QUEENSLAND REGIONAL BUSINESS CASE FOR A CIRCULAR ECONOMY FOR USED TYRES

South West Queensland

Final Report

July 2022

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TyreStewardship AUSTRALIA

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Commonly used abbreviations

Abbreviation	Description
COAG	Council of Australian Governments (since dissolved and replaced with National Cabinet)
DES	Department of Environment and Science (Queensland)
DTMR	Department of Transport & Main Roads (Queensland)
EOLT	End-of-life tyres
EPU	Equivalent passenger unit (as a unit of end-of-life tyre volumes) 1 EPU = 8 kilograms; 1 tonne = 125 EPU
FNQROC	Far North Queensland Regional Organisation of Councils
FTE	Full time equivalent (as a unit of employment)
LGAQ	Local Government Association of Queensland
NQROC	North Queensland Regional Organisation of Councils
OTR tyres	Off the road vehicle tyres (as used for mining, agricultural, earthworks and other applications)
SWQROC	South West Queensland Regional Organisation of Councils
TDF	Tyre derived fuel
TPA	Tonnes per annum
TSA	Tyre Stewardship Australia

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- Local Government Association of Queensland
- Queensland Government
- FNQROC
- NQROC
- SWQROC
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Executive Summary

Southwest Queensland – as defined within the boundaries of the South West Queensland Regional Organisation of Councils (SWQROC) and its members – is an important and growing regional economy that, despite its limited and dispersed population, seeks to achieve greater success in recycling and alleviating the impacts of waste disposal and illegal dumping. The region has flagged tyre recycling as a priority for better environmental outcomes, based on the opportunity to improve the community's and business' access to tyre recovery services.

Historically, SWQROC has dealt with tyre recovery services that are both tenuous and intermittent, which has contributed to end-of-life tyre stockpiling at tyre retailers, agricultural properties and other premises over indefinite periods. Significant levels of illegal dumping may also occur across the southwest, due to a combination of a limited regulatory presence and large open spaces. While illegal disposal practices cause damage to the environment and related harms, both illegal dumping and stockpiling involve a failure to recover economically important resources and a greater reliance on virgin materials in downstream markets.

The observed stockpiling does not appear driven by an intent to avoid or defer end-of-life tyre management responsibilities, but may be an indication of the limited service levels and high transport costs associated with delivering tyre recovery services to the region. The lack of services is itself factored by the smaller volumes generated within the region; and the distance between SWQROC and recovery operations based in southeast Queensland, which may range between 500 and 1,000 kilometres.

Due to the small volumes at stake, in the order of 100 to 150 tonnes of tyres arising each year, the southwest region is unable to attract investment in a regional facility focused on processing its end-of-life tyres. So a solution is likely to concentrate on options to coordinate demand for tyre recovery services, consolidate tyre volumes, and achieve transport economies. As this may require a third party to act on behalf of tyre generators in the SWQROC region, this third party may carry a level of accountability to ensure the tyre recovery solution represents legitimate recycling, delivers value for money, and does not involve undue levels of commercial risk.

As stated above, the volume of tyres arising from the SWQROC region represents a very small fraction of the 112,000 tonnes of end-of-life tyres generated in Queensland each year. However, the problems faced in southwest Queensland repeat across many parts of the country that are somewhat remote and have modest population levels. A viable and affordable tyre recovery path for southwest Queensland may therefore point the way towards a service model for many other parts of Australia outside the major population and economic centres.

This business case shows that there is no reason to neglect the untapped resources stored within the tyres of cars, trucks, buses and large off the road (OTR) vehicles such as tractors, earthmovers and roadworks vehicles. Moreover, there are options at hand for southwest Queensland to adopt a regional tyre consolidation and collection model that delivers access to reliable, cost effective and legitimate tyre recovery services.

The full capture of these benefits will require that a number of barriers to regional tyre recycling are dealt with, and a failure to take action will ensure the status quo continues. These barriers relate to scaling and logistical challenges for the most part, although it is also useful to examine downstream recovery services and end markets to better understand cost efficiencies and risk profiles relating to each solution. Moreover, any options that allow recovered resources to be used in the southwest Queensland may be of interest, providing the means to adopt a circular economy approach to end-of-life tyres generated in the region.

Should the recommended actions in this business case be adopted through a coordinated approach, the combined effect will be to create conditions for one or more tyre collection services to establish in the region on an ongoing and stable basis. This will diminish the need for stockpiling across tyre retailers, farms and other agricultural holdings; and may reduce the prevalence of illegal dumping of tyres.

End-of-life tyres as an early priority for regional circular economies

Through their regional resource recovery plans, many regional organisations of councils in Queensland are looking into options to move to circular economy models. Such models place emphasis on extracting greater economic and social value from materials circulating through their regional economies. The shift to circular economies is one of three priorities set out in the Queensland *Waste Management and Resource Recovery Strategy*.

One avenue to achieve this end is to adopt stronger measures to divert material from landfill, and stoke local demand for these materials as an input to economic activities downstream of a recovery facility. The business case suggests that tyres present a prime candidate for regional organisations, councils and businesses in the southwest of Queensland to achieve early successes in the transition to a circular economy. This view is shaped from the following observations:

- Current unsustainable practices in managing end-of-life tyres reflect a common problem for which a regional solution may be suitable
- Activities for handling and collecting end-of-life tyres involve manageable levels of complexity – tyres are a consolidated, relatively clean stream with maturing end markets – compared with commingled and/or more highly dispersed waste streams
- Commonwealth and Queensland Governments have both pledged funding for the improved management of end-of-life tyres, in line with helping the community to adjust to the ban on exporting whole or baled waste tyres
- TSA is an established and high performing product stewardship organisation with a pronounced focus on achieving regional outcomes away from larger population centres and spheres of economic activity
- The end markets for tyre derived product substantially involve public procurement measures at the local, regional and state tiers of government, giving local councils and the state government a direct means to drive demand for tyre recovery services.
- In past months, mining companies have expressed an evolving interest in recovering their large OTR tyres, which may be a means to augment the volume of tyres available for recovery, while delivering economies of scale to support investment in a regional solution.

On this basis, circular economy leaders and their stakeholders may consider the merits of regional tyre recovery as an entry point or test bed for circular economy approaches that may then be applied more widely to other products and materials.

Purpose of the business case

This business case aims to shed light on the extent that end-of-life tyres (EOLT, or waste tyres) are a problem in regional Queensland, based on prevailing management practices. It aims to test a range of commercially-led options to alleviate this problem, and which may be enabled through various forms of support and intervention.

Across Queensland, about 112,000 tonnes of end-of-life tyres arise each year, including tyres from passenger cars, trucks and off the road vehicles (used in mines, agricultural land, Defence installations, and on road and civil works projects). Of this quantity, about 67,000 tonnes or 60 % are presently being recovered by recycling facilities concentrated in the state's southeast.

While there is no region-specific data for the total volume of end-of-life tyres generated in the southwest each year, waste tracking data suggests that about 100 tonnes are collected and processed from SWQROC council areas, again using facilities in southeast Queensland.

In the absence of a tyre recovery rate for this region, application of a 60 % recovery rate (from state figures) without modification suggests that about 50 to 60 additional tonnes of end-of-life tyres are generated without being retrieved for recovery. The lack of tracking data for this estimated volume suggests these tyres are being stockpiled, buried in mining pits, or are illegally dumped.

The recovery rate may be somewhat less than this state-based 60 % figure, due to obstacles arising from low quantities and large distances. While tyre recovery is currently occurring to some extent in regional Queensland, there are some concerns relating to:

- Low levels of recovery from some sectors and more remote geographies
- Persistent occurrences of illegal dumping activity
- Limited consideration of the efficiencies, outcomes and risks in relation to one recovery solution over another, which may indirectly impact the cost, stability and environmental benefit of recovery services used by end-of-life tyre generators in regional Queensland.

This work unpicks the barriers and challenges that block regional Queensland from accessing more sustainable and value-oriented methods to manage tyres, and sets out alternative options to recycle tyres arising from the regions in line with their benefit and cost profiles. As requested by TSA and for the purposes of this business case, this work concentrates its analysis and findings on three regional areas of Queensland including regions bounded by:

- The South West Queensland Regional Organisation of Councils (SWQROC)
- The North Queensland Regional Organisation of Councils (NQROC)
- The Far North Queensland Regional Organisation of Councils (FNQROC).

After an initial analysis of the regions, it was determined that the regions could be analysed in terms of tyre recovery options and solutions for two areas, i.e.:

i) The SWQROC region as a single end of life tyre catchment; and

ii) The NQROC and FNQROC regions, treated as a combined end-of-life tyre catchment.

This split structure recognises the potential for a northern located facility to process tyres from FNQROC and NQROC as a single combined market (or catchment); whereas tyres arising from the SWQROC region are isolated by geography from the other two areas and are to be treated as a separate market involving much smaller quantities of tyre material.

Challenges in recovering tyres in regional Queensland

In undertaking this business case, a number of challenges for recovering end-of-life tyres from regional Queensland have come to light. These include to varying degrees across the regions:

- Large distances and small volumes across generators (e.g. tyre retailers, mechanic shops, car dealerships, public and commercial fleets) that are associated with remote locations, creating unfavourable transport overheads and limited scale economies which lead to high costs and/or poor access to tyre recovery services[1]
- Somewhat limited and disconnected resource recovery infrastructure networks in locations further away from main population and economic centres, which are not optimised for the efficient transport and consolidation of regional tyre volumes
- Regulatory gaps in collection and related waste tracking, allowing rogue collectors to set up business to collect tyres without adequate oversight to ensure their destinations involve legitimate disposal and/or recycling activities
- Lack of incentives to end stockpiling of large OTR tyres (e.g. removed from tractors and other farming vehicles) on agricultural properties
- Limited drive for shifting mining operations away from in pit burial of OTR tyres, combined with a lack of signals for the market to provide mining tyre recovery services
- Insufficient monitoring and enforcement of illegal dumping activities in more remote locations, such that there is limited private cost in opting for illicit disposal practices
- Incomplete vision and commitment to the use of tyre derived materials in local applications (even where standards and specifications allow for the use of such materials as a commercial input), which could otherwise help strengthen the case for regional tyre recovery

[1] These employment estimates are based on figures provided during tyre recovery industry engagement.

- Limited knowledge across the tyre recovery industry, regarding the commercial potential of operations devoted to servicing southwest Queensland
- Limited price transparency for those accepting end-of-life tyres on behalf of a third party (e.g. transfer stations and tyre retailers that accept end-of-life tyres from vehicle owners), where the fees charged may not accurately reflect the true cost of recovery.

Additional to the above region-specific challenges, a number of issues are presently impacting the tyre recovery sector more generally. These include, for example, the need to respond to a ban on exporting whole and baled end-of-life tyres and the recent rise in labour and international shipping costs (which affects the use of tyre derived fuel in boilers, kilns and furnaces located throughout Asia). Alongside a shortage of workers available to the tyre recovery industry, these factors have contributed to flow on effects in the industry including a rise in tyre collection and processing fees.

These broader trends and developments add to the above listed regional challenges for tyre recovery. Yet this business case establishes that the impediments to better tyre recovery solutions for southwest Queensland are not insurmountable. Rather, they can be overcome through a combined set of actions that signal a strong commitment to tyre recycling outcomes, and draw private operators to the profitable opportunities at play.

Moreover, should a tyre collection and/or recycling service seize the initiative by working with regional bodies to establish a viable model to service remote communities and businesses in the SWQROC region, they may be positioned to roll this model out to other locations. While this may present a valuable business opportunity, it also extends the reach of tyre recovery solutions to parts of Australia that are currently underserviced, and therefore helps to reverse economic disadvantage and support inclusion in the circular economy.

The opportunity for enhancing the recovery of OTR tyres

The SWQROC region includes commercial activities that generate a quantity of OTR tyres such as cotton growing and other agricultural activities, earthworks, and other economic interests. While mining is a major source of OTR tyres in other parts of Queensland, it would appear to be a more minor source of tyres in the SWQROC region.

In the case of farming businesses, it is understood that OTR tyres (i.e. from tractors, harvesters, cotton pickers and other farming equipment) are often stockpiled on premises. This may involve a sub-optimal use of the land under care while degrading the environment, providing a habitat for vermin and pests, and presenting a fire risk. While this practice may not be preferred by farming businesses, it may be viewed as the only available option within the cost and locational constraints faced by the agriculture sector in southwest Queensland.

Unlike the case for passenger car and truck tyres, a dedicated OTR tyre recovery solution needs to factor in one or more mechanical processing stages at the front end, prior to receival at a facility designed to accept and process passenger car and truck tyres. This can add to the cost of recycling larger OTR tyres compared to on road vehicle tyres.

During a subsidised trial for consolidating, transporting and processing tyres from SWQROC (led by Balonne Shire), a significant volume of material originated from agricultural premises. The largest volume of tyres was sourced from two farming and cotton properties located towards the east of the SWQROC region.

Their participation signals that the agriculture sector may be willing to use tyre recovery services, provided that the services and related transport costs are affordable and available when needed. Farming interests should therefore be approached during efforts to lift the recovery level for tyres arising from the SWQROC region, particularly where the regional partners are seeking to achieve scale economies; or where a minimum volume threshold is needed to secure interest from a commercial tyre collection and recovery service provider.

Benefits of recovering end-of-life tyres

A range of benefits to southwest Queensland arise in more fully and reliably recovering tyres, and shifting further away from practices involving long term stockpiling on agricultural and other properties, illegal dumping, and other forms of disposal.

While a proportion of tyres has been recycled on an intermittent basis, the availability and cost of tyre recovery services undermine the region's capture of those benefits. Recovery levels could stand to improve and recycling services could be more accessible, compared to the status quo.

Environmental benefits from greater tyre recovery include the following:

- Recovery of resources that will otherwise be lost from the productive economy
- Reduced exposure to harms caused by illegal tyre dumping and stockpiling including:
  - Risk of fire and costs associated with fire incident responses
  - Degraded natural environs and species habitats
  - Lost visual amenity, and reduced enjoyment of contaminated landscapes
  - Breeding grounds for vermin and animal and human disease vectors
- The opportunity to set an example and lift the accepted standard for managing end of life products and materials
- Better custodianship of land under the care of agriculturalists, mining companies, public bodies, and others, realising tyre management outcomes in line with a 'caring for country' ethos.

Efforts to raise the level of tyre recycling may need to go hand in hand with effective regulation and enforcement against illegal dumping and restrictions against burial options, to stop leakage away from the recycling supply chain as led by rogue actors and others seeking to avoid responsibility for their waste streams. In southwest Queensland this is all the more important, to help reach threshold volumes that are needed to attract a tyre collection service to the region.

The availability of cost effective recycling services helps to lower the incentive for illegal services and business models, by ensuring that recycling fees for legitimate and trustworthy solutions are priced within affordability. Affordable and readily accessible tyre recovery services (potentially in the form of a regional hub) shrink the opportunity for rogue operators to undercut the market, and weaken the case for generators to avoid or defer the use of tyre recovery services.

Economic benefits for southwest Queensland stem from expanded and affordable tyre recovery services offered to businesses, individuals and councils. At present, those based in the southwest cannot exercise the choice to use tyre recovery services at a similar level to those based elsewhere such as southeast Queensland, and have few legal options that are delivered 'on demand' outside of disposal.

However, there may be additional economic benefits in the form of using recovered tyre products such as crumb rubber to displace the use of higher cost virgin material in a range of applications. The southwest Queensland regional economy may benefit if they arrange for the use of this material with local stakeholders and partners, whereas this benefit will be transferred to other parties if the material leaves the region. Research led by the Australian Flexible Pavement Association shows that the addition of crumb rubber into roads greatly extends the operating lifespan of those road assets, involving costs that are substantial below the cost of similar additives such as synthetic binders imported from Queensland.

The above combined environmental and economic benefits underscore the value of adopting a regional circular economy model for end-of-life tyres, wherein partners collaborate across end markets and supply chains to ensure as much material is retained for local economic use as is warranted, with proactive support to drive demand for tyre derived products.

Recovery options in detail

While some of the key issues for southwest Queensland tyre recovery relate to handling and logistics, it is also useful to consider the activities downstream of collection, and how those activities may have a bearing on the outcomes achieved, and the costs and risks indirectly incurred by end-of-life tyre generators in the SWQROC region.

In investigating different options to improve tyre recycling from southwest Queensland, the business case explored passenger car and truck tyre recovery according to:

- Commercially available technologies and their end markets, including:
  - Shredding to around 50 to 150 mm fragment size, for use as a tyre derived fuel
  - Grinding tyres to a smaller particle granule (for use in niche flooring and surfaces and civil applications) or crumb rubber (for use in road construction and maintenance) alongside recovered steel sold into scrap metal markets
  - Pyrolytic decomposition into carbon char, fuel oil and recovered steel, sold into relevant commodity markets and industrial processes (e.g. roadworks)
- Potential location of domestic and international buyers (relevant to tyre derived fuel only)

The potential to operate a facility in or adjacent to southwest Queensland was not examined in detail, recognising the tyre quantities involved are not sufficient to justify investment in a regional facility whose operations focus on recovering tyres from the southwest of the state. Instead, it is assumed that recovery will involve existing facilities in southeast Queensland.

In short, the following configurations of technology, end market and location were deemed the most likely pathways to improve tyre recovery from southwest Queensland, and were therefore analysed in detail in this business case. This determination is based on their technical capacity to process commercial volumes of tyres at competitive prices; the presence of stable and/or growing markets for their products; the presence of supporting and/or complementary commercial activities, and other factors relevant to a Queensland market context.

Technology	Products	Potential facility location(s)
Shredding plant selling to offshore customers	Tyre derived fuel (for energy users abroad)	Southeast Queensland (existing)
Shredding plant selling to Australian customers*	Tyre derived fuel (for domestic energy users)	Southeast Queensland (existing)
Crumb and granulation plant	Rubber crumb, rubber granule and steel	Southeast Queensland (existing)
Pyrolysis plant	Carbon char, fuel oil and steel	Southeast Queensland (existing)

* See further explanation in the text below.

The option to shred tyres and sell to a domestic energy buyer (marked with an asterisk above) underwent a partial investigation only, due to a lack of market precedents on which to base a confident assessment of supply chain and market risks. The absence of historic buyers in the Australian market prevented a full financial analysis of this option. The report therefore focuses on a discussion of issues and factors for interested parties to attend to in exploring this option further.

The sections below outline key findings from a more in depth analysis contained in the main report, and aim to shed light on comparative strengths and weaknesses of each recovery option.

Indicative profitability of tyre recovery options

In conducting a comparison of alternative options, a key consideration is whether a given model to recover tyres from the regions represents a cost effective solution.

For the purposes of this business case, cost effectiveness was compared by building a financial profile of the different options investigated, factoring in underlying supply chain costs and the availability of revenues from the sale of products and recycling fees. To enable a fair comparison across options, a uniform recycling fee of $6 per passenger car tyre (consistent with prices referenced by regional stakeholders) was applied and it was assumed that tyres were collected from sources in the vicinity of Roma or St George (towards the eastern edge of SWQROC).

Other parameters were as determined according to the technologies, products and end markets in question, and the transport overheads due to processing in southeast Queensland.

The business case recognises that any commercial operator will need to retain a margin above and beyond operating costs, both to deliver profits but also to account for a range of additional business pressures and needs outside of its physical operations. This is treated as a 'surplus net of recycling', i.e. a margin that allows the business to grow over time, deliver returns to shareholders, and weather commercial unknowns that are challenging to predict over the medium to long term.

In principle and for a given recycling fee (as described above), this potential margin serves as an indicator of the cost effectiveness of one recovery pathway over another, and the capacity of the supply chain to withstand less favourable market conditions. For each of the recovery options included in this business case and treated with a set of market-relevant operating assumptions, the figure below sets out projected margins per tonne of tyres processed. A key take away from this figure is that solutions with a higher margin are better positioned to outcompete those with a lower margin, all else being equal. That is, they are reflective of a more economically efficient recovery pathway for the region.

(While the business case looked at the option to recover tyres as a waste derived fuel for domestic cement kilns, an inability (due to a lack of reliable data) to perform a quantitative financial analysis on this option means that it has not been included in the figure below).

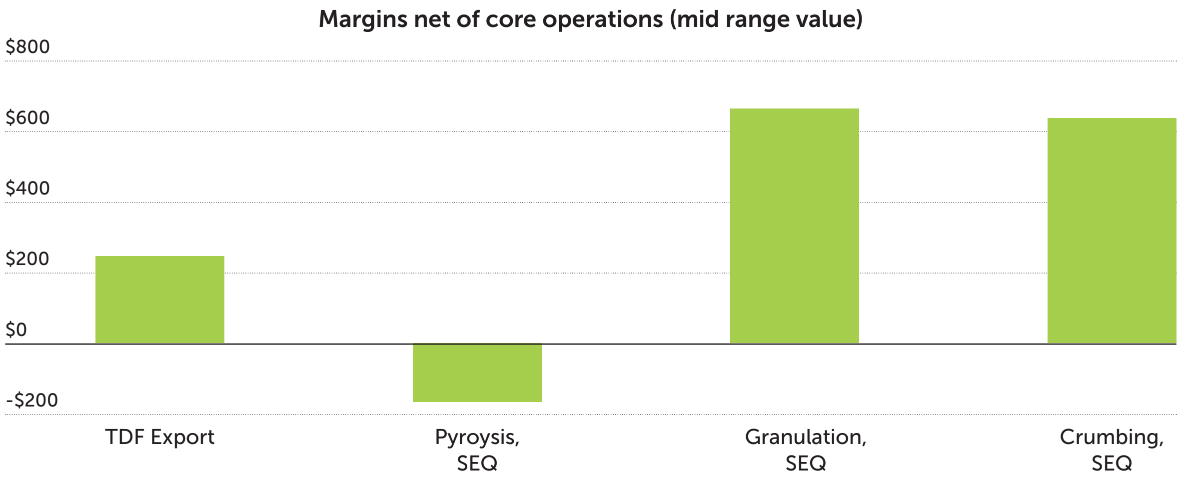


Figure: Mid range surpluses (per tonne) net of recycling operations, estimated for four recovery pathways.

Some factors that drive the observed margins and corresponding cost effectiveness include:

- The high capital costs of pyrolysis plants based in Australia and operating at relevant scales of throughput, combined with the production of commodities currently saleable at the lower end of the value spectrum, lead to low operating margins for this option at the present point in time.
- Although shredding has a comparatively low capital and operating cost profile, international buyers are presently paying low prices for tyre derived fuel (with limited chance of a lift in prices in the foreseeable future) while shipping costs have risen significantly since the Covid-19 outbreak. This results in a net cost to the shredding plant operator, which has to be recovered through recycling fees and leads to eroded commercial margins compared with other options examined.

- A crumbing and granulation facility has moderate to high capital and operating costs compared with shredding, but this is more than compensated by the value of products sold to domestic markets and the avoidance of international shipping overheads.

To summarise, the financial comparison exercise indicates that the most cost effective option for recovering end-of-life tyres from southwest Queensland would involve crumbing and granulation of tyres as suitable for a given feedstock. During industry engagement, it was identified that passenger car, truck and OTR tyres could all be converted to rubber crumb or rubber granule. Additional processing is needed for passenger car tyres, to remove a nylon mesh layer which is not found in truck tyres and OTR tyres, however some operators have managed to overcome this technical challenge.

These processes would leverage existing infrastructure based in southeast Queensland, as the volumes are not adequate for to justify a regional solution.

A market analysis also suggests significant demand for crumb rubber and other products in regional markets in southwest Queensland, although the recycler may need greater certainty of market scale in sectors such as road construction and niche flooring and surfaces, before actively pursuing product sales to buyers and/or downstream operators based in southwest Queensland.

Supply chain and market strengths and weaknesses

A quantitative financial analysis provides partial insight on the commercial viability of different solutions to recover tyres from southwest Queensland. Each supply chain may be exposed to a range of risks and opportunities, both as part of their operating circumstances and in response to evolving commercial environments.

The business case sheds light on these wider factors through a descriptive process, with findings set out as advantages and disadvantages in the table across the following page.

This information may be relevant for those that have a role in bringing together a range of tyre generators and councils in the SWQROC region in a bid to drive sufficient scale of demand for tyre recovery services. Those generators may have questions regarding the downstream fates of their tyres once they are collected, and the table overleaf presents a starting point for further discussion with those generators and a means to navigate trade offs and competing outcomes.

For example, tyre generators may be interested in opting for a recovery solution involving lower commercial risks; reduced greenhouse gas emissions via energy recovery technologies; or the means to reuse recovered materials in the southwest Queensland economy. Alternatively, they may be indifferent to these aspects that sit beyond affordability and legal compliance needs. Nonetheless, it may be prudent for a coordinating body to be prepared for a range of questions and discussion points as it recognises some accountability for downstream activities and impacts.

In the main report, this table contains additional details regarding steps that TSA may take to resolve some of the disadvantages flagged for each technology and end market. These steps are broadly captured within the scope of activities that TSA conducts in its market development operations. These activities may be directly applied to end markets relevant to tyres that originate from southwest Queensland, although a more immediate priority may be to address the logistical and consolidation challenges faced by the region.

