovery levels across the country.

Table 43: Priority catchments of OTR tyres based on estimated tonnes of tyres generated annually, factoring in mining and agriculture sector sources.

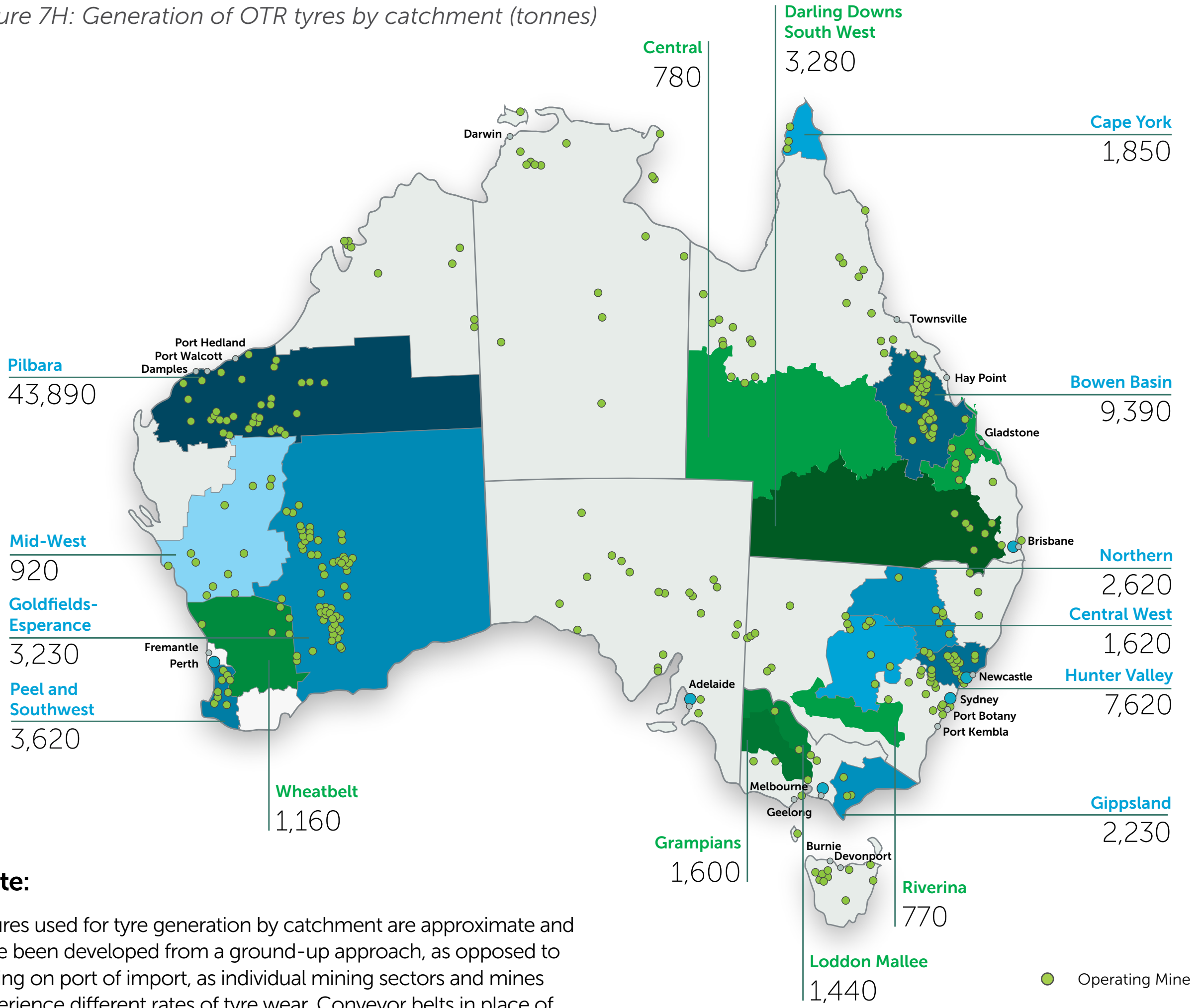
Catchment	Description	End-of-life OTR tyres (tonnes/year, estimated) Mining	Agriculture	Total OTR tyres (% of Priority Catchments)
Pilbara WA	The Pilbara ranks as the largest mining precinct in the country in terms of displacement of earth, with a heavy reliance on open-cut mining vehicles. Iron ore is mined by four major companies (BHP, Rio Tinto, Fortescue Metals Group, Hancock Prospecting), from as far south as Newman to Marble Bar in the north – a range of about 350km. Iron ore is exported from Port Hedland. There are smaller operations extracting gold, lithium, manganese, nickel and other metals in the Pilbara. Agriculture is limited to grazing on native vegetation.	43,890	-	43,890 (49%)
Hunter & North NSW	Thermal coal is mined along an inland corridor in northern NSW with mines clustered around Singleton and Muswellbrook in the Hunter Valley, and around Narrabri in the North West region (i.e. 300km connected by the Kamilaroi and New England Highways). These outfits include large international and smaller domestic operators, using a mix of sole operation and joint venture models. Smaller coal and gold mining sites are located on the periphery of this corridor. There is some overlap in terrain with a number of cropping and grazing districts situated between Newcastle and the northern most coalfields.	10,240	360	10,600 (12%)
Bowen Basin QLD	The Bowen Basin occupies a north-south stretch 200km inland of the Central Queensland coast, and is the state's main coal resource. Most of the Bowen coalfields cluster inside a 300km range, from Moranbah to Blackwater. These mining precincts are connected to Mackay in the north and Rockhampton and Gladstone in the south. A small amount of gold is also mined on the periphery of the Bowen Basin. The Bowen Basin overlaps with the Fitzroy Basin grazelands, where a major beef cattle industry is based. Broadacre cropping also has a substantial presence in the Fitzroy NRM region.	9,390	780	10,170 (11%)
Riverina, Murray & Central West NSW	The three regions running north from the central part of the NSW/ VIC border to central NSW are a major cropping and livestock grazing heartland for the state, and are an important region for recovering agriculture tyres. Towards the east of this catchment are significant goldfields including the Cadia Valley, Cowal and Tomingley mines; and a number of smaller coal mines towards the regional city of Lithgow. While these regions collectively span an area of about 500km in diameter, the catchment is well placed in terms of regional highways and potential consolidation points at regional centres. Its northeast extremity is about 160km east of the industrial and logistics precinct in western Sydney.	1,617	1,500	3,117 (4%)
Peel, Southwest & Lower Wheatbelt WA	The Peel and South West regions include several high production mining operations extracting gold, bauxite, lithium and mineral sands. The Greenbushes lithium mine is the world's leading producer of spodumene. The Boddington mine is perhaps the country's largest open-cut gold mine (along with Cadia Valley mine in Central NSW). These mines are surrounded by substantial livestock operations and broadacre cropping, including the Southwest, Great Southern and Lower Wheatbelt regions. Taking Perth as a northern extremity, this region approximates to an area spanning up to 400km diameter (from Perth to Albany).	3,619	1,180	4,799 (5%)
Mid-west & Upper Wheatbelt WA	This catchment covers the Mid-west region and part of the Wheatbelt, spanning an area up to 500km north of Perth. The catchment includes major broadacre and livestock growing districts of Western Australia. Much of the cropping activity in the Mid-west occurs in the Batavia Coast and North Midlands subregion, closer to the coast. Iron ore and gold mines are placed further inland in the same region (up to 400km east of Northampton). It remains to be confirmed that mining tyre logistics and agriculture tyre logistics can be readily combined in support of recovery activity.	924	960	1,884 (2%)

Catchment	Description	End-of-life OTR tyres (tonnes/year, estimated)		
		Mining	Agriculture	Total OTR tyres (% of Priority Catchments)
Western Victoria VIC	This catchment amalgamates farmlands in the Loddon Mallee and Grampians regions, which are major areas for broadacre agriculture in Victoria. The more western centres (e.g. Horsham) in this district are up to 300km from Melbourne, and serve as a waypoint along major freight corridors between Melbourne and Adelaide. As such, the recovery of agriculture tyres may involve these major roadways, while also potentially linking up with tyre recovery services offered to the Barwon South West region in Victoria and the South East region of South Australia (an added 940 tonnes and 690 tonnes of agriculture tyres respectively, not included in the figures shown).	50	3,040	3,090 (3%)
Goldfields-Esperance WA	The Goldfields-Esperance region of Western Australia is an expansive area that contains the country's largest density of gold mines. The catchment runs roughly from Norseman in the south to beyond Leonora in the north (a span of about 600km), with a major cluster around Kalgoorlie-Boulder and Coolgardie. Some lithium and copper mining is also present in the catchment, at lower activity levels. The region lies about 600km east of the Perth metropolitan area, and involves a variety of larger and smaller goldmining operators (in contrast to some mining tyre catchments that are more concentrated). Nonetheless a small number of operators have multiple large mine sites from which many tyres could be obtained.	3,234	380	3,614 (4%)
North & Yorke Peninsula SA	The North and Yorke Peninsula agriculture districts, to the north and west of Adelaide, comprise a major broadacre cropping region of South Australia. The region runs up to 400km north of Adelaide and across the width of Yorke Peninsula. While the area is not a part of the major mining districts explored elsewhere in the business case, gold mining near Port Augusta and iron ore mining in the Middlebank Ranges may offer quantities of mining tyres additional to those captured from farming activity. Mining tyres from outside this catchment (e.g. from Olympic Dam, further north) could potentially be consolidated to increase overall quantities recovered via the region.	900	400	1,300 (1%)
Darling Downs & Surat Basin QLD	The Darling Downs is Queensland's primary broadacre and irrigation cropping region, and is also a major region for raising livestock (along with Fitzroy Basin). Covering an area up to 500km west of southeast Queensland, this region's agricultural economy is diverse and includes grain, cotton, vegetables, legumes, cattle and sheep raising. The agricultural district overlaps with coal mines that work the Surat Basin, which is presently less developed than the Bowen Basin. Nonetheless, there are about four mining operators active in the catchment, with an estimated 750 tonnes of mining tyres generated each year.	750	3,280	4,030 (5%)
Gippsland VIC	The eastern Victorian region of Gippsland is home to a series of power stations fuelled by brown coal, with coal operations linked to different power generation assets presently owned by Energy Australia and AGL Energy. These coalfields are clustered around Morwell, about 120km east of the heavy industrial precincts of south-eastern Melbourne (e.g. Dandenong South) via the Princes Highway. The surrounding Gippsland region is an agriculture hub, with a balance towards meat and dairy produce, vegetables and wool products. While cereals are also grown, most of the broadacre cropping occurs elsewhere in the state, i.e. western Victoria. Significant forests are also managed in the Gippsland region.	2,233	80	2,313 (3%)
Total				**88,807**

This table shows the tonnes-per-year of OTR tyres generated in each catchment by the sectors with the lowest recovery rates, mining and agriculture:

	Mining	Agriculture	Total OTR tyres (% of Priority Catchments)
Pilbara (WA)	43,890	-	43,890 (49%)
Hunter & Northern (NSW)	10,240	360	10,600 (12%)
Bowen Basin (Qld)	9,390	780	10,170 (11%)
Riverina, Murray & Central West (NSW)	1,620	1,500	3,120 (4%)
Peel, Southwest & lower Wheatbelt (WA)	3,620	1,180	4,800 (5%)
Mid-West & upper Wheatbelt (WA)	920	960	1,880 (2%)
Western Victoria (Vic)	50	3,040	3,090 (3%)
Goldfields-Esperance (WA)	3,230	380	3,610 (4%)
North & Yorke Peninsula (SA)	900	400	1,300 (1%)
Darling Downs & Surat Basin (Qld)	750	3,280	4,030 (5%)
Gippsland (Vic)	2,230	80	2,310 (3%)
			88,800

Figure 7H: Generation of OTR tyres by catchment (tonnes)



Note:

Figures used for tyre generation by catchment are approximate and have been developed from a ground-up approach, as opposed to relying on port of import, as individual mining sectors and mines experience different rates of tyre wear. Conveyor belts in place of mining vehicles adds another layer of complexity to estimating amounts.

While a catchment-based approach to expanding OTR rubber product recovery may not be suitable in all cases, it's a useful starting point to address the areas with the biggest potential.

10.2 Exploration of catchments, barriers, and solutions

The catchment details and potential paths to solutions in this report involve narrow analysis and engagement with stakeholders, and are not a detailed blueprint for how to recover OTR tyres in each catchment. This report does not seek to test and refine assumptions used in each profile. Rather, each section is meant to be illustrative, helping to generate interest in acting at the catchment, state/ territory, and national levels.

To move catchments towards recycling most of their OTR tyres, we will need multiple responses that address the barriers and enablers specific to each catchment (see Chapter 5). In some cases we may need a blend of regulatory and other persuasive measures. Catchments involving larger levels of mining and agriculture activities using heavy vehicles will need a blended approach, meeting each sector's needs.

The catchments described below are a subset from Section 10.1, focussing on the three largest mining catchments and one with a significant agricultural dimension, to show the different challenges associated with that sector.

10.2.1 Pilbara (WA)

The Pilbara catchment describes a region in northwest Western Australia which is a globally dominant producer of iron ore, and the largest concentration of mining tyre use in the country. Various other minerals and precious metals are mined in the region in much lesser quantities, and there is some agriculture in the region.

For the purposes of a functioning catchment, we consider the Pilbara to be a region about 350km in diameter, between 150km and 450km south of Port Hedland (about the size of Tasmania). While an area this large may create concerns about high logistical costs, mining operations are densely clustered, with transport corridors and consolidation points helping to contain overheads.

Mining leases cluster around smaller inland settlements such as Newman, Tom Price and Marble Bar, but the industrial and logistical hub is Port Hedland. The major mining companies manage their own private rail networks to Port Hedland, from where they ship iron ore across the globe. This makes Port Hedland the busiest exporting port in the country in terms of tonnes of commodity loaded and shipped each year. Table 44 shows more details of the Pilbara catchment.

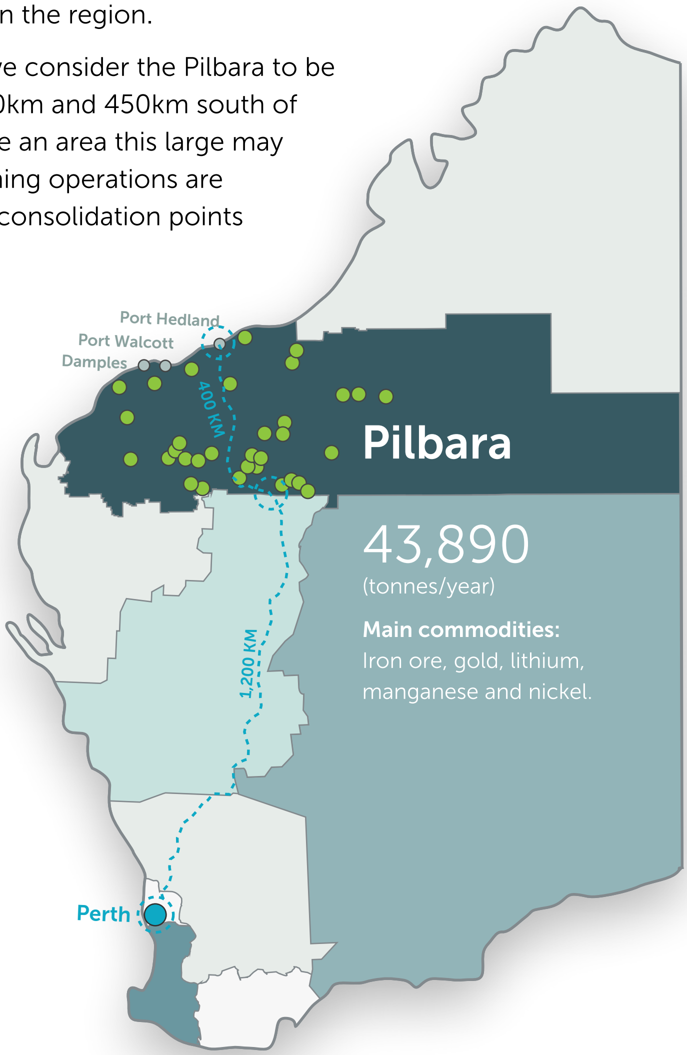


Figure 71: Pilbara catchment

Table 44: Selected features relevant to the generation and potential recovery of OTR tyres from the Pilbara catchment.

Catchment	Pilbara WA
OTR tyre generation (est.)	43,890 tonnes per year mining tyres, mainly from open-cut iron ore operations.
Assumed passenger car, bus and truck tyre quantities	Apart from Karratha (pop. 23,000) and Port Hedland (pop. 16,000), most of the remaining settlements in the region have populations less than 5,000. This places the overall regional population at about 50,000, which may represent in the order of 500 to 1,000 tonnes of automotive tyres per year.
Main commodities	Iron ore plus other minerals and precious metals in smaller quantities including gold, lithium, manganese and nickel.
Connectivity within catchment	Four major mining companies are established in clusters across the catchment which spans 350km in diameter, and typically operate their own separate road and rail corridors. Recent new entrants may be able to enter into agreements to use this existing infrastructure to haul iron ore from their new operations.
Distances to industry centres	A number of smaller townships function as hubs to nearby mine sites. The main industry centre servicing the iron ore sector is Port Hedland, about 150km to 450km away from mining operations (depending on distance south of Port Hedland). Port Hedland is itself 1,600km north of Perth by the Great Northern Highway. This road links through Newman, which itself about 1,200km from Perth, and passes through the iron ore mining catchment.
Distances to major ports	See distances set out above (i.e. to Perth and Port Hedland).
Supply of OTR tyres	Engagement with mining companies suggests OTR tyres are sourced directly from tyre brand importers, with third party logistics companies potentially providing transport assistance. OTR tyres may be sourced via Port Hedland or Perth, with the latter involving substantial road transport to deliver to mining sites.
OTR Tyre sizes	Assumed to be up to 63 inch rim size in mining sector, tending toward larger tyres (i.e. 57 inch rim size or greater).
Community & economic profile	The dominance of iron ore as a regional commodity has led to its being a major influence over the Pilbara region's economic activity. However, there is also nature-based tourism, energy (i.e. a major gas project on Barrow Island) and sheep and cattle grazing in the wider Pilbara region, alongside efforts to expand agriculture, renewable energy and other activities. A number of indigenous communities' traditional lands overlap with the catchment area, whose views need to be taken into consideration with regard to the management of tyres as well as other activities that may lead to impacts.
Known concerns	Disposing of OTR tyres in the Pilbara has not drawn high profile concern, but in recent years, there have been concerns and criticism of mining companies for their treatment of culturally important artefacts in the Pilbara region, including the destruction of the Juukan Gorge sacred cave site in 2020. As such, activities that impact the land more than agreed as necessary may be topics of sensitivity. A further protracted concern relates to risks of irreversible ecosystem and loss of biodiversity, in recognition of the unique biomes and endemic species in the region There has also been recognition that Pilbara townships have experienced significant underinvestment when weighed against the contribution that the region makes to the Australian and Western Australian economies. Measures to help retain investment in local economies, particularly where this leads to local employment and/or retention of financial capital in the Pilbara region may be positively received.

Features

This report estimates that the Pilbara generates about 44,000 tonnes of OTR tyres each year, mostly from the major mining companies. Some of these companies may generate as much tyre waste (by weight) as the next largest OTR tyre catchments. Exact figures for automotive tyres for this region are not available, but we estimated perhaps 500 to 1,000 tonnes of automotive tyres per year, based on the overall population.[93]

This makes a total catchment amount of about 45,000 tonnes per year of OTR and automotive tyres, or about 10% of the national total each year. With the planned expansion of mining operations in the Pilbara, this may increase over time.

With suitable market signals in place, a multi-year commitment of this amount could be enough to support one or more recycling facilities to turn tyres into shred, granule or crumb. This would require identifying a suitable site and end markets, given the distances to processing infrastructure based in Perth.

Table 45 looks at some key barriers to recovery in the Pilbara.

Table 45: Indicative barriers to the recovery of OTR tyres from the Pilbara catchment (details are illustrative, pending further engagement with catchment stakeholders).

Barrier	Nature and extent in Pilbara WA
Low regulatory pressure	Major mining sites are permitted to store and dispose of used mining tyres and rubber conveyors onsite in designated areas of the mine that are defined in the site environmental licence. Site environmental licence conditions are minimal compared to off-site landfilling requirements which include rules for: establishment, construction, filling, rehabilitation, aftercare, and monitoring. There are no state or national requirements to recover the tyre waste. The voluntary TPSS is not resourced to recover waste, nor empowered to mandate recovery.
Low cost of on-site disposal	Permitting on-site burial restricts the establishment of recovery alternatives, as recovery has to compete with low or no cost on-site management. Mining businesses may not accept the relative cost imposition voluntarily. Outside the 'Tyre Landfill Exclusion Zones' (i.e. around Perth), used tyres can be disposed to any licensed landfill, shredded or whole. No landfill levy would be likely for off-site landfills servicing areas generating used OTR products. Significant landfill operator gate fees are still charged. Permitting the off-site landfilling of used OTR products without a landfill levy and without shredding in WA also restricts the ability to establish recovery alternatives, as recovery businesses have to compete with low cost landfilling. However, this is less significant compared to on-site disposal as most landfill operators will still charge a premium gate fee for used OTR products.
Lack of nearby OTR tyre recovery service providers	The nearest fully-operating tyre recovery services are based in Perth, some 1,200 to 1,600km from mine sites in the Pilbara catchment. While there have been some attempts to establish services in the Pilbara, no fully-fledged service is presently active and able to process 45,000 tonnes in that location, though TyreCyle has recently announced investment in processing capacity in the region.
Unfamiliarity and uncertainty towards recovery solutions	Engagement with major mining companies in the Pilbara reveals that attempts are being made to understand the strengths and weaknesses of different tyre recovery options available from the market. However, these companies may face difficulty in independently verifying the commercial risks and ESG outcomes of each solution, and settling on a preferred option.
High OTR tyre recovery fees	The sizes and quantities of tyres arising from the Pilbara suggest that specialised equipment is needed, although the capital investment cost would be relatively low if the full amount of tyres were available for recovery. There may also be high transport costs if the recovery chain is partially based in Perth, although a local solution may be viable. In combination, it may be difficult to ascertain whether tyres from the Pilbara are any more costly to recover compared to automotive tyres recovered from a typical urban environment.

[93] This estimate is based on cross referencing with end-of-life tyre data applicable to similarly populated townships in Queensland.

Barrier	Nature and extent in Pilbara WA
High transport overheads	The question of whether transport costs are unduly high depends on whether a recycling facility is based in Port Hedland (for example) or further away such as in Perth. If tyre recovery takes place in Perth, transport costs may be high as the supply of OTR tyres to mining companies via Port Hedland and via Perth may limit the viability of a reverse logistics transport model that still has to transport tyre waste to Perth
Limited public scrutiny	The lack of visibility of OTR tyre disposal practices in the Pilbara may be a barrier, as it allows mining companies and issuers of mining licences to continue current practices without facing public pressure for those practices.
Lack of business prioritisation	Limited engagement with Pilbara mining companies indicates that they are aware that OTR tyre disposal is an unsatisfactory longer term issue, but there's no sense of urgency to address the issue. It's recognised that different solutions have different environmental outcomes, which may carry implications for what technologies and products are used.
Organisational barriers and procedural overheads	At present, it is difficult to gauge the extent that this is a barrier for mining companies in the Pilbara catchment. However, we have observed a general challenge for large mining companies that may have differing internal perspectives on tyre management approaches and opportunities.
Dispersed waste tyre feedstock	The generation of around 44,000 tonnes of end-of-life OTR tyres each year across four mining operators (i.e. with localised generation in the order of 10,000 to 15,000 tonnes) does not represent undue levels of dispersal.
Lack of investment confidence	From the viewpoint of a tyre processing company, entry into the catchment may be challenging without the certainty of having secured a large enough contract for recovery of tyre waste over multiple years. A single contract with a large company may be enough of a signal to drive investment in new or upgraded capacity. However, while on-site burial is permitted at low or no cost there is little opportunity for recovery businesses to offer an attractive recovery solution.
Uncertain end markets for recovered products	Recovering all 44,000 tonnes of OTR tyres would require a major lift in tyre-derived material entering domestic end markets (e.g. the markets for crumb and granule in WA roads or as TDF). Market research and market development is needed to ensure that this quantity can be absorbed. This may be a lesser issue for exported products, although trade risks should be recognised.
Limited opportunity to test and refine offerings	Tyre recovery operations have had success in engaging and testing service propositions with mining companies based in the Pilbara. A service model may be tested and refined over successive discussions.

Priorities

This analysis reveals some priorities in the Pilbara catchment, such as:

- limited regulatory pressure to recover mining tyres or move towards recovery over in-pit burial
- the low cost of on-site disposal, which is related to the above regulatory environment
- high costs to transport tyres to Perth, although processing facilities in Port Hedland would mitigate this
- moderate levels of prioritisation from mining companies in the region, but little urgency
- uncertainty about the ability of tyre recovery businesses to offload products from 44,000 tonnes of OTR tyres and 1000 tonnes of automotive tyres each year, and the potentially destabilising market impacts.

Scrutiny and public criticism of relying on OTR tyre disposal is modest, perhaps due to more pressing and elevated concerns with the damage and destruction of First Nations cultural assets, risks to endemic biodiversity and underinvestment in Port Hedland and other townships. Table 46 shows a set of actions for TSA and third parties to consider, that try to reduce the effects of these barriers. They are provisional, and will need to be carefully planned and sequenced.

Table 46: Potential roles of TSA and other parties in overcoming key barriers to the recovery of OTR tyres from the Pilbara catchment.

TSA actions	Third party actions
Barrier: Low regulatory pressure	
TSA advocate for and provide evidence towards reforms/ updates to Western Australian and national regulations and licence conditions based on: • the costs and benefits of different recovery options for mining tyres relative to business as usual practice • the viability of OTR tyre recovery solutions tailored to the region • the need to strengthen incentives for mining companies to move to recovery rather than disposal, in line with the level of incentive applied to automotive tyres. **TSA** engage with indigenous people and local communities on the impacts of mining tyre disposal on their cultural values and assets and integrate findings into broader advocacy strategy.	These Western Australian government departments: • **Department of Mines** • **Industry Regulation and Safety** • **EPA** • **Waste Authority** • **Department of Water and Environmental Regulation (DWER)** consider imposing higher standards on disposal of mining tyres and give more clarity on disallowing disposal of mining tyres on-site. **Chamber of Minerals and Energy WA (CME)** help support collaboration between mining companies, TSA and regulators on minimally disruptive and commercially feasible pathways to encourage increased recovery of OTR tyres.
Barrier: Low private cost of on-site disposal	
TSA work with mining companies and communities to understand the true cost of disposal and limited uptake of circular economy approaches to managing tyres, including: • cost of hidden risks and liabilities that this practice fails to account for • external costs transferred to the community and the environment • commercial and environmental opportunity costs during production, use, and disposal/recovery phases **TSA** coordinate business cases and trials to better understand recovery and circular economy options that provide an efficient solution to OTR tyre generators in the catchment – to serve as an evidence-based comparison to disposal	**Mining companies** in the catchment to: • engage with TSA on options to align with corporate ESG values and commit to tyre recovery goals • explore options with suppliers and TSA on ways to extend the working lifespan of mining tyres, including repair, re-tread, revised specifications and revised use and management; • integrate these options into procurement terms and conditions, and incorporate into internal procedures • explore circular economy models and related commercial arrangements with tyre suppliers to lower impacts from the use of OTR tyres • evaluate recovery services for end-of-life mining tyres and conveyor belts • progress towards mining tyre recovery as standard practice across operations. **MCE** to engage with mining companies on the ESG aspects of mining tyres and conveyor belts, and help them find expertise on options. **Tyre brands and supply chain** explore business models and service inclusions with their mining company customers, in line with 'higher order' circular economy outcomes. Provide transparency on impacts of tyre production and supply chains.

