QUEENSLAND REGIONAL BUSINESS CASE FOR A CIRCULAR ECONOMY FOR USED TYRES

North & Far North Queensland

Final Report

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TyreStewardship AUSTRALIA

Queensland regional business case for a circular economy for used tyres – North & Far North Queensland

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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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- NQROC
- SWQROC
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Executive Summary

Introduction

The north and far north of Queensland – bounded by the North Queensland Regional Organisation of Councils (NQROC) and Far North Queensland Regional Organisation of Councils (FNQROC) respectively – are important and diverse regional economies with a growing interest in achieving greater success in recycling. The two regions have flagged tyre recycling as a priority for better environmental outcomes and job creation, predicated on establishing cost efficient and resilient supply chains and end markets for end-of-life tyres.

At present, the majority of end-of-life tyres arising in the two regions are transported to southeast Queensland for recovery in various ways, with a significant minority that may not be recovered or disposed of to landfill. This remaining fraction is understood to be stockpiled at the point of generation, illegally disposed of in the surrounding landscape, or in the case of large off the road (OTR) mining vehicle tyres, buried in mining pits.

There is the opportunity to do better, both in terms of establishing more efficient tyre recovery models for the 5,590 tonnes of tyres currently being processed from the regions each year; and in shifting the balance of tyres managed through recovery in preference to less sustainable stockpiling, burial and disposal practices.

This business case shows that there is no reason to neglect the untapped resources stored within the tyres of cars, trucks, buses and large OTR vehicles such as tractors, earthmovers and roadworks vehicles. Moreover, there are options at hand for north and far north Queensland to encourage a regionally based tyre recycling solution that delivers superior outcomes for their communities, pending the commitment to realise the option through actions applied in concert.

A regional tyre recycling solution provides superior results for north and far north Queensland in terms of:

- Capital investment in Queensland's north, in the order of $5 million in tyre recycling capacity and related infrastructure
- Regional employment outcomes in the order of 10 to 20 FTE, including the development of new skills that are transferable into other technical industries[1]
- Economic diversification and the creation of local business opportunities
- Retention of resources for use within the region, estimated at up to $5.2 million in annual value, and substituting for virgin materials that originate from outside the region
- Savings in the form of reduced costs to haul end-of-life tyres to recovery facilities in southeast Queensland, in the order of $500 per tonne, which may help to reduce incentives to stockpile or illegally dispose of tyres using rogue service providers.

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. This business case has systematically identified those barriers relevant to the adoption of tyre recovery services; investment in services and infrastructure along the recovery supply chain; and the uptake of products using tyre derived materials in end markets within the state of Queensland.

A coordinated package of actions is recommended to address each market impediment in turn, and set the north and far north of Queensland on a path towards a circular economy for used tyres. To be clear, any residual barriers – such as uncertain demand for tyre recycling services and end products – may be interpreted as an undue market risk that blocks investment in a solution. A full and comprehensive approach is essential to stimulate a new tyre recovery industry in the north of the state.

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

Should the recommended actions in this business case be adopted through a coordinated approach, a regionally based tyre recycler will be able to count on favourable conditions across its supply chain and markets. This will lift confidence in and bring forward the necessary private investment, and then allow the recycler to refine a niche business model for regional recycling that may be progressively rolled out to other parts of the country.

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 north and far north 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 north and far north each year, waste tracking data suggests that 5,590 tonnes are collected and processed from the NQROC and FNQROC council areas, using facilities in southeast Queensland.

In the absence of a tyre recovery rate for these regions, application of a 60% recovery rate (from state figures) without modification suggests that about 3,400 additional tonnes of end-of-life tyres are generated without being retrieved for recovery. The lack of tracking data for this volume suggests these tyres are being stockpiled, buried in mining pits, or 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 end-of-life, 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[2]
- 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 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
- Limited knowledge across the tyre recovery industry, regarding the commercial potential in dedicating focused operations in service to the north and far north of 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 end-of-life tyres and the recent rise in international shipping costs (which affects the use of tyre derived fuel in boilers, kilns and furnaces located throughout Asia).

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 north and far north 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.

Northern Queensland's unique advantages for tyre recycling businesses

Against this backdrop of challenges, there are a number of positive factors in support of tyre recovery services tailored to north and far north Queensland. These include:

- A growing interest in a solution that best fits the region, alongside a willingness to collaborate at the regional scale, across councils and regional organisations active in the north and far north
- The Queensland Government's increasing levels of organisation towards and support for regional circular economy outcomes, as evidenced by its investment in regional resource recovery plans and other measures across the state

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

- As yet, the northern coastal and Cape York Peninsula parts of Queensland lack a regional facility, whereas the market for tyre recovery services in southeast Queensland may be close to saturation
- Based on the business case findings, the volumes of readily available tyres from the more accessible parts of NQROC and FNQROC (i.e. exceeding 5,000 tonnes per year) should be ample to support new facilities that specialise in tyre recovery from the region, which may compete on the basis of avoided long distance transport costs.

Responding to these regional advantages, new entrants in the tyre recycling sector have stated an interest in establishing operations in regional markets that are yet to become saturated, including north and far north Queensland, pending an environment conducive to investment.

This business case offers a clear and shared base of evidence from which to form decisions and establish a common agenda towards better tyre recycling outcomes in north and far north Queensland, helping partners to build an investment-attracting environment.

The opportunity for enhancing the recovery of OTR tyres

The FNQROC and NQROC regions may include or may be adjacent to commercial activities that generate large quantities of OTR tyres such as:

- Large bauxite mining operations at Weipa on the Cape York Peninsula
- Coal mines located in Bowen Basin, 500 to 700 km south of Townsville
- Mines near Cairns and Townsville and in the Charters Towers Shire Council area
- Cane growing and cotton growing interests in and near north and far north Queensland.

A majority of these generators currently stockpile OTR tyres on premises or bury them in mining pits, degrading the environment and failing to recover the substantial resources locked up in large tyres.

The availability of these tyres may not be critical to the long term commercial viability of a tyre recovery solution for the north and far north, but may be very useful in terms of providing a stable long term inflow of materials and recycling fee revenues that strengthen the case for investment in related infrastructure.

However, 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 upstream stage is needed to ensure the OTR tyres are in a compatible form (e.g. shredded or sectioned), and may involve additional recycling fees for the OTR tyre generator.

There is no single recommended straightforward path to enable OTR tyres to feed into a regional tyre recovery solution, given dependencies around: source sectors; OTR tyre sizes and quantities; transport distances; requisite specifications dictated by downstream operations; and price tolerances around recycling fees charged to OTR tyre generators.

Moreover, engagement with source industries around a preferred solution and recycling outcomes that align with corporate responsibilities needs to occur, to ensure recovery operators are able to deliver results that comply with minimum corporate standards.

A more targeted industry engagement plan and technology-oriented business case is recommended to ensure a regional OTR tyre recovery solution is fit for purpose and connects with regional stakeholders' needs. This business case should test commercial arrangements amenable to the OTR tyre generator and the tyre recovery operator alike, factoring in features specific to the OTR tyre source and surrounding parts of the recovery supply chain.

Benefits of recovering end-of-life tyres

A range of benefits to north and far north Queensland arise in more fully recovering tyres, and shifting further away from practices involving mining pit burial, illegal dumping, and long term stockpiling.

While a majority of tyres of around 60% is assumed to be recycled through services in southeast Queensland, the remaining 40% of tyres represents a significant quantity dispersed across the countryside in public land, farming properties, and mining tenements. Significant benefits may emerge from the use of an updated approach to regulation and incentive frameworks that are fundamental to well functioning tyre recovery markets.

Environmental benefits

Environmental benefits from greater tyre recovery include the following, coming into play irrespective of whether the greater share of recovery occurs locally or via distant operations:

- 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 that has been leased to mining companies, 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.

At the same time, 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 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

Economic benefits for the north and far north stem from expanded tyre recovery services offered to local businesses, individuals and councils. The scale of local benefit will largely mirror the extent that tyre recovery services are based in the region as opposed to being located elsewhere such as southeast Queensland, and are therefore solution-dependent.

For example, a completely local tyre recycling supply chain that recovers tyres from across the north and far north of Queensland may yield up to 20 direct ongoing full time positions in regional locations. These positions will involve practical skillsets that will prepare the workforce for wider employment opportunities, while offering a level of stability linked to the ongoing supply and demand for resources recovered from tyres. Local employment will be much lower if operations based in the region are limited to handling and consolidation jobs prior to freighting tyres to economic centres based in the southeast of Queensland.

Additional economic benefits from a major lift in tyre recovery through recycling operations based in the region (i.e. in or near Townsville) include:

- The recovery of economically useful resources, worth up to $5.2 million in annual value (assuming the main products come from a crumbing and granulation facility with focused production of rubber crumb, rubber granule and recovered steel)

- The allocation of up to $5 million in financial capital to the regional economy, as needed to construct and commission a main tyre recycling facility in or near Townsville
- The annual retention of 1,700 to 2,000 tonnes of locally recovered steel and 3,900 to 6,300 tonnes of high value rubber commodities for use in the regional economy, displacing the need for customers to import equivalent virgin materials from other parts of the country or from international suppliers
- Avoided costs from sending end-of-life tyres to southeast Queensland, with a net reduction in costs in the order of $500 per tonne or $2.8 million to $4.5 million per year (assuming 5,600 to 9,000 tonnes locally processed each year).

These outcomes stress the greater economic benefit in committing to and supporting a local model for increased tyre recovery, over and above the environmental benefits explained above.

The 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

In investigating different options to improve tyre recycling from the north and far north of Queensland, the business case took the opportunity to explore 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[3]
  - 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)
- Potential to operate a facility in northern Queensland or continue to rely on operations based 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 north and far north 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.

[3] While a crumbing and granulation plant would also have the means to produce tyre shred, it is unlikely that this would be the main product recovered from a crumbing and granulation plant as such a facility would be an example of over-capitalisation for this product compared to a facility that produced shred only. For these reasons, crumbing and granulation is treated as entirely distinct from shredding in this analysis.

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) North Queensland (new operation)
Pyrolysis plant	Carbon char, fuel oil and steel	Southeast Queensland (existing) North Queensland (new operation)

* Require description

However, 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. Taken together, the findings point to preferred options to recover tyres from the north and far north Queensland, while setting out the actions needed to address one or more barriers to investment and commercial operation.

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 $12 per passenger car tyre was applied and it was assumed that tyres were collected from sources in the vicinity of Townsville Regional Council.

Other parameters were as determined according to the technologies, products and end markets in question, and the transport overheads related to regional versus southeast Queensland siting.

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 figure 1)

Margins net of core operations (mid range value)

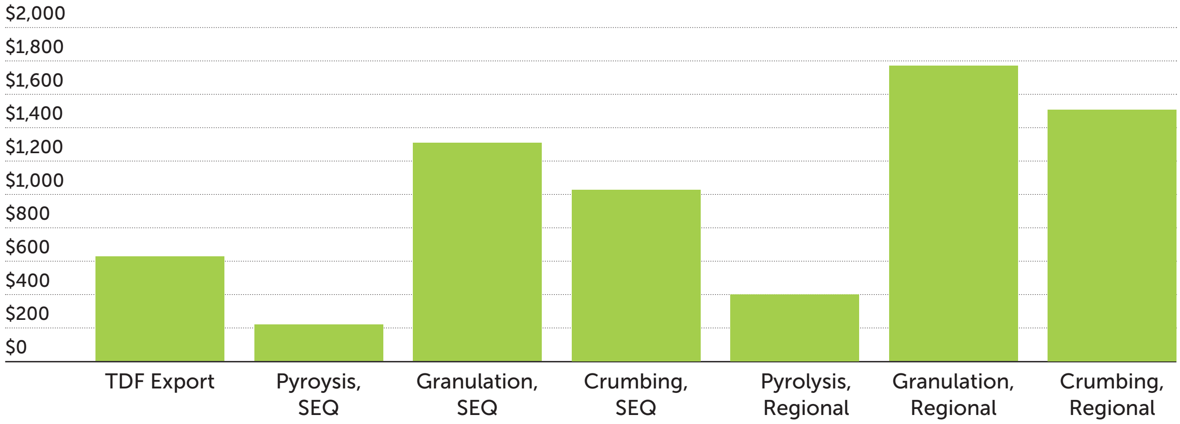


Figure: Mid range surpluses (per tonne) net of recycling operations, estimated for seven recovery pathways for end-of-life tyres generated in the NQROC and FNQROC regions. This chart assumes a recycling fee of $12 per EPU for tyres recovered from NQROC. While there are larger transport costs involved in processing tyres from FNQROC, it is assumed that this is fully offset through a slight increase in recycling fees.

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.
- In comparing regional operations to those based in southeast Queensland, there may be marginal scale economy advantages in operating a facility in southeast Queensland compared with a smaller regional facility. However, these advantages are more than offset in favour of a regional recycling facility, due to the avoidance of expenses related to freighting end-of-life tyres over 1,400 kilometres to a southeast Queensland facility. For a given recycling fee, a regional crumbing and granulation facility is expected to be more cost effective and profitable compared to a southeast Queensland facility, when undertaking a whole-of-supply chain financial analysis.

To summarise, the financial comparison exercise indicates that the most cost effective option for recovering end-of-life tyres from north and far north Queensland would involve a new crumbing and granulation facility based in or near Townsville. However, this is predicated on accessing an ample quantity of tyres to ensure the new infrastructure is used productively. Research suggests that tyres arising across the north and far north and in adjacent townships south of NQROC would be sufficient to meet this need.

A market analysis also suggests significant demand for crumb rubber and other products in regional markets in northern Queensland, although the operator may need greater certainty of buying volume in target markets such as road construction and niche flooring and surfaces.

In practice, the operator may need to sacrifice some of its margins (as above) in order to set a recycling fee low enough to outcompete other service providers currently based in southeast Queensland, and have confidence of achieving the necessary throughput to drive profitability. The business case finds that a regional facility could lower prices beyond the nominal $12 per passenger car tyre while still delivering a commercial surplus to investors. Other competing technologies with lower margins may have less latitude to lower their recycling service fees.

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 north and far north 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 pages, along with actions to address key commercial weaknesses.

As a general rule, the key challenges for a regional crumbing and granulation facility revolve around gaining access to adequate supplies of end-of-life tyres and having certainty regarding the demand for its tyre derived products. For the most part, these are issues pertaining to commercial ramp up, and may be mitigated through a coordinated set of actions to drive market uptake at the upstream and downstream end of the supply chain.

A key advantage for a crumbing and granulation facility is that it allows the operator to pivot[4] between products and markets (subject to the selection and configuration of its componentry), whereas pyrolysis and shredding plants may be less able to pivot in response to shifting market opportunity and risk profiles. Shredding plants in particular appear to be geared towards large volume purchasers of tyre derived fuel, mainly located overseas, whose interest may be influenced by fluctuating freight costs, trade policies, exchange rates and other factors outside the direct control of either party.

Irrespective of the technology involved, the use of a regional tyre facility presents additional advantages beyond transport savings compared with a southeast Queensland operation, by virtue of its enhanced visibility to regional stakeholders and customers. Those looking to drive circular economy and related development outcomes in the north and far north may find it easier to leverage interest from commercial partners if they can point to a local physical presence.

[4] In principle, a crumbing and granulation facility also has the means to produce shred, e.g. for tyre derived fuel markets. However, it may struggle to compete with dedicated shredding facilities given the larger capital outlay needed for a crumbing facility versus a shredding facility.