Processing technology	End markets	Advantages	Disadvantages
Shredding whole tyres to meet TDF specification *Likely applicable to passenger car tyres only*	Kilns, furnaces and boilers located in Asia (e.g. Malaysia, India)	• Operations well established at commercial scale • Limited capital costs and operating costs (per EPU) • High volume end markets	• Very low value product, often below cost to process • High cost to deliver to international end markets • Exposure to market risks • Limited ability to pivot to more profitable products
Shredding whole tyres to meet domestic use TDF specification (assumed to be consistent with international TDF requirements) *Likely applicable to passenger car tyres only*	Domestic alternative solid fuels (i.e. cement kilns, including cement manufacturing in Queensland)	• Operations well established at commercial scale • Limited capital costs and operating costs (per EPU) • Low cost to ship to target customer(s) • Able to pivot from domestic to international buyers	• Customers yet to emerge, limited price discovery • Many sellers and few buyers – limited market influence • Ongoing risk of collapse in demand without notice • Limited ability to pivot to more profitable products
Pyrolysis to generate thermal desorption products (steel, carbon char, fuel oil) *Applicable to all tyre types*	• Carbon char commodity markets • Low grade fuel oil applications • Recovered steel (scrap metal) markets	• Able to take truck and passenger car tyres without separation • Multiple products allowing some level of market diversification	• Unproven at commercial scale in Australia • Carbon char and fuel oil products yet to attract high demand levels • High capital and operating costs • Exposure to competition from global supply chains
Granulation using rubber crumbing facility *Applicable to all tyre types, although operator may tend to use passenger car tyres if able to remove nylon mesh from product streams.*	• Niche mats and flooring • Niche industrial products • Civil applications • Recovered steel (scrap metal) markets	• Well established at commercial scale • Higher margin products • Established and emerging markets for granule • Options to switch markets based on better returns • Option to switch to crumb products pending acceptance as a road input	• Significant capital costs and operating costs (per EPU) • Some markets yet to fully mature • Some potential challenges in removing and dealing with nylon mesh
Crumbing using a rubber crumb facility *Applicable to all tyre types, although operator may tend to use truck and OTR tyres.*	• Crumb rubber modified spray seals and asphalts • Recovered steel (scrap metal) markets	• Well established at commercial scale • Higher margin products • Stable and growing road building markets for crumb rubber • Potential use in local / regional circular economy • Option to switch to granule products	• Higher capital costs & operating costs (per EPU • Potential that the market becomes flooded with crumb rubber sourced from passenger car tyres (downstream of exported bale and TDF market dynamics)

Value of recovered materials

Regional stakeholders may prefer to support a recovery model that generates higher value outputs, and that makes a greater contribution to the regional economy beyond diverting material from landfill, as opposed to support for a model in which the products hold marginal value and in which the economic utility of the recovery process may be called into question.

To this end, the table below sets out the value of recovered resources across the three main recovery technology and end market combinations studied in this business case. For simplicity, upper estimates of each commodity value are used, noting that caution needs to be exercised in interpreting the figures to allow for price fluctuations over a given period. (Note that, in achieving a 100 % recovery rate, the composition between resources recovered from passenger car, truck and OTR tyres may differ from a 60 % recovery rate, due to an overall shift in the proportion of passenger car, truck and OTR tyres being recovered.)

The figures in this table show that the recovery of tyres through crumbing and granulation may yield resources with an aggregate annual value in the range of $51,000 to $84,000, depending on the recovery rate and throughput achieved. In the case of pyrolysis, this range sits between $16,000 and $26,000, although these estimates are qualified in recognition that tyre pyrolysis is an emerging sector in Australia and market information is therefore limited. In the case of shredding to produce a tyre derived fuel for sale to international buyers, this range is between $5,000 and $8,000 per year. However, market research during the business case reveals that some tyre shredding operators are willing to offload tyre derived fuel at no charge to the customer, so actual revenues from its sale may be substantially less than the figures used here.

Table: Annual market value of recovered materials for a given set of technologies and their recovered products.

Resource	Volume (60% recovery)	Sales	Volume (100% recovery)	Sales
Shredding to produce tyre derived fuel				
TDF (at $50/t)	100 tonnes	$5,000	160 tonnes	$8,000
Total		**Total**	**$5,000**	**$8,000**
Crumbing and granulation				
Rubber granule (at $600/t)	20 tonnes	$12,000	40 tonnes	$24,000
Rubber crumb (at $800/t)	40 tonnes	$32,000	60 tonnes	$48,000
Steel (at $240/t)	30 tonnes	$7,200	50 tonnes	$12,000
Total		**$51,200**		**$84,000**
Tyre pyrolysis				
Carbon char (at $200/t)	25 tonnes	$5,000	40 tonnes	$8,000
Fuel oil (at $140/t)	30 tonnes	$4,200	48 tonnes	$6,720
Steel (at $240/t)	30 tonnes	$7,200	48 tonnes	$11,520
Total		**$16,400**		**$26,240**
Recycling fees (at $750/t)	100 tonnes	**$75,000**	160 tonnes	**$120,000**

Addressing logistical challenges in the SWQROC region

Independent of the supply chains and end markets for recovering tyres from the SWQROC region, a key issue for reliable and affordable tyre recovery concerns the efficient transport of end-of-life tyres. In practice, tyre recovery from the SWQROC region is likely to hinge on an ongoing commercial relationship with a collection service who is able to collect end-of-life tyres from across the whole region, as the volumes are not sufficient to support efficient recovery via multiple collection service providers. That collector could be an intermediary with multiple commercial relationships with recovery facilities, or may be a vertically integrated collection and processing service provider.

While Balonne Shire was able to run a consolidated tyre collection trial in which 300 tonnes of accumulated tyre material was recovered, there is the ongoing risk that the volumes that periodically accumulate in the future are of marginal value for a commercial collection partner. At minimum, the trial worked as a means to test market interest and better understand the conditions needed for an operator to fill this regional gap in the market on a more permanent basis..

During industry engagement, operators advised that they would need to collect about 150 tonnes per collection run from a single point in the region's east (such as Roma or St George) which, at current levels of tyre generation and consolidation, could be amassed over an eighteen month period. Regional partners and TSA may seek to lift this volume through, for example:

- More effective and targeted approaches to reduce instances of illegal dumping and drive the uptake of legitimate recycling services
- Engagement with generators of larger volumes of OTR tyres, such as cotton growers and other primary producers, who may be stockpiling end-of-life tyres on their properties and who may be interested in affordable tyre recovery services
- Exploration of options to link up tyre recovery supply chains involving surrounding cities, townships and commercial activities such as those in the Darling Downs region
- Exploration of best practice approaches to scaled transport of end-of-life tyres, including options using joint procurement, better use of existing and planned infrastructure such as transfer stations, use of backhauling arrangements, and widening collection services to cover other end of life products such as white goods, packaging or scrap metal.

Having a larger scale of tyres recovered from the SWQROC region and surrounding areas may help to drive transport efficiencies for tyre recovery supply chains, while potentially encouraging competition in the market. It may also help ensure a continued tyre recovery market presence in the region while improving the rate of recovery.

The need to address illegal dumping and rogue collection services

The project team understands that illegal dumping takes place in Queensland, both due to end-of-life tyre generators deliberately engaging in dumping practices; and due to rogue operators acting as responsible tyre collectors / recyclers while undercutting legitimate service providers. TSA's Queensland auditor and the Queensland Government advise that forestry plantations have been used as dumping grounds, while councils report that roadsides are also impacted by dumping. Local media also identifies farmland as being despoiled by tyre dumping activity.[2]

This suggests a need to ensure broad monitoring and enforcement measures against illegal dumping are effective, and to ensure the waste tracking system is able to recognise and generate intelligence on rogue operators acting outside the legal framework.

Some actions to address these potential deficiencies include:

- Adoption of novel tracking (e.g. electronic tagging) of tyres, so that a trail of responsibilities can be determined from illegally dumped tyres
- Use of geospatial imaging methods to help identify dump sites across the state

[2] https://bundabergtoday.com.au/news/2022/03/28/queensland-farms-becoming-dumping-grounds/

- Performance review of licensing and waste tracking systems, to ensure fitness in preventing rogue operators from competing with legitimate tyre collectors and recyclers
- Focused education of tyre generators including tyre retailers, mechanics and car dealerships, to help them discern between rogue and legitimate operators, and to ensure they understand their responsibility to manage end-of-life tyres appropriately.

While these areas fall within the Queensland Government's responsibilities to lead, there may be a role for TSA and councils to provide input and/or work as partners in pilot projects. TSA may also have a role to support knowledge transfer from other states that may have trialled or fully implemented more effective tracking and monitoring technologies to prevent inappropriate waste management practices.

Capturing the opportunity through coordinated efforts

The business case establishes that tyre recovery from the southwest region of Queensland could be improved in a number of ways. These improvements span the augmented collection and supply of end-of-life tyres to strengthening the demand for tyre derived products, and may include points along the supply chain between these two extremities.

Irrespective of the tyre recovery solution serving the regions, there is a basis to tighten regulation and enforcement activities to lower leakage of usable tyre resources to other practices like illegal dumping. Similarly, end-of-life tyre transport and consolidation arrangements for the region could be rendered more efficient, using a combination of:

- Back hauling and reverse logistics
- Coordinated and shared use of collection services, potentially involving other materials
- The use of transfer stations and other sites as a regional resource consolidation network that functions as a series of nodes to drive collection and transport efficiencies
- Leveraging collection services for centres and businesses in the adjacent Darling Downs.

In terms of supporting demand for products derived from tyres recovered from the SWQROC region, this business case notes that some products – such as steel, crumb, granule and tyre derived fuels – have relatively established end markets that are able to absorb the quantity of products from the SWQROC region over a given time period. Other end markets, such as those for pyrolysis products, may be more tenuous due to a range of factors that go beyond the issues particular to the SWQROC region.

TSA and partners may elect to apply their existing market development expertise and functions to one or more of the end markets for tyre products from the SWQROC region, according to their preferred balance of benefits and outcomes. If the SWQROC councils had an interest in achieving circular economy outcomes from tyre derived products sourced from the region, the immediate opportunity lies in the use of crumb rubber in road building and maintenance projects; although there may be the option to use rubber granule in recreational and sporting surfaces and/or civil works (e.g. permeable pavements).

Table: Overview of actions to address barriers and points of friction in improving tyre recovery from the SWQROC region.

Thematic focus	Response	Lead organisations
Illegal dumping of end-of-life tyres	Improved licensing and waste tracking/ reporting systems for tyre collectors and recyclers. Improved monitoring (e.g. geospatial imaging) and tracking (e.g. electronic tags) of dumping and stockpiles. Greater efforts towards surveillance and enforcement against illegal tyre disposal.	DES with TSA and council support Note: Organisations nominated may be revised in line with establishing an independent environmental regulatory body.
Increased recovery of tyres from selected OTR vehicle industries	Direct engagement with cotton and other agriculture sector sources and their OTR tyre suppliers, aiming to determine a service model and equipment suitable for processing and collecting their end of life OTR tyres. This action may uncover solutions where suppliers agree to take back OTR tyres, potentially leveraging intermediate storage points (which may include transfer stations or other depot facilities).	TSA with council, DES and industry body support, along with leading OTR tyre users.
Consolidated handling and transport Transport efficiencies gained through intra-regional linkages	Investigate opportunities to: • Better leverage public infrastructure (e.g. transfer stations) as a transport and consolidation network across the region • Establish and expand collective procurement of tyre recovery and collection, which may include request for backhauling services • Synchronise collection schedules with services delivered to main centres in the adjacent Darling Downs region	Councils and tyre recovery sector, with TSA support
Demand for end products, as relevant to encourage stable and mature markets	Proactive road construction and maintenance procurement settings, favouring the use of (locally supplied) crumb rubber in place of synthetic polymer binder where relevant, in spray seal and asphalt roads. Exploration of increased use of rubber granule in civil works (permeable pavements), traffic management devices, and niche surfaces (e.g. playground and sporting field surfaces) owned and used by local government. Exploration and uptake may be supported through research funding, demonstration projects, and dedicated regional collaboration bodies (e.g. technical / advisory groups).	Local and state road network managers, supported by TSA, LGAQ and DSDILGP Local and state civil asset managers and engineers, supported by DES, LGAQ and TSA

Taking the next steps for tyre recovery in regional Queensland

The above table sets out recommended actions for TSA, Queensland Government, regional bodies and councils, and other partners to drive a sustained solution for tyre recovery in southwest Queensland. In the near future, it would be suitable to widely engage with current and aspiring tyre recovery businesses on the opportunity to deliver services tailored to customers based in the region. Based on their interest and feedback, it may then be suitable for the partners to develop and commit to a coordinated plan to deliver the recommended actions.

As a national product stewardship organisation, TSA is uniquely positioned to play a lead role in facilitating and coordinating phased implementation of actions to achieve regional recovery as outlined above. Yet there is a strong argument for leadership from SWQROC and the Queensland Government, based on the preferred approach to realise the Queensland *Waste Management and Resource Recovery Strategy* through the development and adoption of regional resource recovery plans.

A collaborative approach between TSA and local, regional and state tiers of government may help to establish a precedent partnership framework that may be applied to other product stewardship priorities of the Queensland Government.

Similarly, a successful regional collaboration model for improved tyre recovery may provide lessons for TSA to adapt elsewhere, particularly in more distant and sparsely populated regions across Australia that face problems in recovering tyres and which have features in common with the southwest of Queensland.

Introduction 1

Purpose 1.1

This business case aims to shed light on the extent that end-of-life tyres (EOLTs, or waste tyres) are a problem in regional Queensland, based on prevailing management practices. It aims to test a range of options to alleviate this problem through optimising commercial solutions, which may be enabled through various forms of support and intervention.

While tyre recovery is currently occurring to some extent in regional Queensland, there are some concerns relating to:

- Low levels of recovery from some sectors and more remote geographies
- Persistent occurrences of illegal dumping activity
- Limited consideration of the efficiencies, outcomes and risks in relation to one recovery solution over another, which may indirectly impact the cost and stability of recovery services used by end-of-life tyre generators in regional Queensland.

In short, prevailing practices may fail to make the most of the resources at hand, and may lead to social and environmental harms and sub optimal tyre recovery arrangements whose costs are passed on to the community. This work unpicks the barriers and challenges that block regional Queensland from accessing more sustainable and value-oriented methods to manage tyres, and sets out alternative options to recycle tyres arising from the regions in line with their benefit and cost profiles. The options investigated are explained in terms of their supply chains, and are characterised from tyre source through to end market.

As requested by TSA and for the purposes of this business case, this work concentrates its analysis and findings on three regional areas of Queensland including regions bounded by:

- The South West Regional Organisation of Councils (SWQROC)
- The North Queensland Regional Organisation of Councils (NQROC)
- The Far North Queensland Regional Organisation of Councils (FNQROC).

However, this study will account for end-of-life tyres arising from adjacent locations to the extent that these volumes may influence the viability of one or more tyre recovery solutions. The placement of the above three regions in terms of distances and transport corridors to existing and new tyre recovery infrastructure and end markets is an important part of this work.

After an initial analysis of the regions, it was determined that the regions could appropriately be analysed in terms of tyre recovery options and solutions for i) the SWQROC region as a single catchment; and ii) the NQROC and FNQROC region treated as a combined tyre catchment. This structured approach recognises the potential for a northern located facility to process tyres from FNQROC and NQROC, whereas there are limited options to join the SWQROC region to the other two areas.

*This report sets out findings pertinent to the **SWQROC region**, noting that there are some significant areas of content and discussion overlap with a companion report that relates to the NQROC and FNQROC regions combined.*

Through this report, SWQROC and other stakeholders will gain an understanding of:

- The commercial viability of one or more paths to recover end-of-life tyres arising in the region, compared with landfill disposal and competing tyre recycling models, and accounting for price tolerances that may preside in different markets
- Potential usages of recovered tyre material in markets in the region and elsewhere, noting and accounting for the risks and opportunities inherent to those uses

- The dependencies and factors driving the development of said end-of-life tyres recovery supply chains, particularly noting the need to address transport and processing efficiencies in the face of long distances and smaller volumes of material available
- Actions and settings that may be needed to unblock investment in these supply chains and recover materials that are of use to the Queensland circular economy.

Development of a business case to drive investment & intervention

This report sets out findings relating to the potential for improving the recovery of end-of-life tyres (EOLTs) from southwest Queensland, drawing on supply chains and services led by private actors enabled by supportive government policy and strong regulation to accumulate, process and sell tyre derived products to various end markets in Queensland and elsewhere.

The work seeks to understand cost drivers and dependencies affecting commercially led tyre recovery, and how those factors accord with price tolerances for those who may need to pay collection fees for tyre recovery. At the same time, the business case needs to recognise both the profit motive that drives investment in commercial services and infrastructure; and the need for businesses to accumulate and maintain a financial reserve to buffer against an evolving range of operational risks and/or allocate to future business expansion.

As with circular economy opportunities in general, a solution to the 'tyre problem' in regional Queensland is predicated on a collective effort across multiple stakeholders that contribute to and enable an efficiently functioning market. No one stakeholder can provide a solution in isolation. Government must regulate disposal and procure end products to support industry, while industry leaders need to be flexible and innovative to capitalise on any emerging opportunities.

In commencing this business case, there is a need to characterise current volumes of end-of-life tyres as generated in the SWQROC region according to the following descriptors:

- Segmentation of tyres generated across the region, according to passenger car, truck and off the road (OTR) tyre volumes[3]
- Management and disposal processes currently used across the region
- Locations and capacities of recovery infrastructure and supply chains, to the extent that they are in place and accessible to businesses and local councils in the region.

This profile for tyres arising in the region is useful as a base of evidence for preparing a business case model for used tyre recovery, according to a range of service configurations. This model includes volume, location and type of tyre material which all carry ramifications for recovery costs, suitability for different end markets, and the scale of commercial operation necessary to deliver meaningful volumes of tyre material for recovery.

Similarly, the nature of current management practices provides some insight into the activities that need to be replaced to drive improved recycling outcomes across the region, and the types of intervention required to tilt practices in a preferred direction.

In completing this work, the project team relied on prior market research made available by TSA and on information volunteered by regulators, commercial operators, councils, and those with a role in different supply chains and end markets. The information contained in this report cannot replace appropriate commercial due diligence activities undertaken by those considering a role in the recovery of tyres from southwest Queensland sources, but may be useful in providing an initial foundation from which to embark on further inquiries relevant to their interests.

[3] 'Off the road vehicle tyres' refers to tyres that are larger than those used for passenger car and trucks and may include tyres worn by, for example: aircraft; graders, bobcats and tractors; forklifts; and earth movers. Industries most relevant to their use include: agriculture; aviation; construction; manufacturing; and mining. In the context of the Northern Territory, it is anticipated that mining OTR tyres are likely to be the majority source, and may use tyres of up to 4 metres in diameter.
Source: Randell Environmental Consulting et al., *Off the road used tyre analysis*, 2020.

Structure of this report

This report is set out according to the following structure, which aims to step through a consideration of the problems and opportunity to capture benefits through a sustained lift in tyre recycling; a comparison of different tyre recycling supply chain options; and a consideration of barriers impeding tyre recycling and responses proposed to unlock greater recycling levels.

The report is therefore broken into the following sections:

1. Introduction
2. Methods
3. The Queensland tyre recovery sector
4. Profile of tyres arising across the region
5. The case for public investment in tyre recovery
6. Exploration of end markets and supply chains
7. Market & supply chain analysis
8. Barriers and responses across the supply chain

Appendices

Methods 2

This business case is concerned with gaining insights into the present practices for managing end-of-life tyres in regional Queensland, and identifying and testing alternative approaches that may yield better outcomes for regional stakeholders. Reporting is broken into two parts, with this report dedicated to findings relevant to the SWQROC region. The methods applied for each region are broadly similar, and are detailed below.

Method structure 2.1

In completing this project the following stages of work were completed.

1. Gather information on policy and regulatory, market, geographical, institutional and other contextual drivers that influence or constrain tyre recovery in the region.
2. Profile end-of-life tyre management practices occurring in the region, including:
   - Volumes of end of life passenger car, truck and OTR tyres arising per year
   - Major source locations, consolidation points and recovery premises available
   - Prevailing management methods, including, for example – disposal, recycling, illegal dumping, and stockpiling – with recovery supply chains described in terms of supply chains and end markets
   - Major corridors to transport tyre material from generation and consolidation points to disposal and/or recovery infrastructure
   - Partners and stakeholders with an existing role in managing end-of-life tyres
   - Key quantitative information relevant to determining opportunities for the commercial recovery of end-of-life tyres from the region, given the need to fit within commercial profit-making and competitive market constraints.
3. Set out alternative recovery scenarios for the region, seeking to match potential opportunities to the regional profile. In preparation for a comparative analysis process, characterise these options in terms of their supply chains and end markets, and commercial factors that drive their viability as a solution for the region.
4. Describe and compare each option in terms of:
   - Commercial performance, framed in terms of financial analyses and ability to compete against alternative options (using quantitative methods), and based on an examination of revenue and cost components (i.e. capital and operating costs)
   - Strategic, supply chain and market risks and uncertainties
   - Barriers impacting establishment and ongoing viability, and measures that may address those barriers.
5. Put forward a recommended approach to encourage improved recovery, based on findings from the above steps. Include responses to build tyre recovery resilience and increase recovery from the region by targeting tyre volumes that are yet to be recovered at an appreciable scale.
6. Report key findings and recommendations via report setting out challenges and opportunities specific to the region.

Information gathering

Information collated and used in this business case came from a range of sources including:

- Technical and market research documents specifically made available by TSA and other sources
- Other documents made available as public information, either as webpage content or downloadable reports, including material made accessible by the Queensland Government
- Opinions and perspectives made available during engagement with a range of stakeholders as elaborated on below.

Every practical effort has been made to appropriately reference sources as footnotes throughout this report, or to otherwise cite findings and views as arising from engagement with one or more groups of stakeholders.

Stakeholder engagement

In order to yield useful and practical recommendations, this business case relies on regionally relevant and accurate information, including an accurate capture of policy, regulatory and market conditions that affect tyre recovery operations and the sale of recovered products. It also needs to account for the concerns and interests of different actors who may have a role to lift tyre recovery outcomes from the region.

To this end, stakeholder engagement activities are important to the business case. Over the course of the project, the following stakeholders and industry representatives generously shared their perspectives, knowledge and expertise:

- Department of Environment and Science (Queensland Government)
- Department of Transport and Main Roads (Queensland Government)
- Balonne Shire
- Representatives of the tyre recovery industry, based in Queensland and elsewhere
- Representatives from downstream users of recovered tyre product (in road construction)

Further details of stakeholders engaged with are set out in Appendix 1.

Financial analysis of tyre recovery supply chains 2.2

Under the Method Structure section (Section 2.1, point 4), reference is made to a financial analysis of different recovery options for end-of-life tyres generated in the region. As this serves as a cornerstone of the business case, further details on this method and its underlying concepts are provided here.

In general terms, the recovery of end-of-life tyres is held to be led by market participants who offer tyre recovery services to those that generate end-of-life tyres (or received those tyres on behalf of a third party), with compensation in the form of a recycling fee. Those service providers then engage in a series of commercial operations to recover valuable resources which are then sold into relevant markets, presumably seeking to favour products and markets that yield satisfactory returns for a given level of investment and commercial effort.

Assuming that end markets and the market for tyre recycling services impose a competitive environment on tyre recovery supply chains and that competing products in each market are largely substitutable, each recycling supply chain is limited in its ability to raise prices and is therefore revenue constrained within a given set of market conditions and a given volume of tyres processed (noting that revenues and operating expenses correlate with those volumes).

As such, each supply chain is under pressure to ensure its revenue base can cover a range of operating costs and commitments to deliver on commercial expectations, which may take the form of:

- Processing and handling costs associated with recovery operations (encapsulating capital and operating expenses)
- Long distance haulage costs, for end-of-life tyres and products as may be relevant
- Other business concerns to account for, which sit outside core processing and transport operations, which may include arrangements to:
  - Address a range of medium to long term market risks
  - Put aside financial reserves to allow for business development and expansion
  - Acquit a range of administrative and managerial duties
  - Distribute profits to shareholders

The relationship between revenue and cost components is described visually in Table 1 overleaf. A key task of the business case is to confirm whether revenues (in the form of recycling fees and sales revenue) are adequate to cover the cost base inherent to each supply chain, while allowing for sufficient excess revenue – denoted here as a surplus 'net of recycling' – to cover a range of additional needs that are not strictly correlated to operating expenses.

Supply chains that cannot cover their processing and handling costs and haulage costs are effectively operating at a loss. Those that can cover these costs but fail to generate significant additional revenues to cover a range of commitments under the banner of a surplus net of recycling may be profitable but are operating under duress, i.e. with limited capacity to adapt to evolving market conditions and emerging challenges, nor to capitalise on new opportunities.

Extensive engagement with the tyre recovery sector confirms that this model sufficiently represents the immediate commercial challenge of each operator, noting that there are also wider supply chain and market risks to attend to (as incorporated into the business case method using qualitative techniques, see Section 2.1).

Table 1: Concept model for main revenue and expense components of a tyre recovery operator.

<table>
<tr><th colspan="2">Expenses and other financial commitments</th><th colspan="2">Financial inflows</th></tr>
<tr><td>Processing & handling costs</td><td>Costs that are core to a given tyre recycling operation, e.g. collection and delivery to processing facilities (excluding long distance freight); handling; processing and packaging as finished goods.</td><td rowspan="2">Recycling fees</td><td rowspan="2">Fees earned from the provision of recycling services to retailers, fleet managers, councils and other parties.
These fees would ideally fall within price tolerances of end-of-life tyre generators to ensure willingness to pay for recovery services.</td></tr>
<tr><td>Long distance freight costs</td><td>Costs associated with delivering end-of-life tyre material from point of generation to main processing facilities; and with shipping products to more distant end markets.</td></tr>
<tr><td>Surplus 'net of recycling'</td><td>Earnings that are surplus to transport and processing costs, which are essential to drive private investment in tyre recovery activities.
This surplus may be put towards, for example:
• Administration costs
• Market, supply chain and currency risk management
• Business development and business expansion
• Profit allocation</td><td>Sales revenue</td><td>Revenue earned from the sale of finished goods such as:
• Steel
• Tyre derived fuel
• Rubber crumb
• Rubber granule
• Pyrolysis products (fuel oil, steel and carbon char)
• Tyre seconds
• Other rubber products</td></tr>
</table>

The Queensland tyre recovery sector 3

Relevant economic and geographic features 3.1

Queensland is the second largest Australian state by land mass (1,727,00 km^2) and occupies the northeast corner of the Australian mainland, along with islands along its Pacific, Torres Strait and Gulf of Carpentaria coastlines.

Queensland is Australia's third largest state by population with 5.2 million residents across 77 local government areas (LGAs). This population is predominantly located in the eleven LGAs comprising southeast Queensland, where 3.8 million Queenslanders (73 % of the total) reside.[4] Much of the remaining population live along the east coast and areas immediately surrounding southeast Queensland, with lower population density in inland and western regions.