TSA actions	Third party actions
Barrier: High transport overheads associated with long distances to potential recovery services	
TSA to engage with parties who could reduce transport costs or provide cost-efficient logistics in the catchment to reduce transport barriers. **TSA** to support OTR tyre transport trials to gather evidence on costs, storage and handling issues, OH&S factors, GHG emissions and other variables.	OTR tyre logistics, transport and handling businesses to: • explore options with customers and tyre importers to perform reverse logistics, storage and related services needed to recover OTR rubber products • partner with TSA on potential trials and end market product development.
Barrier: Lack of business prioritisation	
TSA to continue to engage with relevant parts of mining businesses to promote improving the management and stewardship of OTR tyres over their lifecycles.	**Mining companies** to: • engage with TSA and other stakeholders on an approach to brings a high standard of tyre stewardship into operations (e.g. on-site, procurement, reporting and other responsibilities), and set goals to this end • set out a longer term plan to achieve these goals, working with TSA and other parties where necessary.
Barrier: Uncertainty in tyre recovery businesses being able to offload product	
TSA to: • research the ability of domestic and international markets to absorb the amount of tyre-derived materials from the Pilbara • advise tyre recovery businesses and mining companies • engage in market development as suitable. Note: This may include novel technologies and applications associated with a 'tyres into tyres' circular economy.	**Tyre recycling businesses** to consider a commercially-suitable way to report to **mining companies** the quantity of different products derived from their tyres, and the markets to which they are sold, and to notify the extent and reasoning for any disposal of material to landfill. **Mining companies** to engage with TSA on preferred near-to-longer term tyre recovery outcomes, including ESG performance expectations and tolerances towards end-market risk (i.e. if market conditions prevent or disrupt the recovery and use of tyre-derived materials).
Barrier: Limited public scrutiny and pressure	
TSA to liaise with priority groups, indigenous people and local communities on appropriate paths to engage Pilbara mining companies towards OTR tyre recovery models.	Indigenous people, local communities, and land protection NGOs to engage with TSA on: • cultural values and assets • the potential impact of disposing mining tyres on those values and assets • continue to hold mining companies to account on the impacts of on-site disposal of mining tyres.

Opportunities: the Pilbara as a priority catchment

The Pilbara produces about 10% of all tyre material in the Australian economy each year, so all stakeholders with a national interest in tyre recovery should prioritise this catchment. The sheer amount of material suggests economies of scale that could substantially reduce capital costs per unit tonne recovered, both for established technologies and newly commercialising technologies (see Chapter 4).

In taking on these actions, there should be a level of confidence that a tyre recovery solution is technically workable and commercially justifiable for the Pilbara catchment.

Some strategic questions that need to be resolved in addressing this catchment include:

- what degree of coordination is needed to have the major mining companies agree on a solution for the catchment, to ensure the working capital for recovery is used efficiently
- where to place this infrastructure to balance supply chain components including handling, transport, processing and shipping products to end markets, given evolving levels of ambition in tyre recovery and outcomes
- how to reduce transport costs as far as possible, noting that tyres may be shipped to the Pilbara from Port Hedland and Perth, which may affect reverse logistics opportunities
- what strategy in developing and selling end products gives the mining companies greatest confidence that the tyre material is being fully recovered, to a standard that accords with their ESG obligations and stakeholder expectations
- what support the mining companies need over the longer term, for those that seek to realise an ambitious agenda towards a circular economy for their tyres.

A coordination model

These questions point to the value of a coordinated approach to stewardship of OTR tyres from the Pilbara over the longer term. While respecting concerns about commercial confidentiality and market collusion, a coordination model may be the most efficient and least disruptive way to put the catchment on a stable path towards a circular economy for OTR tyres. There are numerous examples of mining companies in Australia & globally overcoming these concerns to work collaboratively on research, trials, and other significant projects. These offer an existing model of collaboration that could be replicated.

This could start with tyre recovery using commercial technologies currently available in the Australian market. Over the medium-to-long term, the coordination model could introduce new technologies and services, based on superior ESG and/or circular economy results.

The model could coordinate wider circular economy approaches to help Pilbara mining companies and their tyre supply chains to adopt:

- procedures that extend the operating life of OTR tyres, including guidance on driver best practice and protocols to improve maintenance, repair and re-tread practices
- specifications and tyre innovations to improve durability in response to Pilbara conditions
- preferential procurement of OTR tyres that include a level of recycled content
- service model innovation, including potentially reverse logistics requirements, product takeback, or product leasing models
- revised lay out and road construction methods to lessen tyre wear and damage rates.

10.2.2 Hunter Valley and Northern NSW (NSW)

The Hunter Valley and Northern NSW catchment is heavily dominated by tyres from coal mining activity, with some coming from agricultural activity. There is limited broadacre cropping in the region compared to elsewhere in New South Wales, although there is significant cotton production in the west and winemaking in the Hunter Valley.

The mining interests mainly cluster in the Singleton, Muswellbrook, Gunnedah and Narrabri local government areas, and are joined through a single 400km northwest inland route from Newcastle. A smaller scale of coal and gold mining takes place on the edge of this area, towards the eastern and southern parts of the catchment.

Table 47 summarises the key details of the catchment.

Figure 7J: Hunter Valley and Northern NSW catchment

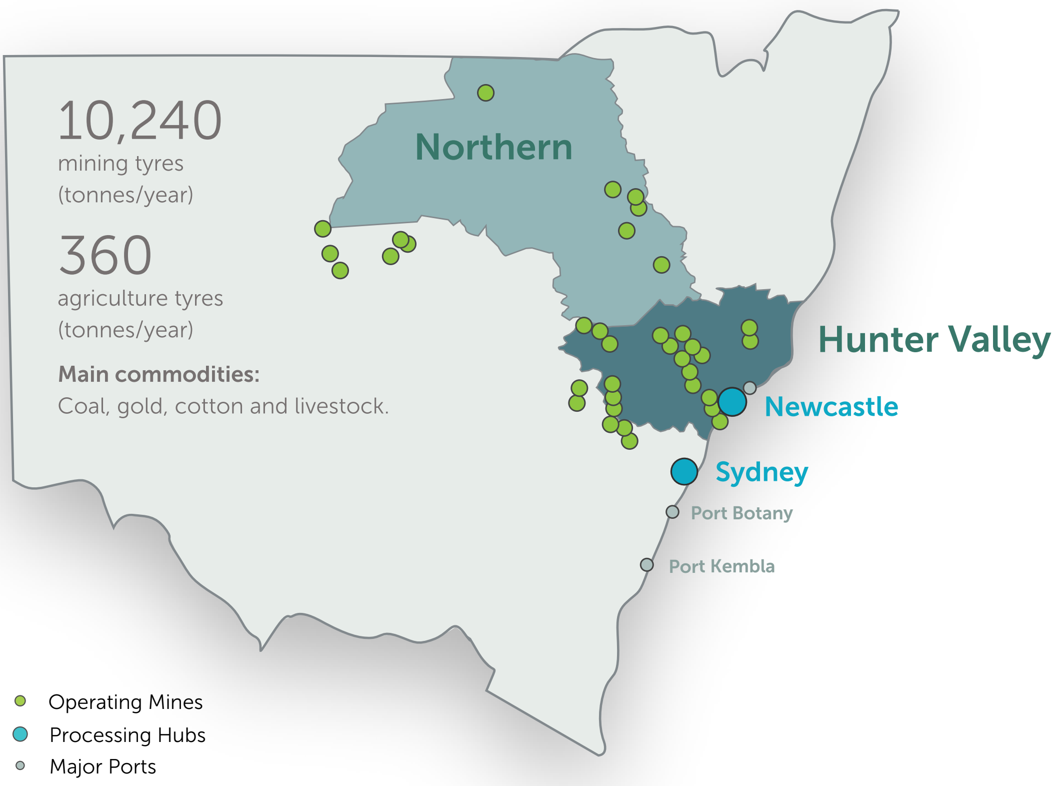


Table 47: Selected features relevant to the generation and potential recovery of OTR tyres from the Hunter Valley & Northern NSW catchment.

Catchment	Hunter Valley and Northern NSW
OTR tyre generation (est.)	10,240 tonnes per year mining tyres, mainly from open-cut operations. 360 tonnes per year agriculture tyres.
Assumed automotive tyre quantities	9,000 tonnes. Large urban centres towards Newcastle and across the catchment suggest a population of around 900,000. Assuming 10 end-of-life tyre tonnes per 1,000 population, we estimate automotive tyre amounts at 9,000 tonnes per year.
Main commodities	Coal, gold, cotton, livestock, other minerals and agriculture products.
Connectivity within catchment	Major coal mines clustered in four LGAs, joined through a single northwest inland route spanning 300km
Distances to industry centres	Narrabri is 400km from Newcastle and 540km from Sydney. Singleton is 100km from Newcastle and 200km from Sydney.
Distances to major ports	400km from Narrabri to Port of Newcastle. 540km from Narrabri to Port Botany.
Supply of tyres	Assumed to be via Port of Newcastle or other NSW port, via road networks. Mining tyres assumed to be supplied directly from importers. Agriculture tyres assumed to be supplied from wholesale and retail networks.
Tyre sizes	Up to 63 inch rim size in mining sector, tending toward larger tyres. A wide range of agriculture sizes given, e.g. cotton, livestock, viticulture and other industry presence.
Community & economic profile	Hunter is characterised by mixed industrial base, e.g. agriculture and other primary industries, manufacturing, coal mining, gold, tourism, and services (healthcare, education, etc.) Towards northern NSW, the community and economy profile becomes more agrarian, with a network of townships supporting primary industries. Multiple Aboriginal Land Councils overlap with major areas of OTR tyre generation from mining and agriculture industries.
Known concerns	Current mining practices involve the disposal of tyres in pits and near state forests, which has contributed to significant opposition to coal mining in the region from indigenous people and local communities. The NSW EPA presently expects coal miners in the catchment to review options for recovering their mining tyres on a two-year basis, on the understanding that the licence to dispose will be retracted when a commercially viable solution becomes available. The NSW EPA also monitors and enforces tyre disposal activities in and near mining operations across the state.

Features

Estimates in this report suggest this catchment generates about 10,600 tonnes of end-of-life OTR tyres each year, mostly from the four coal mining districts extending northwest of Newcastle. About ten companies own and operate the coal mines across the area, and are a blend of smaller local operators and global mining companies. Evidence suggests that mining operations in the area use in-house and third-party mining tyre inspection, maintenance, and repair services.

Exact figures for automotive tyres in the region are not available, but we estimated about 9,000 tonnes of automotive tyres reach their end-of-life each year, based on the population.[94]

This puts the total catchment at about 20,000 tonnes per year, 55% of this being OTR tyres. This may be sufficient material to attract new investment in tyre collection and processing infrastructure. (as set out in Chapter 4), or expand an existing facility.

There are substantial tyre recovery operations in and near Sydney, 200km south of Singleton, the nearest major coal mining area, and some tyre recovery capacity in Newcastle (100km from Singleton), although the scale of this operation has not been investigated in detail. The recovery facility in Newcastle uses tyre-derived material as an input to a range of metal products, including components used in the mining sector. Its incorporation into a tyre recovery supply chain for mining tyres could constitute a form of circular economy for participating mining companies. To do so would require facility upgrades to be able to process large OTR tyres.

Both Sydney and Newcastle have the capacity to support heavy industry and manufacturing, and are major ports offering opportunities for domestic and export market development.

These factors and the barriers described in Chapter 5 gives a picture of the key challenges to shift to OTR tyre recovery in this catchment. Table 48 provides a high-level view of key barriers specific to this catchment.

[94] This estimate is generated from a combination of population estimates for the Hunter Valley and Northern NSW regions and an approximate generation rate of 10 tonnes per year of end-of-life passenger car, bus and truck tyres per thousand people. This rate is based on an analysis of tyre volumes and populations derived from a sampling of townships from elsewhere in Australia.

Table 48: Indicative barriers to the recovery of OTR tyres from the Hunter Valley and Northern NSW catchment (details are illustrative, pending further engagement with catchment stakeholders).

Barrier	Nature and extent in Hunter Valley & Northern NSW
Low regulatory pressure	A review of mining environmental licences in Jan 2023 found no reference to used or waste tyres or conveyors, and no reference to on-site burial requirements. In August 2021, NSW EPA investigated six coal mines, finding that all six mines had buried their tyres without the necessary licence conditions. Unlike Qld and WA licences, the NSW EPA mining licences reviewed do not include specific licence conditions that allow for on-site tyre, track and conveyor belt disposal on-site. While these licence conditions are not in place, it is unclear if on-site burial is permitted in NSW or not. This regulatory ambiguity does not encourage recovery, and may present a risk for mining companies if they are subject to EPA investigations. Compliance enforcement to prevent dumping or stockpiling of agriculture tyres appears to be limited, leading to widespread anecdotal reporting of dumping and stockpiling on farmland. There are no state or national requirements to recover the tyre waste. The voluntary TPSS is not resourced to recover waste, nor empowered to mandate recovery.
Low cost of on-site disposal	The practice of on-site burial of used OTR products in NSW (permitted or not) restricts the ability to establish recovery alternatives, as recovery has to compete with effectively 'no cost' on-site disposal. In NSW, the significant 'waste levy' (or landfill levy) applies in the regulated areas of NSW. Key mining areas, such as the Hunter Coal field, are located mostly within the 'regional levy area'. If tyres, tracks, and conveyors were to be landfilled off-site from mines in these areas, the landfilling fees would be significant (the waste levy plus the landfill operator gate fees). In NSW whole tyres cannot be landfilled in metropolitan areas. In regional areas disposal of tyres to landfill is at the discretion of local government and may require shredding before landfilling. Where waste tyres require shredding before landfilling off-site, it would add another significant cost (compared to disposal whole into the mine void, or on farm). The absence of licence conditions permitting on-site disposal and the potentially very high costs of landfilling off-site in NSW should be of concern to mining operations disposing used OTR products on-site in NSW.
Lack of nearby OTR tyre recovery service providers	This may be a moderate barrier, given that Newcastle recovery and processing facilities may not be positioned to recover OTR tyres yet, and Sydney is up to 540km from Narrabri.
Unfamiliarity and uncertainty towards recovery solutions	The regulatory onus on mining companies to look into tyre recovery options suggest that the sector has some awareness of solutions. There has been limited exposure of farmers to potential tyre recovery options. Some farmers have voiced interest in being able to recycle tyres.
High OTR tyre recovery fees	OTR tyre recovery fees may only be slightly higher compared to automotive tyres due to large catchment generation and the means to spread capital costs for some operations across an amount automotive tyres.

Barrier	Nature and extent in Hunter Valley & Northern NSW
High transport overheads	For mining tyres from Muswellbrook or Singleton, the cost to transport is moderate because of short distances to Newcastle or Sydney. Transport costs are higher for tyres from Gunnedah and Narrabri, and there may be a need to process tyres into smaller pieces and/or employ reverse logistics to lower transport costs.
Limited public scrutiny	Scrutiny on the management of mining tyres in the catchment is high, given broader concerns about the coal mining sectors and historic dumping in state forests. Disclosure of burial amounts is set as a licence condition.
Lack of business prioritisation	Regulation requires mining companies to prioritise finding a solution, but this may be driven by a need to be seen to comply rather than taking ownership of the problem.
Organisational barriers and procedural overheads	At present, it is difficult to gauge the extent that this is a barrier for coal mines in the Hunter Valley and Northern NSW catchment. However, we have observed a general challenge for large mining companies that may have differing internal perspectives on tyre management approaches and opportunities.
Dispersed waste tyre feedstock	The pattern of end-of-life mining tyre is not overly dispersed across the catchment – four main clusters are linked by a major regional road corridor.
Lack of investment confidence	From the viewpoint of a tyre processing company, entry into the catchment may be challenging without the certainty of having secured a large enough contract for recovery of tyre waste over multiple years. A single contract with a large company may be enough of a signal to drive investment in new or upgraded capacity.
Uncertain end markets for recovered products	If an additional 10,600 tonnes of OTR tyre material entered the NSW processing market, this would provide capacity for investment in more processing facilities. The proximity to major ports in Newcastle and Sydney offers an easier opportunity for this material to enter export markets. Nonetheless, if it were used in NSW roads then much or all of this material could be absorbed by the domestic market for recovered products.
Limited opportunity to test and refine offerings	As this catchment is close to Newcastle and Sydney, tyre recovery operators are assumed to be able to engage with mining companies on solutions if they have mutual will. The current exemption from on site burial prohibitions may have led to tyre recovery operators deprioritising the business opportunity.

Table 49: Potential roles of TSA and other parties in addressing barriers to the recovery of OTR tyres from the Hunter Valley & Northern NSW catchment.

TSA actions	Third party actions
Barrier: Low regulatory pressure	
TSA to advocate and give evidence for reforms/updates to NSW and national regulations and licence conditions based on: • the costs and benefits of different recovery options relative to BAU practice • the viability of OTR tyre recovery solutions tailored to the region • the need to strengthen incentives for mining companies and agriculture businesses to recover rather than dispose of OTR tyres, with the same level of incentive as automotive tyres. **TSA** to engage with indigenous people and local communities on the impacts of mining tyre disposal on their cultural values and assets and integrate findings into broader advocacy strategy	EPA NSW and Department of Regional NSW to consider: • increasing standards on disposal of mining tyres • providing more clarity on a near term path to disallow disposal of mining tyres on-site • setting guidelines for using or recovering end-of-life agriculture tyres beyond amounts needed for on-farm applications. **Commonwealth Government** to consider setting advanced recovery fees for tyre types and uses where there is limited take up of tyre recovery services in response to tightened regulations. **NSW Minerals Council** to support collaboration between its members, TSA, and regulators on commercially-viable approaches to increasing mining OTR tyre recovery. **Farming peak bodies to** liaise between farming communities and TSA and NSW EPA on ways to encourage agriculture tyre recovery.
Barrier: Low private cost of on-site disposal	
TSA to work with mining companies and the agriculture sector, and communities to understand true cost of disposal and limited uptake of circular economy approaches to managing tyres, including: • cost of hidden risks and liabilities that this practice fails to account for • external costs transferred to the community and the environment in Hunter Valley and Northern NSW • commercial and environmental opportunity costs during production, use, and disposal/ recovery phases **TSA** to coordinate business cases and trials to better understand recovery and circular economy options for OTR tyre generators in the catchment – to provide an evidence-based comparison to disposal	**Mining companies** in the catchment to: • engage with TSA on options to align with corporate ESG values and commit to tyre recovery goals • explore options with TSA and suppliers on ways to extend the working lifespan of mining tyres, including repair, re-tread, revised specifications and revised use and management • integrate these with procurement terms and conditions and incorporate into internal procedures • explore circular economy models and related commercial arrangements with tyre suppliers to lower impacts from the use of OTR tyres • explore and evaluate recovery services for newly arising and stockpiled end-of-life mining tyres and conveyor belts • move towards mining tyre recovery as standard practice across operations where this is viable. **NSW Minerals Council** to support collaboration between its members, TSA, and regulators on environmentally-sound approaches to mining OTR tyre management. **Farming peak bodies** to: • help drive participation in regional pilots and ongoing services • help TSA prepare guidelines and education material to promote best practice use of agriculture tyres . **Tyre importers and supply chain to** explore business models and services with their mining company customers, in line with 'higher order' circular economy outcomes. Provide transparency on impacts of tyre production and supply chains.

TSA actions	Third party actions
Barrier: Lack of nearby OTR tyre recovery service providers	
TSA to share business case and related engagement with tyre recycling businesses and third parties who may invest or help drive investment in catchment-appropriate solutions.	**Tyre recycling businesses** to consider: • engaging with TSA on commercial needs so they can confidently invest in the catchment • seeking funding to upgrade facilities, build new facilities or invest in equipment to receive OTR tyres • engaging with TSA on the concerns and opportunities of end markets for tyre-derived materials • engaging with mining companies on options to deliver on 'higher order' circular economy outcomes. **EPA NSW** to provide public notice of regulatory changes that would encourage new tyre recovery services to the catchment. **NSW Minerals Council** to engage with coal mining companies at the catchment scale to encourage tyre recovery economies and help drive interest from tyre recovery services. **Councils** and **joint authorities** to similarly encourage investment in the catchment. **NSW Department of Planning & Environment** to offer funding for new tyre processing capacity where appropriate and eligible within grant programs.
Barrier: High transport overheads	
TSA to engage with parties who could reduce transport costs and/or provide cost-efficient logistics in the catchment to reducing transport barriers. **TSA** to support end-of-life OTR tyre transport trials to provide evidence on costs, storage and handling related issues, OH&S factors, GHG emissions and other variables that may affect a sustained transport model.	**OTR tyre retail, logistics, transport and handling businesses** to explore options with customers and tyre importers to perform reverse logistics, storage and related services necessary for recovering end-of-life OTR tyres. Partner with TSA on potential trials. **Farming produce supply chains and cooperatives** and **councils and joint authorities** to explore options to use receival points, transfer station networks and depots as agriculture tyre drop-off points. **Peak bodies in the agriculture sector** to provide education and guidance on how to move from on farm disposal and long-term stockpiling to recovery using a network of drop-off points. If an advanced recycling fee system is implemented, **NSW Government** to introduce a registration and tracking system for legitimate tyre drop-off points.
Barrier: Lack of business prioritisation	
TSA to continue to engage with relevant parts of mining businesses to promote the management and stewardship of OTR tyres over their lifecycles.	**Mining companies** to: • engage with TSA and other stakeholders on ESG goals to internalise a high standard of tyre stewardship into operations (i.e. on-site, procurement, reporting and other responsibilities), and set appropriate goals • set out a longer-term plan to achieve these goals, working with TSA and other parties where necessary.
Barriers: Limited public scrutiny and pressure	
TSA to liaise with indigenous people, local communities, and Aboriginal Land Councils on ways to shift mining companies towards suitable OTR tyre recovery models.	**Aboriginal Land Councils** and **land protection NGOs** and **other parts of the community** continue to hold mining companies to account on the impacts of on-site/state forest land disposal of mining tyres.

Priorities

This analysis reveals some priorities to address in the Hunter Valley and Northern NSW catchment, such as:

- limited regulatory pressure to recover mining tyres
- low cost of on-site disposal, which is related to the above regulatory environment
- limited tyre recovery services nearby that provide a fully-integrated solution for all processing steps for large OTR tyres
- high transport costs, mainly due to challenges in handling large tyres, rather than long distances
- low levels of prioritisation of OTR tyre recovery as standard practice, which appears to link to the low regulatory pressure encouraging recovery and discouraging dumping or stockpiling
- scrutiny and public criticism around the prevailing reliance on OTR tyre disposal, which although present, does not create enough pressure to force a change in practice.

Table 49 shows a set of actions for TSA and third parties to consider, that try to reduce the effects of these barriers. They are provisional, and will need to be carefully planned and sequenced.

Opportunities

The table suggests that, with enough drive, interest, and capacity to work together, there is a path to recover mining tyres and agriculture tyres from the Hunter Valley and Northern NSW catchment *en masse*.

The pattern of mining and agriculture tyre usage across the catchment suggests a level of reverse logistics—potentially of whole mining tyres—to a recovery facility in Newcastle or Sydney, along with a network of drop-off points for agriculture tyres to be consolidated for transport to a recycler. We cannot claim that this solution is optimal or definitive without a more detailed analysis and engagement with catchment stakeholders.

10.2.3 **Bowen Basin (Qld)**

The Bowen Basin catchment in Queensland, like the Hunter Valley and Norther NSW catchment, has a large cluster of coal mining operations throughout. The Fitzroy Basin, which overlaps the Bowen coal mining region, is Australia's largest beef cattle region by commodity value and includes other agricultural activity such as broadacre cropping and horticulture.

Table 50 summarises key details of this catchment.

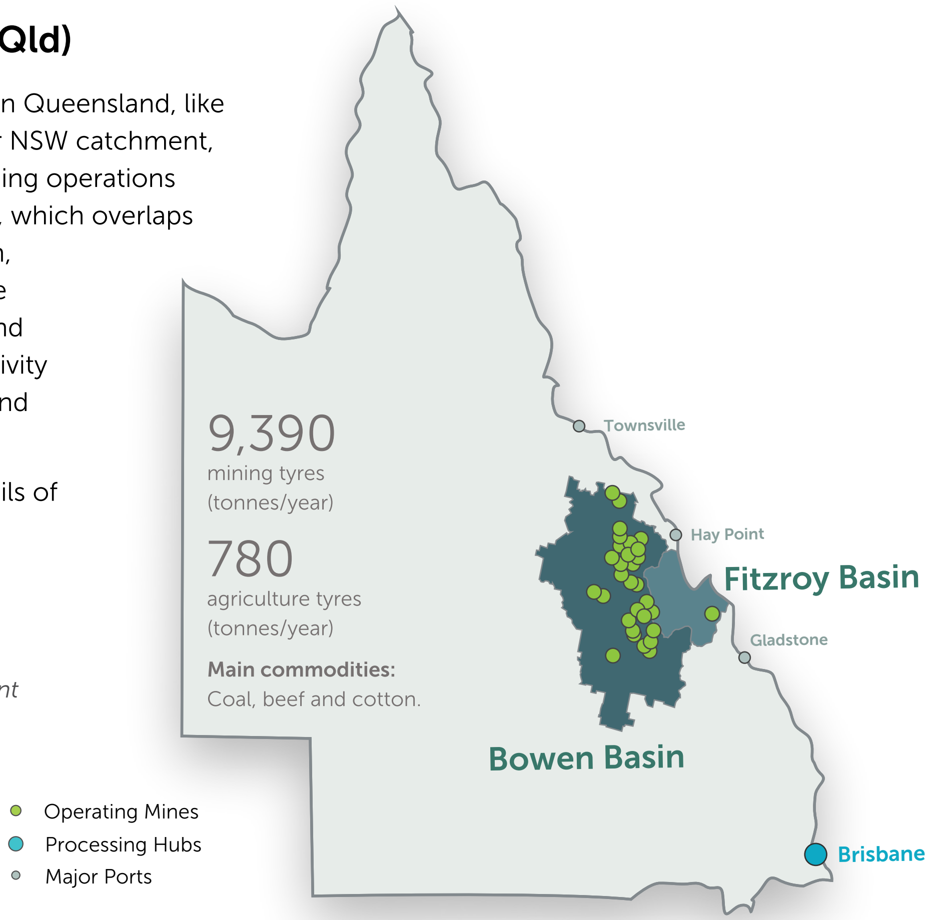


Figure 7K: Bowen Basin catchment

Table 50: Selected features relevant to the generation and potential recovery of OTR tyres from the Bowen Basin catchment.

Catchment	Bowen Basin Qld
OTR tyre generation (est.)	9,390 tonnes per year mining tyres, mainly from open-cut operations. 780 tonnes per year agriculture tyres.
Assumed automotive tyre quantities	4,500 tonnes, based on Queensland waste tracking data and size of large coastal population centres including Yeppoon, Mackay, Gladstone, and Rockhampton. At present, these are likely to be recovered through existing tyre recovery services in southeast Queensland.
Main commodities	Coal, beef, cotton, other minerals and agriculture products.
Connectivity within catchment	There is a large network of coal mines spanning a 300km north-south axis, connected through a series of road networks and bulk commodity rail lines.
Distances to industry centres	The southern end of the catchment (around Blackwater) lies 200km west of Rockhampton and 300km west of Gladstone. Towards the northern end (Moranbah), the catchment is about 200km from Mackay, via major regional roads.
Distances to major ports	In the catchment's north, the road/rail distance to Port of Mackay is 200km. In the catchment's south, the road/rail distance to Port of Gladstone is 300km, and to the Port Alma Shipping Terminal (Port of Rockingham) is 240km.
Supply of tyres	Supply of mining tyres is yet to be confirmed but is understood to be a combination of shipping entry points (Gladstone, Mackay and southeast Queensland) and surface freight to individual coal mines. Tyres used on agriculture vehicles involves a combination of wholesalers and the retail tyre network.
Tyre sizes	Up to 63-inch rim size in mining sector, tending toward larger tyres. A wide range of agriculture sizes given, e.g. cattle, broadacre cropping including cotton and other industries present.
Community & economic profile	While there are major coal mining and agriculture interests across the catchment, the coastal areas have diversified economies and more built-up population centres than in the Bowen Basin. There are large industrial precincts in and near major centres such as Mackay, Gladstone and Rockhampton, including the Gladstone State Development Area.
Known concerns	The Queensland Government Department of Resources recently released its Queensland Resources Industry Development Plan, which seeks to modernise and improve the ways in which resources are extracted and processed in the Queensland economy. This industry plan carries implications for the management of mining and agriculture tyres used in the Bowen Basin and elsewhere across the state. Key priorities include improving the impacts on and opportunities for local communities; becoming a global leader on internalising ESG principles into operations; and incorporating partnerships with indigenous people and local communities.