Processing technology	End markets	Advantages	Disadvantages	Supporting activities
Shredding whole tyres to meet TDF specification • Larger scale existing facilities in southeast Queensland only *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 – e.g. shipping cost volatility and access to containers, trade policy risks, currency exchange risk, limited visibility on downstream social and environmental impacts • Limited ability to pivot to more profitable products • Road freight costs in moving tyres to SE Queensland	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) • Larger scale existing facilities in southeast Queensland • New regional facility processing 5,000+ tonnes/year *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) *For existing SEQ facilities:* • Able to pivot from domestic to international buyers *For new regional facilities:* • Reduced transport cost in freighting TDF directly from region to buyer	• 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 *For existing SEQ facilities:* • Extensive transport of tyres south then product north *For new regional facilities:* • Commercial risk of capital relying on a single buyer	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

Processing technology	End markets	Advantages	Disadvantages	Supporting activities
Pyrolysis to generate thermal desorption products (steel, carbon char, fuel oil) • Larger scale existing facilities in southeast Queensland • New regional facility processing around 5,000 tonnes/year *Applicable to all tyre types*	• Carbon char commodity markets • Low grade fuel oil applications • Recovered steel (scrap metal) market	• Able to take truck and passenger car tyres without separation • Multiple products allowing some level of market diversification *For existing SEQ facilities:* • Capital recovery spread across larger volume *For new regional facilities:* • Reduced transport cost for whole tyres to processor	• 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 *For existing SEQ facilities:* • High transport overheads for tyres to processor *For new regional facilities:* • Potential lack of regional demand, requiring transport of products	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.
Granulation using rubber crumbing facility • Larger scale existing facilities in southeast Queensland • New regional facility processing 5,000+ tonnes/year *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 (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 *For existing SEQ facilities:* • Able to leverage existing capacity & capital *For new regional facilities:* • Reduced transport cost for whole tyres to processor • Localised circular economy	• 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) *For existing SEQ facilities:* • High transport overheads for tyres to processing plant *For new regional facilities:* • Demand uncertainty may defer or impede investment or increase financing costs	Ongoing market development targeting emerging applications (e.g. civil applications), to establish sustained market acceptance *For new regional facilities:* Pending interest from private investors, there may be a basis for public capital allocation, in recognition of residual commercial risks and positive spillovers to the region.

Processing technology	End markets	Advantages	Disadvantages	Supporting activities
Crumbing using a rubber crumb facility • Larger scale existing facilities in southeast Queensland • New regional facility processing 5,000+ tonnes/year *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 when market conditions suit *For existing SEQ facilities:* • Able to leverage existing capacity & capital *For new regional facilities:* • Reduced transport cost for whole tyres to processor • Localised circular economy	• 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) *For existing SEQ facilities:* • High transport overheads for tyres to processing plant *For new regional facilities:* • Demand uncertainty may defer or impede investment or increase financing costs	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. For new regional facilities: Public capital allocation to new facility, in recognition of residual commercial risks and positive spillovers to the region. Proactive procurement of crumb rubber modified seals & asphalts

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. Prices are treated as independent of facility location, i.e. in Townsville or in southeast Queensland, noting that a regionally located facility may lead to a retention of resources usable in local economic activity.

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 $3.2 million to $5.2 million, depending on the recovery rate and throughput achieved. In the case of pyrolysis, this range sits between $0.9 and $1.5 million, 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 $280,000 and $450,000 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: 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)	5,590 tonnes	$279,500	8,990 tonnes	$449,500
Total		**$279,500**		**$449,500**
Crumbing and granulation				
Rubber granule (at $600/t)	1,260 tonnes	$756,000	2,280 tonnes	$1,368,000
Rubber crumb (at $800/t)	2,620 tonnes	$2,096,000	4,000 tonnes	$3,200,000
Steel (at $240/t)	1,720 tonnes	$412,800	2,720 tonnes	$652,800
Total		**$3,264,800**		**$5,220,800**
Tyre pyrolysis				
Carbon char (at $200/t)	1,400 tonnes	$280,000	2,250 tonnes	$450,000
Fuel oil (at $140/t)	1,680 tonnes	$235,200	2,700 tonnes	$378,000
Steel (at $240/t)	1,680 tonnes	$403,200	2,700 tonnes	$648,000
Total		**$918,400**		**$1,476,000**
Recycling fees (at $750/t)	5,590 tonnes	**$4,192,500**	8,990 tonnes	**$6,742,500**

Capturing the opportunity through coordinated efforts

This business case establishes that tyre recovery from the north and far north regions of Queensland could be improved in a number of ways. These improvements span the augmented 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 more distant parts of the regions could be rendered more efficient, using a combination of back hauling, coordinated and shared use of collection services, and the use of transfer stations and other sites as a regionally functional resource consolidation network.

OTR tyres also provide a path to grow the volume of tyres available for recovery from the two regions (and in adjacent mining centres such as Bowen Basin), although more effort and engagement is needed to determine a sustainable commercial model and equipment suitable to allow large OTR tyres to work as a feedstock alongside passenger car and truck tyres.

This business case indicates that a regional crumbing and granulation facility may provide superior recycling and commercial outcomes compared to alternative options including the status quo reliance on facilities based in southeast Queensland. Such a facility may provide the basis for using recovered crumb rubber in nearby state and local government road building and maintenance projects, while helping to bypass unnecessary freight of tyres to southeast Queensland. Other products such as granule may also be used locally in some civil works or made available to buyers in the flooring and civil infrastructure sectors, based elsewhere in the country including southeast Queensland. Unlike other technologies investigated in this work, a crumbing and granulation operation focuses on higher end products and end markets, while allowing the operator to pivot from one product-market combination to another in line with trending demand levels and profit margins.

This facility could contribute to more sustainable road and other assets in the north and far north, while symbolising a regional circular economy model that uses an identified priority waste stream. However, private investment in a regional crumbing and granulation facility may be contingent on certainty that there are buyers – principally road building and maintenance teams (for crumb) and civil works and flooring manufacturers (for granule) – who are willing to take its products at an acceptable price.

Local and state road network managers have a role in proactively placing expectations on road construction and maintenance contractors to use crumb rubber as a binder material wherever suitable. Similarly, civil works procurement teams and engineers could include the exploration of rubber granule containing civil assets such as permeable pavements, playground and recreational/sporting field surfaces, and lightweight concrete composites used in movable bollards and other traffic control devices. TSA and the state government, in line with their roles in market development and industry stimulus, have access to a range of levers and experience to apply in creating, maturing and stabilising end markets at regional, state and larger scales.

Parties looking to invest in and operate a new regional tyre recovery facility may nonetheless face residual levels of risk, particularly during the early years of operation, when the amount of tyres received, processed and sold as products is ramping up and as other links in the supply chain configure to support the facility. There are also a range of environmental and planning approval hurdles that must be overcome before the construction phase. These factors represent risk to the project, which may lead to stalled investment and recovery service delivery.

To counteract this scenario, there may be merit in the Queensland Government providing a capital allocation to a new facility which will bring the risk-return profile of the investment to within commercial tolerances. The offer of co-funding over a limited timeframe may spur private investors to commit in the near term, rather than indefinitely park their investment plans.

Arguably, this public investment is additionally justified in light of the local and regional spillover benefits including private investment in the regional economy; creation of long term jobs; improved accessibility and affordability of tyre recycling services in remote locations; and potentially, reduced instances of illegal disposal and other negligent practices by virtue of having a more visible and regional tyre recovery solution.

In summary, the combined measures outlined above aim to signal a safe and compelling regulatory and market environment to attract investment in a regional facility, and grant confidence that the facility can generate ample returns over its operating lifespan. But in the absence of investment at the regional scale, above-stated measures that seek to encourage greater adoption of tyre recovery services (currently based in southeast Queensland) will deliver a more partial success, albeit with many of the economic benefits transferred to actors based in southeast Queensland and elsewhere.

Should a regional facility be agreed as a top priority for NQROC, FNQROC, their councils and the Queensland Government, the measures in the table below need to be taken on in full and delivered in a coordinated fashion. This will grant greater certainty of attracting a legitimate regional solution, while also providing for a collaboration model that may be reused and adjusted as necessary for other circular economy priorities of the NQROC and FNQROC regions.

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 NQROC and FNQROC regions achieve a tipping point, 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. Moreover, should this approach be successful in attracting a regional operator servicing the north and far north, it will help to ensure that economic value and environmental benefits are retained in the north of the state while providing a template to apply in other areas of the circular economy.

Table 4: Overview of actions to address barriers and points of friction in improving tyre recovery from the NQROC and FNQROC regions, and drive investment in an appropriate tyre recovery facility located towards Queensland's north.

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 mining and other regionally important OTR tyre sources (and their OTR tyre suppliers), aiming to determine a service model and equipment suitable for using OTR tyres as a feedstock alongside passenger car and truck tyres.	TSA with council, DES and industry body (e.g. Queensland Resource Council) support, along with leading OTR tyre users.

Thematic focus	Response	Lead organisations
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 two regions • Establish and expand collective procurement of tyre recovery and collection, which may include request for backhauling services	Councils and tyre recovery sector, with TSA support
Demand for end products, as relevant to encourage stable and mature markets and adequate sales revenue to encourage a regional tyre recovery facility	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
Measures to bring forward private investment in a regional tyre recovery facility, based on an acceptable risk-return profile and in recognition of public spillover benefits	Allocation of proportional public capital allocation in line with perceived public benefits and appropriately share risks. Terms and conditions to drive preference towards serving the regions as a whole, return useful products to local and regional economies, and support economic inclusion.	DSDILGP with support from TSA and councils offering a nominated waste and resource recovery precinct

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 north and far north 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 and near the NQROC and FNQROC regions. 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 NQROC and FNQROC and the Queensland Government, based on their 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 regions across Australia that face problems in recovering tyres and which have features in common with the north and far north of Queensland.

Introduction 1

Purpose 1.1

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.

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 Queensland 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 ***combined NQROC and FNQROC regions****, noting that there are some significant areas of content and discussion overlap with a companion report that relates to the SWQROC region in isolation.*

Through this report, NQROC, FNQROC 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 limited amounts 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 (EOLT) from north and far north Queensland, drawing on supply chains and services led by private actors. These actors are 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 to allocate towards 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 NQROC and FNQROC regions according to the following descriptors:

- Segmentation of tyres generated across the region, according to passenger car, truck and off the road (OTR) tyre volumes[5]
- 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 regions 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; and factors in their 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 supplanted 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, regional bodies, 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 north and far north Queensland sources, but may be useful in providing an initial foundation from which to embark on further inquiries relevant to their interests

[5] '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

1.2

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 NQROC and FNQROC regions. 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
- Tyre volume and other technical and commercial data collated and provided by local councils, regional bodies and 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)
- NQROC
- FNQROC
- Cairns Regional Council
- Townsville City Council
- Palm Island Aboriginal Shire Council
- Mareeba Shire Council
- 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 handle 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, presumed 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 that are internalised to the supply chain, 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. 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, or 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.

Expenses and other financial commitments		**Financial inflows**	
Processing & handling costs	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.	Recycling fees	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.
Long distance freight costs	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.	Sales revenue	**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
Surplus 'net of recycling'	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		

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.[6] 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.[7] 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:[8]

- **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[9]

Major road and rail corridors crosslink the key 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.

[6] https://seqmayors.qld.gov.au/about-us/councils
[7] https://www.qgso.qld.gov.au/statistics/theme/economy/economic-activity/queensland-state-accounts
[8] https://www.treasury.qld.gov.au/queenslands-economy/about-the-queensland-economy/
[9] https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/overview

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.

Incorporating a circular economy approach into its vision,[10] 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.[11] 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.[12]

Pyrolysis of end-of-life tyres is specifically listed as being in the policy scope,[13] 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.[14] 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:[15]

> *'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.

[10] Queensland Government, *Waste management & resource recovery strategy*, p. 7.
[11] Queensland Government, *Energy from waste policy*, 2020.
[12] To clarify, *Energy from waste policy*, p. 5, breaks energy recovery into three separate recovery categories – biological energy recovery; chemical and energy recovery (including liquid and solid fuel production); and thermal energy recovery. The fuel components of pyrolysis (e.g. fuel oil) may be interpreted as an example of the second category.
[13] *Ibid*, p. 6.
[14] *Ibid*, p. 7.
[15] *Ibid*, p. 3.

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.[16]

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.

End-of-life tyres are also prescribed as a trackable waste (under tracking code T140), setting the need 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,[17] the present regulatory landscape does not include a ban on landfill disposal. The aforementioned guidance for managing end-of-life tyres does not explicitly preclude the landfill disposal of tyres.

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 placed on 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.

[16] DES, *Guideline – Management of end-of-life tyres (waste tyres)*, 2020.
[17] https://statements.qld.gov.au/statements/76641

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.

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:[18]

- 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.

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 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.

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

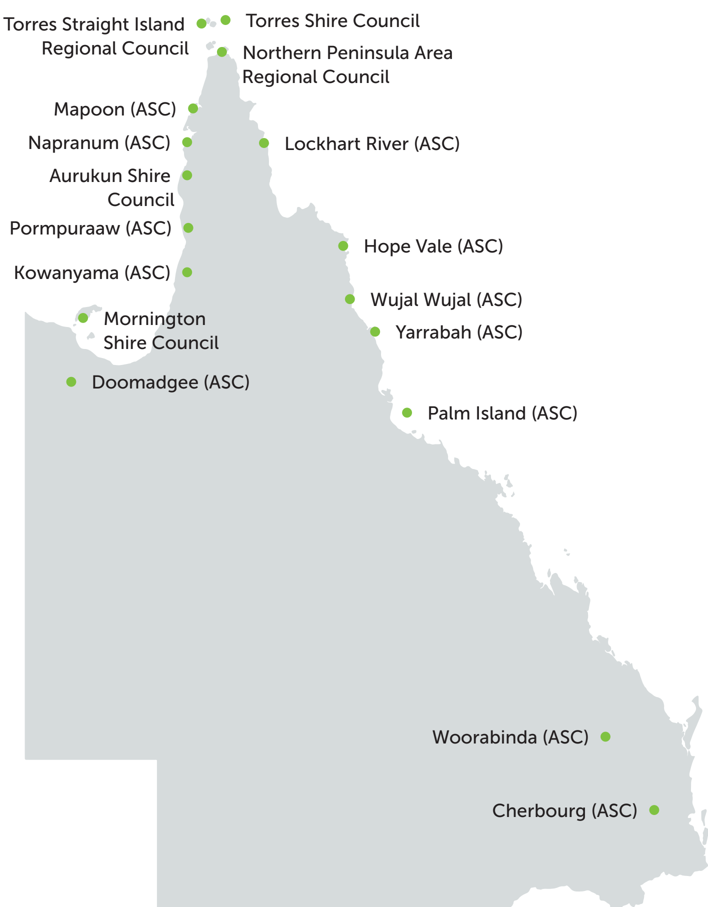
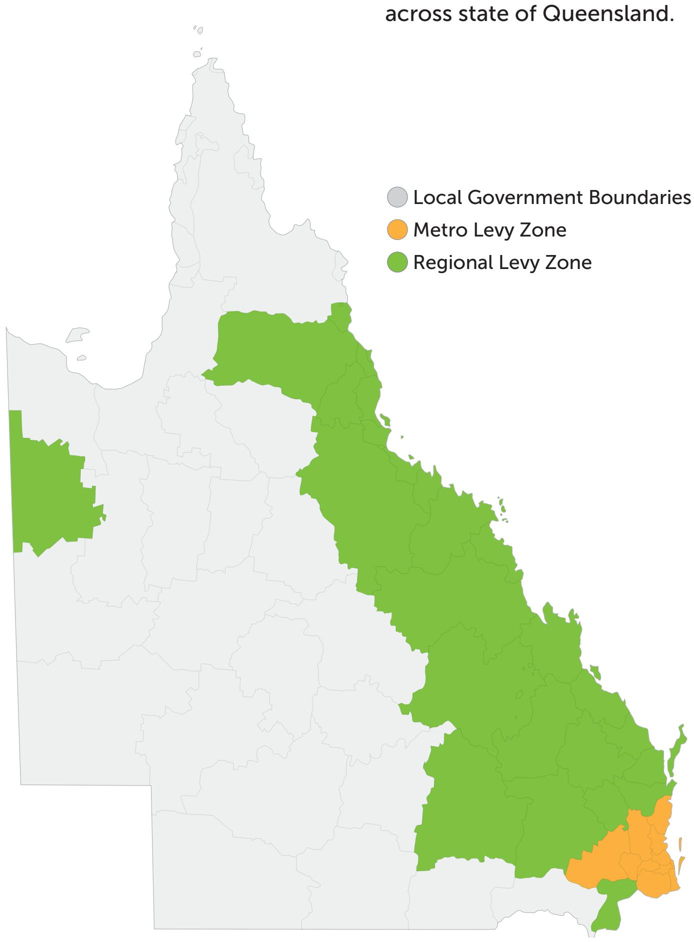


Figure 1: Aboriginal shire councils across the state of Queensland.

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.[19]

Figure 2: Waste levy zones across state of Queensland.



Councils in the FNQROC and NQROC regions that are subject to the waste levy include:

- Mareeba Shire Council
- Douglas Shire Council
- Cairns Regional Council
- Tablelands Regional Council
- Cassowary Coast Regional Council
- Hinchinbrook Shire Council
- Charters Towers Regional Council
- Townsville City Council
- Burdekin Shire Council

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,[20] 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.