The Queensland Gross State Product (GSP) is in the order of $360 billion, or around $70,000 on a per capita basis.[5] The Queensland Government notes the following as major contributing sectors to the state economy, although each region within the Queensland state will have differing levels of dependence on these sectors and will have other areas of economic specialisation:[6]

- **Mining**, estimated at $39.6 billion in value (2019-20) or 12 % of GSP
- **Health care and social assistance**, estimated at $29.2 billion (2019-20) or 9 % of GSP
- **Construction**, estimated at $27.3 billion (2019-20) or 8 % of GSP
- **Education and training**, estimated at $18.4 billion (2019-20) or 5 % of GSP
- **Tourism**, estimated at $12.7 billion (2018-19 estimate, noting effects of Covid-19 in more recent estimates) or 3 % of GSP.
- **Agriculture**, estimated at $10 billion or 2.5% of GSP

Major road and rail corridors crosslink major hubs of economic activity and population centres, and support the transit of people and goods from one point to another. There is a higher concentration of transport infrastructure towards southeast Queensland and along the east coast, in line with the distribution of major population and economic centres. There are also substantial road and rail links into the western hinterland, although the infrastructure is less developed as the geography extends further westward and into the further northern reaches of the Cape York Peninsula.

Policy & regulatory context 3.2

Queensland Waste management & resource recovery strategy

The *Waste management & resource recovery strategy* (2019) sets out the Queensland Government's commitment to reduce waste generation, increase resource recovery and address littering.

The strategy is framed in terms of shifting towards a circular economy, achieved through three strategic priorities, i.e.:

1. Reducing the impact of waste on the environment and communities
2. Transitioning towards a circular economy for waste (with tyres mentioned as a priority stream)
3. Building economic opportunity.

The *Waste management & resource recovery strategy* aims to meet the following targets for 2050, with interim targets in place to guide progress:

- 25 % reduction in household waste
- 90 % of waste is recovered and does not go to landfill
- 75 % recycling rates across all waste types.

[4] https://seqmayors.qld.gov.au/about-us/councils
[5] https://www.qgso.qld.gov.au/statistics/theme/economy/economic-activity/queensland-state-accounts
[6] https://www.treasury.qld.gov.au/queenslands-economy/about-the-queensland-economy/

Incorporating a circular economy approach into its vision,[7] the strategy emphasises a central role for investment in diverse and innovative resource recovery technologies and markets, to recover high value products and generate economic benefits for the state. This framing has parallels with TSA's strategic investment approach to develop markets and supply chains as a means to realise greater tyre recovery.

Further, it may be useful to consider the extent that the adoption of regional solutions, tailored to conditions specific to each region, provides a means to contribute greater diversity and resilience to Queensland's tyre recovery. Those same conditions may help drive resource recovery sector innovation, by presenting a set of circumstances to which solution providers may need to adapt.

Energy from waste policy

As a commitment under the strategy, the Queensland Government released its policy on energy from waste in 2020.[8] This policy may be relevant in the context of waste tyre recovery, given the range of competing end markets and technologies that could potentially contribute to a circular economy for end-of-life tyres.

For example, the use of tyre material as a tyre derived fuel (TDF) or as a pyrolysis feedstock where the main commercial products include fuel oil and syn gas, would fall into the category of energy from waste technologies and applications.

Pyrolysis of end-of-life tyres is specifically listed as being in scope,[9] although industrial non-waste facilities (such as cement kilns and fossil fuel power plants) using a resource under an end of waste (EOW) code may be out of scope.[10] The end of waste code for tyres is explored later in this section, and does not make reference to the use of tyres as a fuel in industrial non-waste facilities. As such, it is evident that the use of tyre material as a fuel in cement kilns, fossil fuel power plants and other facilities should be subject to the policy.

The *Energy from waste policy* makes clear that the Queensland Government has a preference for materials recovery taking precedence over energy recovery, where materials recovery is a practical and viable solution. This stems from the need to protect the Queensland Waste and Resource Management Hierarchy ('the waste hierarchy'), enshrined in the *Waste Reduction and Recycling Act 2011.* As stated in the policy:[11]

> *'Waste should be avoided as a first priority, after which options to reduce, reuse and recycle waste should be pursued. The options for fuel production, energy production, and disposal should be reserved for residual waste that is unsuitable for higher order options.'*

The above guidance needs to be factored into the relative standing of different solutions investigated in this business case, given a preference to align with the state government's position on energy from waste technologies.

Tyres as a regulated and trackable waste

Under the *Environmental Protection Regulation 2019*, end-of-life tyres are listed as a regulated waste. This regulation places responsibilities on parties involved in the generation, storage, handling, transport, receival and treatment / processing of end-of-life tyres as summarised in guidance prepared and issued by DES.[12]

This guidance sets out obligations according to whether a party is recognised as:

- An end-of-life tyre generator (such as tyre retailers)
- An end-of-life tyre transporter
- A waste facility that receives end-of-life tyres and subsequently performs operations including recycling, reprocessing, treatment, storage, incineration, conversion to energy, sorting, consolidation or disposal.

[7] Queensland Government, Waste management & resource recovery strategy, p. 7.
[8] Queensland Government, Energy from waste policy, 2020.
[9] Ibid, p. 6.
[10] Ibid, p. 7.
[11] Ibid, p. 3.
[12] DES, Guideline – Management of end-of-life tyres (waste tyres), 2020.

End-of-life tyres are also prescribed as a trackable waste (under tracking code T140), places requirements to track and record the movement, storage and receipt of end-of-life tyres. Parties involved in any one of these activities are referred to as waste handlers. While the Queensland Government has historically explored options to ban the disposal of end-of-life tyres in landfills,[13] the present regulatory landscape does not include a ban on landfill disposal.

End of waste code – end-of-life tyres

In certain prescribed circumstances, it is beneficial to allow some wastes to be legally treated as a resource and in doing so, reduce the regulatory burden of activities that contribute to the circular economy while incurring a modest level of risk to the community and the environment. The Queensland Government provides for this treatment in the *Waste Reduction and Recycling Act 2011* through the use of end of waste (EOW) codes.

Under this legislation, the chief executive (presently defined as Queensland Department of Environment and Science, DES) is able to issue EOW codes for different waste types, including terms and conditions that need to be satisfied in order for the EOW code to apply.

On 8 February 2021, DES issued an EOW code for tyres as a resource. The code allows for the following usages of end-of-life tyres where the tyre can be treated as a resource rather than a waste, subject to required practices (as set out in the code):

- As acoustic barriers
- For equine applications
- As weights for silage storage systems
- As sediment barriers to prevent erosion
- Manufacturing prefabricated rubber products
- As safety barriers in lawful motor racing events
- As storage platforms for manufactured swimming pools
- As fenders and/or bumpers for mooring marine vessels
- In structural and non-structural civil engineering application(s)
- Manufacturing bituminous binders used in road making applications and/or
- Use in manufacturing processes and applications which transform and incorporate the resource into a final product that complies with relevant Australian Standards for that product.

The EOW code is useful in the context of this business case in providing clarity as to some of the usages for end-of-life tyres which may involve a less onerous regulatory environment (subject to conditions as set out in the code), compared with those that are not listed.

Relatively novel applications and end markets, which should not be dismissed out of hand in this research, may nonetheless face greater regulatory uncertainty and/or compliance costs which may impact a commercial operator's willingness to invest in the supply chain. For example, a private operator establishing a novel means to recover tyres in Queensland may need to account for uncertain timelines in being granted environmental approvals and licences, and uncertainty with respect to the licence conditions placed upon their operations and the costs that such conditions incur.

In contrast, an operator involved in producing and using tyre derived resources as prescribed in the end of waste code may have greater certainty (by virtue of existing precedents) and lower overheads related to waste regulations, in accordance with the intent of the end of waste code.

[13] https://statements.qld.gov.au/statements/76641

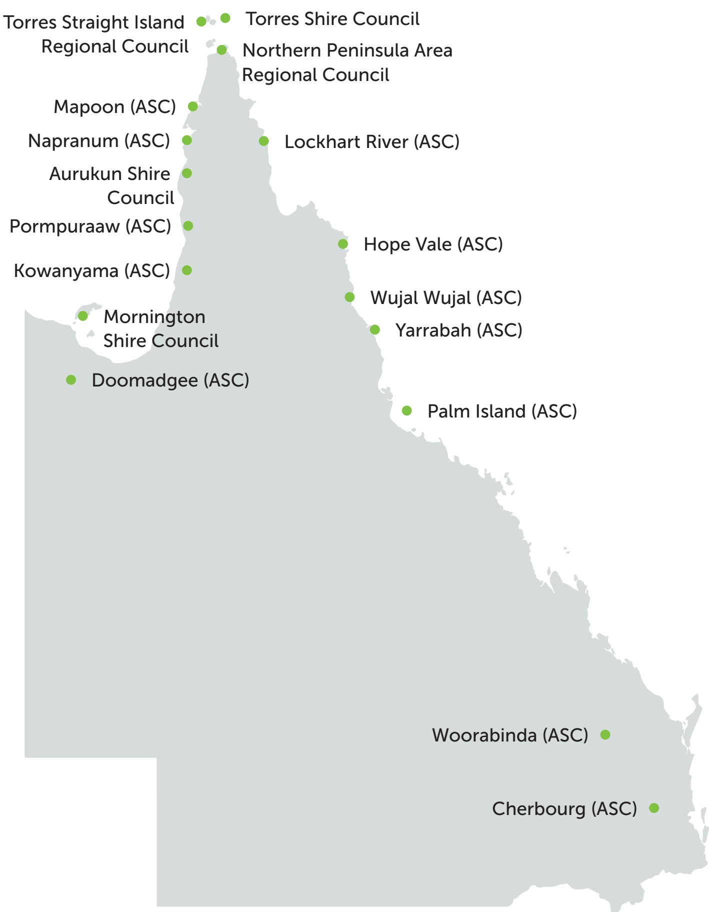
Respecting country

Following the release of the *Waste Management and Resource Recovery Strategy*, the Queensland Government recognised that the seventeen Aboriginal and Torres Strait Islander councils (Figure 1) face particular challenges in achieving zero waste goals over the coming years. These inhibiting factors include:[14]

- Scarce resources and access to capital
- High costs for products and services
- Geographic isolation
- Long transport distances which may impact access to markets
- Depending on location, harsh and unpredictable climates.

In response, the Queensland Government and LGAQ finalised and released *Respecting Country – A sustainable waste strategy for First Nations communities* in 2021. This strategy aims to enable and empower Aboriginal and Torres Strait Islander councils to deliver waste management solutions tailored to the local conditions, and that create economic opportunities and foster employment in their communities.

Figure 1: Aboriginal shire councils across the state of Queensland.



The strategy will guide the preparation of Regional Waste Management Plans that respond to needs and opportunities as identified by the seventeen councils while making a contribution to the *Waste Management and Resource Recovery Strategy* targets.

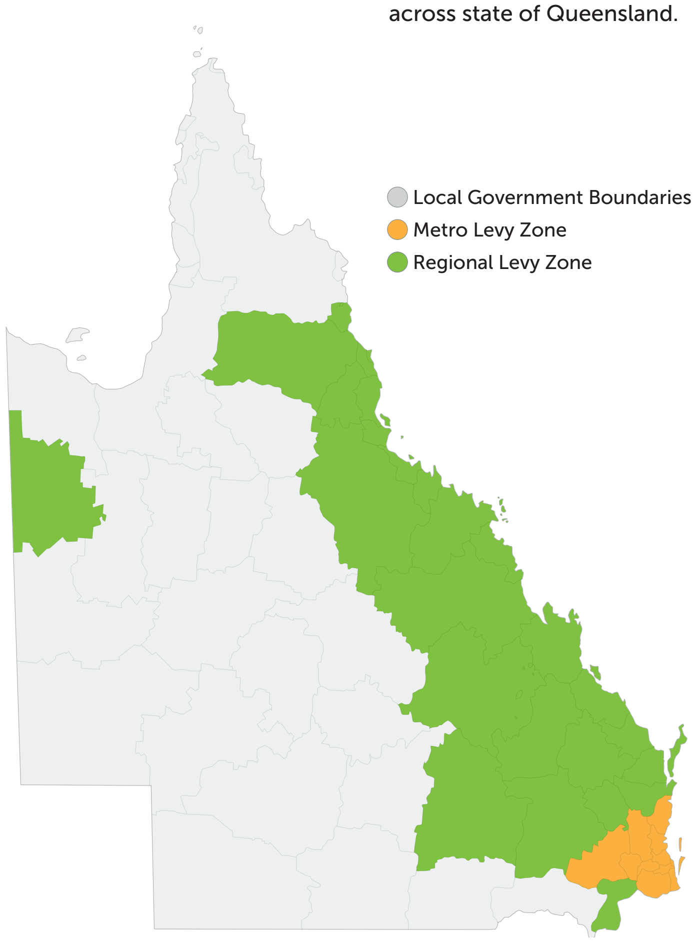
To the extent that the illegal dumping and burning of tyres and the practice of disorganised stockpiling over indefinite periods mars the landscape under Aboriginal and Torres Strait Islander custodianship, some Regional Waste Management Plans may need to place attention on tyres as a priority material to address. Where this is the case, it would be suitable to design and apply solutions that meet the community's needs while adhering to the principles laid out in the *Respecting country* policy.

[14] Queensland Government and LGAQ, Respecting country – *A sustainable waste strategy for First Nations communities*, 2021.

Queensland waste levy

The Queensland Government introduced a levy for waste items disposed of in landfills from 1 July 2019. The levy zone covers 39 out of Queensland's 77 councils, and is estimated to include 90 % of the state's population. From 1 July 2022, the levy zone will be split into two regions – a metro zone (in orange in Figure 2) covering the twelve SEQ councils including Noosa and Toowoomba; and a regional zone (in green) covering the remaining 27 councils.[15]

Figure 2: Waste levy zones across state of Queensland.



In FY2022, the waste levy is set across all LGAs in the levy zone at $85 per tonne for general waste. As a Category 2 regulated waste,[16] the FY2022 levy for waste tyres is set at $115 per tonne for both metro and regional levy zones. From FY2023 to FY2028, the metro zone levy for Category 2 regulated waste will increase by $10 per tonne each year, whereas from FY2023 the regional zone levy will be increased in line with the consumer price index (CPI).

Since the waste levy started, payments have been provided to councils to ensure that the levy has no direct impact on households. From 1 July 2022, all eligible councils will continue to receive a 105% annual payment. From 1 July 2023, the annual payment will be reduced year on year, until it reaches 20 % of the FY2022 payment for metro levy zone councils and selected large regional centres (including Cairns and Townsville). The annual payment for all other councils will continue at 100 % of the FY2022 payment from 1 July 2023.

Recycling Modernisation Fund

Over a recent period, both Commonwealth and Queensland governments have lifted their investment in resource recovery initiatives and infrastructure. In the case of the Commonwealth Government, funding is driven by the introduction of a ban on exporting selected recyclable items (discussed below), including end-of-life tyres (whose ban came into force from 1 December 2021). Granted that the export ban closes off overseas markets for recyclable resources, the Commonwealth Government recognised the need to ensure domestic recovery supply chains for each material subject to an export ban are able to satisfy an increase in demand.

The funding vehicle to stimulate investment – the Recycling Modernisation Fund (RMF) – involves equal co-contributions between state/territory governments and the Commonwealth, such that up to two-thirds of the finance for RMF funded projects may be sourced from public grants programs (implemented by each state and territory under agreement with the Commonwealth Government). In the case of the Queensland implementation, a combined $40 million is offered as public funding.[17]

[15] https://www.qld.gov.au/environment/pollution/management/waste/recovery/disposal-levy/about/from-1-july-2022
[16] https://environment.des.qld.gov.au/management/waste/business/classification
[17] https://www.statedevelopment.qld.gov.au/industry/priority-industries/resource-recovery/queensland-recycling-modernisation-fund

Remote and regional locations across Australia are often at a disadvantage in applying for infrastructure funding that is awarded on a competitive basis, and this reinforces pre-existing disadvantages in the limited private investment in remote and rural recycling infrastructure. Underlying reasons may include:

- Difficulty in connecting with larger and established supply chains and end markets that are typically based in or near major economic centres and industrial zones
- Limited volumes of feedstock materials, which may impact the productivity and payback period of regional capital investments, compared with the same investment elsewhere
- A more fragmented and disparate standard of services and intermediary infrastructure (such as transfer stations and recycling depots) as may be used to consolidate materials prior to delivery to sorting and processing hubs
- Longer distances and related freight overheads, increasing the underlying cost base for recycling compared with alternative options
- Challenges in applying and enforcing higher environmental standards through regulation, which may erode investment confidence.

Responding to the above underinvestment from public agencies and private operators alike, the Commonwealth Government and states and territories embarked on a regional and remote funding stream in parallel to the larger RMF funding commitment.[18] This stream involved a $7 million commitment from the Commonwealth, with matching funds from states and territories and absent of the expectation of additional funding from project proponents.

At the time of writing, the second and last funding round applications are due to close on this program. There is presently a lack of detail as to whether additional funding dedicated to remote and regional projects will be announced in future.

$2.1 billion waste and resource recovery package for Queensland

On 11 December 2021, the Queensland Government announced a total of $2.1 billion in funding for waste and resource recovery initiatives, including a $1.1 billion Recycling and Jobs Fund.[19] This commitment is in support of the Queensland Government's *Waste Management and Resource Recovery Strategy*, which seeks to recover 80 % of all waste and achieve 65 % recycling rates across all waste types by 2030.

The Recycling and Jobs Fund is intended to cover:

- Waste avoidance and behaviour change initiatives
- Recycling and remanufacturing facilities
- Processing and collection infrastructure for recoverable organic material
- Stronger measures to ensure waste and recycling services comply with their obligations
- Research and development and market development activities
- Environmental initiatives that meet community needs, harness job and economic opportunities or improve the environmental impact of waste.

It is understood that investment allocations from this fund will be guided by an overarching investment strategy and regional resource recovery investment plans. Potentially, this may allow for a systematic and needs-based allocation of funding and support for regions, accounting for and seeking to address regional challenges (as raised on the preceding page).

[18] https://minister.awe.gov.au/evans/media-releases/7-million-recycling-regional-and-remote-australia
[19] https://www.qld.gov.au/environment/pollution/management/waste/recovery/disposal-levy/about/from-1-july-2022/waste-resource-recovery-package

General environmental duty to minimise harm to the environment

The Queensland *Environmental Protection Act 1994* includes a broad based provision requiring that members of the public act in a responsible manner towards the environment and display an appropriate level of care. This 'general environmental duty' requires that a person must not carry out any activity that causes or is likely to cause environmental harm, unless measures to prevent or minimise the harm have been taken.[20] A range of enforcement tools may be applied by the Queensland Government o encourage conduct consistent with the duty.

The general environmental duty may have relevance to generators and managers of end-of-life tyres where other more specific environmental statutory tools (such as licences, approvals and regulation) are not available to act upon and enforce.

However, a consideration in determining how to meet the general environmental duty rests upon the financial implications of different actions. In short, it may be argued that if a set of actions (for instance, involving tyre recovery services rather than ongoing stockpiling activities) is deemed unduly onerous in terms of financial cost, this may lessen the obligation to adopt practices that involve reduced environmental harm. However, should the introduction of new services into the market lead to the opportunity to recycle tyres with a lower financial impost, this may strengthen the expectation that the environmental duty involves recovery activities.

COAG ban and issuance of exemptions

Following the Council of Australian Government (COAG) decision to ban the export of waste tyres (and other materials), the Commonwealth Government passed the *Recycling and Waste Reduction Act 2020*. This Act legally backs the announced ban, with regulatory responsibility falling to the Commonwealth Department of Agriculture, Water and the Environment.[21]

From 1 December 2021, this framework disallowed the export of waste tyres with the following exceptions, as set out in the Commonwealth *Recycling and Waste Reduction (Export – Waste Tyres) Rules* ('the rules') that implement the ban:[22]

- Tyres processed into shreds of not more than 150 mm for use as tyre derived fuel
- Tyres exported for re-tread by an appropriate retreading facility, for example, one that is verified by TSA's Foreign End Market program
- Tyres to an appropriate importer for re-use as a second-hand tyre
- Tyres that have been processed into crumbs, buffings or granules.

The rules ban the export of whole used tyres including baled tyres, which is one of the prevailing recovery practices across the country to date, particularly for passenger car tyres.[23] This may lead to a lift in supply of end-of-life tyres to local processing (such as shredding or crumbing) facilities across the country, and adjustments to recycling fees paid by tyre waste generators.

At the time of writing, it is understood that some waste tyre exporters have sought exemptions (as permitted under Section 25 of the rules) to the ban, considering a lack of alternative environmentally sound management options available at some domestic locations. It is understood that at least one tyre processor that sections and exports OTR tyres to then recover crumb rubber in overseas facilities has sought and obtained an exemption from the ban.

The Commonwealth Government's Recycling Modernisation Fund allocates $190 million as co-funding to invest in upgraded and new recovery facilities in parallel to the export ban. This fund is intended to ensure that domestic industry is positioned to improve the recycling of tyres and other materials covered by the export ban (i.e. glass, paper, cardboard and plastics).[24]

[20] https://environment.des.qld.gov.au/management/compliance-enforcement/obligations-duties
[21] https://www.awe.gov.au/environment/protection/waste/exports/tyres
[22] https://www.environment.gov.au/protection/waste/exports/transition
[23] REC et al., Used tyres supply chain and fate analysis (2020).
[24] https://www.awe.gov.au/environment/protection/waste/how-we-manage-waste/recycling-modernisation-fund

Under this funding model, the Commonwealth Government is leveraging equivalent funding from state and territory governments, providing favourable settings for private operators to bring forward investment and lift the domestic capacity to recover each material. On commissioning new recovery capabilities, operators could elect to produce material for domestic markets or opt to export value added products (based on meeting exception thresholds set for each material).

Tyre recovery industry activity, structure & distribution 3.3

Details presented below provide an overview of tyre recovery practices currently in place in the State of Queensland. This information is derived from waste tracking data held by Queensland Government, and data pertaining to accredited recycling and collection activities held by TSA.

This section also draws on a summary briefing prepared for Queensland Government by TSA in 2021 and forwarded to the project team, which examines current industry structure and activity levels, and potential risks faced on the introduction of the COAG ban on exporting waste tyres.[25]

End-of-life tyres arising across the state

During FY2021, an estimated 140,000 tonnes of tyres were purchased in Queensland. During that same year, about 112,000 tonnes of end-of-life tyres were generated. A discrepancy between purchasing figures and end of life volumes in any given year is not unusual, given that end-of-life tyre arisings are driven by purchase and usage levels from previous years and given that there is some loss in tyre mass due to normal use (i.e. due to the effect of wear and friction).

This 112,000 tonne volume can be broken into the following categories:

- 38,000 tonnes of passenger car tyres
- 47,000 tonnes of truck tyres
- 27,000 tonnes of off the road vehicle tyres.

For the purposes of tracking and reporting end-of-life tyre generation, these figures include activities where an existing tyre is removed from a vehicle and replaced with another tyre; and activities where a vehicle reaches its end of life, with tyres remaining attached to that vehicle. Tyre replacement takes place via operations involving fitment centres, mechanical repair, vehicle dealerships, and mobile tyre services.

TSA estimates that 90 % of recovered passenger car and truck tyres are replaced in store with the remaining replaced during on site servicing, performed by mobile service providers or by vehicle owners themselves. Due to this concentration of activity at retail premises, there is a level of volume consolidation and management, i.e. through tyre retailers, car dealerships and mechanics. This is in marked contrast to other end of life products (such as post-consumer packaging), where a key challenge lies in the collection, aggregation and isolation of the product from other waste streams.

Processing activities across Queensland and related end markets

In its briefing paper to Queensland Government, TSA identifies that about 62 % of the 112,000 tonnes of end-of-life tyres were recovered in FY2021 (i.e. 67,000 tonnes). The majority of this recovery involved passenger car tyres (74 % recovery rate) and truck tyres (81 % recovery rate), with only modest recovery of OTR tyres (around 15 % recovered by mass).

The majority of recovery in FY2021, particularly for passenger car and truck tyres, involved exporting as tyre derived fuel (34,800 tonnes) or for reuse (12,900 tonnes). Both of these export uses are permissible under the COAG ban on exporting end-of-life tyres.[26] The export of whole tyres (other than for reuse and/or re-tread) is subject to the export ban, although this is understood to contribute a minor fraction of the total volume of tyres exported from Queensland.

[25] TSA, Tyre export ban – market overview, risks and opportunities, 2021.
[26] https://www.awe.gov.au/environment/protection/waste/exports/tyres

The remainder of tyre recovery occurs through domestic processors, producing for example, crumb rubber, granule and various products synthesised from thermal desorption processes (such as pyrolysis). The majority of these tyre recovery operators, including those producing tyre derived fuels for overseas markets, is based around Brisbane, Ipswich and Gold Coast. Table 2 below sets out the processing services offered by TSA-accredited and non-accredited operators.

Table 2: End-of-life tyre processing operations based in Queensland (Source: TSA).

Operator	Shred / TDF	Crumb or granule	Thermal desorption
Chip Tyre	Yes	Yes	Yes
Tyrecycle	Yes		
Ozcom Recycling	Yes		
Pearl Global	Yes	Yes	Yes
Seven Star Technology	Yes	Yes	
Carroll Engineering	Yes	Yes	
Northern Sands Waste Management	Yes		
LSC Recycling & Rehabilitation*	Yes		
Enviroland / Down to Earth*	Yes		
Green Rubber Australia*	Yes		
Tyre Transitions*	Yes	Yes	

*Not accredited with TSA

As shown in the table, a range of service providers are able to produce crumb rubber and granule or thermal desorption products which may have domestic markets at various levels of maturity and commercial viability (with rubber and granule markets more established and commercially validated than those for pyrolysis products). The other processors are involved in shredding tyres, either for international tyre derived fuel markets or as a processing step prior to other downstream activities including disposal in landfill.

This industry composition is important given current challenges in shipping tyre derived fuel to international buyers. At present and due to the global economic impacts of Covid-19, shipping costs have greatly increased such that the continued export of tyre derived fuel may become commercially unviable. Those businesses that rely on selling tyre derived fuel into export markets may need to re-orient their business model towards other products (e.g. granule or crumb rubber) or to domestic tyre derived fuel uses (i.e. cement kilns in the first instance).

The main usage of crumb rubber is as an additive to asphalts and spray seals in the road construction sector, where truck and OTR tyre derived crumb is preferred over passenger car tyre derived crumb (due to the higher ratio of natural rubber found in truck tyres and the absence of a nylon mesh that needs to be removed). Due to this preference, the roads market may have a limited capacity to absorb material from passenger car tyres in the event that overseas markets for tyre derived fuel become unviable.