Features

This report estimates that this catchment generates about 10,170 tonnes of OTR tyres each year, mostly from coal mining across the Bowen Basin. Similar to the Hunter Valley and Northern NSW catchment, coal mine operations are spread across a number of smaller and larger operators. A mixture of agriculture interests, centred on the Fitzroy Basin, leans strongly towards the beef industry and also generates a significant amount of agriculture tyres.

Waste tracking data from the Queensland Government allows an estimate of about 4,000 to 4,500 tonnes of automotive tyres, mainly from coastal cities and townships. Many of these tyres are likely to be recovered through operations in Mackay and in southeast Queensland. Tyre processing facilities in southeast Queensland are around 600km from the southernmost larger townships neighbouring the Bowen Basin catchment (e.g. Gladstone).

The total generation of end-of-life tyres in or near the catchment is around 14,000 tonnes per year (70% of which are OTR tyres), which could potentially support investment in a regional processing capacity.

The Queensland Government released its *Queensland Resources Industry Development Plan* in June 2022,[95] recognising the need for this sector to play a greater role in achieving a net zero greenhouse gas emissions transition for the state's economy, and to minimise the harmful effects of the sector.

A key outcome for this plan is for the Queensland resources industry to be *'known globally as an ESG leader and recognised as safe, high-wage, environmentally-responsible, and well-regulated, with a strong focus on genuine partnerships with First Nations peoples and sustainable community legacy.'*

Table 51 provides a high-level view of some key issues for this catchment. As with the Hunter Valley and Northern NSW, most OTR tyres generated in the catchment come from mining activity. Also to be expected, there are some broad similarities with the pattern of barriers identified for that catchment (see Section 10.2.2).

[95] Queensland Government, Queensland Resources Industry Development Plan, 2022. https://www.resources.qld.gov.au/qridp/about

Table 51: Indicative barriers to the recovery of OTR tyres from the Bowen Basin catchment (details are illustrative, pending further engagement with catchment stakeholders).

Barrier	Nature and extent in Bowen Basin Qld
Low regulatory pressure	In Qld, used mining tyres, tracks, and conveyors (as 'rubber wastes') are all permitted to be disposed of on-site. Mining environmental licences require a waste management plan that includes: records of the amount and locations of rubber waste disposal; identification of the potential risks to the environment from disposal and control measures in place; how rubber wastes will be managed in accordance with the waste management hierarchy (avoided, reused, recycled, energy recovery, and disposal). As OTR tyre reuse (via retread) and recycling is being established at remote mining locations around the world, it is more difficult for mining sites in Qld to demonstrate that disposal on-site is a satisfactory implementation of the waste management hierarchy. Other than obligations under the waste hierarchy described above, there are no state or national requirements to recover the tyre waste. The voluntary TPSS is not resourced to recover waste, nor empowered to mandate recovery.
Low cost of on-site disposal	Permitting the onsite burial of used OTR products in Qld restricts the ability to establish recovery alternatives, as recovery businesses must compete with low or no cost on-site management. If tyres, tracks, and conveyors were landfilled off-site the total landfilling fees would be significant. Landfill levies apply for off-site waste tyre disposal at licensed landfills in Qld within the 'levy zone'. The Environmental Protection Regulation 2019 sets the price per tonne for tyre waste landfill. Key mining areas of Qld, such as the Bowen Basin, are located within the levy zone. A review of several current landfill licenses in Qld found that tyres are often required to be shredded before landfilling at some, but not all, licensed landfills. This would add another significant cost if OTR tyres were required to be disposed offsite, rather than in a mine void, or on farm.
Lack of nearby OTR tyre recovery service providers	Nearby tyre recovery operators (e.g. in Mackay) may not be processing many OTR tyres, and lack the equipment needed to process large numbers. Other commercial processors in southeast Queensland may also lack suitable equipment to process around 9,000 tonnes of large mining tyres, as well as being affected by longer distances to the Bowen Basin.
Unfamiliarity and uncertainty towards recovery solutions	We understand some mining companies in the Bowen Basin have engaged with tyre processing services and potential end-market buyers, but a broader knowledge of solutions is lacking across other coal mining companies. There has been limited exposure of farmers to potential tyre recovery options, so they may have a poor understanding of options available.
High OTR tyre recovery fees	OTR tyre recovery fees may only be slightly higher than automotive tyre fees due to large catchment generation, and the means to spread capital costs for some operations across an amount of automotive tyres.
High transport overheads	Noting that the Bowen Basin catchment for agriculture tyres and mining tyres is about 200km from major industrial centres in Mackay and Gladstone, and is well serviced by road and rail networks, transport distances may not be a major issue leading to high transport overheads. Transport overheads may be reduced if near-site reduction or reverse logistics approaches are used.
Limited public scrutiny	It is not clear that the issue of on-site tyre disposal or indefinite stockpiling is drawing significant public attention.
Lack of business prioritisation	There is no evidence that mining companies and farmers (e.g. graziers and cotton plantation managers) are prioritising tyre recovery.
Internal barriers and procedural overheads	At present, it is difficult to gauge the extent that this is a barrier for coal mines in the Bowen Basin catchment.

Barrier	Nature and extent in Bowen Basin Qld
Dispersed waste tyre feedstock	End-of-life mining tyres are dispersed due to the spread of operations across the Bowen Basin. Agriculture tyres may be similarly dispersed, requiring efficient collection and consolidation solutions.
Lack of investment confidence	From the viewpoint of a tyre processing company, entry into the catchment may be challenging without the certainty of having secured a large enough contract for recovery of tyre waste over multiple years. A single contract with a large company may be enough of a signal to drive investment in new or upgraded capacity. This uncertainty level is mitigated by the lower investment costs from closer industrial centres and transport infrastructure.
Uncertain end markets for recovered products	If an additional 10,170 tonnes of OTR tyre material entered the Qld processing market, this would provide capacity for investment in more processing facilities. The major ports in Cairns or Brisbane offer an opportunity for this material to enter the export market, but present a logistical challenge that may require processing to occur in regional centres like Mackay or Gladstone before transport by road or rail to port. Nonetheless, if it were used in Qld roads then much or all of this material could be absorbed by the domestic market for recovered products.
Limited opportunity to test and refine offerings	The catchment is at a moderate distance from Mackay and southeast Queensland, so tyre recycling operators are assumed to be able to engage with mining companies to work through potential solutions. Weak incentives to recover tyre waste may have prevented tyre recovery operators from prioritising the opportunity in recycling mining tyres.

Priorities

This analysis shows some priorities to address in the Bowen Basin catchment, such as:

- limited regulatory pressure to recover mining and agriculture tyres, noting that the Department of Resources' Queensland Resource Industry Development Plan shows willingness to use regulation to help make the mining sector an ESG leader (in general terms, without specific mention of how to manage
end-of-life tyres)
- the low cost of on-site disposal, which is related to the above regulatory environment
- limited awareness of mining and agriculture tyre recovery options and their commercial viability, which in part may be due to a lack of social and regulatory imperatives
- limited tyre recovery services that are nearby and can process large mining tyres
- transport costs, noting that this may mainly be caused by the difficulties of handling large tyres rather than long distances (e.g. to Gladstone or Mackay)
- limited evidence that mining companies and farmers in the region are prioritising OTR tyre recovery, apart from one to two examples
- scrutiny and public criticism of OTR tyre disposal does not provide enough pressure to force a change in practice – arguably the Department of Resources' intent to improve outcomes from the mining sector for local communities and build partnerships with First Nations may be a way to raise the issue as a public concern.

Table 52 shows a set of actions for TSA and third parties to consider, that try to reduce the effects of these barriers. They are provisional, and will need to be carefully planned and sequenced in collaboration with stakeholders and government..

With enough enthusiasm and co-operation, there is a way to recover large amounts of mining and agriculture tyres from the Bowen Basin. The Queensland Resource Industry Development Plan may be a way to align OTR tyre recovery with Queensland Government commitments, while the Fitzroy Basin

Association[96] may put the issue in its regional context and provide input from the existing community and stakeholders.

Opportunities

A combination of reverse logistics and size reduction would appear best suited to the pattern and scale of mining and agriculture tyre usage across the Bowen Basin. This could involve, for example, dedicated facilities in Gladstone or Mackay to recover OTR and automotive tyres. Alternatively, some consolidation and processing could be done locally before final processing elsewhere in the state (such as southeast Queensland), offering the added benefit of developing the regional economy.

As is the case for other catchments described in this chapter, we cannot claim that this solution is optimal or definitive without more detailed analysis and engagement with stakeholders.

Table 52: Potential roles of TSA and other parties in overcoming key barriers to the recovery of OTR tyres from the Bowen Basin catchment.

TSA actions	Third party actions
Barrier: Low regulatory pressure	
TSA to advocate for and give evidence for reforms to Queensland and national regulations and licence conditions based on: • the costs and benefits of different recovery options • the viability of OTR tyre recovery solutions tailored to the region • the need to strengthen incentives for mining companies and agriculture businesses to recover rather than dispose of their OTR tyres, similar to the incentive for automotive tyres **TSA** to engage with indigenous people and local communities on the impacts of mining tyre disposal on their cultural values and assets and integrate findings into broader advocacy strategy – this activity may be undertaken in conjunction with the Department of Resources' implementation of the *Queensland Resources Industry Development Plan.*	**Queensland Department of Environment & Science (DES)** and **Department of Resources** to consider: • increasing standards on disposal of mining tyres • providing more clarity on a near-term path to ban on-site disposal • setting guidelines for using and recovering end-of-life agriculture tyres beyond those used on-farm. **Commonwealth Government** to consider setting advanced recovery fees for tyre types and uses where tightened regulations fail to encourage take-up of tyre recovery services. **Queensland Resources Council** to help broker between mining companies, TSA and regulators on the least disruptive and commercially-feasible ways to recover tyres. **Farming peak bodies** to liaise between farming communities, TSA, and Queensland DES on ways to encourage agriculture tyre recovery.

96 https://fba.org.au/about-fba/

TSA actions	Third party actions
Barrier: Low private cost of on-site disposal	
TSA to work with mining companies, the agricultural sector, and communities to understand true cost of disposal, including: • cost of hidden risks and liabilities that this practice fails to account for • external costs transferred to the community and the environment in Bowen Basin and Fitzroy Basin • commercial and environmental opportunity costs during production, use, and disposal/ recovery phases **TSA** to coordinate business cases and trials to better understand recovery and circular economy options for OTR tyre generators – to serve as an evidence-based comparison to disposal	**Mining companies** in the catchment to: • engage with TSA on options to align with corporate ESG values and commit to tyre recovery goals • explore options with TSA and suppliers on measures/guidelines to extend the working lifespan of mining tyres, including repair, re-tread, revised specifications and revised use and management • integrate these with procurement terms and conditions and incorporate into internal procedures • explore circular economy models and commercial arrangements with tyre suppliers to reduce impacts from OTR tyres • explore and evaluate recovery services for end-of-life mining tyres and conveyor belts • move towards mining tyre recovery as standard practice across operations where this is viable. **Queensland Resources Council** to engage with mining companies on the ESG aspects of mining tyres and conveyor belts, and help them find expertise on options. Farming peak bodies and Fitzroy Basin Association to: • drive interest in participation in regional pilots and ongoing services • support TSA prepare guidelines and education material on best practice use of agriculture tyres. **Tyre brands and supply chain** to explore business models and service inclusions with their mining company customers, in line with 'higher order' circular economy outcomes. Provide transparency on impacts of tyre production and supply chains.
Barrier: Unfamiliarity and uncertainty towards OTR tyre recovery solutions	
TSA to engage with mining companies and farming communities in the region on recovery methods that suit the catchment, and ways to use tyre-derived material in the region. Cover perspectives on ESG, OH&S and local and regional economic development opportunities.	**Queensland Resources Council**, **Fitzroy Basin Association** and **Queensland Government** (Department of Resources, DES and Department of State Development, Investment, Local Government & Planning (DSDILGP)) to help TSA establish and recruit mining and agriculture sector participants in relevant engagement workshops, and explain areas of policy overlap and transition support.

TSA actions	Third party actions
Barrier: Lack of nearby OTR tyre recovery service providers	
TSA to share results of business case (above) and related engagement with tyre recycling businesses and third parties who may invest or help drive investment.	**Tyre recycling businesses** to consider: • engaging with TSA on commercial needs so they can confidently invest in the catchment • seeking funding opportunities to upgrade or build facilities or invest in equipment to receive OTR tyres • engaging with TSA on end-markets for tyre-derived materials • engaging with mining companies on ways to deliver 'higher order' circular economy outcomes. **Queensland DES** to provide public notice of shifts in regulatory environment that would encourage new tyre recovery services to the catchment. **Queensland Resources Council** to engage with coal mining companies at the catchment scale to encourage tyre recovery economies and help drive interest from tyre recovery services. **CQROC** and **councils** to encourage investment in the catchment. **DSDILGP** to seek funding for new tyre processing capacity within grant programs.
Barrier: High transport overheads	
TSA to engage with parties who could reduce transport costs or provide cost-efficient logistics in the catchment, to reduce transport barriers. Provide support and engagement as suitable. **TSA** to support transport trials to provide evidence on costs, storage and handling related issues, OH&S factors, GHG emissions and other variables that may affect a sustained transport model.	**OTR tyre retail, logistics, transport and handling businesses** to explore options with customers and tyre importers to perform reverse logistics, storage and related services necessary recover end-of-life OTR tyres. Partner with TSA on potential trials. **Farming produce supply chains and cooperatives** and **councils** and **CQROC** to explore options to use receival points and transfer station networks and depots as agriculture tyre drop-off points. **Peak bodies in the agriculture sector** and **Fitzroy Basin Association** to partner with TSA to provide education and guidance on how to move from on-farm disposal and long-term stockpiling to recovery using a network of drop-off points. If an advanced recycling fee system is implemented, **Queensland Government** to introduce a registration and tracking system for legitimate tyre drop-off points.
Barrier: Lack of business prioritisation	
TSA to continue to engage with mining businesses to improve the management and stewardship of OTR tyres over their lifecycles.	**Mining companies** to: • engage with TSA and other stakeholders to internalise a high standard of tyre stewardship into operations (i.e. on-site, procurement, reporting and other responsibilities), and set goals to this end • set out a longer-term plan to achieve these goals, working with TSA and other parties where necessary.
Barriers: Limited public scrutiny and pressure	
TSA to liaise with priority indigenous people and local communities to Aboriginal Land Councils on appropriate paths to shift mining companies and farmers towards suitable OTR tyre recovery models.	**Aboriginal Land Councils, land protection NGOs,** and **indigenous people and local communities** continue to hold mining companies to account on the impacts of on-site disposal of mining tyres.

10.2.4 **Peel, Southwest & Lower Wheatbelt (WA)**

The Peel, Southwest and Lower Wheatbelt catchment combines three primary industry regions in close proximity, plus a small number of mines extracting gold, bauxite, lithium and mineral sands. The catchment covers major wheat, barley and oat, horticulture, viticulture and sheep and cattle raising operations, so we estimate that there may be similar amounts of agriculture tyres and mining tyres in the region.

The northern point of the catchment aligns to Perth's latitude, with a corresponding Midwest and Upper Wheatbelt catchment for primary industry north of Perth (i.e. with Perth's latitude as its southern boundary). The two areas are treated as separate catchments because it would span up to 1,000km north to south and methods to deliver OTR tyres to facilities or end markets in Perth are likely to have only limited overlap.

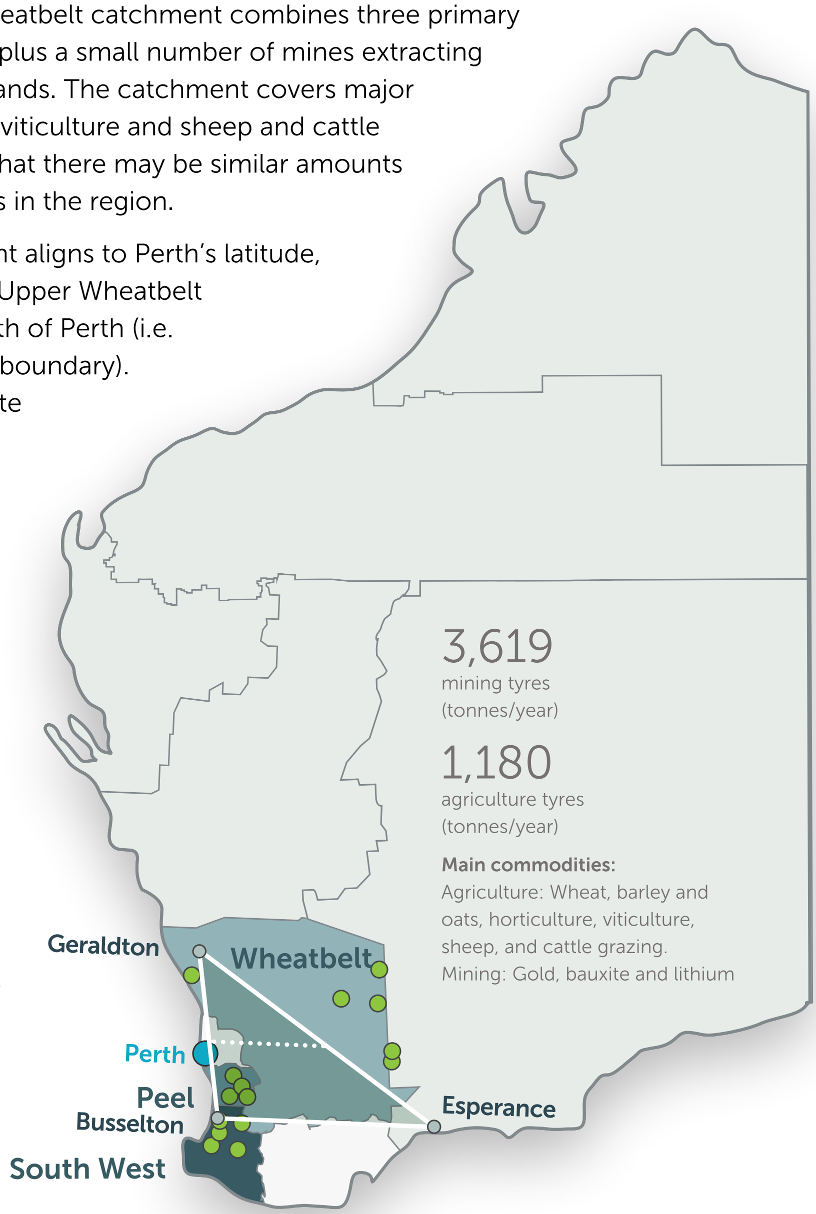


Figure 7L: Peel, Southwest & Lower Wheatbelt catchment

Table 53 summarises the key details of this catchment.

Table 53: Selected features relevant to the generation and potential recovery of OTR tyres from the Peel, Southwest and Lower Wheatbelt catchment.

Catchment	Peel, Southwest and Lower Wheatbelt WA
OTR tyre generation (est.)	3,619 tonnes per year mining tyres, mainly from open-cut operations. 1,180 tonnes per year agriculture tyres.
Assumed automotive tyre quantities	4,000 tonnes. Within the region south of Perth, there may be moderate amounts of automotive tyres that would be able to outcompete tyre recovery solutions in Perth on the basis of lower transport costs. Using an estimate of 10 tonnes of end-of-life tyres per year per 1,000 population, there may be up to 4,000 tonnes of automotive tyres reaching end-of-life each year in the catchment.
Main commodities	Agriculture: Wheat, barley and oats, horticulture, viticulture, sheep and cattle grazing. Mining: Gold, bauxite, lithium, mineral sands, and other minerals.
Connectivity within catchment	The Peel and Southwest regions where the main mining operations are based are well connected via major highways, across a distance of less than 200km. The wheat growing and other agricultural districts extend further to the east to Albany, about 400km southeast from the northern parts of the catchment. Most of the road networks are clustered to the west, with main highways also linking Albany.
Distances to industry centres	The northern part of the catchment is near the Kwinana industrial centre (about 50km from Pinjarra). Southern industrial centres are located within the catchment and include Bunbury, Busselton and Albany (towards the southwest and southeast sections of the catchment).
Distances to major ports	The catchment runs from the south and east of Fremantle Harbour, with major tyre generating activities starting from a distance of 80km from this port. The catchment itself is also connected to the major regional port of Bunbury, which services bulk cargo ships loading with mineral and agriculture commodities.
Supply of tyres	Tyres used on agriculture vehicles may involve a combination of wholesalers and the retail tyre network, with further details to be confirmed. For the mining operations based nearer to Perth (e.g. towards Boddington and Pinjarra), we assume that OTR tyres are imported from Perth and delivered directly or by logistics companies able to truck large mining tyres.
Tyre sizes	Assumed to be a wide range of agriculture sizes given, e.g. cattle, broadacre cropping including cotton and other industries present. Assumed to be up to 63-inch rim size in mining sector, tending toward larger tyres.
Community & economic profile	The catchment crosses regional boundaries with diverse primary industries including agriculture, horticulture, wineries and fisheries; and globally significant mines. The area is a major tourism destination driven by local produce, natural landscape attractions and coastal recreational activities. Major centres display mixed economies including retail, healthcare, education, construction and other services.
Known concerns	At the time of writing, limited attention or concern appears to be directed from third parties towards practices in managing end of life mining and agriculture tyres.

Features

Estimates in this report suggest this catchment generates about 4,800 tonnes of OTR tyres each year, a third of which is generated from agricultural activities. Mining operations are mostly clustered around Pinjarra, Boddington, Busselton and Greenbushes in the western parts of the catchment. Engagement with the mining sector suggests that these sites may also have significant quantities of end-of-life conveyor belts. While these mines coincide with significant agriculture, winemaking and orchard plantings, the bulk of the cereal growing districts are in the eastern parts (i.e. the Wheatbelt and Great Southern regions) of the catchment.

Most of the major townships south of Perth are concentrated along the west coast, with major populations in and around Mandurah, Bunbury and Busselton, as well as Denmark and Albany on the south coast. These centres may generate about 4,000 tonnes of automotive tyres per year. End-of-life tyres in the northern parts of the catchment can be recovered in Perth, which is close by.

The total amount of end-of-life tyres from the catchment is around 9,000 tonnes per year, heavily dispersed across coastal townships, a small number of mining operations, and large tracts of farmland spread across the catchment area. Recovering all of it may be difficult without incentives and a cost-efficient network of consolidation points.

Much of the catchment is less than 200km from Perth, so a more likely approach may be to send tyres for final processing in Perth, rather than building a regional facility. For example, mining companies in and near Pinjarra are, in effect, on the outskirts of Perth and Peel, and may not get much benefit from a facility in the catchment area.

Table 54 gives a high-level view of key issues to attend to in this catchment.

Table 54: Indicative barriers to the recovery of OTR tyres from the Peel, Southwest and Lower Wheatbelt catchment (details are illustrative, pending further engagement with catchment stakeholders).

Barrier	Nature and extent in Peel, Southwest and Lower Wheatbelt WA
Low regulatory pressure	Major mining sites are permitted to store and dispose of used mining tyres and rubber conveyors onsite in designated areas of the mine that are defined in the site environmental licence. Site environmental licence conditions are minimal compared to off-site landfilling requirements which include rules for: establishment, construction, filling, rehabilitation, aftercare, and monitoring. Although agricultural businesses operate under environmental prohibitions against on-site dumping, there is evidence that on-site dumping still regularly occurs. This may point to a compliance and enforcement issue. There are no state or national requirements to recover the tyre waste. The voluntary TPSS is not resourced to recover waste, nor empowered to mandate recovery.
Low cost of on-site disposal	Permitting on-site burial restricts the ability to establish recovery alternatives, as recovery has to compete with low or no cost on-site management. Mining businesses may not accept the relative cost imposition voluntarily. Outside the 'Tyre Landfill Exclusion Zones' (i.e. around Perth), used tyres can be disposed to any licensed landfill, shredded or whole. No landfill levy would be likely for off-site landfills servicing areas generating used OTR products. Significant landfill operator gate fees are still charged. Permitting the off-site landfilling of used OTR products without a landfill levy and without shredding in WA also restricts the ability to establish recovery alternatives, as recovery businesses have to compete with low cost landfilling. However, this is less significant compared to on-site disposal as most landfill operators will still charge a premium gate fee for used OTR products.

Barrier	Nature and extent in Peel, Southwest and Lower Wheatbelt WA
Lack of nearby OTR tyre recovery service providers	Tyre recovery capacity in Western Australia is concentrated in Perth, which may be close enough to the catchment to enable recovery, if facilities are able to manage OTR tyres in large quantities. Some efforts to reduce transport costs may still be necessary, as the distances are up to 200km. At the time of writing, one facility in the north of Perth is commissioning equipment for size reduction of mining tyres. It is likely that this facility and other facilities would be able to process agriculture tyres without this specialised equipment.
Unfamiliarity and uncertainty towards recovery solutions	The larger mining operations in the catchment have been engaging with TSA on potential tyre recovery options, and therefore have a developing understanding of tyre recovery options in various locations. There has been limited exposure of farmers to potential tyre recovery options, so they may have a poor understanding of options available.
High OTR tyre recovery fees	At present, it is difficult to gauge the additional cost of recovering mining tyres and agriculture tyres from the catchment, relative to automotive tyres. It will depend on throughput levels, to spread capital costs and to create efficiencies.
High transport overheads	While transport costs will still be higher than automotive tyres collected in urban centres, the proximity of the catchment to Perth makes transport costs more manageable. If reverse logistics solutions are used then the collection of waste across the catchment may be economically viable.
Limited public scrutiny	At the time of writing, it is not clear that the issue of on-site tyre disposal or indefinite stockpiling is drawing significant public attention. For the mining sector, this may be a lesser priority as some companies are already examining the issue, but there efforts may be hindered by the limited amount of processing and recycling options available.
Lack of business prioritisation	Direct engagement with mining companies in the Peel and Southwest regions suggest that corporate interest in the need to find a tyre recovery solution is growing, driven by internalised sustainability goals and ESG drivers (i.e. with internal top down pressure), but a solution needs to be economically viable. There is little evidence of wide prioritisation among the farming community in the catchment, so this will require further investigation or education initiatives.
Organisational barriers and procedural overheads	Agricultural businesses are more likely to be internally aligned due to their smaller size relative to mining companies. Where these businesses have decided to prioritise sustainability this is likely to be more consistently implemented. Larger mining companies may suffer from the same challenges as elsewhere, particularly with differening internal perspectives on sustainability and tyre recovery objectives.
Dispersed waste tyre feedstock	Due to the relatively small size of the catchment and proximity to Perth, waste tyre dispersal across the catchment is less of a barrier.
Lack of investment confidence	From the viewpoint of a tyre processing company, entry into the catchment may be challenging without the certainty of having secured a large enough contract for recovery of tyre waste over multiple years. A single contract with a large company may be enough of a signal to drive investment in new or upgraded capacity, but this is a harder task because much of the catchment's tyre waste is dispersed across smaller agricultural businesses. This uncertainty level is mitigated by the lower investment costs due to the catchment's proximity to Perth. However, while on-site burial is permitted at low or no cost in mine sites there is little opportunity for recovery businesses to offer an attractive recovery solution.

Barrier	Nature and extent in Peel, Southwest and Lower Wheatbelt WA
Uncertain end markets for recovered products	If an additional 4,800 tonnes of OTR tyre material entered the WA processing market, this would provide capacity for investment in more processing facilities. The major port in Perth offers an opportunity for this material to enter the export market. If it were used in WA roads or as TDF then much or all of this material could be absorbed by the domestic market for recovered products. Development of an OTR tyre recovery facility north of Perth suggests that businesses recognise investment opportunity in this area.
Limited opportunity to test and refine offerings	Evidence of tyre recovery market and business development activity in Western Australia suggests that the sector has been able to engage with mining companies to refine offerings to the market. There is less evidence of engagement and service development for the farming sector, which is likely driven by very high transaction costs.

Priorities

This analysis shows some priorities to address in the Peel, Southwest, and Lower Wheatbelt catchment, such as:

- the absence of regulatory pressure, with state government guidance limited to advising that mining tyre recovery follow company policy and no evident direction towards recovering agriculture tyres
- the low cost of on-site disposal, which results directly from limited regulatory interest
- limited awareness of agriculture tyre recovery options and their commercial viability (although the mining sector has shown effort towards understanding such options)
- transport costs, mainly from the difficulty of managing large tyres, rather than long distances
- limited evidence that the farming communities in the catchment are prioritising OTR tyre recovery (noting that there is some priority in the mining sector, balanced against commercial tolerances) which may due to a lack of awareness of options to use tyre-derived materials in ways that benefit farmers (i.e. beyond informal use of whole tyres in silage production)
- highly-dispersed patterns of agriculture tyre use and disposal.