[19] https://www.qld.gov.au/environment/pollution/management/waste/recovery/disposal-levy/about/from-1-july-2022
[20] https://environment.des.qld.gov.au/management/waste/business/classification

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.[21]

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.[22] 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 have closed for 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.[23] 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 planned 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).

[21] https://www.statedevelopment.qld.gov.au/industry/priority-industries/resource-recovery/queensland-recycling-modernisation-fund
[22] https://minister.awe.gov.au/evans/media-releases/7-million-recycling-regional-and-remote-australia
[23] https://www.qld.gov.au/environment/pollution/management/waste/recovery/disposal-levy/about/from-1-july-2022/waste-re-source-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.[24] A range of enforcement tools may be applied by the Queensland Government to 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.[25]

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:[26]

- 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.[27] 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).[28]

[24] https://environment.des.qld.gov.au/management/compliance-enforcement/obligations-duties
[25] https://www.awe.gov.au/environment/protection/waste/exports/tyres
[26] https://www.environment.gov.au/protection/waste/exports/transition
[27] REC *et al.*, *Used tyres supply chain and fate analysis* (2020).
[28] 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.[29]

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.[30] 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.

[29] TSA, *Tyre export ban – market overview, risks and opportunities*, 2021.
[30] 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, a range of service providers are able to produce crumb rubber and granule and thermal desorption products which may have domestic markets at various levels of maturity and viability (with rubber and granule markets more established and commercially validated than those for pyrolysis products). Other processors are involved in shredding tyres, either for international tyre derived fuel markets or as a step prior to other activities including disposal.

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 use for passenger car tyres, should the export of tyre derived fuel become cost prohibitive due to shipping rates. Existing commercial operators (between Brisbane and Gold Coast) are able to accept 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 tyres that is not being recovered comes to 45,000 tonnes. It may be challenging to precisely identify their fates, 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 generation), over an indefinite period
- Shred and subsequent disposal in landfills
- Burial in mining pits, as may be permitted for OTR tyres used 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 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 domestic end markets may come under further pressure if the current volume (i.e. of 34,800 tonnes) exported as tyre derived fuel becomes untenable compared with domestic uses.

At a state wide 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.

OTR tyre management 3.4

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 require waste tracking 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 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[31] estimates that 23,700 tonne of OTR tyres entered their end of life phase 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.

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

The tonnes that were not recovered were further 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.

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

- During the SWQROC pilot of a coordinated regional model for tyre recycling, the largest contributors of tyres were two cotton plantations. Of the 300 tonnes collected and recycled by this program, about 40% of this volume was provided by cotton plantations.

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.

Regional profiles 4.1

NQROC

The five NQROC councils are located directly south of FNQROC, with Hinchinbrook Shire Council overlapping both regions. The stated role of NQROC is to foster cooperation and resource sharing across councils and advocate regional positions and priorities.[32]

Member councils include:

- Burdekin Shire Council (population 17,000)
- Charters Towers Shire Council (population 12,000)
- Hinchinbrook Shire Council (population 11,000, with Ingham as main centre)
- Palm Island Aboriginal Shire Council (population 2,600)
- City of Townsville (population 194,000)

All of the councils but Charters Towers are located on the coast (or, in the case of Palm Island, off the coast). Charters Towers Shire Council is inland of Townsville, Burdekin and Hinchinbrook, and abuts the Shire of Flinders to the west. The Whitsunday and Isaac local government areas are to the immediate south of the NQROC region.

The total population of the NQROC region is 236,600; and when combined with the FNQROC region (accounting for Hinchinbrook as present in both regions), the north and far north account for some 518,000 people. This sits just below the population of Tasmania (542,000) and is just over double that of the Northern Territory (247,000).

According to the Department of State Development (DSDILGP), the NQROC region contributes over $17.1 billion annually to the Queensland economy and is home to 247,000 people. This population is most densely located in Townsville and the surrounding local government areas, and along the eastern coastline.

The region is noted to have one of the most diverse economic bases in Australia with major industries spanning:[33]

- Public administration and safety
- Manufacturing
- Construction
- Rental, hiring and real estate services
- Health care and social assistance
- Education and training

The regional city of Townsville has a designated Defence Industry Hub and is a regional manufacturing hub.[34] It is also a major logistical centre with major rail and road connections and third largest port in Queensland. Using Townsville as a reference point, the following distances within the region and to other major centres apply:

- Charters Towers to Townsville – 136 kilometres (via Flinders Highway)
- Townsville to Mackay – 1,335 kilometres (via Bruce Highway)
- Townsville to Brisbane – 386 kilometres (via Bruce Highway)
- Townsville to Cairns – 347 kilometres (via Bruce Highway)

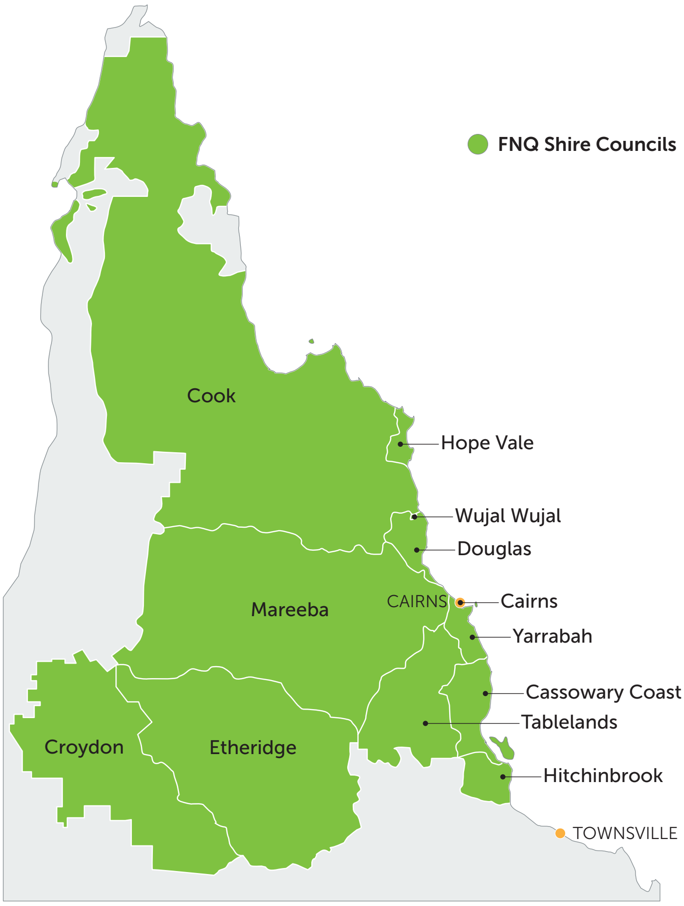
[32] https://www.nqroc.qld.gov.au/our-region
[33] https://www.statedevelopment.qld.gov.au/regions/queensland/north-qld
[34] https://statements.qld.gov.au/statements/95333

FNQROC

FNQROC comprises a total of twelve councils (see map and list of councils below) largely placed in the centre, east and south of the Cape York Peninsula. The region holds a population[35] of 292,000 and generates a gross regional product of $16.75 billion.

Populations and economic activity are concentrated in the coastal southeast, and progressively taper off in inland and northern directions. Cairns is the main regional centre, with nearby councils (i.e. Tablelands, Mareeba and Cassowary Coast) also holding larger populations.

- **Cook Shire Council**
  (4,400 centred in Cooktown)
- **Hope Vale Aboriginal Shire Council**
  (1,500)
- **Mareeba Shire Council**
  (22,700 centred in Mareeba)
- **Wujal Wujal Aboriginal Shire Council**
  (300)
- **Douglas Shire Council**
  (12,000 centred in Port Douglas and Mossman)
- **Cairns Regional Council**
  (162,000)
- **Yarrabah Aboriginal Shire Council**
  (2,600)
- **Cassowary Coast Regional Council**
  (30,000 centred in Innisfail, Tully, Cardwell and Mission Beach)
- **Tablelands Regional Council**
  (25,500 centred in Atherton)
- **Croydon Shire Council**
  (300 centred in Croydon)
- **Etheridge Shire Council**
  (800 across multiple centres)
- **Hinchinbrook Shire Council**
  (11,000, with Ingham as main centre)



FNQROC comprises a total of twelve councils largely placed in the centre, east and south of the Cape York Peninsula.

According to the Queensland Government, main industries in the region include: seafood, fruit, dairy and livestock; aviation; construction; defence (centred on HMAS Cairns); education (two universities); health; manufacturing; marine engineering and boatbuilding; and tourism, arts and culture. The region is adjacent to the Great Barrier Reef and Daintree Rainforest.

A number of mining operations are also based in the FNQROC region, including including Rio Tinto (Weipa), Mitsubishi Corporation (Cape Flattery Silica), New Century Resources (Lawn Hill), Consolidated Tin Mines (Mount Garnet), and Metro Mining (Weipa).[36]

[35] https://www.statedevelopment.qld.gov.au/regions/queensland/far-north-qld
[36] https://www.tiq.qld.gov.au/invest/regional-investment-opportunities/far-north-queensland/

In October 2021, the Queensland Government (DSDILGP) released its *Far North Queensland: Major Projects Pipeline*, setting out a raft of infrastructure and economic development investments in the region over the coming years.[37] Current and upcoming transport sector projects are also separately listed on the DTMR website.[38]

The main corridor to the FNQROC region is the coastal Bruce Highway, running from Cairns down to southeast Queensland. A rail freight line runs adjacent to the highway, passing all the major east coast centres through to Brisbane.

The following distances link major cities and towns along this coastal axis:

- Cooktown (the northernmost town) to Cairns – 326 kilometres
- Cairns to Townsville – 347 kilometres
- Cairns to Mackay – 732 kilometres
- Cairns to Brisbane – 1,678 kilometres

Other major roadways include the Kennedy Highway which broadly cuts across the base of Cape York Peninsula; and Mulligan Highway and the Peninsula Developmental Road which run northwards into and cut through the peninsula.

In October 2016, the FNQROC councils explored and set priorities for waste management and resource recovery across the region. According to the FNQROC Regional Strategic Infrastructure Officer, this was the last region-wide planning and options analysis exercise for waste and resource recovery. Noting the time elapsed (and market and policy developments over that period), the FNQROC is at the early stages of a new phase of regional resource recovery planning. This new phase will place greater emphasis on circular economy adoption, including the development of a strategic approach and corresponding methods to enable a greater use of recovered materials in the regional economy.

End-of-life tyre recovery practices, facilities & services 4.2

Council and private collection facilities and services

The management of end-of-life tyres, as undertaken by the majority of councils in the two regions, aims to focus on tyre recycling wherever this is practical. For a majority of councils in both regions, council transfer stations are able to accept tyres across a range of vehicle types, from motorbikes, cars and trucks to a limited range of OTR tyres.

A few inland councils – such as Croydon and Etheridge – are not serviced by a commercial operator. Instead, these councils evidently stockpile the tyres as they accumulate; or temporarily bury them (to manage pests) with the aspiration to recover them as and when an affordable recycling solution becomes available.

In the case of Palm Island Aboriginal Shire, tyres are stockpiled at the local transfer station given the additional challenge of returning used tyres to the mainland. Pending access to funding, the council organises for the tyres to be ferried to the mainland (via Port of Lucinda) and then trucked to a consolidation point in Townsville. The city then arranges the material to be collected under its contract with a private operator. Palm Island officers note that the charges for contaminated tyres are about three-fold those for clean tyres, which impairs the affordability of this service.

Council stakeholders clarified that the fee structure charged by transfer stations for tyre recovery is nominally correlated with the size of the tyre and involves direct pass through of fees charged by downstream recycling operators, with some councils opting to add their own handling fee. Tyres on the rim would typically involve a surcharge (to cover removal of the rim).

[37] https://www.statedevelopment.qld.gov.au/__data/assets/pdf_file/0022/17860/fnq-major-projects-pipeline-booklet.pdf
[38] https://www.tmr.qld.gov.au/projects/districts/northern

Based on information shared by council representatives, it is understood that the tyres collected through transfer stations reflect a minor volume compared with end-of-life tyres collected directly from retailers in larger townships and regional cities, who are also understood to engage tyre recycling service providers based in and near southeast Queensland. However, in the case of some of the more remotely located tyre retailers, the tyre collection service can be infrequent and may cause a backlog of tyres stockpiled and awaiting collection.

It is understood that a typical fee paid by retailers is in the order of $12 per EPU (up from $5 per EPU in past years) for pick up and recovery. A review of fees charged at transfer stations across the NQROC and FNQROC regions suggest fees in the order of $5 to $12 per passenger car tyre (i.e. per EPU). Transfer station fees for 4x4 vehicle / light truck tyres may range between $9 and $18 across the regions; and typically range between $20 to $30 per truck tyre. These prices are elevated relative to SWQROC fees (of around $6 per EPU) and may reflect larger distances and higher transport costs in sending material to southeast Queensland and beyond for processing. Within each region, there does not appear to be a further correlation between fee and distance to southeast Queensland, suggesting other factors as influencing pricing policy.[39]

Disposal of shredded tyre material in landfills is apparently not common in either region. Waste tracking data (below) seems to confirm that tyres are mainly collected for processing rather than disposal. However, there may be significant tyre volumes that are retained on site or illegally dumped, which would not be captured in tracking data systems in place for legitimate collection, recovery and disposal activities.

It is understood that there is a level of tyre dumping on roadsides and in gullies in some local government areas, and some on site stockpiling of large OTR tyres on farmlands and of truck tyres at various transport company depots. Mining tyres are understood to be managed in pit, typical of prevailing practice across the country.

There is a privately owned and operated regional landfill located midway between Atherton and Mareeba township (i.e. 90 kilometres inland of Cairns), managed by a joint venture between Remondis and FGF. This Springmount Waste Management Facility[40] could potentially have an as-yet-unidentified role in tyre recovery.

4.2 End-of-life tyre volumes

NQROC region tyre arisings

Waste tracking data from 2019-20 was provided to this project by the Queensland Government (Table 3). From a geographic standpoint, location information was provided using suburbs and towns as the relevant category, rather than postcode or local government area.

An ensuing analysis resulted in the table below, tracking overall movements of tyre waste generated across NQROC. It is notable that all the destination locations coincide with accredited recycling service locations in Southeast Queensland, where the material received is processed into end products rather than being shredded before being disposed in landfills. 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. The tracking data also suggests that reporting entities are not disposing significant volumes to local landfills.

[39] The price ranges in this paragraph do not include fees charged at Palm Island's transfer station, which is elevated by virtue of the need to internalise marine freight costs (i.e. to the mainland).
[40] https://www.fgf.com.au/waste-management

Table 3: Tyre movements originating from NQROC region in 2019-20 (Source: Queensland Government).

LGA	Suburbs / towns	Volume (2019-20)	Destinations
Townsville	Townsville, Idalia, Garbutt, Kirwan, Thuringowa, The Willows, Deeragun, Bohle, Fairfield	3,045 tonnes	Southeast Queensland
Charters Towers	Charters Towers	65 tonnes	
Burdekin	Home Hill, Ayr	86 tonnes	
Hinchinbrook	Ingham	137 tonnes	
Palm Island Aboriginal Shire	Palm Island	0 tonnes	n/a
Total		**3,333 tonnes**	

Collection and management through council facilities

Engagement with council representatives suggests that council facilities have had a modest role in the collection and subsequent recovery of end-of-life tyres from the NQROC region. The largest council, Townsville, identified some 142 tonnes of tyres collected through its recovery infrastructure network. Other councils are likely to have smaller volumes and may only make a marginal contribution to the above stated recovery figure of 3,333 tonnes from 2019-20.

This is not to suggest that council infrastructure is of marginal relevance to tyre recovery, noting the potential role that transfer stations and other consolidation points may have in making tyre recovery more practical and affordable in more remote locations. This may be especially important for lifting the recovery rate of OTR tyres and on road tyres generated in smaller settlements and townships.

FNQROC tyre arisings

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 towns as the relevant category, rather than postcode or local government area.

The ensuing analysis resulted in Table 4 (on next page), tracking overall movements of tyre waste generated across FNQROC. It is notable that the majority of destination locations coincide with accredited recycling service locations in Southeast Queensland, apart from one instance of intra-council transfer of 13 tonnes. 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. The tracking data also suggests that reporting entities are not disposing significant volumes to local landfills.

Table 4: Tyre movements originating from FNQROC region in 2019-20 (Source: Queensland Government).