The rubber granule market may be a more certain usage for passenger car tyres should the export of tyre derived fuel become cost prohibitive due to shipping rates. Existing commercial operators (based between Brisbane and Gold Coast) are able to accept rubber granule as a manufacturing input for commercial flooring, acoustic surfacing, recreational and sports surfaces, and other applications.

Pyrolysis and use as an energy source in domestic cement kilns may also emerge as alternative recovery pathways for passenger car tyres, although these solutions are not yet proven at a commercial scale in the Australian market context.

The remaining volume of end-of-life tyres that is not being recovered comes to 45,000 tonnes. It may be challenging to identify their fates to a high degree of accuracy, but will involve some combination of:

- Stockpiling at the point of generation, over an indeterminate period (e.g. on farmland or as a result of backyard mechanic operations)
- Stockpiling at an interim point (i.e. away from point of generation), over an indefinite period
- Shred and subsequent disposal in landfills
- Burial in mining pits, as may be permitted for OTR tyres generated during mining activities
- Mismanagement via illegal practices such as burning, dumping in the countryside or along roadways, burial, or as a component of abandoned vehicles
- Informal reuse at the lower volume scale (garden ornaments and bedding, bike track siding and other efforts to repurpose at a small scale).

TSA's analysis of current processing infrastructure suggests there is not sufficient local capacity to process this outstanding volume (i.e. 45,000 tonnes) of end-of-life tyres in Queensland. The existing sector and related domestic end markets may come under further pressure if the current volume (i.e. of 34,800 tonnes) exported overseas as tyre derived fuel becomes commercially untenable compared with domestic applications.

At a statewide level, this suggests a need to expand the capacity to process end-of-life tyres for domestic end markets, as a contingency against international supply chain factors. But equally, there is a need to introduce upstream measures (i.e. at point of generation) to channel more of the outstanding 45,000 tonnes into the recovery sector; and downstream measures (i.e. at point of end use) to ensure the increased volume of tyre derivatives have mature and stable end markets. Given this shortfall in capacity, it may be preferred to locate additional infrastructure near to end-of-life tyre sources while stimulating nearby end markets and related supply chains.

Profile of tyres arising from the SWQROC region 4

General profile 4.1

SWQROC has a membership of six councils in and near the southwest corner of the state, predominantly clustered towards the border with New South Wales. The regional population is in the order of 24,000 people across a total area of 320,000 km^2. In general terms, it is more sparsely populated than FNQROC and NQROC (populations 292,000 and 236,600 respectively) and lacks regional centres of the equivalent scale of Cairns, Townsville and other major towns and cities along the east coast.

Member councils include:

- **Balonne Shire Counci**l (population 4,300)
- **Bulloo Shire Council** (population 330)
- **Maranoa Regional Council** (population 12,800, with Roma as the main urban centre)
- **Murweh Shire Council** (population 4,300)
- **Paroo Shire Council** (population 1,600)
- **Quilpie Shire Council** (population 800)

The regional population is skewed towards the east (i.e. approaching southeast Queensland), with major centres including Roma (Maranoa), St George (Balonne) and Charleville (Murweh). Other major townships across the region include Quilpie (Quilpie), Cunnamulla (Paroo), Thargomindah (Bulloo) and Mitchell (also in Maranoa).

The region has an annual gross regional product in the order of $2.7 billion, with major industries including mining, agriculture and health. Tourism, renewable energy and logistics are also emerging sectors, with a regional intermodal freight hub recently established in Morven (Murweh) to support livestock transport to southeast Queensland.

Road and rail corridors link urban centres and townships across the region, while providing a means to connect with points external to SWQROC. The main highways servicing the region are concentrated in the region's centre and towards the east of the region and include:

- The Warrego Highway, running east from Charleville through Morven, Mitchell and Roma to Toowoomba (with a total distance of 618 kilometres)
- The east-west Cecil Plains Road and Moonie Highway linking Toowoomba to St George (367 kilometres)
- The east-west Balonne Highway linking St George to Cunnamulla (293 kilometres)
- The Diamantina Developmental Road connecting Charleville to Quilpie (running 211 kilometres east-west)
- The north-south Mitchell Highway connecting Charleville to Cunnamulla (199 kilometres) and then continuing southwards into New South Wales
- The north-south Carnarvon Highway linking Roma to St George (196 kilometres) and then continuing southwards into New South Wales.

Additional to these major routes, there are smaller roads servicing more minor population centres as well as providing transport corridors into the far western corner of the region.

In terms of southwest Queensland rail logistics, the Queensland Rail Western System[27] covers the rail network servicing the regional economy. This line passes from Brisbane through Toowoomba, and then passes through Roma to Charleville. From there, the main line splits into an east-west branch terminating at Quilpie and a north-south branch terminating at Cunnamulla.

[27] https://www.queenslandrail.com.au/forbusiness/the-regional-network

End-of-life tyre recovery practices, facilities & services

4.2

The following table sets out information on tyre recovery options available via SWQROC council infrastructure and services (Table 3). Compared to other regions included in this study, there is somewhat less information on fees and charges for end-of-life tyre management, potentially as a consequence of the historically limited availability of ongoing or 'on demand' recovery services.[28]

As some landfills are unstaffed and unlicensed and given the absence of explicit guidance against disposal, some unmonitored landfill disposal of tyres may occur in the region. Guidance issued by Quilpie Shire Council on its landfill waste management procedures advised that tyres received at the landfill should be segregated for separate burial in a 'tyre pit'.[29]

Table 3: Details of tyre recovery options available to third parties using council recycling infrastructure available in the SWQROC region, as published on council websites and related local waste service publications.

Council	Locations	Unit	Fees (per unit)
Maranoa	Roma *Other facilities are explicitly stated as unable to accept waste tyres*	Car tyre Truck tyre Tractor / earthmover *Fees include a state waste levy plus a council charge*	$13.27 $26.43 $111.83
Ballone	No details of waste tyre management arrangements listed on council website. Advice concerning kerbside collection requests that residents do not leave tyres out for collection.		
Bulloo	No details of waste tyre management arrangements listed on council website.		
Murweh	No details of waste tyre management arrangements listed on council website.		
Paroo	Tyres are mentioned as a major problem in terms of illegal dumping. Tyres are not accepted at the major landfill (Cunnamulla) but parties can contact the council for fees applicable for disposing at the main council depot.		
Quilpie	No details of waste tyre management arrangements listed on council website. Guidance material on landfill management appears to indicate that tyres are accepted at Quilpie landfill, and are separately buried in a 'tyre pit'.		

Noting the lack of established tyre collection and processing services available to councils, businesses and the wider community across the SWQROC region, the Queensland Government, TSA and councils (led by Balonne Shire Council) arranged for a collective regional pilot for end-of-life tyre collection services. In this 2020-21 trial, a project officer was appointed to coordinate involvement in the trial across waste generators including residents, tyre retailers, car dealerships and agriculture-related businesses. The trial successfully arranged for the aggregated recovery of 302 tonnes of waste tyres through a single collection service, including passenger car, truck, and OTR tyres (from cotton and other agriculture sectors).

This collective approach allowed Balonne Shire (as leading council) and regional partners to access an affordable service for tyre collection and processing. The fees offered across the pilot are set out in Table 4 below. The trial may point to a collective approach for collecting tyres across the region, which may be facilitated by local councils and their resource recovery infrastructure.

[28] The project team reviewed details available through council websites including waste management service pages, waste facility guidance, and fees and charges documents.
[29] https://quilpie.qld.gov.au/wp-content/uploads/2019/06/EP.02-A-Landfill-Waste-Management-Procedure-2017-09-19.pdf

Table 4: Fees applied to the recovery of tyres through the 2020-21 regional tyre recycling pilot, based on size and type of tyre.

Tyre	Charge per unit
Passenger car	$3.50
4WD / SUV	$5.00
Light truck, < 17 inches	$8.00
Truck	$14.00
Tractor, < 1.5 m	$90.00
Tractor, > 1.5 m	$150.00

The trial partners have since moved to establish the service on an ongoing basis. A key condition for its continuation is the need to accumulate collectible stockpiles amounting to 150 tonnes across the region, in order to make collection commercially viable. Once this volume is reached (typically across an 18 month period), the collection service provider arranges to collect the tyres for processing in southeast Queensland.

End-of-life tyre volumes 4.3

Waste tracking data from 2019-20 was provided to this project by the Queensland Government. From a geographic standpoint, location information was provided using suburbs and townships as the relevant category, rather than postcode or local government area.

This resulted in Table 5 below, tracking overall movements of tyre waste generated across SWQROC in 2019-20. It is notable that the destination locations coincide with accredited recycling service locations (i.e. in Southeast Queensland). This suggests that there is little volume transiting between intermediate premises (e.g. consolidation points) in the region tracked in the data, indicating a low risk of duplicate counting.

Table 5: Tyre movements originating from SWQROC region in 2019-20 (Source: Queensland Government).

LGA	Suburbs / towns	Volume (2019-20)	Destinations
Maranoa	Roma	77 tonnes	Southeast Queensland
Quilpie	Quilpie	15 tonnes	
Total		**92 tonnes**	

Implied levels of stockpile accumulation, on site burial and illegal tyre dumping

At present, there is limited region-scale data relating to stockpiling and illegal dumping levels of tyres across Queensland. The tracking data for SWQROC suggests that the majority of tyre movements registered with the state government arises from transport to recovery facilities based in southeast Queensland, with little material findings its way to landfill sites. However, there may be some instances of households or backyard mechanics sending tyres to landfill, either on their own or commingled with other materials, which has not been tracked in the data.

Noting that the recovery rate for end-of-life tyres across the state was estimated at 62 % in 2020-21, if this rate was uniformly applied across the state then the total end-of-life tyre arisings in the SWQROC region may be around 150 tonnes per year (of which 92 or so tonnes would represent a 62 % recovery rate).

Some caution needs to be exercised in using this figure, as the SWQROC region is substantially different to Queensland as a whole (i.e. more so than is the case for NQROC and FNQROC); and the small volumes generated in the region mean that observed recycling levels may be heavily subject to the prevailing practices of one or two larger generators of end-of-life tyres (such as cotton plantation and other primary industry operations). In short, there may be a need to improve the understanding of sectors generating end-of-life tyres across the region, including a profile of predominant management practices and the volumes associated with such practices, irrespective of whether they are accurately captured in existing waste tracking systems.

The outstanding 60 tonnes of tyre material that is not recovered each year may be subject to the following practices, to varying degrees:

- Accumulation as stockpiles either at the point of generation or elsewhere, as may be the case for OTR tyres generated on agricultural properties
- Illegal activities such as burning, dumping or being included with abandoned vehicles
- Small scale non-commercial reuse practices, which may not be tracked in the system
- Burial at the site of generation, as may be the case for tyres used in mining activities.

Errors in the tracking system and its usage may also be a contributing factor, i.e. there may be some volumes that have been misreported. Caution needs to be exercised in extrapolating total volumes generated from volumes observed as being recycled, particularly given a range of region-specific factors that may be at play.

Some observations on tyre arisings in the SWQROC region

The Queensland Government data confirm that, in general terms, very small volumes of tyres are collected for processing from the SWQROC region in the context of the state's overall volume. As ongoing practice, i.e. outside the bounds of the 2020-21 pilot, a majority of tonnages appear to be collected from Maranoa Regional Council.

The officer managing the Balonne Shire pilot disclosed that pilot participants seem to generate about 150 tonnes in aggregate every 18 months, or about 100 tonnes per year, across a broad spectrum of generators including those responsible for OTR tyres. This quantity may increase over time, where this can be supported by outreach, consistently low fees, and a supportive regulatory environment.

Activity levels involved in this consolidated recovery pilot may be a more accurate estimate than the annual figures derived from Queensland Government data, as this information is captured on a live and ongoing basis linked to a regional commercial service. It may also be less subject to distortive effects caused by proportionally large collections taking place on either side of the end of a given financial year.

A first glance at recovery and processing in the region 4.4

Previous work completed for TSA, exploring the business case for the recovery of tyres in the Northern Territory, suggests that there is a minimum yearly quantity of tyres needed in order for a local facility to be able to process end products from raw tyre material.

In the Northern Territory context, industry stakeholders suggested that around 2,000 tonnes per year would be a realistic minimum quantity to attract investment, although this volume would remain marginal if there was not a clear pathway to increase throughput and turnover over time. It is evident that this volume is not available from SWQROC sources (in the absence of tyre quantities derived from other sources), given the roughly 100 tonnes collected per year via the collaborative collection pilot led by Balonne Shire.

This suggests that a fully integrated solution is unlikely to be viably located within the SWQROC. Moreover, a tyre collection service provider may only show interest in the region if they can access the vast majority of end-of-life tyres arising rather than a smaller subset of tyres that signify a marginal commercial opportunity. As such, efforts to drive tyre recovery from southwest Queensland should operate on the assumption that a single collection service provider will operate in the region, rather than the presence of multiple providers competing for smaller fractions of the overall regional market.

To drive commercial interest from a collection service and improve circular economy outcomes and/or transport efficiencies for the region, the following options may be pursued:

- Delivery of a region-wide program to promote and drive increased uptake of tyre recycling services and consolidation using existing infrastructure, including targeted OTR tyre sources (e.g. cotton growers and other agricultural industries)
- Partial processing of whole OTR tyres into sectioned or shredded tyres at an operation located in the region (as a means to lower transport costs) prior to transport to final processing facilities elsewhere
- Arrangements to take tyre derived products back from an inter-regional processor, in order to use in local applications (e.g. road building, livestock matting, bunds and other devices to manage floods and spillages), potentially backhauling the material during a tyre collection run
- Ongoing engagement with targeted sectors, in an effort to develop an improved standard of practice in the management of end-of-life tyres, which may leverage the historic involvement of one or more OTR tyre generators in the regional pilot
- Engagement with selected tyre suppliers including OTR tyre suppliers with a large footprint in the region, to consider offering services to backhaul end-of-life tyres after shipping new tyres to the region.

OTR tyre management 4.5

There are challenges in the visibility and estimation of OTR tyres arising across the state of Queensland. This is due to a number of drivers including, for example, the tendency of OTR tyre generators to manage their end-of-life tyres on site (i.e. without meeting conditions that would otherwise trip waste tracking systems used by the Queensland Government).

This on site management may include setting aside large tyres over indefinite periods as may be standard practice in some agriculture sectors; or the burial of end-of-life tyres in mining pits as is common practice in the mining sector. To some extent, these practices are tolerated in light of the lack of nearby tyre recycling facilities that have the equipment needed to process tyres that may be more than four metres in diameter and over four tonnes by mass.

Further, the disposal of these tyres in landfills may be less preferred than storage on premises, given the costs involved and the landfill air space expended in placing large tyres in landfill cells.

With the introduction of a set of OTR tyre brand owners and importers to the Australian Tyre Stewardship Scheme, there is a growing expectation on OTR vehicle owners to send end-of-life tyres to recycling services. As the brand owners and importers will pay voluntary levies to the stewardship scheme, there is a standing budget that may be dedicated to explore, encourage and help establish OTR tyre recycling services, supply chains and end markets.

Previous work completed for TSA[30] estimates that 23,700 tonnes of OTR tyres entered their end of life phase in Queensland in 2018-19. Of this quantity, 21,100 tonnes were estimated to have been managed in a way that did not involve recovery. 1,800 tonnes were estimated to have been recovered involving export to other countries while 800 tonnes were estimated to have been locally recovered.

The tonnes that were not recovered were broken down as follows:

- On site disposal (including burial in mining pits) – 19,200 tonnes
- Disposal in landfill – 900 tonnes
- Dumping and dispersed throughout the landscape – 600 tonnes
- Accumulated stockpiles – 400 tonnes.

[30] REC, Used tyres supply chain and fate analysis, 2020.

Despite the limited regulatory pressure to manage OTR tyres and the poor availability of nearby recovery operations, there are some indications that OTR tyre generators across Queensland are interested in recycling rather than on site management.

- During the SWQROC pilot of a coordinated regional model for tyre recycling, the largest contributors were two cotton growing properties. Of the 300 tonnes collected in the pilot, 40 % of this volume (or 120 tonnes) was sourced from cotton growers.
- During engagement with stakeholders based in the FNQROC region, the team became aware of a large mining operation based on the Cape York Peninsula, which is actively exploring OTR tyre recycling options. This operation is understood to generate 2,000 tonnes of OTR tyres per year (i.e. separate to figures estimated in the FNQROC section of this report) and has a stockpile of 20,000 tonnes awaiting recovery.

This interest could be built into a large fraction of the tyres recovered from the region, leading to transport efficiencies that may be shared with other tyre recycling customers.

The case for public investment in tyre recovery 5

Before examining the feasibility of recovering a greater amount of end-of-life tyres from the SWQROC region, there is value in reviewing the range and extent of any benefits in doing so. This will mobilise interest in addressing the problem and help TSA and public sector partners to gauge what effort of response is suitable to realise those additional benefits.

Current and unrealised levels of tyre recovery 5.1

Waste tracking data made available by the Queensland Government suggests that about 90 to 100 tonnes of tyres are recovered from the SWQROC region via facilities located in southeast Queensland, with this recovery assisted by a pilot program to consolidate end-of-life tyres and lower transport costs. Engagement with the tyre recovery industry suggests that an ongoing service may be possible after the pilot, hinging on the potential to collect tyres in consignments of the order of 150 tonnes in size, on a roughly eighteen month cycle.

The waste tracking system did not provide evidence of end-of-life tyres being sent to local landfills for disposal, suggesting that local landfills are not accepting appreciable volumes of tyres. As the tracking platform only tracks licensed waste movements, it does not provide information on tyres that are not recovered, which may be handled through, for example:

- Storage and/or burial at the point of generation, as may be the case for agricultural or mining OTR tyres, or for small backyard mechanics or DIY tyre replacement
- Disposal, potentially at unlicensed and/or unstaffed landfills, by collectors who are not using the waste tracking system
- Illegal disposal at various locations across the region, as individual tyres or as tyres dumped en masse, or as tyres attached to abandoned vehicles.

Due to the absence of tracking data, it is challenging to gain an estimate of tyre volumes managed according to each of the ways listed above. However, engagement with DES suggests that illegal dumping is a significant problem and that tyres make up a considerable proportion of illegally dumped items. Engagement with other stakeholders also suggests that on premises storage of agricultural tyres is a prevailing practice across the region, with growers historically disinclined to pay for tyre management services.

In a 2020 report commissioned by TSA, about 70 % of the end-of-life tyres arising in Queensland (i.e. 71,000 tonnes out of 102,000 tonnes in total) were estimated as being recovered in 2018-19.[31] The Queensland Government's *Recycling and Waste in Queensland 2020* report estimates that 52,900 tonnes of tyres were recovered in 2019-20, although did not provide an estimate of total volumes of tyre waste arising in that year.

While these figures are not broken into regional results, there are grounds to suggest that significant volumes of tyres from the SWQROC region remain unrecovered, potentially in the order of 40 to 60 additional tonnes per year. A range of benefits as set out below may be achieved through increased tyre recovery from the region.

The economic value of tyres recovered from the region 5.2

Working with an assumed tyre recovery volume of 100 tonnes of tyres, and a further 60 tonnes of tyres that could be recovered each year, Table 6 below sets out potential resources that may be recovered from the region. These estimates are based on different recovery supply chains available to the region (as set out in Section 6). Each supply chain produces its own set of recovered resources – the table should not be read as cumulative across supply chains.

[31] Randell Environmental Consulting, Used tyres supply chain and fate analysis, 2020.

In the absence of further data, the breakdown of the potential volume of 60 tonnes will follow the same assumed breakdown across passenger car, truck and OTR tyres as was identified for Queensland as a whole in the previous work commissioned by TSA.[32]

In the case of tyre derived fuel (TDF) recovery, volumes are represented in terms of TDF outputs (in tonnes) and in terms of equivalent tonnes of black coal. This is for the purpose of representing the recovered tyre material in a way that reflects a major commodity for which it substitutes, allowing that TDF generates an additional 30 % of energy yield during combustion compared with black coal. This TDF may be viewed as a partially renewable fuel, based on the predominantly rubber content, although any minor nylon or carbon black component may be from petrochemical sources which are ultimately fossil fuel in origin.

Table 6: The beneficial recovery of resources that may be obtained through recycling tyres using different processing technologies. Indicative volumes of recovered resources include a column showing resources recovered at existing recovery rates (i.e. 60 % recovery, middle column); and additional resources recovered if the remaining end-of-life tyres were recovered to deliver a 100 % recovery rate (i.e. right hand column).

Recovery technology supply chains	Input tyre volume (historic) 100 tonnes as: • 40 tonnes OTR • 40 tonnes truck • 20 tonnes passenger car	Input tyre volume (potential) 60 tonnes as: • 14 tonnes OTR • 24 tonnes truck • 22 tonnes passenger car
Shredding (to produce TDF)	**100 tonnes TDF** (130 tonnes black coal equivalent)	**60 tonnes TDF** (78 tonnes black coal equivalent)
Pyrolysis (syn gas product consumed on site)	25 tonnes carbon char 30 tonnes fuel oil 30 tonnes steel	15 tonnes carbon char 18 tonnes fuel oil 18 tonnes steel
Granulation and/or crumbing	68 tonnes crumb and/or granule 32 tonnes steel	42 tonnes crumb and/or granule 18 tonnes steel

In practice, the recovery of tyres from the SWQROC region may involve a balance of different recovery technologies and products, as some tyres lend themselves to different recovery paths to greater or lesser degrees than other tyres. For example, TDF recovery is typically reserved for passenger car tyres, whereas crumb rubber is typically recovered from truck and OTR tyres. The balance of commodities recovered from different supply chain combinations, allowing for these commercial preferences, is set out in Section 6. However, the above table is useful in setting out a range of valuable commodities that are recoverable and saleable, provided that end-of-life tyre generators are motivated and able to use tyre recovery services on offer.

The recovery of resources is important both in its own right and in comparison to other less environmentally benign pathways for end-of-life tyres arising from southwest Queensland. In the case of some materials, particularly crumb rubber, there may be the added benefit of using the products in local economic activities such as roadbuilding projects.

Local employment and economic opportunities

In terms of economic opportunity, the limited volume of materials available from the SWQROC region may provide for modest employment opportunities in the region. These are likely to involve roles in transporting tyres from source points across the region (from tyre retailers, agricultural holdings, car dealers and public transfer stations) to consolidation points towards the east. Potentially, the transport and handling of end-of-life tyres could be combined with similar activities applied to other materials arising from the region (e.g. scrap metals; e-waste) or from key industries such as the cotton growing industry.

Quantities of end-of-life tyres arising in SWQROC are not sufficient to set up permanent recycling facilities in the region itself, and any tyre recovery path is likely to leverage standing capacity elsewhere in the state, such as in southeast Queensland.

[32] While an alternative option would be to use a breakdown following the profile of tyres recovered during the Balonne Shire pilot, this recovery volume was likely to be skewed towards OTR tyres which made up about 40 % of the overall volume recovered (due to participation from Cubbie Station and Kia Ora cotton growers).

Benefits of alleviating environmental & amenity impacts

Reducing environmental impacts through commercial tyre recovery

A driver for lifting the amount of tyres recovered from the SWQROC region is to deliver on a range of environmental and amenity benefits. TSA identifies the following benefits among others[33] which could be enhanced in line with the increased recovery of tyres from the region:

- Tyre recycling will lead to an increased use of a resource stream currently being disposed of as waste, offsetting the demand for resources that would otherwise be needed
- Tyre recycling will reduce the number of tyres that are not going to an environmentally sound use, and which may currently give rise to detrimental impacts (as summarised in the next section).

Tackling improper tyre disposal practices

Queensland Department of Environment and Science recognises illegal dumping as a serious problem, and has historically had to deal with illegally dumped tyres as a significant issue.

For example, in 2020, a man was fined for renting vehicles and trailers and then offering services to manage end-of-life tyres on behalf of automotive businesses for a fee.[34] In total, the man dumped 3,500 tyres (i.e. in the order of 30 tonnes) across 17 locations across the southeast of Queensland over a four month period.

Known problems associated with the illegal dumping of tyres include the following concerns.

- It leads to a degraded environment, including eroded landscapes, damaged habitats, diminished cultural and heritage value, and impaired natural water drainage paths
- It degrades public land and lowers the value of surrounding properties, noting that the Queensland Government and councils often are left to pay the cost of decontaminating Crown land and council property respectively
- It presents a major fire hazard, leading to further damage to property and bushland
- It impairs the visual amenity of land, deterring residents' and visitors' enjoyment of Queensland's natural environs
- It attracts pathogens and disease vectors, in the form of mosquito and vermin breeding grounds, in near proximity to regional settlements
- It invites further illegal dumping – of tyres and other waste streams – through signalling a tolerance towards irresponsible disposal behaviours.

Efforts to raise the level of tyre recycling may need to go hand in hand with effective regulation and enforcement against illegal dumping, to stop leakage away from the recycling supply chain as led by rogue actors seeking to avoid responsibility for their waste streams.

Such leakage diminishes the potential revenue stream for legitimate recovery, undermining the potential for ongoing business models predicated on the productive use of recovered tyre resources. On the other hand, a proactive and effective stance against illegal tyre dumping will help to ensure tyre recovery operations are able to compete on an even playing field while helping to protect the Queensland environment.

[33] https://www.tyrestewardship.org.au/about-tsa/scheme/
[34] https://www.des.qld.gov.au/our-department/news-media/mediareleases/2020/man-fined-for-illegally-dumping-tyres

Tyre recovery end markets and supply chains 6

In this section, commercial tyre recovery technologies, supply chains and end markets are selected and described in general terms. For brevity, the section only focuses on pathways to recover tyres that are at a level of commercial maturity that would allow them to play a reliable and near term role in supporting recycling and energy recovery outcomes for end-of-life tyre generators in the region.

Early stage and emerging technologies have been omitted, along with end market applications in which there is no clear evidence of near term demand for tyre derived products.

In most of the examples set out below, the business case is able to set out indicative operating costs that account for combined capital and running expenses. It does so by factoring in an assumed sustainable level of throughput of material, i.e. the level that is needed to make the project a worthwhile investment. Because tyre recovery operations that serve the SWROC region are likely to involve existing plant and equipment that already serve large markets, this assumption is likely to be reflective of real world market conditions.