Similarities with other catchments include lack of regulatory imperative and limited attention towards recovery, and issues with moving large tyres.

One difference is that the mining companies here are actively exploring tyre recovery solutions, and the tyre recovery sector has begun to invest in specialised equipment needed to reduce the size of large mining tyres. If this plant starts operating, mining licence issuers may be able to disallow on-site disposal of mining tyres (and potentially conveyor belts) on the basis that there's a commercially-viable recovery option in this catchment.

An agriculture-heavy catchment...

The main difference is that agriculture tyres are a major source of OTR tyres. This creates a different pattern of features including:

- high dispersion and large quantities of agriculture tyres e.g. from tractors and combine harvesters – with implications for transaction costs per unit tonne recovered, and for keeping transport overheads in check
- a lot of tyres that are unwieldy to move but can be processed in facilities that take automotive tyres
- relatively informal and fragmented practices for end-of-life management in multiple farming industries involving various sizes of business, potentially spanning burial, burning, stockpiling and

secondary use (such as silage). This leads to a pattern of behaviours that need to be influenced using a variety of techniques.

… Requiring a different approach

To achieve success recovering agriculture tyres from across the catchment, these settings need to change simultaneously:

- strong and consistently effective incentives for farmers to recover agriculture tyres, such as:
  - advance recovery fees, through a regulated scheme so they have a direct financial incentive to bring end-of-life tyres to recovery points
  - regulation requiring that they hand end-of-life tyres to point of sale or a designated recovery point, with potential monitoring through the retail chain of transactions
- a convenient network of collection hubs, creating scale economies at appropriate locations for processers to invest, consider using existing commercial and public sector premises such as transfer stations and council depots, tyre retail yards, and/or commodity receival points (such as wheat bins)
- introducing distributed mobile or stationary infrastructure to lessen transport costs – e.g. baling or shredding equipment for end-of-life farming tyres – from consolidation points to a suitable recovery facility
- in-depth engagement and behaviour change programs to help agricultural communities change practices, and understand what to do when new systems come in place.

Opportunities

A key objective of these measures is to ensure that enough tyres are recovered in a small enough area to create scale economies and commercially viable recovery opportunities. If we only recover a few tyres from a given location, this will increase transport costs and become uneconomical.

Engaging with the farming community could involve exploring what uses for end-of-life tyre product would be most useful and/or appealing, including on-farm re-use options. This notes that products used to for sileage, improvement of regional roads, and flood and erosion protection may all be seen as having direct benefits to farmers and regional communities.

In Table 55 we present a set of actions for TSA and third parties to consider, to reduce the barriers faced in the Peel, Southwest and Lower Wheatbelt catchment. They are provisional, and will need to be carefully planned and sequenced.

The pattern and scale of mining and agriculture tyre usage across the catchment, alongside well-established road corridors, suggest that OTR tyre recovery can be achieved through a combination of measures. A final processing facility in Perth may be able to recover and convert OTR tyre material into useful finished products, if we can overcome the challenges in transporting agriculture tyres there.

As with all catchments, the business case does not claim that this solution is optimal or definitive, and recommends more engagement with catchment stakeholders to determine feasibility of options.

Table 55: Potential roles of TSA and other parties in overcoming key barriers to the recovery of OTR tyres from the Peel, Southwest and Lower Wheatbelt catchment.

TSA actions	Third party actions
Barrier: Low regulatory pressure	
TSA to advocate for and provide evidence towards reforms/updates to Western Australian and national regulations and licence conditions based on: • the costs and benefits of different recovery options • the viability of OTR tyre recovery solutions tailored to the region • the need to strengthen incentives for agricultural concerns to recover OTR tyres, in line with the level of incentive applied to automotive tyres **TSA** engage with indigenous people and local communities on the impacts of mining tyre disposal on their cultural values and assets and integrate findings into broader advocacy strategy. **TSA** to devise and implement a way to estimate a representative amount of end-of-life tyres legitimately used on-farm, as part of its national recovery performance level.	**Western Australian Department of Mines, Industry Regulation and Safety, EPA, Waste Authority and Department of Water and Environmental Regulation (DWER)** to consider: • imposing higher standards on disposal of mining tyres • providing more clarity on a near-term path to disallow disposal of mining tyres on-site • setting guidelines for recovering end-of-life agriculture tyres beyond an amount suitable for on-farm applications • introducing regulations, including options to monitor activities through retail transactions. **Commonwealth Government** to consider setting advanced recovery fees for tyre types and uses if tightened regulations have little effect, with agriculture tyres a priority. **Chamber of Minerals and Energy WA (CME)** to help broker between mining companies, TSA and regulators on feasible pathways to recover tyres. **Farming peak bodies** to liaise between farming communities and TSA and DWER on appropriate settings and measures to encourage agriculture tyre recovery.
Barrier: Low private cost of on-site disposal	
TSA to work with mining companies, the agriculture sector and communities to understand true cost of disposal managing tyres, including: • cost of hidden risks and liabilities that this practice fails to account for • external costs transferred to the community and the environment in the Peel, Southwest and Lower Wheatbelt • commercial and environmental opportunity costs. **TSA** to coordinate business cases and trials to better understand recovery and circular economy options that provide an efficient solution to OTR tyre generators in the catchment – to serve as an evidence-based comparison to disposal	**Mining companies** in the catchment to: • engage with TSA to align corporate ESG values and commit to tyre recovery goals • explore options with TSA and suppliers on ways to extend the lifespan of mining tyres, including repair, re-tread, revised specifications and revised use and management • Integrate these with procurement terms and conditions and incorporate into internal procedures • explore circular economy models and commercial arrangements with tyre suppliers • explore recovery services for all OTR rubber products • progress towards making mining tyre recovery standard practice where viable. **MCE** to engage with mining companies on the ESG aspects of mining tyres and conveyor belts, and help them find expertise on options. **Farming peak bodies** to: • help drive participation in regional pilots and ongoing services • help TSA create guidelines for best practice use of agriculture tyres **Tyre brands and supply chain** to explore business models and service inclusions with their mining company and agriculture customers, in line with 'higher order' circular economy outcomes. Provide transparency on impacts of tyre production and supply chains.

TSA actions	Third party actions
Barrier: Unfamiliarity and uncertainty towards OTR tyre recovery solutions	
TSA to engage with farming communities on recovery methods that could fit the catchment, and preferences given for using tyre-derived material. Cover perspectives on ESG, OH&S and local and regional economic development opportunities.	**DWER**, **EPA**, **Department of Agriculture** and **Agriculture & farming peak bodies'** regional officers to help TSA establish and recruit agriculture sector participants in engagement workshops, and explain areas of policy overlap and transition support.
Barriers: High transport overheads and highly dispersed patterns of tyre use	
TSA to engage with parties who could reduce transport costs or provide cost-efficient logistics (including functioning as a receival point and/or providing shredding and baling functions), to reduce transport barriers. **TSA** to support OTR tyre transport trials to provide strong evidence on costs, storage and handling related issues, OH&S factors, GHG emissions and other variables.	**OTR tyre retail, logistics, transport and handling businesses** to explore options with customers and tyre importers to perform reverse logistics, storage and related services needed to recover OTR tyres. Partner with TSA on potential trials. **Farming produce supply chains and cooperatives** and **councils** to explore options to use receival points and transfer station networks and depots as agriculture tyre drop-off points. **Peak bodies in the agriculture sector** to partner with TSA to provide education on how to move from on-farm disposal and long-term stockpiling to recovery using a network of drop-off points or collection services. If an advanced recycling fee system is implemented, **Western Australian Government** to introduce a registration and tracking system for legitimate tyre drop-off points.
Barrier: Lack of business prioritisation	
TSA to engage with agricultural communities to improve the management and stewardship of OTR tyres over their lifecycles.	Agriculture & farming peak bodies and other regional farming bodies to: • engage with TSA and other stakeholders on the best way to build a high standard of tyre stewardship into farming practice, to achieve better environmental outcomes and to get better value from tyres. • prepare related guidance targeted to the needs of different agriculture industries in the catchment.

10.3 The need for general and specific catchment responses

This chapter shows that eleven catchments generate most of the unrecovered OTR tyres, based on the distribution of mining and agriculture activity across the country. These catchments account for around 65% of all OTR tyres (factoring in other OTR industries including aviation, trade, manufacturing and construction).

The methods used to estimate the total amounts of mining and agriculture tyres required a geographic allocation of national estimates (see Chapter 8 and Chapter 9). These estimates will be validated through catchment-level business cases using verified data-sets, so we will need to validate and refine these estimates through 'bottom up' approaches at the catchment scale.

If TSA and partners can encourage high recovery rates from mining and agricultural interests in these catchments to around 60%, we can reach the national all-tyre recovery rate of 80%.

Some of the logistics, recovery services and infrastructure needed in those catchments may also make it easier to recover automotive tyres in regional Australia. This will help counter the historic skewing of circular economy opportunities and investments towards major cities and industrial centres, where the volumes and consolidation of used tyres for collection and processing are economically viable.

Similarities across catchments

Examining four of the catchments revealed similarities and differences, and we conclude that high recovery rates of mining and agriculture tyres are achievable if we take strong enough measures and apply them in concert.

These actions stem from the barriers, markets, and regulatory settings in each catchment, as well as the opportunities to work with multiple important stakeholders and partners. It is vital that we identify and confirm complementary interests and values so these stakeholders become longer term partners and advocates for a solution suitable to each catchment.

In all cases, high OTR tyres and related products recovery rates in each catchment will need some combination of:

1. Understanding the drivers, interests, and tensions to be resolved, to determine the costs and benefits of recovering OTR tyres and related products.
2. Provide investment confidence through stable volumes of used OTR tyres and stimulated end-markets for tyre-derived material; as well as processing, recovery and end-market uses that support mining and agricultures ESG goals.
3. Effective inducements for agriculture businesses and farms to recover agriculture tyres beyond a reasonable degree of on-farm usage – which may involve a level of targeted guidance, well designed regulation and/or the use of advance recovery fees.
4. Pragmatic mechanisms to reduce transport, handling and logistical overheads from the need to move large heavy tyres considerable distances, and potentially from multiple highly-dispersed points of origin.
5. Engagement with the tyre recovery industry - both established businesses and potential new entrants - supporting investment that is aligned to end-market capacity for their tyre-derived material and reflects the increasingly circular standards, duties of care and ESG principles expected from OTR generators.
6. Engagement and behaviour-change activities with OTR tyre generators including changes in interactions with suppliers to improve circular economy outcomes, that cater to the needs of OTR tyre generators in the catchment, while using regional, community and sectoral support organisations', peak bodies' and/or commercial partners' experience, relationships and networks.

7. Including the views and voices of those that have a land and/or community custodianship role in the catchment, to bring scrutiny to current practices and legitimate new approaches to the use and end-of-life management of OTR tyres.

Tailoring the approach

In each catchment section in this chapter, we described a more precise approach to applying these elements, tailored to the features of that catchment. These suggested approaches are highly provisional and illustrative, and need closer engagement with catchment stakeholders and a more detailed analysis of commercial, environmental and institutional aspects of each catchment.

Further catchment-level planning, analysis and engagement will determine the feasibility and viability of specific approaches to address the barriers and increase the rate of OTR tyre resources recovery.

Success will be dependent on factors included in the catchment characteristic outlined earlier in this chapter, and include intangible characteristics such as willingness and motivation of businesses, the local government and community bodies; and experience in co-ordinating projects across commercial, government, community, environmental and social enterprises.

In the next chapter we apply the lessons from this catchment-level analysis to the national scale, to set out a range of actions to achieve higher rates of OTR tyre recovery. We also use the list of catchments from the start of this chapter to show how recovering OTR tyres OTR tyres is the only way the National Waste Policy objectives of 80% recovery rates can be achieved.

10.4 Catchment features and impacts on recovery costs

At the beginning of this chapter, we explained that each catchment has a set of unique features that make a cost-benefit analysis at the national scale vague, lacking in specificity needed at the catchment-level to be successful.

Rather we recommend a catchment level approach to assessing used tyre recovery solutions.

10.4.1 Private recovery

The same point applies to generating an estimate of OTR tyre recovery private costs for a given catchment, because of dependencies across (see Chapter 4 for a more detailed discussion):

- which types of recovery technology and end products and markets are viewed as legitimate by OTR tyre generators
- distances to recovery facilities or consolidation points, and from recovery facilities to end markets
- costs of commercial inputs including labour, energy, debt, plant and equipment, commercial lease and insurances that need to be internalised into a tyre recovery business model
- the scale and timeframes of processing operation that in turn drive the opportunity to spread fixed costs over a larger tonnage of tyres
- long-term price and demand trends for various types of tyre-derived materials, and related risks (e.g. price risk, exchange rate risk, market downturn risk, etc.)
- profit and return on investment targets for those willing to invest in OTR tyre recovery services, subject to commercial terms and the commercial environment
- the existence or lack of positive incentives to reduce the private cost of recovering OTR tyres.

The private cost of recovery also needs to be weighed against the costs and liabilities of continuing disposal practices (see Chapter 3). Public costs and benefits may also be factored in, based on whether governments will intervene.

10.4.2 How recovery might work

The two main recovery solutions that we have identified can be termed 'reverse logistics' and 'consolidation at a recovery centre'. An important part of solving the high transport and processing costs of OTR recovery involves applying a reverse logistics approach.

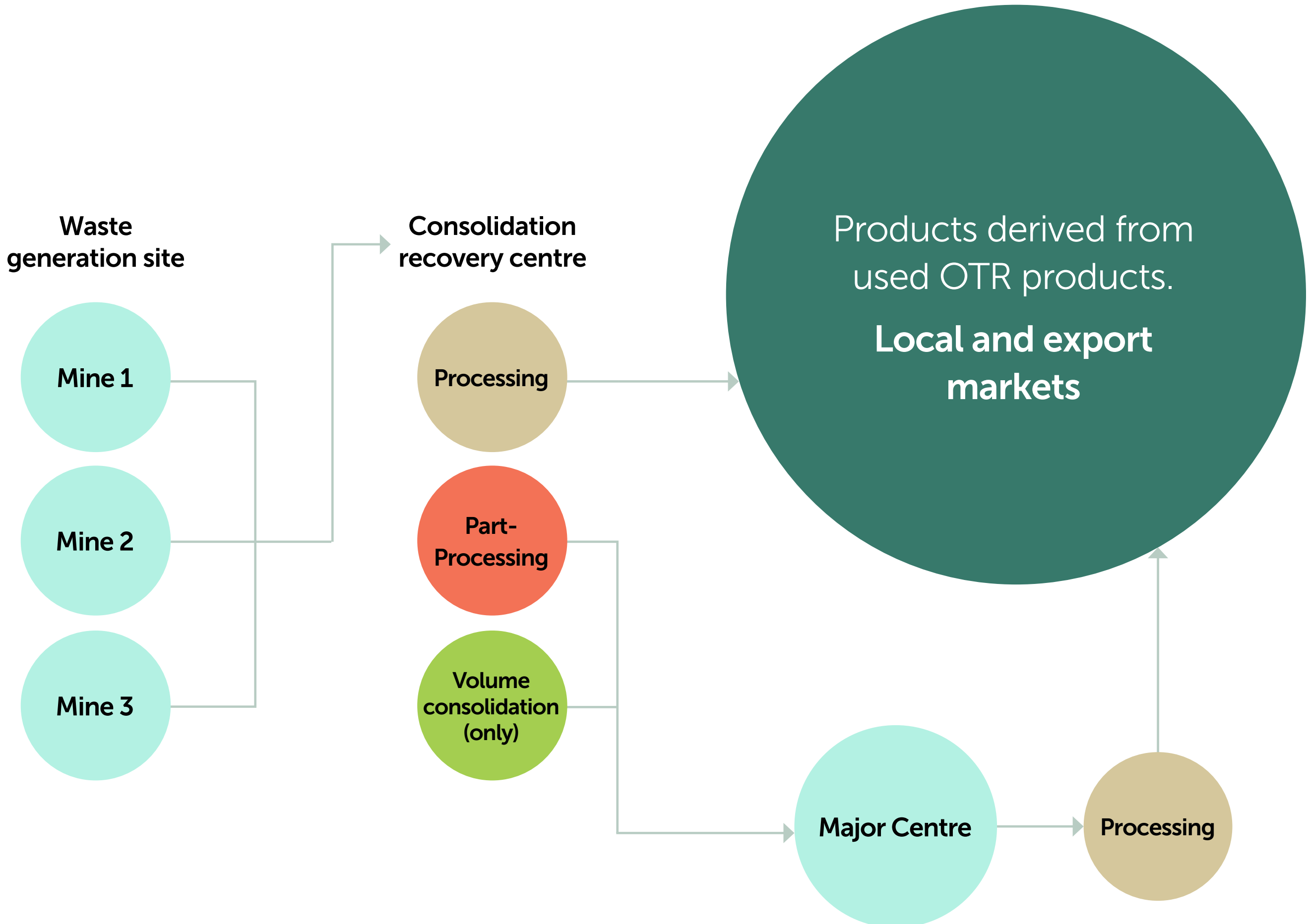
Reverse logistics

Reverse logistics is the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or proper disposal. Our ideal approach to reverse logistics involves the tyre seller collecting their previously sold tyres when they deliver new tyres, using the same logistics network for both delivery and recovery. They would then take their old tyres back to their own processing facilities for re-tread or material recovery within their own circular economy of tyre management, or deliver the waste to a third-party processing service.

Consolidation at a recovery centre

Consolidation at a recovery centre within a catchment involves multiple waste generation sites consolidating their waste tyres, conveyors, or tracks into one centralised location convenient for all sites. This consolidation point would either process the waste directly into a product, or sort and process it for delivery to another processing facility. Processing at the consolidation point or another facility would turn it into a product which might be used locally or exported.

Figure 8: indicative sequence for a reverse logistics supply chain.



What it might cost

Collection costs vary depending on the distance travelled. This is an estimate of those costs depending on distance:

Table 56: estimated cost of transporting large mining tyres in regional and remote Australia.

Mine Site	Lower		Upper		Comments
	$/unit	$/tonne	$/unit	$/tonne	
Regional	$1,000	$333	$1,800	$600	Collection costs vary by distance travelled. 'Regional' collections typically allow for up to 500 kms from processor.
Remote	$1,400	$467	$2,300	$767	Collection costs vary by distance travelled. 'Remote' collections typically allow for up to 1,000 kms from processor.

This table shows the cost of processing tyres also depends on the way that they are processed:

Table 57: estimated cost of typical OTR rubber product recovery processes.

Process	Lower	Upper	Comments
	$/tonne	$/tonne	
Recycling (crumbed rubber - onshore)	$600	$800	Assumes an additional $200/tonne to process large mining tyres for de-beading and extra size reduction costs. Crumbing costs are typically $400 - $600 per tonne.
Recovery via pyrolysis (oil, syngas, act. carbon - onshore)	$300	$500	Costs are for whole mining tyres processing.
Energy recovery (tyre derived fuel - exported)	$285	$300	Assumes an additional $200/tonne to process large mining tyres for de-beading and extra size reduction costs. Typical costs for TDF exports are around $85 to $100.

Relative value

In the most expensive case-mining companies in remote areas-it would cost from $1,285 to $3,100 to collect and process a three-tonne used mining tyre. Given that on average a new tyre costs $45,000, these costs represent a fraction (7% at most) of the cost of a new tyre.

Clearly, a reverse logistics approach would need to be tailored to catchments or regions depending on their concentration of OTR rubber products.

10.4.3 A hypothetical

We can estimate private recovery costs in the form of a cost band for recovery services based on some assumptions.

As an illustrative example, estimating the cost of recovering mining tyres might use these assumptions:

1. The opportunity to recover mining tyres is about 10,000 tonnes per year from a single catchment (similar to the amount available in Bowen Basin or the Hunter Valley and Northern NSW), with up to five years' of tyres made available to the recycler (to enable the operator to finance the project).
2. The OTR tyre generators are interested in a solution that delivers material recovery, i.e. converting end-of-life OTR tyres into steel and crumb rubber. This pathway requires primary sectioning and final processing (crumbing steps) to manage large mining tyres (see Chapter 4), which are assumed to take place at one site.

3. Tyres may be recovered from distances of up to 500km from the recovery facility, and can be transported to a tyre recovery facility in bulk. There may be options to lock in back-hauling services from those that deliver new tyres to the mine site or other suitable trucks leaving the catchment with space for back-hauling tyres whole or partially processed to reduce their size.
4. Commodity, plant and equipment (capital expenses) and operating expenses all follow recent market values, although a new recycling facility operator may factor in a contingency of up to 15% of the capital outlay.

Under these above assumptions, recovering mining tyres from a catchment may involve fees of $400 to $900 per tonne if the full 10,000 tonnes were available to a single tyre recovery operator over a five-year contract. This range would be closer to $600 to $1,100 per tonne if only 5,000 tonnes were available.

Whether these ranges would be a compelling commercial offer depends on multiple factors, including how individual mining companies in the catchment approach ESG materiality of OTR tyre disposal, and what benchmarks they use to determine their business-as-usual costs and benefits associated with disposal.

For example, some mining companies may adopt a business-as-usual scenario where tyre disposal in-pit is allowed in the current regulatory environment. Others may take a more risk-centric approach, assuming that tyre in-pit disposal will eventually be regulated in the same way as automotive tyres, and may try to identify a 'shadow price' that emulates the impact of an increased level of regulation or price incentives to encourage diversion from landfill.

These estimates depend on some critical commercial factors, particularly:

- options to lower transport costs (via back hauling/reverse logistics)
- whether the operator can reduce their capital risk exposure so they can apply a lower project contingency to their business model
- the size of the market risks in selling recovered materials, potentially requiring the operator to discount the revenue from recovering commercial products and make up the difference using higher recovery fees charged to the OTR tyre consumer.

There are also other commercial variables inside the operator's business model – e.g. expected profit retention, administrative overheads and similar – that we cannot easily include in an arm's-length financial model in a national business case.

Non-financial costs are also critical commercial factors to be considered and include brand reputation, community sentiment, board and shareholder expectations and achieving ESG and sustainability statements.

For comparison, earlier estimates of the cost to recover OTR tyres (again, that resort to simplifying assumptions) from an Australian catchment are in the range of $600 to $1,500 per tonne.

Our analysis falls within this previous range of estimates, but is an illustrative example only and should not be interpreted as an accurate estimate of recovery service offerings for a specific catchment use case.

11. Delivering early wins

This chapter brings together some of this report's findings back to a national context.

From our research it's clear that while trade, manufacture, construction, and aviation tyres are concentrated in and near major urban populations and industry centres, mining and agriculture tyres are concentrated unevenly across Australia.

The regional and industry-led pattern of use create barriers to moving OTR tyres and related products from disposal to recovery. This chapter examines some of the major themes of making these transitions at the national scale.

11.1 Catchments as a pathway to achieve OTR recovery

In Chapter 10 we identified eleven major OTR tyre catchments across the country, that together account for over 90,000 tonnes of OTR tyres, or 65% of the national annual total generation of used OTR tyres. This total was based on a national breakdown of mining and agriculture sector activity and should be refined over coming years.

Chapter 10 showed that to achieve significant OTR tyre recovery we will need to take a range of actions. These actions will have different success rates on mining and agriculture tyre recovery levels. Stronger incentive-based mechanisms such as advance recycling fees and regulatory or licence settings may have more potential to create great change and faster than more persuasion-oriented measures. All instruments have a role, in their own right and in helping other complementary measures succeed. The settings and interventions must consider the entire capability and capacity across the entire value chain, ensuring that we aren't simply shifting the problem along the recovery pathway.

11.1.1 A national target

If the amount of OTR tyres we estimate could be recovered from each catchment (see Section 10.1) is plausible, we can form a realistic view of their contribution to a national target. For example, measures applied to mining operations in each catchment could potentially achieve close to 100% mining tyre recovery by 2030, through strong and well-designed conditions applied to mining licences, backed with measures to minimise costs, avoid disruption, and lessen the risk of conflict or uncertainty about other corporate imperatives.

In the case of the agriculture sector, success may be somewhat patchier due to a range of factors that are less present in the mining sector. Some difficulties in achieving used tyre recovery in the agriculture sector include:

- very high levels of segmentation coupled with the presence of businesses that widely range in scale and practice – this may affect the penetration and response to each actions and solutions
- lack of historic regulatory instruments and surveillance activities we can use to better understand potential used tyre recovery solutions
- greater diversity in attitudes and practices towards end-of-life OTR tyres spanning a baseline level of recovery via third parties, legitimate uses on-site, burning, indefinite stockpiling, burial and dumping on public land – and how intractable some of the less environmentally-sound practices may be despite effort to drive change
- less ESG-related scrutiny and pressure from third parties such as shareholders, non-profit organisations and broader society

- higher dispersion across a region, so that some agriculture businesses may face challenging obstacles to access tyre recovery services.

For these reasons, any attempt to forecast an agriculture tyre recovery level for a given catchment should be conservative compared to forecasts for mining tyre recovery.

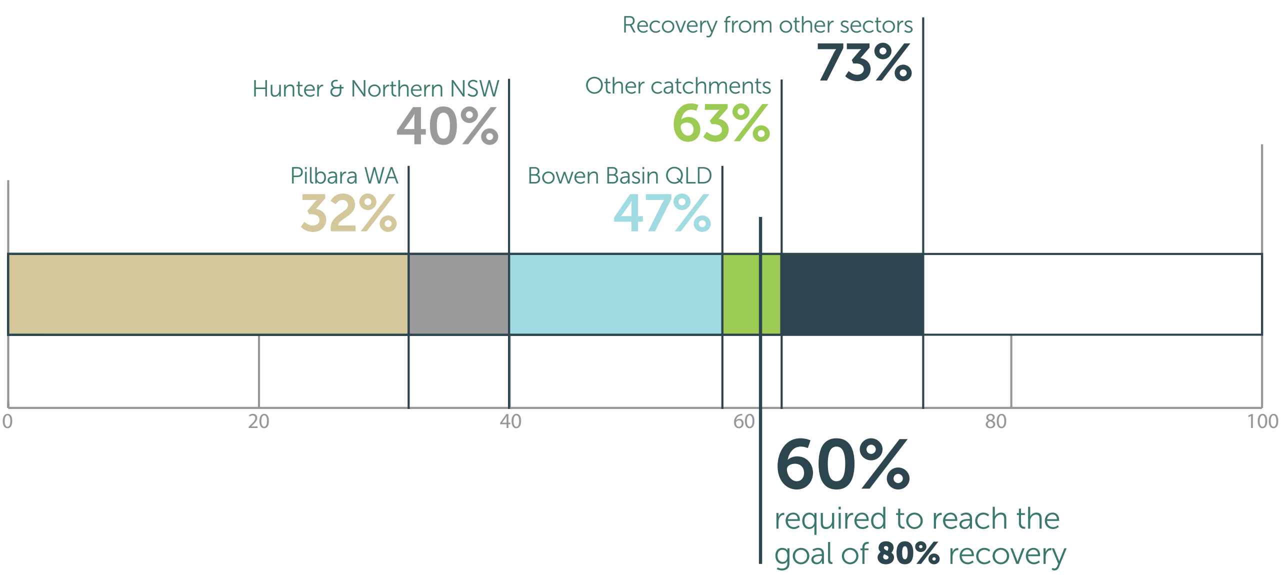
11.1.2 Recovery contribution by catchment

Assuming a concerted effort towards OTR tyre recovery in each catchment, we can reasonably assume up to 95% of mining tyres from each catchment and up to 70% of agriculture tyres from each catchment could be recovered annually by 2030. These percentages are an average across catchments, although a catchment-by-catchment breakdown is shown in Table 58.

Table 58: Potential recovery of OTR tyres from selected catchments, including cumulative contribution of OTR tyre recovery (righthand column).