LGA	Suburbs / towns	Volume (2019-20)	Destinations
Cairns	Babinda, Garden Vale, Mt Sheridan, Edmonton, Cairns, Portsmith, North Cairns, Smithfield	1,239 tonnes (Adjusted to account for 13 tonnes' transfer inside the LGA)	Southeast Queensland
Cassowary Coast	Cardwell, Mission Beach, Tully, Innisfail	280 tonnes	
Tablelands	Atherton, Malanda	311 tonnes	
Mareeba	Mareeba	344 tonnes	
Cook Shire	Cooktown	33 tonnes	
Etheridge	Georgetown	36 tonnes	
Total		**2,256 tonnes**	

Combined volumes across the north and far north

Drawing on the waste tracking data provided by the Queensland Government (for the 2019-20 financial year), there may be a combined annual volume of tyres collected and tracked from across the two regions in the order of 5,589 tonnes. About 77% of this material comes from the two regional centres of Townsville and Cairns.

While there are limits to applying the statewide recovery rate of 62% to component regions, there is not sufficient regional data to generate an estimate of the current recovery rates for FNQROC and NQROC. However, if the statewide recovery rate was used in the absence of more representative data, it suggests that there are an additional 3,426 tonnes of tyre material arising in the two regions which are not being collected and tracked through the Queensland Government system.

Provisionally, this quantity of end-of-life tyre material may be suitable for driving investment in a regional tyre recovery facility. At the time of writing, the Townsville City Council has been making plans for a waste and resource recovery precinct, which may be a suitable location for such a facility. This placement could potentially enable recovery of end-of-life tyre volumes from councils to the south of the NQROC region such as Mackay and Yeppoon, as well as receiving OTR tyres from mining operations near Townsville and further afield (e.g. Bowen Basin).

4.4 Observations on tyre arisings in the north and far north

Assuming accuracy in the Queensland waste tracking data, the following observations are useful.

- The Queensland Government tracking data suggests a total volume of ~5,589 tonnes transported from NQROC and FNQROC to processors in the southeast. It may be inferred that all of this material was recovered.
- The tracking data does not give evidence for significant consolidation within or outside the regions prior to recovery over 2019-20, with tracking data showing a total of 13 tonnes transported between points inside FNQROC. The destination suburbs in southeast Queensland align with TSA-accredited recovery facility locations.
- As may be expected, data sets indicate a large volume of tyres collected and processed from City of Townsville (3,045 tonnes) and Cairns Regional Council (1,239 tonnes), with a combined contribution of 77% of the total amount.
- While it is not the ideal method of estimate, assuming that the statewide recovery rate of 62% applied in the two regions would mean that there are about 3,426 tonnes of tyres being generated each year,

which are not being recovered and are not being sent to landfill (based on Queensland Government tracking data).

- From the above points, opportunities to improve tyre recovery outcomes may centre on the following:
  - Improved transport efficiencies, potentially involving a level of local pre-processing to improve packing densities prior to southbound transit.
  - Replacement of southeast Queensland recovery processes with processes that are regionally localised, potentially lowering freight costs while leading to local economic benefits (e.g. investment, business opportunity and employment) and the option to use the material for local 'circular economy' purposes.
  - Improved capture of tyre arisings that are presently managed through sub-optimal activities such as stockpiling over indeterminate periods, illegal dumping, on site burial and other practices (i.e. not captured in TSA or waste tracking data sets), potentially involving a combination of incentives and improved placement of high quality recovery infrastructure and related services throughout the region.

Implied levels of stockpile accumulation, on site burial and illegal tyre dumping across the north and far north

At present, there is limited region-scale data relating to stockpiling and illegal dumping levels of tyres across Queensland. The tracking data for NQROC and FNQROC suggests that the majority of movements registered with the state government arises from transport to recovery facilities based in southeast Queensland, with little to no material finding its way to legitimate landfills. However, there may be some instances of households or backyard mechanics sending tyres to landfill, either as separate material or commingled with other materials, which has not been tracked in the data.

Extrapolation of the statewide resource recovery rate to the two regions suggests that around 3,400 tonnes of end-of-life tyres from the regions are not being recovered in a given year, yet tracking data suggests that it is not being sent to landfills either.

Potentially, this material may be subject (to varying degrees) to the following practices that are not being picked up through the government tracking system:

- 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 also needs to be exercised in extrapolating total volumes generated from volumes observed as being recovered, particularly given a range of region-specific factors that may be at play.

In an ideal case, TSA and partners would have the means to measure or estimate the volume of tyres arising across the two regions directly (i.e. independent of the state's tracking system), and confirm regionally representative recovery rates from this reference data.

Scale of recovery and processing potential based on regional arisings

TSA provided the project team with a subset of FNQROC and NQROC tyre collection data, broken into types of tyres.

- Of the 277 tonnes collected across 7 NQROC postcodes, 74% of the material was categorised as tyres sourced from on-road trucks and 26% was categorised as tyres sourced from passenger cars (with no volumes attributed to OTR tyres)
- Of the 631 tonnes collected across 19 FNQROC postcodes, 69% of the material was categorised as tyres sourced from on-road trucks and 31% was categorised as tyres sourced from passenger cars (with no volumes attributed to OTR tyres).

These percentages may be a reflection of the relative volumes of truck tyres and passenger car tyres arising and/or differing recovery rates for each type of tyre, without providing sufficient information to understand the relative strength of the two contributing factors.

Assuming a degree of representativeness and applying these percentages to the total tonnes collected from NQROC and FNQROC regions (according to 2019-20 waste tracking data):

- Some 870 tonnes of passenger car tyres and 2,460 tonnes of truck tyres are currently collected from NQROC for recovery
- Some 700 tonnes of passenger car tyres and 1,570 tonnes of truck tyres are currently collected from FNQROC for recovery.

That is, a combined 1,570 tonnes of passenger car tyres and 4,030 tonnes of truck tyres are estimated to have been recovered from the two regions in 2019-20. Based on prior analyses conducted for TSA, there are some tyre derived products and end uses that are suited to passenger car tyre and truck tyre feedstocks; whereas others are suited to truck tyres only. The table below sets out combinations of end products and usages that may be derived from the above passenger car and truck tyre arisings. Figures should be read as rough estimates only.

Table 5: Potential groupings of products derived from tyres, based on NQROC and FNQROC volumes tracked by Queensland Government.

Product	Source materials	Volume
Product grouping – tyre derived fuel		
Tyre shred	Passenger car & truck tyres	5,590 tonnes
Product grouping – pyrolysis (indicative volumes only, given dependency on plant configuration) NB: Syngas may be partially or wholly consumed to power the pyrolysis unit		
Carbon char	Passenger car & truck tyres	1,400 tonnes
Recovered steel		1,680 tonnes
Heavy oil / liquid fuels		1,680 tonnes
Unrefined syngas (CO, CH4, H2, other gases)		840 tonnes
Refined rubber products		
Crumb rubber (for asphalts and spray seals)	Truck tyres	2,620 tonnes
Rubber granule (for niche flooring and civil uses)	Passenger car tyres	1,260 tonnes
Recovered steel	Passenger car & truck tyres	1,720 tonnes

Table 5 shows that there are substantial volumes of resources that may be recovered from tyres collected from the region, without accounting for additional recovery that may be achieved through addressing stockpiling and illegal dumping. The supply chains and end markets for these products are detailed later in this report, and serve as a basis to investigate the commercial viability of different tyre recovery models that could service the two regions.

OTR tyre management 4.6

The above analysis shows scant evidence of OTR tyre recovery occurring in the north and far north of Queensland at the present time, with the possible exception of tyres from urban based OTR vehicles such as road building and earthworks vehicles. However, there may be opportunity to lift the recovery of OTR tyres by targeting mining vehicles used in operations from the following locations:[41]

- Cape York Peninsula, including large bauxite mining operations at Weipa, 820 km northwest of Cairns
- Bowen Basin black coal mines, 500 to 700 km south of Townsville
- Other mines near Cairns and Townsville and in the Charters Towers Shire Council area.

OTR tyres from these locations may be supplemented with other sources including agricultural vehicle tyres used in cane growing[42] and cotton growing[43] industries based in and near north and far north Queensland.

[41] https://qurex.com.au/explore/explore-maps/
[42] https://www.queenslandplaces.com.au/sugar-regions
[43] https://cottonaustralia.com.au/where-is-cotton-grown

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 the two regions, 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 5,590 tonnes of tyres are annually recovered from the north and far north regions via facilities located in southeast Queensland. 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 (or mismanaged) according to each of the ways listed above. Using statewide resource recovery rates, an estimated 3,400 tonnes of end-of-life tyres are assumed as outstanding, i.e. they remain to be collected and processed through tyre recovery services for the two regions. To varying degrees, this volume may presently be handled by the above non-recovery activities.

The economic value of tyres recovered from the region 5.2

Working with an assumed recovery volume of 5,590 tonnes of tyres, and a further 3,400 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 the previous section). Each supply chain produces its own set of recovered resources – the table should not be read as cumulative across supply chains.

In the absence of further data, the breakdown of the potential volume of 3,400 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. This includes a volume of OTR tyres that has not been observed in the profile of tyres recovered to date, and actions to fully realise tyre recovery for the regions will need to target OTR tyre generators as well as lift recovery from passenger car and truck tyre sources.

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)** 5,590 tonnes as: • 0 tonnes OTR • 4,030 tonnes truck • 1,570 tonnes passenger car	**Input tyre volume (potential)** 3,400 tonnes as: • 760 tonnes OTR • 1,360 tonnes truck • 1,280 tonnes passenger car
Shredding (to produce TDF)	5,590 tonnes TDF (7,270 tonnes black coal equivalent)	3,400 tonnes TDF (4,420 tonnes black coal equivalent)
Pyrolysis (syn gas product consumed on site)	1,400 tonnes carbon char 1,680 tonnes fuel oil 1,680 tonnes steel	850 tonnes carbon char 1,020 tonnes fuel oil 1,020 tonnes steel
Granulation and/or crumbing	3,870 tonnes crumb and/or granule 1,720 tonnes steel	2,400 tonnes crumb and/or granule 1,000 tonnes steel

In practice, the recovery of tyres from the regions 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 8. 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 north and far north 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

Local economic opportunities arise from the recovery of tyres from the north and far north of Queensland, in line with the delivery of tyre collection and recycling/recovery services and the production of useful commodities. At present, end-of-life tyre collection services already take place in the two regions, although there may be scope for marginal lifts in collection activity and related employment, should there be an increase in quantities collected from the region.

With respect to processing tyre material into various products – such as rubber granule and crumb, pyrolysis products, and tyre shred – economic and employment benefits will be supply chain dependent. In the case of continued or expanded recovery using facilities located in southeast Queensland, additional employment outcomes may be marginal as the scale of tyre material from the north and far north is modest compared to the volumes already being processed in southeast Queensland. However, the establishment of a new facility in the north or far north is more certain of creating jobs while retaining products for local use.

For example, based on prior studies undertaken for TSA, a rubber crumb and granulation facility processing 5,000+ tonnes of tyres each year may involve the creation of around 20 or more ongoing full time jobs in the north of the state. At the same time, the operation produces crumb and granule for road projects, civil infrastructure and niche flooring applications in the region and elsewhere in the state. While a new regional pyrolysis plant may involve a similar number of employees, there is less certainty regarding the economic value of the materials recovered, and the stability of any ongoing positions will be correlated to the ability of the pyrolysis facility to establish, grow and maintain markets for its products over the longer term.

Benefits of alleviating environmental & amenity impacts

Reducing environmental impacts through commercial tyre recovery

A driver for lifting the amount of tyres recovered from regional Queensland is to deliver on a range of environmental and amenity benefits. TSA identifies the following benefits among others[44] 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.[45] In total, the man dumped 3,500 tyres (i.e. in the order of 30 tonnes) across 17 locations throughout 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.

[44] https://www.tyrestewardship.org.au/about-tsa/scheme/
[45] 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

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 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. This assumption is likely to be reflective of real world market conditions where:

- The region largely depends on tyre recovery facilities that are already operating in southeast Queensland, which have a record of processing tyres from large tyre recovery markets and selling recovered material to established end markets, or
- The region predominantly relies on newer local tyre recovery facilities, who may have diminished economies of scale but are able to compensate through reduced transport costs, yet need to be satisfied that there is enough demand for their tyre recycling services and finished goods to provide adequate returns on their capital outlay.

With respect to the second point, a newer regional facility (based near Townsville or similar) would potentially need to process tyres in the range of 5,000+ tonnes per year and have confidence in selling its products to strong markets. As such, the new facility would need to annually capture the majority of the existing 5,590 tonnes currently collected in the two regions; and/or a quantity of additional volumes in the region; and/or a volume from adjacent centres (potentially as far south as Rockhampton and Bowen Basin).

Following these general descriptions of tyre recovery pathways, the next section will more closely examine each technology and end market combination across a range of criteria that will provide insights into their viability and effectiveness as solutions for the north and far north regions. That section will incorporate additional supply chain costs in the form of long haul freight from the region to the main processing facility (as may be necessary), and will analyse their strengths and drawbacks given current and emerging features of their commercial environments.

Reference recycling fees for the north and far north regions

In order to fully characterise the commercial supply chains that may be able to service end-of-life tyre generators in each region, there is the need to derive and apply a reference recycling fee (i.e. the price paid for recycling services, expressed per EPU or per tonne).

Stakeholder engagement suggests that tyre retailers are charged at a rate of about $12 per EPU in each region, and Queensland Government waste tracking data suggest that the larger share of tyre recycling services take place as a direct commercial arrangement between retailers and collectors or recyclers.

In both the NQROC and FNQROC regions, transfer stations apply a spread of fees that do not necessarily track with their relative distances to processing facilities. Taking a weighted average approach (based on relative quantities processed from each region) to generate regionally representative transfer station fees, the following price points emerge:

- **For NQROC**, a weighted average price (across Townsville, Charters Towers and Hinchinbrook) per car tyre recycled comes to $6.30; and per truck tyre comes to $23.40
- **For FNQROC**, a weighted average price (across Cairns, Cassowary Coast, Tablelands, Mareeba, Cook and Etheridge) per car tyre recycled comes to $7.70; and per truck tyre comes to $28.20.

Each passenger car tyre equates to 1 EPU, while each truck tyre equates to 2 EPU. The above figures seem to indicate that transfer stations are undercharging for passenger car tyres received for processing, compared with the charges they apply for truck tyres (which come to $12 to $14 per EPU) and compared with recycling fees charged by collectors and recyclers to tyre retailers.

For the purposes of modelling activities in scope for this business case, it is reasonable to apply a reference recycling fee of $12 per EPU (or $1,500 per tonne) for tyres recovered from the NQROC and of $13 per EPU (or $1,750 per EPU) for tyres recovered from the FNQROC region. These prices may be elevated relative to fees charged in more metropolitan locations, as may be necessary to internalise and recover additional long haul transport overheads.

Changes in production factor costs and end market conditions may cause recyclers to set new fees from time to time (to the extent that they are unconstrained by competitors), in order to balance cashflow and maintain profits. In this way, the recycling fee plays an important stabilising role, responding to adverse downstream market movements and related uncertainties.

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 black 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.[46]

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.[47] (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.)

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

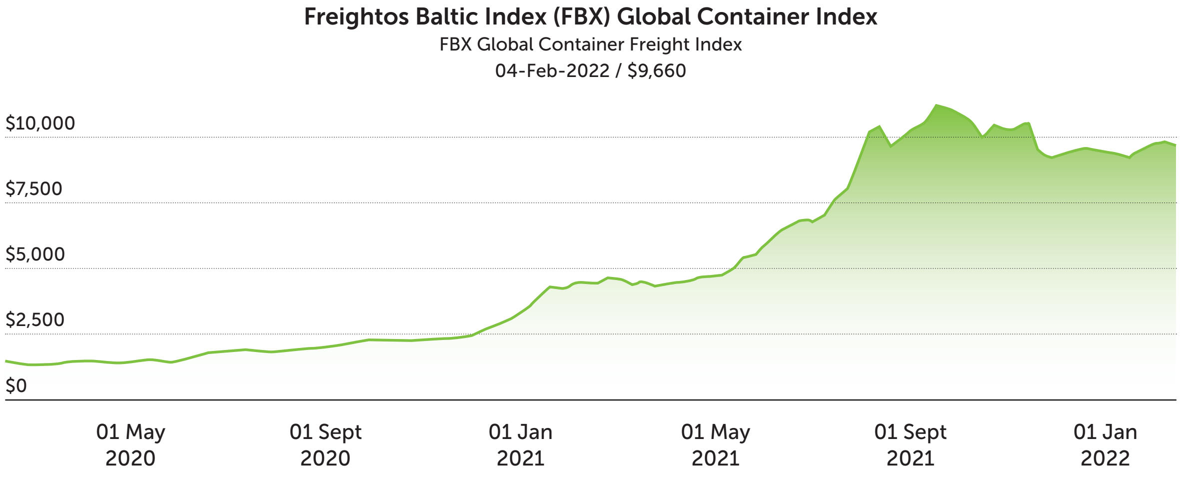


Figure 3: Freightos Baltic Index, mid 2020 to early 2022, reflecting rising trends in container shipping costs. (Source: https://fbx.freightos.com/)

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.[48] 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.