Commercial recovery supply chains – key features 6.1

Tyre derived fuel for international markets

An established method for recovering tyres from the Australian market involves their mechanical processing via a commercial scale shredding plant, to generate a shredded product that falls within a standard grade of 50 mm to 150 mm in length.

Dedicated tyre derived fuel plants operate near major sources of end-of-life tyres across the country, including in southeast Queensland, New South Wales, Adelaide and elsewhere. A large fraction of passenger car tyres recovered from Queensland is dealt with in this manner, through southeast Queensland-based facilities.

These tyre shredding plants differ from more general purpose shredding equipment that can handle tyres and a range of other materials (such as mattresses and woody waste), for the purpose of rendering bulky waste streams into a more easily managed and transported form. The general purpose machinery often lacks the ability to meet a tight specification and may be more prone to wear given the prolonged mechanical stress involved, and is unsuitable as the primary means to process tyres to the grade in question.

The shredded product is exported as a tyre derived fuel or TDF, whereupon cement kilns, furnaces and boilers across Asia (e.g. in India and Malaysia) use this material as a replacement for coal as an industrial energy source. TDF is seen as a useful alternative as its calorific value typically exceeds that of thermal coal by up to 30 %, on a weight to weight basis. (The domestic market for TDF is explored in a subsequent section, as its features are distinct from the more established overseas market.)

Despite the COAG ban on exporting waste tyres, TDF is permitted to be exported on the grounds that it is a recovered product processed to a standard which has established end markets. This tradable commodity status is distinct from exporting the material as an unprocessed waste.[35]

However, there are developing challenges for this application due to rising shipping costs. As shown in the index chart below (Figure 3), shipping rates have risen steeply since the Covid-19 pandemic has taken hold, with containerised shipping prices rising eight-fold compared with figures from before the start of 2020.[36] (Note, the y-axis numbers should be read as an index composed of multiple shipping prices sourced across the globe to generate an aggregated trend over time, rather than as absolute monetary amounts applying to any one shipping route.)

[35] https://www.awe.gov.au/environment/protection/waste/exports/tyres
[36] https://www.freightos.com/freight-resources/coronavirus-updates/

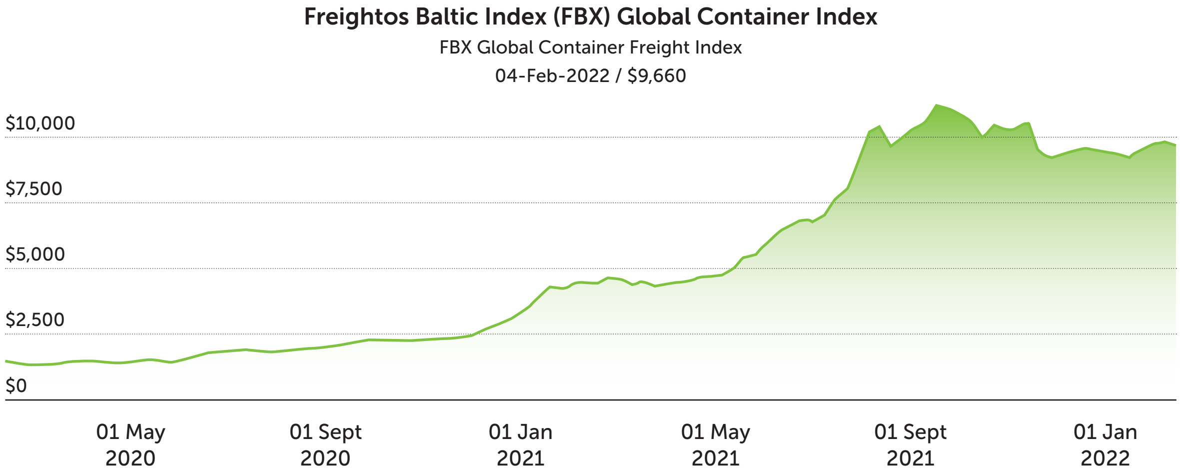


Figure 3: Freightos Baltic Index, mid 2020 to early 2022, reflecting rising trends in container shipping costs. (Source: https://fbx.freightos.com/)

Engagement with industry suggests costs in the order of $6,000 per 40 foot shipping container of TDF, translating to a per tonne shipping cost of around $250.[37] Industry also stated that access to shipping containers was also proving difficult, with freight companies reluctant to provide containers for the transport of waste derived products.

This rise in shipping costs needs to be internalised to the supply chain for exported TDF in one way or another, potentially involving a combination of higher recycling fees and/or TDF sales price, or as reduced profitability across the supply chain. At present, international TDF prices have dropped to near zero levels, with exporters seeking to negotiate with buyers around sharing shipping costs instead of paying a higher price.

The broader insight from the above discussion is that the export of TDF involves greater commercial risk and reduced competitiveness as a means to recover tyres than in the past, and may prove less viable in the longer term compared to alternatives that provide a more stable return to those involved in the supply chain. One such option emerging in the domestic market involves the use of TDF in a cement kiln based in Queensland (discussed in further detail below).

In historic terms, the sales value of exported TDF has been lower than the cost to produce (i.e. independent of shipping costs) and has fallen to near zero levels. Recycling fees continue to play a necessary role to address this gap while providing a more certain return on investment.

Due to these negative margins on the commodity sales side, the export of TDF has traditionally involved passenger car tyres only, with better and more stable returns for truck tyre material achieved through processing into other goods (despite the higher operating and capital costs involved). The export market has appeal in its ability to absorb very large quantities of material and is therefore of particular value to larger operators.

A smaller recycling facility may be less drawn to the international TDF market, given shipping cost and currency market uncertainties, administrative overheads associated with overseas trade, and the need to locate near to commercial ports. This means that any route to recover passenger car tyres as an internationally traded TDF is likely to involve a large shredding facility located at major population and/or industrial centres, rather than involving one or more small scale regional facilities managed by an independent operator.

The table below sets out key parameters for the conversion of passenger car tyres to TDF for export, excluding the cost to send whole end-of-life tyres to the facility. These figures (updated to include land freight estimates dependent on facility location) are used in the business case to test the viability of TDF production and export for tyres arising from each region, compared with alternative solutions that could emerge over time.

[37] TSA market research suggests that recent months have seen shipping costs range in the order of $3,500 to $10,000 per shipping container. Assuming a 40 foot container has a maximum capacity of 23.5 tonnes based on regulation, the cost to ship TDF would range between $150 and $425 per tonne. A reference cost of $250 per tonne will be used in subsequent financial analysis.

Tyre derived fuel – exported Source materials – passenger car tyres		
	Cost per tonne	**Sales revenue per tonne**
Processing costs	$85 - $95 (per tonne)	–
International shipping costs	$150 - $425 (per tonne)	–
Sale of TDF	–	$0 - $50 (per tonne)
Recycling fees (at $6 per EPU)	–	$750 (per tonne)

Estimated market size:

As an internationally traded commodity used in heavy industry manufacturing, the end market for exported TDF may be viewed as inexhaustible, relative to the scale of supply sourced from Queensland.

However, international shipping factors and foreign country trade policies may be sources of risk in terms of tyre recyclers' continued access to these markets.

Tyre derived fuel for domestic markets (cement kilns)

In recent months, the Australian cement industry has revitalised an interest in accepting tyre derived fuel as a substitute energy source among other alternatives, with cement companies seeking potential solutions from the tyre recovery sectors operating in Queensland (Gladstone) and Tasmania (Railton). Other energy sources such as biomass are also in scope for consideration.

Depending on the specifications required by the cement industry (which may demand tyre shred dimensions within defined tolerances), local tyre recyclers may be able to supply a quantity of TDF to the Queensland cement kiln with operating costs similar to those incurred for TDF exported to overseas buyers. However, there is the added benefit of local TDF markets being less exposed to international shipping overheads and related cost volatilities (as explored above), making local TDF markets more favourable than the currently served export markets.

At present, cement manufacturers' price tolerances for TDF are somewhat uncertain. While coal prices may offer a coarse-grained benchmark, a cement manufacturer is assumed to need to account for additional commercial factors including:

- Any modifications to plant and operations as needed to accept and use TDF as a fuel, noting that a recent upgrade to allow a New Zealand cement kiln to use TDF required $NZ 25 million ($AU 23.5 million) in capital investment[38]
- Differences in calorific value (noting an increase in calorific value over thermal coal of about 30 %, potentially attracting a premium per unit mass for TDF over coal)
- Regulatory overheads and control measures related to burning refuse derived fuels, including differences in the handling and disposal of post combustion wastes and emissions compared to the products of coal combustion
- The status and allocation of property rights related to carbon offsets, attributed to fossil fuels being replaced with alternative fuels that incur a lower GHG emissions profile.

Allowing for the above uncertainties, the following table sets out reference commercial parameters for the use of TDF in domestic cement kilns as are used in this business case. In practice, operating costs and price points will be specific to the commercial terms set between a cement manufacturer and one or more suppliers.

Parameters related to freight costs will need to account for transit from sources to a processing facility as well as movement of TDF to the destination cement kiln. While it may be presumed that some level of shredding is required prior to use in a local cement kiln (as required for international TDF), this may not be the case and will ultimately depend on the outcomes of trials undertaken at the cement kiln.

[38] https://fletcherbuilding.com/news/golden-bay-cement-sustainable-disposal-solution-for-waste-tyres-a-new-zealand-first/

If the kiln has broad tolerances for the size of tyre product used as an energy source, then limited handling may be required prior to combustion and the material could potentially be sent directly to the kiln post consolidation (i.e. without a processing stage).

Noting the above unknowns, it is presently assumed that a local cement kiln will need a level of processing similar to that expected by international buyers of TDF, i.e. shredded to a size between 50 mm and 150 mm in length.

Tyre derived fuel – local cement kiln use Source materials – primarily passenger car tyres (although may take truck or OTR tyres)		
	Cost per tonne	**Sales revenue per tonne**
Processing costs	$85 - $95 (per tonne)	–
Sale of TDF	–	To be determined
Recycling fees (at $6 per EPU)	–	$750 (per tonne)
Estimated market size: Using a New Zealand facility as an approximate precedent, total TDF demand in Queensland may be in the order of 40,000 tonnes of TDF per year.		

The recent decision by a New Zealand cement kiln operator to take TDF may be instructive, in terms of detailing the potential demand for TDF from a cement kiln. In this example, the operator chose to substitute 15 % of the coal used in its operations, and in doing so, consume 3 million shredded tyres or 24,000 tonnes of TDF in firing the 967,000 tonnes capacity kiln.[39] Assuming Queensland cement kiln operations have outputs in the order of 1.5 million tonnes per year, total demand for TDF may be in the order of 40,000 tonnes per year (i.e. assuming all waste derived fuel is delivered in the form of tyres and substitutes for up to 15 % of the black coal demand). For reference, the total volume of end-of-life tyres arising in Queensland is around 100,000 tonnes per year, with around 40,000 tonnes of passenger car tyres.

Depending on the above factors and the scale of demand at play, the use of TDF in the domestic cement industry may displace one or more existing markets for end-of-life tyres and/or present a commercially feasible opportunity to recover challenging tyre feedstocks (such as OTR tyres from one or more price-sensitive sectors). In principle, domestic TDF applications would be of greatest social benefit where they displace the most marginal tyre recovery options presently in the market or allow for recovery that would not otherwise occur. These wider market effects are difficult to predict, much less influence, from a third party standpoint. Nonetheless, they may be important to monitor given the risk of sub-optimal impacts on the wider tyre recovery sector.

Both the Queensland *Energy from Waste* policy and the end of waste code for end-of-life tyres may be pertinent to the use of TDF in a Queensland cement kiln. The policy clearly places material recovery as a greater priority than energy recovery, where a waste stream may have multiple recovery pathways available. Direct combustion of solid wastes is treated as less preferred compared with the derivation of liquid fuels from waste.

The policy advises that industrial facilities such as cement kilns which use waste as a fuel under an end of waste (EOW) code are out of scope for the policy. However, the end of waste code for tyres does not grant the use of tyres as a fuel for cement kilns (or for any other type of facility). As such, the use of TDF in cement kilns is not exempt from the *Energy from Waste* policy.

On balance, the preferred TDF feedstock for a Queensland cement kiln would involve consumption of passenger car sourced TDF that would otherwise go to overseas energy users. In this case, the feedstock would not displace existing material recovery efforts applied to truck tyres, and would not involve a downwards step with respect to the *Energy from Waste* policy. However, in order for this path to be successful and drive the necessary investment from cement kiln operators, passenger car tyre processors need to strongly commit to serving domestic kilns rather than intermittently shifting between domestic and export TDF markets in line with evolving market opportunities.

[39] https://www.goldenbay.co.nz/about-us/our-profile/

Crumb rubber for use in roads

For the recovery of end of life truck tyres, an important supply chain involves the processing of the rubber content into a fine crumb for use in a range of road applications. In this recovery path, whole or coarsely shredded truck tyres are fed into an integrated plant that progressively grinds down the material to smaller particles (of less than 1 mm diameter) that may then be taken into downstream road works operations (as well as some other smaller volume niche applications). These road works may involve dedicated asphalt and spray seal blending plants at fixed locations, or smaller scale mobile plants for blending to occur at the point of application.

The value of crumb rubber in this process is as a substitute for synthetic polymer binders, and it may be added in formulations of around 10 % by mass for spray seals[40] and up to 20 % by mass for asphalts[41] of various types. The binder – whether crumb rubber or polymer based – has a role in improving the operating life of roads, while reducing the extent of in use fatigue, cracking and deformation. In most cases, the extended lifespan of the road asset more than compensates for the higher upfront construction costs involved in upgrading from unmodified spray seals and asphalts to so-called 'modified' spray seals and asphalts using a binder additive.

'Crumb rubber modified binder' is used in spray seals and asphalts in jurisdictions whose road specifications allow for the use of crumb rubber binders in main roads and local roads, including Queensland and other states. This application has been a major area of market stimulus led by TSA and state and Commonwealth Government partners, and is the leading domestic usage of recovered truck tyre material in the country.

In this supply chain, up to 35 % of the truck tyre material is recovered as scrap steel with the remainder recovered as crumb rubber. While the process can also handle passenger car tyres, the road construction market is presently less accepting of this material, in part due to limited familiarity and a concern that performance properties will alter in light of the higher synthetic content of passenger car tyres compared with truck tyres. (In contrast, truck tyres tend to incorporate a greater proportion of natural rubber).

Recent research for TSA suggests that, in applications involving up to 10 % crumb rubber additions (e.g. in spray seals), the performance of passenger car based crumb rubber is indistinguishable from that of crumb rubber derived from truck tyres. These findings may be shared to help overcome resistance to the use of passenger car tyre crumb rubber in spray seals, and expand the range of tyre sources usable in road applications.

While passenger car tyres may have up to 80 % rubber and up to 20 % steel, there is also a nylon layer that the crumbing plant needs to be able to remove from the rubber matrix. Some crumb rubber plants may need to upgrade their processes to deal with nylon waste before they are able to handle and process passenger car tyres into crumb rubber.

At present, Queensland sourced truck tyres are converted into crumb in processing plants in various parts of Queensland and in interstate facilities (i.e. in New South Wales and Victoria). Those Queensland based facilities are concentrated in the southeast and are able to sell crumb rubber for road construction projects within Queensland and in neighbouring markets.

Unlike the case for tyre derived fuel, which depends on overseas markets and domestic cement kilns that are in few locations, there may be the opportunity for entirely localised supply chains and end markets for crumb rubber. Plants to manufacture crumb and granule may be economically viable at a scale of throughput as low as 3,500 to 5,000 tonnes per year, and downstream road construction operations can be flexible to the scale of crumb rubber supply.

For example, across the country, some road builders have introduced large stationary blending units that are designed to receive crumb rubber. Other road builders have opted for smaller mobile blending units that are geared to work with lower volumes and road projects that are located in more remote parts of the country.

[40] https://www.tyrestewardship.org.au/product/spray-seal/
[41] https://www.tyrestewardship.org.au/product/asphalt/

Due to the need to produce a uniformly sized grain of 1 mm or less in diameter, crumb rubber production is both capital and operationally intensive and therefore involves significant internal costs. This is countered by the higher value of crumb rubber compared to other tyre rubber derivatives, as shown in the table below. Because rubber crumb can be sold at a profit relative to processing costs, end of life truck tyres are a valuable feedstock for the tyre recycling sector.

Rubber crumb and steel recovery

Source materials – OTR and truck tyres for all road types; passenger car, OTR and truck tyres for spray seals pending established market acceptance

	Cost per tonne	Sales revenue per tonne
Processing costs	\$300 - \$600 (per tonne)	–
Sale of steel	–	\$100 - \$240 (per tonne)
Sale of crumb rubber	–	\$550 - \$800 (per tonne)
Recycling fees (at \$6 per EPU)	–	\$750 (per tonne)

Estimated market size:

DTMR has referenced crumb rubber consumption to June 2021 accounting for 1.1 million EPUs (from a 2015 base year) or an average of 1,467 tonnes of EOLTs per year. DTMR provided an estimate for total consumption of rubber crumb across the state controlled network of 3,893 tonnes of EOLTs for the current financial year (FY2022).

A review of current and planned DTMR state controlled network maintenance activity suggest potential demand for rubber crumb consuming in the range of 3,509 and 8,528 tonnes of EOLTs per year statewide.

The project team estimates potential demand for rubber crumb consuming up to between 420 and 1,510 tonnes of EOLTs per year across the SWQROC region. Of which, the annual DTMR maintenance of state controlled network in the southwest district has potential to consume between 340 and 950 tonnes of EOLTs per year. See Appendix 2 for further details.

A risk to the use of locally supplied crumb rubber in road projects arises in the form of crumb rubber import. This is a particular challenge where the crumb rubber is manufactured in countries (such as Canada) that use eco-fees to ensure the recovery of end-of-life tyres. In effect, the eco-fee allows the crumb rubber producer to subsidise its cost base and sell its crumb rubber at a discounted price in local and foreign markets. While the high price of shipping may currently work as a buffer against competition from imports, these conditions cannot be assumed to hold indefinitely. Local producers need to be able to operate efficiently while offering a high quality product that is recognised and preferred by the Australian road industry.

Whereas tyre derived fuels require minimal downstream processing prior to their use as a substitute fuel, the use of crumb rubber in roads requires downstream adjustments in roadbuilding operations in order to make use of this material. The key issue is that crumb rubber is more prone to settling in the spray seal or asphalt mix, compared to synthetic polymer binder.

As such, there is a need to invest in high shear mixing plant and/or mobile facilities that allow for blending and subsequent road laying before the crumb rubber becomes unevenly dispersed. This business case will therefore look at the processing of tyres into crumb rubber in combination with one or more different downstream road building configurations.

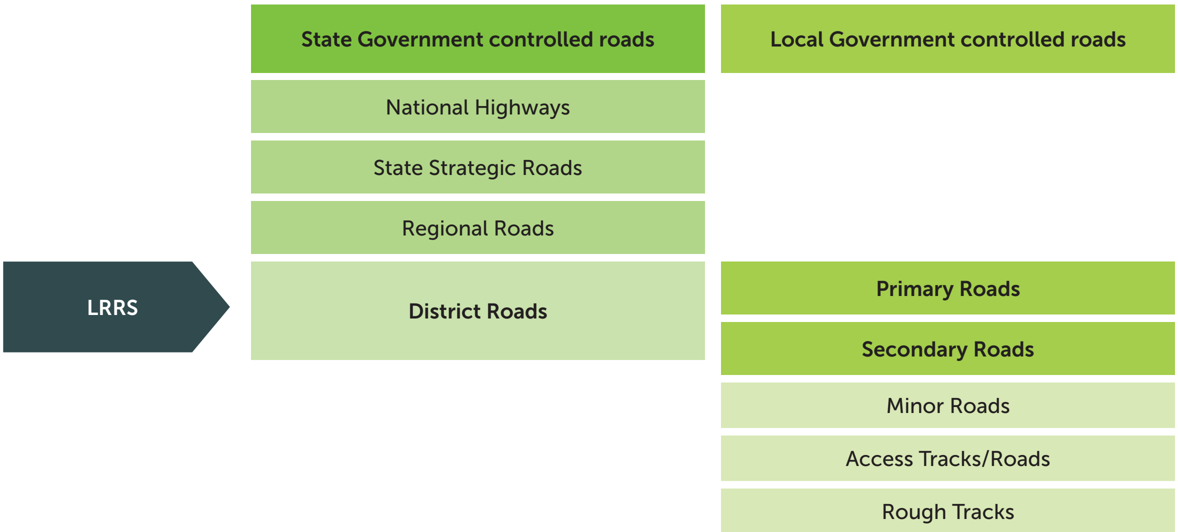
Estimating potential road network demand

The road network in Queensland is approximately 134,000 kilometres in length. The road network includes the state controlled network being approximately 34,000 kilometres and the local government controlled network approaching 100,000 kilometres (including many unsealed roads).

The management of the road network[42] is summarised by Figure 4 below, with the:

- Department of Transport and Main Roads (DTMR) having oversight of National Highways, State Strategic Roads and Regional Roads
- Roads and Transport Alliance, including district offices of DTMR and 17 Regional Roads and Transport Groups (RRTGs) managing District Roads, Primary Roads and Secondary Roads (some 38,000 kms of Local Roads of Regional Significance)
- Remaining roads managed by Local and Aboriginal Councils throughout the state.

Figure 4: Classes of state and local roads in Queensland.



At the state level, approximately 75 % of the 34,000 kilometres of network or approximately 25,500 kms is spray sealed road; and 3,400 kilometres (10% of the state controlled network) is asphalt, with the remainder unsealed. Assuming an 8 year replacement (on average) for spray sealed road and a 15 year replacement for asphalt, maintenance of the state network provides potential for crumb rubber consumption of approximately 7,000 tonnes of EOLTs per annum.

However, according to information provided by DTMR for this investigation, the level of maintenance activity across the state controlled network by road district and in aggregate varies year to year. Analysis of DTMR maintenance data (see Appendix 2) would suggest some variability year on year, with current levels of potential demand for rubber crumb consuming in the range of 3,500 and 8,500 tonnes of EOLTs each year.

Note: DTMR referenced current crumb rubber consumption diverting 1.1 million EPUs[43] from landfill to June 2021 (from a base year of 2015) and suggested the number will be revised to 1.5 or 1.6 million EPUs by June 2022. This equates to an average of 1,467 tonnes per year of EOLTs to June 2021; and approximately 3,200 tonnes of EOLTs in the FY2022.

Estimating potential road network consumption of crumb rubber in SWQROC

The project team estimates potential demand for rubber crumb consuming between 422 and 1,500 tonnes of EOLTs per annum across SWQROC. This is based on analysis of current and planned projects and activities across the DTMR state network maintenance program, QTRIP and the current SWRRTG four year program of works. See Appendix 2 for an outline of the analysis and assumptions supporting this estimated range.

A more conservative estimate, focusing on annual DTMR maintenance of the state controlled network in the South West suggests demand for rubber crumb potentially consuming between 340 and 950 tonnes of EOLTs per annum.

[42] See page 14, Roads Alliance Operational Guidelines (2011), LGAQ and Queensland Government.
[43] See https://www.tmr.qld.gov.au/Community-and-environment/Planning-for-the-future/Building-sustainable-roads

Rubber granule for use in civil works and safety flooring

Rubber granules are an intermediate sized grain recovered from end-of-life tyres, of about 2 to 15 mm in diameter. They have a range of uses including civil works (e.g. in permeable pavements, lightweight concretes and other applications) and soft, non-slip flooring and matting (which may be used in playgrounds, gymnasiums, sporting fields and athletics tracks and other niche spaces).

Granule is made using the same equipment as crumb rubber, although the processing effort is less intensive and may induce less wear on equipment. For this reason, the cost to produce rubber granule is somewhat less than the cost to produce crumb rubber.

Rubber granule applications play an important role in the tyre recovery sector, as they provide a materials recovery outlet for rubber and steel derived from passenger car tyres. Recalling from preceding sections, truck tyres are the preferred source for crumb rubber used in roads, with a lesser acceptance level for passenger car tyre crumb. And while passenger car tyres are used in making tyre derived fuels, this application represents energy recovery rather than materials recovery.

Further, the practice of exporting TDF may be less viable for smaller operators given the range of risks and overheads involved, and given that smaller recyclers may be unable to fulfil the volumes demanded by overseas energy users. Rubber granule is therefore particularly relevant for smaller regional tyre recovery operations who lack the means to supply international TDF markets.

Rubber granule should therefore be seen as a useful niche for those operators that are unable to service TDF customers, but need to find end markets for rubber liberated from passenger car tyres. The main downside for rubber granule is that the current markets may be somewhat constrained. Demand for soft, non-slip flooring may be relatively limited albeit stable; and markets for civil applications are still emerging and are yet to exhibit reliable demand.

In terms of the Queensland market, there are businesses that currently accept granule for use in floorings and surfaces, and may be positioned to take more material from regional sources. The civil works market (i.e. permeable pavements and lightweight concrete) is yet to fall into place and may take some years before appreciable volumes are recovered through this pathway. Nonetheless, civil engineering applications may come to play a significant role over the medium to long term, pending proactive market development activities in appropriate locations.

Engagement with the tyre recycling sector suggests that there are robust relationships with granule customers, who are able to make use of present levels of granule production and have signalled a willingness to purchase larger volumes in future years. Given the modest volumes of tyres generated from the SWQROC region, there is reason to expect that the market readily absorb increased amounts of granule that may be sourced from tyres from the SWQROC region.

Rubber granule and steel recovery

Source materials – passenger car tyres (assuming preferential use of truck tyres as crumb rubber)

	Cost per tonne	Sales revenue per tonne
Processing costs	$250 - $550 (per tonne)	–
Sale of steel	–	$100 - $240 (per tonne)
Sale of crumb rubber	–	$500 - $600 (per tonne)
Recycling fees (at $6 per EPU)	–	$750 (per tonne)

Estimated market size:

While this study was unable to quantify the annual demand for Queensland sourced rubber granule, industry engagement confirmed strong and stable demand and a projected increased intake of rubber granule in coming years, pending available supply.