Catchment	Total OTR tyres (tonnes per year)	Recovered amount (tonnes per year)	Cumulative total (tonnes per year,%)
Pilbara WA	43,890	41,700	41,700 (32%)
Hunter & Northern NSW	10,600	10,000	51,700 (40%)
Bowen Basin QLD	10,170	9,500	61,200 (47%)
Riverina, Murray & Central West NSW	3,117	2,600	63,800 (49%)
Peel, Southwest & Lower Wheatbelt WA	4,799	4,300	68,100 (52%)
Mid-West & Upper Wheatbelt WA	1,884	1,500	69,600 (54%)
Western Victoria VIC	3,090	2,200	71,800 (55%)
Goldfields-Esperance WA	3,614	3,300	75,100 (58%)
North & Yorke Peninsula SA	1,300	1,100	76,200 (59%)
Darling Downs & Surat Basin QLD	4,030	3,000	79,200 (61%)
Gippsland VIC	2,313	2,200	81,400 (63%)
Recovery from other sectors		**14,000**	**95,400 (73%)**

Figure 8A: Recovery contribution by catchment



In Chapter 7 we determined that we could achieve a national tyre recovery rate of 80% if the combined level of additional OTR tyre recovery (i.e. from mining and agriculture sectors) reached or surpassed 60,000 tonnes per year. The table suggests that this is possible if the desired recovery rates are achieved in the four largest catchments.

Its for this reason we recommend focusing on the top four catchments as a priority. Noting that TSA has already begun working with a cohort of mining companies operating in the Pilbara region, as well as commenced business cases for the Northern NSW and Bowen Basin catchments.

Similar success levels across all eleven catchments would deliver further tonnes per year of mining and agriculture tyres. This would bring the overall OTR tyre sector closer to the 80% target in its own right, closer to alignment with automotive tyre recovery levels, which sit around 90%.

11.1.3 Relative importance of catchments

This analysis is also instructive in terms of the national importance of some catchments. For example, the Pilbara catchment is estimated potential to contribute 41,700 tonnes per year to a national OTR tyre recovery outcome.

Without mining tyres being recovered from the Pilbara, the ten remaining catchments might only deliver 39,700 tonnes of OTR tyre recoveries per year, which is well below the identified gap of 60,000 – 80,000 tonnes per year. At best, the OTR tyre recovery rate across all sectors could come to 31%, if recovery from the Pilbara is excluded.

The table also shows that the top five catchments dominate the OTR tyre recovery potential from mining and agriculture sectors. These catchments all produce 3,000 tonnes per year or more, while the remainder only offer about 3,000 tonnes per year or less. This is not to discount effort towards working with stakeholders in these remaining catchments, but to acknowledge that the five larger catchments represent a greater potential in reaching a national result while also offering workable economies of scale.

The smaller catchments (and selected individual mining tenements or agriculture districts) may nonetheless hold additional interest due to, for example, the community concerns and environmental and economic needs of the region; or due to the prospect of using services recover regional automotive tyres that may otherwise be missed. This may elevate the catchment's importance and merit.

TSA is working on large-scale interventions that include all tyre types, including OTR related products. One such example is TSA's work with the local and Territory governments and commercial and tyre recovery businesses in the Northern Territory, where there are high levels of illegal dumping, recovery rates have remained persistently low and there is significant opportunities for increased used of rubber crumb in roads.

11.2 Measures to achieve OTR tyre recovery

TSA will need to undertake a range of measures to drive the shift towards OTR tyre recovery in the mining and agriculture sectors.

In Chapter 6 we defined some general categories of TSA activity, we use these in Table 59 below to cross reference against the TSA actions described in Chapter 10 under the sections for each catchment (Sections 10.2.1 to 10.2.4).

It is likely that these actions, or variations developed through collaboration and lessons learnt, will be relevant to, and support recovery in other catchments that were not covered in detail in Chapter 10.

Table 59: Indicative measures for TSA consideration in pursuing the improved recovery of OTR tyres, factoring in identified features of key OTR tyre catchments across the country.

TSA activity category	Activity to drive OTR tyre recovery
Verify OTR product related material flows and their impacts on Scheme outcomes	Work with mining companies and the agriculture sector, and communities to understand the true cost of disposal and the limited uptake of circular economy approaches to managing tyres, including cost of hidden risks and liabilities; external costs transferred to the community and the environment; greenhouse gas emissions across full product lifecycles; and commercial and environmental opportunity costs during production, use, and disposal/recovery phases. Implement a way to estimate or factor in end-of-life tyres legitimately used on farm as part of its national recovery performance figures, with separate OTR, car and truck categories.
Fund trials, research and activities to specifically addresss OTR barriers and gaps	Coordinate business cases and trials to better understand recovery and circular economy options that provide an efficient solution to OTR tyre generators in priority catchments. Include automotive tyres and rubber tracks and conveyor belts where relevant. Support end-of-life OTR tyre transport trials to provide strong evidence on costs, storage and handling issues, OH&S factors, GHG emissions and other variables that may affect a sustained transport model.
Stimulate and strengthen the resilience of tyre recovery supply chains	Engage with parties who could reduce transport costs or provide cost-efficient transport and logistics in each catchment, to reduce transport barriers. Provide support and engagement as suitable. Support market development initiatives to ensure a reliable destination for recovered materials.
Conduct and coordinate research in support of the Scheme's aims	Research needed reforms to state, territory and national regulations and licence conditions relating to OTR tyre recovery based on: • the economic, social and environmental costs and benefits of different recovery options relative to business-as-usual practices • the viability of OTR tyre recovery solutions tailored to the region • the need to strengthen incentives for mining companies and agriculture businesses to recover their end-of-life OTR tyres, in line with the level of incentive applied to owners of automotive tyres. Research the ability of automotive tyre processing and international markets to absorb tyre-derived material from OTR tyre catchments on top of existing sources; advise recovery businesses and OTR tyre sources of research findings; and engage in market development as suitable.
Engage in communications, and advocacy	Engage with relevant parts of mining companies and agriculture communities to elevate improve the management and stewardship of OTR tyres over their lifecycles, while maintaining high levels of workplace safety. Engage with mining companies and farming communities at the catchment scale on different tyre recovery methods (technologies, products and end markets), and engage on preferences, given different outcomes and potential benefits of using tyre-derived material in the region. Cover perspectives on ESG, OH&S, GHG emissions reduction, and local and regional economic development opportunities. Engage with indigenous peoples and local communities on the impacts of mining tyre disposal on their cultural values and assets, and integrate findings into an advocacy strategy; liaise on what they see as appropriate paths to shift practices towards suitable OTR tyre recovery models. Share results of catchment business cases and related engagement with tyre recycling businesses and third parties, who may invest in catchment-appropriate solutions.

National or local scale

In this table, some of the actions may best be developed and applied at the national level, while others may be suitable at state/territory, regional or individual business or supply chain level.

TSA should continue to expand its activities to include conveyor belts and rubber tracks, with a view that these products will be included in future iterations of a tyre scheme - whether regulated or voluntary. Opportunities for solutions that include all tyre types, not just OTR, should continue to be explored, to help achieve economies of scale, more efficient recovery services in particular in regional and remote areas, and reduce illegal dumping.

There are equally important initiatives that third-party agencies and regulators, peak bodies, OTR tyre importers and end-of-life OTR tyre generators need to take responsibility for. Many of these are described in Chapter 10. Some activities that sit beyond the individual catchment scale, i.e. to influence and contribute to a national agenda, are separately covered below.

Other TSA-led activities

TSA may need other things to drive the national agenda of a circular economy for OTR tyres. Some are less focused on achieving on-the-ground success in individual catchments and are concerned with evolving the Scheme's contribution to the circular economy. These include:

- continue to encourage all OTR tyre importers to contribute to the scheme and create a level playing field without free-riders
- continue to support the commercialisation of manufacturing and end-markets using tyre-derived material, stimulating capacity and capability for more tyre-derived material from OTR tyre volumes
- explore relevant emerging technologies which may enable 'higher order' circular economy outcomes for tyres used in the Australian economy
- explore and pursue a global leadership role in the circular economy for tyres, recognising the increasing internalisation of ESG principles and circular economy models across supply chains
- develop as a data, knowledge and centre of expertise, including advocating greater transparency of impacts and opportunities across tyre production (i.e. upstream of use) and recovery (i.e. downstream of use) supply chains
- coordinate across stakeholders to come to a common, practical definition and interpretation of a circular economy for OTR tyres, and integration into the Scheme
- engage on the expansion of roles and new business/service models across the tyre supply chain, including retailers, logistics and after-sales care and maintenance services, where they can help remove barriers or deliver efficiencies
- advocate to public bodies at regional, state and territory, and national scales on what they can do to support OTR tyre recovery and move to a circular economy for tyres.

This approach resonates with the Scheme's aim of a national target, while providing recovery solutions that account for the catchment-based distribution of OTR tyres and the potential for economies of scale.

A key task for TSA when working with its partners to drive change is to ensure that these two levels of influence are well synchronised and mutually reinforcing.

11.3 From tyre recovery to a circular economy

Reviewing the history of the tyre stewardship in Australia, in its early years there was limited understanding of what happened to tyres at their end-of-life. Like many other waste streams at the time sending their material off-shore for processing, of particular concern was a lack of clarity about how tyres sent overseas were managed.

There was a concern that most tyres were being disposed of or recovered through practices that harmed the environment and human health and safety, particularly in locations with limited regulation.

11.3.1 More accountability and data

Since then, TSA and partners have addressed this transparency issue, through improved reporting from accredited recovery businesses and through its foreign end-markets verfication program. Substantial effort to stimulate and invest in domestic end markets has also seen a measurable shift away from disposing of end-of-life tyres and towards recovery.

As explained in the opening chapters, this success has mainly come through wins in the recovery of end-of-life automotive tyres. While these tyres may be easier to recover, they have mostly come from many smaller individual businesses and households and intermediated through tyre retailers.

As a result, concerns about the environmental outcomes of one recovery path versus another has been muted. Many retail tyre customers probably never ask how their tyres are recycled, and the answer to this question may not be to hand. A typical retail customer also lacks the purchasing power and scale of influence to distinguish and act on different tyre recovery paths.

11.3.2 Then expanding

The shift towards recovering OTR tyres has invited a wider discussion of the merits of one recovery path over another. This has been partly led by mining companies who have corporate environmental imperatives that require them to consider the differences, with some stating preferences towards materials recovery over energy recovery, and local solutions over more distant recovery activities. Numerous mining companies have openly expressed interest in a ‘tyres-into-tyres’ recovery solution as their preferred result.

With no tyre manufacturing in Australia, this position needs to be unpacked with the Australian context in mind. It must be said that it would be foolish to do nothing while we wait for the gold-plated circular economy solutions to be available in Australia. This approach would mean we continue with the least circular option of burying hundreds of thousands of tonnes of OTR tyres each year. Beyond these imperatives, larger mining companies also have significant tyre market footprints nationally and globally, and need to make decisions based on multiple years’ commitment towards corporate ESG strategies.

Depending on their scale of operation, their ten-year OTR tyre budget may run into the tens of millions to hundreds of millions of dollars, i.e. at a scale way beyond the capital outlay for tyre recovery infrastructure in Australia. They represent massive potential to create new business models to recover OTR tyres in Australia, and entirely new business models for these tyres are supplied and serviced during their use.

At the same time, TSA’s engagement with the tyre industry has shown a willingness by global tyre manufacturers to explore and invest in technologies, businesses and service models that are more attuned to a circular economy approach. These ventures include:

- acquiring recycling companies
- developing and integrating technologies to enable end-of-life tyre material to be used in repairing, re-treading or manufacturing new OTR tyres
- piloting tyre leasing models

This shows a foundation for tyre manufacturers and their customers to build new commercial arrangements if there's enough common appetite and mutually-compatible objectives.

Economic regions such as North America and the European Union (EU) are increasingly seeking to ensure environmentally-sound practices are internalised to international supply chains. The consideration of Carbon Border Adjustment Mechanisms[97] and legislation to prevent importation of goods linked to deforestation are two recent examples led by the EU.[98]

11.3.3 The value of voluntary measures

Voluntary measures to factor environmental social issues into supply chains (rather than during the end-of-life phase alone), may position Australian businesses better to avoid future disruption if national or regional policy measures are introduced to protect the environment.

This represents a prudent strategy, given shifts towards ESG principles by businesses that buy Australian mining and farm produce, who are themselves looking to minimise their environmental liabilities across their own supply chains. There may be other benefits, such as improved talent retention, as younger and environmentally-engaged workers gravitate towards roles where their employers' behaviours reflect their own values.

Bringing these drivers and trends together, it would be suitable for the Tyre Product Stewardship Scheme to develop its base of knowledge of what a circular economy approach to OTR tyres may look like, and work with leading tyre brands and OTR tyres users to bring this approach to reality.

This will position OTR tyre generators to achieve tyre recovery using established technologies in the nearer term, while pursuing different strategies to incorporate circular economy principles into their operations.

11.4 The need for partners to drive change

While TSA's role is to administer the Scheme and coordinate activities to achieve the Scheme objectives, other parties need to contribute in line with their capabilities, functions and responsibilities.

Chapter 10 laid out activities at the catchment scale in detail (using four example catchments), but there are broader roles and shifts to be recognised and attended to.

In some instances, this may involve expanding or reframing historic roles and relationships, given the features affecting the use and recovery of OTR rubber products in Australia. There may be different methods that apply to automotive tyres.

[97] https://www.abc.net.au/news/2021-08-17/australian-exporters-pay-the-price-with-european-carbon-tax/100379998
[98] https://www.abc.net.au/news/2022-12-06/eu-agrees-law-preventing-import-of-goods-linked-to-deforestation/101741034

11.4.1 More required of OTR tyre importers

Under the current voluntary scheme arrangements:

- tyre importers contribute a levy tied to each tyre sold into the Australian market
- tyre retailers, used tyre collectors and recyclers participate in the scheme by reporting tyre data and being accredited (and audited) by TSA.

Levies support the scheme objectives including market development funding, while reporting enables TSA to understand volumes and locations of used tyres, and scheme performance against the objectives.

These important contributions need to continue, with a growing base of levy payers over time, to ensure a greater share of the tyre market and a lessening impact from free riders. That said, OTR tyre importers may be called upon – both based on Scheme drivers and large customers' ESG drivers alike – to do more than pay an annual levy.

As pivotal actors in the global supply chain for OTR tyres, they are key partners in the shift to a circular economy for tyre products. They are uniquely positioned to aid this transition by:

- disclosing supply chain impacts – on greenhouse gas emissions, water cycles, fair trading practices, deforestation and biodiversity loss, and other concerns – to their major customers so that they can make informed tyre supply and recovery decisions and use their purchasing power to influence those impacts
- working with large customers – mainly mining companies but potentially farming communities – on business model and product specifications to increase the ease of recycling and recovery and to reduce the materials intensity in using OTR tyres in their business operations
- influencing their supply chain partners, i.e. retail and logistics partners, to play a greater role in assisting recovery (see further details below)
- investing in or partnering with one or more parts of the tyre recovery supply chain over the medium- to longer-term, potentially involving reprocessing capacity, in a way that helps to enable a 'tyres-into-tyres' recovery model.

This range of commercial interests and stewardship activities may be applied equally across Scheme outcomes and the needs of major OTR tyre customers. The more proactive suppliers therefore stand to benefit, as innovative market leaders who are positioned to respond to new opportunities shaped by the circular economy.

11.4.2 Local and regional OTR tyre services need to join

For passenger car and tyre retail, the role of the retailers and their networks may be limited compared to their role in supporting OTR tyre stewardship and the circular economy for OTR tyres.

For smaller automotive tyres, the retailer's main job is to sell and refit new tyres in place of damaged and worn tyres, while performing related services such as wheel alignment. The retailer also has a duty to engage a used tyre collection service to recover the tyres.

Depending on the sector and range of services within scope, the retail and after-sales network for OTR tyres is more complex and occupies a wider range of niches. As explained in Chapter 4, OTR tyre retail and after-sales services may include:

- long distance haulage to remote points of use (mining tenements and farms)
- inspection for maintenance, repair, re-tread or disposal
- repair and re-tread services (noting limited demand for re-tread in Australia)
- tyre replacement
- removal of end-of-life tyres for subsequent disposal or recovery off-site (in limited cases).

These niche OTR tyre businesses could offer more services to the circular economy, with potential to expand into:

- providing reverse logistics services and/or tyre drop-off points
- increasing offering of repair and re-tread services
- delivering one or more stages of tyre recovery (e.g. shredding, baling or processing into final products) targeting regional OTR and automotive tyres
- educating on vehicle usage to minimise wear and damage, and on the safe management of end-of-life tyres
- customer-facing engagement and promoting opportunities to participate in OTR tyre recovery trials coordinated by TSA and/or other parties.

In short, TSA and others with a stake in the circular economy for tyres need to understand the present range of activities and outlook of this sector, both at the national and catchment scale, and potentially use their unique services and functions in the OTR tyre supply chain.

11.4.3 The rules for and costs of disposal need to be fair

The mining sector not paying offsite disposal costs like everybody else

In Australia, for nearly 50 years solid wastes have been required to be taken to offsite licensed landfills, with two notable exceptions: coal ash from power stations, and OTR rubber products on mining sites. Industry and the broader community are required to pay for offsite disposal of used tyres, conveyors and tracks at licensed landfills. Mining operations are an exception as they dispose onsite at little or no cost.

These offsite licensed landfilling costs include:

1. The state or territory **landfilling levies** that are in place to assist in the development of waste recovery alternatives to unsustainable ongoing landfilling.
2. The **gate fees** that are charged by the landfill operator. These fees vary for each waste type and are often high for waste tyres as landfill operators may not want tyres as they are difficult to compact in the landfill cell. Gate fees for used large OTR products can be very high due to the difficulty in handling and landfilling these wastes.
3. Some jurisdictions **require that waste tyres are shredded** before landfilling as the landfilling of whole tyres in large quantities is problematic for landfill compaction and long term stability. This can add another significant cost for offsite landfilling, especially for large OTR products.

It is worth noting that key mining areas of QLD and NSW are located within landfill levy zones. If used OTR rubber products were landfilled offsite, the total fees would be significant. The mining sector risks a sudden increase in costs if they were to lose their current permission to bury these products onsite, which can be mitigated by working to develop recovery pathways now.

Offsite licensed landfill operations follow much stricter rules

State and territory governments have long adopted the 'precautionary principal' in licensing landfills to protect the surrounding environment. They require basal clay liners and capping, leachate collection and treatment, site rehabilitation, and aftercare (including groundwater impact monitoring).

These requirements are not in place at mining site disposal areas, which creates an inconsistent social, environmental and economic framework in Australia.

The basic minimum landfill construction standards are typically for landfills receiving 'solid inert waste' (i.e. not taking wastes that rapidly degrade such as food wastes).

Solid inert landfill basal liner construction typically includes four layers including:

- a sub-base layer
- an engineered clay liners layer of at least 0.5 m think and compacted
- drainage layer/leachate collection system to remove leachate that is typically diverted to a dedicated pond area where it is evaporated and or treated
- a geotextile layer. Source EPA Victoria guideline page 19.

There is also the important landfill capping phase of solid inert landfill construction requirements that are similar to the basal lining requirements, outlined above.

Inert waste landfill cells are also typically required to be separated from the natural (unpumped) groundwater level by two meters.

There appears to be no justification for these landfilling requirements not to be applied to onsite landfills at mining sites. State and territory governments should resolve this inconsistency as it undermines used OTR product recovery.

If solid inert waste landfilling siting, design, construction, rehabilitation and aftercare requirements were consistently applied to onsite mining landfills there would be a significant incentive for miners to recover used OTR products.

11.4.4 Recognise local conditions and work with regional partners

Although catchments may have features in common, each catchment has its own regional profile.

For the Scheme's purposes, this profile hinges on the types of mining and agriculture activity that drive the usages and disposal practices of OTR tyres. But local economic interests, cultural assets, social norms and practices, landscapes and geography, demographic character, and accumulated regional history within and between different groups are also relevant to this profile.

In short, **each catchment has an intricate regional mosaic that needs to be heard and understood to identify how to best change the ways to move from in pit disposal to circular resource recovery options.**

Collaborating across government, commercial, environmental and social enterprises is complex. TSA's strategies in working at the catchment-level should look at the community as a whole, being flexible in approach, listening and learning from local experience, and working with the local stakeholder and community's strengths.

This method will enable the Scheme to use the relationships, networks, expertise, and language in the catchment, while factoring in local interests and values into emerging opportunities. Greater local awareness of the costs and lost resources of disposing OTR tyres will help to sustain scrutiny and pressure on businesses that don't recover OTR tyres, and on third parties who enable disposal to continue.

11.4.5 Ongoing cycles of circular economy innovation needed

We have previously explored differences between how automotive tyres are supplied, used and disposed of, compared to mining and agriculture tyres. The physical features of OTR tyres, their distribution pattern, and regulatory environments they're subject to, create differences in how they can be recovered compared to automotive tyres.

Some of the major users of OTR tyres in the mining sector also seek distinct outcomes in how to recover their tyres over the longer term, which may not match existing methods. Their sense of ownership of a tyre recovery solution and the costs, benefits and risks involved, may be material to their engagement with the tyre recovery industry. To these customers it is not a simple binary choice between disposal and recovery, and they may expect finer details of the ESG impacts across the whole recovery chain.

This shows that the business model for recovering automotive tyres in urban settings will need to evolve to meet the needs of major users of OTR tyres. For some larger OTR tyre users, their access to capital and scale of operation enables them invest in an in-house solution. This is precisely how some parts of the mining and agriculture sectors have begun to resolve their demand for low-emissions energy, i.e. by deploying and managing their own assets.

While the Scheme is agnostic in terms of who delivers OTR tyre recovery services to different customers, we recognise the depth of expertise, perseverance, processing capacity and business acumen of the current tyre recovery sector. Service providers in the sector have a natural place to engage with mining and agriculture sector users of OTR tyres, and have an important role in bridging the gap between end-of-life OTR tyres as an untapped resource and the demand for tyre-derived material.

As with OTR tyre suppliers though, higher levels of disclosure and greater pressure to innovate will be placed on businesses looking to work with OTR tyre generators, and they will need to respond to stay relevant.

It is in the Scheme's interest that the expectations and capabilities of the tyre recovery sector be transparent between customers and suppliers. This will lower the costs to deliver OTR tyre solutions and help avoid stranded capital.

There may be an important role in brokering between OTR tyre customers and tyre recovery service providers, which can be shared across tyre stewardship, peak bodies and others who serve as impartial and independent centres of knowledge.

11.4.6 Shared leadership should be encouraged

Sectors that use OTR tyres have a significant learning curve to shift from on-site tyre disposal to tyre recovery, as mining and agricultural companies may not be familiar with what drives the costs and benefits of one recovery path over another. This may in turn breed uncertainty, deferred commitment and avoiding responsibilities that will prevent the shift towards recovery at a national level.

To get out of this dilemma, OTR tyre generators need to make confident decisions and commitments towards tyre recovery. Larger businesses such as mining companies and major agricultural holdings have the capacity to bring different parts of their business together 'as one' where it comes to managing OTR tyres. This includes procurement considerations when purchasing tyres as well as a preferring to purchase products made from recycled tyres.

This internal alignment requires that when making a decision, businesses ensure that all elements point in the same direction (i.e. factors driving commercial fiduciary responsibility, community relations, ESG obligations, legal compliance, risk management, corporate culture and executive direction). The path to OTR tyre recovery needs to become a 'a standard consideration' in terms of this internal and external alignment. This whole of organisation approach will harness the purchasing power of larger businesses to drive innovation and long-terms solutions for OTR tyre recovery.

The Scheme needs to use every measure at its disposal (i.e. including third parties with a shared interest) to:

- develop a shared ownership of the problem and buy in to the opportunity
- ensure that all parties are working towards the same direction.

This will help OTR tyre generators and tyre recovery sector and make confident decisions, while enabling them to participate in a global economy that demands an increasing accountability towards environmental impacts.

Glossary

Term	Definition
Accreditation	Recognition by Tyre Stewardship Australia (TSA) that a business or organisation has made a commitment to, and meets the requirements of, the Scheme.
Accredited voluntary arrangement	A voluntary product stewardship arrangement accredited by the Australian Government under the voluntary product stewardship provisions of the Australian Government's Product Stewardship Act 2011.
Action Plan	The timeline and the steps that the applicant proposes to undertake to meet the commitments of the Categories nominated by the applicant. This includes how the applicant will promote participation in the Scheme to businesses and other organisations.
AMIF	Australian Motor Industry Federation.
Applicant	A business or organisation that is a legal entity with an ABN or ACN and has applied to become a Participant.
ATIC	Australian Tyre Industry Council.
Auto Parts Recycler	A business or organisation that salvages used automobiles and parts including auto wreckers, metal recyclers etc.
Baler	An individual, business or organisation that compacts end-of-life tyres into dense bales for the purposes of aggregation and transport. Balers may bale tyres for transport within Australia or to overseas destinations for further reprocessing. For the purposes of TSA participant categories, a baler is classified as a Collector.
By-product	A substance or object, resulting from a production process, the primary aim of which is not the production of that item. An example is steel from the shredding or pyrolysis of tyres.
Casings	The rigid, inner of a tyre upon which a tread is placed. Typically, tyres good enough for re-tread or resale as seconds are referred to as casings.
Collector	An individual, business or organisation that collects and/or transports end-of-life tyres in any part of Australia for recycling, re-use or disposal. For the purposes of the Scheme, a transporter is a collector.
Consumer	The final purchaser of a tyre. As the owner, a Consumer shares responsibility for the appropriate disposal of a tyre when it reaches its end-of-life.
Crumb rubber	A highly-refined rubber product, typically less than 1mm in diameter, made from recycled tyres.
Direct incineration of tyres	The incineration of tyres for disposal and without effective energy recovery.
Dispersal to the open environment	The dispersal of rubber from in-use tyres to the open environment (land, waterways, etc.) due to wear of the tyre tread.
Disposal	The dumping, landfilling, direct incineration, unsustainable burning, and stockpiling as an end point of used tyres.
Domestic recycling	Activities that occur to recycle or reprocess waste tyres within Australia.
Down Stream Vendor (DSV)	An individual, business or organisation that processes output (in the form of end-of-life tyre) from Australian tyre recyclers and/or collectors. A DSV is usually the last facility to reprocess an end-of-life tyre.

Term	Definition
End user	An end user is a person or organization that ultimately uses or consumes a product or service, such as an individual or business that purchases and uses tyres.
End-of-life tyre (EOL Tyre)	A tyre that is deemed no longer capable of performing the function for which it was originally made.
Energy recovery	The use of used tyres in a thermal process to recover energy for electricity generation or industrial process.
Environment Protection and Heritage Council (EPHC)	See Standing Council on Environment and Water.
Environmentally sound use	The use of whole, part or recovered components of end-of-life for applications that minimise or prevent environmental, health and safety damage or harm.
Equivalent Passenger Unit (EPU)	A standardised measure for the quantity of tyres. One EPU contains as much rubber and other materials as a 'typical' passenger tyre. For the purposes of this Scheme, the assumed weight of one new EPU is taken to be 9.5 kg and one end-of-life EPU is taken to be 8 kg. See Appendix 1 of the TPSS Guidelines, which provides the list of EPU ratios for different types of tyres that apply for the purposes of reporting by tyre importers under the Scheme and the list of ratios that apply for reporting by tyre recyclers under the Scheme.
Export	Export from Australia.
Export agent and brokers FEM	An intermediary individual, business or organisation that primarily manages the export of end-of-life tyre to overseas destinations.
Export participant	A Scheme participant who is an export agent and brokers or FEM vendors/ supplier.
FCAI	The Federal Chamber of Automotive Industries.
Fleet operator	An entity that owns or operates a fleet of vehicles, including private and Australian and state and territory government fleet operators.
Fleet participant	A Scheme participant who is responsible for the operation of a fleet of vehicles including primary and secondary industries.
Foreign End Markets (FEM)	The end destination (overseas) of Australian generated end-of-life tyres and/or tyre derived material for reprocessing. Whilst FEM vendors cannot be accredited under the Scheme, they play a role in better transparency of the sustainable management of end-of-life tyre via involvement in the FEM Program where overseas facilities are verified to ensure no environmental and social harm.
Gate fee	See Recycling gate fee.
ICMM	International Council for Mining and Metals
Import	Import into Australia.
Importer participant	A Scheme participant who is responsible for the import of new tyres for use in Australia. This includes tyre manufacturers, tyre importers, vehicle importers, and mining tyre importers.
Importer	An organisation who is responsible for the import of new tyres for use in Australia. This includes tyre manufacturers, tyre importers, vehicle importers, and mining tyre importers.