[48] 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.

The box 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.

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 $12 per EPU	–	$1,500 (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[49]
- Differences in calorific value (noting an increase in calorific value over black 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.

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

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. 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 $12 per EPU	–	$1,500 (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.[50] 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.

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

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.

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[51] and up to 20% by mass for asphalts[52] 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 a 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.

[51] https://www.tyrestewardship.org.au/product/spray-seal/
[52] https://www.tyrestewardship.org.au/product/asphalt/

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. For the purposes of this business case, it is useful to examine crumb rubber supply chains operating at the larger scale (i.e. from existing facilities based in southeast Queensland), and at the smaller scale (i.e. from new facilities situated within or near to end-of-life tyre catchments from the north and far north of the state).

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.

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.

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 For large SEQ facility For smaller regional facility	\$300 - \$600 (per tonne) Towards \$300 (per tonne) Towards \$600 (per tonne)	– – –
Sale of steel	–	\$100 - \$240 (per tonne)
Sale of crumb rubber	–	\$550 - \$800 (per tonne)
Recycling fees At \$12 per EPU	–	\$1,500 (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). This FY2022 current consumption estimate includes 990 tonnes of EOLTs in the far north and 106 tonnes of EOLTs in the north.

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.

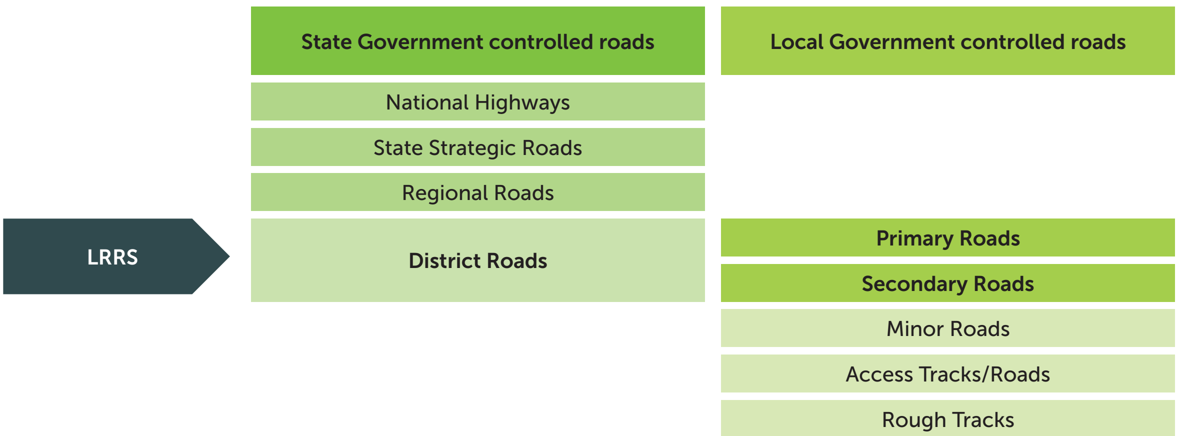
The project team estimates potential demand for rubber crumb consuming up to 3,000 tonnes of EOLTs per year across FNQROC and NQROC combined. Of which, the annual DTMR maintenance of state controlled network in the far north and northern districts has potential to consume between 478 and 1,686 tonnes of EOLTs per year. See Appendix 2 for further details.

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[53] 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.



[53] See page 14, *Roads Alliance Operational Guidelines* (2011), LGAQ and Queensland Government.

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.

Actual estimates of rubber crumb consumption across the state controlled network were provided by DTMR, rising from equivalent consumption of 441 tonnes of EOLTs in FY2016 to an estimated consumption of 3,893 tonnes EOLTs in FY2022. Estimated current crumb consumption in FY2022 for DTMR-led FNQROC and NQROC road projects is 990 and 106 tonnes of EOLTs respectively (see Appendix 2 for further detail).

Estimating potential road network consumption of crumb rubber in NQROC & FNQROC

The project team estimates potential demand for rubber crumb consuming up to 3,000 tonnes of EOLTs per year across FNQROC and NQROC combined. This is based on an analysis of current and planned projects and activities across the DTMR state network maintenance program, QTRIP and RRTG works.

A more conservative estimate, focusing on annual DTMR maintenance of the state controlled network in the far north and north suggests demand for rubber crumb potentially consuming between 478 and 1,686 tonnes of EOLTs per year.

See Appendix 2 for an outline of the analysis and assumptions supporting this estimated range.

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 regions, there is reason to expect that the market can readily absorb increased amounts of granule that may be sourced from tyres from regional Queensland.

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)	–
For large SEQ facility	Towards $250 (per tonne)	–
For smaller regional facility	Towards $550 (per tonne)	–
Sale of steel	–	$100 - $240 (per tonne)
Sale of crumb rubber	–	$500 - $600 (per tonne)
Recycling fees At $12 per EPU	–	$1,500 (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).[54] 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. This facility is intended to pyrolyse the residual rubber attached to 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.[55]

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

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 (existing facility) **Processing costs** (new facility)	$800 - $1,200 (per tonne) $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 $12 per EPU	–	$1,500 (per tonne)

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.

Provisionally, the north and far north Queensland regions could generate sufficient quantities of end-of-life tyres to attract investment in a regional small to medium scale pyrolysis plant. However, its operating costs could be very high, particularly during periods of low throughput and modest capital utilisation, which may then necessitate higher recycling fees than may otherwise be the case. A regional facility may be additionally disadvantaged in terms of end markets, where there may be a lack of local buyers for carbon char and fuel oil products. For completeness, this business case will examine options to recover products from north and far north Queensland tyres either through existing southeast Queensland pyrolysis equipment, or through a new plant located in or near the two regions.

Practical recovery of OTR tyres

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 membership 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

6.3

The above explorations of products and markets show that different uses for tyre derived resources 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 in mind, Table 7 below combines end markets and their locations with their relevant processing infrastructure, and suggests 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 that are realistic for each regional catchment.

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 mainly based in southeast Queensland, exploiting the large volumes of tyres and proximity to end markets and freight links.

For some markets and supply chains, the viability of smaller regional facilities serving one or more of the three regions targeted in this study is relevant. 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 5,000+ tonnes of passenger car and truck tyres that are presently being processed from those catchments, and a further quantity of passenger car, truck, OTR tyres arising that are not yet being processed.

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 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 table (Table 8) sets out alternative options for recycling tyres that arise from the three regions (FNQROC and NQROC combined, and SWQROC treated separately), including business as usual practices where applicable.

While it is envisaged that the foundation of each option will involve the recovery of passenger car and truck tyres as primary materials which may have distinct recovery pathways, 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 the FNQROC and NQROC regions. As previously indicated, it is most likely that tyre recovery for this region could involve the use of existing facilities in southeast Queensland or new facilities towards the north of the state, with the annual arisings of tyres from the two regions being potentially sufficient to justify a dedicated regional facility.

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, and strategic barriers and opportunities that may be more challenging to express in numerical terms.

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 the regional markets.

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. factoring in their wider supply chains and target markets rather than narrowly focusing on key processing technologies), 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

This section is structured to compare the recovery options available to the two regions (combined as a single catchment), given the opportunity to source tyres from different points of generation. Where relevant to the technologies and end markets in question, tyre feedstocks are separated into passenger car, truck and OTR vehicle sourced tyres.

In this section, a series of tyre recovery options for the combined NQROC and FNQROC regions 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

In completing this exercise, the relative advantages and disadvantages of different tyre recovery solutions for the regional catchment become clear. However, the goal is not necessarily to determine an unambiguous 'winning solution' for the 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 (reported on separately) and the combined FNQROC and NQROC regions 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 and involve new capital at risk.

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 and to trade under favourable pricing and demand conditions. This customer retention may arise from having a competitive business model, confirmed 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.[56]

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 greater 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 NQROC & FNQROC region 7.1

With around 5,600 tonnes of end-of-life tyres being handled each year from across the FNQROC and NQROC local government areas, the volumes are arguably sufficient to justify a dedicated regional tyre recycling facility. This dedicated facility would need to have any scaling disadvantages compensated for through locational strengths, which may need to include access to local end markets as well as local catchments of tyre material. Where a technology / supply chain combination could foreseeably be located in or near the north or far north of Queensland, this variant will need to be explored alongside the option to rely on services from similar technologies and supply chains found in southeast Queensland.

This variant is most relevant to pyrolysis and crumbing/granulation technologies. However, a smaller regional shredding facility may be less viable except where it is producing tyre derived fuel for a local energy user, although this recovery pathway comes with its own set of risks.

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 Townsville to southeast Queensland of around 1,400 kilometres by road, an estimated long haul cost of $4.00 per EPU or $500 per tonne has been used in the ensuing analyses. The distance from Cairns to southeast Queensland of around 1,700 kilometres by road would incur a long haul cost of $4.90 per EPU or $600 per tonne. As such, there is an addition 90 cents per EPU that needs to be internalised in servicing Cairns compared with Townsville, which roughly equates to the differential in recycling fees paid by the two regions.

This balancing out of costs and revenues between tyre recovery services delivered to NQROC and FNQROC means that a financial analysis of competing solutions can be simplified across the two regions. In the analysis below, it is assumed that typical recycling fees are set at $12 per EPU ($1,500 per tonne) and that long haul freight costs come to $500 per tonne, i.e. as applies to southeast Queensland facilities serving customers in the NQROC region. Any findings relating to the financial viability of the same facility serving FNQROC customers remain unchanged, assuming $1 per EPU extra charged and around 90 cents additionally incurred in freight costs.

For the use a local tyre recovery facility (e.g. based in or near Townsville), these long haul freight costs may not apply for NQROC customers although a minor haulage fee may apply for customers based in FNQROC (or very distant parts of the NQROC region). There may be additional logistical cost factors to account for, depending on the location of end markets outside the two regions – these will be accounted for as may be specific to different solutions.

[56] 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.

Production of TDF for international markets

Financial profile

This recovery pathway involves transporting passenger car tyres from the north and far north regions to existing tyre recovery facilities in southeast Queensland, which then shred the tyres to meet a specification required for offshore energy applications. For reasons that will become apparent below, it is unlikely that this supply chain and technology combination would favour a new regional shredding facility in northern parts of the state, under present market conditions.

Shredding tyres to make TDF is a lower cost process compared with other processing methods for end-of-life tyres, with previous studies[57] 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 NQROC to southeast Queensland may be in the range of $500 per tonne.

Assuming recycling fees of about $12 per tyre or $1,500 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 $480 to $815 per tonne. This compares favourably against historic revenues for processing passenger car tyres in the order of $300 per tonne, with high recycling fees substantially offsetting the recent increase in shipping container costs.

However, this positive outlook should be interpreted with caution, as the supply chain and end markets involve substantial risks and uncertainties that may impact profitability. Moreover, other competing options may come to erode the ability to impose high recycling fees on the market. For example, the arrival of local tyre granulation capacity in the market could potentially outcompete the export of TDF, based on its more favourable profitability.

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 if this trend continues, may threaten to impair 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.

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).

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

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.

For the above reasons, a newly established regional shredding facility to service international TDF markets may not represent a strong investment opportunity. Such a facility may fail to capture scale economies, while needing to internalise a range of relatively fixed administrative (i.e. export related) costs and some volatile costs of production (related to international shipping costs). Proponents of a new regional facility may fail to recover their capital costs over the lifetime of the asset due to these above factors, whereas existing facilities in southeast Queensland may already have recovered their upfront capital costs and are less risk exposed.

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 to investors, 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 black 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 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[58] 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.

The production of TDF for domestic consumers could take place in existing facilities based in southeast Queensland, incurring an estimated freight charge for southward transit of about $500 per tonne. However, the TDF product would then need to be trucked 550 kilometres northwards to a cement kiln based in Gladstone.

While there may be significant transport efficiencies in placing a new shredding facility closer to Gladstone or closer to the point of production (such as Townsville), it is not clear that the risk profile for this end market allows for this option. Any new facility would need certainty of a return over its commercial lifespan, which may not be possible given the reliance on a sole customer (operating in an untested regulatory environment). In such situations, the supplier will typically want a long term supply contract to ensure a profitable return on capital, while the buyer will typically want a shorter term contract to allow more opportunity to test the market for competing offerings and to benefit from lowering production cost curves. The differences in expectations and the market power imbalance between a cement kiln and new TDF facility (as opposed to an existing facility) may render the option of new tailor-made facility unworkable.

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.

[58] 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).

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.

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.

Recovery via southeast Queensland based facilities

As set out at the beginning of this section, transport costs for hauling whole passenger car tyres from NQROC to southeast Queensland may be in the range of $500 per tonne.

Assuming recycling fees of $12 per tyre or $1,500 per tonne, the practice of recovering granule from passenger car tyres in the southeast of the state may generate a surplus in the order of $1,050 to $1,590 per tonne.

Recovery via a new rubber crumbing and granulation facility based in north Queensland

Alternatively, there may be provision to base a new facility in north Queensland, with a site in or near to Townsville potentially representing an optimal location between tyre sources in the north and far north, and granule markets based locally or in more southern regions. Engagement with the tyre recovery industry (both during the current study and the business case for recovering tyres in the Northern Territory) suggests that the identified 5,000+ tonnes collected each year may be enough material to justify a new regional crumbing and granulation operation.

In this situation, operating costs may be in the vicinity of $350 to $550 per tonne, although this is more than offset by the absence of long distance transport from points of generation to the processing facility. Using commodity price ranges and recycling fees as stated above, it is foreseeable that a local granulation facility may return a surplus in the order of $1,550 to $1,990 per tonne.

In this situation, there may be a need to internalise product transport costs, although these may be significantly lower than the cost of freighting unprocessed whole tyres. In part, granule held in bulka bags will be more dense and easier to handle compared to whole tyres. But there may be some local applications (e.g. in flooring, permeable pavement or road applications) which will involve no additional long haul transport activities. On balance, a local granule production facility would appear to be price competitive with existing facilities in southeast Queensland.

Both granulation scenarios appeared to deliver margins that 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 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 and granule 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.[59] (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 NQROC and FNQROC sourced passenger car tyres to rubber granulation facilities, based in southeast or northern 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. The anticipated volumes from the north and far north (and other adjacent regions) would appear to meet this criterion, although a new facility may need to compete aggressively to ramp up and lock in the volumes required.

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.

[59] 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.

In the case of a smaller regional facility, there may be additional opportunities by virtue of promoting local circular economy outcomes. Potentially, the establishment of a local facility may help to raise the profile of rubber granule as an industrial input, and help to normalise tyre recycling into granule as the preferred practice in the region. For example, NQROC and FNQROC could explore the option of forming circular economy supply chain alliances with those industries with a role in end-of-life tyre recovery, geared towards maximising the local benefits.

This option may be less workable for granulation facilities located further afield, which will inherently have a lesser ability to exploit a local profile.

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, although this number might be higher for a plant with limited throughput.

Use of existing pyrolysis facilities in southeast Queensland

In the case where existing pyrolysis facilities in the southeast of Queensland are used to process tyres from the north, transport costs for hauling whole passenger car tyres from northern Queensland to southeast Queensland may be in the range of $500 per tonne.

Given operating costs and sales revenues above and assuming inflows from recycling fees of around $1,500 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 profit of $120 to $360 per tonne.

Use of existing pyrolysis facilities in southeast Queensland

The option to locate a new tyre pyrolysis facility in the north of the state may present the means to bypass up to $500 in whole tyre transport costs, although this reduced overhead may be offset by higher operating costs on a per unit basis. The pyrolysis operator may suffer from higher than normal operating costs during the early years, as the facility's throughput ramps up from a low base.