Pyrolysis derived products

Pyrolysis is distinct from the recovery of products such as TDF, granule and crumb which all rely on mechanical processing methods to produce a saleable rubber-based commodity. Tyre pyrolysis is a controlled decomposition process that involves heating tyres from various sources to 400˚C to 1,200˚C in an oxygen-depleted atmosphere, to recover a range of products including carbon char, scrap steel, syngas and crude oil (which may then be refined to a higher grade oil).[44] Depending on the facility, there may be a need to shred the tyres to improve batch loading into the pyrolysis unit, and/or to ensure a uniform pyrolysis environment.

The use of this technology in Australia is in its early years, with but a few examples of small scale commercial facilities which have been operating over a limited time span. Those facilities include Pearl Global's small scale batch facility located in Stapylton, Queensland (operating at around 3,500 tonnes throughput per year with stated capacity of 10,000 tonnes per year) and a demonstration facility in Warren, NSW, that is not processing appreciable quantities of material.

Other facilities may be in the works elsewhere in the country, including a facility planned by Chip Tyre that is able to pyrolyse residual rubber attached to the steel wire product from granulation and crumbing processes (in a bid to produce a purer steel wire while generating fuel oil and carbon char products from rubber contaminants attached to the wire), along with whole end-of-life tyres.[45]

The current level of market activity and investment in pyrolysis suggests that the technology is some distance from commercial maturity. A number of challenges to work through prior to its ongoing viability in the Australian market include:

- The current reliance on low to moderate value commodity products (which are exposed to price volatility and competition from large scale global supply chains) as the main revenue driver additional to recycling fees
- The use of batchwise thermal processing steps whose workflows, settings and methods are yet to be optimised and may not readily scale to commercial quantities
- Uncertainty regarding stable ongoing demand for the main end products (apart from steel, which has a well established scrap metal market), yet which needs to be sustained over the operating lifespan of any new facility.

Despite these commercial obstacles, the business case examines the option of recovering regional end-of-life tyres through pyrolysis technologies and the sale of related products. The table below sets out estimated commodity prices for each recovered resource, alongside operating costs for a smaller scale pyrolysis plant (based on publicly released information).

Pyrolysis derived products
Source materials – all tyre types although passenger car tyres potentially the most viable source

	Cost per tonne	Sales revenue per tonne
Processing costs	$800 - $1,200 (per tonne)	
Sale of steel		$100 - $240 (per tonne)
Sale of carbon char (asphalt input)		Up to $200 (per tonne)
Sale of fuel oil, unrefined		Up to $140 (per tonne)
Sale of syngas (assumed onsite use)		$0 (per tonne)
Recycling fees (at $6 per EPU)		$750 (per tonne)

[44] ARUP and Rawtec, Tyre Pyrolysis and Gasification technologies: A Brief Guide for Government and Industry, 2018.
[45] https://www.couriermail.com.au/news/queensland/ipswich/childs-play-to-power-up-ipswich-tyre-recycling-plant/news-story/

Estimated market size:

At present, there appear to be developing markets for carbon char (inert aggregate and binder for asphalts) and fuel oil (industrial fuel) in the Queensland road construction sector. These markets involve moderate prices for pyrolysis products, compared with other markets that may attract higher prices but would also expect a higher grade of product to use as a commercial input (e.g. refined fuels and carbon black).

Given the relative scale of road construction compared to the regional volumes of end-of-life tyres, this market may be able to absorb modest increases in the supply of carbon char and fuel oil, pending a lift in market acceptance. Recovered steel is assumed to be readily sold into national and global markets.

Practical recovery of OTR tyres 6.2

Across Australia, the predominant means to manage OTR tyres involves burial on site (in the case of mining vehicle tyres) and stockpiling over indeterminate periods (in the case of agriculture vehicle tyres). Little recovery of OTR tyres is occurring, either as recovered materials or as an energy product. Nonetheless, some recovery is occurring or is being explored in the form of:

- Sectioning large OTR tyres from the mining sector into smaller units (e.g. four or five segments per tyre) using hydraulic shears attached to an excavator, prior to loading into shipping containers to complete processing overseas – either as a tyre derived fuel or as crumb rubber
- Consolidation of OTR tyres at intermediate regional locations, whereupon a heavy duty mobile shredder conducts preliminary shredding prior to transport of the material to a more central crumb rubber facility.

Further to the above, it is understood that a new facility based outside of Sydney has the means to process OTR tyres at scale. As the facility is only recently commissioned at the time of writing, it is yet to gear up for commercial quantities of OTR tyres and is instead recovering tyres from other vehicle types. Over time, an increasing share of its output may arise from OTR tyres.

With the recent participation of OTR tyre importers to the national Tyre Product Stewardship Scheme, there is an increasing focus on establishing sustainable solutions for the recovery of OTR tyres. TSA is therefore conducting a number of pilots across the country, which may ultimately inform the options available for OTR tyres sourced from regional Queensland.

For now, the business case manages the recovery of OTR tyres as involving a 'pre-processing' step to convert whole OTR tyres into a form which can then be treated in a manner similar to truck tyres in one or more downstream operations and supply chains. For example, as above, the pre-processing step may involve rudimentary shredding and transport to a facility, which also accepts truck tyres as a precursor to crumb rubber and steel products.

From a modelling perspective, the key requirement is to factor in an additional pre-processing cost and related transit overheads. Indicatively, the table below represents the additional cost to pre-process OTR tyres into a manageable form, over and above subsequent supply chain costs that mirror those for truck tyres for a given supply chain and end market.

OTR tyre pre-processing – shredding and containerised transport

	Cost per tonne
Pre-processing costs ((additional to downstream cost items)	Up to $400 per tonne
Estimated freight rate (per tonne kilometre)	Dependent on location of premises

The details above are a coarse estimate only, given challenges in setting assumptions that reflect:

- Distances of OTR tyre generation from consolidation points and recovery facilities
- Size of tyre and the type(s) of tyre processing technologies that may be most suitable in processing whole OTR tyres into more manageable pieces
- Levels of demand for OTR tyre processing services, which drive the volume of tyres over which fixed capital costs may be spread.

Location and freight considerations

The above explorations of markets and supply chains show that different uses for tyre derived product require different facilities and supply chains, which are limited in where they can be economically located. Factors involved in siting each type of facility may include, for example:

- Locations of source tyres and end markets
- The relevant scales of operation needed to support commercial viability, with scaling and related risk factors driving placement of some facilities close to larger volumes
- Reliance on transport infrastructure such as rail corridors and international ports
- Transport economies enabled through partial or complete processing prior to shipment to end markets and/or downstream manufacturers
- Distribution of logistical (e.g. transfer stations; freight services) and production (e.g. energy supply; skilled workforces; appropriately zoned and licensed premises) factors
- Social licence and community acceptance levels.

With the above factors in mind, Table 7 below combines end markets and their locations with their relevant tyre processing infrastructure, and suggests preferred locations for a shortlist of infrastructure options given the need to receive end-of-life tyres from one or more of the three Queensland regions. This process allows the business case to factor in freight costs for different supply chains and end markets, while accounting for source locations and the physical form in which the tyre material may be transported (e.g. as whole intact tyres, rudimentary shred, or final products such as TDF, crumb or granule) along the supply chain to end destinations.

The size of available catchments and markets that may be accessed by a recycling facility are two dominant drivers for locating that facility, given the need to allocate and utilise productive capital. At present, Queensland tyre recycling facilities are all based in southeast Queensland, exploiting both the large volumes generated and proximity to end markets and freight links.

However, for some end markets and supply chains, it is reasonable to consider the viability of smaller regional facilities serving one or more of the three regions targeted in this study. In this case, the primary goal is to seek reduced transport overheads that sufficiently compensate for diminished scale economies. Industry engagement and a determination of tyres arising in each region suggests that it may be economical for a facility located in or near north and far north Queensland, noting the order of 6,000+ tonnes of passenger car and truck tyres and an additional quantity of OTR tyres arising, pending interest from relevant sectors.

However, a regional facility is less feasible in the southwest, owing to the smaller quantities at hand. For the southwest, the key issue may be to determine the preferred end markets that leverage existing southeast Queensland recycling capacity, and to then optimise logistics and the placement of recovery activities along the supply chain in order to minimise costs. Even in this situation, there may be a need to source a minimum quantity of OTR tyres from the region to make a tyre recovery services worthwhile to a private recycling/collection operator.

Accounting for the above, the comparison of different end markets and supply chains for the three regions will revolve around facilities and their outputs, based around southeast Queensland or alternatively the north or far north of the state. For each scenario, the main focus will be on passenger car and truck tyre processing and conversion into end products, given reliable feedstock levels. Where relevant, the ability to process some amount of locally accessible OTR tyres will also be considered as a means to supplement car and truck sourced feedstocks (and in the case of the southwest, this volume may be integral to supply chain viability).

Table 7: Locational considerations for tyre processing capacity, as influenced by end market, processing technology and regional sourcing. Note: Details set out in this table are not intended to reflect locations of existing tyre recovery services (although some services may exist in one or more of the stated locations as set out in Section 3.3), but to reflect potential locations of tyre recovery services, which are then analysed and compared in terms of their commercial viability for recovering tyres from from SWQROC, NQROC and FNQROC regions.

Facility	Location	Regional catchments	Other catchments	Products	End markets
Large shredding facility	Southeast Queensland	FNQROC & NQROC SWQROC	Southeast Queensland Other regions	Tyre derived fuel	International energy users Local cement industry
Smaller regional shredding facility	Townsville or Gladstone (near cement kiln operations)	FNQROC & NQROC	Other regional centres (Mackay; Rockhampton) & rural locations	Tyre derived fuel	Local cement industry
Rubber crumb facility (large scale)	Southeast Queensland or interstate (NSW, Victoria)	FNQROC & NQROC SWQROC	Southeast Queensland Other regions	Recovered steel	Scrap metal markets
				Crumb rubber	Road building sector
				Granule	Civil works Niche flooring
Rubber crumb facility (region scale)	Townsville or similar north / far north location	FNQROC & NQROC	Other regional centres & rural locations	Recovered steel	Scrap metal markets
				Crumb rubber	Road building sector
				Granule	Civil works Niche flooring
Small commercial pyrolysis plant	Southeast Queensland	FNQROC & NQROC SWQROC	Southeast Queensland Other regions	Recovered steel	Scrap metal markets
				Carbon char	Road building sector
				Fuel oil	Road building sector
Small commercial pyrolysis plant	Townsville or similar north / far north location	FNQROC & NQROC	Other regional centres & rural locations	Recovered steel	Scrap metal markets
				Carbon char	Road building sector
				Fuel oil	Road building sector

Regional recovery scenarios for comparative analysis

6.4

Bringing together the above points, the following points (Table 8) set out alternative options for recycling tyres that arise from the three regions (FNQROC, NQROC and SWQROC), including business as usual practices.

While it is envisaged that the foundation of each option will involve the recovery of passenger car and truck tyres as primary materials, each option may also involve an emerging volume of OTR tyres available to recover following practices used to recover truck tyres.

Table 8: Combinations of passenger car, truck and OTR tyre processing facilities and their end markets and locations, viewed as being minimally viable for each region. Due to proximity, it is assumed that FNQROC and NQROC can be treated as a single combined catchment, while SWQROC remains a separate catchment.

FNQROC and NQROC (combined regional catchment of around 5,000+ tonnes per year)
1. **Passenger car tyres** collected for recovery of TDF for export from southeast Queensland. **Truck tyres** collected for recovery of crumb rubber in southeast Queensland or more southern states, and then used in nearby road building projects.
2. **Passenger car tyres** collected for recovery of TDF for domestic use in cement kilns, with shredding taking place in southeast Queensland. **Truck tyres** collected for recovery of crumb rubber in southeast Queensland or more southern states, and then used in nearby road building projects.
3. **Passenger car tyres and truck tyres** collected and subject to pyrolysis treatment in southeast Queensland, with carbon char, fuel oil and steel sold to local buyers (road builders and scrap metal merchants).
4. **Passenger car tyres** collected for recovery of granule in newly established local crumbing facilities, for use in local civil works and/or as an input to niche flooring manufacture (in southern Queensland). **Truck tyres** collected for recovery of crumb in newly established local crumbing facilities, for use in local road building projects. **Note:** This option may involve a level of passenger car tyre material converted to crumb rubber and used in spray seal applications.
5. **Passenger car tyres and truck tyres** collected and subject to pyrolysis treatment in a newly established local pyrolysis facility, with carbon char, fuel oil and steel sold to local buyers (road builders and scrap metal merchants).
SWQROC (single regional catchment of around 100 to 140 tonnes per year)
1. **Passenger car tyres** collected for recovery of TDF for export from southeast Queensland. **Truck tyres** collected for recovery of crumb rubber in southeast Queensland or more southern states, and then used in nearby road building projects.
2. **Passenger car tyres and truck tyres** collected and subject to pyrolysis treatment in southeast Queensland, with carbon char, fuel oil and steel sold to local buyers (road builders and scrap metal merchants).
3. **Passenger car tyres and truck tyres** collected for recovery of granule and crumb rubber in southeast Queensland, with the crumb rubber then returned to SWQROC for road building projects (spray seal applications).

In the next section of the business case, a more detailed analysis of these options is set out for each region. While a focus of this analysis involves a quantitative financial model to understand their commercial viability and ability to return profits in a competitive market environment, this analysis will also need to account for market and supply chain risks, strategic barriers and opportunities that may be challenging to numerate.

Where relevant, the business case also needs to explore any distinguishing outcomes that may arise between one solution and another. For example, in a given region, there may be preferences towards a solution in line with the following points:

- Local employment opportunities
- Environmental impacts including alignment with the waste hierarchy
- Achievement of local and regional circular economy objectives
- Impacts on market resilience and efficient pricing
- Differential capacities to unlock and tap into difficult market segments such as stockpiled tyres, OTR tyres and/or illegally disposed tyres.

Taking a multi-pronged analytical approach as described above will empower decision makers, private commercial operators and investors, and stakeholders to navigate the strengths and weaknesses of different tyre recovery solutions pertinent to each regional market.

This approach recognises that multiple actors need to commit in order to lock in the success of one or more tyre recovery pathways (i.e. including their supply chains and target markets), each of which will have their own interests and priorities to attend to. It is therefore essential that this business case transparently lays out the pros and cons of each option from multiple viewpoints (as described above).

Market & supply chain analysis

In this section, a series of tyre recovery options for the SWQROC region will be explored and analysed according to several metrics covering:

- Commercial viability, based on an analysis of cost and revenue profiles
- Risks and barriers relating to their supply chains and end markets
- Wider opportunities, impacts and potential benefits to the region and the state

This section is structured to compare the options available to the SWQROC region, given the opportunity to source tyres from that catchment. Where relevant to the technologies and end markets in question, tyre feedstocks are separated into passenger car, truck and OTR vehicle sourced tyres.

In completing this exercise, the relative advantages and disadvantages of different tyre recovery solutions for the region become clear. However, the goal is not necessarily to determine an unambiguous 'winning solution' for each region but to provide insights into the potential outcomes of each option and to ascertain the conditions needed in order to ensure a preferred solution is successful.

A key point of difference between the SWQROC region and the combined FNQROC and NQROC regions (reported on separately) is the scale of material that may be collected from each, with SWQROC volumes much lower than those available from the combined region.

As mentioned elsewhere, this means that a local facility is far less viable for SWQROC sourced tyres, and any solution will come to rely on facilities based elsewhere such as southeast Queensland. While this presents fewer options for SWQROC, it also means that none of the options for SWQROC entirely hinge upon new infrastructure that predominantly relies on tyre material from the southwest. So long as there is an efficient means to consolidate and transport tyres to said facilities, there are few risks involved in switching from one solution to another.

In contrast, the volumes across FNQROC and NQROC combine to provide enough material to support a regional facility, depending on the technology and supply chain at hand. While this introduces additional options for the combined region, those options carry a higher degree of dependence on regionally sourced tyres.

As such, the stakes involved in customers switching between one solution and another are higher for regional facility operators, and they would need a degree of confidence in their strategy to retain customers. This customer retention may arise from competitive pricing, recognition of local benefits, and/or other features unique to a regional tyre recovery model.

The need to factor in a recycling surplus for private operators

As a key benchmark for understanding the commercial viability of a tyre recovery solution for the region, it is useful to consider typical operations and operating margins prior to the market and supply chain instabilities caused by the Covid-19 pandemic. Prior to 2020, the difference between revenues (from recycling fees and the sale of recovered TDF product) in recovering passenger car tyres and the operating costs (i.e. for processing and transport activities) came to around $2.40 per EPU or $300 per tonne.

Assuming a competitive market, this return may reflect a minimum profitability required by tyre recyclers in order to cover a range of business needs that sit outside of core operations, a so-called 'recycling surplus.' In effect, this surplus responds to a range of wider business considerations, e.g. buffers against market risk, profit-taking, business expansion and so on (see Section 2.2).

While tyre recyclers may need to reset their profit expectations over coming years, this benchmark is still relevant at least until a new equilibrium in recycling services and operating costs asserts itself. The timing of this equilibrium may need to factor in, for example:

- The time it takes for international supply chains and shipping costs to stabilise, following the pandemic and following recent military conflicts in eastern Europe

- Time to allow for recent policy instruments – including the ban on exporting waste tyres and related infrastructure funding – to influence the supply and demand of different tyre recovery services
- Other sources of market volatility that may emerge in the short term.

For the purposes of this business case, this benchmark surplus is used as a 'rule of thumb' to gauge the commercial viability of different recycling solutions, based on the financial profile.[46]

That is, recovery supply chains that operate with a surplus that is substantially below this benchmark (i.e. of $300 per tonne) are viewed as operating under significant financial strain. Such businesses may be under pressure to either raise their recycling fees (rendering them less competitive) or to lower their profit expectations (eroding their ability to attract capital and/or to stave off future business risks), and are potentially marginal compared with competing alternatives in the tyre recycling market.

In contrast, supply chains that can operate with surpluses of $300 per tonne or more may be more commercially resilient over the coming period, notwithstanding other business risks (as will be discussed as relevant).

Options to recover tyres from the SWQROC region 7.1

The SWQROC region is spread along the western length of Queensland's southern borders. Its population of 24,000 spread across 320,000 m^2 is both smaller and more dispersed than the northern and far northern populations of Queensland.

With around 150 tonnes of end-of-life tyres arising each year, the volumes are much too small to justify a dedicated regional tyre recycling facility. Any recycling endeavour will therefore need to rely on the efficient collection and consolidated delivery of tyres from the region to one or more service providers located elsewhere such as southeast Queensland. These service providers would need to rely on an intake of tyre volumes from other sources such as client bases from in and around Brisbane and Gold Coast and other regions.

During a pilot tyre recycling project coordinated by Balonne Shire, the transport of end-of-life tyres to recycling facilities in southeast Queensland was subsidised. However, there may be the option to continue this service or to adopt similar options, with southeast Queensland operations and end markets revolving around:

- The production of tyre derived fuel for international buyers from passenger car tyres, alongside the production of crumb rubber and steel from truck and OTR tyres
- The production of tyre derived fuel for domestic cement kilns from passenger car tyres, alongside the production of crumb rubber and steel from truck and OTR tyres
- The production of rubber granule (for use in civil works and niche flooring) and steel from passenger car tyres, alongside the production of crumb rubber and steel from truck and OTR tyres
- Thermal breakdown of all tyres into pyrolysis products including fuel oil, carbon char and recovered steel.

In essence, this options analysis for SWQROC tyre recovery compares the cases where passenger car tyres may be shredded for tyre derived fuel for international and local energy needs; grinded into granule for flooring and civil works applications; or pyrolysed into a range of products. It also compares models for truck (and OTR) tyre recovery involving production of crumb rubber; or pyrolysis into a range of products.[47]

It is envisaged that each of these operations would most likely occur in southeast Queensland in an existing facility or a new facility that is able to obtain scale economies through access to tyre material from locations other than the SWQROC region.

[46] There are other viability factors that sit outside a purely financial analysis, which will also be covered albeit via qualitative (discursive) rather than quantitative methods.
[47] From a technical standpoint, passenger car tyres could be grinded into crumb rubber, and truck tyres could be grinded into granule, using the same crumbing facility. However, these options have not been covered in their own right in order to simplify the comparison. Profit margins between operating costs and revenue from the sale of granule and crumb products are anticipated to be roughly equivalent across a given facility's crumbing and granule production processes.

Previous studies undertaken for TSA suggest whole tyre long haul transport (via B double walking floor trailers) may cost in the order of $0.30 per EPU per 100 kilometres. Given distances from SWQROC (Roma or St George) of around 450 kilometres, an estimated long haul cost of $1.20 per EPU or $150 per tonne has been used in the ensuing analyses.

Passenger car tyre recovery 7.2

Production of TDF for international markets

Financial profile

As explained in previous sections, this recovery pathway involves transporting passenger car tyres from the SWQROC region to existing tyre recovery facilities in southeast Queensland, which then shred the tyres to meet a specification required for offshore energy applications.

While there may be merit in undertaking some preliminary shredding at a consolidation point (such as in Roma) within the region to reduce transport costs, this would use a mobile shredder which may not be able to produce a consistent dimension. But given the limited value of exported TDF, this extra handling may not be justified.

Shredding tyres to make TDF is a lower cost process compared with other processing methods for end-of-life tyres, with previous studies[48] for TSA estimating a processing cost of $85 to $95 per tonne of TDF. However, recent costs to freight the finished TDF to end markets (e.g. in Malaysia) are in the order of $150 to $425, with international shipping displaying high levels of price volatility and supply constraints. Industry stakeholders have advised that TDF is attracting low price levels, between zero and $50 per tonne.

As set out at the beginning of this section, transport costs for hauling whole passenger car tyres from SWQROC to southeast Queensland may be in the range of $150 per tonne.

Assuming recycling fees of about $6 per tyre or $750 per tonne, it may be estimated that the production and export of TDF through facilities based in southeast Queensland may generate a revenue surplus in the order of $80 to $415 per tonne. This compares against historic revenues for processing passenger car tyres in the order of $300 per tonne.

In other words, the export of TDF may only be marginally profitable and potentially less profitable under current market conditions compared to previous time periods, largely due to international shipping difficulties and unfavourable TDF prices.

Supply chain and end market barriers and risks

A key benefit of this recovery path is that the international market for tyre derived fuels is well established, with buyers located in southeast Asia and beyond. Recycling operators do not need to synchronise their production ramp up in line with emerging market acceptance. This removes some uncertainty from their business equation.

On the other hand, there are risks and overheads related to international market exposure. The operator may need to account for currency risks, trade policy risks (e.g. the equivalent of the Chinese National Sword policy enacted by other countries), and risks related to shipping such as delays in offloading goods and import duties. As previously mentioned, shipping costs have risen markedly since the Coronavirus pandemic established, and may continue to erode the profitability of exporting TDF.

With the recent introduction of a ban on exporting baled tyres, it is reasonable to anticipate that some of this volume will instead be processed into TDF. Any effects on price and market acceptance may be difficult to predict.

[48] Randell Environmental Consulting, *Used tyres supply chain and fate analysis,* 2020. Figures derived from sale price and profit estimates.

On one hand, the tyre derived fuel market is very large and may be able to absorb these additional volumes without a major price adjustment (noting very low prices in the present market context). Yet on the other hand, a larger influx of TDF from Australia (and other sources) may put greater pressure on overseas trade ministries to limit access to their markets in the form of quotas or bans (as introduced by the People's Republic of China).

The supply chain for TDF relies on a single processing activity to produce TDF with given size properties to allow for use as an energy resource. The shredding process has limited application for other markets, aside from potential use as a domestic fuel discussed below. While this keeps operating costs low, it comes with the disadvantage of having limited means to pivot to other known applications and markets.

Wider opportunities, impacts and benefits

The above discussion describes a supply chain and end market that involves low operating costs, and low to zero revenue from the sale of TDF in international markets. Shipping costs have steadily risen over the past several years, and are difficult to project into the future. Should shipping costs continue to rise or should end markets contract, the supply chain has limited options but to raise recycling fees and/or substantially lower profit margins.

However, future recycling fees may be contained due to competition from other recycling services targeting passenger car tyres; and reduced profits may be unpalatable given that this would represent a decline from longer term profit levels, and may not position the recycler to adapt to future risks and opportunities.

To take a more optimistic position, commercial shipping constraints may dissolve in coming years, such that the cost to deliver TDF into international market will lessen and the TDF supply chain may become more profitable. However, there is no compelling reason to assume that this direction is any more likely than a future that involves a continued elevation of shipping costs.

As a final point, the Queensland Government has announced further funding for resource recovery and other initiatives in line with achieving state recycling targets over coming decades. While this may provide an opportunity to expand out facilities to process tyres into TDF, it may be recalled that TDF is disfavoured in light of the *Energy from Waste policy.* Further state capital allocation may therefore support alternatives to TDF processing without providing the same support to TDF, increasing the level of competition faced by TDF processors.

Production of TDF for domestic energy use

Financial profile

The usage of TDF for stationary energy needs is well established for facilities overseas, although is yet to gain common acceptance in Australia. Recently, the Australian cement industry has shown an interest in using waste derived fuels – including TDF – as an energy source that may partially substitute for the use of thermal coal.

At present, the prospect for using TDF in Australian cement kilns is unclear due to a range of factors that are yet to be resolved, such as:

- The scale of cement production operations (and other TDF users) in different parts of the country including Queensland, over a given time horizon
- The comparative appeal of TDF as an alternative fuel source for Australian cement kilns, relative to other competing waste derived fuels that may be similarly appropriate
- The volume of TDF sought by cement kilns in Queensland and elsewhere relative to TDF volumes produced, dictating the balance of supply and demand, and therefore influencing TDF pricing levels
- Specifications that drive some level of processing prior to use of TDF in Australia, which may or may not be similar to the specifications applied to TDF consumed elsewhere
- Price tolerances for the cement kiln operator, potentially influenced by: black coal pricing levels, regulatory overheads, investment in plant upgrades and revised operations (which may involve some commercial trade offs), differences in calorific value relative to coal, and the formal recognition and allocation of carbon offsets as may be relevant.

In short, there are a number of commercial factors that preclude a detailed financial analysis of the commercial viability for using TDF for local stationary energy applications. While prices for black coal have trended towards $270 per tonne[49] at the start of 2022, this value may only serve as a loose guide for what a cement kiln operator may be willing to pay for TDF, given the wider commercial factors listed above.