Term	Definition
Industry and commercial group participant	A Scheme participant who is not responsible for the management of new or used tyres such as industry associations
In-use	Tyres that are in demand for the purpose for which they were originally made.
Landfill	Waste disposal sites used for the authorised deposit of solid waste onto or into land.
Local government	A government entity with powers and geographical distribution established by a state or the Northern Territory. A 'Local government' can also be referred to as a local council, city, shire, town or municipality. See also advice on the Australian Capital Territory on page 28 of the TPSS Guidelines.
Local/domestic recycler	An individual, business or organisation that recycles end-of-life tyres in Australia.
Material flow analysis (MFA)	MFA is an analytical method to quantify flows and stocks of materials in a well-defined system. MFA is used to study material flows across different industrial sectors. When combined with an assessment of the costs associated with material flows this business-oriented application of MFA is called material flow cost accounting. MFA is an important tool in establishing a circular economy.
Mechanical repair business or auto service centre	An individual, business or organisation that maintains and repairs motor vehicles.
Miners	Businesses or organisations that are engaged in the exploration for, and extraction and primary processing of, minerals in Australia, including coal and petroleum. Primary processing is taken to include the processing of minerals up to the first pouring of refined metal but fabrication beyond that stage is excluded.
Mining tyre importer	Any business or organisation importing tyres that are to be used by businesses or organisations engaged in the exploration for, and extraction and primary processing of, minerals in Australia, including coal and petroleum.
Mobile tyre service	Mobile tyre services are tyre services that are not store based and require equipment that is moved to the point of disposal.
Non-motorised trailer	A trailer, vehicle, caravan or camper towed behind a motorised vehicle.
Off-the-road (OTR) tyre	OTR tyres for the purposes of the Scheme and this business case are those tyres that: Are not fitted or attached to two-wheeled vehicles, passenger cars (including four wheel drive vehicles), trucks or other large on road vehicles during their use, irrespective of this use being on road or off road; and Are used on vehicles involved in heavy duty applications in industries such as mining, agriculture, aviation, manufacturing, construction and defence (but not limited to those industries); and Are of a size and/or weight that is incompatible with currently-active tyre recovery facilities and related operations (including transport, storage and/or processing steps) designed to recover passenger car and truck tyres, in the absence of prior additional or adapted handling or processing steps.
On-line tyre retailer	An on-line tyre retailer facilitates tyre sales primarily through an online interface or portal. Tyres are often fitted by a third party which could include a physical retail store, mobile service or mechanical repair business.

Term	Definition
Participant	A business or organisation that has received accreditation from Tyre Stewardship Australia and made a commitment to meet the requirements of the Scheme.
Participant requirement	All participants of the Scheme are required to adhere to a series of general commitments in ensuring that used tyres are disposed of in a manner that constitutes an environmentally sound use. In addition to general commitments, specific participant categories are required to adhere to specific conditions that they operate in compliance with key laws and standards including in relation to the environment, occupational health and safety, and employment
Parties to the scheme	The Australian Motor Industry Federation, Australian Tyre Industry Council, Australian Tyre Recyclers Association, and Federal Chamber of Automotive Industries which came together to develop the Guidelines and support the establishment of Tyre Stewardship Australia; and who have approved these Guidelines.
Processing	Manual, mechanical or thermal alteration of end-of-life tyres for the purpose of recycling or productive reutilisation of tyre material.
Product stewardship	A policy approach recognising that manufacturers, importers, retailers, governments and other persons have a shared responsibility for the environmental impacts of a product throughout its full life cycle. A product stewardship scheme establishes a means for relevant parties in the product chain to share responsibility for the products they produce, handle, purchase, use and discard.
Recovery	Used tyres that are collected and either reused, recycled or recovered for embodied energy (energy recovery) either in Australia, or overseas.
Recycle	A process to recover constituent materials from end-of-life tyres and use those materials to produce other products.
Recycler	see Tyre recycler.
Recycling fee	The money that is paid when end-of-life tyres change hands in the supply chain and covers the costs associated with activities such as handling, storage, transport and recycling.
Recycling gate fee	The money paid to a tyre recycler to ensure the environmentally sound use of end-of-life tyre.
Repurposing	The use of an end-of-life tyre whole for another use other than for recycling or energy recovery. This includes use in civil engineering, motorway protective barriers and agriculture where permitted under state regulations.
Resource recovery	The process of extracting materials or energy from a waste stream through reuse, recycling or recovering energy from waste.
Retailer	A business or organisation that offers products for sale at retail through any means, including sales outlets, catalogues, or the Internet. For the purposes of the Scheme, a tyre re-treader is a retailer.
Retailer participant	A Scheme participant who is responsible for the replacement of a used tyre. This includes mobile tyre services, vehicle dealerships, mechanical repair businesses and fitment centres who sell retail tyres to customers.
Re-treader	An entity that gives new tread to a tyre. For the purposes of the Scheme, a tyre re-treader is a Retailer.
Reuse	To use a collected tyre for the same or similar purpose as the original purpose without subjecting the tyre to a manufacturing process that would change its physical appearance.

Term	Definition
Rubber granule	A refined rubber product, typically 2mm – 15mm, made from recycled tyres.
Scheme	The Tyre Product Stewardship scheme administered by TSA, being the arrangement between parties in the tyre supply chain to share responsibility for the long term management of end-of-life tyres in Australia, as set out in this document.
Scheme participant	A business or organisation that has made a commitment to operate in a manner that aligns practices to the achievement of Scheme objectives and has been accredited by Tyre Stewardship Australia. Scheme participants can be referred to as Accredited participant, Accredited Scheme participant, Scheme participant, or participant.
Standing Council on Environment and Water	The body comprising Ministers from the Australian Government, the Australian Capital Territory, New South Wales, Victoria, Northern Territory, Queensland, South Australia and Western Australia plus others. The Council considers matters of national significance on environment and water issues. It replaces the Environment Protection and Heritage Council.
Transporter	see Collector
Tyre	A vulcanised rubber product designed to be fitted to a wheel for use on, or already fitted to, motorised vehicles and non-motorised trailers towed behind motorised vehicles. **For the purposes of these Guidelines,** 'tyre' includes, but is not limited to, a tyre for motorcycles, passenger cars, box trailers, caravans, light commercial vehicles, trucks and truck trailers, buses, mining and earth moving vehicles, cranes, excavators, graders, farm machinery, and forklifts.
Tyre-derived fuel (TDF)	A fuel derived from end-of-life tyres and includes whole and shredded tyres used for this purpose.
Tyre-derived material (TDM)	Any product produced from rubber, steel, textile or other material recovered from recycling end-of-life tyre. This was previously referred to as TDP. For TSA, TDM is the preferred terminology for this concept as TDP is already an established acronym in plastics recycling, referring to thermal depolymerization.
Tyre-derived product (TDP)	See TDM.
Tyre importers and vehicle manufacturers and importers	Businesses or organisations that are engaged in tyre importing, vehicle importing or vehicle manufacturing and are first to supply a tyre to the domestic Australian market.
Tyre product stewardship scheme ("the Scheme", "TPSS")	The arrangement between parties in the tyre supply chain to share responsibility for the long term management of end-of-life tyres in Australia.
Tyre sections	A business or organisation recovering rubber, steel, textile and/or other materials and processing it into a form whereby it can be used as an intermediate product in the manufacture of TDP, or to recover energy from end-of-life tyres.
Tyre recycler	For the purpose of the Scheme, a tyre retailer means a business or organisation that offers tyres for retail sale through means such as traditional retail stores or on-line. A tyre retailer includes mobile tyre services, vehicle dealerships, mechanical repair businesses and fitment centres who sell retail tyres to customers.
Tyre retailer	The entity created to administer the Scheme.

Term	Definition
Tyre Stewardship Australia (TSA)	Shredded tyres prepared to a specification for use as aggregate in civil engineering applications.
Used tyre	A tyre that is deemed no longer capable of performing the function for which it was originally made.
Used tyre baler	An individual, business or organisation that compacts used tyres into dense bales for the purposes of aggregation and transportation for further processing or recycling. Balers may bale tyres for transport within Australia or to verified Foreign End Markets (FEM) for further processing or recycling.
Used tyre collector	An individual, business or organisation that collects and/or transports used tyres in any part of Australia. This includes transporters, balers, local waste facility, auto parts recyclers.
Used tyre fates	What happens to Australian used tyres when they reach the end of their useful life (either in Australian or overseas) including re-use, recycling, energy recovery, and disposal fates.
Vehicle dealerships	A business or organisation that offers vehicles for retail sale through means such as through traditional retail stores or on-line.
Vehicle importers	A business or organisation involved in vehicle importation and are first to supply a tyre to the domestic Australian market.
Waste facility	Private or government operated facilities such as transfer stations and landfills for the purpose of disposal and/or recovery of used tyres by individuals and businesses. A waste facility includes a business who recycles tyres.

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Section 5 – Appendices

Appendix 1 - Conveyors & Tracks

Conveyors

1 Introduction

This report provides the analysis of rubber conveyor belt consumption and end of life management and fate in the 2021-22 financial year. It includes:

- An overview of the product type, its applications and how the product varies to meet the application requirements.
- The estimated product consumption in the 2021-22 derived from analysis of Australian import data and onshore manufacturing (where this occurs).
- Discussion of end of life (used) product waste generation, waste management, and fate (recycled, sent for energy recovery or disposed).

2 Conveyor belts

2.1 Overview

Conveyor belts are used in a wide variety of materials handling applications, from small belts used in mobile machinery plant through to very large and long belts used to shift/load millions of tonnes of resources each year.

Conveyor belts size, weight, width, construction and materials composition are dependent on the belt application. The Australian Bureau of Statistics (ABS) imports data segregates rubber conveyors by the belt width and by the reinforcing materials (either steel or fabric). The reinforcement material used in conveyors is particularly relevant to the business case analysis as it has implications for the barriers and opportunities of conveyor recovery.

Australia imports significant quantities of conveyor belts, some fully fabricated to length ready for use and also in lengths (rolls) for fitting onshore to the application. Unlike tyres and rubber tracks, Australia still manufactures conveyors onshore, and consumption is therefore derived from the sum of imports and onshore manufacturing. Onshore manufacturing focuses mainly on large belt applications for heavy industries such as mining, where the belts are custom made for the client site and application.

2.2 Estimated conveyor belt consumption in Australia

2.2.1 Conveyor imports

The ABS provides import data for Australian conveyor belt imports in seven different product categories. Table 1 provides the import tonnages for conveyors for the 2021-22 financial year for each jurisdiction and shows the following:

- Around 30,000 tonnes of conveyors were imported into Australia in 2021-22.
- Belts reinforced with steel made up only around 35% of imports, with 65% of belt imports reinforced with textile materials.
- WA dominated consumption across almost all belt types, followed by Qld, then NSW and Vic reflecting the scale of the resource sectors in these states.
- SA, Tas, NT all imported only relatively minor conveyor tonnages in 2021-22.

Table 60 Australian conveyor import tonnages by type and jurisdiction 2021-22 (Source ABS).

Conveyor type	Imports (Tonnes)	%	Total %
Conveyor belts or belting, of vulcanised rubber, reinforced only with metal, exceeding 915 mm but not exceeding 1375 mm in width	**1,684**		**6%**
New South Wales	190	11%	
Queensland	273	16%	
South Australia	21	1%	
Victoria	0	0%	
Western Australia	1,200	71%	
Conveyor belts or belting, of vulcanised rubber, reinforced only with metal, exceeding 1375 mm in width	**8,384**		**28%**
New South Wales	116	1%	
Northern Territory	153	2%	
Queensland	172	2%	
Victoria	19	0%	
Western Australia	7,925	95%	
Conveyor belts or belting, of vulcanised rubber, reinforced only with metal, not exceeding 915 mm in width	**252**		**1%**
New South Wales	3	1%	
Queensland	27	11%	
South Australia	-	0%	
Tasmania	3	1%	
Victoria	24	10%	
Western Australia	195	77%	
Conveyor belting, of vulcanised rubber, reinforced only with textile materials, not exceeding 915 mm in width	**3,047**		**10%**
New South Wales	602	20%	
Northern Territory	7	0%	
Queensland	1,042	34%	
South Australia	138	5%	
Tasmania	7	0%	
Victoria	423	14%	
Western Australia	829	27%	
Conveyor belting, of vulcanised rubber, reinforced only with textile materials, exceeding 915 mm in width	**3,802**		**13%**
New South Wales	662	17%	
Northern Territory	46	1%	
Queensland	918	24%	
South Australia	105	3%	
Victoria	438	12%	
Western Australia	1,632	43%	

Conveyor type	Imports (Tonnes)	%	Total %
Conveyor belts, of vulcanised rubber, reinforced only with textile materials	**12,469**		**41%**
New South Wales	2,278	18%	
Northern Territory	162	1%	
Queensland	1,876	15%	
South Australia	374	3%	
Tasmania	-	0%	
Victoria	1,765	14%	
Western Australia	6,013	48%	
Conveyor belts or belting, of vulcanised rubber (excl. those reinforced only with metal or only with textile materials)	**408**		**1%**
New South Wales	112	28%	
Queensland	121	30%	
South Australia	2	0%	
Tasmania	-	0%	
Victoria	66	16%	
Western Australia	106	26%	
Total	**~30,000**		**100%**

Review of ABS data for the 2020-21 financial year identified around 34,000 tonnes of conveyor imports, with similar proportions of belt type imports as shown in Table 60. This indicates that conveyor imports are relativily stable at around 30,000 to 35,000 tonnes per year.

2.2.2 Conveyor manufacturing in Australia

Continental (ContiTech) and Fenner Conveyors (a Michelin Group Company) both manufacture conveyors in Australia. Continental does all manufacturing in Bayswater Victoria and Fenner has eight manufacturing facilities around the country. Both companies have distribution and conveyor servicing centres set-up around the country, and in close proximity to major resource extraction areas.

The amount and type of conveyors manufactured onshore by Continental and Fenner is commercially sensitive information and actual production amounts are not known. Both companies are manufacturing large belts to service the resource sector, in particular, and therefore it is estimated that at least the equivalent of the imported belt tonnages are manufactured onshore.

For the purposes of the business case, an estimated 30,000 to 50,000 tonnes of onshore conveyor manufacturing is assumed.

It is also assumed that the conveyor types that are manufactured onshore are similar in composition to conveyors imports (i.e. belts reinforced with steel around 35% and 65% reinforced with textile materials). Whilst onshore manufacturing is understood to focus on large heavy duty belts servicing the resource sector, less abrasive resources such as coal are understood to use fabric belts, rather than steel belts.

Conveyor belt refurbishment

Both Continental and Fenner provide conveyor repair services and also complete belt refurbishment services. Belt refurbishment is similar to tyre re-treading, i.e. using the belt carcass and applying a new rubber covering. Continental's website (Dec 2022) states that approximately 80% of all belts can be refurbished and promotes the following benefits of belt refurbishment:

- 65-75% of the new belt price, depending of used belt type and conditions
- Same life / warranty time as a new belt
- Reduction of disposal cost / stock
- Less pollution.

Industry consultation indicates that belt refurbishment is currently not widely adopted in Australia, due to labour costs, logistics of belt removal and transport, and clients often preferencing the convenience of full belt replacement.

2.2.3 Estimated total conveyor belt consumption

Based on the analysis presented above, the total estimated conveyor belt consumption (imports plus onshore manufacturing) is 60,000 to 85,000 tonnes per annum. Exports of conveyor belts out of Australia are assumed to be insignificant.

Based on the composition of conveyor belt imports, it is assumed that around 35% of the total conveyor belt consumption tonnages are reinforced with steel and the remaining 65% are reinforced with textile materials.

Table 61 includes a summary of the upper and lower estimates of rubber conveyor consumption in Australia per year. It also provides the estimated proportion of conveyor type based on the reinforcement material (steel or fabric).

Table 61 Estimated Australian conveyor belt consumption total and by type (tonnes per year)

	Consumption estimate (tonnes per year)	
	Lower	**Upper**
Conveyor imports	30,000	35,000
Onshore conveyor manufacturing	30,000	50,000
Total	60,000	85,000
Conveyor type		
Steel reinforced	20,000	30,000
Fabric reinforced	40,000	55,000

2.3 Used conveyor waste generation, management, and fate

2.3.1 Waste generation

The lifespan of conveyor belts determines the period between consumption and the generation of waste conveyors.

CSIRO 2022[1] notes that the "life span of conveyor belts depend on the application, usage and volumes and types of materials the conveyor belts are used for moving. Belts often last for 11-12 months, some

[1] Boxall NJ, Tobin S, Minunno R, Cheng KY, Zaman A, Kaksonen AH. (2022) *Exploring opportunities for increasing value recovery from end-of-life tyres and conveyor belts in Western Australia.* Report for: Department of Water and Environmental Regulation (DWER) and Tyre Stewardship Australia (TSA). CSIRO, Australia.

less or more. The causes of reported conveyor belt failures include (1) product failure (rare); (2) damage (e.g., by large rocks); (3) worn out or fatigue of the casing (in this case, generally a longer section of the belt would need to be replaced). Many mines have the equipment to measure belt thickness and damage of conveyor belts in real-time to enable predictive maintenance or replacement of the belts, and hence, the projected lifespan of the conveyor belts does not necessarily reflect when they get changed out and disposed. They might get changed out during shutdowns if the forecast indicates that it is too risky to wait longer in case a failure happens during a time that will interrupt operations. For example, the operation of conveyor belts is critical during the loading of ships in ports. Therefore, some of the remaining lifespan of a belt may be sacrificed, but the degree of the sacrifice depends on the location and the criticality of the belt. Conveyor belts are generally repaired on-site as it is not practical to send long conveyor belts for repair. The damaged conveyor belt can be repaired by doing what is known as "splicing", which joins the steel cords within the belt together. This involves matching up steel cords, cables joining, heating, and curing of rubber.

According to one stakeholder, when conveyor belts reach their end of life, most mine sites stockpile them on-site. There is reluctance to bury the entire steel wheel that holds the conveyor belt, and typically there is a lot of land area around mine sites for stockpiling. Unlike EOLTs, there are no restrictions to stockpiling these materials. One stakeholder estimated that approximately 25 % of used conveyor belts would be buried on-site." Page 33.

Whilst there is uncertainty regarding the lifespan of conveyor belts (i.e. how lifespans could be extended by repair or refurbishment, or reduced due to early replacement) it can be assumed that the annual consumption of new conveyor products (60,000 to 85,000 tonnes) is in-effect the 'replacement rate' of current conveyors that are in-use. Therefore, it can be assumed that over-time,

the consumption tonnages of conveyors equate to waste generation as conveyors that are imported or manufactured onshore are assumed to be consumed (not stockpiled or unsold).

Given the relatively short lifespan noted by CSIRO 2022, of around a year, estimating waste generation of conveyors based on the previous few years of consumption is reasonable.

Therefore, it is **estimated that around 60,000 to 85,000 tonnes of waste conveyors are generated in Australia currently.** This estimate would decrease or increase with any significant change in consumption in future years and conveyor consumption needs to be monitored annually.

2.3.2 Conveyor waste management and fate

The lifespan of conveyor belts determines the period between consumption and the generation of waste conveyors.

As noted above CSIRO 2022, industry consultation found that conveyor belts used in the resource sectors are being stockpiled onsite in conveyor belt 'grave yard' areas or are being buried onsite.

Industry consultation completed for the business case found that there are only very small tonnages of conveyor recovery in Australia, currently (in the hundreds of tonnes per year). This finding is verified by the findings of CSIRO 2022, that analysed WA in detail (where conveyor consumption and waste generation is highest): "Currently, there are no dedicated recycling facilities for conveyor belts in WA. Stakeholders indicated that existing EOLT processing facilities are not designed for processing end-of-life conveyor belts because technically, this is problematic due to (1) size of used conveyor belts being too large to be handled by existing equipment; (2) composition of conveyor belts being too complex (e.g., embedded with fibre and steel cords that would cause damage to equipment).

However, the same infrastructure that is used for tyre shredding and crumbing, could potentially also be used for processing conveyor belts after initial size reduction. Anecdotally, some companies are investigating the opportunities of setting up conveyor belt recycling plants in WA and shredding conveyor belts to extract steel and produce rubber crumbs. Based on stakeholder interviews, some companies receive old scrap conveyor belts from their clients for free, returning the belts to Perth. Some end-of-life conveyor belts are used to make top liners and used on agricultural floors to protect the hooves of animals. Lightweight ply or poly woven conveyor belts are to some extent repurposed for agricultural uses, e.g., in the horse industry in Hunter Valley in NSW. Heavier steel cord conveyor belts are not commonly reused this way." Page 40.

Based on the above, Table 62 includes the assumed waste management and fate proportions for waste conveyors in Australia currently.

Table 62 Assumed used conveyor waste management and fate proportions currently (%)

Conveyor belt type	Reuse	Recycling	Energy recovery	Landfill (offsite)	Stockpiling (onsite)	Buried (onsite)
Steel reinforcement	0%	0%	0%	0%	75%	25%
Fabric reinforcement	<1%	0%	0%	50%	25%	25%

Steel belts, mostly used in large heavy applications such as iron ore mining, are all assumed to be either stockpiled onsite or buried in-pit onsite. There may be some minor amount of reuse or recycling of these belts, however, no data could be identified to support this, and onsite management is understood to be the current fate of steel conveyors.

Fabric reinforced belts are used in a wider range of applications, including smaller applications within manufacturing in urban areas. Where these smaller fabric belts reach end of life, in urban areas, they are assumed to be sent to permitted landfills (offsite) and this is assumed to be around 50% of waste fabric belt tonnages. Where fabric belts are use in large and remote applications, such

as coal mines, it is assumed that the belts are managed onsite either in stockpiles or via pit burial (~50%).

Industry consultation identified a small industry set-up to reuse fabric reinforced conveyor belts, by repurposing them into flooring for the equine industry or as 'tub liners' for utility vehicles. However the tonnages reused are assumed to be less that 1% (<1,000 tonnes) nationally.

Tracks

1 Introduction

This report provides the analysis of rubber tracks consumption and end of life management and fate in the 2021-22 financial year. It includes:

1. An overview of the product type, its applications and how the product varies to meet the application requirements.
2. The estimated product consumption in the 2021-22 derived from analysis of Australian import data and onshore manufacturing (where this occurs).
3. Discussion of end of life (used) product waste generation, waste management, and fate (recycled, sent for energy recovery or disposed).

2 Rubber tracks

2.1 Overview

Rubber tracks have long been used on small to medium sized excavator applications and are increasingly being used across a variety of other construction vehicles (e.g. skid steers) and agricultural applications (e.g. tractor tracks). Consultation with track suppliers points to a significant shift in recent years from wheeled construction and agriculture vehicles to tracked vehicles that has seen rapid growth in track imports.

The rubber track size, weight, width, construction and materials composition are dependent on the track application. Like tyres, tracks are imported into Australia as a complete product ready for fitting to specific vehicles. Tracks are not imported as a 'roll' and then cut to size, as is the case with some conveyor product. Australia imports all track products and there is no onshore manufacturing.

Whilst composition of tracks varies by product specification, all tracks are understood to have a relatively high proportion of steel (to give tracks the required tensile strength) and the rubber that is used has a high proportion of natural rubber.

2.2 Estimated rubber track consumption in Australia

2.2.1 Rubber track imports

The ABS provides import data for Australian rubber track imports, although the import code may include some tonnages that are not rubber tracks, as the import code description is a catch-all for rubber not reported under a range of other import codes targeting rubber product imports.

Consultation with conveyor suppliers confirmed that the import code used for tracks is typically the 4016 prefix followed by a range of postfix codes linked to product type.

Table 1 provides the import tonnages for the codes covering rubber track for the 2021-22 financial year for each jurisdiction and shows the following:

- Around 25,000 to 30,000 tonnes of tracks were imported into Australia in 2021-22. Noting that the import codes may be capturing some imports that are not tracks and therefore be less than the 30,000 tonnes identified.
- Vic had the highest consumption, followed by NSW, Qld, then WA reflecting the scale of the construction and agricultural activity across these states.

- Consultation with suppliers found that most (~75%) of track imports were for construction vehicles (excavator and skid steers), which is reflected in the high import numbers for Vic and NSW, in particular, where construction activity drives consumption.

Table 1 Australian imports for codes covering rubber track by jurisdiction 2021-22, tonnes (Source ABS).

Import codes covering track imports	Tonnes
4016100012	797
Articles of cellular, vulcanised rubber, not covered by the preceding headings of this Chapter	
(excl. articles of hard rubber of HS 4017)	
New South Wales	182
Northern Territory	0
Queensland	100
South Australia	8
Tasmania	58
Victoria	408
Western Australia	41
4016990058	30,846
Articles of vulcanised rubber, not previously specified or included (excl. floor coverings, mats, erasers, gaskets, washers, seals, boat or dock fenders, inflatable articles, stationery & printers blankets; those of cellular or hard rubber)	
New South Wales	9,119
Northern Territory	4
Queensland	5,712
South Australia	691
Tasmania	26
Victoria	11,504
Western Australia	3,791
Total	**31,644**

Review of ABS data for the 2020-21 financial year identified around 30,000 tonnes of imports for codes covering rubber tracks, with similar state consumption proportions as shown in Table 1. This indicates that track imports are relativily stable at around 25,000 to 30,000 tonnes per year.

2.2.2 Estimated total track consumption

Based on the analysis presented above, the **total estimated track consumption is 25,000 to 30,000 tonnes per annum.** Exports of tracks out of Australia are assumed to be insignificant.

However, tracks consumption may increase significantly in future years if the shift from wheeled machines to tracked machines continues in construction and agriculture and consumption needs to be monitoried each year.

Table 64 includes a summary of the upper and lower estimates of tracks consumption in Australia per year by application.

Table 64 Estimated Australian tracks consumption total and by application (tonnes per year)

	Consumption estimate (tonnes per year)	
	Lower	Upper
Construction	18,750	22,500
Agriculture	6,250	7,500
Total	25,000	30,000

2.3 Used tracks waste generation, management, and fate

2.3.1 Waste generation

The lifespan of rubber tracks determines the period between consumption and the generation of waste. Whilst there is uncertainty regarding the lifespan of tracks (i.e. how lifespans could be extended by repair or a low amount of use, or reduced due to early failure) it can be assumed that the annual consumption of new conveyor products (25,000 to 30,000 tonnes) is in-effect the 'replacement rate' of tracks that are in-use.

Therefore, it can be assumed that over-time, the consumption tonnages of tracks equates to waste generation as tracks that are imported are assumed to be consumed (not stockpiled or unsold).

It is estimated that around 25,000 to 30,000 tonnes of waste tracks are generated in Australia currently. This estimate would decrease or increase with any significant change in consumption in future years and track consumption needs to be monitored annually.

2.3.2 Track waste management and fate

Industry consultation completed for the business case could not identify any verifiable track recycling services. There are companies online marketing recycling and disposal services for tracks, however, the recycling processes could not be verified, and it is therefore assumed that where this service is offered, the track is still disposed to landfill.

In Australia, currently, it is assumed that all tracks used by the construction sector are disposed to landfill (offsite) either directly by the consumer or via a collection company that takes the track to landfill.

Consultation with tracks suppliers for the agriculture sector found that almost all used tracks generated by farmers are kept on farm where the tracks are either stockpiled, buried or burned.

The recovery and recycling of tracks represents a challenge and an opportunity. The challenge is to provide a recovery process that can handle the high steel content and manage the size and weight of tracks without needing to build a stand-alone 'tracks only' plant. There is unlikely to be sufficient consolidated tonnages to make a standalone tracks processing plant a viable investment.

The opportunity is the relatively high value materials in used tracks (i.e. steel and natural rubber) that typically have good off-take markets.

Appendix 2 - Tyre Construction and Materials

A tyre is a complex engineering product, and consists of a variety of different rubber compounds, reinforcing materials and other additives. These materials are all carefully selected for the diverse conditions and performance considerations required for a tyre's operation. This summary paper will discuss the general construction and composition of the average tyre, the impacts these factors have on end-of-life reprocessing, and some of the knowledge gaps relating to OTR tyres.