Assuming operating costs in the order of $1,200 per tonne and sales revenues unchanged, a new tyre pyrolysis plant in the north may generate returns in the range of $400 to $450 per tonne. However, the supply chain may need to internalise additional transport costs for freighting one or more products to end markets outside the region, should the operator fail to secure buyers for scrap steel, carbon char or fuel oil in the north of the state.

While tyre pyrolysis can deliver a positive return as shown above, it may not be adequate given the risk profile of this technology, and given the much higher margins achievable through alternative solutions. The operation may therefore be substantially exposed to downward movement in recycling fees, which could lead to increasingly marginal performance. For example, a recycling fee of $10 per tonne would lower profit margins to $100 to $200 per tonne, which may be unviable over the longer term.

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. 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.

Recovery via southeast Queensland based facilities

Transport costs for hauling whole truck tyres from the north to southeast Queensland may be in the range of $500 per tonne. Assuming recycling fees set at $12 per EPU or $1,500 per tonne, a crumb rubber facility based in the southeast may be able to process truck tyres while earning a margin in the vicinity of $800 to $1,300 per tonne.

Recovery via a new rubber crumbing and granulation facility based in north Queensland

Engagement with the tyre recovery industry has revealed substantial interest in investing in a crumbing and granulation facility in the north of Queensland, based on the volume of tyres currently being processed and the potential to recover additional quantities of end-of-life tyres.

A northern facility will be able to avoid whole tyre transport costs of about $500 per tonne in avoiding the need to process in and around Brisbane. However, there may be slightly higher operating costs, assumed to be in the range of $300 to $600 per tonne. The business case estimates that, at a recycling fee of $12 per EPY or $1,500 per tonne, a new tyre crumbing and granulation facility may earn a surplus in the order of $1,250 to $1,800 per tonne.

This estimate assumes that the facility is capable of reaching throughput levels of around 5,000 tonnes per year early in its operating lifespan, and a failure to lift processing volumes may substantially erode the facility's profitability. However, the high margins as estimated above could allow the operator to aggressively compete on price, in order to capture a significant market share as early as possible.

The above margins estimated for a crumbing facility (irrespective of location), 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 in the market grants an element of choice to end-of-life tyre generators 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. It also means that the supply chain carries a degree of resilience against future commercial pressures that are presently not known, compared with alternative solutions that are inflexible in their product lines and destination markets.

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*. The analysis above suggests that there is an opportunity for this transition to play out at a statewide scale, as is the current case with tyres collected and processed into crumb rubber and granule in the southeast before shipping those products to various end markets in Queensland and elsewhere.

But there may also be the option to foster a circular economy approach at the regional scale, focused on tyres and other leading materials. Arguably, the regional approach will benefit from lower greenhouse gas emissions and overheads associated with transport, while retaining value through local jobs and local substitution of virgin inputs.

Given the regional employment and environmental benefits gained from a local tyre recovery facility over and above those achieved from using southeast Queensland facilities, it may be suitable to recognise a public return from this option. This return could justify a public allocation of capital to the facility, helping to bring the risk-return profile to within private investor tolerances. This measure may be suitable given that a granulation and crumbing plant may face some early challenges in aligning and ramping up feedstocks with end markets for its recovered products, irrespective of favourable market conditions and long term commercial prospects.

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.

In the case of a new regional pyrolysis facility, there is the added problem of having to manage high per unit operating cost prior to reaching more sustainable throughput levels, while also facing the threat of alternative technologies (such as a regional crumbing and granule plant) with a more competitive financial profile entering the market.

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 north and far north regions. 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

Earlier in this report, it was identified that the FNQROC and NQROC regions may include or may be adjacent to significant commercial activities that generate large quantities of OTR tyres. In particular, the following operations were singled out:

- Large bauxite mining operations at Weipa on the Cape York Peninsula, 820 km northwest of Cairns
- Coal mines located in Bowen Basin, 500 to 700 km south of Townsville
- Other mines near Cairns and Townsville and in the Charters Towers Shire Council area
- Canegrowing and cotton growing interests in and near north and far north Queensland.

A subset of OTR tyre brand owners and importers have recently signed up as levy paying members of the Australian Tyre Stewardship Scheme, alongside increasing interest from the mining sector to take responsibility for its end of life products. It is therefore reasonable to plan for and engage with the above industries as contributors of end-of-life tyre volumes to a tyre recovery supply chain for Queensland's north and far north.

The availability of these tyres may not be critical to the long term commercial viability of a tyre recovery solution for the north and far north, but may be very useful in terms of providing a stable long term inflow of materials and recycling revenue fees that strengthen the case for investment in related infrastructure. For example, one or more mines could potentially contract a new facility to process 2,000 or more tonnes of tyres over multiple years (for example, up to a decade, pending availability of material) over and above the 5,000+ tyres presently processed from the two regions, helping to sure up the financial profile of any capital project outlays.

Without pre-empting a preferred solution, a regional OTR tyre recovery supply chain based around the north and far north may be more viable than sending the material to southeast Queensland, on the basis of avoided transport costs. However, each recovery pathway may need to factor in one or more processes at the front end to ensure the OTR tyres are in a physical form amenable to treatment in a facility designed to accept and process passenger car and truck tyres.

These pre-processing steps may involve one or more of the following:

- Sectioning of large (more than 2 metres diameter) OTR tyres into smaller sub units, using hydraulic shears
- Passage of sectioned tyres and/or medium (up to 2 metres diameter) OTR tyres into a large mobile shredder
- Debeading and shredding of whole large OTR tyres into recovered steel and large shred using a dedicated stationary plant, ready for subsequent downstream processing.

There is no single recommended straightforward path to enable OTR tyres to feed into a regional tyre recovery solution, given dependencies around: source sectors; OTR tyre sizes and quantities; transport distances; requisite specifications dictated by downstream operations; and price tolerances around recycling fees charged to OTR tyre generators.

Moreover, engagement with source industries around a preferred solution and recycling outcomes that align with corporate responsibilities needs to occur, to ensure recovery operators are able to deliver results that comply with minimum corporate standards. A more targeted and detailed industry engagement plan and technology-oriented business case may be necessary to ensure a regional OTR tyre recovery solution is fit for purpose and connects with regional stakeholders' needs.

Tyre recovery options for NQROC & FNQROC 8

For convenience, the key features of each of the recovery pathways for tyres arising from the two regions are set out in Table 11 (across the three 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

The quantities of end-of-life tyres arising from the NQROC and FNQROC regions indicate that there are sufficient volumes to encourage a regional tyre recovery facility, pending sufficient confidence from proponents that they can lock in enough demand from tyre recycling customers and customers buying recovered resources.

It is unlikely that an operator based in the north or far north could survive while only servicing a minority of customers, and would ideally need to process 5,000+ tonnes of tyres each year. This may be realistic for a crumbing and granulation plant, whose financial profile may allow it to strongly compete on recycling fee prices while leveraging strong and stable demand for granule and crumb, both in regional and statewide markets.

But this dominant market position would be less tenable for a regional pyrolysis plant, whose operating costs and tenuous end markets leave this technology exposed to being displaced by more efficient and established alternatives. Similarly, a regional tyre derived fuel processor seeking to serve domestic energy users (e.g. cement kilns) may not present an enticing investment prospect, given that there is only a single buyer in this market while there are many potential sellers; and the regulatory landscape for this recovery path remains untested.

Irrespective of a final regionally located processing technology and its end market(s), a viable regional option presents some advantages over the reliance on facilities based in southeast Queensland. In particular, significant transport costs and related greenhouse gas emissions may be bypassed. Further, the regional option helps to ensure the economic value from tyre recovery – in the form of capital investment, jobs, and useful commodities made available to nearby users – is retained locally rather than transferred to more distant beneficiaries.

However, due to the time taken to build a base of customers on both the tyre recovery and end markets sides of the supply chain, a new regional facility carries some risks in its early years which may block or delay private investment. Tyre recovery operators may be wary of investing in the absence of a clear market signal that there is strong demand, and there may be a role from local councils, regional bodies and state government in stimulating market demand. Similarly, there may be a basis for a public capital allocation, given the public benefits at stake.

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

Passenger car tyres				
Processing technology	**End markets**	**Advantages**	**Disadvantages**	**Supporting activities**
Shredding whole tyres to meet TDF specification • Larger scale existing facilities in southeast Queensland 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 – e.g. shipping cost volatility and access to containers, trade policy risks, currency exchange risk, limited visibility on downstream social and environmental impacts • Limited ability to pivot to more profitable products • Road freight costs in moving tyres to SE Queensland	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) • Larger scale existing facilities in southeast Queensland • New regional facility processing 5,000+ tonnes/year	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) *For existing SEQ facilities:* • Able to pivot from domestic to international buyers *For new regional facilities:* • Reduced transport cost in freighting TDF directly from region to buyer	• 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 *For existing SEQ facilities:* • Extensive transport of tyres south then product north *For new regional facilities:* • Commercial risk of capital relying on a single buyer	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

Passenger car tyres				
Processing technology	**End markets**	**Advantages**	**Disadvantages**	**Supporting activities**
Pyrolysis to generate thermal desorption products (steel, carbon char, fuel oil) • Larger scale existing facilities in southeast Queensland • New regional facility processing around 5,000 tonnes/year	• Carbon char commodity markets • Low grade fuel oil applications • Recovered steel (scrap metal) market	• Able to take truck and passenger car tyres without separation • Multiple products allowing some level of market diversification *For existing SEQ facilities:* • Capital recovery spread across larger volume *For new regional facilities:* • Reduced transport cost for whole tyres to processor	• 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 *For existing SEQ facilities:* • High transport overheads for tyres to processor *For new regional facilities:* • Potential lack of regional demand, requiring transport of products	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.
Granulation using rubber crumbing facility • Larger scale existing facilities in southeast Queensland • New regional facility processing 5,000+ tonnes/year	• 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 *For existing SEQ facilities:* • Able to leverage existing capacity & capital *For new regional facilities:* • Reduced transport cost for whole tyres to processor • Localised circular economy	• 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) *For existing SEQ facilities:* • High transport overheads for tyres to processing plant *For new regional facilities:* • Demand uncertainty may defer or impede investment or increase financing costs	Ongoing market development targeting emerging applications (e.g. civil applications), to establish sustained market acceptance *For new regional facilities:* Pending interest from private investors, there may be a basis for public capital allocation, in recognition of residual commercial risks and positive spillovers to the region.

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 • Larger scale existing facilities in southeast Queensland • New regional facility processing 5,000+ tonnes/year	• 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 *For existing SEQ facilities:* • Able to leverage existing capacity & capital *For new regional facilities:* • Reduced transport cost for whole tyres to processor • Localised circular economy	• 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) *For existing SEQ facilities:* • High transport overheads for tyres to processing plant *For new regional facilities:* • Demand uncertainty may defer or impede investment or increase financing costs	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. For new regional facilities: Public capital allocation to new facility, in recognition of residual commercial risks and positive spillovers to the region. Proactive procurement of crumb rubber modified seals & asphalts
Pyrolysis to generate thermal desorption products (steel, carbon char, fuel oil) • Larger scale existing facilities in southeast Queensland • New regional facility processing 5,000+ tonnes/year	• 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 *For existing SEQ facilities:* • Capital recovery spread across larger volume *For new regional facilities:* • Reduced transport cost for tyres to processor	• 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 *For existing SEQ facilities:* • High transport overheads for tyres to processor *For new regional facilities:* • Potential lack of regional demand, requiring transport of products	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

Existing facilities based in the southeast cover a range of technologies and end markets including: shredding to produce tyre derived fuel for international (and potentially domestic) markets; crumbing and granulation to produce higher value crumb and granule for roads, civil infrastructure and niche flooring applications; and pyrolysis to generate a range of bulk commodities.

They principally benefit from their established presence and economies of scale, which mean that they are at a commercial stage involving less capital at risk. However, their southeast location requires that substantial transport costs be internalised in their financial profile. In some cases, particularly for pyrolysis and shredding (for solid fuel) based solutions, there are additional market and supply chain risks that are not at play to the same extent for crumbing and granulation solutions. In the case of pyrolysis, some of the end markets and the quality of products may be legitimately questioned. In the case of shredding to produce tyre derived fuel, a range of shipping risks and foreign country trade policy risks may render current markets inaccessible or commercially unfeasible.

Comparison of recycling surplus profiles 8.2

The preceding sections sought to estimate the net returns available to different supply chains that recover their various products from tyres collected from the NQROC and FNQROC regions, once operating and logistical cost factors are accounted for.

In each example, it was assumed that tyre processing would occur through incumbent facilities based in the southeast of Queensland or through new region-scale facilities, with costs covering:

- On site operations
- Long distance haulage of tyres, where appropriate to a southeast Queensland facility
- Transport of derived products to downstream purchasers (i.e. overseas or involving surface freight to a domestic facility in the case of TDF consumption, 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 predicted 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.

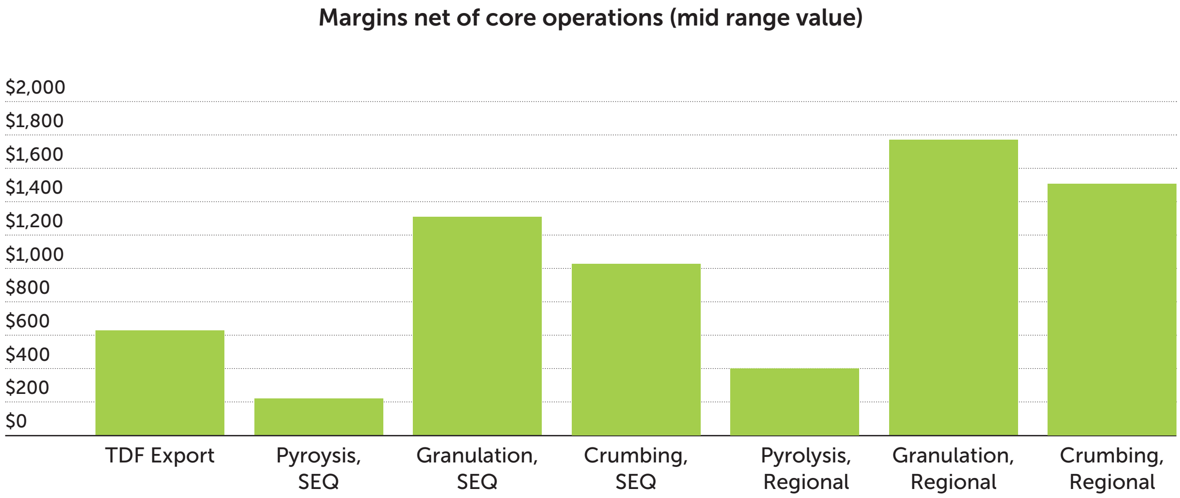
Figure 5 overleaf sets out a comparison of surpluses for the remaining recovery models that may be available to end-of-life tyre generators based in north and far north. For simplicity, only the mid-range values are provided.

The figure shows that each recovery pathway is able to generate a margin, although the processing of passenger car tyres into TDF for export is shown to generate lower margins than the other solutions investigated in this business case. These margins may also be lower than historic returns for exporting TDF, and may not be sustainable in the longer term given the higher profitability of other options for recovering passenger car tyres (namely, crumbing or granulation, in either southeast Queensland or regional facilities). The greater margins for other solutions could conceivably allow those competing operations to offer lower recycling fees while maintaining a positive return, and push the export of TDF out of the market.

This observation points to a broader recognition that the current $12 per EPU for tyre recovery services in NQROC and FNQROC may be somewhat inflated, and present an opportunity for new players to enter the market. For example, a new regional crumbing and granulation plant could potentially establish and offer tyre recycling services at a lower price point while still performing as a profitable enterprise.

(For illustrative purposes, operating with a recycling fee of $8 per EPU, the new facility would lower its margins from around $1,600 per tonne to $1,100 per tonne according to modelling in this business case, which may still be sustainable over the longer term while helping to establish a strong market presence. Other solutions such as TDF production and pyrolysis may struggle to compete at this price point.)

Figure 5: Mid range surpluses (per tonne) net of recycling operations, estimated for seven recovery pathways for end-of-life tyres generated in the NQROC and FNQROC regions. This chart assumes a recycling fee of $12 per EPU for tyres recovered from NQROC. While there are larger transport costs involved in processing tyres from FNQROC, it is assumed that this is fully offset through a slight increase in recycling fees.



This chart also shows that, although there are other market risks and investment barriers to address (covered elsewhere), a regional tyre crumbing and granulation facility may be in a position to directly compete with and replace similar facilities based in the southeast. While a regional facility may have higher operating costs due to more limited economies of scale, the reduced haulage overheads more than compensate for this factor.