Assuming domestic TDF applications require similar specifications as are used by international buyers of TDF, it is likely that processing costs will stay in the order of $85 to $95 per tonne. Local TDF consumption has the potential of avoiding high international shipping costs, in the order of $150 to $425 avoided per tonne of TDF relative to the international sales option. So from the viewpoint of end-of-life tyre generators, the domestic end market may provide an alternative path to use TDF, where the business model is less dependent on higher recycling fees to cover escalating shipping costs.

Supply chain and end market barriers and risks

It would be appropriate for the Queensland tyre recycling sector to monitor for opportunities and explore options with the cement industry (and other markets), given the advantages relative to international sale of TDF (outlined above), while taking account of the risks associated with this market. This report identifies that a Queensland cement kiln operating at 1.5 million tonnes cement production per year may demand as much as 40,000 tonnes of TDF, assuming a 15 % substitution of its black coal intake being fully met with end-of-life tyre material. This is about the same volume of end of life passenger car tyres arising in Queensland in recent years.

This domestic use of TDF could represent significantly lower supply chain and trade risks compared with the international sale of TDF, as discussed above. However, it may carry other risks due to the limited number of buyers in this emerging energy market, and the lack of regulatory certainty. The use of waste derived fuels in cement kilns may also be subject to high levels of competitive pressure, given the appeal of offloading various other refuse materials as an energy source compared with the costs associated with waste treatment and/or disposal.

This combination of few buyers and many potential sellers may lead to TDF price and demand instability in the near to medium term, especially where supply levels are volatile across all waste derived fuels and demand levels relatively inelastic. This may lead to less predictable margins for supplying local cement kilns with TDF.

Wider opportunities, impacts and benefits

The use of solid waste derived fuels in domestic stationary energy applications is not a high priority for the Queensland Government, as explained in its *Energy from Waste policy*, despite the greenhouse gas abatement that this activity may entail. Further, the use of tyres as a solid fuel for cement manufacturing is not a permitted use recognised in the relevant end of waste code for used tyres. Should Australian cement kilns exhibit strong demand for TDF as an energy input, it may be suitable for relevant commercial stakeholders to advocate for recognition in the end of waste code while seeking clarity on other industrial energy applications.

[49] At the time of writing, energy commodity values have entered a more volatile period potentially due to military conflict in Ukraine. The quoted $270 per tonne refers to a pricing period before the recognised conflict period (i.e. prior to late February 2022).

Rubber granule production for civil and safety flooring applications

Financial profile

The above supply chains centre on the production of a shred product for energy applications, envisaging a primary reliance on high grade shredding equipment that can reliably produce a consistent output. An alternative option involves taking the end of life passenger car tyres to a tyre crumbing facility, which has the means to generate a range of rubber products with the steel and nylon components of the tyre removed.

This facility can produce a range of rubber products such as granule and crumb for different end markets, while recovering steel for sale to scrap metal merchants. Depending on the facility, it may be able to recover the nylon for use in insulation applications or may discard the nylon as a waste product. Because the nylon mesh is not found in truck and OTR tyres, this added complication is not present and makes their recovery easier.

Focusing on the granule option, the operating cost to process passenger car tyres may be in the order of $250 to $550, depending on the facility in question. The various end products may range in their sales prices, including steel recovery (up to 20 %) in the range of $100 to $240 per tonne and granule (up to 80 %) in the range of $500 to $600 per tonne.

As set out at the beginning of this section, transport costs for hauling whole passenger car tyres from SWQROC to southeast Queensland may be in the range of $150 per tonne.

Assuming recycling fees of $6 per tyre or $750 per tonne, the practice of recovering granule from passenger car tyres may generate a surplus in the order of $470 to $878 per tonne.

This estimate assumes sufficient throughput at the facility to ensure the equipment is efficiently utilised, and that the significant capital costs generate an adequate return. It may be noted that the above stated margins are significantly higher than the margin for exporting TDF, under current market conditions.

While the passenger car tyres could alternatively be processed into crumb rubber (and steel) products, it is understood that there is a general preference to use truck tyre derived rubber crumb in road applications. However, it is also understood that spray seal roads are able to be made with passenger car and/or truck tyre crumb rubber interchangeably, without loss in performance.

This allows a crumb rubber plant to focus on different end markets according to relevant demand and price levels. In any event, it is largely expected that the profitability of deriving crumb or granule from passenger car tyre inputs is largely equivalent, and the above financial analysis adequately represents the potential margins in converting car tyres to crumb.[50] (In the following section, the financial profile of converting truck tyres to crumb is laid out, which may be additionally instructive.)

Supply chain and end market barriers and risks

There are limited supply chain risks in sending SWQROC sourced passenger car tyres to facilities that recover rubber granule and steel, based in southeast Queensland. There are several companies that are able to undertake crumbing processes, and the process is well established.

Compared to other recovery pathways for passenger car tyres, this option is capital intensive and involves the production of higher value products. As such, a newer crumbing facility is highly dependent on accessing significant volumes of tyre material and on being able to sell its products to strong and stable end markets. But because the SWQROC sourced tyres are likely to rely on existing facilities that have historically drawn on larger tyre volumes and end markets based in southeast Queensland, this risk is minimal.

[50] To elaborate, the process of converting tyres to crumb involves higher operating costs (as a finer particle size requires additional grinding effort) compared with granule production, however this is largely offset by the higher prices commanded in the sale of crumb relative to granule.

The key issue is to ensure efficient consolidation and transport of passenger car tyres from a holding point located to the eastern end of the SWQROC region, to help keep freight costs to a minimum. SWQROC, led by Balonne Shire, has previously trialled some transport and aggregation options and has had success in moving 300 tonne volumes of end-of-life tyres. This trial suggests that 150 tonne volumes may be collected every 18 months from Roma or St George, combining car, truck and OTR tyres for collection over an 18 month period. The trial partners have been able to identify at least one operator willing to provide this service.

In terms of end markets, there are both existing and emerging markets in Queensland for rubber granule sourced from passenger car tyres, suggesting that this solution involves modest end market risks. Rubber floor and matting manufacturing operations are based in southeast Queensland, and have a record of using recycled rubber granule in a wide range of products for use in industrial, recreational, sports, gymnasium, and acoustically sensitive applications.

Over time, there may be an increased interest in the use of permeable pavements (in car park, footpath, and other civil assets) that take up to 25 kilograms of granule per square metre, although this application is yet to establish in the Queensland market. Other niches for rubber granule may include industrial bunding and spill management equipment, and other products.

While there may be some risk of competition from imported rubber and granule, current shipping costs may help to protect local producers from the supply of imports, although this may change in coming years. However, those same shipping costs together with the ban on exporting baled tyres, may lead to a greater supply of domesticated sourced granule which may ultimately suppress granule prices in the medium term. If this comes to pass, the granule supply chain may become less profitable or may need to involve higher recycling fees to retain current profit levels.

Wider opportunities, impacts and benefits

The pathway of sending passenger car tyres to a crumbing and granule facility carries some advantages in the form of flexibility between different rubber products (principally crumb and granule), a range of end markets for those rubber products, and the ability to recover steel as a secondary product stream that may help to hedge against fluctuating prices for rubber-based commodities. This allows the rubber granule supply chain to seek market opportunities as they evolve, in line with the rise and fall of prices and demand levels as explored above.

Pyrolysis treatment

While pyrolysis is somewhat established as applied to tyre feedstocks in overseas market settings, it is still an emerging technology in Australia and is yet to be applied at scale. This means that there is limited data on the financial profile of Australian tyre pyrolysis operations. Studies undertaken for TSA suggest that the current products from tyre pyrolysis in Australia are relatively low grade and are subject to competition from other volume commodities that are produced from globally established supply chains.

Based on these studies, it may be assumed that in the absence of further refining and value-adding activities, tyre pyrolysis will generate the following products (with their price ranges in brackets):

- Steel, up to 30 % of the tyre input ($100 to $240 per tonne recovered)
- Low grade fuel oil, up to 30 % of the tyre input (in the order of $140 per tonne recovered)
- Low grade carbon char, up to 25 % of the tyre input (up to $200 per tonne recovered).

These products do not include a volume of syn gas which is assumed to be consumed on site to provide power to the pyrolysis unit.

There is limited data relating to the costs of running a tyre pyrolysis plant in Australia, but the lack of larger commercial scale operations is likely to lead to high running costs. Analysis of publicly available commercial documents suggests running expenses for pyrolysis in the order of $800 to $1,000 per tonne. Transport costs for hauling whole passenger car tyres from SWQROC to southeast Queensland may be in the range of $150 per tonne.

Given operating costs and sales revenues above and assuming inflows from recycling fees of around $750 per tonne, it is not clear that tyre pyrolysis is competitively viable in Australia as yet as the above balance of costs and revenues leads to a net loss of $35 to $280 per tonne.

More concerning, the operation may be substantially exposed to downward movement in recycling fees, which could lead to increasingly marginal performance.

As a separate matter, it is not clear that the current products and end markets from pyrolysis represent high value recycling outcomes. Industry engagement suggests that some products such as carbon char may be difficult to produce at a standard allowing for confident demand, in which case it may be difficult to prove that the carbon char output represents a legitimate recycling outcome. Pyrolysis operators may seek to invest more effort into delivering a high grade product but this may not be able to directly compete with existing alternatives in the carbon char market, that may be available at lower price points.

In summary, while there appears to be modest scale pyrolysis operations that are able to take passenger car tyres in the Queensland market, the financial profile of this technology suggests that it has a marginal role for the time being. As there are some questions as to the technical performance and/or demand of some products such as carbon char, there is some uncertainty as to whether this technology maximises recovery compared with other solutions.

Truck and OTR tyre recovery 7.3

Rubber crumb production

End of life truck tyres are a highly desired input for rubber crumbing facilities, based on their strong demand as a bitumen binder in road building projects in certain parts of the country.

This demand is fuelled by the properties of crumb rubber in conferring durability and cracking resistance performance benefits to asphalts and spray seals at a lower price than synthetic polymer binders that have been historically used. Truck tyres are viewed favourably due to the absence of a nylon mesh layer and due to the higher prevalence of natural rubber in the tyre material. Passenger car tyres received at a crumbing facility may preferentially be processed into granule as discussed above, although from a technical standpoint, the only substantial difference between processing truck tyres and car tyres into rubber or granule is the need to remove nylon from passenger car tyres.

The recovery of crumb rubber from truck tyres generally involves higher processing effort than granule recovery, and is estimated in the order of $300 to $600 per tonne, depending on the facility. As set out at the beginning of this section, transport costs for hauling whole truck tyres from SWQROC to southeast Queensland may be in the range of $150 per tonne.

Sales revenue may presently be in the order of $100 to $240 per tonne for steel and $550 to $800 per tonne of crumb rubber, with markets presently favouring the upper end of each range. Assuming recycling fees set at $6 per EPU or $750 per tonne, a crumb rubber facility may be able to process truck tyres while earning a margin in the vicinity of $400 to $900 per tonne.

These margins, along with the strong and growing demand for crumb rubber in road building and the lack of nylon mesh to remove during processing, help to explain why crumb (and granule) production is favoured over the shredding of truck tyres into a solid fuel product.

Even allowing for potential interest in TDF as a fuel in domestic cement kilns, rubber crumb production is likely to remain an attractive practice for truck tyre recovery, particularly given the market power held by a small number of cement kilns relative to many potential suppliers of waste derived fuel, and the upper limits for domestic TDF demand in Queensland of around 40,000 tonnes TDF per year.

Supply chain and end market barriers and risks

As with the case for recovering granule from passenger car tyres (above), supply chain risks involved in converting truck tyres to crumb rubber and steel are limited. Crumbing is a well established practice in Queensland and in other parts of the country, and demand for rubber crumb in the road building sector remains high. The presence of multiple service providers allows SWQROC based tyre generators an element of choice in the market while helping to ensure efficient pricing and competitively low recycling fees.

Moreover, the ability to process passenger car and truck tyres into a range of products including granule and crumb allows a degree of market flexibility for tyre crumbing facilities, allowing them to re-balance their products and end markets in line with trending demands and profitability levels. This benefits the tyre generator by helping to keep fees low, and by helping to ensure the supply chain is not unduly reliant on recycling fees to drive commercial viability.

An analysis of markets for crumb rubber as a road construction input suggests that the potential demand for crumb rubber in roads is able to absorb the volume likely to be recovered from truck and passenger car tyres collected and processed from the SWQROC region, particularly if crumb rubber continues to displace synthetic polymer in the binder market. Even allowing for a full recovery of SWQROC sourced passenger car and truck tyres as crumb rubber, both regional demand and statewide demand for crumb rubber in roads is likely to exceed the level produced from those tyres.

As with the case for getting passenger car tyres from SWQROC to a processing facility, a historic issue for the region has been to secure services to transport truck tyre material from a consolidation point in the east of the region to an appropriate recycler. Through a pilot led by Balonne Shire, it appears that this barrier has been resolved – a commercial partner is now able to offer services to pick up passenger car, truck and OTR tyres as often as is practical, in the order of 150 tonnes collected every 18 month period.

Wider opportunities, impacts and benefits

The pathway of sending truck tyres to a crumbing facility delivers flexibility between different rubber products (principally crumb and granule) supplied to a range of end markets, with steel recovery helping to hedge against shifting prices for rubber-based commodities. This allows the rubber granule supply chain to seek market opportunities as they evolve, in line with the rise and fall of prices and demand levels as explored above.

Over time, there may be more applications for crumb, granule and other products in line with a transition to a circular economy as set out in the Queensland Government's *Waste Management and Resource Recovery Strategy*.

Pyrolysis treatment

The potential to use pyrolysis as a means to recover passenger car tyres was dealt with in earlier sections of this report, and the findings for truck tyre pyrolysis largely mirror that discussion. That is:

- The financial performance of current tyre pyrolysis operations in Australia is yet to be proven, and operators may struggle to sustain profit margins after accounting for core processing costs, recycling fees, and revenue from the sale of commercial outputs.
- Some of the products from pyrolysis are yet to attract strong and reliable demand given their quality relative to competing alternatives, which poses questions as to the efficacy and completeness of this technology as a resource recovery solution.
- Some of the low to moderate value products – such as carbon char and fuel oil – may be especially exposed to global competition and price fluctuations, which may place an inordinate emphasis on recycling fees both to ensure profitability and to buffer against negative price movements that may be difficult to predict with confidence.

Some of the above weaknesses in the tyre pyrolysis business model may be circumvented over time, through ongoing operational improvements and market development activities. Pending this future point, the technology may be viewed as commercially mature and reliable as a resource recovery pathway suitable for tyres generated from the SWQROC region. However, there is still a need for pyrolysis technologies to compete against currently established solutions that rely on mechanical processing techniques.

Should a tyre generator (or agent acting on behalf of said generator) be interested in pyrolysis as a solution, it would be prudent to seek information on the commercial resilience and commodity value of its outputs; and to gain an understanding of the operator's history in finding healthy and stable end markets that are able to absorb the full scale of its output products. This information is essential for understanding the stability and legitimacy of all recovery offerings in the market, but may be especially relevant to pyrolysis and other more emerging technologies.

Additional processes to achieve OTR tyre recovery

During the trial for consolidating, transporting and processing tyres from SWQROC (led by Balonne Shire), a significant volume of material originated from agricultural premises. The largest volume of tyres was sourced from Cubbie Station, a large farming property (93,000 hectares) involved in mainly cotton, but also wheat, sorghum, sunflower and chickpea production.[51] A smaller cotton plantation, Kia Ora, was also involved in the trial. Both of these properties are located towards the east of the SWQROC region, which may help to limit their freight costs in delivering large OTR tyres to processors based in southeast Queensland.

The participation of the two cotton producers suggests that the agriculture sector may be willing to use tyre recovery services irrespective of the opportunity to retain agricultural vehicle tyres on property, provided that the services and related transport costs are affordable.

An analysis of tyres used for cotton harvesters and pickers suggest that cotton plantation vehicle tyres may be less than two metres in diameter,[52] and may be amenable to pre-processing with existing mobile shredding equipment fitted with large intake hoppers.[53, 54] Once the tyres are shredded to aid handling and transport, they can be processed in a crumbing facility.

While the volume of OTR tyres arising from the SWQROC region alone may not be enough to cover the capital costs of a suitable mobile shredder in their own right, the cost to transport an existing shredder to a suitable location (such as Roma or St George) and then pre-shred agricultural tyres to a nominal length could potentially be recovered through recycling fees. These fees would need to additionally cover processing of this shredded material at a downstream crumbing facility.

Prior work for TSA (Northern Territory business case for recovering tyres) suggests an operating cost of about $400 per tonne to transport and shred OTR tyres to a suitable size (subject to source location), additional to other operating costs for processing truck tyres into crumb rubber and steel. This may be a profitable service if the tyre recycler can pass through these additional costs to the OTR vehicle owner.

Noting that increased tyre collection volumes may help to improve transport efficiencies, Balonne Shire and tyre recyclers working in the SWQROC region may wish to establish whether other large regional landholders are interested in tyre recycling services that are managed through a centralised arrangement. The service partners could initially target cotton plantations based on established precedent, although may need to establish an efficient process to consolidate tyres from more central parts of the region as well as tyres available east of SWQROC.

[51] https://cubbie.com.au/photo-albums/crops/
[52] https://www.bkt-tires.com/ww/en/agriculture/p2
[53] https://tana.fi/products/tana-shredder-440dt/
[54] https://www.untha.com/en/products/xr-mobil-e

According to Cotton Australia, the main regions for cotton growing in Australia are:

- The Central Highlands, Darling Downs, Border Rivers, St George, Mungindi and Dirranbandi regions of Queensland
- The Gwydir, Namoi, Macquarie, Murrumbidgee, Murray and Lachlan valleys of New South Wales.[55]

In essence, these regions together straddle the Queensland – New South Wales border and may present an opportunity to engage with the sector en masse while exploring a solution for recycling OTR tyres across the industry as a whole.

Beyond cotton production, other OTR tyre sources in the SWQROC may involve other agriculture-based sectors, earthworks and other industries. At present, there do not appear to be significant levels of mining activity that may give rise to OTR tyre volumes.

[55] https://cottonaustralia.com.au/where-is-cotton-grown

Tyre recovery options for SWQROC 8

For convenience, the key features of each of the recovery pathways for tyres arising from the SWQROC region are set out in Table 9 (across the two following pages). This table additionally sets out the foremost advantages and disadvantages of each combination of supply chain and end market, along with activities that could be undertaken by TSA to strengthen the viability of each pathway.

These supporting measures respond to challenges and barriers specific to each recovery path, as opposed to generic measures that are often put forward in the resource recovery space (such as education programs and broad application capital funding). Such generic measures may not be based on an in depth analysis and evidence substantiating the extent and materiality of the obstacles at play.

Prior to TSA decisions on investing in any one activity nominated, the organisation may need to determine whether the activity is compatible with its role and whether the end market and supply chain is in a position to make meaningful use of the results from that activity.

Strengths and weaknesses of supply chains & markets 8.1

As explained earlier in this report, it is unlikely that there are sufficient volumes of end-of-life tyres arising from the SWQROC to encourage a regional tyre recovery facility. Instead, tyre recovery services are more likely to leverage existing operators based in southeast Queensland, which already serve a large market and have existing relationships with downstream operators.

End-of-life tyre generators in the region may explore these options according to their service profile (i.e. pricing, punctuality, willingness to accept tyres of different sizes and levels of contamination, end products etc.) with limited direct exposure to supply chain and end market risks, and may shift between service providers according to their evolving preferences. Depending on their attachment to recovery outcomes, it is reasonable to expect that most customers will mainly be interested in price, convenience, and (one hopes) whether or not the recycler is suitably licensed. A typical tyre recycling customer may be indifferent to other facets including downstream fates, so long as prices remain stable.

The availability of tyre recovery services to SWQROC customers hinges upon having enough demand to make it worthwhile for an operator to offer and deliver those services, and this may require an intermediary to act on behalf of multiple tyre generators across the region. In this case, the advantages and disadvantages of different service offerings may be relevant, given that this intermediary is representing a range of third parties and may have a duty of care obligation to pursue the best options or lowest risk options available at a given point in time.

Table 9: Summary of strengths and weaknesses of different supply chains and end markets for end-of-life tyres recovered from the SWQROC region.

Passenger car tyres				
Processing technology	**End markets**	**Advantages**	**Disadvantages**	**Supporting activities**
Shredding whole tyres to meet TDF specification	Kilns, furnaces and boilers located in Asia (e.g. Malaysia, India)	• Operations well established at commercial scale • Limited capital costs and operating costs (per EPU) • High volume end markets	• Very low value product, often below cost to process • High cost to deliver to international end markets • Exposure to market risks – e.g. shipping cost volatility and access to containers, trade policy risks, currency exchange risk • Limited ability to pivot to more profitable products	Ongoing market and supply chain risk analysis to help tyre recovery industry participants plan market entry and market exit based on risk/return profile
Shredding whole tyres to meet domestic use TDF specification (assumed to be consistent with international TDF requirements)	Domestic alternative solid fuels (i.e. cement kilns	• Operations well established at commercial scale • Limited capital costs and operating costs (per EPU) • Low cost to ship to target customer(s)	• Customers yet to emerge, limited price discovery • Many sellers and few buyers – limited market influence • Ongoing risk of collapse in demand without notice • Limited ability to pivot to more profitable products	Facilitated engagement between cement industry, tyre recovery industry and regulators to reduce uncertainty and instability for those seeking to supply local waste derived fuel markets
Pyrolysis to generate thermal desorption products (steel, carbon char, fuel oil)	• Carbon char commodity markets • Low grade fuel oil applications • Recovered steel (scrap metal) markets	• Able to take truck and passenger car tyres without separation • Multiple products allowing some level of market diversification	• Unproven at commercial scale in Australia • Carbon char and fuel oil products yet to attract high demand levels • High capital and operating costs • Exposure to competition from global supply chains	Engagement with pyrolysis operators on the quality and volumes of main outputs, and their potential markets (including support for independent quality testing, if and when appropriate). Support with market development activities, pending capacity to reliably produce useful products of a given standard.

Passenger car tyres				
Processing technology	**End markets**	**Advantages**	**Disadvantages**	**Supporting activities**
Granulation using rubber crumbing facility	• Niche mats and flooring • Niche industrial products • Civil applications (permeable pavements; lightweight concrete) • Recovered steel (scrap metal) markets	• Well established at commercial scale • Higher margin products • Established and emerging markets for granule • Options to switch markets based on better returns • Option to switch to crumb products pending acceptance as a road input	• Significant capital costs and operating costs (per EPU) • Some markets yet to fully mature • Some potential challenges in removing and dealing with nylon mesh (depending on operator competencies)	Ongoing market development targeting emerging applications (e.g. civil applications), to establish sustained market acceptance

Truck tyres and OTR tyres (OTR tyres pre-processed into shred prior to final recovery processes)				
Processing technology	**End markets**	**Advantages**	**Disadvantages**	**Supporting activities**
Crumbing using a rubber crumb facility	• Crumb rubber modified spray seals and asphalts • Recovered steel (scrap metal) markets	• Well established at commercial scale • Higher margin products • Stable and growing road building markets for crumb rubber • Potential use in local / regional circular economy • Option to switch to granule products when market conditions suit	• Significant capital costs and operating costs (per EPU) • Potential that the market becomes flooded with crumb rubber sourced from passenger car tyres (as a potential downstream impact of flight from exported bale and TDF markets)	Promotion and demonstration of road projects using crumb rubber in the two regions, to showcase crumb rubber in roads as a 'low hanging fruit' for those pursuing local circular economy outcomes Ongoing watching brief regarding cascading effects on the crumb rubber sector, in response to shifts in passenger car tyre recovery markets.
Pyrolysis to generate thermal desorption products (steel, carbon char, fuel oil)	• Carbon char commodity markets • Low grade fuel oil applications • Recovered steel (scrap metal) markets	• Able to take truck and passenger car tyres without separation • Multiple products allowing some level of market diversification	• Unproven at commercial scale in Australia • Carbon char and fuel oil products yet to attract high demand levels • High capital and operating costs • Exposure to competition from global supply chains	Engagement with pyrolysis operators on the quality and volumes of main outputs, and their potential markets (including support for independent quality testing, if and when appropriate). Support with market development activities, pending capacity to reliably produce useful products of a given standard

Comparison of recycling surplus profiles

The preceding sections sought to estimate the net returns available to different supply chains that recover their various products from tyres collected from the SWQROC region, once operating and logistical cost factors are accounted for. In each example, it was assumed that tyre processing would occur through facilities based in the southeast of Queensland, with costs covering:

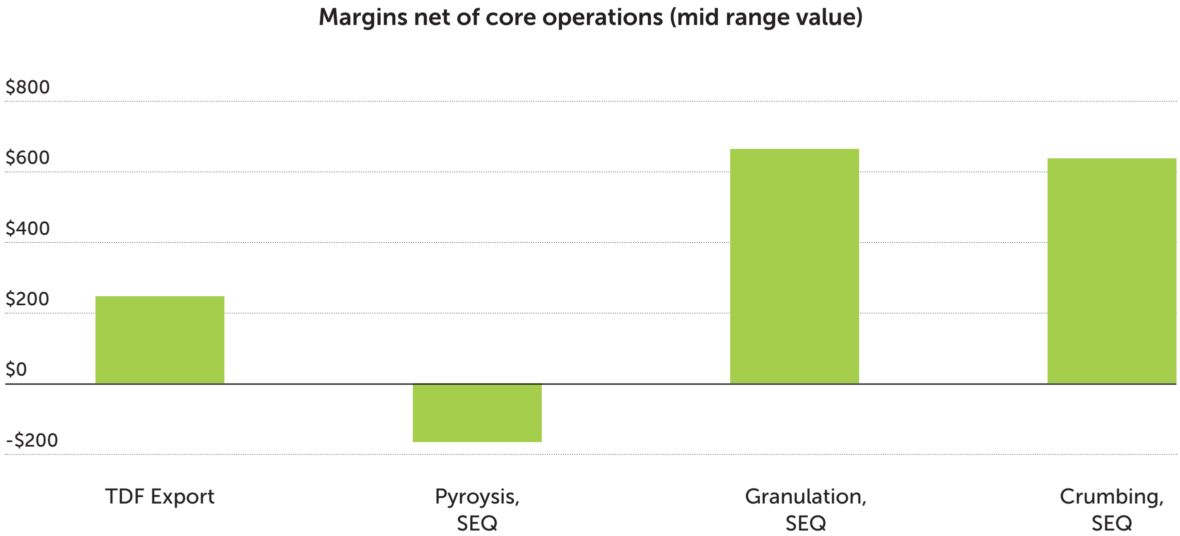
- On site operations
- Long distance haulage of tyres to a southeast Queensland facility
- Transport of derived products to downstream purchasers (i.e. overseas in the case of TDF export, others assumed to be local to the processing facility)

Against this base of costs, the supply chain was assumed to be able to capture revenues through recycling fees and the sale of recovered goods. In completing this analysis, a range of recycling surpluses was generated for each supply chain, with the exception of the recovery of TDF for use in local cement kilns. In this case, there is a lack of clarity around sales price which prevents a meaningful estimate of returns and cash surpluses for this recovery model.