General tyre construction

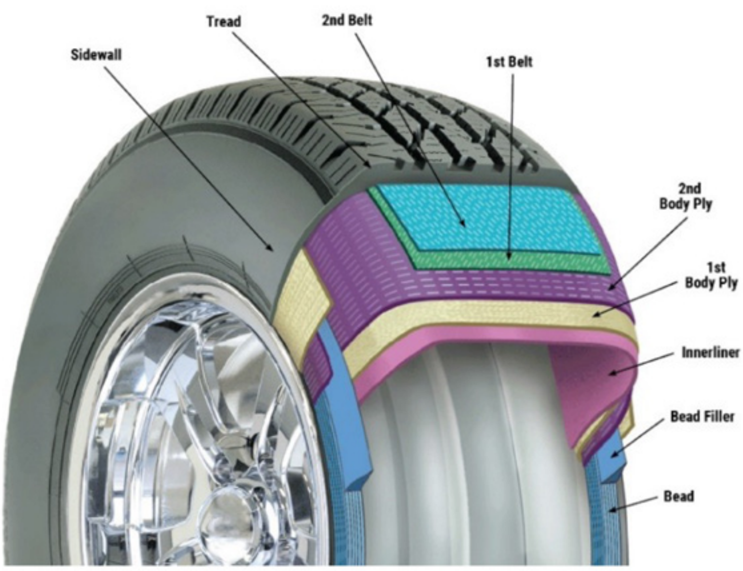
Most tyres are pneumatically inflated and are designed to provide key functional attributes such as a surface contact area, flexible shock absorbance and cushioning, traction over a surface, vehicle weight and load bearing capacity, the ability to transmit driving/steering forces and abrasion resistance. All pneumatic tyres will consist of what's referred to as the body/casing and the tread.1,2

The body of the tyre needs to provide both strength and the ability to contain compressed air. Components of a tyre body can include:

- **Bead**: strands of wire (steel) to anchor the tyre to the wheel rim.
- **Bead filler**: a rubber compound to provide rigidity and stability to the bead and lower sidewall area.
- **Inner liner**: a rubber compound designed to limit permeability and keep the tyres inflation pressure.
- **Body ply**: Tyres have one or more casing plies, making up the skeleton of the tyre to provide strength to contain the inflation pressure. In passenger tyres the ply generally consists of a fabric, such as polyester or nylon. In truck tyres the ply is generally a steel body ply. The plies within a tyre are either radial or bias, based on the direction of the ply around the tyre body.
- **Belts**: Steel cords which provide stability for the tread layer.
- **Sidewall**: A rubber compound which covers the body plies and belts, providing protection for the rest of the casing and a location for tyre information.

The tread of a tyre consists of a rubber compound with a pattern to provide optimal grip, traction, rolling resistance and abrasion resistance to treadwear.

Figure 1: An example of the construction and typical components of a pneumatic tyre. [1]



[1] U.S Tire Manufacturers Association. What's In A Tire. https://www.ustires.org/whats-tire-0 (2020).

General tyre composition

A tyre is made up of a unique mixture of materials, with each component carefully selected based on the requirements of the tyre. The previous section outlined the role of the metal and textile reinforcements, as well as different rubber compounds in each section of the tyre.

The compounds within a tyre consist of a mixture of different elastomers/polymers, reinforcing fillers and other additives. During manufacturing, the materials are combined in a unique formulation for each component, then pre-formed (for example extruded), assembled, then cured.

Table 1: Assumed used conveyor waste management and fate proportions currently (%)

Materials of Construction	Material function	Passenger	Truck	OTR#
Metal Reinforcement	Resistance and rigidity.	14%	22%	12%
Fabric (E.g. Nylon/ Radon)	Resistance, endurance, and comfort.	5%	1%	10%
Elastomer (natural/ synthetic rubbers)	Durability, rolling resistance, wear and traction/grip, reduces heat generation.	45%	47%	47%
Carbon black/silica (fillers)	Wear resistance (abrasion), tear resistance (tensile strength), lower rolling resistance, wet grip, UV protection.	25%	23%	22%
Oils/antidegradants/ resins	Processing aids, softeners, inhibits external temperature, prevent light/ozone degradation.	8-9%	4%	6%
Zinc Oxide	Accelerators and crosslink formation in rubber	1-2%	2%	2%
Curing Agents (e.g. sulfur)		1%	1%	1%
Total		100%	100%	100%
Approximate Biomass %	For emission factors and reporting	~23.1%	~31.5%	-
Natural Rubber (NR) vs	NR: high mechanical resistance, reduces heat generation.	18.4%	33.2%	-
Synthetic Rubber (SR)	SR: often better longevity and rolling resistance	26.5%	33.2%	-

Tyre compositions will vary depending on tyre type/brand; the above numbers are an average of tyre compositions from various international sources. [2 3 4 5 6 7 8 9]

Note # - OTR tyre example composition is derived from one international reference only and is the subject of further research by TSA in 2023 to more accurately illustrate variability within and across sectoral uses.

[2] U.S Tire Manufacturers Association. What's In A Tire. https://www.ustires.org/whats-tire-0 (2020).

[3] Shulman, V. L. Management of end-of-life tires. Tire Waste and Recycling (INC, 2021). doi:10.1016/b978-0-12-820685-0.00027-2.

[4] Gursel, A., Akca, E. & Sen, N. A review on devulcanization of waste tire rubber. Period. Eng. Nat. Sci. 6, 154–160 (2018).

[5] United Nations: Environment Programme. Basel Convention Series: Technical Guidelines on the Identification and Management of Used Tyres/Secretariat of the Basel Convention. October http://www.basel.int/meetings/sbc/workdoc/old docs/tech-usedtyres.pdf (2002).

[6] European Tyre & Rubber Manufacturers' Association (ETRMA). Guidance on the use of VULCANIZED-RUBBER PSEUDO SUBSTANCES in IMDS declarations of tyres. (2013).

[7] Continental. Tire Mixture: What's in your tires? https://www.continental-tires.com/car/tire-knowledge/tire-basics/tire-mixture (2021).

[8] Rodríguez, L. S., Bermejo Muñoz, J. M., Zambon, A. & Faure, J. P. Determination of the Biomass Content of End-of-Life Tyres. in Biomass Volume Estimation and Valorization for Energy (InTech, 2017). doi:10.5772/65830.

[9] Limited, A. & R. E. E. The Composition of a Tyre: Typical Components. www.wrap.org.uk (2006).

Whilst most tyre formulations contain similar ingredients and approximate weight percentages, the exact mixture of materials will depend on the type of tyre, the tyre use and which component of the tyre it is intended for (tread/sidewall/casing formulations may vary due to function).

A key difference between passenger, truck and OTR tyres is the types of elastomers used, particularly in the thickest section of the tyre, the tread. Truck and OTR tyres have a much higher percentage of Natural Rubber (NR), or the chemically identical synthetic rubber Polyisoprene (IR). This is due to the much lower heat build-up characteristics of NR over synthetic Styrene Butadiene Rubber (SBR). In passenger car treads, the thinner cross section means there is lower heat build-up and here SBR is favoured over NR for its combination of superior wet grip, treadwear and rolling resistance.

Each material component has a unique and crucial role to play in the function of a tyre, as summarised in the table above.

The impact of tyre composition on tyre recovery

The composition of different tyre types is an important factor to consider for the end-of-life processing stage, the performance and quality of the tyre derived material in end-markets, and the health and environmental impacts of the material. Furthermore, during the life of a tyre, it is expected there will be both significant tread wear and possible environmental contamination. The table above provides an indication of the average tyre formulation and construction, and whilst there may be a reduced amount of rubber available due to tread wear, increasing the percentage of non-rubber constituent (metals and fibre), the proportions of each constituent in the rubber formulations will remain consistent.

Reprocessing impacts

Physical reprocessing is designed to deconstruct the tyre and separate the steel from the compounded rubber component during successive size reduction steps. These processes aim to produce steel-free tyre derived materials such as rubber granules and crumb rubber. For larger OTR tyres, the increase in the size of steel beads is important to consider during reprocessing, as it is unlikely that conventional equipment will be able to effectively shred and separate the steel from large/extra-large tyres.

Sophisticated equipment has emerged that is able to liberate the fibre component from the elastomer and steel, which opens further opportunity for processing of tyres with a high percentage of fibre in the casing (namely passenger tyres and agriculture tyres). Not all tyre recyclers producing shred, granules and crumb rubber have access to this equipment. Therefore, it is crucial to understand which tyres contain high proportions of fibre, to guide facilities on which tyre types they have the capacity to reprocess.

Chemical recycling processes are also emerging, such as pyrolysis and devulcanisation, and are beginning to enter the tyre recovery sector globally. Importantly, the consistency and quality of output products from these processes is reliant on the homogeneity of the input feedstock material. A reliably consistent tyre feedstock or feedstock tyre combination will require accurate information on tyre composition.

Information regarding the different tyre reprocessing technologies, and the technical and commercial maturity of these technologies are discussed in more detail in section 4 of the business case.

End-market impacts

Recovered tyre rubber is flexible, strong and resilient, as well as impact, noise, and vibration absorbing. It is therefore a desirable material for inclusion in many engineering, construction and surfacing products, of which opportunities are continuously being realised.

One barrier faced to allow reprocessed materials in new products is the technical specifications often required for each industry. For example, crumb rubber from truck tyres is commonly used and incorporated into crumb rubber modified sprayed seals and asphalt, due to the beneficial properties relating to the different rubbers and carbon black.

Whilst similar polymers and fillers will be present in other tyre types (passenger and OTR), it is crucial that the different proportions of each do not impact the mechanical properties of the resultant road. As such, TSA is supporting ongoing projects to investigate whether crumb rubber from different tyre types will meet technical specifications to enable uptake in asphalt road projects.

A similar approach may be required in other areas, such as concrete and permeable pavements, depending on the technical specifications in each market. Thus, robust understanding of the chemical composition of each tyre is crucial to support and direct the research and trials in these markets.

Key knowledge gaps and future research

Whilst general information regarding tyre design, construction and composition is readily available, there is a clear lack of information regarding specific OTR tyre categories. After a detailed literature review of this topic, only one original source could be identified for the make-up of an OTR tyre, with no information on tyre size or type.8

This reference provides a helpful foundation, however work conducted via National OTR Business Case demonstrates that the many categories and subcategories of OTR tyres are both unique and varied. The assumption that conveyor belts and tyres used for agriculture, earthmoving, aviation, and construction all have the same composition is an oversimplification. Subsequently, understanding tyre construction and composition is important for both conventional and emerging processing technologies and end-markets.

Filling this knowledge gap regarding OTR tyre and conveyor belt composition will assist efforts to recover OTR tyres and conveyor belts in Australia. TSA is therefore embarking on research projects involving analytical testing to determine the chemical composition of different OTR tyre sizes and categories. This research is planned for 2023 and expected to provide general information, without divulging commercially sensitive information, to the industry to support increased OTR tyre recovery.

Finally, it is important in the management of end-of-life materials that they are rendered benign and don't cause potential harm in the reuse opportunities afforded by product stewardship, particularly any environmental or human health impacts. Global awareness and regulations are increasing regarding chemicals of potential concern and hazardous substances in materials and products. With a better understanding of material composition, these potential risks can be better understood, and any hazards managed and eliminated to avoid any unintended impacts and mismanagement issues.

TSA have been actively working on multiple research projects to date, which aim to address different market barriers and knowledge gaps regarding end-of-life tyres. These research projects include:

- Analytical testing for the presence of chemicals of potential concern in tyre derived materials.
- Developing management frameworks to mitigate any environmental and health impacts.
- Evaluation and management of site contamination risks for OTR tyres and conveyor belts.

These and other ongoing research studies will provide a better understanding of tyre composition, and hazards and risks that can be managed and eliminated to avoid future barriers preventing a circular economy for all tyres. As Australia moves towards a circular economy, it is important to design both for circular reuse and for end-of-life management.

Appendix 3 - OTR regulatory framework summary

1 Introduction

This section provides analysis of the regulatory framework that applies to the current management practices of used[1] OTR tyres, tracks and conveyor belts utilised in the mining and agriculture sectors (including permitted onsite storage and disposal, offsite transport, storage, reprocessing, landfilling, and illegal disposal).

The purpose of this section is to provide a summary of the rules that allow (or prohibit) the current management of most used OTR tyres, tracks and conveyor belts. This is important context when considering the development of recovery options for used OTR tyres, tracks and conveyors. The content focuses on the Australian states that generate the majority of used OTR tyres and conveyors – Qld, WA and NSW.

A summary table and list of key findings is provided first, followed by supporting analysis and reference materials.

2 Summary of regulatory framework analysis for Qld, WA and NSW

Table 1 Summary of regulatory frameworks for current management practices of used OTR tyres, tracks and conveyor belts in the mining and agriculture sectors

State	Onsite disposal (for mining sites only)	Storage (offsite)	Transport (offsite)	Reprocessing (offsite)	Offsite licensed landfill disposal	Illegal disposal (dumping)
QLD	'Rubber wastes' permitted to be disposed on-site. Licence requires waste hierarchy be implemented and locations recorded. Department has warned industry that onsite disposal may not be allowed in future.	>4 tonnes or 4m3 of used tyres **(approx. 500 passenger tyres)**, requires approval/ permit.	Used tyres are 'trackable waste'. Used tyre generators, transporters and reprocessors all have tracking requirements.	Permit required for **any (no threshold)** facility receiving used tyres for recycling, reprocessing, treatment, storage, incineration, energy recovery, sorting, consolidation or disposal.	Permit required. Landfill levy (Category 2 regulated waste): **$125 per tonne (plus gate fee)**, increasing $10/year, next 3 years. Tyres often required to be shredded adding another significant cost to landfilling offsite.	Significant dumping penalties. For example - **PIN $2,300 (individual), or $7,187 (corporation).** Taken to court: maximum **$57,500 (individual), $287,500 (corporation).**

[1] **Used tyres** is the term adopted for this section. It refers to end of life tyres and also **waste tyres** (a term often used in tyre regulation and included in several extracts included).

State	Onsite disposal (for mining sites only)	Storage (offsite)	Transport (offsite)	Reprocessing (offsite)	Offsite licensed landfill disposal	Illegal disposal (dumping)
WA	Permitted onsite disposal of tyres and conveyor belts. Location required to be reported, rules for batching of tyre burial and 500 mm of cover to be maintained.	Without a licence: • <500 tyres for a tyre fitting premises • <100 tyres for any other place. Define storage of >100 tyres as 'pollution' and "alteration of the environment."	Used tyres require 'controlled waste tracking form' (CWTF) to be used. Generators, transporters and facilities receiving >200 kgs of used tyres must complete CWTF.	Any facility that receives **>1,000** tonnes of used tyres for reprocessing or treatment (including associated storage), requires licensing by the Department. Tyre pyrolysis is regulated separately as 'char manufacturing' and requires licensing by the Department where 10 or more tonnes per year of fuel and/or carbonaceous or enriched carbon material is produced.	Outside the 'Tyre Landfill Exclusion Zones', used tyres can be disposed to a licensed landfill approved to accept tyres, shredded or whole. Standalone tyre landfills accepting 500 or more tonnes of tyres per year require licensing by the Department. **Assume zero landfill levy** for offsite landfills servicing areas generating used OTR tyres and conveyors. Significant landfill operator gate fees are still charged.	>100 used tyres defined as pollution, "alteration of the environment." Significant dumping penalties. For example - Maximum penalty for dumping of **$62,500 (individual) and $125,000 (corporation).**
NSW	Unlike Qld and WA licences, NSW mining licences (some or all) do not have specific requirements for onsite tyre, track and conveyor belt disposal onsite. Whilst these licence conditions are not in place, **it is unclear if onsite burial is permitted in NSW, or not.**	Any facility that stores >5 tonnes or **500 used tyres** requires approval / permit.	Used tyre generators, transporters and facilities receiving used tyres (>200 kgs or 20 tyres), must track and report to NSW EPA using 'WasteLocate'.	Any facility that **processes >5,000 tonnes** of used tyres per year, requires approval/permit. Notably higher than Qld and WA.	'Waste levy' (or landfill levy): • **Metro $151.60/tonne (plus gate fees)** • **Regional $87.30/tonne (plus gate fees).** Whole tyres cannot be landfilled in metro areas, in regional areas may require shredding. Where required, shredding would add significant cost.	Significant dumping penalties. For example - **On the spot fines: $7500 (individuals), $15,000 (corporations).** **Dumping offences: maximum $250,000 (individual), $1,000,000 (corporation)**

Used tyre regulatory framework review key findings:

- As used OTR tyre reuse and recycling is being established at remote mining locations around the world, it is more difficult for mining companies in Australia to demonstrate that the waste hierarchy is being implemented whilst they continue to simply dispose used tyres onsite.
- Unlike Qld and WA licences, the NSW EPA mining licences (some or all) do not have specific requirements for onsite tyre and conveyor belt disposal onsite. Whilst these licence conditions are not in place, it is unclear if onsite burial is permitted in NSW, or not.
- As the costs for disposing tyres, tracks and conveyors at offsite licensed landfill increases significantly, there is an increased financial driver to use mining sites, that are only allowed to bury tyres generated onsite, to illegally dispose tyres generated offsite. Mining companies should ensure that staff understand the licence limitations and ensure processes are in place to ensure no waste tyres are received from offsite generators.
- Qld, WA and NSW all have waste tyre transport tracking requirements. These requirements are important to consider before transporting of used tyres via a backloading arrangements from mining or farming sites to a tyre reprocessing facility.
- Key mining areas of Qld and NSW are located within landfill levy zones. If tyres, tracks, and conveyors were to be landfilled offsite, the landfilling fees would be significant (the landfill levy plus the landfill operator gate fees). In addition, tyres are often required to be shredded before landfilling at offsite licensed landfills – adding another significant cost.
- The combined risks of a lack of certainty regarding NSW mines being licensed to dispose their waste tyres onsite, the significant costs associated with offsite landfilling at a licensed landfill, and the increasing risk of mine sites being targeted for illegal dumping of tyres from offsite – should be driving investment in recovery solutions being implemented for OTR tyres, tracks and conveyors from the mining sector.
- There are significant fines and penalties for illegal dumping of waste tyres, which could impact the agriculture sector in particular where it is understood that significant amounts of waste tyres are disposed on farm via burial or burning (without a licence to do so).

3 Queensland

3.1 Permitted onsite storage and disposal on mining premises

In Qld used mining tyres, tracks and conveyors are all permitted to be disposed onsite with no limits on quantities. For example the Environmental authority EPML00318213 for the BHP Peak Downs Coal Mine includes the following requirements for 'bulk rubber'[2], see page 18:

The following types of waste are permitted to be disposed of within the mining leases listed on this environmental authority:

a) bulk rubber;

b) inert waste;

c) poly-pipe and other plastic;

d) fibreglass;

e) treated and untreated timber;

f) asphalt; and

g) asbestos.

These types of waste may be disposed of:

a) in pits or voids;

b) in spoil emplacements; and

c) left insitu below ground level.

The permit also includes the requirement for the development of a waste management plan for the site, which includes, amongst other things:

- requirements to record the amount and locations (GPS coordinates) of rubber waste disposed on-site
- identification of the potential risks to the environment from rubber waste disposal can control measures in place
- how rubber waste will be managed in accordance with the waste management hierarchy (avoided, reused, recycled, energy recovery, disposal).

As OTR tyre reuse and recycling is being established at remote mining locations around the world, it is more difficult for mining sites in Qld to demonstrate that the waste hierarchy is being implemented as is required within their waste management plans (and continue simply disposing rubber wastes onsite).

Eight years ago, the Qld Department of Environment and Science have published *Operational policy, Mining, Disposal and storage of scrap tyres at mine sites* (DES 2014). This policy is still online (at the time or writing) and states that new mining approvals should apply the 'waste hierarchy' in the management of used mining tyres by:

- *2.1 Avoidance,*
  When negotiating purchase agreements with new tyre suppliers, seek take-back clauses to maximise freight backloading opportunities.
- *2.2 Recycling*
  Explore opportunities to recycle scrap tyres on-site and locally through use in impact-absorbing surfaces, bitumen and road construction, pastoral and agricultural use, and civil engineering applications.

[2] Bulk rubber means **tyres, conveyor belt, and other similar rubber waste**

- *2.3 Waste-to-energy*
  Use existing opportunities in Queensland to recover the intrinsic energy value through waste-to-energy options.
- *2.4 Disposal*
  (a) Tyres stored awaiting disposal—or transport for take-back and, recycling, or waste-to-energy options – should be stockpiled in volumes less than 3m in height and 200 square metres in area. Additional fire precautions should be taken, including removal of grass and other materials within a 10m radius of the scrap tyre store. Tyres should be stored in a manner that prevents water retention and minimises mosquito breeding events. Options may include holing side-walls, covering with tarpaulins, spraying with a non-persistent insecticide, or reducing the stockpile during rain events.

  (b) Disposing of scrap tyres in underground stopes is acceptable provided this practice does not cause an unacceptable fire risk or compromise mine safety.

  (c) Disposing of scrap tyres in spoil emplacements is acceptable, provided tyres are placed as deep in the spoil as possible but not directly on the pit floor. Placement should ensure scrap tyres do not impede saturated aquifers and do not compromise the stability of the consolidated landform.

  (d) Disposing of scrap tyres (and other wastes) on mine sites is a notifiable activity under Schedule 3 of the Environmental Protection Act 1994, and the locations of the disposal sites need to be recorded on the Environmental Management Register.

As noted in the TSA 2020 *Mining industry off the road Used Tyre Analysis*, the Qld Department of Environment and Science has held discussions at senior level of Government with the Minerals Council of Australia flagging the Department's expectation for the current management practices for used mining tyres to change as new processing options come online and that the Department would consider banning onsite used tyre disposal if industry do not pursue an alternative to onsite disposal.

3.2 Storage of used tyres

In 2020, the Qld Department of Environment and Science published the guideline titled *Waste Handler Management of End-of-Life Tyres* (Waste Tyres). The guideline provides a useful summary of the waste tyre management and storage requirements including the following:

> *Under the Environmental Protection Act 1994, every person in Queensland holds the requirement to take all measures to prevent or minimise the risk of environmental harm (the General Environmental Duty). During storage you are required to minimise the environmental risks associated with the storage of tyres. These risks may relate to fire or the harbouring of vermin and pests, including mosquitoes.*
>
> *Most tyre retailers do not require specific licensing from the department, in the form of an Environmental Authority (EA). However, if you receive and* ***store more than 4 tonnes or 4m3 of EOL tyres at any one time (approximately 500 passenger tyres), you are required to hold an EA before operating.*** *Operating this level of activity is known as undertaking an Environmentally Relevant Activity (ERA), specifically (ERA) 62 – Resource recovery and transfer facility operation for which an EA is required.*
>
> *In addition to the department, there are other government bodies that manage risks posed by EOL tyres. Queensland Fire and Emergency Services has legislation (Fire and Emergency Services Act 1900) in place requiring occupiers of premises to take measures for the purpose of reducing the risk of fire occurring at the site.*

Whilst the Qld threshold for permitting storage is higher than that in WA (see section 3.2), the Qld 'General Environmental Duty' head of power under the *Environmental Protection Act 1994* means that anybody can be prosecuted for storage of waste tyres (regardless of the amounts of tyres), where the storage of the waste tyres impacts on the surrounding environment (e.g. due to fire or other impacts).

The Qld Government *Guideline – Prevention of fires in waste stockpiles* details the requirements for tyre storage to prevent fires. Qld Government requires any person who stores more than 500 tyres to take steps to minimise the risk of fire, including pile size and separation distances.

3.3 Transporting of used tyres (offsite)

Used tyres are a 'trackable waste' in Qld. This means that used tyre generators, transporters and reprocessors all have specific waste management requirements to meet, as set out below.

These requirements are important to consider before transporting of used tyres via a backloading arrangements from mining or farming sites in Qld to a tyre reprocessing facility.

The *Waste Handler Management of End-of-Life Tyres (Waste Tyres)* guideline summarises the offsite transport and tracking requirements for used tyres.

For the **generators** of used tyres (mining companies, farmer, etc.) the following requirements need to be met for the transport of the used tyres offsite:

> *… you are required to ensure the individual or company engaged to transport any amount of your EOL tyres, operates under a relevant EA for ERA 57 – Transporting Regulated Waste and completes documentation for waste tracking. It is recommended you obtain a copy of the EA before allowing any person to remove EOL tyres. **It is an offence under s.96 of the Environmental Protection Regulation 2019 for a generator to give trackable regulated waste to a transporter who does not hold an EA for ERA57.***

For the **transporter** of the used tyres the following waste tracking requirements apply:

- *Hold a valid EA for ERA 57 Regulated Waste Transport and comply with the conditions contained therein;*
- *Ensure you fulfil your obligations under the waste tracking provisions by recording, submitting and keeping prescribed information about the waste via WTC as stated above (see Division 3 of Part 9 in Chapter 5 of the Regulation). Schedule 12 of the same Regulation lists the prescribed information that must be handed between parties in the waste transaction;*
- *The WRR Act requires a transporter to provide delivery information to a waste facility where relevant, regarding how much of the waste is subject to the waste levy and whether the waste was generated in the waste levy zone or outside of Queensland (see sections 53 and 54).*
- *EOL tyres must be taken to a place that can lawfully receive that waste. You should ensure that you have checked and can demonstrate that the place you are taking the EOL tyres is lawful.*

For used tyres **reprocessors** the following waste tracking requirement apply:

- *Recording of the prescribed information onto the waste tracking form (paper-based WTC) or via the Connect system at the time the waste is received.*
- *Provide a copy of this information to the department by either emailing or posting the completed paper WTC to the department within 7 days of the waste being received OR submitting the information to Connect.*
- *Notify the department within 7 days of becoming aware of a discrepancy in the information received from the transporter when compared to the nature of the actual load of waste received. For example, the transporter has indicated that 200 tyres have been transported but there are only 100 tyres that you have received.*
- *Keep the records identified above for at least 5 years.*

3.4 Reprocessing of used tyres

Any facility receiving used tyres for recycling, reprocessing, treatment, storage, incineration, conversion to energy, sorting, consolidation or disposal (including disposal to landfill) must hold an Environmental Authority (EA) that permits the relevant activities at the facility. There appears to be no minimum permitting threshold for receipt of used tyres for reprocessing in Qld.

3.5 Offsite disposal at licensed landfill

As noted above, an Environmental Authority is required for offsite landfilling of used tyres, tracks and conveyors.

Landfill levies apply in Qld for the landfilling of waste tyres within the 'levy zone'. The Qld Government website (Jan 2023) explains that the levy zone covers 39 out of 77 local government areas in Queensland.

The levy zone is divided into two areas:

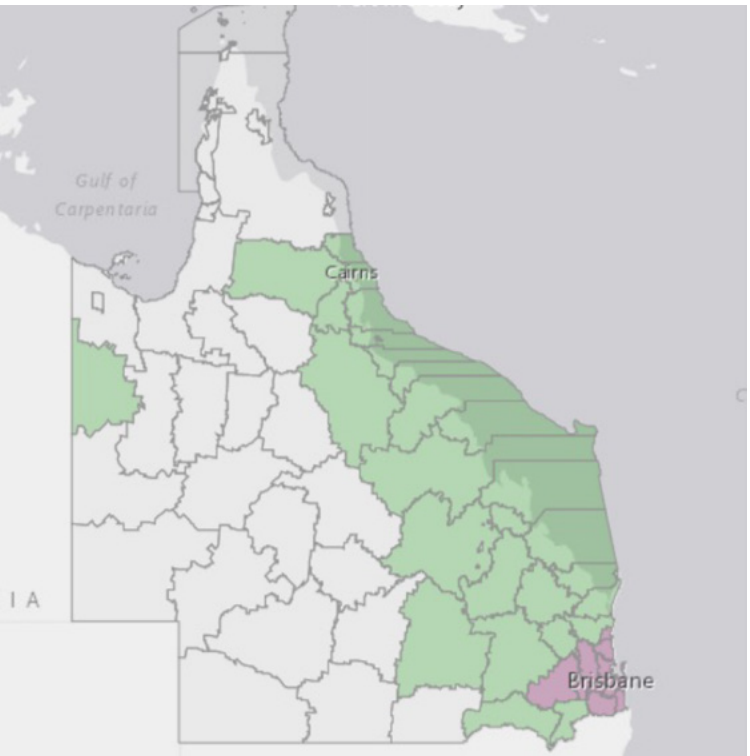
- the metro zone—comprising of the 12 south-east Queensland local government areas
- the regional zone—made up of the remaining 27 local government areas in the current levy zone.

The Environmental Protection Regulation 2019 set-out the current landfill levy for waste tyres (that are a Category 2 regulated waste) at $125 per tonne in 2022-23 and in set to increase $10 per year for the next 3 years. Figure 1 illustrates the local government areas where the landfill levy is applied in Qld.