However, this performance will ultimately rest on being able to amass larger quantities of tyres for processing (and to spread upfront capital costs across) as quickly as possible, and to identify and sell granule and crumb products to a growing market of downstream buyers who are willing to pay a sustainable price to the operator. A private investor would need confidence that these early market risks can be overcome (or shared with third parties) before committing to a new regional facility.

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 5,590 tonnes each year as well as covering a situation in which a further 3,400 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)	5,590 tonnes	$279,500	8,990 tonnes	$449,500
Total		**$279,500**		**$449,500**
Crumbing and granulation				
Rubber granule (at $600/t)	1,260 tonnes	$756,000	2,280 tonnes	$1,368,000
Rubber crumb (at $800/t)	2,620 tonnes	$2,096,000	4,000 tonnes	$3,200,000
Steel (at $240/t)	1,720 tonnes	$412,800	2,720 tonnes	$652,800
Total		**$3,264,800**		**$5,220,800**
Tyre pyrolysis				
Carbon char (at $200/t)	1,400 tonnes	$280,000	2,250 tonnes	$450,000
Fuel oil (at $140/t)	1,680 tonnes	$235,200	2,700 tonnes	$378,000
Steel (at $240/t)	1,680 tonnes	$403,200	2,700 tonnes	$648,000
Total		**$918,400**		**$1,476,000**
Recycling fees (at $750/t)	5,590 tonnes	**$4,192,500**	8,990 tonnes	**$6,742,500**

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 $3.2 million to $5.2 million, depending on the recovery rate and throughput achieved. In the case of pyrolysis, this range sits between $0.9 and $1.5 million, 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 $280,000 and $450,000 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

The analysis of potential tyre recovery solutions for the NQROC and FNQROC regions points to several tyre recovery pathways, derived from facilities in southeast Queensland with an established market presence and/or new regional facilities that are yet to be commissioned and build a base of customers.

In the former case, there may be limited areas where TSA and the Queensland Government may help improve tyre recovery outcomes for the regions. These areas may be oriented around:

- 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.

In the case where it is deemed suitable to support and drive development and introduction of a local tyre recycling facility in the Queensland market, there may be an additional call to provide financial support in the form of project capital; and encourage commercial partnerships and public services as a means to ensure there are ample quantities of tyres being processed to deliver a worthwhile return on investment.

Further to these actions which are specific to end markets and their supply chains, there is additional merit in stimulating intra-regional transport efficiencies between different locations in the north and far north, to maximise throughput and to circumvent locational disadvantages. These transport-related measures apply across the board (i.e. irrespective of the supply chains and processing technologies involved) 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 Table 11, a key issue for efficient tyre recovery from the two regions concerns the cost effective transport of end-of-life tyre material. The total amount of tyres from the NQROC and FNQROC regions and from major urban settlements such as Townsville and Cairns lend themselves to economies of scale in collection and transport. However, the more distant reaches of the Cape York Peninsula and western/inland parts of the two regions may face obstacles in accessing tyre recycling services due to the smaller amounts of tyres arising from dispersed and/or poorly connected sources.

These transport barriers may not be critical to the feasibility of a tyre recycling service for the regions, but may involve regional disadvantage and/or reduced affordability. Moreover, the lack of an affordable tyre recovery service may contribute to illegal dumping in more remote local government areas, where high costs for legitimate services may lead to undercutting by rogue operators. From this standpoint, it becomes important to support more efficient transport from less densely populated and more remote local government areas.

Regional partners and TSA may unlock intra-regional transport efficiencies through, for example:

- Providing for a strong regulatory presence to minimise the leakage of end-of-life tyres from legitimate tyre collection services and supply chains available across the NQROC and FNQROC regions, at locations where illegal disposal may have an inordinate impact on the quantities available for collection
- Setting up networks of transfer stations and consolidation points (which could involve third party and/or tyre retail premises) to support accessible tyre drop off locations
- Regional procurement of tyre collection services, allowing smaller and more remote councils to leverage procurement activities led by larger councils
- Exploration of more efficient approaches to moving end-of-life tyres (and other end of life products) across the region including backhauling and services to simultaneously collect multiple types of end of life products (e.g. e-waste and larger white goods; scrap metal; other materials specific to regionally significant industries).

Having a larger scale of tyres recovered from remote locations within the regions (and surrounding areas) may help to drive transport efficiencies for tyre recovery supply chains, while potentially encouraging competition in the market.

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 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 methods to prevent illegal end-of-life tyre management practices.

Options to draw tyre material from nearby regions 8.6

To some degree, the borders surrounding the NQROC and FNQROC regions do not necessarily align with the most viable areas from which a regional facility may collect tyres, as the ability to service different locations is independent of local government borders. The key drivers for the ability to process tyres from different sources are commercial in nature, and distances from point of origin to processing facility are one such driver, given its influence on overall supply chain costs.

For a facility based in the north of Queensland, it may be useful to understand the amount of tyres arising in nearby economic centres outside the NQROC and FNQROC region. This will provide a sense of prospective tyre material that may be processed, should the facility be in a position to compete with alternative service providers operating elsewhere in Queensland. Due to geography, these locations will mainly involve coastal and/or industrial centres south of NQROC, and may reinforce the advantages of locating a facility towards the southern parts of the combined NQROC and FNQROC area (i.e. in or near Townsville).

The following table sets out total volumes generated and tracked from selected centres immediately south of NQROC, using Queensland Government waste tracking data made available to the project. This total quantity of 5,167 tonnes (in FY2020) relate to tyres that are already sent to southeast Queensland for processing, noting that they may respond to competitive offers from elsewhere. The distance information relates to road distances between each city or town and Townsville; 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).

Tyre generators located nearer to NQROC may be more receptive to a new market entrant to the north, compared with generators placed closer to southeast Queensland. As the table shows, about 2,000 tonnes of tyres arise in locations that are closer to Townsville than they are to southeast Queensland, with a further 1,260 tonnes that are roughly equidistant. These estimates do not include OTR tyres and other tyres not included in waste tracking data.

A recycling operator looking to establish a tyre recycling service in the north of the state may find it useful to consult this table when gauging the likely market size relevant to its business model, and consider these figures in the context of the additional 5,590 tonnes that are already being processed from sources within NQROC and FNQROC each year (according to Queensland waste tracking data).

Table 11: Regional centres and towns near NQROC, with their distances from Townsville and southeast Queensland, and annual volumes of tyres arising as derived from Queensland Government waste tracking data.

Town & postcode(s)	Distance to Townsville	Distance to Redbank	Annual volume (FY2020)
Mackay (4740)	386 km	976 km	1,992 tonnes
Rockhampton (4700, 4701)	718 km	641 km	1,009 tonnes
Yeppoon (4703)	736 km	681 km	250 tonnes
Gladstone (4680)	825 km	540 km	974 tonnes
Bundaberg (4670)	1,005 km	387 km	942 tonnes
Total			**5,167 tonnes**

The value of coordination towards regional solution 8.7

The above sections of this report show that tyre recovery from the north and far north regions could be improved in a number of ways. These improvements span the augmented supply of end-of-life tyre materials to recovery supply chains to the strengthening of end markets for tyre derived products, and points in the supply chain between these 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 more distant parts of the regions could be rendered more efficient (and therefore more viable to implement), using a combination of back hauling, coordinated and shared use of collection services (for tyres and other materials), and the use of transfer stations and other sites as a regionally functional consolidation network.

OTR tyres also provide a path to grow the volume of tyres available for recovery from the two regions (and in adjacent mining centres such as Bowen Basin), although more effort and engagement is needed to determine a sustainable commercial model and equipment suitable to allow large OTR tyres to work as a feedstock alongside passenger car and truck tyres.

The analyses earlier in this report indicate that a regional crumbing and granulation facility may provide superior recycling and commercial outcomes compared to alternative options including the status quo reliance on facilities based in southeast Queensland. Such a facility may provide the basis for using recovered crumb rubber in nearby state and local government road building and maintenance projects, while helping to bypass unnecessary freight of tyres to southeast Queensland. Other products such as granule may also be used locally in some civil works or made available to buyers in the flooring and civil infrastructure sectors, based elsewhere in the country including southeast Queensland. Unlike other technologies investigated in this work, a crumbing and granulation operation focuses on higher end products and end markets, while allowing the operator to pivot from one product-market combination to another in line with trending demand levels and profit margins.

This facility could contribute to more sustainable roads and other assets in the north and far north, while symbolising a regional circular economy model that uses an identified priority waste stream. However, private investment in a regional crumbing and granulation facility may be contingent on certainty that there are buyers – principally road building and maintenance teams (for crumb) and civil works and flooring manufacturers (for granule) – who are willing to take its products at an acceptable price.

Local and state road network managers therefore have a role in proactively placing expectations on road construction and maintenance contractors to use crumb rubber as a binder material wherever suitable. Similarly, civil works procurement teams and engineers could include the exploration of rubber granule containing civil assets such as permeable pavements, playground and recreational/sporting field surfaces, and lightweight concrete composites used in movable bollards and other traffic control devices. TSA and the state government, in line with their roles in market development and industry stimulus, have access to a range of levers and experience to apply in creating, maturing and stabilising end markets at regional, state and larger scales.

Parties looking to invest in and operate a new regional tyre recovery facility may nonetheless face residual levels of risk, particularly during the early years of operation, when the amount of tyres received, processed and sold as products is ramping up and as other links in the supply chain configure to support the facility. There are also a range of environmental and planning approval hurdles that must be overcome before the construction phase. These factors represent risk to the project, which may lead to stalled investment and recovery service delivery. To counteract this scenario, there may be merit in the Queensland Government providing a capital allocation to a new facility which will bring the risk-return profile of the investment to within commercial tolerances. The offer of co-funding over a limited timeframe may spur private investors to commit in the near term, rather than indefinitely park their investment plans.

Arguably, this public investment is additionally justified in light of the local and regional spillover benefits including private investment in the regional economy; creation of long term jobs; improved accessibility and affordability of tyre recycling services in remote locations; and potentially, reduced instances of illegal disposal and other negligent practices by virtue of having a more visible and regional tyre recovery solution.

In summary, the combined measures outlined above aim to signal a safe and compelling regulatory and market environment to attract investment in a regional facility, and grant confidence that the facility can generate ample returns over its operating lifespan. But in the absence of investment at the regional scale, above-stated measures that seek to encourage greater adoption of tyre recovery services (currently based in southeast Queensland) will deliver a more partial success, albeit with many of the economic benefits transferred to actors based in southeast Queensland and elsewhere.

Should a regionally located facility be agreed as a top priority for NQROC, FNQROC, their councils and the Queensland Government, the measures in Table 12 need to be taken on in full and delivered in a coordinated fashion. This will grant greater certainty of attracting a legitimate regional solution, while also providing for a collaboration model that may be reused and adjusted as necessary for other circular economy priorities of the NQROC and FNQROC regions.

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 NQROC and FNQROC regions achieve a tipping point, 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. Moreover, should this approach be successful in attracting a regional operator servicing the north and far north, it will help to ensure that economic value and environmental benefits are retained in the north of the state while providing a template to apply in other areas of the circular economy.

Table 12: Overview of actions to address barriers and points of friction in improving tyre recovery from the NQROC and FNQRIC regions, and drive investment in an appropriate tyre recovery facility located towards Queensland's north.

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 mining and other regionally important OTR tyre sources, aiming to determine a service model and equipment suitable for using OTR tyres as a feedstock alongside passenger car and truck tyres.	TSA with council, DES and industry body (e.g. Queensland Resource Council) 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 two regions • Establish and expand collective procurement of tyre recovery and collection, which may include request for backhauling services	Councils and tyre recovery sector, with TSA support
Demand for end products, as relevant to encourage stable and mature markets and adequate sales revenue to encourage a regional tyre recovery facility	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
Measures to bring forward private investment in a regional tyre recovery facility, based on an acceptable risk-return profile and in recognition of public spillover benefits	Allocation of proportional public capital allocation in line with perceived public benefits and appropriately share risks. Terms and conditions to drive preference towards serving the regions as a whole, return useful products to local and regional economies, and support economic inclusion.	DSDILGP with support from TSA and councils offering a nominated waste and resource recovery precinct

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

In estimating current and potential road network demand for crumb rubber the project team has utilised a range of information from DTMR and Local Government sources predominantly. Key inputs and analysis are outlined below.

Estimated consumption of crumb rubber by DTMR managed projects

The following information (Table 13) was provided by DTMR to the project team for the purposes of this project, with the following qualifiers:

- That figures cover estimated crumb rubber usage on TMR projects since 2015/16. Provided as approximations only.
- Past usage may not necessarily be an indication of future use, while noting current trend toward increased consumption overall.

Table 13: Estimated consumption of crumb rubber by TMR projects to 2022 (in tonnes).

District	Locations	2016	2017	2018	2019	2020	2021	2022
South Coast	Nerang	0	0	0	0	9	27	103
Metropolitan	Brisbane	0	0	0	0	0	0.05	0
North Coast	Maroochydore	0	0	0	0	37	22	76
Wide Bay / Burnett	Bundaberg	0	183	315	317	406	543	423
Darling Downs	Toowoomba	0	283	95	186	524	202	99
South West	Roma	309	99	734	772	582	473	556
Fitzroy	Rockhampton	0	0	0	0	164	0	700
Central West	Barcaldine	0	0	0	0	32	128	0
Mackay / Whitsundays	Mackay	0	0	0	0	0	0	0
Northern	Townsville	0	0	0	0	47	52	74
Far North	Cairns	0	0	0	0	52	380	693
North West	Cloncurry	0	0	0	0	0	0	0
Total (tonnes crumb rubber)		**309**	**566**	**1,144**	**1,275**	**1,851**	**1,826**	**2,725**
Total no. tyres ('000's)		**55**	**101**	**204**	**227**	**330**	**326**	**487**
Tonnes EOLTs		**441**	**809**	**1635**	**1821**	**2644**	**2609**	**3893**

Note: All figures for financial years. 2022 financial year is estimated based on consumption at 05/04/2022.

While the vast majority of rubber crumb processing occurs in the Metropolitan district, there is little to no consumption of rubber crumb in TMR projects within the Metropolitan district. While unconfirmed, it may be assumed the relatively low consumption in the Metropolitan district may be due to limited incorporation of crumb rubber into asphalts to date and/or higher proportion of council led (i.e. non TMR local road) projects in the Metropolitan district.

Both the South West and Wide Bay / Burnett districts appear to have displayed relatively strong demand for crumb rubber, with the Far North and Fitzroy districts displaying strong growth in recent years.

Focusing on the Northern and Far North TMR districts, Table 14 provides an estimation of EOLTs consumption for each of those districts.

Table 14: TMR project consumption of crumb rubber in Northern and Far North districts (tonnes)

District	Locations	2016	2017	2018	2019	2020	2021	2022
Northern	Townsville	0	0	0	0	47	52	74
Total no. tyres ('000's)		0	0	0	0	8,421	9,220	13,235
Tonnes EOLTs		0	0	0	0	67	74	106
Far North	Cairns	0	0	0	0	52	380	693
Total no. tyres ('000's)		0	0	0	0	9,233	67,835	123,699
Tonnes EOLTs		0	0	0	0	74	543	990

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 15 below.
- Planned works over 2 years (2021/22 and 2022/23 financial years) – see Table 16 below.

In providing this information, DTMR provided the following qualifiers:

- 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 15: Completed maintenance of existing pavements over 5.5 years to August 2021 (kilometres).

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 16: Planned maintenance of existing pavements over 2022 and 2023 financial years.

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.[60] These figures are replicated below (Table 17), with an additional column reframing the EPUs as total tonnes of tyre material (via conversion factor 0.008 tonnes per EPU).

Table 17: Estimated consumption of end-of-life tyres (EOLTs) 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

[60] 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 17 and Table 18 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[61] 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.

Estimating potential QTRIP and RRTG road network activity

The project team reviewed QTRIP information to identify potential and planned projects in the Northern and Far North districts relevant to potential consumption of rubber crumb (i.e. works consuming spray seal and/or asphalt). For road projects Hinchinbrook Council is included in the Northern District, a departure from their inclusion within the FNQROC.