Figure 5 below sets out a comparison of surpluses for the remaining recovery models that may be available to end-of-life tyre generators based in SWQROC. For simplicity, only the mid-range values are provided here. It is evident that pyrolysis operations are presently unable to generate a reliable profit. While the export of TDF may be profitable, it may be less profitable today than in the past, where a return of around $300 per tonne may have been typical for the industry. Key issues for this recovery path include low prices for TDF and very high shipping overheads.

In contrast, both rubber granulation and rubber crumbing appear to be highly profitable (noting that, in the case of passenger car tyres, there is a need to manage a nylon mesh component of the tyre during processing). These recovery paths are not substantially exposed to international shipping difficulties, and benefit from prices for the sale of recovered materials that exceed operating costs. While they are capital-intensive operations, this is a peripheral concern for tyres arising from SWQROC, as there are existing facilities that are able to have their capital costs spread over an existing customer base.

Figure 5: Mid range surpluses (per tonne) net of recycling operations, estimated for four recovery pathways for end-of-life tyres generated in the SWQROC region.



Revenues from the sale of recovered materials 8.3

A look at absolute sales revenues is of secondary economic importance for comparing options, compared to a fuller analysis of commercial profitability across tyre recovery supply chains. Yet the market value of recovered products can reveal insights in terms of how much the recovery supply chain relies on recycling fees versus sales based on value of recovered commodities.

Regional stakeholders may prefer to support a recovery model that generates higher value outputs, and that makes a greater contribution to the regional economy beyond diverting material from landfill, as opposed to support for a model in which the products hold marginal value and in which the economic utility of the recovery process may be called into question.

To this end, Table 10 below sets out the value of recovered resources across the three main recovery technology and end market combinations studied in this business case. The estimates below cover a baseline recovery quantity of 100 tonnes each year as well as covering a situation in which a further 60 tonnes of tyres are recovered (nominally a 100 % recovery rate). The additional volumes assume that the whole of state recovery rate for tyres, i.e. of 60 %, is applicable to the region and that additional (near full) recovery is achievable.

For simplicity, upper estimates of each commodity value are used, noting that caution needs to be exercised in interpreting the figures to allow for price fluctuations over a given period. Prices are treated as independent of facility location, i.e. in Townsville or in southeast Queensland.

Table 10: Market value of recovered materials for a given set of technologies and their recovered products.

Resource	Volume (60% recovery)	Sales	Volume (100% recovery)	Sales
Shredding to produce tyre derived fuel				
TDF (at $50/t)	100 tonnes	$5,000	160 tonnes	$8,000
Total		**Total**	**$5,000**	**$8,000**
Crumbing and granulation				
Rubber granule (at $600/t)	20 tonnes	$12,000	40 tonnes	$24,000
Rubber crumb (at $800/t)	40 tonnes	$32,000	60 tonnes	$48,000
Steel (at $240/t)	30 tonnes	$7,200	50 tonnes	$12,000
Total		**$51,200**		**$84,000**
Tyre pyrolysis				
Carbon char (at $200/t)	25 tonnes	$5,000	40 tonnes	$8,000
Fuel oil (at $140/t)	30 tonnes	$4,200	48 tonnes	$6,720
Steel (at $240/t)	30 tonnes	$7,200	48 tonnes	$11,520
Total		**$16,400**		**$26,240**
Recycling fees (at $750/t)	100 tonnes	**$75,000**	160 tonnes	**$120,000**

The figures in this table show that the recovery of tyres through crumbing and granulation may yield resources with an aggregate value in the range of $51,000 to $84,000, depending on the recovery rate and throughput achieved. In the case of pyrolysis, this range sits between $16,000 and $26,000, although these estimates are qualified in recognition that tyre pyrolysis is an emerging sector in Australia and market information is therefore limited. In the case of shredding to produce a tyre derived fuel for sale to international buyers, this range is between $5,000 and $8,000 per year. However, market research during the business case reveals that some tyre shredding operators are willing to offload tyre derived fuel at no charge to the customer, so actual revenues from its sale may be substantially less than the figures used here.

Opportunities to support tyre recycling outcomes 8.4

Noting a reliance on existing services that are integrated with established markets and a larger supply of end-of-life tyre materials, there may be limited areas where TSA and the Queensland Government may help improve tyre recovery outcomes for the SWQROC region. As set out in the table, supply chains and end markets may strengthen in response to activities relating to:

- Gathering and supplying knowledge on supply chain and end market risks, particularly as they relate to domestic and international TDF markets
- Engagement facilitation between the cement industry, TDF suppliers and regulators in order to increase certainty and decrease potential risks and sources of instability for the emerging application of TDF as a waste derived fuel for domestic industries
- Developing a realistic and impartial perspective on the readiness of the tyre pyrolysis sector to supply products to a range of end markets, accounting for product volume and quality and the specifications and price tolerances applicable to different end uses, and to undertake related market development (pending outcomes of this market analysis)
- Developing emerging markets for rubber granule and crumb to build the resilience of tyre crumbing and granulation operations, particularly to hedge against potential spillover effects from adverse market and supply chain factors relating to the production of TDF
- Supporting the use of crumb rubber on local roads, to demonstrate this application as a 'low hanging fruit' for councils wishing to pursue local and regional circular economies.

Further to these actions which are specific to end markets and their supply chains, there is additional merit in stimulating transport efficiencies between SWQROC sources of end-of-life tyres and processing facilities. These transport-related measures apply across the board and are explained below.

The need to build volumes and achieve transport efficiencies 8.5

Independent of the supply chains and end markets listed in the table, a key issue for efficient tyre recovery from the SWQROC region concerns the cost effective transport of end-of-life tyre material. While Balonne Shire was able to run a consolidated tyre collection trial in which 300 tonnes of tyre material was recovered, there is the ongoing risk that the volumes periodically collected in the future are of marginal interest for a commercial collection partner.

During industry engagement, operators advised that they would need to collect about 150 tonnes per collection service from a single point in the region's east (such as Roma or St George) which, at current levels of tyre generation and consolidation, could be amassed over an eighteen month period. Regional partners and TSA may seek to lift this volume through, for example:

- More effective and targeted approaches to reduce instances of illegal dumping and drive the uptake of legitimate recycling services, noting the additional benefits that come with addressing dumping
- Engagement with generators of larger volumes of OTR tyres, such as cotton growers and other primary producers, who may be stockpiling end-of-life tyres on their properties over the longer term and who may be interested in affordable options to access tyre recovery services
- Exploration of options to link up tyre recovery supply chains that may be developed from surrounding cities, townships and commercial activities including those located in the Darling Downs region
- Exploration of best practice approaches to scaled transport of end-of-life tyres, including options using joint procurement, better use of existing and planned infrastructure such as transfer stations, use of backhauling arrangements, and widening collection services to cover other end of life products such as white goods, packaging or scrap metal.

Having a larger scale of tyres recovered from the SWQROC region and surrounding areas may help to drive transport efficiencies for tyre recovery supply chains, while potentially encouraging competition in the market. It may also help ensure a continued tyre recovery market presence in the region while improving the rate of recovery.

In relation to the first point above, there is a driving need to ensure confidence in the regulatory regime to prevent illegal dumping, and encourage the use of licensed tyre collectors and recyclers. The project team understands that illegal dumping takes place in Queensland, both due to end-of-life tyre generators deliberately engaging in dumping practices; and due to rogue operators acting as responsible tyre collectors / recyclers while undercutting legitimate service providers. This suggests a need to ensure broad monitoring and enforcement measures against illegal dumping are effective, and to ensure the waste tracking system is able to recognise and generate intelligence on rogue operators acting outside the legal framework.

Some actions to address these potential deficiencies include:

- Adoption of novel tracking (e.g. electronic tagging) of tyres, so that a trail of responsibilities can be determined from illegally dumped tyres
- Use of geospatial imaging methods to help identify dump sites across the state
- Performance review of licensing and waste tracking systems, to ensure fitness in preventing rogue operators from competing with legitimate tyre collectors and recyclers
- Focused education of tyre generators including tyre retailers, mechanics and car dealerships, to help them discern between rogue and legitimate operators, and to ensure they understand their responsibility to manage end-of-life tyres appropriately.

While these areas are within the Queensland Government's responsibilities to lead, there may be a role for TSA and local councils to provide input and/or work as partners in pilot projects. TSA may also have a role in supporting knowledge transfer from other jurisdictions that have trialled novel tracking and monitoring technologies to prevent inappropriate end-of-life tyre management practices.

Options to draw tyre material from nearby regions 8.6

As suggested above, there may be the option to link tyre collection services offered to SWQROC with tyres generated in industries, townships and cities based in Darling Downs, given that a tyre collection truck will need to pass through the Darling Downs region to deliver tyres to recovery operators based in southeast Queensland. Depending on scheduling and volumes involved, it may be cost efficient to arrange for tyres to be picked up at one or more locations on the way through to the recycling facility.

The following table sets out total volumes generated and tracked from selected Darling Downs settlements, using Queensland Government waste tracking data made available to the project. These volumes relate to tyres that are already sent to southeast Queensland for processing. This table does not include larger volumes that may be stockpiled over the longer term, as may be the case for tyres generated by the mining and agriculture sectors active in the Darling Downs region. The distance information relates to road distances between each city or town and St George; and between each city or town and Redbank, noting that there are tyre recovery facilities located in southeast Queensland in Redbank, Ipswich, Rocklea and Bethania.

Table 11: Regional centres and towns in or near the Darling Downs area, with their distances from eastern SWQROC and southeast Queensland and annual volumes of tyres arising as derived from Queensland Government waste tracking data.

Town & postcode(s)	Distance to St George	Distance to Redbank	Annual volume (FY2020)
Toowoomba (4350)	367 km	99 km	1,486 tonnes
Dalby (4405)	303 km	183 km	439 tonnes
Warwick (4370)	400 km	129 km	239 tonnes
Chinchilla (4413)	301 km	263 km	202 tonnes
Goondiwindi (4390)	200 km	325 km	172 tonnes
Stanthorpe (4380)	399 km	192 km	69 tonnes
Oakey (4401)	359 km	127 km	63 tonnes
Pittsworth (4356)	341 km	142 km	42 tonnes
Total			**2,712 tonnes**

In examining this table, the total volumes presented are significantly larger than the 90 to 100 tonnes generated from across SWQROC each year. From this perspective, it may be more cost efficient for a tyre recycling collector to visit an intermediate consolidation point in SWQROC (located in Roma or St George), once or twice per year, on the back of existing collection services delivered to one or more customers based in Darling Downs.

The value of a coordinated approach to intervention 8.7

The above sections indicate that tyre recovery from the SWQROC could be improved in terms of the collection and recovery rate, which may take place through improved regulation and prevention of illegal practices; and through engagement with sectors that may be stockpiling larger OTR tyres, such as cotton growing and other agriculture-based industries.

The report also identifies the need to ensure collection, consolidation and transport steps in the recovery chain occur in a cost efficient manner, which may be mediated through collective procurement, engagement to drive the uptake of tyre recovery services in the region, linking transport activities with collection and transport services occurring in the adjacent region (Darling Downs), and/or the use of backhauling where available.

In terms of supply chains and end markets, there are a range of viable alternatives available to tyre recovery customers in the region, with differing profiles in terms of commercial viability and risk exposure, and in terms of the economic and environmental value gained from recycling. In the case of crumb rubber, there may be the option to use the product in local road building and maintenance projects, while other end markets are likely to be more distantly located.

While some suggested efforts are put forward to strengthen and reduce the risk exposure of different end markets and supply chains are put forward in this report, it is likely that the main focus needs to be on improving the supply of end-of-life tyres (and recovery rate) from the region, and strengthening transport efficiencies as explained above.

Table 12 overleaf recommends activities for partners to lead and collaborate on in a coordinated manner, and address the key issues confronting tyre recovery from the SWQROC region.

The key benefit in taking a collaborative approach is in ensuring that the influence of different actions applied across each point in the supply chain – from point of generation to end market, and all points in between as necessary – will be reinforcing in nature. It is hoped that this strategy will help tyre recovery in the SWQROC region reach a tipping points, where tyre recovery is both maximally efficient yet resilient, and is seen as an appealing option for all end-of-life tyre generators active in the area.

Table 12: Overview of actions to address barriers and points of friction in improving tyre recovery from the SWQROC region.

Thematic focus	Response	Lead organisations
Illegal dumping of end-of-life tyres	Improved licensing and waste tracking/ reporting systems for tyre collectors and recyclers. Improved monitoring (e.g. geospatial imaging) and tracking (e.g. electronic tags) of dumping and stockpiles.	DES with TSA and council support
Increased recovery of tyres from selected OTR vehicle industries	Direct engagement with cotton and other agriculture sector sources and their OTR tyre suppliers, aiming to determine a service model and equipment suitable for processing and collecting their end of life OTR tyres. This action may uncover solutions where suppliers agree to take back OTR tyres, potentially leveraging intermediate storage points (which may include transfer stations or other depot facilities).	TSA with council, DES and industry body support
Consolidated handling and transport Transport efficiencies gained through inter-regional linkages	Investigate opportunities to: • Better leverage public infrastructure (e.g. transfer stations) • Continue and expand collective procurement, which may include request for backhauling services • Link with collection routes in the Darling Downs region	Councils and tyre recovery, with TSA support
Targeted support to reduce end market and supply chain risks	Responses specific to each supply chain and end market set out in Table 10	TSA and others as appropriate

Appendix 1 – Stakeholder engagement

Over the course of this business case, the following organisations were engaged with in order to meet a range of objectives including:

- Information gathering and validation of business case inputs
- Incorporation of diverse and informed perspectives
- Testing of different scenarios and their potential impacts, in support of improved accuracy of findings
- Generation of buy in and momentum towards one or more solutions in support of increased tyre recovery for the Northern Territory.

In the majority of cases, engagement activities took the form of remote meetings with one or more representatives from the organisation in question, with follow up correspondence with participants as relevant to the business case.

In limited cases, TSA directly participated in stakeholder engagement activities, for the purposes of directly reflecting TSA's perspectives and building relationships relevant to tyre recovery in regional Queensland.

- SWQROC
- NQROC
- FNQROC
- Balonne Shire Council
- Cairns Regional Council
- Townsville City Council
- Palm Island Aboriginal Shire Council
- Mareeba Shire Council
- Local Government Association of Queensland
- Queensland Department of Environment & Science
- Queensland Department of Main Roads & Transport
- Tyrecycle
- Carroll Engineering Services
- S & J Australian Scrap Tyre Disposal
- Remondis Australia
- RPQ Pty Ltd

Appendix 2 – Road network demand for crumb rubber

Estimating road network maintenance activity

In September 2021, DTMR provided TSA with a summary of DTMR surfacing quantities. The information was provided as:

- Complete jobs over 5.5 years (January 2016 – August 2021) – see Table 13 below.
- Planned works over 2 years (2021/22 and 2022/23 financial years) – see Table 14 below.

In providing this information via personal communication, DTMR provided the following notes:

- The quantities provided are approximates only
- This data is for information only – DTMR does not guarantee the accuracy of this data, or that future works will follow the trends of completed or planned works
- The quantities are given as carriageway kilometres – in some instances the works may include multiple lanes (including traffic lanes and shoulders), however this has not been specifically accounted for
- The quantities only take into account pavement resurfacing and rehabilitation works (maintenance of existing pavements)
- Quantities for new construction are not included in these figures – an estimate of these quantities is more difficult to obtain, however QTRIP may give an indication
- The column 'Other' includes geotextile seals, slurry surfacing and bitumen emulsion seals
- The quantities are not specific to crumb rubber treatments (for example, PMB seals includes a combination of conventional polymer modified bitumen and crumb rubber).

Table 13: Completed maintenance of existing pavements over 5.5 years to August 2021.
Source: DTMR (via personal communication).

Completed Works - Total Road Segment Length (Jan 2016 – Aug 2021)						
DTMR District	Dense graded asphalt (km)	Open graded asphalt (km)	Stone mastic asphalt (km)	Straight bitumen seal (km)	PMB sprayed seal (km)	Other
Central West	11.8			110.0	3,093.9	
Darling Downs	86.6	30.2	25.3	752.0	1,804.9	106.5
Far North	258.0	90.8	158.0	951.5	1,173.3	31.4
Fitzroy	46.6	0.6		634.8	833.4	12.9
Mackay/Whitsunday	37.3	0.5		482.9	384.4	
Metropolitan	119.8	14.5	75.3	28.8	43.8	
North Coast	168.9	28.9	13.4	113.7	129.1	
North West	42.2			4,088.1	1,133.8	381.0
Northern	200.9	0.8	6.6	20.2	895.3	253.6
South Coast	95.8	0.4	7.4	54.9	61.1	3.8
South West	151.1			127.7	2,423.2	2.1
Wide Bay/Burnett	754.3	45.1	0.4	948.4	1,331.2	27.3
Total	**1,973.3**	**211.8**	**286.2**	**8,313.0**	**13,307.2**	**818.6**

Table 14: Planned maintenance of existing pavements over FY2022 and FY2023. Source: DTMR.

Planned Works - Total Road Segment Length (2021/2022, 2022/2023)						
DTMR District	Dense graded asphalt (km)	Open graded asphalt (km)	Stone mastic asphalt (km)	Straight bitumen seal (km)	PMB sprayed seal (km)	Other
Central West	1.7			37.0	607.6	
Darling Downs	11.8	1.0	3.1	311.4	467.9	27.1
Far North	33.1		11.7	282.8	114.7	5.3
Fitzroy	1.5			158.0	129.3	1.8
Mackay/Whitsunday	3.2			112.2	184.4	2.2
Metropolitan	27.4	8.7	10.6		13.8	
North Coast	82.6	27.4	25.0	100.3	22.2	
North West	1.9			388.0	171.3	4.0
Northern	13.3		2.0	41.1	69.8	20.3
South Coast	25.2	7.0	3.7	69.1	40.2	
South West				123.8	474.3	4.8
Wide Bay/Burnett	10.5			142.1	89.1	7.7
Total	**212.2**	**44.2**	**56.1**	**1,765.7**	**2,384.6**	**73.2**

Estimating consumption of EOLTs per kilometre of road application

A previous study on TSA's behalf identified the demand for crumb rubber and tyre EPUs needed to construct single lane roadways using crumb rubber binder in various spray seal and asphalt formulations.[56] These figures are replicated below (Table 15), with an additional column reframing the EPUs as total tonnes of tyre material (via conversion factor 0.008 tonnes per EPU).

Table 15: Estimated consumption of end-of-life tyres according to type of road application.

End-of-life tyre demand per lane-kilometre for various surfacing treatments				
Sealing type	Application (L/m2)	% crumb rubber in binder	EOLTs (EPU / km)	EOLTs (tonnes / km)
High stress seal	1.20	5%	37	0.296
Extreme stress seal	1.40	10%	86	0.688
Strain alleviating membrane seal	1.60	15%	147	1.176
Strain alleviating membrane interlayer seal	1.80	20%	221	1.768
Asphalt type	Thickness (mm)	% crumb rubber in binder	EOLT EPU / km	EOLT (tonnes / km)
Open grade	35	22%	427	3.416
Density grade	50	20%	704	5.632

[56] Bitumen Solutions, Study of the Australian bitumen and asphalt industry's capabilities and challenges in handling tyre derived crumb rubber technologies, (undated).

Estimating potential state controlled road network consumption of crumb rubber

A conservative estimate of potential demand for rubber crumb across the state is based solely on an estimate of DTMR annual maintenance of the state controlled road network.

Assuming 75 % of the 34,000 km network are spray sealed roads and 10 % are asphalt as advised by DTMR, 8 and 15 year replacement cycles (i.e. applied respectively) would create potential crumb rubber consumption of approximately 7,000 tonnes of EOLTs per year across the two road surface types.

Further analysis of the DTMR maintenance data (see Table 14 and Table 15 above) would suggest some variability year on year, with current levels of potential demand in the range of 3,500 and 8,500 tonnes of EOLTs per year.

Note: DTMR referenced current consumption of 1.1 million EPUs[57] to June 2021 (from a base year of 2015) and suggested the number will be revised to 1.5 or 1.6 million EPUs by June 2022. This equates to an average of 1,467 tonnes per year of EOLTs to June 2021 and approximately 3,200 tonnes of EOLTs in FY2022 (assuming a conversion factor of 8 kilograms per EPU).

Estimating potential road network activity in SWQROC

The SWQROC region is consistent in geography with the South West road district (above), meaning the local government members of SWQROC are also members of the district.

In addition to relevant South West district information outlined in the above reference tables, the project team reviewed QTRIP information to identify potential and planned projects in the South West district as is relevant to potential consumption of rubber crumb (i.e. works consuming spray seal and/or asphalt). Any explicitly referenced funded projects via the Transport Infrastructure Development Scheme (TIDS) were excluded given crossover with project management via the SWRRTG four program (discussed below).

Table 16: QTRIP projects in South West district with potential to consume crumb rubber.

Council	Investment ID	Network	Investment Name
Balonne Shire	1832490	State	Balonne Highway (St George - Bollon), rehabilitate pavement
Balonne Shire	1693206	State	Carnarvon Highway (Mungindi - St George), widen and seal
Bulloo Shire	1693108	State	Bulloo Developmental Road (Cunnamulla - Thargomindah), widen and seal
Bulloo Shire	1890852	State	Bulloo Developmental Road (Thargomindah - Bundeena), 2020 Disaster Recovery Funding Arrangements restoration works
Maranoa Regional	1693205	State	Carnarvon Highway (Injune - Rolleston), widen and seal
Maranoa Regional	1693207	State	Carnarvon Highway (Roma - Injune), widen and replace culvert
Maranoa Regional	1693208	State	Roma - Condamine Road, widen and strengthen pavement
Maranoa Regional	1824295	Local	Creek Street and Chambers Street (Amby), pavement upgrade
Maranoa Regional	1824276	Local	Primaries Road loop extension, Roma saleyard precinct, construct to a sealed standard
Murweh Shire	1202918	State	Mitchell Highway (Cunnamulla - Charleville), widen and seal

[57] See https://www.tmr.qld.gov.au/Community-and-environment/Planning-for-the-future/Building-sustainable-roads

Council	Investment ID	Network	Investment Name
Paroo Shire	1234185	Local	Balonne Highway, Cunnamulla - Bollon rest area, pave and seal
Quilpie Shire	1691831	State	Diamantina Developmental Road (Charleville - Quilpie), widen and seal
Quilpie Shire	2000597	State	Diamantina Developmental Road (Quilpie - Windorah), widen and seal pavement
Other works			Programmed Maintenance
Other works			Rehabilitation
Other works			Routine Maintenance

Aggregated and combined QTRIP investment for these projects is outlined in Table 17 (below).

Table 17: QTRIP investment into projects in the South West district

Year	Aggregate project value
2021 expected to 30 June	$7,522,862
2022 total (expected)	$72,411,855
2023 total (expected)	$52,849,512
2024 total (expected)	$47,530,108
2025 total (expected)	$47,530,108

The project team also reviewed the SWRRTG four year works program (2021 – 25)[58] to gather further understanding of current and proposed road projects managed via the SWRRTG. Excluding unsealed road works and focusing on projects involving application of spray seal (at minimum), the works program implied a potential aggregate project value of between approximately $4 million and $8 million per year. A review of chain distances for proposed road works provided evidence to support an assumed cost of $200,000 per kilometre for spray seal.

Estimating potential road network consumption of crumb rubber in SWQROC

Building on the analysis above, in estimating potential consumption of crumb rubber in SWQROC, the following assumptions have been applied:

- SWRRTG program of investment sits separate to QTRIP project investment for the south west (excluding TDIS funding)
- A cost of $200,000 per km of spray seal road (dual lane) can be applied as an average cost in the SWQROC
- QTRIP and SWRRTG projects are composed of spray sealed (dual lane) road build only.

Combining the potential activity across three areas, as outlined in Table 18 (below), the project team estimates demand for rubber crumb consuming between 420 and 1,500 tonnes of EOLTs per year across SWQROC. A more conservative estimate, focusing on annual DTMR maintenance of state controlled network in the South West suggests demand for rubber crumb consuming between 340 and 950 tonnes of EOLTs per year across the South West.

[58] See https://www.swrrtg.com/4-year-works-program

Table 18: Potential consumption of crumb rubber in SWQROC.

DTMR Maintenance of State Controlled Network in South West								
Per annum	PMB spray seal		Bitumen spray seal		Asphalt - open		Asphalt - dense	
	Low	High	Low	High	Low	High	Low	High
Kilometres	237	441	23	62	0	0	0	27
EOLTs (tonnes)	326	607	14	37	0	0	0	309
QTRIP projects in South West district with potential to consume crumb rubber								
Per annum	PMB spray seal		Bitumen spray seal		Asphalt - open		Asphalt - dense	
Kilometres	38	362						
EOLTs (tonnes)	52	498						
SWRRTG works program projects with potential to consume crumb rubber								
Per annum	PMB spray seal		Bitumen spray seal		Asphalt - open		Asphalt - dense	
Kilometres	22	43						
EOLTs (tonnes)	30	59						

Tyre Stewardship Australia's National Tyre Product Stewardship Scheme has been recognised as best practice product stewardship by the Commonwealth Government. The accreditation, under the government's new Recycling and Waste Reduction legislation, provides independent verification of the Scheme's positive environmental and human health outcomes and will help TSA expedite the markets, funding and solutions associated with end-of-life tyres.