It is worth noting that key mining areas of Qld, such as the Bowen Basin area, are located within the levy zone. If tyres, tracks, and conveyors were to be landfilled offsite, the landfilling fees would be significant (the landfill levy plus the landfill operator gate fees).

Review of several current landfill licenses, that can be viewed here, found that tyres are often required to be shredded before landfilling at some, but not all, licensed landfills. This would add another significant cost if OTR tyres were required to be disposed offsite, rather than in a mine void, or on farm.

Figure 1: Qld landfill levy zone (shaded LGAs in in the levy zone)



3.6 Illegal disposal of tyres

Queensland's Waste Reduction and Recycling Act 2011 (WRR Act) provides provisions to prevent illegal dumping across Queensland. Under the WRR Act, it is an offence for a person to unlawfully dispose waste.

The WRR Act defines illegal dumping in two categories:

- illegal dumping—200 litres or more, to less than 2500 litres
- illegal dumping—2500 litres and over.

The Qld law allows officers to issue penalty infringement notices (PIN) as well as compliance notices for the clean-up of the unlawfully disposed tyres. The fines and penalties for dumping are significant. For example, unlawful disposal of less than 2500 litres of waste (which would likely apply to a large agricultural tyre) could result in a PIN for $2,300 for an individual, or $7,187 for a corporation. If the matter was taken to court the fines could be maximum of $57,500 for an individual, or $287,500 for a corporation. Source: Queensland Government website, Jan 2023.

4 Western Australia

4.1 Permitted onsite storage and disposal on mining premises

In WA used mining tyres are permitted to be disposed onsite in designated areas that are defined in the mining site environmental licence.

WA licences sometimes contain specific requirements for used mining tyre storage and onsite burial.

For example, the current Newcrest Telfer Gold Mine licence, page 9, requires the following for storage:

> *Storage of tyres shall only take place within the tyre storage/burial areas shown on the Landfill Area Map in Schedule 1 (Figure 3).*
>
> *a) Not more than 40,000 used tyres shall be stored at the premises at any one time;*
>
> *b) Used tyre stacks shall not exceed 1000 tyres per stack and 5 m in height; and*
>
> *c) Used tyre stacks are to be stored no less than 4 m from any other tyre stacks.*

The licence also specifies the onsite burial disposal requirements for used mining tyres as follows:

> *Burial of tyres shall only take place within the tyre burial areas shown on the Landfill Area Map in Schedule 1 (Figure 3 and Figure 5).*
>
> *- Tyres shall only be landfilled:*
>
> > *a. in batches separated from each other by at least 100mm of soil and each consisting of not more than 40 cubic metres of tyres reduced to pieces; or*
> >
> > *b. in batches separated from each other by at least 100mm of soil and each consisting of not more than 1000 whole tyres.*
>
> *- Cell locations where tyres are to be buried will be surveyed and the latitude and longitude recorded.*

Figure 2 shows the 'landfill map area' referred to above, extracted from page 29 of the licence. Large storages of used tyres can be seen in separated piles awaiting burial.

Figure 2 Example of permitted mining tyre storage and burial area at Telfer Gold Mine in WA

Another example is the current licence for the BHP Mt Whaleback iron ore mine that includes almost the same burial requirements as detailed above. Importantly, the Mt Whaleback licence specifies these burial disposal requirements for "tyres, plastics, and rubbers including **used conveyor belts**".

Part 6 of the *Environmental Protection Regulations 1987* also require that tyres that are buried onsite at these mining sites are covered with a minimum of 500 mm of soil and that the "drainage, safety, soil erosion and soil stability at, and in the vicinity of, the site of that burial are adequately controlled".

The above two examples illustrate the current permitting of onsite burial disposal of OTR tyres and conveyor belts at mining sites in WA.

4.2 Storage of used tyres

Part 6 of the Environment Protection Regulation 1987 allows for storage of tyres without requiring a licence of up to **500 tyres at a tyre fitting business** or up to **100 tyres in any other place.**

To store a higher quantity of tyres requires a licence that specifies limits and storage requirements such as those included in the example licences, above. The regulations also define storage of tyres in amounts greater than those outlined above as 'pollution' and "is a prescribed alteration of the environment."

Interestingly, the regulations state that: "For the purposes of these regulations the size of a tyre is to be disregarded when computing the number of tyres in question." The regulations also provide a conversion factor of 100 tyres per two cubic meters of shredded tyres; however, it is unclear if this conversion factor is used to enforce storage limits (which would be difficult for whole tyres).

4.3 Transporting of used tyres (offsite)

In WA tyre retailers, tyre retreaders and the waste tyre transporters can each be guilty of an offence when waste tyres are transported to a place that cannot lawfully be used as a waste facility.

The WA *Environmental Protection (Controlled Waste) Regulations 2004* set out the requirements for tracking loads of waste tyres in WA

Waste tyre generators, transporters and facilities receiving waste tyres in WA weighing more than 200 kilograms must track and report this waste to the Department of Water and Environmental Regulation (DWER) via a 'controlled waste tracking form' (CWTF).

The information required to be recorded in CWTF is similar to that outlined for Qld (Section 2.3).

Again, it is important to consider the WA waste tyre tracking requirements before transporting used tyres via a backloading arrangements from mining or farming site in WA to a tyre reprocessing facility.

4.4 Reprocessing of used tyres

Under Category 61A Schedule 1 of the Environment Protection Regulation 1987, any solid waste facility that receives more than **1,000 tonnes** of waste produced on other premises for storage, reprocessing, treatment, or discharged onto land requires works approval and licensing by DWER. This threshold would likely capture any commercial OTR tyre, track or conveyor reprocessing facility.

4.5 Incineration of tyres

Part 6 of the *Environment Protection Regulation 1987* allows for incineration of tyres at licensed facilities in WA providing that a set of emission standards are met.

The Chief Executive Officer of the DWER also may approve any other method of disposal for used tyres.

4.6 Offsite disposal at licensed landfill

There are 'Tyre Landfill Exclusion Zones' in Western Australia that are applied to metropolitan and regional centre areas, as defined in Schedule 5 of *the Environmental Protection Regulations 1987*. In these zones landfilling tyres is not permitted unless approval is given by the Chief Executive Officer of the DWER.

Outside of the Tyre Landfill Exclusion Zones, tyres can be disposed to any landfill licensed to receive tyres and can be landfilled **shredded or whole**. Part 6 of *the Environment Protection Regulations 1987* provides general requirements for the disposal of tyres as follows, however conditions on individual licenses may vary:

- Shredded (size reduced) tyres are in batches of no more than 40 m^3, separated from each other by at least 100 mm of soil, and have a final soil cover of not less than 500 mm.
- Whole tyres are in batches of no more than 1,000 tyres, separated from each other by at least 100 mm of soil, and have a final soil cover of not less than 500 mm.

The DWER website details how landfill disposal levies are applied in WA. Landfill levies are only required to be paid for wastes received at licensed landfills in the **metropolitan region** and waste collected within the Perth metropolitan region that is received at licensed landfills outside of the metropolitan region.[4]

However, a very small proportion of used OTR tyres, tracks, and conveyors would be disposed in the metropolitan region. It can be assumed that zero landfill levy would be applied to any offsite licensed landfill servicing areas generating the bulk of WA's used OTR tyres, tracks and conveyors.

Although no landfill levy can be assumed, there can still be significant gate fees applied by the operator to receive OTR tyres, tracks and conveyors. Landfill operators typically do not want to receive OTR

[3] Licence required where landfill takes **500 tonnes** or more per year

[4] Used tyres are classified as 'inert waste' and would therefore by levied at $105 per cubic meter.

tyres, tracks and conveyors as they can be very bulky, difficult to handle onsite and at the landfill tipping face and they also do not compact well in the landfill, consuming valuable airspace and making the landfill more prone to differential settlement and waste exposure in the longer term.

CSIRO 2022 (page 14) reviewed the local government information for landfill gate fees across WA and found the following regarding landfill gate fees:

> *"…For the Earthmoving category, there were 17 different descriptors of EOLTs, dictated by machinery type and size included in this category, which resulted in the scheduled fees ranging from $50.00 to $210.00, depending on the size and whether it was accepted on rim and with contamination.*
>
> *Most regional LGAs have accepted truck tyres (including truck, heavy truck, large, bobcat). LGAs with pastoral industries located within their region have also accepted earthmoving tyres (e.g., tractor tyres), though the categorisation of the tyres accepted in this size range has been dependent on inclusion and descriptors in the scheduled fees. In some instances, LGAs have listed price on asking (POA) for these larger and speciality tyres.*
>
> *Only two regional LGAs had schedule fees for OTR tyres from mining vehicles, and these were categorised as Haulpak or similar. These were LGAs with mining tenements located within their shire, and the* ***disposal fee was $420 at one shire, and $1,140 at the other shire.*** *No other LGAs within WA accepted mining OTR tyres at LGA-managed waste management facilities. Despite this, the scheduled fee for disposal of these tyres differed by a factor of greater than 2.5 between the scheduled fees of the two LGAs.*
>
> *Similarly, only 5 LGAs in regional WA specified other rubber products in their scheduled fees. The categories included shredded tyres and commercial rubber products (including or excluding conveyor belts). The scheduled fees for these materials have typically been given as a minimum charge per tonne, and the fee ranges from* ***$29.70/tonne for shredded tyres to $880.00/tonne for commercial rubber products (including conveyor belts).*** *The LGAs that have listed conveyor belts specifically within their scheduled fees have been in regions of WA where mining has been a dominant industry. No LGA- or Regional Council-managed facilities in the Perth and Peel region have listed conveyor belts or other rubber products in their scheduled fees."*

The very high relative gate fees charged for OTR tyres, tracks, and conveyors reflects the difficulty in managing these wastes within an offsite landfill licensed to receive a range of other wastes.

4.7 Illegal disposal of tyres

As noted in Section 3.2, the storage of more than 100 tyres on a non-permitted site is defined as pollution and an "alteration of the environment."

Whilst licensed mining sites are not impacted by this threshold, large farming operations would likely be in breach of this legislation if storing more than 100 tyres onsite.

In addition to the above, amendments to *the Environmental Protection Act 1986 (Section 49A)* have been made to help reduce illegal dumping of unwanted waste materials, including tyres.

Subsection 49A(2) creates an offence for discharging or abandoning waste into water to which the public has access, and subsection 49A(3) creates an offence for discharging or abandoning waste into any place other than water to which the public has access. The maximum penalty for an offence against section 49A is $62,500 for an individual and $125,000 for a body corporate.

5 New South Wales

5.1 Permitted onsite storage and disposal on mining premises

A review of mining licences, in Jan 2023, such as the Mt Arthur Coal mine licence, one of NSW largest coal mines, or the two Whitehaven coal mines licences, found no reference to used or waste tyres and no reference to onsite burial requirements.

As noted in the TSA 2020 *Mining industry off the road Used Tyre Analysis,* consultation with NSW EPA staff found that mining tyres are allowed by EPA to be stored and disposed onsite with no limits on quantities or location. EPA also noted that if a farmer in NSW was to bury waste tyres on their farm it would be an offence. NSW EPA noted that it is likely to review the status of mining tyre onsite disposal in its annual review of regulations.

In August 2021, NSW EPA published this media release that stated the following:

> *The NSW Environment Protection Authority (EPA) has issued Official Cautions to six open cut coal mines in the Namoi and Liverpool Plains regions following an EPA investigation into the burial of waste haul truck tyres*
>
> *The investigation was in response to allegations of illegal receipt and burial of waste tyres at one open-cut coal mine in the Namoi region in June 2020.*
>
> *EPA Director Regulatory Operations Stephen Budgen said while the EPA did not find evidence that these tyres were brought onto the mine sites from other areas, the investigation identified that all six mines had buried their tyres without the necessary licence conditions.*
>
> *"The EPA is ensuring appropriate environmental safeguards are in place before on-site disposal is allowed to continue at mines," Mr Budgen said.*
>
> ***"We found instances of tyres being buried without necessary licence conditions at various times between 2014-2020.***
>
> *"While no environmental harm was found to have occurred, the EPA issued Official Cautions to all six of the open cut coal mines we investigated."*

The media release flags two important issues:

1. Unlike Qld and WA licences, the NSW EPA mining licences (some or all) do not have specific requirements for onsite tyre, track and conveyor belt disposal onsite. Whilst these licence conditions are not in place, it is unclear if onsite burial is permitted in NSW, or not.
2. As the costs for disposing tyres, tracks and conveyors at offsite licensed landfills increases significantly,[5] there is an increased financial driver to use mining sites, that are only allowed to bury tyres generated onsite, to illegally dispose tyres generated offsite. Mining companies should ensure that staff understand the site licence limitations and ensure processes are in place to ensure no waste tyres are received from offsite generators.

The combined risks of a lack of certainty regarding NSW mines being licensed to dispose their waste tyres onsite, the significant costs associated with offsite landfilling at a licensed landfill[6], and the increasing risk of mine sites being targeted for illegal dumping of tyres from offsite, should be driving investment in recovery solutions being implemented for OTR tyres, tracks and conveyors.

[5] Due to increasing landfill levies and landfill regulation and decreasing licensed landfill availability

[6] See Section 4.4

5.2 Storage of used tyres

The NSW EPA *Protection of the Environment Operations Act 1997*, Schedule 1, requires that any facility that stores more than **five tonnes or 500 waste (used) tyres**, or involves processing more than 5,000 tonnes of waste tyres per year, is required to hold an environment protection licence. NSW EPA defines waste tyres as: used, rejected or unwanted tyres, including casings, seconds, shredded tyres or tyre pieces.

NSW Fire and Rescue Fire Safety *Guideline for bulk storage of rubber tyres* sets out the requirements for open and indoor storage of waste tyres in NSW.

5.3 Transporting of used tyres (offsite)

In NSW tyre retailers, tyre retreaders and the waste tyre transporters can each be guilty of an offence when waste tyres are transported to a place that cannot lawfully be used as a waste facility.

The NSW *Protection of the Environment Operations (Waste) Regulation 2014* sets out the requirements for tracking loads of waste tyres in NSW.

Waste tyre generators, transporters and facilities receiving waste tyres in NSW weighing more than 200 kilograms, or consisting of 20 or more tyres, in one load must track and report this waste to the EPA using the online tracking system called WasteLocate.

The information required to be recorded in WasteLocate is similar to that outlined for Qld (Section 2.3). Again, it is important to consider the NSW waste tyre tracking requirements before transporting used tyres via a backloading arrangements from mining or farming site in NSW to a tyre reprocessing facility.

5.4 Reprocessing of used tyres

As noted in section 4.1, any facility that **processes more than 5,000 tonnes of waste tyres per year**, is required to hold an environment protection licence. This is notably higher than Qld and WA.

5.5 Offsite disposal at licensed landfill

In NSW the 'waste levy' (or landfill levy) applies in the regulated areas of NSW which comprises the Sydney metropolitan area, the Illawarra and Hunter regions, the central and north coast local government areas to the Queensland border as well as the Blue Mountains, Wingecarribee and Wollondilly local government areas.

The 2022–23 waste levy rates are:

- **Metropolitan Levy Area: $151.60 per tonne**
- **Regional Levy Area: $87.30 per tonne.**

It is worth noting that key mining areas of NSW, such as the Hunter Coal field, are located mostly within the 'regional levy area'. If tyres, tracks, and conveyors were to be landfilled offsite, the landfilling fees would be significant (the waste levy plus the landfill operator gate fees).

In NSW whole tyres cannot be landfilled in metropolitan areas, in regional areas disposal of tyres to landfill is at the discretion of local government and may require shredding before landfilling. Where waste tyres require shredding before landfilling offsite, it would add another significant cost (compared to disposal whole into the mine void, or on farm).

4.6 Illegal disposal of tyres

NSW EPA has significant fines and penalties for illegal dumping of used tyres, summarised below.

On-the-spot fines for illegal dumping:

- $7500 on-the-spot fine for individuals
- $15,000 on-the-spot fine for corporations.

'Strict liability: waste dumping offences:

- Maximum penalty for an individual of $250,000 and, in the case of a continuing offence, a further daily penalty of $60,000
- Maximum penalty for a corporation of $1,000,000 and in the case of a continuing offence, a further daily penalty of $120,000.

Wilful or negligent disposal of waste causing actual or likely harm to the environment:

- Maximum penalty for an individual of $1,000,000 and/or 7-year prison sentence for wilful offences; $500,000 and/or 4-year prison sentence for negligent offences
- Maximum penalty for a corporation of $5,000,000 for wilful offences; $2,000,000 for negligent offences.

Appendix 4 - Global Examples of Used OTR Product Management

TSA completed a desk based review of the global management of used (end-of-life) OTR products (tyres, tracks and conveyors) and the regulatory levers and interventions that have been used to improve resource recovery (i.e. retreading, recycling into products, or use as a fuel replacement).

Countries were selected for review because they had similar characteristic to the Australian context and/or based on their published OTR products resource recovery performance. In total, seven countries were reviewed as outlined in the table below.

Table 1: Assumed used conveyor waste management and fate proportions currently (%)

Country	Significant mining	Significant agriculture	Remote location large OTRs?	Tyre stewardship in place?
Canada	✓		✓	✓
South Africa	✓		✓	✓
Chile	✓		✓	Developing
New Zealand		✓		Developing
Denmark		✓		✓
France		✓		✓
Germany		✓	100%	100%

To clearly understand how OTR products are being managed typically requires review of the overall tyre stewardship schemes. Historically, most stewardship schemes have been implemented primarily to drive the recovery of passenger, truck and bus tyres. Globally there are examples of successful tyre stewardship schemes that have been in operation for 20 years. However, information regarding OTR management and recovery rates is often lacking in detail, as publications focus on the overall tyre recovery. In particular, detailed information regarding the management of large and giant OTR tyres (above 35 inch rim diameter) is lacking, globally.

There is, however, enough evidence to provide some benchmarking of Australia's OTR recovery rate.

Australia's current estimated recovery rate for OTR tyres of <15% is well below several of the

jurisdictions' reviewed. For example, Canada (Ontario) at 87% and Denmark at 100% OTR recovery, in 2019. Both Ontario and Denmark mostly achieved these recovery rates by recycling the OTR tyres via granulation processes. Table 66 provides a summary of the most relevant review findings (including more detail regarding the above mentioned recovery rates).

Australia has challenges to overcome in order to recover used OTR products including large transport distances for some mining OTR products to processing facilities. So, it is difficult to make an 'apples to apples' comparison with any single jurisdiction. However, noting transport distances and costs, other countries are proving that used OTR tyre manual handling, logistics, processing, and supply into established end markets is both technically feasible and economically viable – with the right scheme and/or policy settings in place.

Regarding the explicit and deliberate inclusion of rubber tracks and conveyors into tyre schemes: no examples have been identified where tracks or conveyors have been clearly incorporated into a tyre stewardship scheme. It is likely that tracks are being collected to some extent within the current OTR tyre collections. However, it is not known if any jurisdiction is successfully recycling these collected tracks. The inclusion of conveyor belts into tyre collection and processing systems was not identified in any of the jurisdictions reviewed and may be unproven at scale (globally).

Table 2: Global stewardship schemes for OTR tyres (type, levy, funding, and recovery rate and technologies used)

Country	Scheme type	Levy and funding design	OTR tyre recovery rates & technology used
Canada (Ontario)	• Extended producer responsibility scheme (EPR) with legislated recovery rate. Scheme administered by Resource Productivity and Recovery Authority (RPRA). • Requires producers of all tyres (including all OTRs) to collect and process tyres to meet the mandated recovery rates (by weight) of 85% and 60% for large OTRs (>700kgs). • The activities allowed to count towards the mandated recovery rates include: reuse, re-tread, processing into a range of products, drainage aggregate, and road base. • Significantly, use of tyres as fuel or fuel supplement is not allowed to count towards the targets. Nor is any land disposal. Also, limit of only 20% of recovery can be via aggregate and road base products. • The regulations appear to effectively require backloading of large OTRs, which may be a key enabler of large and giant OTR tyres in Ontario. • Appears to be working well currently, with a reported recovery rate of 87% of large (>700 kgs) OTRs in 2020. • Regulations are intended to promote competition between producer responsibility organizations (PROs) that bid on each producer's tyres stocks. • Would require significant enforcement by RPRA to ensure that tyres are being recycled as there is no funding provided for tonnages of recycling achieved. • The exclusion of energy recovery (fuel) from the 85% and 60% (for large OTRs) targets is significant in the Australian context where most of the current recovery is understood to be achieved via TDF (exported).	• The only fees are for tyre producers (importers, manufacturers). • They pay a 'Registry fee' that funds RPRA admin, auditing and enforcement. • There are no fees for service providers or producer responsibility organizations (PROs). • The annual variable Registry fees for large producers of tyres (>1000 tyres) are based on the previous year's Registry fees, plus adjustments for prior year surplus or deficit. • The 2020 base variable fee was 13.5 cents per tyre (EPU). • For small tyre producers (<1000 tyres) a flat annual Registry fee of $75 is paid. • The number of tyre supplied is based on a rolling average of three years (2017-2019 for 2021 fees).	• RPRA reported that in 2019, 87% of large OTRs (>700 kgs) were recovered. • RPRA also reported that overall tyres were mostly processed by granulation and crumbing processes. Some tyre re-tread was also reported. • Recovery via TDF use is excluded from RPRA mandatory recovery targets. Pyrolysis technologies may also be excluded from RPRA mandatory recovery targets; however, this is less explicit in the regulations.

Country	Scheme type	Levy and funding design	OTR tyre recovery rates & technology used
France	• The France EPR scheme was operationally implemented in March 2004 and applies to all tyres including OTRs. • Producers of new tyres and importers of tyres or vehicles equipped with tyres are required to organise and finance the collection and treatment of their used tyres within the limit of the tonnages they put on the French market the previous year. • Most producers contract out these obligations to a 'collective organisation' (CO). There are currently, six COs operating and some individual producers operating independent takeback operations. Aliapur and FRP are the two largest COs by far, accounting for around 90% of 2020 collections.	• Collective Organisations (such as Aliapur) are funded by an 'eco-tax' that is included in the cost of each tyre that requires processing. • Aliapur (by far the largest CO in France) finance collections and processing with the eco-tax paid for each tyre that requires processing ($1.9 AU for passenger vehicle tyres in 2021). • Aliapur eco-tax has been steadily decreasing, it started at $3.5 AU for passenger vehicle in 2004. • Aliapur funding goes to whole supply chain of collection (45%), transport (17%), processing (24%) and also about 5% to R&D. • Largest OTR included in Aliapur fees structure has an assumed average weight of 465 kgs and a fee of $170 AU per tyre or around 86 EPUs.	• Analysis of ADEME (French Environment and Energy Management Agency) 2020 reporting shows a recovery rate of 78% for OTR tyres in the 'AGRI' (60-200 kg) and 'GC2' (>200 kg) categories combined. • The larger OTR category 'GC2' was reported as recovered via (in order of tonnes): 'use in public works and civil engineering', processed into TDF for cement industry, and some processing to crumb or TDA. • There is a notable difference in what is accounted for as tyre recovery between Canada Ontario and France.
Denmark	• One of the oldest and most successful stewardship systems in the world. • Began in 1995, a mandatory levy-based system, with a fixed levy being charged on all tyres imported into or manufactured in Denmark. • Collection: EPA-approved tyre collectors collect ELTs at car dealers, tyre shops, garages etc. free of charge. • Recycling: tyres suitable for re-tread are delivered to re-tread companies. Scrap tyres are delivered to EPA approved recycling plants for granulation or pyrolysis treatment (only). A minimum recycling rate of 50% must be achieved. Processing into TDF appears not to be supported by the scheme. • Subsidy payment: a subsidy is paid to the tyre collector by the Danish Tyre Trade Environmental Foundation on behalf of the EPA for used tyres delivered to approved recycling plants. The subsidy is graduated according to the extent of recycling at the plant where the collected ELTs are delivered. • Approvals: each ELT collector and processor of ELTs must • be approved by EPA to be eligible for subsidy payment.	• Tyre producers and importers pay a levy to the • Customs and Tax Administration (Skat). • Tyres fitted to vehicles are not levied, only loose tyres. • The tyre producer levy varies between $2.5 to $50 AU per tyre depending on the type/size (with 10 to ≥ 24 inch listed). The largest rim size listed is ≥ 24 inches. • A subsidy is paid to the tyre collector by the Danish Tyre Trade Environmental Foundation where tyres are taken to approved recycling plants. • Subsidy is paid to the tyre collectors per kg, in 2021: Max. $0.35 AU for tyres with rim diameter < 24 inches. Max. $0.50 AU for tyres with rim diameter ≥ 24 inches. • The subsidy is graduated according to the extent of recycling at the plant where the used tyres are delivered. Each reprocessing facility must demonstrate the recycling rate (% by weight) and this is then applied to the maximum subsidy fees per kilo above. • It appears that tyre reprocessors receive no direct subsidy from the Department. They would in-effect receive part of the collection subsidy via the gate fees they charge tyre collectors.	• Since 2001, OTR collection and recycling rates have been published at around 100% of the estimated tonnages of sales. • Denmark have achieved almost 20 years of full OTR recovery. It should be noted that Denmark does not have significant tonnages of large and giant OTRs from remote mining sites, like Australia. • It also appears that this recovery has been via granulation and pyrolysis processing (not via TDF). • Both granulation and pyrolysis processes are approved by EPA to receive tyres under the scheme. • Whilst recovery rates are published, the splits between granulation and pyrolysis are not. • The use of TDF is not a subsidised process.

Country	Scheme type	Levy and funding design	OTR tyre recovery rates & technology used
Chile	• Chile have recently implemented mandatory collection and recovery rates for all tyres (including all OTRs). • The new regulations set progressively higher targets for collections and recovery each year for the next 8 years. • By 2028, 90% of tyres with less than 57 inch rim diameter must be collected and recovered. For >57 inch, 100% recovery is required by 2028, 75% by 2025.	• It is unclear what levy collection and refund arrangements are to be put in place under the new scheme. • Levy system appears to be similar to Ontario's (i.e. setting recovery targets and producers working out the solution alone or with PROs with little or no levy charged and no funding to incentivise recovery).	• As noted adjacent, by 2028, 90% (< 57 inch), 100% (>57 inch) recovery required, 75% by2025. • Kal Tyre have recently commissioned a large new pyrolysis plant in Chile specifically to process all types of mining OTR tyres.
New Zealand	EPR scheme, mandatory 'tyre stewardship fee' on all imported and locally manufactured tyres (inc. OTR) to be paid to scheme operator 'Tyrewise'. To be implemented in 2023.	• Collection of significant fees at the point of sale ($5.50 NZ per EPU, 9.5 kgs) to support (via incentive payments) the collection, transport and processing of used tyres. • Proposed fee $5.50 NZ per EPU paid by importer and local manufacturers. • Tyrewise to provide incentive funds to whole supply chain (tyre collectors through to new product manufactures using tyres). • Higher levels of incentive funding provided for recycling than TDF (energy recovery). • OTR tyres are covered by the scheme but the largest tyre included is "Off road earthmovers" at 63.3 EPU eq. (or 600 kgs, or $348 NZ, $325 AU). • This is lower than the Australian limit of 200 EPUs (or 1,900 kgs). However, the Australian levy is only 25 cents per EPU (i.e. Australian levies are limited to $50 AU per tyre, regardless of size, NZ would be limited to $325 AU). • It is unclear if NZ are proposing an upper limit on EPU application for large OTRs weighing 3,000-5,000 kgs.	• Tyrewise, 2012, includes the following (dated but still relevant) estimate of pathways for all used tyres: • 14% of ELTs exported for reuse, energy or material recovery • • 12% of ELTs are processed for material recovery in New Zealand • 4% of ELTs are re-used on farm, • 67% or 54,000 tonnes of ELTs are unaccounted for, either going to landfill, used on farm, illegally stockpiled or dumped No data was identified specific to OTR recovery rates. NZ have some tyre shredding and TDF to cement kiln capacity onshore, however, no capacity noted for OTRs specifically.

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Notes

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TyreStewardship
AUSTRALIA

ABN:44 164 971 939
Address: 2/59 Keele Street,
Collingwood, VIC 3066
Phone: 03 9977 7820
Email: getonboard@tyrestewardship.org.au
Website:tyrestewardship.org.au

Australian Government Accredited Product Stewardship Scheme