Relevant QTRIP road project investment (i.e. having potential to consume rubber crumb) in the North and Far North districts exclude investments into projects labelled with the following key words:

- Accessibility Upgrades, Active transport, Bridges, Culverts, Shared Path, Infrastructure improvements, Line marking, Rest areas, Flood programs, School programs, Strategy, Safety improvements or programs, Public Transport, Rail, Boating (or similar), Pathways, Cycleways, Road Operations (related improvement), Signals, Signage, Noise barriers, Programs, Business Case, Planning, Signals, Systems, Funding Commitment (unless specific to road upgrade).
- While new intersections / intersection upgrades have potential to incorporate rubber crumb into asphalt, these projects and related investment have also been excluded.

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

Table 18: QTRIP projects in Northern district with potential to consume crumb rubber.

Council	InvestID	Network	Investment Name
Burdekin Shire	865301	National	Bruce Highway (Bowen - Ayr), Fredericksfield Road to Homestead Road, construct overtaking lanes
Burdekin Shire	1751129	Local	Allen Road (Barratta), reconstruct pavement
Burdekin Shire	1145533	Local	Barratta Road (Upper Haughton), various locations, rehabilitate pavement
Burdekin Shire	1134006	Local	Beach Road (Ayr), rehabilitate pavement
Burdekin Shire	1913791	Local	Fiveways Road (Brandon), pavement reconstruction
Burdekin Shire	1914018	Local	Groper Creek Road (Inkerman), reseal works
Burdekin Shire	1915441	Local	Hughes Road (Barratta), pavement reconstruction
Burdekin Shire	1914013	Local	McLain Road (Giru), reseal works
Burdekin Shire	1528583	Local	School Road (Clare), Clare township to Barratta Road, widen pavement and improve drainage
Charters Towers	315972	State	Gregory Developmental Road (Belyando Crossing - Charters Towers), approaches to Boomerang Creek, widen and seal
Charters Towers	1534377	State	Gregory Developmental Road (Charters Towers - The Lynd), Airport Drive to Lucky Springs Road, strengthen and widen pavement
Charters Towers	1697820	State	Gregory Developmental Road (Charters Towers - The Lynd), Marble Creek to Christmas Creek, widen pavement
Charters Towers	1156080	Local	Ewan Road, Hidden Valley to Paluma, reconstruction works
Charters Towers	377014	Local	Lake Buchanan Road (Pentland), Jumpup stabilisation section, rehabilitate pavement
Charters Towers	718440	Local	Victory Street, Milchester Road to York Street (Queenton), asphalt overlay and junction alignment
Charters Towers	1912367	Local	Weir Road (Charters Towers), reseal works
Hinchinbrook	934732	National	Bruce Highway (Townsville - Ingham), Grasso's Road to Lannercost Street and Townsville Road intersection, widen and seal
Hinchinbrook	1134121	Local	Cooks Lane (Ingham), various locations, pave and seal
Hinchinbrook	1917599	Local	Cooks Lane (Ingham), widen pavement
Hinchinbrook	728139	Local	Four Mile Road (Braemeadows), various locations, pave and seal and improve drainage
Hinchinbrook	1917916	Local	Jourama Road and Jourama Falls Road, reseal works
Hinchinbrook	1146058	Local	Lannercost Extension Road (Lannercost), various locations, pave and seal
Hinchinbrook	728142	Local	McIlwraith Street (Ingham), various locations, pave and seal
Hinchinbrook	1134122	Local	Mount Fox Road (Upper Stone), various locations, rehabilitate pavement
Hinchinbrook	728335	Local	Palm Avenue (Ingham), pave and seal
Hinchinbrook	1533437	Local	Patterson Parade (Hinchinbrook), widen pavement
Hinchinbrook	1134120	Local	Taylors Beach Road (Taylors Beach), pave and seal
Hinchinbrook	375011	Local	Venables Crossing Road (Trebonne), various locations, pave and seal
Hinchinbrook	1916083	Local	Wallaman Falls Road (Ingham), various locations, reseal

Council	InvestID	Network	Investment Name
Hinchinbrook	10959	Local	Wallaman Falls Road (Ingham), various locations, widen and seal
Hinchinbrook	1533520	Local	Warrens Hill Road (Ingham), various locations, pave and seal
Townsville City	865016	National	Bruce Highway (Townsville - Ingham), Leichhardt Creek to Lilypond Creek, construct overtaking lanes
Townsville City	1451417	National	Flinders Highway (Townsville - Charters Towers), Townsville to Mingela Range (Package 1 and 2), construct overtaking lanes
Townsville City	1059916	National	Townsville Ring Road (Stage 5)
Townsville City	1776745	State	Garbutt - Upper Ross Road (Riverway Drive, Stage 2), Allambie Lane to Dunlop Street, duplicate to four lanes
Townsville City	1648310	State	Hervey Range Developmental Road (Townsville - Battery), Rupertswood Drive to Black River Road, widen pavement
Townsville City	1697467	State	North Townsville Road (Townsville), strengthen pavement
Townsville City	1810958	Local	Alma Bay to Horseshoe Bay (Magnetic Island), upgrade various roads
Townsville City	1133901	Local	Ingham Road (Garbutt), Mather Street to Webb Drive, duplicate to four lanes
Townsville City	1145210	Local	Ingham Road, Webb Drive to Enterprise Street (Mount St John), duplicate to four lanes
Townsville City	1817986	Local	Jones Road, Lansdown Eco Industrial Precinct (Calcium), construct and upgrade roads
Other works			Construction Works
Other works			Programmed Maintenance
Other works			Rehabilitation
Other works			Routine Maintenance

Aggregated and combined QTRIP investment for these Northern projects is outlined in Table 19.

Table 19: QTRIP investment into projects in the Northern district

Year	Aggregate project value
2022 total (expected)	$158,142,844
2023 total (expected)	$191,694,240
2024 total (expected)	$148,920,818
2025 total (expected)	$148,920,818

Table 20: QTRIP projects in Far North district with potential to consume crumb rubber.

Local Government	InvestID	Network	Investment Name
Cairns Regional	383276	National	Bruce Highway, Cairns Southern Access Corridor (Stage 3), Edmonton to Gordonvale, construction
Cairns Regional	384407	National	Bruce Highway, Cairns Southern Access Corridor (Stage 4), Kate Street to Aumuller Street, widen to six lanes
Cairns Regional	1351442	National	Cairns Ring Road (Cairns CBD to Smithfield)
Cairns Regional	1810618	State	Cairns Western Arterial Road, Redlynch Connector Road to Captain Cook Highway, duplication
Cairns Regional	538017	State	Captain Cook Highway, Smithfield Bypass
Cairns Regional	1816601	Local	Links Drive (Woree), rehabilitate and widen

Local Government	InvestID	Network	Investment Name
Cassowary Coast	9351	National	Bruce Highway (Ingham - Innisfail), Smiths Gap, construct southbound overtaking lane and fauna overpass
Cassowary Coast	1191841	State	Boogan Road, widen and strengthen pavement
Cook Shire	1446013	State	Peninsula Developmental Road (Coen - Weipa), Archer River Crossing southern approach, pave and seal
Cook Shire	1445943	State	Peninsula Developmental Road (Coen - Weipa), Merluna to York Downs, pave and seal
Cook Shire	1447579	State	Peninsula Developmental Road (Laura - Coen), Bamboo to south of Duck Holes, pave and seal
Cook Shire	1445940	State	Peninsula Developmental Road (Laura - Coen), Musgrave to Red Blanket (Part A), pave and seal
Cook Shire	1447584	State	Peninsula Developmental Road (Laura - Coen), Musgrave to Red Blanket (Part B), pave and seal
Cook Shire	1447586	State	Peninsula Developmental Road (Laura - Coen), Yarraden to Three Sisters (Part A), pave and seal
Cook Shire	1445871	State	Peninsula Developmental Road (Laura - Coen), Yarraden to Three Sisters (Part B), pave and seal
Cook Shire	1445283	State	Peninsula Developmental Road (Laura - Coen), Yarraden to Three Sisters (Part C), pave and seal
Cook Shire	1811000	Local	Aurukun Road (Section 1), bitumen seal and drainage
Cook Shire	1811029	Local	Aurukun Road (Section 2), bitumen seal and drainage
Cook Shire	1811045	Local	Aurukun Road (Section 3), bitumen seal and drainage
Cook Shire	1811099	Local	Aurukun Road (Section 4), bitumen seal and drainage
Cook Shire	1950316	Local	Boundary Street, pave and seal
Cook Shire	1952039	Local	Garden Street, pave and seal
Cook Shire	1811317	Local	Pormpuraaw Road, Colman River, replace causeway and seal
Cook Shire	1811327	Local	Pormpuraaw Road (Section 3), bitumen seal and drainage
Cook Shire	1949637	Local	Savage Street, Cooktown, seal unsealed road
Cook Shire	1952090	Local	Sherrin Esplanade, Cooktown, pave and seal
Croydon Shire	1952071	Local	Croydon - Richmond Road, pave and seal
Etheridge Shire	1512197	State	Gulf Developmental Road (Croydon - Georgetown) (Package 2), strengthen and widen pavement
Etheridge Shire	1512054	State	Gulf Developmental Road (Georgetown - Mount Garnet) (Package 1), strengthen and widen pavement
Etheridge Shire	1950374	Local	North Head Road, pave and seal
Etheridge Shire	1498319	Local	Strathmore Road (Section 2), construct to sealed standard
Hope Vale Aboriginal Shire	1816605	Local	Banana Farm Road and Airport Road (Hope Vale), upgrade existing bypass
Lockhart River Aboriginal Shire	1810457	Local	Portland Roads Road (Section 2), bitumen seal and drainage
Lockhart River Aboriginal Shire	1810640	Local	Portland Roads Road (Section 1), bitumen seal and drainage
Mareeba Shire	1442454	State	Burke Developmental Road (Normanton - Dimbulah) (Section 1), progressive sealing

Local Government	InvestID	Network	Investment Name
Mareeba Shire	1619431	State	Burke Developmental Road (Normanton - Dimbulah) (Section 2), progressive sealing
Mareeba Shire	1779365	State	Kennedy Highway (Cairns - Mareeba), rehabilitate and widen
Mareeba Shire	1952766	Local	Bower Road, widen and seal
Mareeba Shire	1952841	Local	Euluma Creek Road, rehabilitate and widen
Mareeba Shire	1952675	Local	Euluma Creek Road, widen and seal
Tablelands Regional	1953413	Local	Brooks Road, widen and seal
Tablelands Regional	1953414	Local	Lawson Street, widen and seal
Various local governments	1194277	State	Cairns to Northern Territory Border corridor upgrade, funding commitment
Various local governments	1195159	State	Cooktown to Weipa Corridor upgrade, funding commitment
Other works			Construction Works
Other works			Programmed Maintenance
Other works			Rehabilitation
Other works			Routine Maintenance

Aggregated and combined QTRIP investment for these Far North projects is outlined in Table 21.

Table 21: QTRIP investment into projects in the Far North district

Year	Aggregate project value
2022 total (expected)	$312,019,913
2023 total (expected)	$295,620,889
2024 total (expected)	$280,804,462
2025 total (expected)	$280,804,462

Four year RRTG work programs for Northern and Far North districts were not provided to the project team. Therefore the project team reviewed FNQROC council budgets for 2021 and 2022FY's to gather further understanding of current and proposed road projects managed via Councils / RRTGs. Excluding unsealed road works and focusing on projects involving application of spray seal (at minimum), the works for FNQROC (excluding Hinchinbrook) implied a potential aggregate project value of approximately $8 million per year. A review of chain distances for proposed road works provided evidence to support an assumed cost of $300,000 per kilometre for spray seal. A similar annual expenditure and cost has been assumed for the Northern Councils (RRTG)

Estimating actual and potential road network consumption of crumb rubber in NQROC and FNQROC

Building on the analysis above, in estimating potential consumption of crumb rubber in NQROC (including Hinchinbrook Council) and FNQROC (excluding Hinchinbrook Council), the following assumptions have been applied:

- Relevant QTRIP road project investment (i.e. having potential to consume rubber crumb) in the North and Far North districts exclude investments into projects labelled with the following key words:
  - Accessibility Upgrades, Active transport, Bridges, Culverts, Shared Path, Infrastructure improvements, Line marking, Rest areas, Flood programs, School programs, Strategy, Safety improvements or programs, Public Transport, Rail, Boating (or similar), Pathways, Cycleways, Road

Operations (related improvement), Signals, Signage, Noise barriers, Programs, Business Case, Planning, Signals, Systems, Funding Commitment (unless specific to road upgrade).

  - While new intersections / intersection upgrades have potential to incorporate rubber crumb into asphalt, these projects and related investment have also been excluded.

- A cost of $300,000 per km of spray seal road (dual lane) can be applied as an average cost in the NQROC and FNQROC (for QTRIP and RRTG relevant works)
- QTRIP and RRTG projects are composed of spray sealed (dual lane) road build only.

Table 22: Potential consumption of crumb rubber in Northern district (NQROC and Hinchinbrook Council).

DTMR Maintenance of State Controlled Network in Northern district								
Per annum	PMB spray seal		Bitumen spray seal		Asphalt - open		Asphalt – dense	
	Low	High	Low	High	Low	High	Low	High
Kilometres	35	163	10	21	0	0	7	37
EOLTs (tonnes)	48	224	6	12	0	1	75	411
QTRIP & RRTG projects in Northern district with potential to consume crumb rubber								
Per annum	PMB spray seal		Bitumen spray seal		Asphalt - open		Asphalt - dense	
Kilometres	496	638						
EOLTs (tonnes)	683	879						

Table 23: Potential consumption of crumb rubber in Far North (FNQROC less Hinchinbrook).

DTMR Maintenance of State Controlled Network in the Far North district								
Per annum	PMB spray seal		Bitumen spray seal		Asphalt - open		Asphalt - dense	
	Low	High	Low	High	Low	High	Low	High
Kilometres	57	213	141	173	0	17	17	47
EOLTs (tonnes)	79	294	84	102	0	113	186	528
QTRIP & RRTG projects in the Far North district with potential to consume crumb rubber								
Per annum	PMB spray seal		Bitumen spray seal		Asphalt - open		Asphalt - dense	
Kilometres	971	1084						
EOLTs (tonnes)	1336	1492						

Focusing on DTMR managed projects, Table 24 (below) provides indicative high and low ranges for potential consumption of rubber crumb for FNQROC, NQROC and combined. These potential estimates of consumption for DTMR managed projects are compared with actual and estimated consumption for the 2021 and 2022FY's (as outlined previously in Table 15 above). While FNQROC consumption in 2022FY would appear to be nearing higher end of potential consumption, there appears to be scope for considerable increase in NQROC.

Table 24: Actual and potential DTMR led rubber crumb consumption within FNQROC & NQROC (EOLTs tonnes).

DTMR maintenance (State network) - consumption EOLTs (tonnes per annum)				
Seal & Asphalt	Potential (low)	Potential (high)	Actual 2021	Est. 2022
FNQROC	349	1,037	543	990
NQROC	129	649	74	106
Combined	**478**	**1,686**	**617**	**1,096**

Aggregating potentially relevant QTRIP and local (RRTG) projects for the Far North and Northern districts (including projects across Tables 22 to 24 above), additional potential consumption of rubber crumb is outlined in Table *25*.

In formulating estimates for QTRIP and RRTG:

- Both high and low consumption estimates assume approx $300K / km on average for spray sealed road across FNQROC / NQROC.
- Range (high to low) based on QTRIP road projects (i.e. proposed expenditure 2022FY to 2025FY) excluding non-road projects and intersection upgrades.

Table 25: Potential rubber crumb consumption across relevant QTRIP and RRTG projects in FNQROC and NQROC (equivalent EOLT tonnes).

QTRIP new road and RRTG estimate		
Spray seal only	Potential (low)	Potential (high)
FNQROC	1326	1482
NQROC	683	879
Combined	**2009**	**2361**

In summary:

- There is strong and growing demand for crumb into TMR road maintenance in FNQROC and NQROC consuming 1,000 tonnes/year EOLTs with all rubber crumb currently supplied from SE Queensland.
- 5,600 tonnes of tyres (car and truck) from the far north and north are transported to SE Queensland for processing into crumb, granule and other products.
- Estimated additional QTRIP / RRTG demand for crumb into roads in order of 2,000 tonnes EOLT per year. Potentially spray seal only, although some anecdotal evidence of rubber crumb into asphalt trials being pursued by TMR.

Taken together there is potential crumb rubber demand in the order of 3,000 tonnes EOLT equivalent per year, in the north and far north.

TyreStewardship AUSTRALIA

Australian Government Accredited Product Stewardship Scheme

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.